SIEMENS

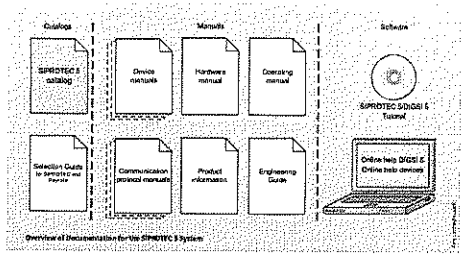
SIPROTEC 5 for Every Application and Requirement

SIPROTEC 5 – Devices
Protection, Automation and Monitoring

Catalog SIPROTEC 5.01 · Edition 4

siemens.com/siprotec

Overview of documentation



Overview of Documentation for the SIPROTEC 5 System

SIPROTEC 5 catalog

The catalog describes the system features and the devices of SIPROTEC 5.

Selection guide for SIPROTEC and Reyrolle

The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

Device manuals

Each Device manual describes the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.

Hardware manual

The Hardware manual describes the hardware building blocks and device combinations of the SIPROTEC 5 device family.

Operating manual

The Operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.

Communication protocol manual

The Communication protocol manual contains a description of the protocols for communication within the SIPROTEC 5 device family and to higher-level network control centers.

Product information

The Product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.

Engineering Guide

The Engineering Guide describes the essential steps when engineering with DIGSI 5. In addition, the Engineering Guide shows you how to load a planned configuration in a SIPROTEC 5 device and update the functionality of the SIPROTEC 5 device.

DIGSI 5 online help

The DIGSI 5 online help contains a help package for DIGSI 5 and CFC. The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles and editors. The help package for CFC includes an introduction to CFC programming, basic examples of working with CFC, and a reference chapter with all the CFC blocks available for the SIPROTEC 5 range.

SIPROTEC 5/DIGSI 5 Tutorial

The tutorial on the DVD contains brief information about important product features, more detailed information about the individual technical areas, as well as operating sequences with tasks based on practical operation and a brief explanation.

Content

SIPROTEC 5 Devices, Protection, Automation and Monitoring

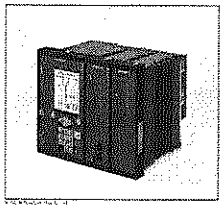
SIPROTEC 5
Devices, Protection, Automation and Monitoring

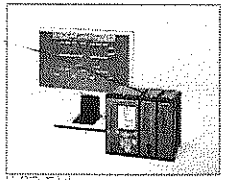
Catalog SIPROTEC 5.01 · Edition 4

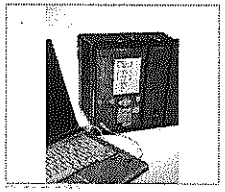
Content

Content

Editorial







Editorial

SIPROTEC has been a recognized brand leader in digital protection and bay units for the energy market for decades. The Siemens high performance SIPROTEC devices cover the entire power spectrum and can be implemented in a wide range of fields – from power generation to every high voltage transmission and distribution network application.

"Smart and intuitive 'to order' is the Siemens response to the present and future challenges to achieve a reliable and efficient energy supply. SIPROTEC 5 is an active component of the energy efficient smart grid and an important building block in the complex distributed energy supply systems and networks solutions.

The next generation of SIPROTEC devices, SIPROTEC 5, is based on the proven properties of SIPROTEC 4 to provide you with a new, modern platform of hardware and software. The platform offers an excellent solution to the challenges associated with existing and structures and workflows. The quality, reliability and proven functions of the former system have been preserved. Innovative approaches including before and after, safety and security, and network stability monitoring (PMU functionality) have been added.

The pioneering system architecture puts you in full control of communication connections. A powerful, reliable communication infrastructure, combined with the flexible engineering capabilities serves as the basis for handling distributed decentralized system structures. For you, "Configured to Communicate" in SIPROTEC 5 means: Communication is the central component of the system architecture to provide the flexibility, safety and security needed now and in future, automated distributed network solutions.

With SIPROTEC 5, you are using a new generation of intelligent, digital multifunction bay units. The new operating tool DIGSI 5 gives you the individual support you want – it handles your specific workflow requirements, from system design to device selection and beyond, covering the entire device lifecycle. The result: often cost savings over the entire lifecycle without compromising safety or system availability.

With the new SIPROTEC 5 generation, you are well equipped to meet the prevailing economic and availability demands imposed on your networks. The philosophy of SIPROTEC 5 is reflected in the modularity and flexibility of its hardware and software components. Perfectly tailored to the solution for for your applications and requirements for the application and standards behind of power automation.

SIPROTEC 5

Introduction – Solutions for the power systems of today and the future

Solutions for the power systems of today and the future

SIPROTEC has been established on the energy market for decades as a powerful and complete system family of digital protection relays and bay units, from Siemens. SIPROTEC products devices from Siemens can be used consistently throughout all applications in medium or high voltage, with SIPROTEC, operators have their places literally and safely under control, and have the basis to implement cost effective solutions for all tasks in modular, intelligent and "smart" power systems. Users can combine the units of the individual SIPROTEC device series as will for solving a variety of tasks – SIPROTEC stands for continuity, openness and future-proof design.

As the innovation driver and trendsetter in the field of power system protection for 100 years, Siemens helps you to design your power systems in an intelligent, ecological, reliable and efficient way, and to operate them economically. As a pioneer, Siemens has decisively influenced the development of digital power system protection (Figure 1.17). The first application went into operation in Wuerzburg, Germany, in 1977. Consistent structures of protection and control functions for all SIPROTEC devices was the innovation step in the 90s. After the release of the IEC 61850 communication standard in 2004, Siemens was the first manufacturer worldwide to put a device with this communication standard into operation. More than 500,000 SIPROTEC devices with IEC 61850 are in operation throughout the world.

Many users have appraised SIPROTEC protection devices for use in their power systems. The devices have also been certified by independent test institutes and universities (PEHLA, EPRI, LOVD, Laboratories).

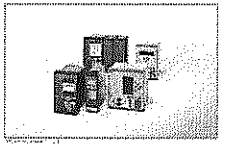


Figure 1.17 SIPROTEC family

How can you benefit from this experience?

- Proven and complete applications
- Optimum cooperation of the components in the system
- Highest quality of hardware and functionality
- Excellent operator friendliness of devices and tools
- Easy data exchange between applications
- Excellent consistency of product and system
- Reduced complexity due to simple operation
- Siemens is a reliable, worldwide operating name

Information about the SIPROTEC 4 and SIPROTEC Compact product families can be found in the related catalog or at www.siemens.com/siprotec

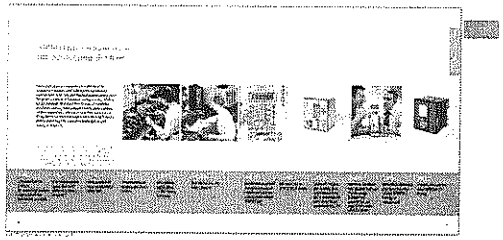


Figure 1.12 SIPROTEC – pioneer for generations

The new benchmark for protection, automation and monitoring

The SIPROTEC 5 range is based on many years of experience of the SIPROTEC 4 generations and has specifically been developed for the new requirements in the power supply systems. For this purpose, SIPROTEC 5 is equipped with numerous functionalities and device types. With the integrated Ethernet interfaces and IEC 61850-9-2 as a protocol it is also ideally prepared for the increasingly complex processes – from design through operation to service and retrofit.

Thanks to the high degree of flexibility of hardware and software, the specialization of the device types can be tailored to the customized application and adjusted to the user's changing requirements throughout the entire lifecycle.

In addition to the reliable and selective protection and the complete automation functions, SIPROTEC 5 offers an extensive database for operating and monitoring modern power systems. Synchronized event (SoE), network quality data and extensive measurement data are available for the requirements of the respective utility.

- Powerful protection functions ensure the safety of equipment and staff
- Individually configurable devices save time and cost in initial investment and for spare parts storage, maintenance, expansion and adaptation of your plant
- Arc protection, detection of transient ground faults, and a process bus can easily be integrated and configured
- Powerful and easy handling of devices and software thanks to a user friendly design
- Increased reliability and quality of the engineering process
- Consistent implementation of high safety and security standards
- Powerful communication requirements ensure rare and safe the solutions
- Full compatibility between IEC 61850 Editions 1 and 2
- Integrated switch for low cost and independent optical and electrical Ethernet rings
- Redundancy protocols RSTP, PRP and HSR for maximum availability
- Efficient operating concepts due to flexible configuration of IEC 61850 Edition 2
- Comprehensive database to monitor modern power systems
- Optimal smart automation platform for your power systems based on integrated control and measurement units (Ethernet and Power Quality functions

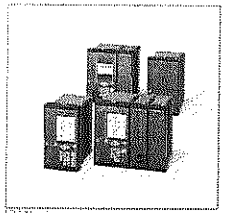


Figure 1.13 SIPROTEC 5 – Modular hardware

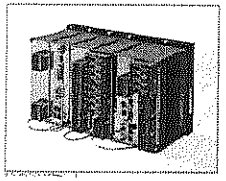


Figure 1.14 SIPROTEC 5 – Modular process connection

The SIPROTEC 5 product family, with its modular hardware, the intelligent use of powerful microprocessor technology, and the consistent implementation of communication standards, has defined a new standard for modern protection devices. With the SIPROTEC 5 DIGSI 5 engineering tool, the user benefits from a new, intuitive, and flexible software concept that has been developed and tested with great care. The high performance and flexibility of the platform, extended cyber security, and the maintenance of present and future demands are the main focus of development.

Holistic workflow

End-to-end engineering from system design to commissioning makes your work more efficient on the whole process.

The big benefits of SIPROTEC 5 in the operation phase and during service and maintenance activities are particularly supported by the new DIGSI 5 tool. It helps all persons involved along all the steps in the workflow, allowing the system, device management and cyber security tasks, the design of individual device display pages and tests without compromising quality (figure 1.27).

Holistic workflow in SIPROTEC 5 means:

- Integrated, consistent system and device engineering – from the single line of the plant as the basis to device parameterization
- Simple, intuitive graphical switching of primary and secondary equipment
- Switched application templates for the most frequently used applications
- Manufacturer-independent tool for easy system engineering
- Open interfaces for seamless integration into your process environment
- Integrated tools for testing during engineering, commissioning, and for analyzing operational faults and events, such as system failures in switching processes.

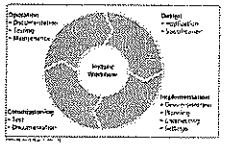


Figure 1.27 Holistic workflow – from design to service

Holistic workflow in SIPROTEC 5 means for you:

Around-the-clock from system design to operation – over plant department boundaries – save time, reduce data redundancy and transparency throughout the entire lifecycle of your plant

Perfectly tailored to

Individual requirements of the power system and their changes is the most important requirement for the engineering system. SIPROTEC 5 was developed to easily adapt and modify it with its many flexible and flexible solutions, whether as a stand-alone device, SIPROTEC 5 provides a perfect solution for your specific requirements.

Perfectly tailored to SIPROTEC 5 means:

- Modular system design for full flexibility, functionality and communication to meet the perfect fit to your needs
- The broad integration of a wide range of applications, such as protection, control, data interface, power quality or fault recorders
- The new connection and communication possibilities for all devices in the family
- Innovative mechanical technology ensures easy assembly and other handabilities at the highest possible degree of safety
- Identical connection throughout the entire system family ensures future training requirements and increased safety. Example terminal arrangement technology (CARE) for the line protection devices 7SD, 7SA6, 7SJ6
- Each device can be ordered to be customized individually for your specific requirements
- Innovative accessories available in all devices at the same time and can easily be retrofitted as needed for the future.

Perfectly tailored to or SIPROTEC 5 means for you: Individually configurable devices save money on initial investment, spare parts storage, maintenance, extension and adaptation of your system

Figure 1.29 SIPROTEC 5 – innovative technology

Designed to communicate

The coordinating system of modern plants communication today under your control. Powerful, flexible, and above all self-able communication is the prerequisite for distributed and decentralized system topologies, such as smart grids. In the system architecture of SIPROTEC 5, we have attached immense importance to communication, and we have gone to many lateral lengths to ensure that you are ideally equipped for the communication demands of today and the future.

Designed to communicate in SIPROTEC 5 means:

- Adaptable to the topology of your communication structure using parameters (ring, star, network, etc.)
- Scalable redundancy in hardware and software (protocols to match your requirements)

- Multiple communication channels to address higher-level systems
- Pluggable and upgradeable communication modules
- Hardware modules decoupled from the currently used communication protocol
- 2 independent Ethernet protocols in one module
- Extensive routines for self-connections, functions and operations workflows
- Expansion module for process bus communication

Designed to communicate in SIPROTEC 5 means for you: Communication as an integral component of the system architecture provides you with the flexibility and safeguards you need in densely networked systems today and in the future.

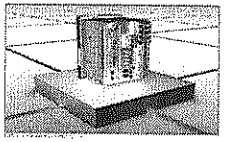


Figure 1.23 SIPROTEC 5 devices with various communication options

Safety and security inside

Multilayer safety mechanisms in all levels of the system safety chain provide you with the highest possible levels of safety and availability. Safety for humans and the plant, and operation availability, are the top priorities. As the power systems become more and more complex, conventional safety mechanisms are no longer adequate. For this reason, a safety concept has been integrated in the SIPROTEC 5 device architecture that is designed to address and counteract these multilayer aspects in a holistic approach.

Safety and security inside in SIPROTEC 5 means:

- Proven functions for the protection of plants and personnel, partially developed from DIGSI classics
- Long-lasting, rugged connection technology (modules, plugs) and a well-balanced layout of the entire electronics for highest resilience against surges, EMC, climate and mechanical stress
- Self-diagnostics self-monitoring routines identify and report device faults immediately and reliably
- Conformity with the stringent Cyber Security requirements in accordance with the industry standards and regulations, such as BDEW White Paper and NERC CIP

- Encryption along the entire communication route between DIGSI 5 and device, in accordance with the recommendations of industry standards and best practices
- Automatic locking of access attempts and sabotage-proof operators or the devices and systems

Smart Automation for Grids

Climate change and dwindling fossil fuels are fostering a total re-evaluation of the energy supply industry, from generation to distribution and consumption. This is having fundamental effects on the structure and operation of the power systems.

Smart automation, the intelligent power automation system, is a logical next step, components designed to preserve the stability of these power systems and at the same time conserve energy and reduce costs.

With SIPROTEC 5 and the unique spectrum of integrated functionality, you have the optimum smart automation platform for your smart power systems.

Smart automation for grids in SIPROTEC 5 means:

- Open, scalable architecture for IT-expertise and new functions
- "Smart functions", for example for network operation, analysis of faults or power quality (power system monitoring, power control unit, fault locators)
- Integrated automation with optimized logic blocks based on the IEC 61131-3 standard
- High-precision acquisition and processing of process values and synchronization to other components in Smart Grid
- Protection, automation and monitoring in Smart Grid

SIPROTEC 5 devices have specifically been designed to meet the requirements of the modern grid, secure the future and offer the necessary automation platform.

The elements that connect the five mentioned innovation highlights are IEC 61850 Edition 2 and an thoroughly designed user-oriented implementation in SIPROTEC 5.

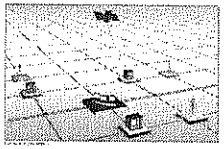


Figure 1.24 SIPROTEC 5 – highly automated power supply

IEC 61850 – Simply usable

Systems, that operate on IEC 61850, make the full potential of this global standard easily usable for you.

The IEC 61850 standard is more than just a substation automation protocol. It comprehensively defines data types, functions and communication in substation needs. In Edition 2, the influence of the standard is extended to more domains and applications of the energy supply industry.

Siemens was actively involved in the process of standardization from Edition 1 to Edition 2, and with the largest number of completed installations in the world, our experience as a manufacturer of the IEC 61850 standard jointly with key customers, are designed to implementation in SIPROTEC 5, paying close attention to interoperability, flexibility and compatibility between Editions 1 and 2.

Besides the standard protocol IEC 61850, SIPROTEC 5 also supports other protocols, such as IEC 60870-5-103, IEC 60870-5-104, DNP 3 (serial or TCP) or Modbus TCP.

Meet the standard

IEC 61850

'IEC 61850 – Simply usable' in SIPROTEC 5 means:

- A stand-alone IEC 61850 system configurator allows IEC 61850 configuration of SIPROTEC 5, SIPROTEC 4 and devices from other vendors
- Full compatibility with Editions 1 and 2
- Open interfaces in IEC 61850 system configurator enable seamless system configuration and interoperability
- Conversion of the complexity of the IEC 61850 data model through intelligent user concepts
- Flexible object modelling, degrees of freedom in object addressing and flexible communication services ensure the highest possible degree of interoperability and effective exchange and expansion concepts
- Handling optimization based on many projects and close cooperation with customers from all fields of application
- Protection settings via IEC 61850
- Using several communication modules in Edition 2

The implementation of IEC 61850 Edition 2 unleashes the full potential of this standard by continually supporting your operational needs and simplifying handling.

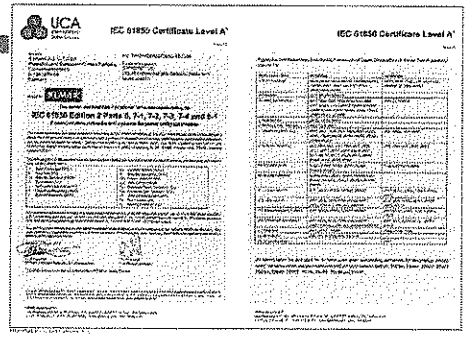


Figure 1.26 Certificates IEC 61850 Edition 2 available

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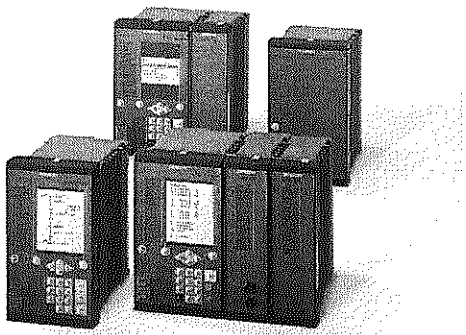

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SIPROTEC 5 Devices and Fields of Application

Device Types

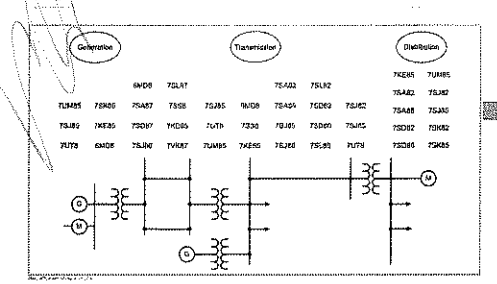


Figure 2.1/1 Fields of application of the SIPROTEC 5 devices

The graphic gives an overview of the utilization of SIPROTEC 5 devices in the power system. With consumer energy producers, or particular, if there is power infeed into the grid at all voltage levels. Protected objects are busbars, overhead lines or cables, and transformers. These objects have the corresponding power flow levels identified.

Device Types

A short two digit code represents easy identification of the SIPROTEC 5 devices. The first digit (6 or 7) stands for digital technology. The two letters describe the functionality, and the last two digits identify special properties. Further details can be found in the catalog section of the related device description.

Definition of the device types by their designation

Device Types

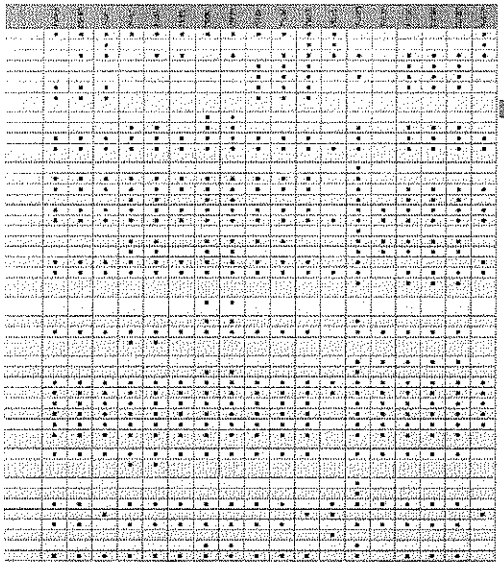
Overcurrent protection	
Overcurrent protection with PSM* and coupling	7SJ62, 7SJ63
Line protection	
Distance protection with PSM* and coupling	7SA87, 7SA86, 7SA84
Line differential protection with PSM* and coupling	7SD82, 7SD86, 7SD87
Line differential protection with PSM* and coupling	7SL82, 7SL86, 7SL87
Differential protection	
Overcurrent protection for one side* PSM*	7SJ86
Transformer protection	
Transformer protection with PSM* and coupling	7UT82, 7UT85, 7UT86, 7UT87
Motor protection	
Motor protection with PSM* and coupling	7SK82, 7SK85
Generator protection	
Generator protection	7UM85
Busbar protection	
Busbar protection	7SS85
Bay controllers	
Bay controllers for communication-oriented substation automation (IEC 61850, IEC 60870-5-104, DNP3) and gateway functions	6MD85, 6MD86
Fault recorders	
Fault recorders, can be combined with power quality recordings and local control (with PSM*)	7KE85

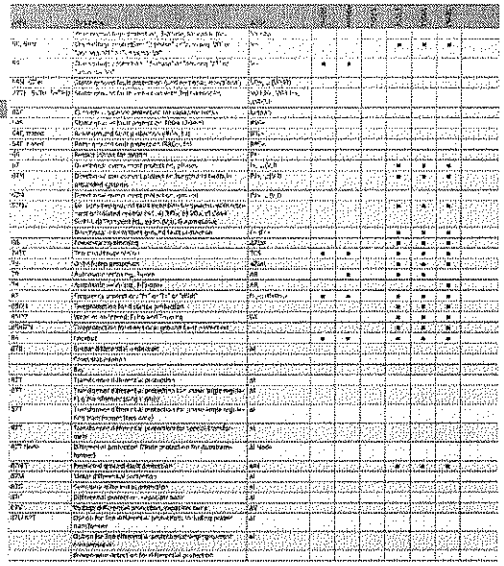
Table 2.1/1 Available device types* in the SIPROTEC 5 system

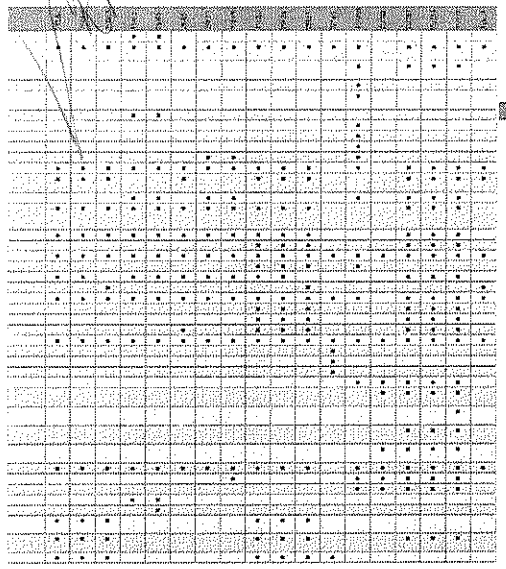
(1) optional

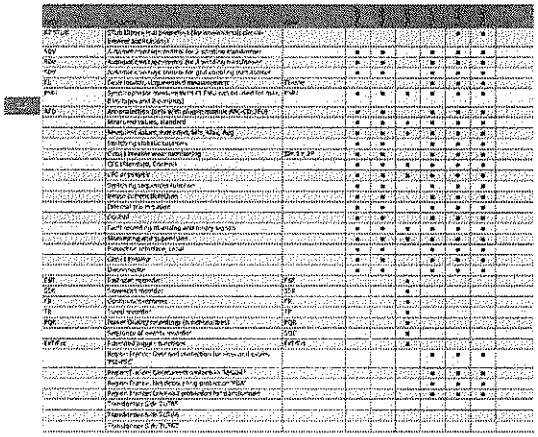
Relay Selection Guide

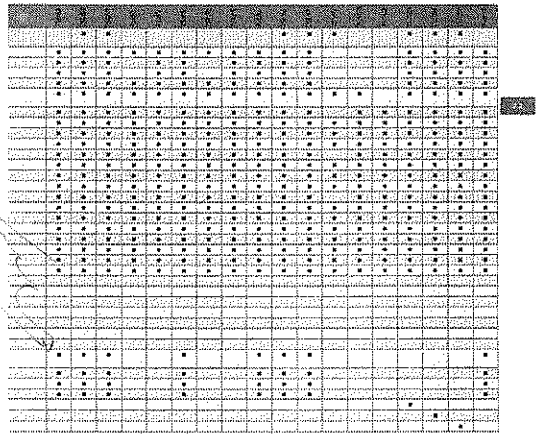
Relay Selection Guide











Application Examples – Medium voltage

Medium-voltage applications for all system grounding types

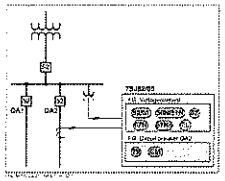


Figure 2.3/1 Medium-voltage applications for all system grounding types

Properties

- Reliable detection of transient and static ground faults
- Cost saving due to integrated transient function
- Directional and non-directional protection and control functions
- Acquisition and transmission of fault variables possible

Protection and control of several feeders with one device

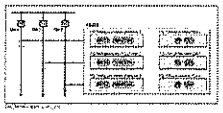


Figure 2.3/2 Protection and control of several feeders with one device

Properties

- Reduced investment with one device for several feeders
- Easy parameterization
- Shorter commissioning times
- Protecting up to 7 feeders with a single device reduces costs

Fast fault clearance in double-fed line (closed) rings

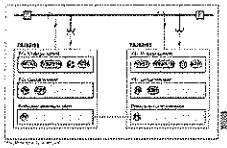


Figure 2.3/3 Earth-fault protection in double-fed line (closed) rings

Properties

- Directional DAF/DDAFT protection without grading times
- Fast fault clearance
- Low cost due to integrated protection interface
- Monitored data exchange
- Adaptable to different communication infrastructure

Central control of multiple feeders and dedicated protection

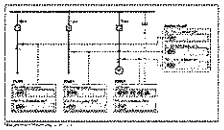


Figure 2.3/4 Central control of multiple feeders and dedicated protection

Properties

- Protection for each bay
- Central control for multiple feeders
- High availability because backup protection functions can be activated in the central relay

Application Examples – Motor protection

Induction motor protection and control

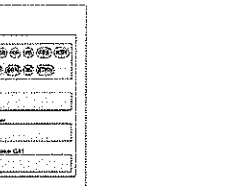


Figure 2.3/5 Induction motor protection and control

Properties

- Reduced investment due to protection and control in one device
- Thermal motor protection functions for reliable motor start-up
- Thermal motor protection functions with direct connection of temperature sensors

Motor protection with differential protection

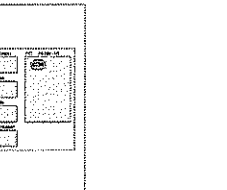


Figure 2.3/6 Motor protection with differential protection

Properties

- Autonomous differential protection functions
- High sensitivity and short tripping times due to differential protection function
- Separate acquisition and monitoring of the current transformers

Motor protection and easier differential protection

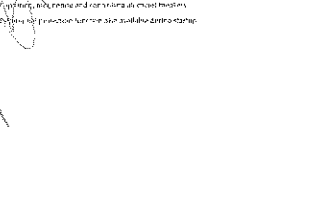


Figure 2.3/7 Motor protection and easier differential protection

Properties

- Differential protection function provides high responsivity and short tripping times
- Integration of the differential protection function in a separate function group reduces costs

Differential motor protection with Korndorfer starter

Figure 2.3/8 Differential motor protection with Korndorfer starter

Application Examples – Motor protection

- Automation, interlocking and monitoring via circuit breaker
- Optional load shedding function with auxiliary contactor

Application Examples – Transformer protection

Two-winding transformer

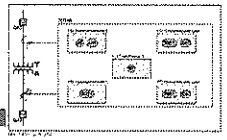


Figure 2.3/9 Two-winding transformer

Properties

- Clear assignment of the functions to the primary element
- Reduced investment
- Single-pole panel interior
- Reduced wiring and commissioning

Two-winding transformer with 2 incoming feeders (e.g. double circuit-breaker switchgear) protection

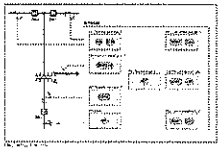


Figure 2.3/10 Two-winding transformer with 2 incoming feeders (e.g. double circuit-breaker switchgear) protection

Properties

- Separate acquisition, measuring and control of all circuit breakers
- High sensitivity with single-line ground fault differential protection
- Cost savings due to 6 CT sets / 2 VT sets in one unit

Autotransformer bank

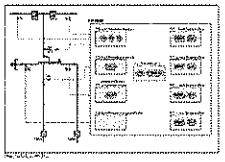


Figure 2.3/11 Autotransformer bank

- Reduced investment due to integration of the differential and node protection function in one unit (87 and 87 Node)
- High sensitivity with single-line to ground faults

Protection and backup protection solution for 3-winding transformers

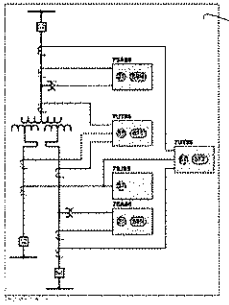


Figure 2.3/12 Protection and backup protection solution for 3-winding transformers

Application Examples – Transformer protection

Properties

- Easy design of the protection and backup protection concept
- Inclusion of line protection devices
- Increased availability

Three-winding transformer with differential protection 87T and distance protection 21

Figure 2.3/13 Three-winding transformer with differential protection 87T and distance protection 21

Properties

- Integrated backup protection function for all protected systems
- Easy engineering
- Increased flexibility for different plant versions

Application Examples – Generator protection

Unit connection of a small-power generator

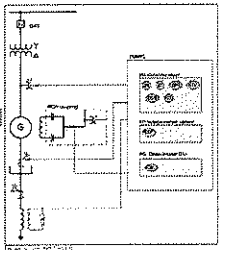


Figure 2.3/14 Unit connection of a small-power generator

Properties

- All functions in one device (complete protection)
- Basic hardware (I/O + HP)
- Preconfigured with the "Generator basic" application template

Unit connection of a medium-power generator

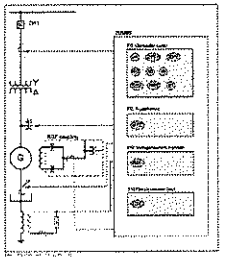


Figure 2.3/15 Unit connection of a medium-power generator

Properties

- All functions in one device (complete protection)
- Basic hardware (I/O + HP)
- Preconfigured with the "Generator unit connection basic" application template
- Stator ground fault protection protects 100% of the stator winding by evaluating the fundamental component and the 3rd harmonic (27TH, 27TN)
- Differential protection of generator transformer unit: function 87T

Application Examples – Generator protection

Unit connection of a generator of medium to high power

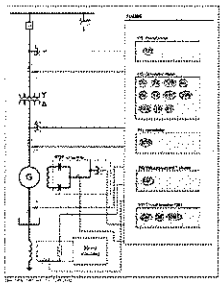


Figure 2.3.11 Unit connection of a generator of medium to high power

Properties

- All functions in one device keep investments low
- Minimum hardware (2/3 x 19")
- Preconfigured with the "Generator unit connection without circuit breaker" application template
- Stand-alone differential protection for generator (87G) and generator transformer (87T)
- Rest 100% stator ground fault protection by coupling 20 Hz voltage
- Stator ground fault protection possible at plant standstill
- Synchrocheck release by the device during manual synchronization
- Redundancy by device doubling

Unit connection of a generator with auxiliary transformer

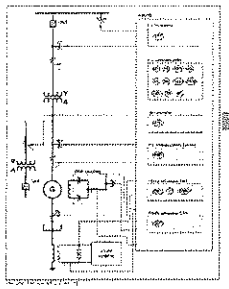


Figure 2.3.12 Unit connection of a generator with auxiliary transformer

Properties

- All functions in one device keep investments low
- Minimum hardware (2/3 x 19")
- Modification of the "Generator unit connection without circuit breaker" application template
- Stand-alone differential protection for generator (87G) and generator transformer (87T)
- Implementation of the restrictive differential protection as "end" feeder differential protection
- Rest 100% stator ground fault protection by coupling 20 Hz voltage
- Stator ground fault protection possible at standstill
- Synchrocheck release by the device during manual synchronization
- Redundancy by device doubling

Application Examples – Generator protection

Busbar connection of a generator

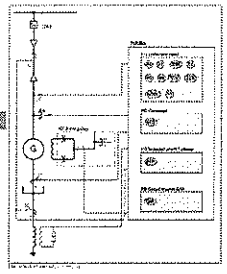


Figure 2.3.13 Busbar connection of a generator

Properties

- All functions in one device keep investments low
- Basic hardware (1/2 x 19")
- Preconfigured with the "Generator busbar connection" application template
- Stand-alone differential protection for the generator (87G)
- Directional stator ground fault protection (67N/G)
- Redundancy by device doubling

High-power generator with protection in switchgear

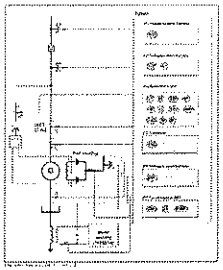


Figure 2.3.14 High-power generator with protection in switchgear

Properties

- The delivery includes generator, excitation and generator protection of a plant unit connection for a steam turbine
- All functions in one device keep investments low
- Minimum hardware (2/3 x 19")
- Modification of the "Generator unit connection without circuit breaker" application template
- Switchgear inverse power protection by connection to 3 voltage transformers (Dahlander)
- Separate protection for the excitation transformer
- Synchrocheck release by the device during manual switching operation
- Redundancy by device doubling

Application Examples – Line protection

Ring line and radial operation

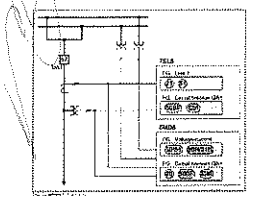


Figure 2.3.15 Ring line and radial operation

Properties

- Clear assignment of protection and control to separate devices
- Less external components by detection and selection of busbar voltage in the device
- High reliability due to backup protection functions in the 6MD, bay controller
- High availability due to emergency control in the 7SJ6 protection device

Low-cost protection and device redundancy

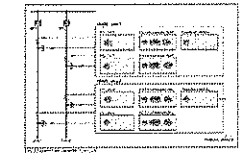


Figure 2.3.16 Low-cost protection and device redundancy

Properties

- High availability due to protection and device redundancy
- Low cost because only 2 devices required for 2 lines
- Reliable because of parallel processing of the protection functions in the devices.

Distance protection of two parallel lines with one device

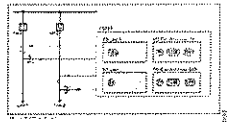


Figure 2.3.17 Distance protection of two parallel lines with one device

Properties

- Low cost due to protection of both lines in one device
- Stable due to overcompensation of the influence of the parallel line for the distance protection function

Self-healing multi-end configurations

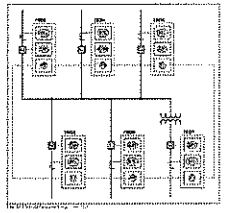


Figure 2.3.18 Self-healing multi-end system

Properties

- High availability because differential protection is also active when a communication fails
- Self-healing due to redundant communication routing in a chain topology
- High ease of maintenance because single line ends can be taken out of the differential protection configuration for commissioning and servicing.

Application Examples – Line protection

Impedance protection for the low-voltage side of a transformer

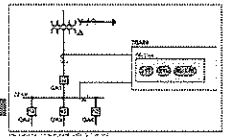


Figure 2.3.19 Impedance protection

Properties

- The impedance protection for transformers (ANSI 21T) permits effective backup protection with zones that reach in the transformer
- A second impedance protection device can be used in the same function group to protect the busbar or the low voltage side cable in zone interlocking (see 2.1.4.8)
- The impedance protection also provides the impedance backup protection for the medium voltage feeders with highly selective detection and stability under a heavy load.

Dual breaker applications

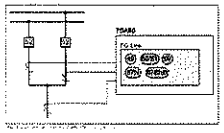


Figure 2.3.20 Dual breaker applications

Properties

- Soft separate measurement of the CT current from both breakers or high precision is possible.
- Separate measurement of CT currents requires stability during CT saturation. Saturation of only 1 current path is sufficient for detection of a fault.

Application Examples – Breaker-and-a-half layout

Modular and distributed protection and control solution

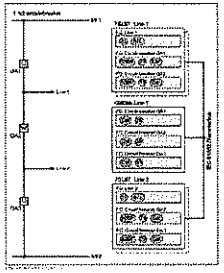


Figure 2.3.21 Modular and distributed protection and control solution

Properties

- Clear function-oriented assignment of protection and control
- High availability due to protection redundancy (Main 1 and Main 2)
- Simple reliable central control of the entire diameter
- Reliable due to emergency control in every line in the faulted line device
- Reduced wiring due to integrated voltage selection
- Isolated with diameter bus based on IEC 61850
  - electrically isolated data exchange
  - reduced wiring
  - easy expansion

Low-cost device and protective redundancy in breaker-and-a-half arrangements

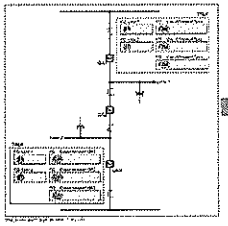


Figure 2.3.22 Low-cost device and protective redundancy in breaker-and-a-half arrangements

Properties

- Unambiguous allocation of the main protection function (line differential protection 87) to one line in one device (Main 1)
- The distance protection function (21) is implemented in the protection device of the other line by a second "line" function group
- High availability and safety by device and protection redundancy
- Low cross-line programming and commissioning complexity because only two devices

Application Examples – Capacitor banks

Protection of a capacitor bank in an H connection

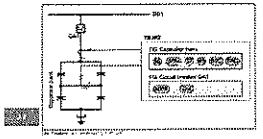


Figure 2.3.23 Protection of a capacitor bank in an H connection

Properties

- Precisely adapted size in 4-diameter function group and application specific protection function, such as peak overvoltage protection (ANSI 59C) and sensitive current unbalance protection (ANSI 60C)
- Low cost due to integration of all necessary functions in one device

Protection of an MSCDN capacitor bank (MSCDN = Mechanically Switched Circuit Breaker with Damping Network)

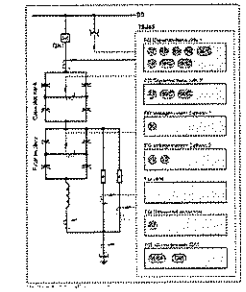


Figure 2.3.24 Protection of an MSCDN capacitor bank

Properties

- Optimum protection of complex MSCDN applications with flexible hardware and a flexible function design
- Low cost due to the integration of all necessary functions in one device for up to seven 3-phase measuring points
- Generation of current sum and current differential in the current inputs of the protection function group "3-phase unit"
- Selection of current and voltage signals up to the 50th harmonic with a high accuracy for protective and operational measured values

Application Examples – Busbar protection

Double busbar feeder with bireba coupler

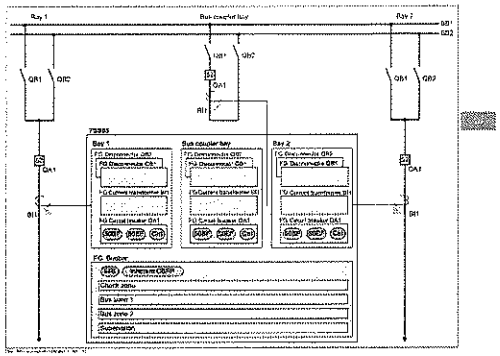


Figure 2.3.10 Double busbar feeder with bireba coupler

Properties

- Central busbar protection
- Summary of all primary components of a bay in the "6 by Plexy"
- One device for up to 20 measuring points
- Flexible adaptation to the topology (up to 6 busbar sections and 3 busbar couplers configurable)
- Integrated disconnector image
- Comfortable graphical project engineering with DIGSI 5.

Application Examples – Power system monitoring unit PMU

Grid monitoring and PMU

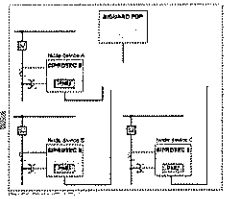
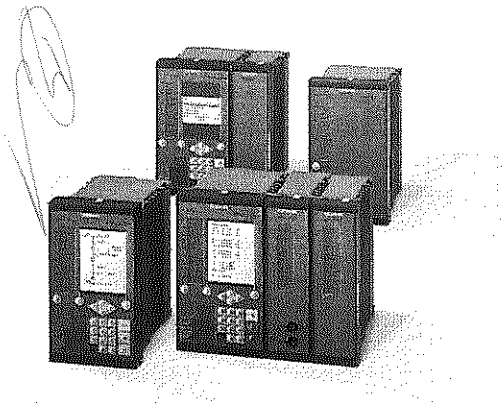


Figure 2.3.11 Principle of PMU application and communication

Properties

- Each SIPROTEC 5 device can be equipped or retrofitted with the PMU function
- Online and offline evaluation of the PMU data in the monitoring system, SIGUARD PDP.

SIEMENS



www.siemens.com/siprotec

Feeder and Overcurrent Protection

Feeder and Overcurrent Protection – SIPROTEC 7SJ82, 7SJ85

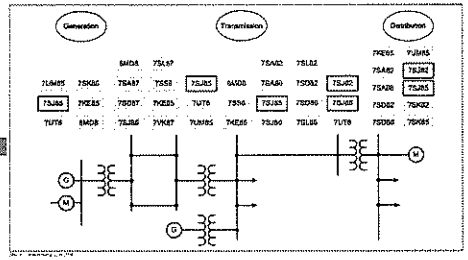


Figure 2.4.1 Typical application of the SIPROTEC 5 devices

SIPROTEC 7SJ82, 7SJ85

The main protection functions of the SIPROTEC 5 overcurrent protection devices are based on the overcurrent protection principle. Although they primarily protect feeders and lines in the distribution system, they can also be used in a high voltage power system without any problems. The hardware quantity structure, which can flexibly be extended, permits several feeders to be protected with one device. Due to the large number of available functions and the great flexibility, the device is suitable for a multitude of additional protection and monitoring applications. Specifically for utilization as backup and emergency protection for line protection, we recommend using the SIPROTEC 7SJ85. The large number of automation functions permits the device to be used in all fields of energy supply.

The devices contain all important auxiliary functions of an economically today for safe network operation. This includes functions like protection, control, measurement and monitoring. The large number of communication interfaces and communication protocols satisfies the requirements of communication and selective protection as well as automated operation.

Commissioning and maintenance work can be completed safely, quickly and thus cost-effectively with high performance functions. The modular structure makes SIPROTEC 5 devices able to be adapted flexibly to the individual requirements.

Construction

The difference between the standard models SIPROTEC 7SJ82 and SIPROTEC 7SJ85 is in the combination of their hardware quantity structure.

7SJ82	3 current transformers, 4 voltage transformers (standard), 11 or 23 binary inputs, 8 or 16 binary outputs
7SJ85	8 current transformers, 7 voltage transformers (standard), 15 or 31 binary inputs, 16 or 32 binary outputs

Feeder and Overcurrent Protection – SIPROTEC 7SJ82

Description

The SIPROTEC 7SJ82 overcurrent protection has specifically been designed for a cost effective and compact protection of feeders and lines in medium voltage and high voltage systems. With its flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7SJ82 offers "state oriented system solutions with high invest, meet security and low operating costs.

Basic hardware	Voltage and current measurement (3-phase) and binary inputs and outputs
Inputs and outputs	3 current transformers, 4 voltage transformers (standard), 11 or 23 binary inputs, 8 or 16 binary outputs, 1 or 2 life contacts
Hardware flexibility	3 current transformers, 7 binary inputs, 7 binary outputs
Housing/weight	Different hardware quantity structures for housing/mounting types are available (housing with 1/3 or 1/2 base width), housing with detachable terminal blocks, pluggable terminals or screw terminals
Human-machine interface	Optional operation panel with graphic display, function keys and programmable LEDs

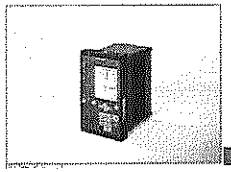


Figure 2.4.2 SIPROTEC 7SJ82

Benefits

- Compact and low-cost overcurrent protection
- Safety due to powerful protection functions
- Data security and transparency over the entire lifecycle of the plant saves time and money
- Purposeful and easy handling of devices and software thanks to a user friendly design
- Increased reliability and quality of the engineering process
- Consistent implementation of high safety and security specifications
- Powerful communication components ensure safe and efficient solutions
- Full compatibility between IEC 61850 Editions 1 and 2
- Implementation variety and low operating costs due to future-oriented validity protection

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Directional and non-directional overcurrent protection with additional functions
- Optimized tripping times due to directional comparison and protection data communication
- Detection of weak, intermittent and continuous ground faults (Cleaning contact functions in the suppressed-coil-ground and isolated power systems
- Arc protection
- Overvoltage- and undervoltage protection
- Frequency protection and frequency change protection for load shedding applications
- Power protection, configurable as active or reactive power protection
- Protection functions for capacitor banks, such as overcurrent, overload, current unbalance, peak overvoltage, or differential protection
- Reactive power undervoltage protection (QU protection)
- Control, circuit-breaker and disconnector switching protection, circuit breaker failure protection
- Circuit breaker failure protection
- Circuit breaker response measuring
- Graphical logic editor to create powerful automation functions in the device
- Extraction of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (such as peak overvoltage protection for capacitors) and operational measured values
- Single-line representation on small or large displays
- Integrated electrical Ethernet (IEC 61850-8-1 and IEC 61850 messaging and GOOSE)
- Two variants of pluggable communication modules, usable for different and redundant protocols: IEC 61850 (IEC 61850-8-1 or -9-2), IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP)
- Serial protection data communication via optical fibers, 2-wire or 3-wire pilot wires and communication networks (IEEE C37.94, and different, including redundancy switchover between direct and routed topology)
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW White Paper requirements
- Time synchronization with IEEE 1588
- Supervision functions (battery voltage, current and voltage symmetry, current and voltage sum, trip circuit supervision)
- Battery backup for real-time and event buffers

Feeder and Overcurrent Protection – SIPROTEC 7SJ82

Applications

- Detection and selective 1-pole tripping of short circuits in electrical equipment of star networks, lines with infeed at one or two ends, parallel lines and open or closed ring systems of all voltage levels
- Detection of ground faults in systems in arc suppression coil, ground power systems or star, ring, or meshed arrangement
- Backup protection for differential protection devices of all kind for lines, transformers, generators, motors, and busbars
- Transformer and monitoring of climate equipment banks
- Phasor Measurement Unit (PMU)
- Reverse power protection
- Load shedding applications
- Automatic switchover

Application templates

Application templates are available in DIGSI 5 for standard applications. They comprise all basic configurations and default settings.

The following application templates are available

Non-directional overcurrent protection

- Overcurrent protection (non-directional) for phases and ground
- Transformer at peak current detection

Directional overcurrent protection – ungrounded system

- Overcurrent protection (directional and non-directional) for phases and ground
- Transformer at peak current detection
- Measuring voltage failure supervision

Directional overcurrent protection – resonant-grounded/isolated system

- Overcurrent protection (directional and non-directional) for phases
- Sensitive directional ground fault detection for star-point ground faults
- Sensitive directional ground fault detection for transient and steady-ground faults (transient function)
- Transformer inrush current detection
- Measuring voltage failure supervision

Capacitor bank – U protection

- Overcurrent protection for phase and ground
- Current unbalance protection for capacitor banks
- Peak overvoltage protection
- Overload protection
- Undercurrent protection

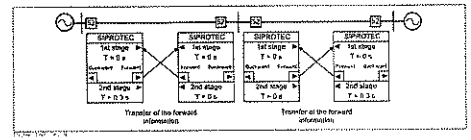


Figure 2.4.3 Application example: Principle of directional comparison protection for short circuit and ground faults

Application examples

Directional comparison protection via protection interface for power line runs with in feed at two ends

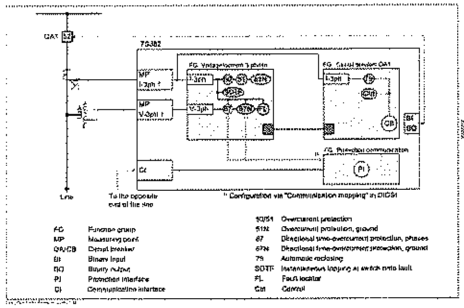
Load in directional comparison of the directional overcurrent protection, you can implement directional comparison protection for power line runs with in feed at two ends. Directional comparison protection is used for the selective isolation of a faulty line section independent of closed rings, for example). Switches are required in line runs, that is, they do not suffer the disadvantages of long tripping times. The unit allows regions that directional comparison can be realized and between the individual protection stations. The information exchange can, for example, be implemented via a protection interface. Alterna-

tion of the protection interface are IEC 60870-5-103/104 or, via point-to-point connection, with or without voltage.

Figure 2.4.3 shows the function of the directional comparison protection. The function of the protection is the application of a SIPROTEC 7SJ82 for the application. The "Directional O" protection uses overcurrent protection – or underfrequency application functions is used at each end. In addition, the devices are additionally equipped with a transmit and receive for protection purposes. The transmitter can be activated by the "Directional O" protection stage(s) and/or DIGSI 5 is used to determine the protection stage to be transferred to the opposite end and released from the application end. The received signal is evaluated via the binary input signals of

SIPROTEC 5 Devices and Fields of Application

Feeder and Overcurrent Protection – SIPROTEC 7SJ82



FG	Function group	50/51	Overcurrent protection
MP	Measuring point	51N	Overcurrent protection, ground
QA/CB	Circuit breaker	67	Directional time-overcurrent protection, phases
BI	Binary input	67N	Directional time-overcurrent protection, ground
BO	Binary output	79	Automatic reclosing
PI	Protection interface	SOTF	Instantaneous tripping at switch onto fault
CI	Communication interface	FL	Fault locator
		Ctrl	Control

Figure 2.4/4 [illegible]

SIPROTEC 5 Devices and Fields of Application

Feeder and Overcurrent Protection – SIPROTEC 7SJ82

Functions, application templates

[illegible]

SIPROTEC 5 Devices and Fields of Application

Feeder and Overcurrent Protection – SIPROTEC 7SJ82

[illegible]

Table 2.4/1 SIPROTEC 7SJ82 – Functions and application templates

1 Non-directional OC 3-ph

2 Non-directional OC 3-ph, 4-ph

3 Directional OC – grounded system

4 Directional OC – resonant grounded/isolated system

5 Capacitor bank H-bridge

SIPROTEC 5 Devices and Fields of Application

Feeder and Overcurrent Protection – SIPROTEC 7SJ82

Standard variants

Standard variants for SIPROTEC 7SJ82

[illegible]

Table 2.4/2 Standard variants for SIPROTEC 7SJ82

The technical data of the devices can be found in the manual www.siemens.com/siprotec

SIPROTEC 5 Devices and Fields of Application

Feeder and Overcurrent Protection – SIPROTEC 7SJ85

Description

The SIPROTEC 7SJ85 overcurrent protection has been designed specifically for the protection of feeders and lines. Due to its modular structure and flexibility and the powerful engineering tool DIGSI 5, SIPROTEC 7SJ85 offers future-oriented system solutions with high investment security and low operating costs.

Main function	Overcurrent protection for all voltage levels
Inputs and outputs	5 predefined standard variants with 4 current transformers, 4 voltage transformers, 11 to 59 binary inputs, 9 to 33 binary outputs
Hardware flexibility	Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system
Housing width	1/3 × 19" to 2/1 × 19"

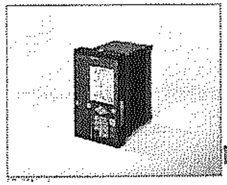


Figure 2.4/5 SIPROTEC 7SJ85

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Directional and non-directional overcurrent protection with additional functions
- Protection of up to 4 feeders with up to 40 analog inputs
- Optimized tripping times due to directional comparison and protection data communication
- Detection of static and transient ground faults (Flexible concept function) in arc-suppression-coil-ground and isolated power systems
- Arc protection
- Overvoltage and undervoltage protection
- Power protection, configurable as active or reactive power protection
- Frequency protection and frequency change protection for load shedding applications
- Protection functions for capacitor banks, such as overcurrent, overload, current unbalance, peak overvoltage, or differential protection
- Reactive power undervoltage protection (QU protection)
- Recognition of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (such as peak overvoltage protection for capacitors) and operational measured values
- Control, synchrocheck and switchgear interlocking protection
- Circuit-breaker failure protection
- Circuit-breaker restrike monitoring
- Graphical logic editor to create powerful automation functions in the device
- Single-line representation in small or large display
- Integrated electrical Ethernet RJ45 for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- Two optional pluggable communication modules, usable for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP))
- Serial protection data communication via optical fibers, two-wire connections and communication networks (IEEE C37.94, and others), including automatic switchover between ring and chain topology
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW Whitepaper requirements
- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Time synchronization with IEEE 1588
- Powerful fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for easy tests and commissioning

Applications

- Detection and selective 3-pole tripping of short circuits in electrical equipment of star networks, lines with infeed at one or two ends, parallel lines and open or closed ring systems of all voltage levels
- Backup protection for differential protection devices of all kinds for lines, transformers, generators, motors, and busbars
- Protection and monitoring of capacitor banks
- Phasor Measurement Unit (PMU)
- Reverse-power protection
- Load shedding applications
- Automatic switchover

SIPROTEC 5 Devices and Fields of Application

Feeder and Overcurrent Protection – SIPROTEC 7SJ85

Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings.

The following application templates are available:

Non-directional overcurrent protection

- Overcurrent protection (non-directional) for phases and ground
- Transformer inrush current detection

Directional overcurrent protection – grounded system

- Overcurrent protection (directional and non-directional) for phases and ground
- Transformer inrush current detection
- Measuring voltage failure supervision

Directional overcurrent protection – resonant grounded/isolated system

- Overcurrent protection (directional and non-directional) for phases
- Sensitive directional ground fault detection for static ground faults
- Sensitive directional ground fault detection for transient and static ground faults (transient function)
- Transformer inrush current detection
- Measuring voltage failure supervision

Capacitor bank: H connection + 3 × RLC

- Time overcurrent protection for phases and ground
- Capacitor bank unbalance protection
- Peak overvoltage protection
- Overload protection
- Undercurrent protection

Capacitor bank: MSCDN

- Overcurrent protection for phase and ground
- Current unbalance protection for capacitor banks
- Differential protection for capacitor
- Peak overvoltage protection
- Overload protection
- Undercurrent protection

Application examples

Direction comparison protection via protection data interface for lines supplied from two sides

Direction comparison protection can be realized with the help of direction determination of the directional overcurrent protection in the case of lines which are supplied from two sides. The direction comparison protection is designed to selectively isolate a faulty line section (e.g., sections of rings) in high speed, i.e., no long graded times will slow down the tripping process. The precondition of this procedure is that direction information can be exchanged between the individual protective relays. This information exchange can be realized via a protection data interface, for instance. Alternatives to the protection data interface are IEC 61850 GOOSE or pilot wires for signal transmission with an additional voltage loop.

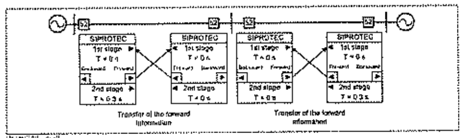


Figure 2.4/6 Function overview of the direction comparison protection via protection data interface

The SIPROTEC 7SJ82 application example (Figure 2.4/6) shows the functions and the basic configuration for this application.

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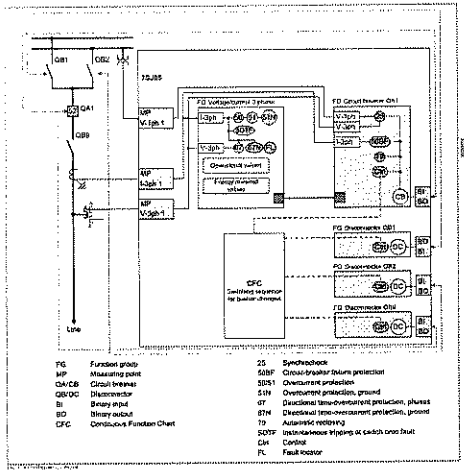

Figure 2/47 Application example: Overcurrent protection 7SJ85 at a double busbar feeder

Protection and control at a double busbar

In the *Figure 2/47*, a double busbar feeder is protected and additionally controlled by a SIPROTEC 7SJ85. This example is based on the application template "Directional time-overcurrent protection – grounded power system". In addition to the application template, the functions Circuit-breaker failure protection, Automatic reclosing and Synchrocheck in the circuit-breaker function group are needed and reconfigured. These functions can easily be added via "drag and drop" from the DIGSI 5 function library. Operational measured values are directly measured values are calculated in the "Voltage current 3ph" function group. They are available for output on the display, transfer to the substation automation technology, and processing in the CFC. A switching sequence stored in the CFC that is activated via a function key starts an automatically executing busbar switch-over process.

Protection of a capacitor bank

Figure 2/48 shows protection of a capacitor bank in an H connection. For this application, the device has special functions for the protection of capacitor banks. Thanks to the modularity and performance of SIPROTEC 5, the complete application can be protected by one device.

Properties:

- Short-circuit protection (ANSI 50, 50N) for phase and ground faults
- Peak overvoltage protection (ANSI 59C) for protection of the dielectric of the bank from harmful peak voltages, in particular, caused by harmonics, consideration of harmonics up to the 50th order; the peak voltage being calculated from the current by integration
- Overload protection (ANSI 49) for protection of the bank from thermal overload
- Very sensitive current unbalance protection (ANSI 60C) for detecting the failure of a single capacitor element, as alarm and protection function. Manual and automatic adjustment in the bay. The automatic compensation permits consideration of dynamic unbalances, e.g. caused by temperature influences
- Undercurrent protection (ANSI 37) for tripping the local circuit breaker when the incoming feeder is disconnected, and therefore protection from hazardous reenergization of the nondischarged bank, e.g. in phase opposition
- Circuit-breaker failure protection (ANSI 50BF).

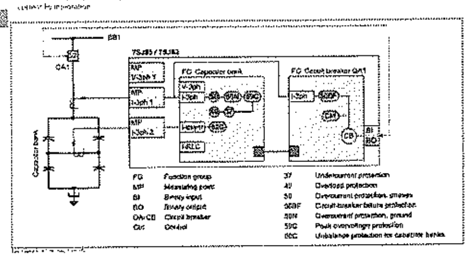

Figure 2/48 Protection of a capacitor bank in H connection

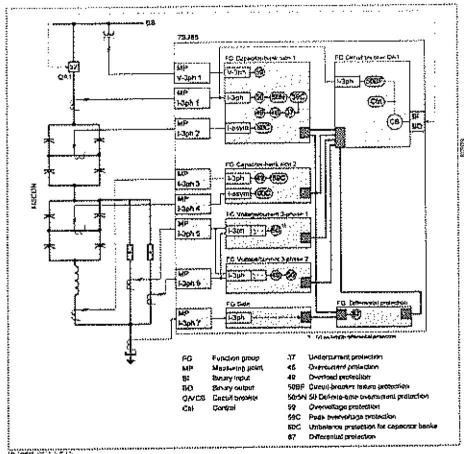

Figure 2/49 Application example: MSCDN capacitor bank

Protection of an MSCDN capacitor bank (MSCDN = Mechanically Switched Capacitor with Damping Network)

In *Figure 2/49*, the SIPROTEC 7SJ85 protects the capacitor bank in H connection and additionally the associated damping network. Thanks to the modular structure and performance of SIPROTEC 5, the complete application can be protected with one single device.

Properties:

- Capturing up to seven 3-phase measuring points
- Short-circuit protection (ANSI 50, 50N) for phase and ground faults
- Peak overvoltage protection (ANSI 59C) to protect the dielectric medium of the bank against dangerous peak overvoltage, in particular caused by the harmonic components with consideration of up to the 50th harmonic component. The peak voltage is calculated by integration of the current

- Overload protection (ANSI 49) to protect the bank against thermal overload
- Very sensitive current-unbalance protection (ANSI 60C) to detect the outage of individual capacitor elements as monitoring and protection function. Manual and automatic adjustment in the bay. Automatic adjustment permits dynamic unbalances (caused by temperature influence, for example) to be taken into account
- Differential protection (87C) over the entire capacitor bank to protect against short circuits inside the entire installation
- Overload and overcurrent protection via the two resistors and a simple differential protection that is to detect an outage of one of the two resistors. For this purpose, current sum and current difference are determined with the current measuring points in the R branches, at the inputs of the VI 3-phase function groups
- Undercurrent protection (ANSI 37) to trip the local circuit breaker when the infeed is disconnected providing protection against hazardous voltage at the non discharged bank, for example, in phase opposition
- Circuit-breaker failure protection (ANSI 50BF).

Functions, application templates

ANSI	Functions	Abbr.	Available	1	2	3	4	5	6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ANSI	Functions	Abbr.	Available	1	2	3	4	5	6
87V	[illegible]	ΔV	■						
90V	Automatic voltage control for 2 winding transformer		■						
90V	Automatic voltage control for 3 winding transformer		■						
90V	Automatic voltage control for grid coupling transformer		■						
FL	Fault locator, single-ended measurement	FLoc	■						
PMU	Synchrophasor measurement (1 PMU can be used for max. 8 voltages and 8 currents)	PMU	■						
AFD	[illegible]		■						
	Measured values, standard		■	■	■	■	■	■	■
	Measured values, extended: Min, Max, Avg		■						
	Switching statistic counters		■						
	Circuit breaker wear monitoring	ΣIx, I²t, 2P	■						
	CFC (Standard, Control)		■	■	■	■	■	■	■
	CFC arithmetic		■						
	Switching sequences function		■						
	Inrush current detection		■	■	■	■	■		
	External trip initiation		■						
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Function points class:				0	0	30	50	200	300

The configuration and function points for your application can be ascertained in the SIPROTEC 5 order configurator under www.siemens.com/siprotec

Table 2.4/1 SIPROTEC 7SJ85 – Functions and application templates

1 Non-directional OC (1-11)
2 Non-directional OC (1-11, 3-4V)
3 Directional OC – grounded system
4 Directional OC – resonant-grounded/isolated system
5 Capacitor bank: H-bridge + 1-FRC
6 Capacitor bank: MSCDN

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Standard variants

Standard variants for SIPROTEC 7SJ85		
S1	[illegible]	
S2	[illegible]	
S3	[illegible]	
S4	[illegible]	
S5	[illegible]	

Table 2.4/4 Standard variants for SIPROTEC 7SJ85

The technical data of the devices can be found in the manual www.siemens.com/siprotec

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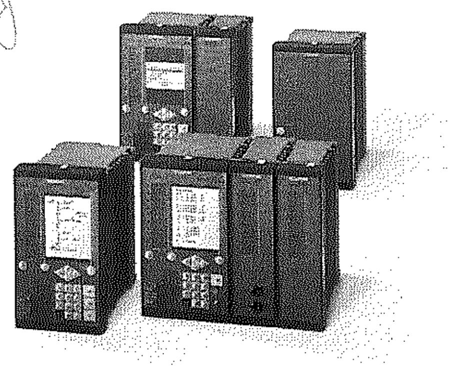


www.siemens.com/siprotec

Line Protection

SIPROTEC 5 Devices and Fields of Application

Line Protection – SIPROTEC 7SA8, 7SD8, 7SL8, 7VK8, 7SJ86

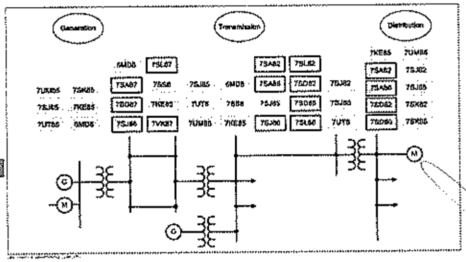


Figure 2.5/1 Fields of application of the SIPROTEC 5 devices

SIPROTEC 7SA8, 7SD8, 7SL8, 7VK8, 7SJ86

SIPROTEC 5 line protection devices protect overhead lines and cables on all voltage levels with highest selectivity possible. The large number of protection and automatic functions available permits their utilization in all areas of line protection. The devices contain all important auxiliary functions that are necessary today for safe network operation. This includes control, measurement and monitoring functions. The large number of communication interfaces and communication protocols satisfies the requirements of communication-based selective protection and of automated operation. Commissioning and maintenance work can be completed safely, quickly and thus cost-effectively with high-performance test functions. Their modular structure permits SIPROTEC 5 line protection devices always to be adapted flexibly to the individual requirements.

Features

The device types are defined by their main protection functions and by essential differentiating characteristics. For devices with flexible configurability of the hardware quantity structure, you can select various standard variants when ordering. Expandability through supplemental modules allows for individual adaptation to specific applications such as more analog channels for breaker and a half technology, or more binary contacts (see "Overview of the standard variants").

Definition of the device types by their designation

Main protection functions

Distinguishing features

7 XX YY

Main protection			
7	SA		Distance protection
7	SD		Differential protection
7	SL		Distance and differential protection
7	[illegible]		Overcurrent protection
7	VK		Circuit-breaker management
Essential differentiating characteristics			
7		82	• [illegible] • [illegible]
7		86	• [illegible] • [illegible]
7		87	• [illegible] • [illegible]

SIPROTEC 5 Devices and Fields of Application

Line Protection – SIPROTEC 7SA8, 7SD8, 7SL8, 7VK8, 7SJ86

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Distance protection	■	■	■	■			■	■	■		
Differential protection				■	■	■	■	■	■		
Overcurrent protection for line	■	■	■	■	■	■	■	■	■		■
Circuit-breaker management										■	
[illegible]	■	■		■	■		■	■			■
1-pole/3-pole trip command			■			■			■	■	
Flexibly configurable hardware		■	■		■	■		■	■	■	■

Table 2.5/1 Essential differentiating characteristics of the main protection types

SIPROTEC 5 Devices and Fields of Application

Line Protection – SIPROTEC 7SA8, 7SD8, 7SL8, 7VK8, 7SJ86

Distance Protection – SIPROTEC 7SA82

Description

The SIPROTEC 7SA82 distance protection has been designed particularly for the cost-optimized and compact protection of lines in medium-voltage and high-voltage systems. With its flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7SA82 offers future-oriented system solutions with high investment security and low operating costs.

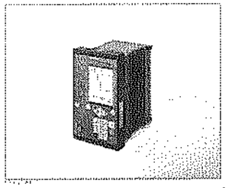


Figure 2.6/1 SIPROTEC 7SA82

Benefits

Functions

DIGSI 5 permits all functions to be configured and combined as required.

Distance Protection – SIPROTEC 7SA82

Applications

Application templates

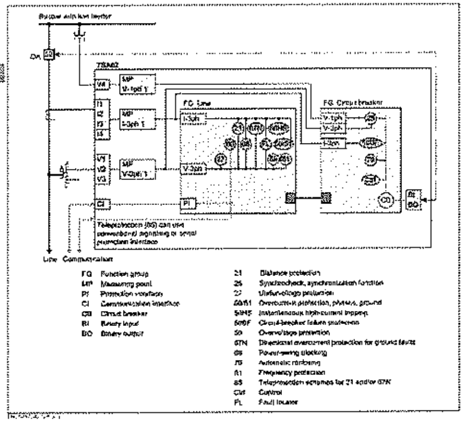


Figure 2.6/2 Application example: Distance protection for overhead line

Distance Protection – SIPROTEC 7SA82

Functions and application templates

[illegible]

Distance Protection – SIPROTEC 7SA82

[illegible]

Table 2.6/1 SIPROTEC 7SA82 – Functions and application templates

1	DIS basic
2	DIS, compensated, neutral point with AR
3	DIS, overhead line, solid grounded neutral point

Distance Protection – SIPROTEC 7SA86

Description

The SIPROTEC 7SA86 distance protection has specifically been designed for the protection of lines. Due to its modular structure and flexibility and the powerful engineering tool DIGSI 5, SIPROTEC 7SA86 offers future-oriented system solutions with high investment security and low operating costs.

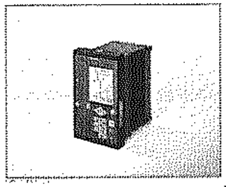


Figure 2.6/3 SIPROTEC 7SA86

Functions

DIGSI 5 permits all functions to be configured and combined as required.

Applications

Application templates

Distance Protection – SIPROTEC 7SA86

The following application templates are available:

- Basic
- Distance protection for overhead line for grounded systems with AR
- Distance protection with MHO distance zone characteristics for overhead line for grounded systems, with AR
- Distance protection for overhead line for grounded systems, with AR for applications with breaker-and-a-half scheme
- Distance protection with MHO distance zone characteristics for overhead line for grounded systems, with AR for applications with breaker-and-a-half scheme

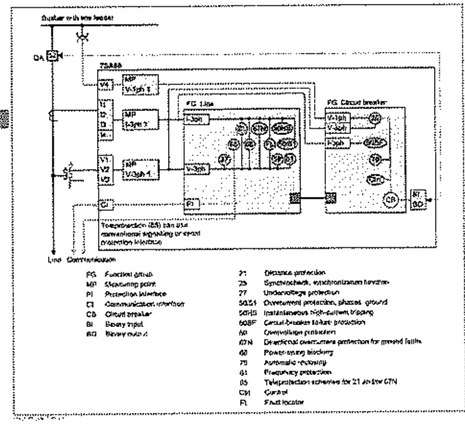


Figure 2.6/4 Application example: Distance protection for overhead line

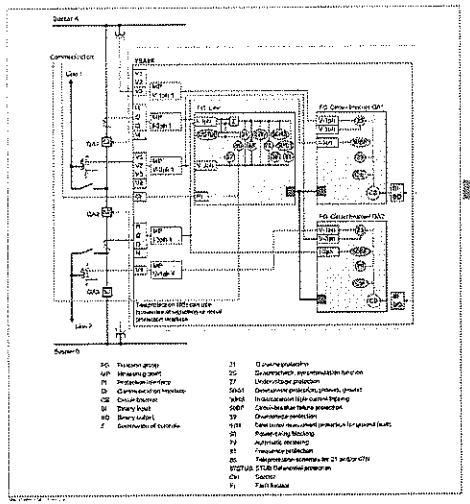
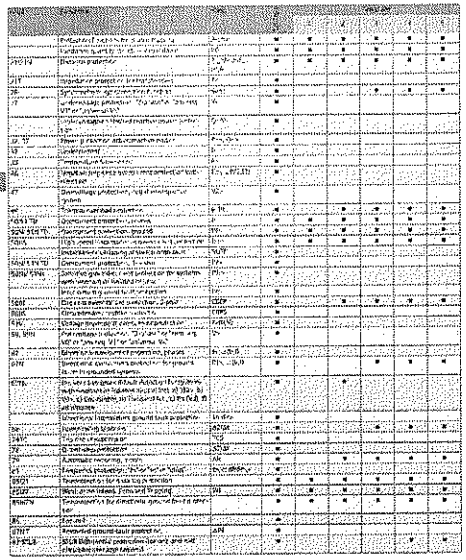


Figure 2.6/7 Application example: Distance protection for overhead line with three-pole tripping and single-pole tripping



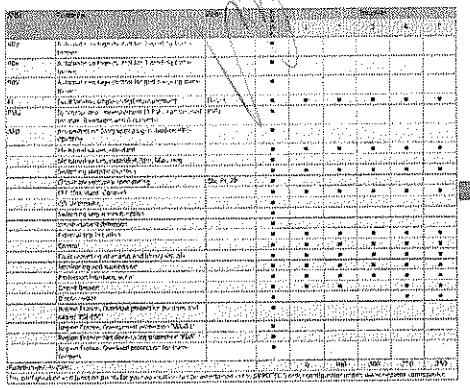


Table 2.6/2 SIPROTEC 7SA86 – Functions and application templates

1	DIS Basic
2	DIS complete, medium power with SR
3	DIS RMD overhead line, solid grounded transformer
4	DIS RMD overhead line, solid grounded transformer, 1.5 CB
5	DIS Silm overhead line, solid grounded transformer, 1.5 CB

Description

The SIPROTEC 7SA87 distance protection has specifically been designed for the protection of lines. Due to its modular structure and flexibility and the powerful engineering tool DIGSI 5, SIPROTEC 7SA87 offers future-oriented system solutions with high investment security and low operating costs.

Main Function	Distance protection
Tripping	1-pole and 3-pole, with multi-shot reclosing, 1 to 9
Pick-up characteristics	32 quadrilateral or circular characteristics with up to 9 zones, each independently settable, forward, reverse, non-directional
Hardware variants	Flexible, adjustable I/O quantity structure with 4 to 40 binary inputs, 4 to 40 binary outputs

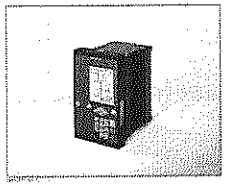


Figure 2.6/8 SIPROTEC 7SA87

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Minimum tripping time, 9 ms
- 6 independent measuring loops as system distance protection
- Several distance protection functions can be selected, Classic, reactance method (RMD), Impedance protection for cable element
- Directional backup protection and various additional functions
- Recognition of static, intermittent and transient ground faults (flexible control function or sensitive ground current and isolated power systems)
- Adaptive power swing blocking, out of step protection
- Detection of current transformer saturation for fast tripping with full accuracy
- Arc protection
- Power protection, configurable as active or reactive power protection
- Reactive power undervoltage protection (QU protection)
- Detection of current and voltage asymmetry in the 50Hz frequency and high accuracy for selected protective functions (such as thermal overload protection) and operational measured values
- 1-pole automatic reclosing function
- Control, specified for circuit-breaker interfacing protection
- Graphical logic editor to create powerful automation functions in the device
- Single-line representation in small or large display
- Integrated electrical breaker test for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- Optional redundant pluggable communication module, usable for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP))

- Serial protection data communication via optical fibers, two-wire connections and communication networks (IEEE C37.94, and others), including automatic switchover/ring topology and chain topology
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW White Paper requirements
- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Time synchronization using IEEE 1588
- Powerful fault recording (buffer for 8 fault record time of 20 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for simple test and commissioning
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

Applications

- Overhead lines and cables with 1-pole and 3-pole tripping of short, medium and long transmission lines with non-solidly grounded neutral, solidly grounded neutral, compensated networks, lines with series capacitors or with parallel lines and open or closed ring systems at voltage levels
- Lines with tapping(s), e.g. in case of an open transformer end or open ring system at any, also in meshed, subordinated or radial networks
- Protection data communication over different physical and logical media such as optical fiber, two-wire connections, and communication networks
- Backup protection for differential protection devices of all kinds of lines, transformers, generators, motors, and busbars
- Fault locator measurements and (PMU).

Application templates

Application templates are available in DIGSI for standard applications. They contain all basic configurations and default settings.

The following application templates are available:

- Basic distance protection
- Distance protection reactance method (RMD) for overhead line or grounded systems, with AR
- Distance protection reactance method (RMD) for overhead line or grounded systems, with AR for applications with breaker- and a half scheme(s)

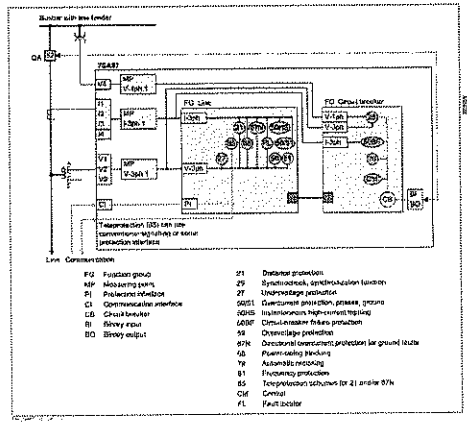


Figure 2.6/9 Application example: Distance protection for two-end line

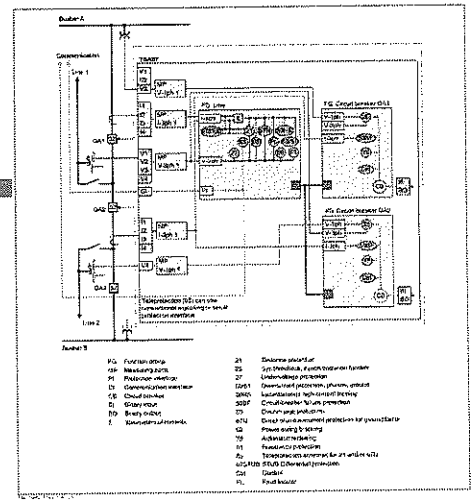
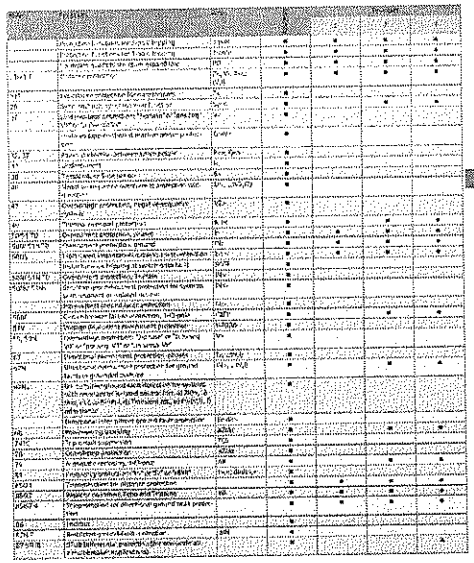


Figure 2.6/10 Application example: Distance protection for two-end line with one CB at each end

Functions, application templates



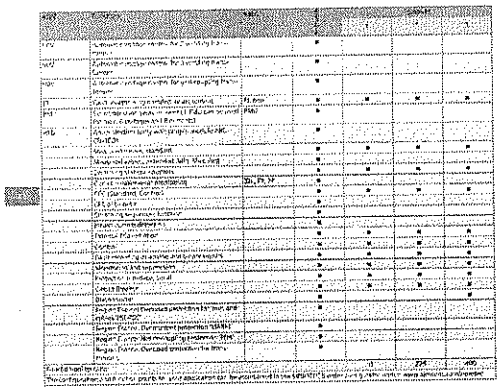


Table 2.3/1 SIPROTEC 7SA87 – Functions and application templates

1 DIS Basic
2 DIS RMB overhead line, solidly grounded neutral point
3 DIS RMB overhead line, Petersen coil or neutral point, 1.5 CB

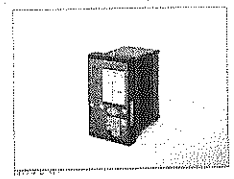


Figure 2.3/1 Function overview of SIPROTEC 7SD82

Description

The SIPROTEC 7SD82 line differential protection relay is designed and built specifically for use in high-voltage power systems with single-ended or multi-ended infeed and with any type of grounding. The relay is suitable for lines/cables of any length with any conductor material and any cross-section. It is applicable on transmission lines with two ends or three ends.

Hardware flexibility	• Adaptation to the primary application by means of optional interfaces • Communication converter for copper or fiber-optic connections
Easy engineering	• Integrated DIGSI 5 operation and display • Graphical logic editor to create powerful automation functions • Simple, clear parameterization and configuration using DIGSI 5
Safe and reliable	• Secure communication using encryption and signature methods • Cyber Security event logging according to NERC CIP • Role-based user management and authorization

Benefits

- Compact and fast, complete differential protection
- Safety due to powerful protective functions
- Data security and maintenance over the entire lifecycle of the plant – even after 20 years
- Economical and simple operation of the devices and reliable interlocking concept thereby
- Increased reliability and quality of the engineering process
- Convenient implementation and IT high safety and security measures
- Powerful communication components ensure safe and effective solutions
- Full redundancy between IEC 61850 Editions 1 and 2
- Most advanced security and flow operating functions due to further powerful system solutions

Functions

DIGSI 5 provides all functions to be configured as many times as required

- Minimum tripping time: 17 ms
- Main protection function: a differential protection with adaptive operation for maximum sensitivity and stability even with the most different transformer errors, current transformer saturation and capacitive charging currents
- Directional backup protection and numerous additional functions
- Recognition of static, pendulum and transient ground faults (Holmes-related function) for safe suppression even in grounded and isolated power systems
- Detection of current transformer saturation
- Arc protection
- Power protection, configurable as active or reactive power protection

- Transformers and compensating coils in the protection zone
- Detection of ground faults in isolated or arc-suppression coil ground power systems in star, ring, or meshed arrangement
- Serial protection data communication over different distances and media, such as optical fibers, two-wire connections, and communication networks
- Phase segregated test (7SD82)

Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings.

The following application templates are available:

- Basic differential protection
- Differential protection for overhead line

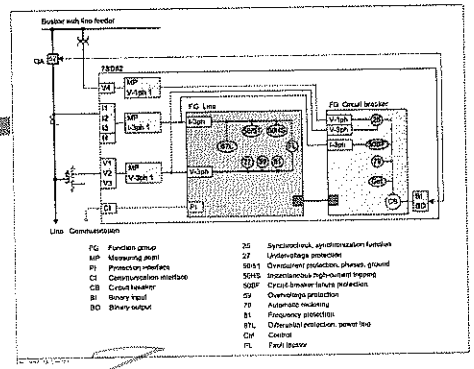
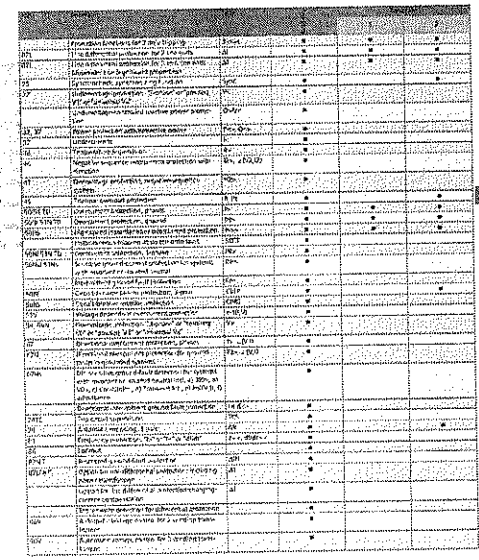


Figure 2.3/2 Typical application: line differential protection for overhead line

Functions, application templates



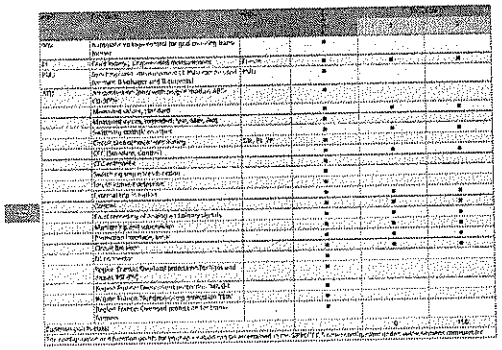


Table 2.3/1 SIPROTEC 7SD82 – Functions and application templates

1 DIFF basic
2 DIFF overhead line

Description

The SIPROTEC 7SD86 line differential protection has specifically been designed for the protection of lines. With the modular hardware flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7SD86 offers future-oriented system solutions with high investment security and low operating costs.

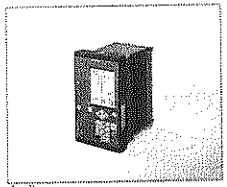


Figure 2.7-1 SIPROTEC 7SD86

Functions

DIGSI 5 permits all functions to be configured and combined as required

- Minimum tripping time: 9 ms
- Main protection function is differential protection with added line algorithm for maximum sensitivity and stability even with the most different transformer errors, current transformer saturation and capacitive charging currents
- Directional backup protection and various additional functions
- Recognition of static, dynamic and transient ground faults (flexible contact processing) in the suppression coil grounded or isolated power systems
- Detection of current transformer saturation
- Arc protection
- Power protection, configurable as active or reactive power protection
- Fast trip power and voltage protection (QU protection)
- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protective functions (such as thermal overload protection) and operational measured values
- 1-pole automatic reclosing function
- Control, synchrocheck and switchgear interlocking protection
- Graphical logic editor to create powerful automation functions in the device
- Single-line representation in small or large display
- Integrated electrical Ethernet RJ45 for DIGSI 5 and IEC 61850 (operating and GOOSE)
- Up to 8 optional pluggable communication modules, usable for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP))
- Serial protection data communication via optical fibers, two-wire connections and communication networks (IEEE C37.94, and others), including automatic switchover between ring and chain topology
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW White Paper requirements
- Phasor measurement unit (PMU) for synchrophasor measured values, and IEEE C37.118 protocol
- Time synchronization using IEEE 1588
- Powerful fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure

Applications

- Line protection for all voltage levels with 3-pole tripping
- Phase-selective protection of overhead lines and cables with single-ended and multi-ended infeed of all lengths with up to 6 line ends
- Also used in switchgear with breaker-and-a-half configuration
- Transformers and compensating coils in the protection zone
- Detection of ground faults in isolated or arc suppression coil ground power systems in star, ring, or meshed arrangement
- Protection data communication over different distances and physical media, such as optical fiber, two-wire connections, and communication networks
- Phasor measurement unit (PMU).

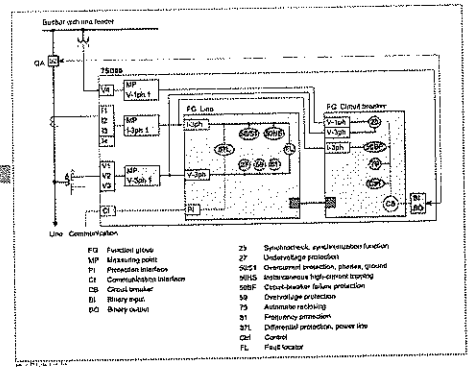
Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings.

The following application templates are available:

- Basic differential protection
- Differential protection for overhead line

- Differential protection for overhead line with one breaker in the protection range
- Differential protection for overhead line, for applications with breaker-and-a-half schemes



FC Function group
MP Measuring point
PI Protection interface
CI Communication interface
CB Circuit breaker
BI Binary input
BO Binary output

ZS Synchrocheck, synchronization function
27 Undervoltage protection
50/51 Overcurrent protection, phase, ground
50HS Instantaneous high-current tripping
50BF Circuit-breaker failure protection
59 Overvoltage protection
79 Automatic reclosing
81 Frequency protection
87L Differential protection, power line
Ctrl Control
FL Fault locator

Figure 2.7-4 Application example: line differential protection for overhead line with breaker-and-a-half scheme

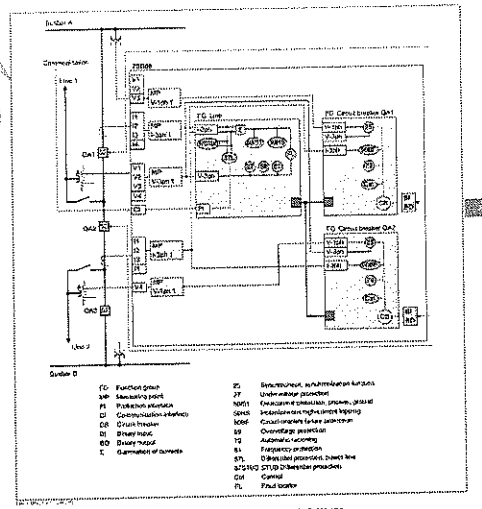
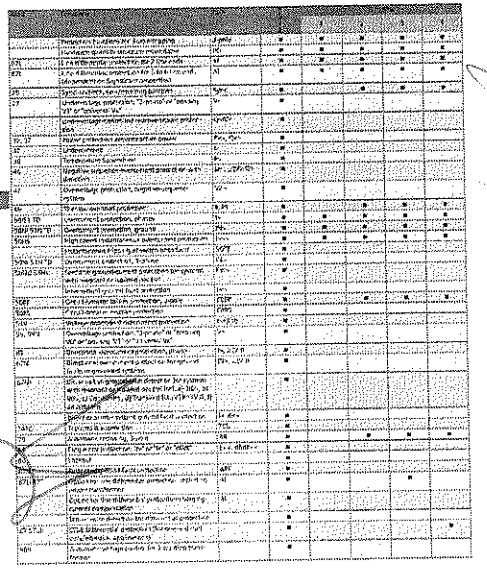


Figure 2.7-5 Application example: line differential protection for overhead line with breaker-and-a-half scheme

Functions, application templates



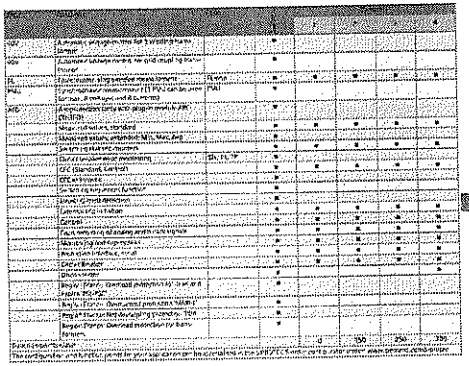


Table 2.7-1 SIPROTEC 7SD86: Functions and typical applications

1	DIFF Basic
2	DIFF overhead line
3	DIFF overhead line with 1 pole tripping
4	DIFF overhead line, 1.5 CB

Description

The SIPROTEC 7SD87 differential protection is suitable for the selective protection of overhead lines and cables with single-ended and multi-ended infeed of all lengths with up to 6 ends. Synchronous and compensating coils in the protection range are also possible. With its modular structure, flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7SD87 offers future-oriented system solutions with high investment security and low operating costs.

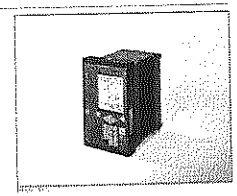


Figure 2.7-7 SIPROTEC 7SD87

Functions

DIGSI 5 permits all functions to be configured and combined as required

- Minimum tripping time: 9 ms
- Main protection function is differential protection with added line algorithm for maximum sensitivity and stability even with the most different transformer errors, current transformer saturation and capacitive charging currents
- Directional backup protection and various additional functions
- Recognition of static, dynamic and transient ground faults (flexible contact processing) in the suppression coil grounded or isolated power systems
- Detection of current transformer saturation
- Arc protection
- Power protection, configurable as active or reactive power protection
- Fast trip power and voltage protection (QU protection)
- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protective functions (such as thermal overload protection) and operational measured values
- 1-3 pole automatic reclosing function
- Control, synchrocheck and switchgear interlocking protection
- Graphical logic editor to create powerful automation functions in the device
- Single-line representation in small or large display
- Integrated electrical Ethernet RJ45 for DIGSI 5 and IEC 61850 (operating and GOOSE)
- Up to 3 optional pluggable communication modules, usable for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP))
- Serial protection data communication via optical fibers, two-wire connections and communication networks (IEEE C37.94, and others), including automatic switchover between ring and chain topology
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW White Paper requirements
- Phasor measurement unit (PMU) for synchrophasor measured values, and IEEE C37.118 protocol
- Time synchronization using IEEE 1588
- Powerful fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

Applications

- Line protection for all voltage levels with 1-pole and 3-pole tripping
- Phase-selective protection of overhead lines and cables with single-ended and multi-ended infeed of all lengths with up to 6 line ends
- Also used in switchgear with breaker-and-a-half configuration
- Transformers and compensating coils in the protection range are possible
- Detection of ground faults in isolated or arc suppression coil ground power systems in star, ring, or meshed arrangement
- Protection data communication over different distances and physical media, such as optical fiber, two-wire connections, and communication networks
- Phasor measurement unit (PMU)

Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings.

The following application templates are available:

- Basic differential protection
- Differential protection for overhead line
- Differential protection for overhead line, for applications with breaker-and-a-half schemes

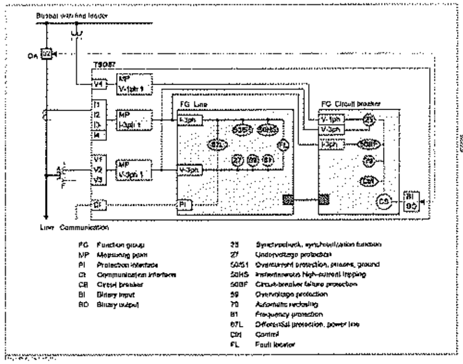


Figure 2.7/7 Application example: Line differential protection for overhead line

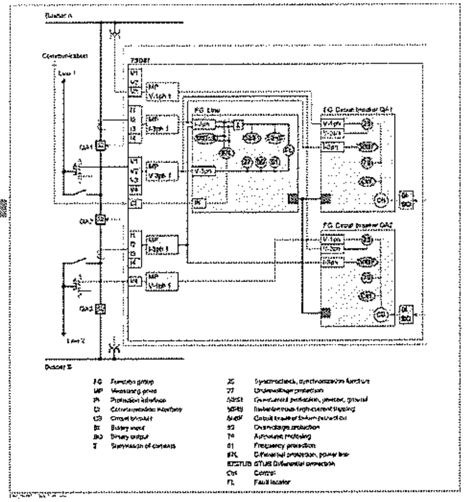


Figure 2.7/8 Application example: Line differential protection for overhead line with breaker-and-a-half scheme

Functions, application templates

[illegible]

[illegible]

Table 2.7/1 SIPROTEC 7SD87 – Functions and application templates

1 Diff Basic
2 Diff overhead line
3 Diff overhead line 1.5 CB

Description

The combined SIPROTEC 7SL82 line differential and distance protection has been designed particularly for the cost-optimized and compact protection of lines in medium-voltage and high-voltage systems. With its flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7SL82 offers future-oriented system solutions with high investment security and low operating costs.

Main function	Differential protection and distance protection for medium-voltage and high-voltage applications
Tripping	3-pole, minimum tripping time: 19 ms
Inputs and outputs	4 current transformers, 4 voltage transformers (optional), 11 or 23 binary inputs, 9 or 16 binary outputs
Hardware flexibility	Different hardware quantity structures for binary inputs and outputs are available in the 1/3 base module. Adding 1/6 expansion modules is not possible; available with large or small display
Housing width	1/3 x 19"

Benefits

- Compact and low-cost line differential and distance protection
- Safety due to powerful protection functions
- Data security and transparency over the entire lifecycle of the plant save time and money
- Purposeful and simple operation of the devices and software thanks to user-friendly design
- Increased reliability and quality of the engineering process
- Consistent implementation of high safety and security mechanisms
- Powerful communication components ensure safe and effective solutions
- Full compatibility between IEC 61850 Editions 1 and 2
- High investment security and low operating costs due to future-oriented system solutions.

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Minimum tripping time: 19 ms
- Main protection function is differential protection with adaptive algorithm for maximum sensitivity and stability even with the most different transformer errors, current transformer saturation and capacitive charging currents
- Several distance protection functions as backup protection or 2nd main protection for selection: Classic, Reactance method (RMD), impedance protection for transformers
- Directional backup protection and various additional functions
- Recognition of static, intermittent and transient ground faults (transient function) in arc-suppression-coil-ground and isolated power systems
- Detection of current transformer saturation for fast tripping with high accuracy

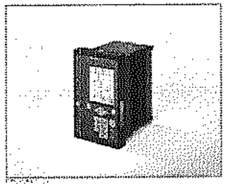


Figure 2.8/1 SIPROTEC 7SL82

- Adaptive power swing blocking
- Arc protection
- Reactive power undervoltage protection (QU protection)
- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (such as thermal overload protection) and operational measured values
- Control, synchrocheck and switchgear interlocking protection
- Graphical logic editor to create powerful automation functions in the device
- Single-line representation in small or large display
- Integrated electrical Ethernet RJ45 for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- Two optional pluggable communication modules, usable for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP))
- Serial protection data communication via optical fibers, two-wire connections and communication networks (IEEE C37.94, and others), including automatic switchover between ring and chain topology
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW Whitepaper requirements
- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Time synchronization using IEEE 1588
- Powerful fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for easy tests and commissioning

Applications

- Line protection for all voltage levels with 3-pole tripping
- Phase-selective protection of overhead lines and cables with single-ended and multi-ended infeed of all lengths with up to 6 line ends
- Transformers and compensating coils in the protection zone
- Detection of ground faults in isolated or arc-suppression-coil-ground power systems in star, ring, or meshed arrangement
- Protection data communication over different distances and physical media, such as optical fiber, two-wire connections, and communication networks
- Phasor measurement unit (PMU)

Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings.

The following application templates are available:

- Basic differential and distance protection
- Differential and distance protection for overhead line in grounded systems.

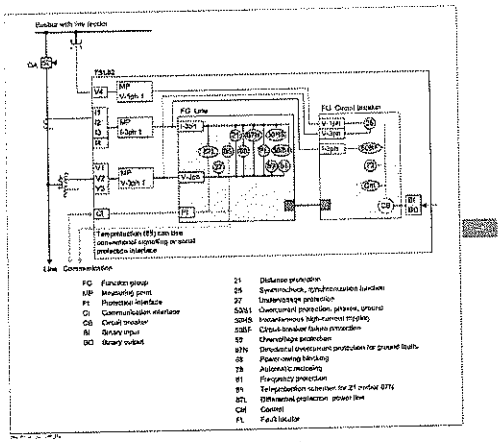


Figure 2.8-2 Assignment of function groups to the differential and distance protection power system

21	Distance protection for phases and ground (quadrilateral characteristic)	21/FL	●	●	●
	Distance protection for phases and ground (MHO characteristic)	21/FL	●	●	●
21T	Transformer distance protection	21T		●	●
25	Synchrocheck, synchronization function	25	●	●	●
27	Undervoltage protection	27	●	●	●
27/59	Undervoltage/overvoltage protection	27/59	●	●	●
50/51	Overcurrent protection, phases and ground	50/51	●	●	●
50HS	Instantaneous high-current tripping	50HS	●	●	●
50BF	Circuit-breaker failure protection	50BF	●	●	●
59	Overvoltage protection, negative-sequence system	59Q	●	●	●
59R	Overvoltage protection, residual voltage	59R	●	●	●
67N	Directional overcurrent protection for ground faults	67N	●	●	●
68	Power-swing detection/tripping	68/78	●	●	●
74TC	Trip-circuit supervision	74TC	●	●	●
78	Out-of-step protection	68/78	●	●	●
79	Automatic reclosing	79	●	●	●
81	Frequency protection	81	●	●	●
81R	Rate of frequency change protection	81R	●	●	●
85/21	Teleprotection for distance protection	85/21	●	●	●
85/67N	Teleprotection for directional ground fault protection	85/67N	●	●	●
85/87L	Teleprotection for line differential protection	85/87L	●	●	●
86	Lockout	86	●	●	●
87L	Line differential protection for 2 ends	87L	●	●	●
87L	Line differential protection for 3 ends	87L		●	●
87L	Line differential protection for 4 ends	87L			●
87T	Transformer differential protection (2 windings)	87T		●	●
87T	Transformer differential protection (3 windings)	87T			●
87STUB	Busbar protection for 1½ breaker arrangements	87STUB			●
BAY	Bay controller	BAY	●	●	●
CBM	Circuit-breaker monitoring	CBM	●	●	●
CFC	Continuous function chart	CFC	●	●	●
CM	Control and management functions	CM	●	●	●
COMM1	Communication protocol	COMM1	●	●	●
COMM2	Communication protocol	COMM2	●	●	●
DMD	Demand calculation	DMD	●	●	●
FL	Fault locator	FL	●	●	●
IEC 61850	IEC 61850	IEC 61850	●	●	●
IEC 62439	IEC 62439	IEC 62439	●	●	●
LOGIC	Logic	LOGIC	●	●	●
MEAS	Measured values, extended	MEAS	●	●	●
MEAS	Measured values, basic	MEAS	●	●	●
MT	Measurement transducer	MT	●	●	●
PMU	Synchrophasor measurement (PMU)	PMU	●	●	●
PQ	Power quality	PQ	●	●	●
PROT	Protection interface, serial	PROT	●	●	●
RIO	Remote input/output	RIO	●	●	●
SAFE	Safety concept	SAFE	●	●	●
SEQ	Sequence	SEQ	●	●	●
SFMON	Supervision	SFMON	●	●	●
SYNC	Synchronization	SYNC	●	●	●
TAP	Tap changer	TAP		●	●
TH	Thermal overload protection	49/TH	●	●	●
VI	Voltage/current transformer supervision	VI	●	●	●

21	Distance protection for phases and ground (quadrilateral characteristic)	21/FL	●	●	●
	Distance protection for phases and ground (MHO characteristic)	21/FL	●	●	●
21T	Transformer distance protection	21T		●	●
25	Synchrocheck, synchronization function	25	●	●	●
27	Undervoltage protection	27	●	●	●
27/59	Undervoltage/overvoltage protection	27/59	●	●	●
50/51	Overcurrent protection, phases and ground	50/51	●	●	●
50HS	Instantaneous high-current tripping	50HS	●	●	●
50BF	Circuit-breaker failure protection	50BF	●	●	●
59	Overvoltage protection, negative-sequence system	59Q	●	●	●
59R	Overvoltage protection, residual voltage	59R	●	●	●
67N	Directional overcurrent protection for ground faults	67N	●	●	●
68	Power-swing detection/tripping	68/78	●	●	●
74TC	Trip-circuit supervision	74TC	●	●	●
78	Out-of-step protection	68/78	●	●	●
79	Automatic reclosing	79	●	●	●
81	Frequency protection	81	●	●	●
81R	Rate of frequency change protection	81R	●	●	●
85/21	Teleprotection for distance protection	85/21	●	●	●
85/67N	Teleprotection for directional ground fault protection	85/67N	●	●	●
85/87L	Teleprotection for line differential protection	85/87L	●	●	●
86	Lockout	86	●	●	●
87L	Line differential protection for 2 ends	87L	●	●	●
87L	Line differential protection for 3 ends	87L		●	●
87L	Line differential protection for 4 ends	87L			●
87T	Transformer differential protection (2 windings)	87T		●	●
87T	Transformer differential protection (3 windings)	87T			●
87STUB	Busbar protection for 1½ breaker arrangements	87STUB			●
BAY	Bay controller	BAY	●	●	●
CBM	Circuit-breaker monitoring	CBM	●	●	●
CFC	Continuous function chart	CFC	●	●	●
CM	Control and management functions	CM	●	●	●
COMM1	Communication protocol	COMM1	●	●	●
COMM2	Communication protocol	COMM2	●	●	●
DMD	Demand calculation	DMD	●	●	●
FL	Fault locator	FL	●	●	●
IEC 61850	IEC 61850	IEC 61850	●	●	●
IEC 62439	IEC 62439	IEC 62439	●	●	●
LOGIC	Logic	LOGIC	●	●	●
MEAS	Measured values, extended	MEAS	●	●	●
MEAS	Measured values, basic	MEAS	●	●	●
MT	Measurement transducer	MT	●	●	●
PMU	Synchrophasor measurement (PMU)	PMU	●	●	●
PQ	Power quality	PQ	●	●	●
PROT	Protection interface, serial	PROT	●	●	●
RIO	Remote input/output	RIO	●	●	●
SAFE	Safety concept	SAFE	●	●	●
SEQ	Sequence	SEQ	●	●	●
SFMON	Supervision	SFMON	●	●	●
SYNC	Synchronization	SYNC	●	●	●
TAP	Tap changer	TAP		●	●
TH	Thermal overload protection	49/TH	●	●	●
VI	Voltage/current transformer supervision	VI	●	●	●

Table 2.8-1 SIPROTEC 7SL82 – Functions and application templates

1 DAPPDIS Basic

2 DAPPDIS.RMD overhead line, solid grounded neutral point

Description

The numerical SIPROTEC 7SL86 line differential and distance protection has specifically been designed for the protection of lines, with its modular structure, flexibility and the powerful DIGSI 5 engineering tool. SIPROTEC 7SL86 offers future-oriented systems solutions with high investment security and low operating costs.

Short fault clearing time	Differential and distance protection Typical minimum tripping time: 15 ms
Hardware and interfaces	1/3-pole tripping Up to 4 protection interfaces via direct fiber-optic connection or communication networks Up to 6 current transformers, 4 voltage transformers All 3-pole tripping, 8 x BI, 6 x BO, 1 x life contact
Hardware flexibility	Flexible hardware quantity structure for adaptation to the size of the system Pre-fabricated housing for easy retrofitting
Operating system	DIGSI 5 or IEC 61850

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Minimum tripping times
- Main protection function is differential protection with adaptive algorithm for maximum sensitivity and stability even with the most different transformer ratios, current transformer saturation, and capacitive charging currents
- Several distance protection functions as backup protection or 2nd main protection for selection: Classic, numerical method (MHO), impedance protection for transformers
- Overcurrent backup protection and various additional functions
- Adaptive power swing blocking, out-of-step protection
- Detection of current transformer saturation for fast tripping with high accuracy
- AR protection
- Reactive power undervoltage protection (QU protection)
- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (such as thermal overload protection) and operational measurements
- 1-pole automatic reclosing function
- Control, switchgear and circuit-breaker interlocking protection
- Fault locator for exact power fault allocation functions in the device
- Single line representation in small or large displays
- Integrated electrical Ethernet RJ45 for DIGSI and IEC 61850 (depending on ordering)
- Up to 4 optional pluggable communication modules, usable for differential and main distance protocols: IEC 61850 8-1, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP/IP)
- Simultaneous data communication via optical fibers, with several interfaces and communication networks (IEEE C37.94, and others), including automatic switchover between ring and multi-terminal

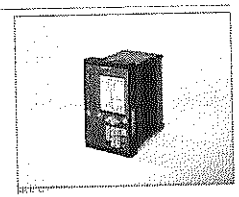


Figure 2.8-1 SIPROTEC 7SL86

- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW, IEC 62351 for power system data
- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Time synchronization via IRIG-B, PTP, SNTP
- Powerful fault recording (buffer) for max. 8 max. 1 min for 8 ms at 8 kHz or 32 s at 1 kHz
- Flexibly functions for easy tests and commissioning
- Flexibly adjustable LED property descriptions within the range of the SIPROTEC 5 modular system

Applications

- Line protection for all voltage levels with 1-pole and 3-pole tripping
- Protection protection of overhead lines and cables with single-ended and multi-ended infeed with up to 6 current ends
- Also used in solidly-earthed networks with parallel lines
- Transformers and block units protection
- Detection of short circuits and ground faults in the protection zone
- Detection of short circuits in resistance-grounded and ground power systems (star point, or isolated) measurement
- Protection data communication over different distances and physical media, such as optical fiber, for communication, and communication networks
- Phasor measurement unit (PMU)

Application templates

Application templates are available for DIGSI for operating options. They comprise all typical configurations and default settings.

The following application templates are available:

- Basic
- Differential and distance protection with RMD for overhead line in grounded systems
- Differential and distance protection with RMD for overhead line in grounded systems, with all the applications such as breaker and a half scheme

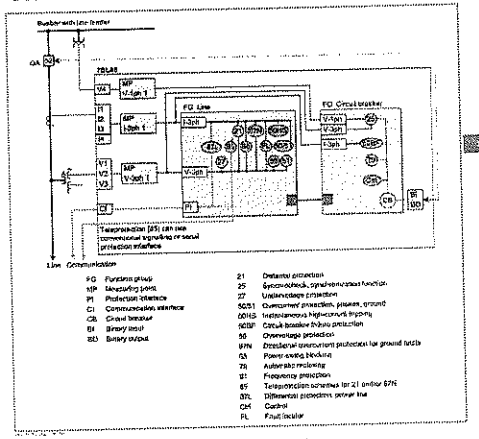


Figure 2.8-4 Application example: Differential and distance protection for overhead line

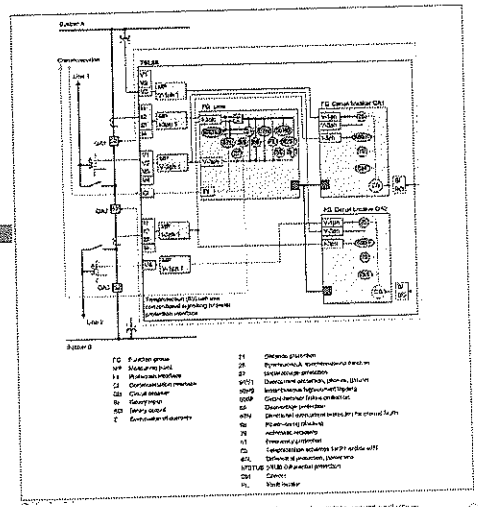


Figure 2.8-5 Application example: Differential and distance protection for overhead line with 1½ breaker arrangement

SIPROTEC 5 Devices and Fields of Application

Differential and Distance Protection – SIPROTEC 7SL86

Functions, application templates

[illegible]

SIPROTEC 5 Devices and Fields of Application

Differential and Distance Protection – SIPROTEC 7SL86

[illegible]

Table 2.8/3 SIPROTEC 7SL86 – Functions and application templates

1 DIFF/DIS Basic

2 DIFF/DIS RMD overhead line, solid grounded neutral point

3 DIFF/DIS RMD overhead line, 1.5 CB

SIPROTEC 5 Devices and Fields of Application

Differential and Distance Protection – SIPROTEC 7SL87

Description

The combined SIPROTEC 7SL87 line differential and distance protection has specifically been designed for the protection of lines. With its modular structure, flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7SL87 offers future-oriented system solutions with high investment security and low operating costs.

Main function	Differential and distance protection
Tripping	1-pole and 3-pole, minimum tripping time 9 ms
Inputs and outputs	12 predefined standard variants with 4/4 or 8/8 current/voltage transformers, 5 to 31 binary inputs, 8 to 46 binary outputs
Hardware flexibility	Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system
Housing width	1/3 × 19" to 2/1 × 19"

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Minimum tripping time: 9 ms
- Main protection: line-selective differential protection with adaptive algorithm for maximum sensitivity and stability even with the most different transformer errors, current transformer saturation and capacitive charging currents
- Several distance protection functions as backup protection or 2nd main protection for selection: Classic, reactance method (RMD), impedance protection for transformers
- Directional backup protection and various additional functions
- Adaptive power swing blocking, out-of-step protection
- Detection of current transformer saturation for fast tripping with high accuracy
- Arc protection
- Reactive power undervoltage protection (QU protection)
- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (such as thermal overload protection) and operational measured values
- 1-/3-pole automatic reclosing function
- Control, synchrocheck and switchgear interlocking protection
- Graphical logic editor to create powerful automation functions in the device
- Single-line representation in small or large display
- Integrated electrical Ethernet RJ45 for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- Up to 4 optional pluggable communication modules, usable for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP))
- Serial protection data communication via optical fibers, two-wire connections and communication networks (IEEE C37.94, and others, including automatic switchover between ring and chain topology)
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW Whitepaper requirements
- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Time synchronization using IEEE 1588
- Powerful fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

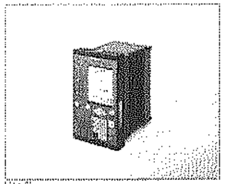


Figure 2.8/6 SIPROTEC 7SL87

Applications

- Line protection for all voltage levels with 1-pole and 3-pole tripping
- Phase-selective protection of overhead lines and cables with single-ended and multi-ended infeed of all lengths with up to 6 line ends
- Also used in switchgear with breaker-and-a-half configuration
- Transformers and compensating coils in the protection zone
- Detection of ground faults in isolated or arc-suppression coil ground power systems in star, ring, or meshed arrangement
- Protection data communication over different distances and physical media, such as optical fiber, two-wire connections, and communication networks
- Phasor measurement unit (PMU)

Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings.

SIPROTEC 5 Devices and Fields of Application

Differential and Distance Protection – SIPROTEC 7SL87

The following application templates are available:

- Basic differential and distance protection
- Differential and distance protection with RMD for overhead line in grounded systems
- Differential and distance protection with RMD for overhead line in grounded systems for applications with breaker-and-a-half schemes.

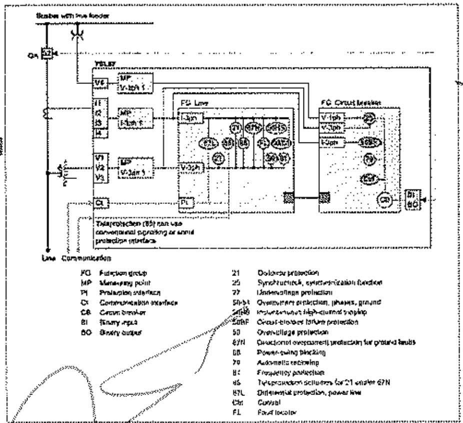


Figure 2.8/7 Application example: Combined line differential and distance protection for overhead line

SIPROTEC 5 Devices and Fields of Application

Differential and Distance Protection – SIPROTEC 7SL87

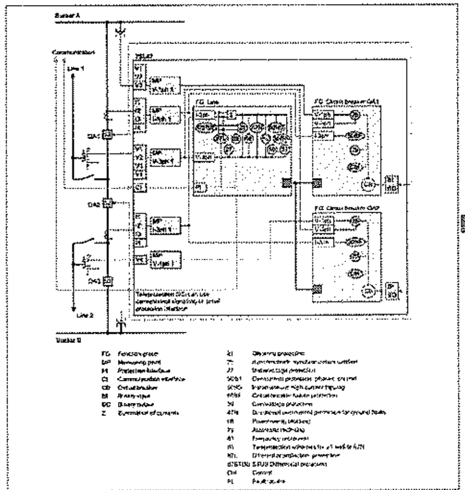


Figure 2.8/8 Application example: Combined line differential and distance protection for overhead line in breaker-and-a-half scheme

SIPROTEC 5 Devices and Fields of Application

Differential and Distance Protection – SIPROTEC 7SL87

Functions, application templates

[illegible]

178

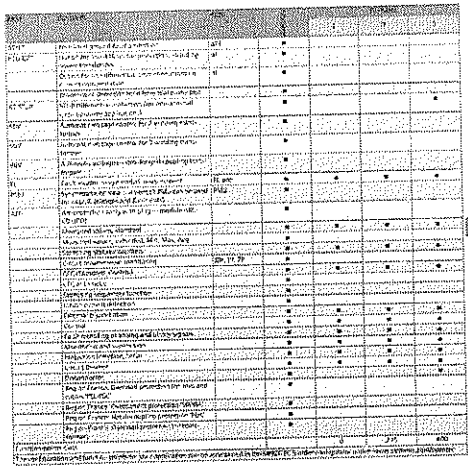


Table 2-61 SIPROTEC 7SL87 - Functions and application templates

1 DIFF/PDIS 6-pole

2 DIFF/PDIS 1½AD overhead line, short grounded neutral point

3 DIFF/PDIS 1½AD overhead line, 1 ½ CB

Description

The SIPROTEC 7VK87 circuit-breaker management device has been specifically developed for automatic reclosing and circuit-breaker control. It is available in two versions: the 1/3-pole version (7VK87.1) for single-pole and three-pole tripping, and the 3-pole version (7VK87.3) for three-pole tripping only. Both versions are available in panel surface-mounted housing and in cubicle mounting housing.

Number of inputs and outputs	Maximum number of binary inputs and outputs can be configured as required (depending on the number of I/O boards in the device)
Current transformer	4 (3 phase current transformers and 1 ground current transformer)
Voltage transformer	4 (3 phase-to-ground voltages and 1 displacement voltage or 1 phase-to-phase voltage)
Housing, dimensions	1/3-pole version: 1/2 x 19" (7VK87.1) or 1/1 x 19" (7VK87.3)

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Automatic reclosing functions and synchronization, interconnection applications with 1 pole and 3 pole tripping
- Circuit-breaker failure protection (1 pole and 3 pole tripping)
- Control functions/logic and measured-value processing protection
- Voltage controller (7VK87.3)
- Arc protection
- Voltage protection
- Graphic logic editor to create powerful automation functions in the device
- Single-line representation in small or large display
- Integrated electrical control panel for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- Up to 4 options of pluggable communication modules allow for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP))
- Serial protection data communication via optical fibers, copper cable (multiple and communication networks (IEEE C37.94, and others), including symmetric switchover between ring and chain topology
- Redundancy protocol, PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW White Paper requirements

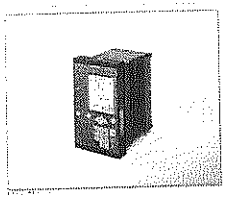


Figure 2-91 Circuit-breaker management device 7VK87

- CB time measurements with 7POL) for switchgear monitored relays and IEEE C37.118 protocol
- Time synchronization using IEEE 1588
- Fault event recording (buffer for a max. record time of 80 s at 8 kHz or 160 s at 4 kHz)
- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

Applications

- Automatic reclosing after 1/3 pole tripping
- Synchronism and voltage reclosing
- Circuit-breaker failure protection
- Also used in conjunction with breaker and a half configuration
- Backup overcurrent and voltage protection
- Protection data communication over different distances and physical media, such as optical fiber, pilot wire connection, and communication networks
- Phasor measurement unit (PMU).

Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings.

Th = Following applications template is available

• Basic control breaker management device

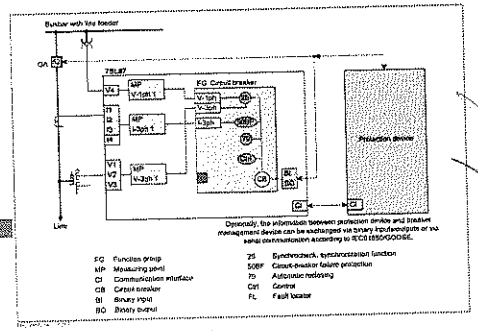
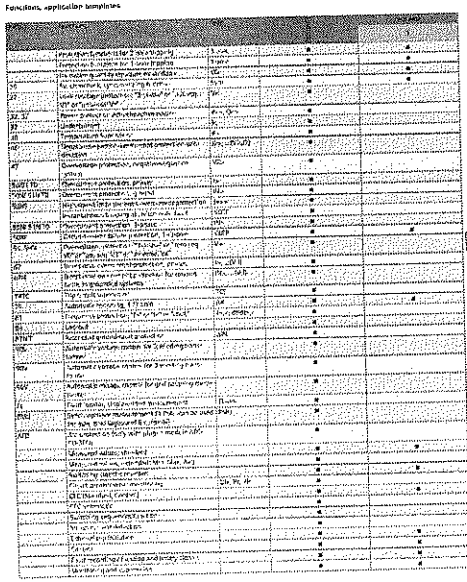


Figure 2-92 Busbar with one feeder

Functions, application templates



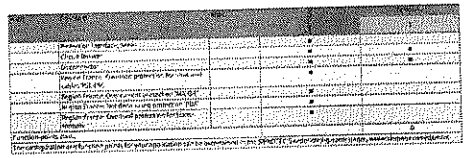


Table 2-81 SIPROTEC 7VK87 - Functions and application templates

1 Basic (79 AR, 25 Sync., 50BF Breaker fail. prot.)

SIPROTEC 5 Devices and Fields of Application

Overcurrent Protection as Backup Protection for Line Protection – SIPROTEC 7SJ86

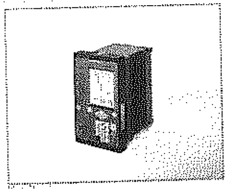


Figure 2.10/1 SIPROTEC 7SJ86

Description

The SIPROTEC 7SJ86 overcurrent protection has specifically been designed as backup or emergency protection for the line protection devices. With its modular structure, flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7SJ86 offers future-oriented system solutions with high investment security and low operating costs.

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Overcurrent protection as backup / emergency line protection for all voltage levels with 3-pole tripping
- Optimized tripping times due to directional comparison and protection data communication
- Recognition of static, intermittent and transient ground faults (transient function) in arc-suppression coil grounded and isolated power systems
- Arc protection
- Overvoltage and undervoltage protection
- Frequency protection and frequency change protection for load shedding applications
- Power protection, configurable as active or reactive power protection
- Protection functions for capacitor banks, such as overcurrent, overload, current unbalance, peak overvoltage, or differential protection
- Reactive power undervoltage protection (QU protection)
- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (such as thermal overload protection) and operational measured values
- Control, synchrocheck and switchgear interlocking protection
- Circuit-breaker failure protection
- Circuit-breaker restrike monitoring
- Graphical logic editor to create powerful automation functions in the device
- Single-line representation in small or large display
- Integrated electrical Ethernet RJ45 for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- 2 optional pluggable communication modules, usable for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (serial and TCP))
- Serial protection data communication via optical fibers, two-wire connections and communication networks (IEEE C37.94, and others), including automatic switchover between ring and chain topology
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW Whitepaper requirements
- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Time synchronization using IEEE 1588
- Powerful fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

Applications

- Backup and emergency protection for line protection
- Detection and selective 3-pole tripping of short circuits in electrical equipment of star networks, lines with infeed at one or two ends, parallel lines and open or closed ring systems of all voltage levels
- Utilization in switchgear with breaker-and-a-half configuration
- Detection of ground faults in isolated or arc-suppression-coil-ground power systems in star, ring, or meshed arrangement
- Backup protection for differential protection devices of all kind for lines, transformers, generators, motors, and busbars
- Protection and monitoring of capacitor banks
- Phasor Measurement Unit (PMU)
- Reverse-power protection

SIPROTEC 5 Devices and Fields of Application

Overcurrent Protection as Backup Protection for Line Protection – SIPROTEC 7SJ86

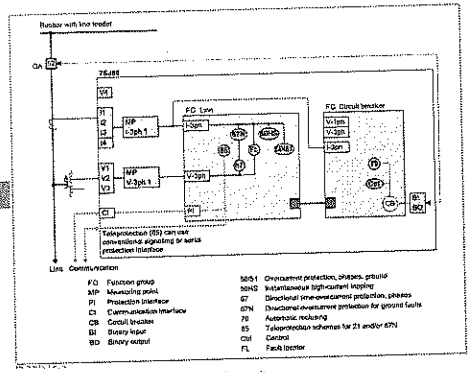
Application templates

Application templates are available in DIGSI 5 for standard applications. They comprise all basic configurations and default settings.

The following application templates are available:

- SIPROTEC 7SJ86 non-directional overcurrent protection
- SIPROTEC 7SJ86 directional overcurrent protection

Figure 2.10/2 shows an application example for directional protection of an overhead line. The functional scope is based on the application template directional overcurrent protection. In addition, the functions fault locator and automatic reclosing were loaded from the DIGSI 5 library.



FG	Function group	50/51	Overcurrent protection, phases, ground
MP	Measuring point	50HS	Instantaneous high-current tripping
PI	Protection interface	67	Directional time-overcurrent protection, phases
CI	Communication interface	67N	Directional overcurrent protection for ground faults
CB	Circuit breaker	79	Automatic reclosing
BI	Binary input	85	Teleprotection schemes for 21 and/or 67N
BO	Binary output	Ctrl	Control
		FL	Fault locator

Figure 2.10/2 Application example: directional overcurrent protection for overhead line

SIPROTEC 5 Devices and Fields of Application

Overcurrent Protection as Backup Protection for Line Protection – SIPROTEC 7SJ86

Functions and application templates

[illegible]

SIPROTEC 5 Devices and Fields of Application

Overcurrent Protection as Backup Protection for Line Protection – SIPROTEC 7SJ86

[illegible]

Table 2.10/1 SIPROTEC 7SJ86 – Functions and application templates

1 Non-directional OC (11, 41 V)

2 Directional OC – grounded system

SIPROTEC 5 Devices and Fields of Application

Overcurrent Protection as Backup Protection for Line Protection – Line Protection

Standard variants

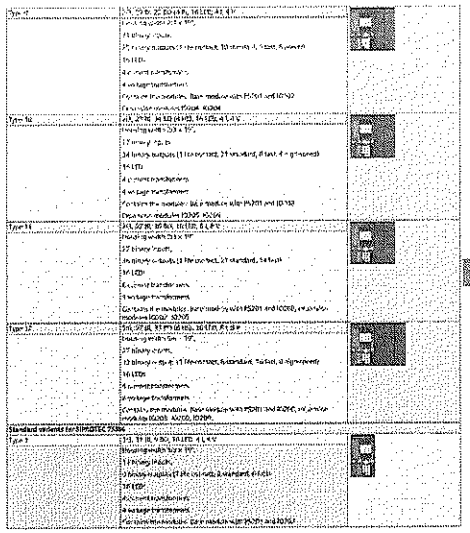
[illegible]

SIPROTEC 5 Devices and Fields of Application

Overcurrent Protection as Backup Protection for Line Protection – Line Protection

[illegible]

180



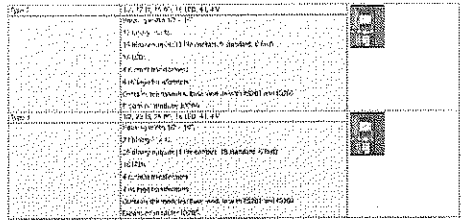


Table 2.10-2

The technical data of the device can be found in the manual (www.siemens.com/siprotec).

SIEMENS

www.siemens.com/siprotec

Transformer Differential Protection

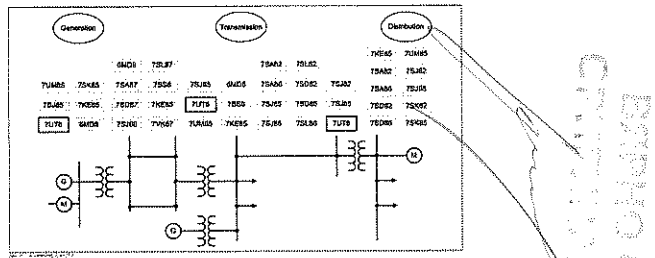


Figure 2.11-1

SIPROTEC 7UT82, 7UT85, 7UT86, 7UT87

SIPROTEC 5 transformer differential protection devices are multifunctional devices whose main protection functions are based on the differential protection principle. They protect different types of transformers, such as two winding, three winding and multi winding transformers with different numbers of feeds, using primary and, besides standard power transformers, also auto transformers.

The devices can be used on all voltage levels. The large number of protection and automation functions, present in all fields of electric power supply. The devices contain all important secondary functions that today are necessary for safe network operation. This includes control, measurement and monitoring functions. The large number of communication, installation and commissioning user interface samples the implementation of IEC communication based selective protection and of substation automation.

Commissioning and maintenance work can be completed safely, quickly and thus cost effectively. With "high" performance functions. Their modular structure presents SIPROTEC 5 power network different full protection designs, always to be adapted exactly able to the requirements.

For your order, you can select the devices from various standard variants. Additional expansion modules permit the device to be adapted to your specific application (see "Overview of the Standard Variants").

Definition of the device types, by their design sizes

Type		
1	1/3	1/2
2	1/2	1/1
3	1/1	2/1

Description

The SIPROTEC 7UT82 transformer differential protection has been designed specifically for the protection of two winding transformers. It is the main protection for the transformer and partners many other protection and monitoring functions. The additional protection functions can also be used as backup protection for protected downstream objects (such as cables, lines). In this process, you are also supported by the modular expandability of the hardware. With its modular structure, flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7UT82 often helps reserved system solutions with high level energy security and low operating costs.

Basic structure	1/3 housing with 4 binary inputs and 4 binary outputs, 1 current input, 1 voltage input, 1 life contact, 1 USB interface, 1 Ethernet interface for DIGSI 5 and IEC 61850
Option, expansion 1	2 x further current inputs and voltage inputs, 1 x 1-phase current inputs or the person
Module and design	2 predefined standard variants (2 current transformers, 3 voltage inputs, 7 binary inputs, 8 binary outputs)
Expansion capability	Up to 20 binary inputs and 16 binary outputs with the 7XR93 expansion, can not possible as add. HS transmission modules, available with high and small density
Housing width	1/3 to 1/1

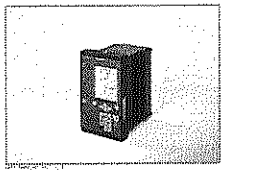


Figure 2.11-2 SIPROTEC 5 7UT82 transformer differential protection (1/3 device, standard variant #1)

Benefits

- Compact and low-cost transformer differential protection
- Many easy-to-use powerful protection functions
- Easy setup and transparency over the entire lifecycle of the plant (see time and money)
- Supported and simple operation of the devices and software thanks to user friendly design
- Increased reliability and quality of the engineering process
- Conserved implementation of high safety and security standards
- Powerful communication components ensure safe and effective solutions
- Full compatibility between IEC 61850 Editions 1 and 2
- Highly available Ethernet communication due to integrated Ethernet redundancy protocols PRP and HSR

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Two/three differential protection for two winding trans (multi-side variable additional protection functions
- Transformer differential protection for group single regulating transformers or the single core type
- Universal usability of the permissible measuring points
- Applicable from average up to extra high voltage
- Protection of standard power transformers, auto transformers, and reactors
- Increased sensitivity with only neutral point ground faults through a sensitive ground fault differential protection
- Flexible adaptation to the transformer vector group
- Controlling, closing and several other operations
- Safe switches in current star voltage connection with different degrees of selectivity
- Adaptive adaptation of the operate curve to the transformer tap position
- Arc protection
- Graphical logic editor to create powerful information and functions in the device
- Single-line representation in small or large displays
- Integrated electrical Ethernet (LAN) for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- Up to 2 optical pluggable communication modules, usable for different and redundant protocols IEC 61850, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 (only and TCP/IP)
- Serial protective data communication via optical fibers, pilot wire connections, and communication networks (IEEE C37.94, and others), including automatic switchover between ring and chain topology
- Redundancy protocols PRP and HSR
- Cyber security, in accordance with NERC CIP and BDEW White Paper requirements
- Time synchronization using IEEE 1588
- Powerful fault recording (buffer for 3 max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for measurements and commissioning

Applications

Application templates are available in DIGSI 5 for standard applications. They contain basic configurations and default settings. These can be used directly or as a template for application-

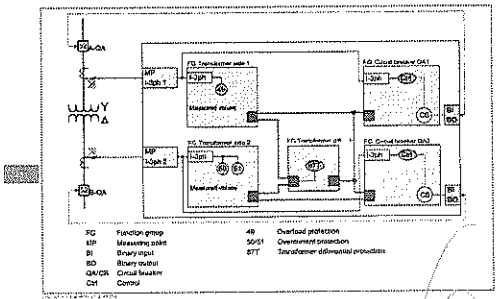
related adaptation. The available measuring points make several applications possible. Prior to ordering a device, please configure the application with DIGSI 5. Table "Examples and application templates" shows the scope of function of the device. Use the configurator to determine the necessary function points.

The *figure 2.11-1* shows the type of attachment of an application template, the six binary inputs used, the function groups used, their criterion of inverse current, and the predefined functions. The example shows the two winding transformer with ground fault differential protection.

Application examples

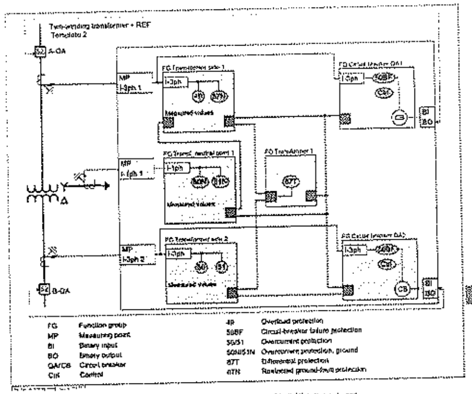
Two winding transformer bank:

- Differential protection
- Overload protection, backup protection for the downstream electrical power system



FG	Function group	49	Overload protection
MP	Measuring point	50/51	Overcurrent protection
BI	Binary input	87T	Transformer differential protection
BO	Binary output		
QA/CB	Circuit breaker		
Ctrl	Control		

Figure 2.11-3 Application template for a two winding transformer



FG	Function group	49	Overload protection
MP	Measuring point	50BF	Circuit-breaker failure protection
BI	Binary input	50/51	Overcurrent protection
BO	Binary output	50N/51N	Overcurrent protection, ground
QA/CB	Circuit breaker	87T	Differential protection
CIt	Control	87N	Restricted ground-fault protection

Figure 2.11/4 Application example: Protection of a two-winding transformer with restricted ground-fault differential protection

Two-winding transformer with restricted ground-fault protection (REF)

- Differential protection
- Ground fault differential protection on the star side
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

Functions and application templates

[illegible]

Table 2.11/1 SIPROTEC 7UT82 – Functions and application templates

1 Two-winding transformer basic (87T)
2 Two-winding transformer (87T, 50BF, 87N)
x Mated DIFF (87M)

Description

The SIPROTEC 7UT85 transformer differential protection has been designed specifically for the protection of two-winding transformers (2 sides). It is the main protection for the transformer and contains many other protection and monitoring functions. The additional protection functions can also be used as backup protection for protected downstream objects (such as cables, lines). In this process, you are also supported by the modular expandability of the hardware. With its modular structure, flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7UT85 offers future-oriented system solutions with high investment security and low operating costs.

Main function	1 differential protection function (standard) with additional stabilization; up to 2 ground-fault differential protection functions
Usable measuring points	5 x 3-phase current measuring points, 3 x 1-phase current measuring points, 3 x 3-phase voltage measuring points; expandable to 3 sides
Inputs and outputs	2 predefined standard variants with 8 current transformers, 7 binary inputs, 7 to 23 binary outputs
Hardware flexibility	Flexibly adjustable and expandable I/O quantity structure within the scope of the SIPROTEC 5 modular system
Housing width	1/3 x 19" to 2/1 x 19"

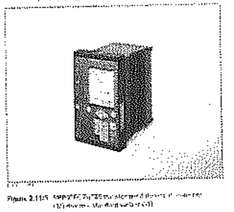


Figure 2.11/5 SIPROTEC 7UT85 transformer differential protection (1/3 device – standard variant)

- Typical properties of a transformer differential protection such as flexible adaptation to the transformer vector group, control of inrush and overexcitation processes, safe behavior in the case of current-transformer saturation with different degrees of saturation
- Adaptive adaptation of the operate curve to the transformer tap position
- Increased sensitivity with near neutral-point ground faults through a separate ground-fault differential protection
- Additional current and voltage inputs can be supplemented for standard protection functions, such as overcurrent, voltage, frequency, etc.
- Arc protection
- Voltage controller function ANSI 90V for two-winding transformers, three-winding transformers and grid coupling transformers
- Graphical logic editor to create powerful automation functions in the device
- Up to 4 pluggable communication modules, usable for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, DNP3 (serial and TCP), Modbus TCP)
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW Whitepaper requirements
- Secure serial protection data communication, also over great distances and all available physical media (fiber-optic cable, 2-wire connections and communication networks)
- Capturing operational measured variables and protection function measured values to evaluate the plant state, to support commissioning, and to analyze faults
- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Powerful fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)

Benefits

- Safety due to powerful protection functions
- Data security and transparency over the entire lifecycle of the plant save time and money
- Purposeful and simple operation of the devices and software thanks to user-friendly design
- Increased reliability and quality of the engineering process
- Consistent implementation of high safety and security mechanisms
- Powerful communication components ensure safe and effective solutions
- Full compatibility between IEC 61850 Editions 1 and 2
- Highly available Ethernet communication due to integrated Ethernet redundancy protocols PRP and HSR

Functions

DIGSI 5 permits all functions to be configured and combined as required

- Transformer differential protection for two-winding transformers with versatile, additional protection functions, expandable to 3 windings
- Transformer differential protection for phase-angle regulating transformers of the single core type and special transformers
- Universal usability of the permissible measuring points
- Applicable from average up to extra-high voltage
- Protection of standard power transformers, auto transformers and motors

- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

Applications

Application templates are available in DIGSI for standard applications. They contain basic configurations and default settings. These can be used directly or as a template for application-related adaptation. The available measuring points make varied applications possible. Prior to ordering a device, please configure the application with DIGSI. Table "Functions and application templates" shows the functional scope of the device. Use the configurator to determine the necessary function points.

Application examples

Two-winding transformer basic (Figure 2.11/6)

- Differential protection
- Overload protection, backup protection for the downstream electrical power system

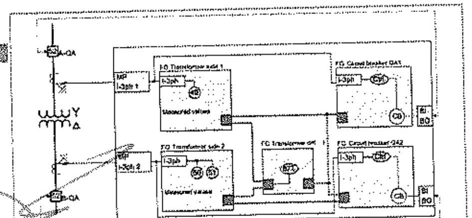
Two-winding transformer with restricted ground-fault differential protection (REF) (Figure 2.11/7)

- Differential protection
- Ground fault differential protection on the star side
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

Two-winding transformer in breaker-and-a-half application (Figure 2.11/8)

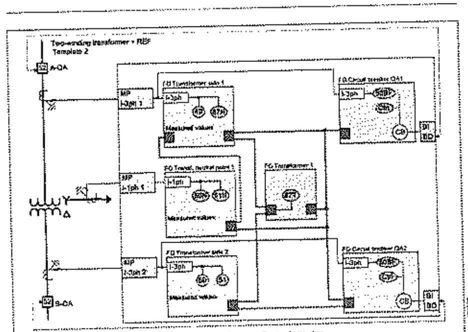
- Differential protection
- Ground fault differential protection on the star side
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

The Figure 2.11/6 shows the typical structure of an application template, the measuring points used, the function groups used, their internal interconnection, and the predefined functions. The example shows the two-winding transformer with ground fault differential protection.



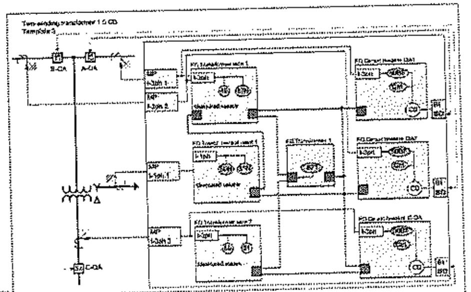
FG	Function group	49	Overload protection
MP	Measuring point	50/51	Overcurrent protection
BI	Binary input	87T	Transformer differential protection
BO	Binary output		
QA/CB	Circuit breaker		
CIt	Control		

Figure 2.11/6 Application example: Protection of a two-winding transformer



FG	Function group	49	Overload protection
MP	Measuring point	50BF	Circuit-breaker failure protection
BI	Binary input	50/51	Overcurrent protection
BO	Binary output	50N/51N	Overcurrent protection, ground
QA/CB	Circuit breaker	87T	Differential protection
CIt	Control	87N	Restricted ground-fault protection

Figure 2.11/7 Application example: Protection of a two-winding transformer with ground-fault differential protection



FG	Function group	49	Overload protection
MP	Measuring point	50BF	Circuit-breaker failure protection
BI	Binary input	50/51	Overcurrent protection
BO	Binary output	50N/51N	Overcurrent protection, ground
QA/CB	Circuit breaker	87T	Transformer differential protection
CIt	Control	87N	Restricted ground-fault protection

Figure 2.11/8 Application example: Protection of a two-winding transformer in breaker-and-a-half layout

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SIPROTEC 5 Devices and Fields of Application

Transformer Differential Protection – SIPROTEC 7UT85

Functions and application templates

[illegible]

SIPROTEC 5 Devices and Fields of Application

Transformer Differential Protection – SIPROTEC 7UT85

[illegible]

Table 2.11/3 SIPROTEC 7UT85 – Functions and application templates

1 Two-winding transformer basic (87T)

2 Two-winding transformer (87T, 50BF, 87N)

3 Two-winding transformer 1,5CB (87T, 50BF, 87N)

SIPROTEC 5 Devices and Fields of Application

Transformer Differential Protection – SIPROTEC 7UT85

[illegible]

SIPROTEC 5 Devices and Fields of Application

Transformer Differential Protection – SIPROTEC 7UT86

Description

The SIPROTEC 7UT86 transformer differential protection has been designed specifically for the protection of three-winding transformers [illegible]. It is the main protection for the transformer and contains many other protection and monitoring functions. The additional protection functions can also be used as backup protection for protected downstream objects (such as cables, lines). In this process, you are also supported by the modular expandability of the hardware. The device supports all SIPROTEC 5 system properties. It enables future-oriented system solutions with high investment security and low operating costs. With its modular structure, flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7UT86 offers future-oriented system solutions with high investment security and low operating costs.

[illegible]

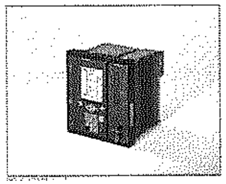

Figure 2.11/9 SIPROTEC 7UT86 [illegible]

[illegible]

SIPROTEC 5 Devices and Fields of Application

Transformer Differential Protection – SIPROTEC 7UT86

- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Powerful fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

Applications

Application templates are available in DIGSI 5 for standard applications. They contain basic configurations and default settings. These can be used directly or as a template for application-related adaptation. The available measuring points make varied applications possible. Prior to ordering a device, please configure the application with DIGSI 5. Table "Functions and application templates" shows the functional scope of the device. Use the configurator to determine the necessary function points.

Application examples

The application templates of the SIPROTEC 7UT85 are also available for the SIPROTEC 7UT86.

In addition, the following templates are available:

Three-winding transformer basic

- Differential protection

Auto transformer with stabilizing winding

- Differential protection for the complete transformer bank [illegible]
- Ground-fault differential protection [illegible]
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

Three-winding transformer in breaker-and-a-half layout

- Differential protection
- Ground-fault differential protection on the star side
- Ground-current protection on the neutral side as backup protection for the electrical power system
- Overload protection
- Circuit-breaker failure protection
- Frequency and voltage protection on the neutral side

Figure 2.11/10 shows the template for the protection of a three-winding transformer in a breaker-and-a-half layout. You can recognize the 3 required function groups for the transformer side, the integration of the ground-fault differential protection as well as the internal interconnection and selected functions. In addition, a voltage transformer is available on the upper voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made as required by the system.

SIPROTEC 5 Devices and Fields of Application

Transformer Differential Protection – SIPROTEC 7UT86

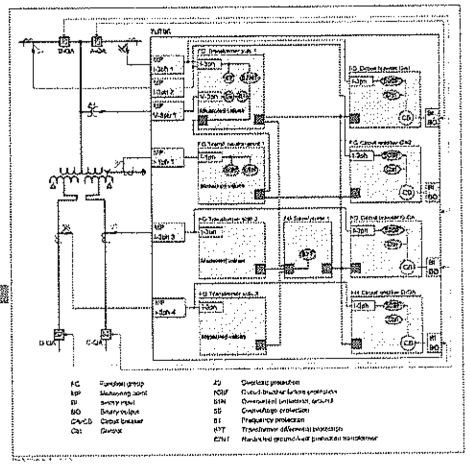

Figure 2.11/10 [illegible]

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Functions and application templates

[illegible]

[illegible]

Table 2.11/3 SIPROTEC 7UT86 – Functions and application templates

1 Three-winding transformer basic (87T)
2 Three-winding transformer 1.5CB (87T, 50BF, 87N)
3 Three-winding transformer (87T, 50BF, 87N, 21)
4 Autotransformer (87T, 87N, 50BF)

[illegible]

SIPROTEC 5 Devices and Fields of Application

Transformer Differential Protection – SIPROTEC 7UT87

Description

The SIPROTEC 7UT87 transformer differential protection has been designed specifically for the protection of multi-winding transformers (up to 5 sides). Furthermore, it is to be used where numerous measuring points (up to 7 3-pole current measuring points) are required. Another application is simultaneous protection of two parallel transformers (additional fast backup protection). The SIPROTEC 7UT87 is the main protection for the transformer and contains many other protection and monitoring functions. The additional protection functions can also be used as backup protection for protected downstream objects (such as cables, line). With its modular structure, flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7UT87 offers future-oriented system solutions with high investment security and low operating costs.

Main function	Up to 3 differential protection functions with additional stabilization (in different transformer function groups), up to 5 ground fault differential protection functions. For auto transformer applications, two differential protection functions can be processed in an auto transformer function group.
Usable measuring points	7 x 3-phase current measuring points, 5 x 1-phase current measuring points, 5 x 3-phase voltage measuring points
Inputs and outputs	2 predefined standard variants with 20 current transformers, 4 voltage transformers, 15 to 27 binary inputs, 22 to 38 binary outputs
Hardware flexibility	Flexibly adjustable and expandable I/O quantity structure within the scope of the SIPROTEC 5 modular system
Housing width	2/3 x 19" to 2/1 x 19"

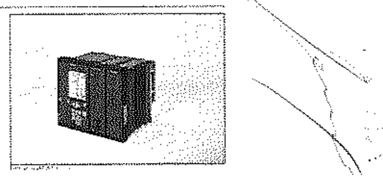


Figure 2.11/11 SIPROTEC 7UT87 transformer differential protection (2/1 device – standard variant Q3)

Functions

DIGSI 5 permits all functions to be configured and combined as required. In SIPROTEC 7UT87, two transformer function groups can be used.

- Transformer differential protection for multi-winding transformers with versatile, additional protection functions (multi-winding transformers are typical in power converter applications such as HVDC)
- Transformer differential protection for phase angle regulating transformers of the single core and two core types, and special transformers
- Transformer protection applications with up to seven 3-phase current measuring points
- Simultaneous differential protection for two parallel transformers (such as two 2-winding transformers)
- Universal usability of the permissible measuring points
- Applicable from average up to extra-high voltage
- Protection of standard power transformers, auto transformers and motors
- Typical properties of a transformer differential protection such as flexible adaptation to the transformer vector group, control of inrush and overexcitation processes, safe behavior in the case of current transformer saturation with different degrees of saturation
- Arc protection
- Voltage controller function ANSI 90V for two winding transformers, three winding transformers and grid coupling transformers
- Adaptive adaptation of the operate curve to the transformer tap position
- Increased sensitivity with near neutral-point ground faults through a separate ground fault differential protection
- Additional current and voltage inputs can be supplements for standard protection functions, such as overcurrent, voltage, frequency, etc.
- Graphical logic editor to create powerful automation functions in the device
- Up to 4 pluggable communication modules, usable for different and redundant protocols (IEC 61850, IEC 60870-5-103, IEC 60870-5-104, DNP3 (serial and TCP), Modbus TCP)
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW Whitepaper requirements
- Secure serial protection data communication, also over great distances and all available physical media (fiber-optic cable, 2-wire connections, and communication networks)
- Capturing operational measured variables and protection function measured values to evaluate the plant state, to support commissioning, and to analyze faults
- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Powerful fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

SIPROTEC 5 Devices and Fields of Application

Transformer Differential Protection – SIPROTEC 7UT87

Application templates

All application templates that were described for the SIPROTEC 7UT85 and SIPROTEC 7UT86 devices can be used in SIPROTEC 7UT87.

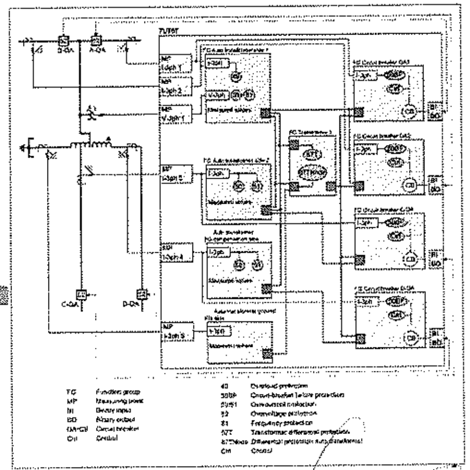
In addition, the following template is available:

Auto transformer with stabilizing winding in breaker-and-a-half [illegible]

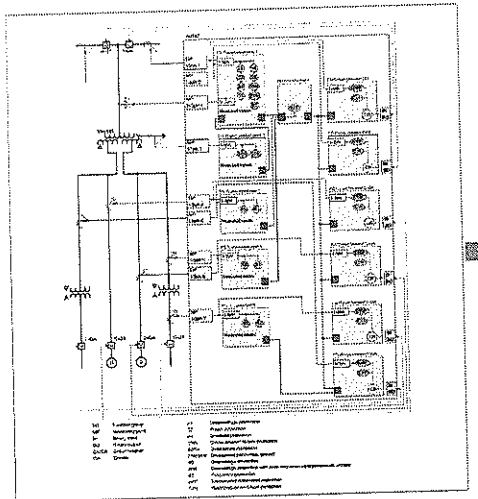
- Differential protection for the complete transformer (auto transformer winding + stabilizing winding)
- Interexchange protection for the auto winding for recording ground faults (3-phase recording of the neutral point current)
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection
- Frequency and voltage protection on the upper voltage side.

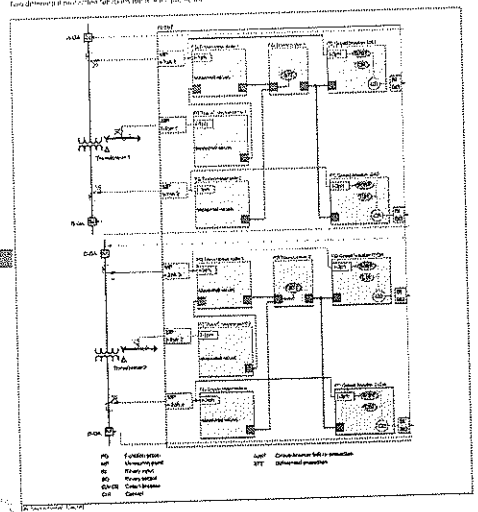
SIPROTEC 5 Devices and Fields of Application

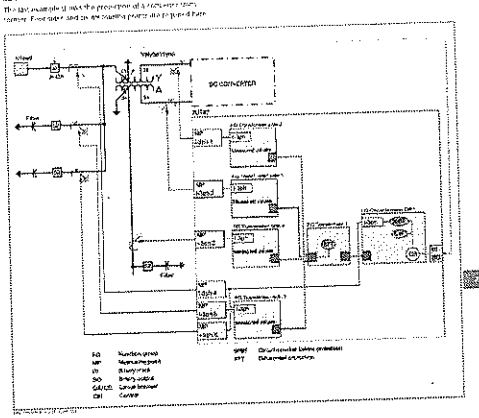
Transformer Differential Protection – SIPROTEC 7UT87

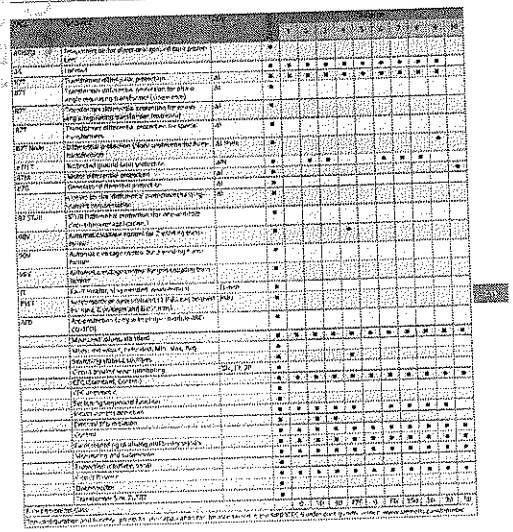


[illegible]









[illegible]

Example 3

This example requires a large number of three-phase current measuring points for a complex application in the power plant field. Figure 2.11/13 shows a possible configuration.

Figure 2.11/13 Possible application of SIPROTEC 7UT87 in a power plant (up to seven 3-phase current measuring points)

Example 4

Another example is a two-winding ... parallel transformers. The differential protection function is doubled. ... [illegible]

[illegible] ... protect both transformers.

Figure 2.11/14 Protection of two parallel transformers with one SIPROTEC 7UT87

Example 5

The last example shows the protection of a converter transformer. ... measuring points are required here.

Figure 2.11/15 Protection of a converter transformer

Functions and application templates

Table 2.11/4 SIPROTEC 7UT87 – Functions and application templates

1 Two winding transformer basic (87T)
2 Two winding transformer (87T, 50BF, 87N)

3 Two winding transformer 1,5CB (87T, 50BF, 87N)
4 Two winding transformer (87T, 50BF, 87N, 90V)
5 Three winding transformer basic (87T)
6 Three winding transformer 1,5CB (87T, 50BF, 87N)
7 Three winding transformer (87T, 50BF, 87N, 21)
8 Autotransformer (87T, 87N, 50BF)
9 Autotransformer 1,5CB (two 87T, 50BF, 59, 27, 81)
10 Motor DIFF (87M, 50BF, 27, 81, 46, 49)

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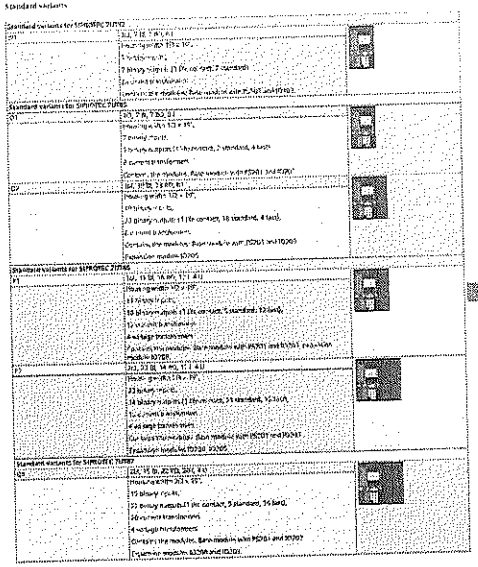
Transformer Differential Protection – Standard variants

Standard variants



Transformer Differential Protection – Standard variants

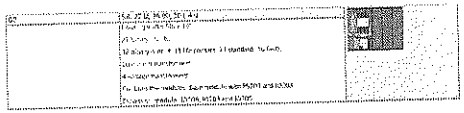


Table 2.1.4 Standard variants for typical applications of the 7UT6 protection device

T3 = Electrical alarm, if the device can be used in the marine sector (German Lloyd)

Application Templates

Motor Protection

Motor Protection – SIPROTEC 7SK82, 7SK85

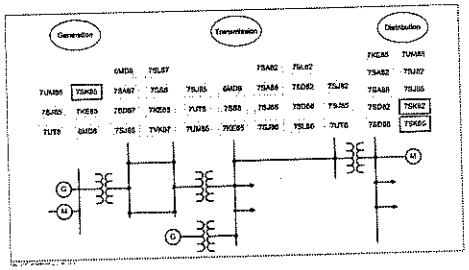


Figure 2.1.2.1 Typical application of SIPROTEC 5 devices

SIPROTEC 7SK82, 7SK85

SIPROTEC 5 motor protection devices have been designed specifically for the protection of asynchronous motors of small and medium power.

The devices monitor all important auxiliary functions that today are necessary for safe and reliable operation. This includes functions for protection, control, measurement and monitoring. The large number of communication interfaces and communication protocols satisfies the requirements for communication based substation protection, as well as substation operation.

Commissioning and maintenance work can be completed safely, quickly and thus cost-effectively with high performance test functions. These modular characteristics of SIPROTEC 5 devices allow you to be optimally equipped to individual requirements.

Functions

The different between the two device models SIPROTEC 7SK82 and SIPROTEC 7SK85 is in the available physical interfaces, number of binary channels

7SK82	Ethernet communication module for short-range fibre optic and RS485 communication (IEC 61850 GOOSE, Modbus RTU, DNP3 serial)
7SK85	Ethernet communication module for short-range fibre optic and RS485 communication (IEC 61850 GOOSE, Modbus RTU, DNP3 serial) and 4 additional analog inputs (sensitive or standard)

Motor Protection – SIPROTEC 7SK82

Description

The SIPROTEC 7SK82 motor protection that has been designed particularly for a cost optimized and compact solution of small to medium sized motors. With its flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7SK82 offers future-oriented system solutions with high investment security and low operating costs.

Hardware flexibility	Motor protection package with flexible analog and binary I/O (up to 4 current, 4 voltage inputs, 7 standard, 11 binary inputs, 8 or 16 binary outputs, 9 or 16 LEDs)
Housing width	1/3 x 19"

Benefits

- Compact and low cost motor protection
- Safety due to powerful protection functions
- Easy handling and transparency over the entire lifecycle of the plant like commissioning, operation, maintenance
- Time and cost reduction during engineering process
- Increased reliability and quality of the engineering process
- Easy object implementation of high safety and security measures
- Powerful communication components ensure safe and effective information
- Full interoperability between IEC 61850 Editions 1 and 2
- High investment security and low operating costs due to future oriented system solution

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Motor protection functions: Starting time supervision, thermal overload protection for stator and rotor, restart inhibit, unbalanced load protection, load jam protection
- Stator and bearing temperature, max. supervising 24 temperature sensors with external RTD unit
- Sensitive ground fault protection (non-directional, directional to phase, cos φ, sin φ)
- Directional and non-directional overcurrent protection (phase, ground, negative sequence) with additional functions
- Detection of ground faults in compensated or isolated neutral point systems
- Overvoltage and undervoltage protection
- Jog protection
- Power protection, configurable as active or reactive power protection

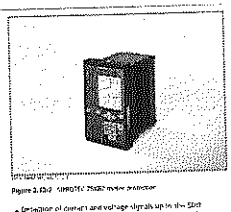


Figure 2.1.2.2 SIPROTEC 7SK82 motor protection

- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (such as thermal overload protection) and operational measured values
- Control, switchcheck and switchgear interlocking protection
- Graphical logic editor to create powerful automation functions in the device
- Single line representation in small or large display
- Integrated electrical Ethernet RJ45 for DIGSI 5 and IEC 61850 (operating and GOOSE)
- Two optional pluggable communication modules, usable for different and redundant protocols: IEC 61850, IEC 60870-5-103, IEC 60870-5-104, DNP3 (serial and TCP), Modbus TCP/IP
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW whitepaper requirements
- Secure serial protection data communication, also over great distances and all available physical media (fiber optic cable, 2 wire connections and communication networks)
- Capturing operational measured variables, set protection function measured values to evaluate the plant state, to support commissioning, and to analyze faults
- PTP time synchronization (PTP, IEEE 1588 v2 process bus profile) with an accuracy of better than 1 µs
- Powerful fault recording (buffer for 8 analog, 20 binary and 64 group indications) with a sampling frequency of up to 64 kHz (1.25 kHz)
- Auxiliary functions for easy tests and commissioning

Applications

- Protection against thermal overload of the stator and rotor due to current, cooling problems or pollution
- Protection against thermal overload of the rotor during startup due to too short startups, emergency starts or startups of blocked rotor
- Minimizing the voltage problems or plant outage

Motor Protection – SIPROTEC 7SK82

- Monitoring the thermal state and the bearing temperatures with temperature measurement
- Detection of idling times of pumps and compressors, for example
- Detection of ground faults in the motor
- Protection against misuse of current circuits
- Protection against inrushes due to undervoltage

Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings.

The following application templates are available:

Current measurement

- Thermal overload protection for stator and rotor
- Starting time supervision
- Restart inhibit
- Unbalanced load protection (thermal)
- Temperature supervision
- Load jam protection
- Overcurrent protection (non-directional) for phases and ground
- Transformer inrush current detection

Current and voltage measurement

- Thermal overload protection for stator and rotor
- Starting time supervision
- Restart inhibit
- Unbalanced load protection (thermal)
- Temperature supervision
- Load jam protection
- Overcurrent protection (non-directional) for phases and ground
- Transformer inrush current detection
- Sensitive directional ground fault detection for cos φ, sin φ
- Overvoltage protection with zero-sequence system V0
- Undervoltage protection with positive-sequence system V1
- Fuse failure monitor

Application Example

SIPROTEC 7SK82 – protection of a motor of medium power

The motor protective functions and the overcurrent protection of the SIPROTEC 7SK82 protect an asynchronous motor of medium power (up to approximately 2 MW) against thermal and mechanical overload and short circuits. The directional sensitive ground fault detection and the overvoltage protection with zero sequence voltage V0 detect stator ground faults in the motor. An external RTD unit captures and monitors the thermal state of the motor and the bearing temperatures. The RTD unit connects to the device via Ethernet or serial communication.

Figure 2.1.2.3 shows the functional scope and the basic configuration of a SIPROTEC 7SK82 for the application, here based on the application template "Current and voltage measurement". In addition, the device must be equipped with a plug-in module for communication with the RTD unit.

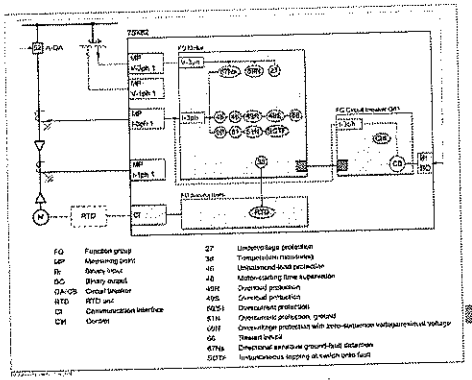
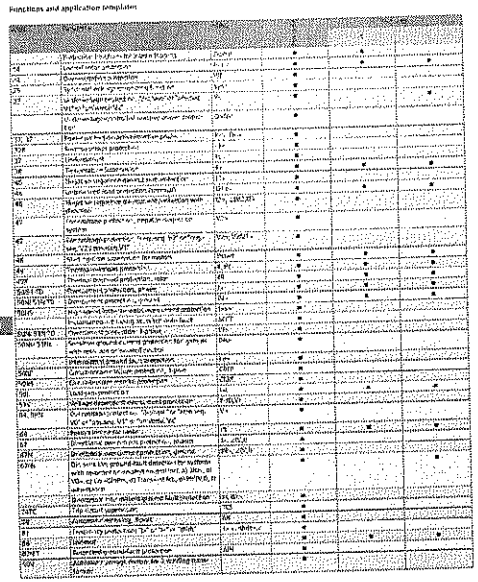


Figure 2.12/3 Busbar voltage measurement via a voltage transformer

Functions and application templates



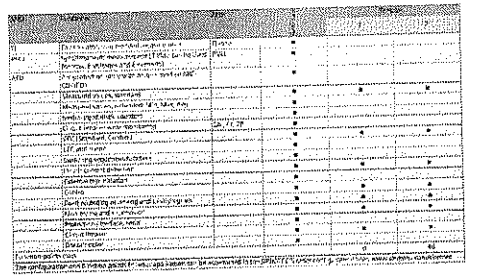


Table 2.12/1 SIPROTEC 7SK82 – measurement and protection functions

1 Current measurement

2 Current and voltage measurement

Description

The SIPROTEC 7SK85 motor protection is designed for the protection of motors of all sizes. With its modular structure, flexibility and the powerful DIGSI 5 engineering tool, SIPROTEC 7SK85 offers future-oriented system solutions with high investment security and low operating costs.

Main function	Type of protection (in accordance with ANSI code)
Protection functions	3 (motor) differential protection, 4 thermal overloads, 4 restart inhibits, 11 inrush restraints, 6 in 12 asymmetrical
Measurement functions	Operating measurement, min/max/average values and expanded statistics, energy meter, trending, limit value monitoring, fault recording (analog and binary channels), phasor measurement (synchrophasor)
Hardware	1/3 x 19" to 1/1 x 19"

Benefits

- Safety due to powerful protection functions
- Dependability and flexibility over the entire lifecycle of the plant save time and money
- Purposeful and simple operation of the devices and software thanks to user-friendly design
- Increased reliability and quality of the engineering process
- Consistent implementation of high safety and security mechanisms
- Powerful communication components ensure safe and easy system selection
- Full compatibility between IEC 61850 Editions 1 and 2
- High investment security and low operating costs due to future-oriented system solution

Functions

DIGSI 5 permits all functions to be configured and combined as required.

- Motor protection functions: Startup time monitoring, thermal overload protection for stator and rotor, restart inhibit, locked load protection, load jam protection
- Stator and bearing temperature monitoring via temperature detection with external RTD units
- Differential motor protection as fast short-circuit protection for motors of high power
- Sensitive ground-fault protection (cos φ, sin φ, admittance, transient ground-fault), directional or non-directional
- Sensitive and non-directional overcurrent protection (short-circuit protection with additional functions)
- Detection of ground faults in isolated and compensated neutral ground power systems
- U/f overvoltage and undervoltage protection
- Arc protection
- Power protection (reverse, forward active and reactive power protection)

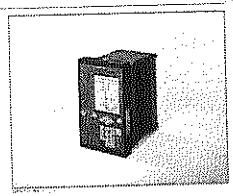


Figure 2.12/4 SIPROTEC 7SK85 motor protection device (housing size 1/3 wide) in a simple graphical standard topology with a small operator panel with function keys

- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (such as thermal overload protection) and operational measured values
- Thermal, synchronized and overload restart inhibiting protection
- Graphical logic editor to create powerful protection functions in the device
- Synchrophasor via Ethernet (IEEE 1588 for DIGSI 5 and IEC 61850 (experimental and GOOSE))
- Up to 4 pluggable communication modules, usable for redundant and redundant protocols: IEC 61850, IEC 60870-5-103, IEC 60870-5-104, DNP3 (serial and TCP), Modbus TCP)
- Redundancy protocols PRP and HSR
- Cyber security: e.g. connection with RADIUS (for AAA) and LDAP (for role assignment)
- Secure serial protection data communication: also via optical direct, 820 nm, 2 FO max. 1.5 mi (2.5 km) with 64 kbit/s
- Supports the standard IEC 61850 with GOOSE and MMS
- Supports the standard IEC 61850 Edition 2 including process bus
- Powerful fault recording (buffer for a max. record time of 80 s at 1 kHz or 320 s at 250 Hz)
- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure due to the adaptive 7XG/7XR SIPROTEC 5 modular system

Applications

- Protection against thermal overload of the motor from over current, cooling problems or pollution
- Protection against thermal overload of the motor during startup due to frequent startups, excessively long startups or blocked rotor
- Monitoring for voltage unbalance or phase outage
- Maintaining the thermal state and the bearing temperatures with temperature measurement
- Detection of stiffen (frozen) pumps and compressors, for example
- Detection of ground faults in the motor
- Protection against motor short circuits
- Protection against instability due to undervoltage

Application templates

Application templates are available in DIGSI for standard applications. These comprise all basic configurations and default settings.

The following application templates are available:

Current measurement

- Thermal overload protection for stator and rotor
- Starting-time supervision
- Restart inhibit
- Unbalanced-load protection (thermal)
- Temperature supervision
- Load jam protection
- Overcurrent protection (non-directional) for phases and ground
- Transformer inrush current detection

Current and voltage measurement

- Thermal overload protection for stator and rotor
- Starting-time supervision
- Restart inhibit
- Unbalanced-load protection (thermal)
- Temperature supervision
- Load jam protection
- Overcurrent protection (non-directional) for phases and ground
- Transformer inrush current detection
- Sensitive directional ground-fault detection for systems with isolated or resonant-grounded and for delivering of stator ground faults
- Overvoltage protection with zero-sequence system V0
- Undervoltage protection with positive-sequence system V1
- Fuse failure monitor

Motor differential protection, current and voltage measurement

- Motor differential protection
- Thermal overload protection for stator and rotor
- Starting-time supervision
- Restart inhibit
- Unbalanced-load protection (thermal)
- Temperature supervision
- Load jam protection
- Overcurrent protection (non-directional) for phases and ground
- Transformer inrush current detection
- Sensitive directional ground-fault detection for systems with isolated or resonant-grounded and for delivering of stator ground faults
- Overvoltage protection with zero-sequence system V0
- Undervoltage protection with positive-sequence system V1
- Unbalance voltage/fuse supervision

Application example

SIPROTEC 7SK85 – protecting a medium-sized motor

An asynchronous medium-power motor (up to approx. 2 MW) is protected against thermal and mechanical overloads as well as other errors with the motor protection functions and timeover current protection of the 7SK85. The directional sensitive ground-fault detection and overvoltage protection with zero-system voltage V0 detect motor winding faults in the neutral. The thermal state of the motor and bearing temperatures are acquired and monitored via an external RTD box. The RTD box is connected to the device via Ethernet communication.

Figure 2.12/5 shows the function scope and the basic configuration of a SIPROTEC 7SK85 for this application. The appropriate template current and voltage measurement is used as a basis. Additionally, the device has to be equipped with a plug-in module for communication with the RTD box.

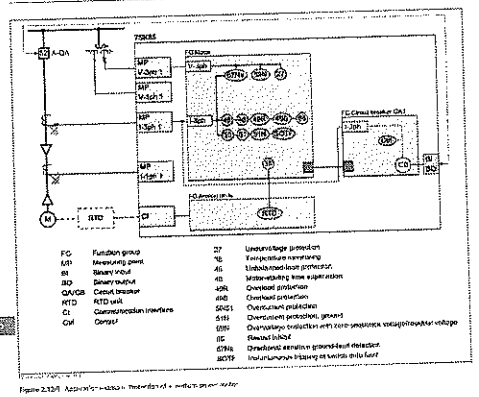
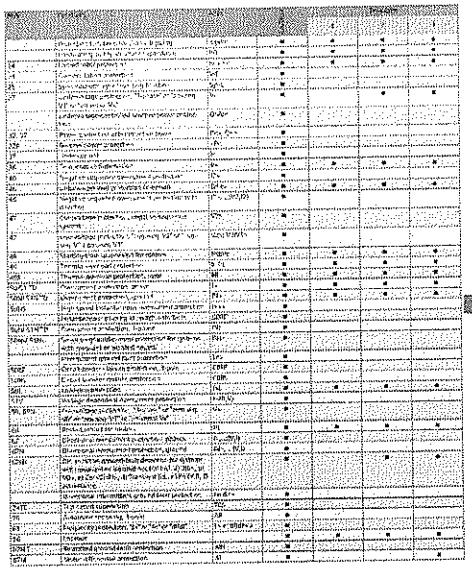


Figure 2.12/6 Application example: motor protection and motor starter

Function and application templates



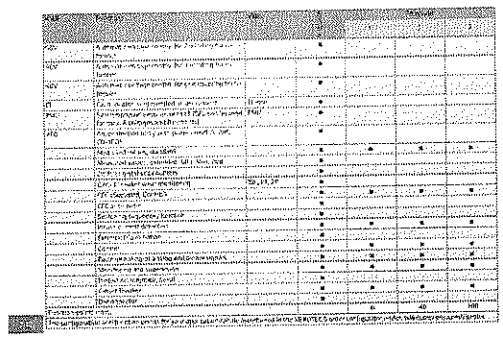


Table 2.12/2 SIPROTEC 7SK85 (...) standard variants

1 Current measurement
2 Current and voltage measurement
3 Differential prot. + cur. & volt. meas.

Standard variants

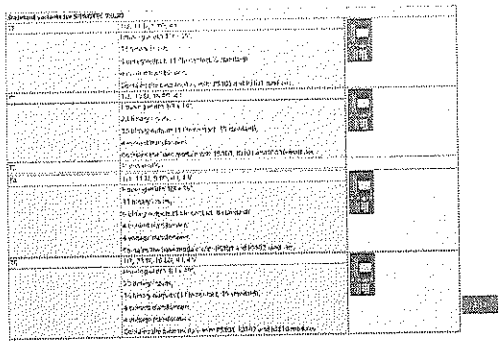


Table 2.12/3 Standard variants for SIPROTEC 7SK85 motor protection devices

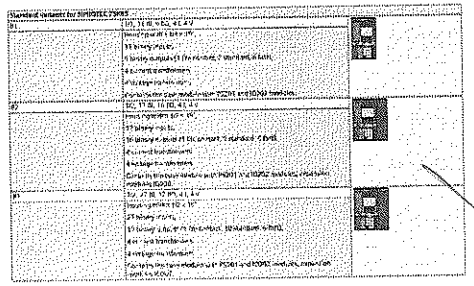
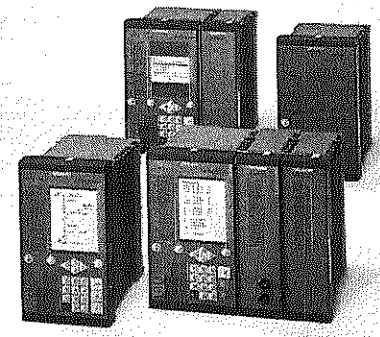


Table 2.12/4 Standard variants for SIPROTEC 7SK85 motor protection devices

The preferred fields of application can be found in the overall overview on page 2.12/10

SIEMENS



Answers for energy.

Generator Protection

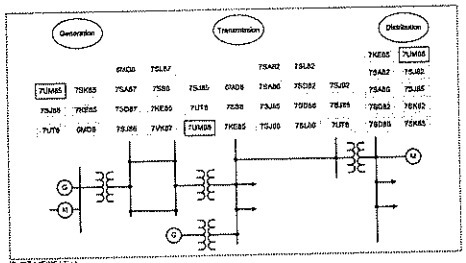


Figure 2.13/1 Typical applications with SIPROTEC 5 devices

SIPROTEC 7UM85

The main protection functions of SIPROTEC 5 generator protection devices 7UM85 are based on typical generator protection functions (stator and rotor ground fault protection, reverse power protection, unbalanced load protection, differential protection, underimpedance protection and pole slipping). They protect generators and power plant blocks in basically all configurations. The protection functions are independent and have been proven successfully in numerous projects, so any unique and customer-specific requirements can be implemented by the application templates. Using the DIGSI 5 engineering tool, you can download the required functions from the library into the 7UM85 device. The available functional scope is limited by the ordered function points. You may order additional points without any problems.

For your order, you can select the desired base variant (standard variant), additional hardware modules or the device can be adapted to your specific application (see "Overview of the available variants").

Condition monitoring and maintenance work can be completed safely, quickly and most economically with high performance test functions. These modular expansion possibly SIPROTEC 5 devices always to be adapted flexibly to the individual requirements.

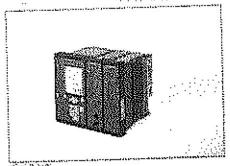
Function

Scalable hardware and functionality as required is a special feature of the SIPROTEC 7UM85 device models. Using the base variant, you can create the hardware configuration (modules, I/O, measuring points), as well as input and output (control, binary signals, LEDs) as required by the application. Using the DIGSI 5 engineering tool, you can download the required functions from the library into the 7UM85 device. The available functional scope is limited by the ordered function points. You may order additional points without any problems.

Standard variants for SIPROTEC 7UM85	
7UM85	Base variant with 4 current inputs, 4 voltage inputs, 11 binary inputs, 8 binary outputs, 1 life contact, 1 serial interface, 1 Ethernet interface (IEC 61850), 1 RTD-box interface, 1 USB interface, 1 system interface (IEC 61850), 1 operator interface, 1 ethernet interface (IEC 61850), 1 time synchronization interface, 1 protection interface, 1 battery buffered real-time clock, 1 slot for expansion modules, 1 slot for communication module, 1 slot for RTD-box, 1 slot for communication module

SIPROTEC 5 Devices and Fields of Application

Generator Protection – SIPROTEC 7UM85



Benefits

Functions

SIPROTEC 5 Devices and Fields of Application

Generator Protection – SIPROTEC 7UM85

Applications

Application Templates

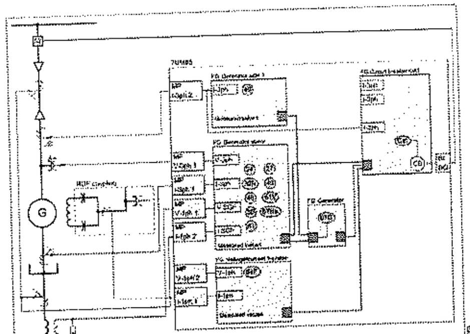
Generator busbar, advanced basic
- Basic protection functions
- Generator differential protection
- Underexcitation protection

Generator unit connection basic
- Basic protection functions
- Transformer differential protection as overall protection (transformer + generator)
- Underexcitation protection
- 100% stator ground fault protection with 3rd harmonic

Generator unit connection advanced
- Basic protection functions
- Transformer differential protection
- Generator differential protection
- Underexcitation protection
- Out-of-Step Protection
- 100% stator ground fault protection with 20 Hz coupling
- Synchronization function (without adjusting commands)
- Circuit-breaker failure protection

SIPROTEC 5 Devices and Fields of Application

Generator Protection – SIPROTEC 7UM85

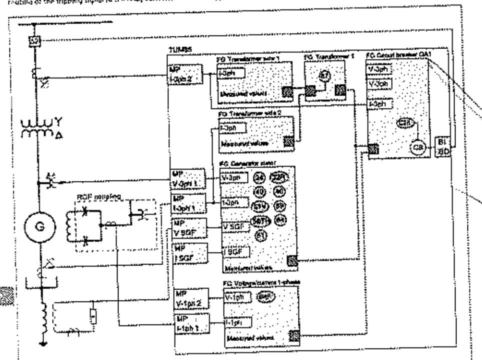


FG	Function group
MP	Measuring point
CB	Circuit breaker
BI	Binary input
BO	Binary output
Ctrl	Control

Application examples

SIPROTEC 5 Devices and Fields of Application

Generator Protection – SIPROTEC 7UM85

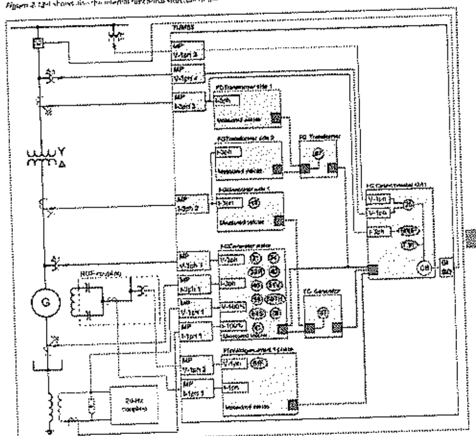


FG	Function group
MP	Measuring point
CB	Circuit breaker
BI	Binary input
BO	Binary output
Ctrl	Control

24	Overexcitation protection
32R	Reverse-power protection
40	Underexcitation protection
46	Unbalanced-load protection
51V	Voltage-dependent overcurrent protection
59	Overvoltage protection
59TH	Stator ground-fault protection with 3rd harmonic
64	Rotor ground-fault protection
64F	Rotor ground-fault protection
81	Frequency protection
87	Transformer differential protection

SIPROTEC 5 Devices and Fields of Application

Generator Protection – SIPROTEC 7UM85



SIPROTEC 5 Devices and Fields of Application

Generator Protection – SIPROTEC 7UM85

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Functions, application templates

ANSI	Functions	Abbr.	Available	1	2	3	4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ANSI	Functions	Abbr.	Available	1	2	3	4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 2.13/1 SIPROTEC 7UM85 – Functions and application templates

1 Generator basic
2 Generator busbar connection
3 Generator unit connection basic
4 Generator unit connection extended

Standard variants

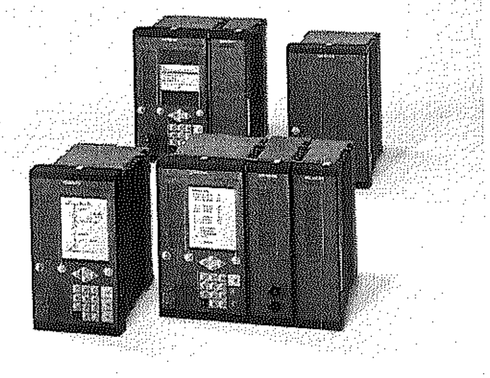
Standard variants for SIPROTEC 7UM85		
AA1	1/2, 11 BI, 9 BO, 4V, 4I	
	[illegible]	
AA2	1/2, 7 BI, 14 BO, 4V, 4I	
	[illegible]	
AA3	1/2, 11 BI, 20 BO, 4V, 8I	
	[illegible]	
AA4 (in preparation (V7.3) and later)	1/2, 11 BI, 15 BO, 7V, 6I, 4MU	
	[illegible]	

AA5	2/3, 15 BI, 20 BO, 7V, 14I, 4MU	
	Housing width 2/3 x 19"	
	15 binary inputs	
	20 binary outputs (1 life contact, 5 standard, 14 fast)	
	7 voltage transformer inputs	
	14 current transformer inputs	
	2 sensitive ground-current inputs	
	4 fast measuring transducer inputs [illegible] 20 mA, 10 V	
	[illegible]	
	[illegible]	

Table 2.13/2 Standard variants for SIPROTEC 7UM85

The technical data of the devices can be found in the manual
www.siemens.com/siprotec

SIEMENS



www.siemens.com/siprotec

Busbar Protection

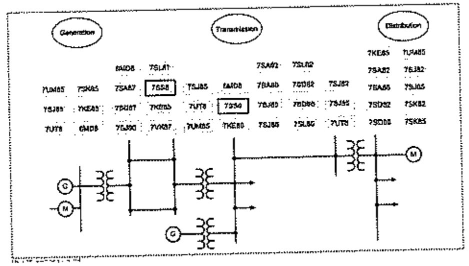


Figure 2.14/1 Fields of application of the SIPROTEC 5 devices

SIPROTEC 7SS85

The SIPROTEC 7SS85 busbar protection has been designed with the highest selectivity possible for a large variety of different busbars and all voltage levels. Additional protection and control functions extend the field of application to a comprehensive station protection.

The SIPROTEC 7SS85 is suited for the following system configurations:

- Single busbars with/without transfer busbar
- Double busbars with/without transfer busbar
- Triple busbars
- Breaker-and-a-half layout method
- [illegible]
- Truck Type Switchgear
- Systems with combined busbars (alternatively main/transfer busbar)
- 1 current transformers
- [illegible]
- Ring busbars

[illegible]

Significant property	Description
0	[illegible]
A	[illegible]
B	[illegible]
C	[illegible]
E	[illegible]
T	[illegible]

Table 2.14/1 [illegible]

Applications

The central busbar protection SIPROTEC 7SS85 includes the following maximum quantity structure:

- [illegible]
- [illegible]
- [illegible]
- 4 bus sections (protection zones)
- 4 bus couplers (with 1 or 2 current transformers)
- 2 auxiliary busbars (bus sections without measuring function)
- Optional [illegible]

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SIPROTEC 7SS85

The busbar protection SIPROTEC 7SS85 is a selective, fast- and high-sensitive busbar protection device for busbars, T-bar- and mesh-type high voltage systems with a large variety of busbar configurations. Selection of the device base variant and the number of protection and bay modules functionally tailored to the application and the modular hardware structure permit optimum adaptation of the SIPROTEC 7SS85 to a large variety of system configurations and current and future requirements up to the highest degree of user protection.

Selection of the device base variant (functionality, binary inputs and outputs) and the modular hardware structure permit optimum adaptation of the SIPROTEC 7SS85 to a large variety of system configurations and functional requirements.

Benefits

- Safety by measuring methods proven and reliable for 25 years.
- Simple creation and adaptation of the configuration for the whole busbar life-cycle.
- Clearly structured by fully graphical engineering and online plant visualization with DIGSI 5
- Protection of up to 20 feeders with a single device

Functions

The table "Functions and templates" shows all functions that are available in the SIPROTEC 7SS85. All functions can be configured as required with DIGSI 5. Using some functions requires the appropriate number of free function points to be available in the device. The function point calculator in the online configurator provides support in determining the required number of function points for your device. The freely-assignable function points are also shown during project engineering with DIGSI 5.

Characteristic key values of SIPROTEC 7SS85

- Phase-selective measurement and display
- Selective tripping of faulty busbar sections
- Disconnector independent check zone as additional tripping criterion
- Shortest tripping times (<2 ms) to ensure maximum stability and minimum damage in the system
- Highest stability in case of external faults, also in case of transformer saturation, through stabilization with tripping currents
- Operate curve with freely adjustable characteristic curve sections
- Additional operate curve with increased sensitivity for low-current faults, for example in resistance-grounded power systems
- Fast recognition of internal and external faults requires only 2 ms of saturation-free time of the current transformer
- Using closed-slot core or linearized current transformers or a plant is possible
- Adaptation of different current transformation per parameterization
- Straight-line and dimensioning of current transformers and stabilization factor

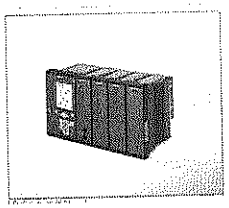

Figure 2.142 SIPROTEC 7SS85 in a 1/2 rack width

- Three tripping (and close) commands allow individual tripping times after busbar faults as well as multi-phase reclosing in case of single-pole circuit breakers
- The integrated circuit breaker failure protection per circuit breaker trips in the event of a busbar short circuit and provides a trip signal to the circuit breaker at the line end. The adjacent busbar (up to 4 coupling circuit breaker) too.
- Three parameter sets (combination of current and voltage transformation ratio, characteristic and phase rotation) can be stored. This prevents the protection from performing too slightly or too sensitively, which reduces the effort for routine checks.
- Various control possibilities, such as bay out of order, circuit breaker blocking (non-disconnected circuit breakers), blocking of protection zones or circuit breaker failure protection, make the adaptation to operationally caused special cases of use/system status.
- Optional 1/3 pole 3 pole circuit breaker failure protection using the integrated disconnector image or optical coupled breakers of the busbar section selector
- Optional end fault protection for the protection of the section between circuit breaker and current transformer for feeders and bus couplers
- Direct tripping of protection zones through external signals
- Release of the tripping of a protection zone through additional external signals
- Pickup-of tripping through additional, external phase selective signals
- Optional overcurrent protection phase / ground per bay
- Optional voltage and frequency protection for up to nine 3 phase voltage transformers. This may also be used for the implementation of an integrated undervoltage release
- Optional cross stabilization as additional tripping release in 3 pole encapsulated gas insulated switchgear.

Function library and application templates

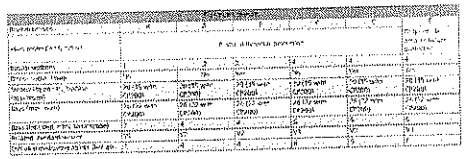

Table 2.147 Selected properties and standard variants

Configuration and parameterization

For all the line diagram depiction, the primary topology of your plant. From the DIGSI 5 library, add a SIPROTEC 7SS85 device and the necessary function blocks. Connect the primary elements of the single line diagram (busbars, connections, disconnectors, circuit breakers) to the inputs and outputs of the device. This establishes the logical interface.

In DIGSI 5 online access, the information that is important for commissioning, operation and analysis is shown in the single line diagram. The current position can be seen in addition to the measured values at the feeders and the protection relay.

Additionally, you operate infrastructure devices special operational states, for example in "Bay out of order" or removal protection of selectively, with direct coupling of binaries via disconnectors (busbar replica) by discrete wiring.

Using standardized SIPROTEC 5 hardware ensures flexible adaptation to a large variety of busbar configurations and simple expandability.

Operate curve with increased sensibility

In point-zone grounded networks, single-phase short-circuits are in a range of the rated current. An independent characteristic curve is available to provide busbar protection with appropriate sensitivity. In these cases, too, the characteristic curve provides separated parameters for the pickup thresholds and for a limitation of the sector area. For this case, too, the integrated circuit-breaker failure protection has a corresponding characteristic curve. The characteristic curve is activated via a binary input. Detecting a high residual voltage is a characteristic of a single pole fault in one isolated networks.

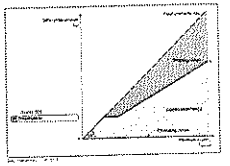

Figure 2.148 Standard characteristic curve

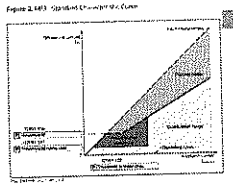

Figure 2.149 Sensitive characteristic curve

Disconnector image

With multiple busbars, disconnectors can be used to switch bays to different busbar sections (busbar zones). For a correct assignment of the bay elements to the appropriate protection

zones, the positions of the disconnectors are needed at busbar failure protection and in circuit breaker failure protection. The disconnector image that is integrated in the device performs the detailed administration of the switching states. In the event of a busbar fault, it is necessary to send commands for the individual circuit breakers, as also determined via the disconnector image.

This function is characterized by the following features:

- Processing up to 20 bays and 3 busbar sections
- Disconnector position and position monitoring
- Due to the program assignment "Disconnector NOT off – Disconnector on", adjusted disconnector positions can also be set manually.
- Storage of the disconnector setting in the event of an auxiliary voltage failure
- Convenient graphical power engineering with the DIGSI 5 operating program.
- Runtime graphical visualization of the switchgear with DIGSI 5 in online mode

Application templates

Project engineering of a double busbar

The following figure shows a typical structure of engineering with DIGSI 5, the measuring points used, the "device" groups used, and their interconnections.

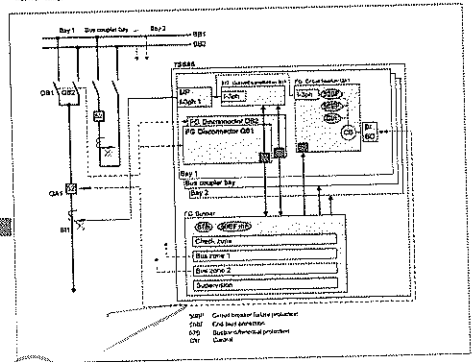

Figure 2.145 Busbar protection – Project engineering – example of a double busbar

Stub protection

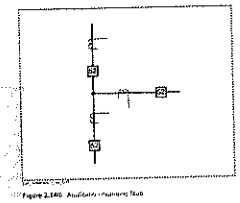

Figure 2.146 Auxiliary measuring loop

significant feature 9 (differential protection for a protection zone), a typical solution is available for you. With 2 feeders, it is called a connection car also be protected, if a circuit breaker and a power transformer exist in the connection.

Protection of a single busbar

Single busbars can be segmented into several sections using bus-section couplers (circuit breakers and current transformers or busbar disconnectors). With the variant with bus section coupler, every zone is selectively protectable.

With the variant with bus-section disconnectors, selective protection is possible only with open disconnectors.

For this, the disconnector position must be recorded in the device.

According to the number of the busbar sections, the significant feature 9 (differential protection for 1 protection zone), significant feature A (differential protection for 2 protection zones) and significant feature C (differential protection for 4 protection zones) are used.

For more than 4 zones and bus-section couplers, two SIPROTEC 7SS85 devices are used.

The differential protection for so-called stubs supplies a protection zone and inputs for 4 current measuring points. With the

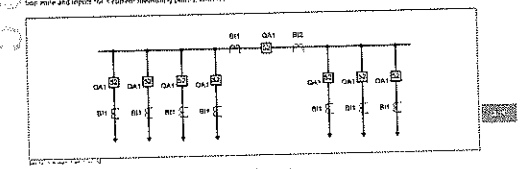

Figure 2.147 Principle of a double busbar with 2 feeders and bus-section coupler

H connections

H connection 1 can be looked at as two single busbars, each with 2 feeders on both sides of the coupling or disconnector.

Accordingly, the significant feature A (differential protection for 2 protection zones) is used. One SIPROTEC 7SS85 meets the configuration for 5 bays.

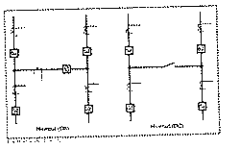

Figure 2.148 Busbar protection – H connection of double busbars

Protection of a breaker-and-a-half arrangement

Busbars in a breaker-and-a-half layout permit an interlaced operation of infeed and feeders over double a busbar range. They are thus usefully coupled during operation.

Breaker-and-a-half arrangements are protected like two single busbars. As shown in Figure 2.149 requires a SIPROTEC 7SS85 device with the significant property A (differential protection for 2 protection zones). The SIPROTEC 7SS85 must be designed for 10 bays corresponds to 5 cross branches or "diameters".

With more than 20 feeders (10 diameters), one SIPROTEC 7SS85 device with the significant property D (differential protection for 1 protection zone) is used for each busbar. The middle circuit breakers and current transformers are not relevant to the busbar differential protection. In SIPROTEC 7SS85, however, a protection-responding circuit breaker failure protection can be implemented.

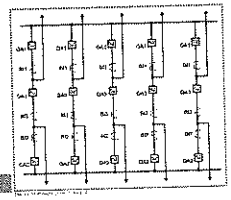

Figure 2.149 1 1/2 circuit breaker arrangement

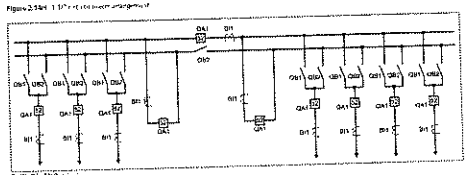

Figure 2.150 Busbar protection – 1 1/2 circuit breaker arrangement – example

Protection of a double busbar

Double-busbar systems allow the connection of a multi-interlaced operation of feeders to equipment. Each busbar or each switchable busbar section can be selectively protected.

Some feeds can be connected to various busbars (protection zones). The disconnector positions must be determined in the busbar connection.

In the integrated disconnector image, the dynamic modeling of the switching state of the system results in accordance with the current positions and the configured topology.

For a system arrangement with Figure 2.151 to a SIPROTEC 7SS85 device of the significant feature D (differential protection for 4 protection zones and disconnector image) is needed.

Systems with transfer busbars or combined busbars

Transfer busbars are provided in order to maintain operation in case of repair or breakdown of circuit-breakers. In this case, the circuit-breaker which is to be repaired is replaced by the transfer busbar coupler circuit-breaker. The current flowing in the selected circuit is then measured by the busbar coupler circuit-breaker.

The busbar topology can be set in the system configurator in the operating state. Each of the busbars, or the busbar coupler, can be switched in or out of the busbar topology. Further busbars can be added via cascading.

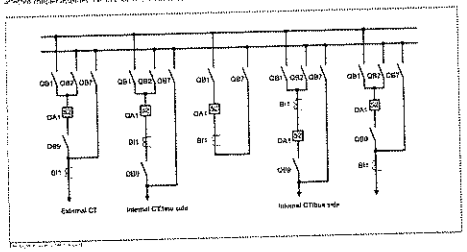

Figure 2.14/11 Busbar coupler with combined bus or

For a system in accordance with *Figure 2.14/11*, a SIPROTEC 7SS85 device of the type/Pos. feature B (differential protection for 2 protection zones and circuit-breaker image) is needed.

Functions, application templates

	Busbar protection, low impedance	1	•	
	Busbar protection, high-impedance		•	
	Breaker failure protection, 1-pole		•	
	Breaker failure protection, 3-pole		•	
27	Undervoltage protection	1	•	
	3-phase		•	
59	Overvoltage protection	1	•	
47	Overvoltage protection, negative-sequence system		•	
	3-phase		•	
50/51	Time-overcurrent protection, phase	1	•	
50N/51N	Time-overcurrent protection, ground	1	•	
50/51	Directional time-overcurrent protection, phase	1	•	
50N/51N	Directional time-overcurrent protection, ground	1	•	
67/67N	Directional comparison protection		•	
50HS	Instantaneous high-speed phase overcurrent, 1-phase	1	•	
50BF	Circuit-breaker failure protection	1	•	
79	Automatic reclosing function	1	•	
81	Overfrequency protection, f > or underfrequency protection, f <	1	•	
	Overfrequency protection, f >		•	
	Underfrequency protection, f <		•	
81R	Rate of frequency change protection, df/dt	1	•	
	Rate of frequency change protection, df/dt		•	
74TC	Trip circuit supervision	1	•	
	2 binary inputs		•	
	3 binary inputs		•	
86	Lockout	1	•	
	Lockout, configurable		•	
	Operating hours counter	1	•	
	Operating hours counter, configurable		•	
	Circuit-breaker wear monitoring	1	•	
	Circuit-breaker wear monitoring, configurable		•	
	Trip circuit supervision	1	•	
	2 binary inputs		•	
	3 binary inputs		•	
	Control	1	•	
	Control, extended		•	
	Switching authority	1	•	
	Switching authority, extended		•	
	Control of circuit-breakers	1	•	
	Control of disconnectors (isolators)	1	•	
	Control of ground switches	1	•	
	Control of switches with two operate commands	1	•	
	Position indication, switch	1	•	
	Position indication, switch, extended		•	
	Position indication, disconnector (isolator)	1	•	
	Position indication, disconnector (isolator), extended		•	
	Position indication, ground switch	1	•	
	Position indication, ground switch, extended		•	
	Position indication, switch with two operate commands	1	•	
	Position indication, switch with two operate commands, extended		•	
	Manual close command	1	•	
	Manual close command, extended		•	
	Interlocking	1	•	
	Interlocking, extended		•	
	Circuit breaker		•	
	Disconnector		•	
	Ground switch		•	

Table 2.14/3 SIPROTEC 7SS85 – Functions and application templates

1 busbar coupler

Standard variants

V1	1/3-ph, 4 BIs, 3 BOs 1/3-ph, 8 BIs, 4 BOs 15 binary inputs 1 binary input (threshold can be set separately), 4 standard, 11 fast 12 command outputs Can be combined with ports P3201 and P3202 modules Can be combined with 7XV5662	
V2	1/3-ph, 4 BIs, 3 BOs 1/3-ph, 8 BIs, 4 BOs 15 binary inputs 1 binary input (threshold can be set separately), 4 standard, 11 fast 24 command outputs Can be combined with ports P3201 and P3202 modules 1 x USART, RS 232/RS 485	
V3	1/3-ph, 4 BIs, 3 BOs 1/3-ph, 8 BIs, 4 BOs 15 binary inputs 1 binary input (threshold can be set separately), 4 standard, 11 fast 24 command outputs Can be combined with ports P3201 and P3202 modules 1 x USART, RS 232/RS 485	

Table 2.14/4 Variants available for SIPROTEC 7SS85

The technical data of the device can be found in the online help www.siemens.com/siprotec

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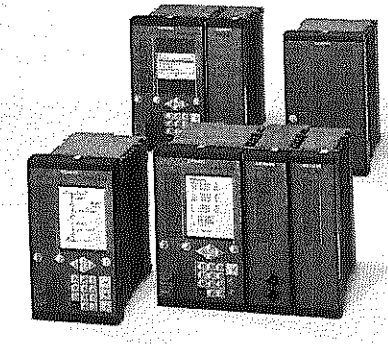


Answers for energy and infrastructure

Bay Controllers

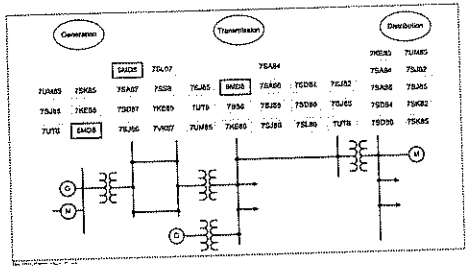


Figure 2.15/1 Overview of application of SIPROTEC 5 devices

SIPROTEC 6MD85, 6MD86

SIPROTEC 5 bay controllers are compact and versatile members of the voltage levels. The large number of current and voltage terminals provides the devices to be used in all fields of energy supply.

The devices contain all important auxiliary functions that are necessary for safe and economical relay. The available functions for protection, control, measurement and monitoring. The large number of communication interfaces and communication protocols satisfies the requirements of communication. Optimal solutions for prevention and of arc protection are provided.

Commissioning and maintenance work can be completed safely, quickly and thus cost-effectively with high performance tool functions. Because of a modular hardware design, the SIPROTEC 5 bay controllers can flexibly be flexibly adapted to specific requirements.

Overview of the SIPROTEC 6MD85 and 6MD86 devices

The SIPROTEC 5 bay controllers are based on the flexible and powerful SIPROTEC 5 modular system. The ordering variant with basic relay covers standard variants. Expandability through supplementary modules allows for individual solutions for specific applications.

Key features

The key characteristics are differentiated in SIPROTEC 6MD85 and SIPROTEC 6MD86 product groups.

Although the SIPROTEC 6MD85 devices are designed for applications in distribution systems, they can also be used in high voltage and extra high voltage applications.

The SIPROTEC 6MD86 devices are designed for applications in the power transmission system. They are housed with a maximum variety of available functions. Both device types can be flexibly configured in your hardware implementation.

	6MD85	6MD86
Circuit-breaker failure protection	Optional	Optional
3-phase tripping	Optional	•
Switching authority	Optional	•
CFC, 8 charts	Optional	•
Measurement of phasor values	Optional	•
Number of switching devices	Optional	1
Ground switch	Optional	1
Synchrophasor	Optional	•

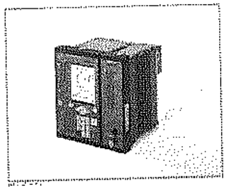
Table 2.15/1 Functional differentiation of 6MD85 and 6MD86

Common points:

- Configuration of a large number of protection functions
- Flexible adaptation of the binary I/O number
- Optionally available: phasor measurement unit (PMU)
- Powerful communication with CFC

SIPROTEC 5 Devices and Fields of Application

Bay Controllers – SIPROTEC 6MD85



Functions

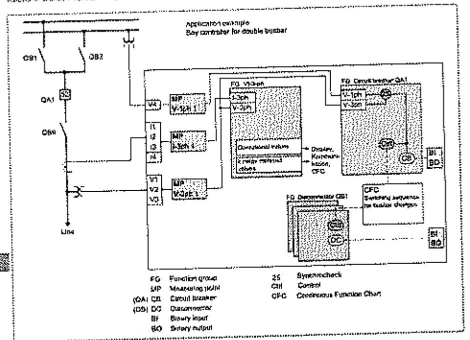
Applications

Application example

SIPROTEC 5 Devices and Fields of Application

Bay Controllers – SIPROTEC 6MD85

Application example with switching sequence



SIPROTEC 5 Devices and Fields of Application

Bay Controllers – SIPROTEC 6MD85

Functions, application templates

Table 2.15/2 SIPROTEC 6MD85 – Functions and application templates

1 Standard

2 Not Configured

3 Extended Control

SIPROTEC 5 Devices and Fields of Application

Bay Controllers – SIPROTEC 6MD86

Description

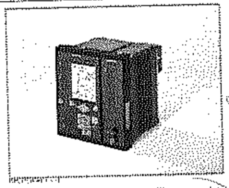


Figure 2.15/4 SIPROTEC 6MD86

Functions

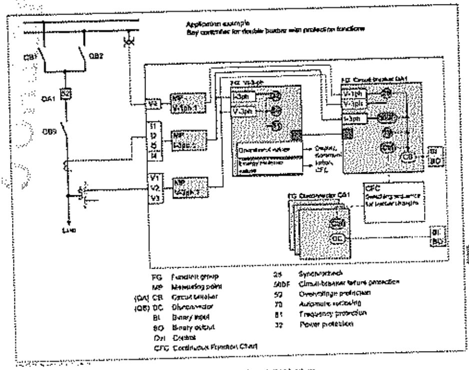
Applications

Application Templates

SIPROTEC 5 Devices and Fields of Application

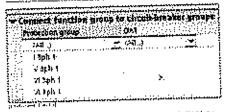
Bay Controllers – SIPROTEC 6MD86

Double busbar with protection functions



SIPROTEC 5 Devices and Fields of Application

Bay Controllers – SIPROTEC 6MD86



Breaker-and-a-half diameter with protection and control systems

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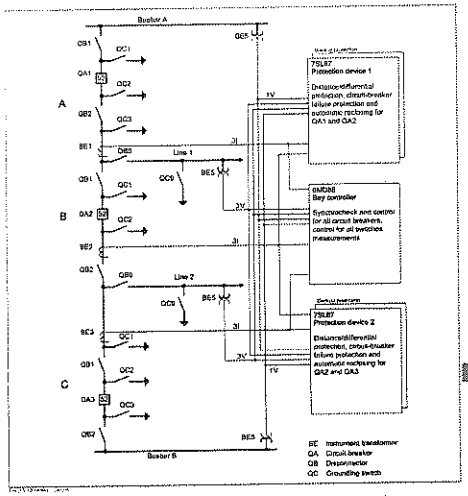


Figure 2.15 Application example, busbar and circuit layout with one bay controller and two protection devices (example)

Figure 2.15 shows the principal dynamic characteristics of combined-voltage values for the synchrocheck functions of the three circuit breakers in the bay controller SIPROTEC 6MD86. Every set (hashed) function (ANSI number 25) requires the two voltages V1(set) and V2(set) (feeder voltage and reference voltage). For the central circuit breaker QA2 there are two parameter sets, each for both voltages, depending on the position of the disconnectors and the circuit breakers. For the two external circuit breakers QA1 and QA3, there is only one possibility for one voltage (that is, the adjacent busbar), whereas the other voltage is connected with one of three possibilities (also dependent on the position of the switching devices).

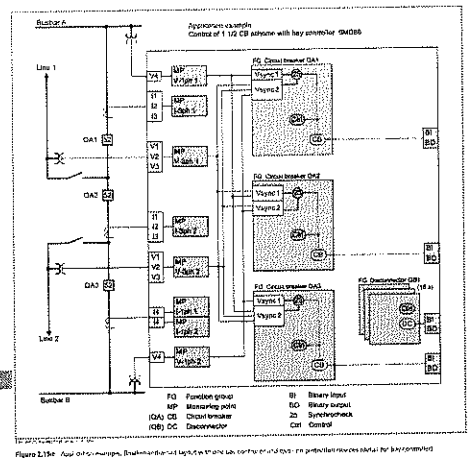


Figure 2.15 Application examples, double-busbar circuit layout with one bay controller and two protection devices (example)

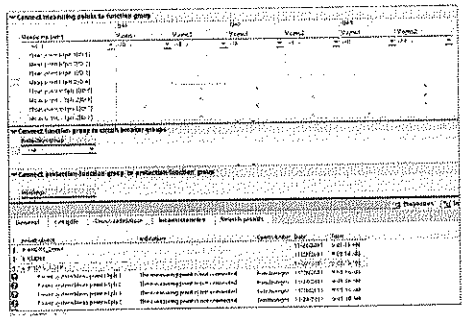


Figure 2.15 Assignment of the connection voltage channels to the voltage measurement locations (example)

Figure 2.15 shows the diagram of the editor "Function Group Connections". It is still open that one possible transfer or reference voltage for the synchrocheck are assigned to the inputs V1(set) and V2(set).

The ID number of the measured values is used to select the previously applied operational voltages in a CFC (*Figure 2.15*).

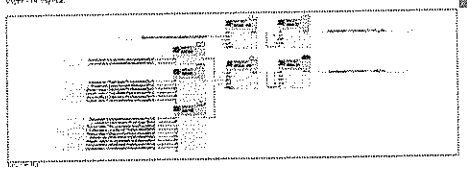


Figure 2.15 CFC connection of the operational measured values

Phasor Measurement Unit

PMUs measure current and voltage by amount and phase at selected stations of the transmission system. The high precision time synchronization via GPS allows comparing measured values from different substations. For short and dowling contingencies in the system state and dynamic events such as power swing conditions.

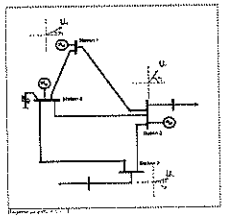


Figure 2.15 Power swing detection and phasor measurement

When selecting the option "Phasor Measurement Unit", the devices determine current and voltage phasors, provide them with highly accurate time stamps and transmit them for analysis together with other measured values (frequency, speed of frequency change) using the IEEE C37.118 communication protocol, see *Figure 2.15*. Using synchrophasors and a suitable analysis program (for example SIGUARD PDP), it is possible to automatically detect power swings and trigger alarms, which are sent to the control center, for example.

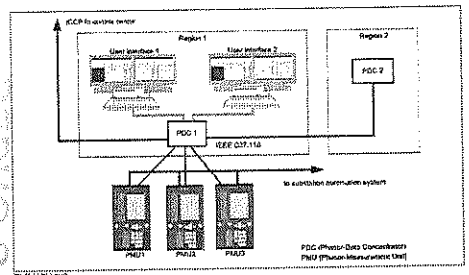


Figure 2.15 Connection of 3 Phasor Measurement Devices (PMU) via Phasor Data Concentrator (PDC) to SIGUARD PDP

When using the PMU function, a function group "FG PMU" is created in the device. This function group calculates the phasors and analog values, conducts the time stamping and sends the data to the selected Ethernet interface using the IEEE C37.118 protocol. Three PMU data can be processed, stored and provided by one device channels. Up to three client IP addresses can be assigned to the device.

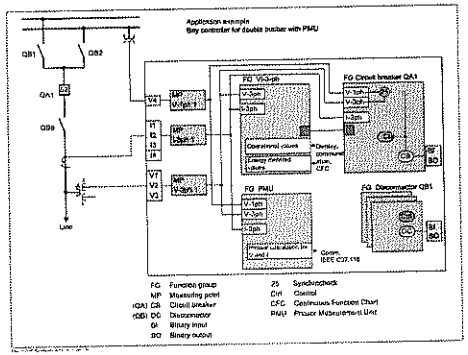


Figure 2.15 Example of a bay controller for double busbar with PMU

Function-, application templates

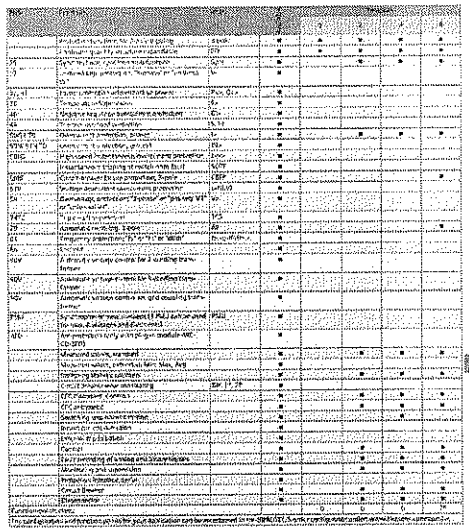


Table 2.15-1 SIPROTEC 5MD85 - Functions and application templates

1 Not Functional
2 1/3 US Size
3 Standard Double Busbar
4 1½ CB Size 2

Standard variants

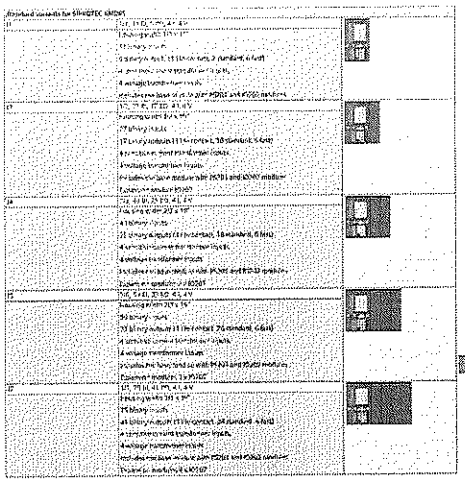
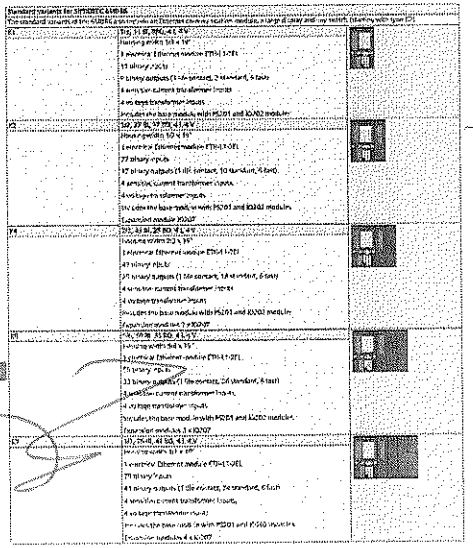


Table 2.15-4 Standard variants for bay controllers SIPROTEC 6MD85



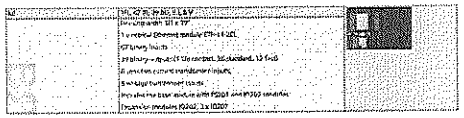


Table 2.15-5 Standard variants for bay controllers SIPROTEC 6MD85

The technical data of the devices can be found in the manual
www.siemens.com/siprotec

SIEMENS

www.siemens.com/siprotec

Fault Recorder

SIPROTEC 5 Devices and Fields of Application

Fault Recorder – SIPROTEC 7KE85

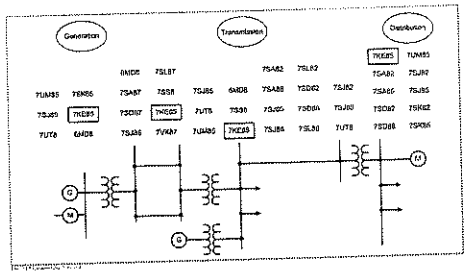


Figure 2.161 Example of application for SIPROTEC 5 devices

SIPROTEC 7KE85

SIPROTEC Fault Recorders are a component part of the SIPROTEC 5 modular system and support all SIPROTEC 5 system properties. They can be used individually as well as personally within the range of system solutions.

The SIPROTEC 7KE85 Fault Recorder is designed to suit present and future requirements of substation energy market. Powerful and reliable recording combined with flexible engineering and communication features provide the basis for maximum supply reliability.

Commissioning and maintenance work can be completed safely, quickly and then cost-effectively with high performance test functions. Thorough time-bundle sensitive, SIPROTEC 5 fault recorders can always be ideally adapted to specific requirements.

The SIPROTEC 7KE85 Fault Recorder has the following additional functionalities compared to the SIPROTEC 5 protection devices and bay controllers:

- Sampling configurable from 1 to 16 kHz
- Mass storage of 16 GB
- All recorders capable of running in parallel
- Individually triggered recorders
- Continuous recorder
- Separate activation of the recorders
- Freely configurable memory for each recorder
- Additional quality information supplement to the records
- Power quality recordings
- Recording of GOOSE messages in continuous recorder

Distinguishing features

The SIPROTEC 7KE85 Fault Recorder can be configured with different base functions:

Base function	Characteristics
Fault Recorder	Classic function (fault recording, event logging)
PMU	Synchronized phasor measurement (Phasor Measurement Unit C37.118/IEC61)
Power Quality recording	Continuous recording of power quality parameters (voltage, current, frequency)
Logic	Free programmable logic (CFC)

SIPROTEC 5 Devices and Fields of Application

Fault Recorder – SIPROTEC 7KE85

Description

Powerful fault recorder with integrated measurement of up to three phase-to-earth systems according to IEC 61850-9-2 LE and power quality measurement, according to IEC 61000-4-30. Due to the great flexibility of trigger functions, the SIPROTEC 7KE85 is specially suited for use in the transmission system and substation as well as in industrial plants. Synchronization is possible via IRIG-B, GPS, IEEE 1588 PTP or IEC 61850-9-2.

Base function	Fault Recorder
Fault Recorder	• Powerful fault recorder with 1 kHz sampling rate • Continuous recorder • Sequence-of-events recorder • Fast data transmission via Ethernet with IEC 61850-9-2 LE • Time synchronization via IRIG-B, GPS, IEEE 1588 PTP or IEC 61850-9-2
PMU	• Phasor measurement unit (PMU) according to IEC/IEEE 60255-118-1 and IEC 61850-90-5 • Synchrophasor transmission according to IEEE C37.118.2 and IEC 61850-90-5 • Simultaneous transmission of 4 PMU data sets • Low latency (< 3 ms)
Power Quality recording	• Power quality recorder according to IEC 61000-4-30 Class A • Flicker recorder according to IEC 61000-4-15 • Harmonics and interharmonics recorder up to 2.5 kHz according to IEC 61000-4-7 • Transient recorder

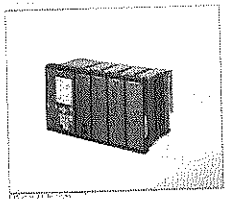


Figure 2.162 Fault recorder 7KE85 in device housing with integrated operator panel

Benefits

- Clear, expanded documentation and focused analysis of power system responses and failures
- Data security and monitoring over the entire lifecycle of the plant: one time and money
- Economical and simple operation of the devices and software thanks to one and standardized
- Increased reliability and quality of the engineering process
- Powerful communication compliance of new secure and efficient solutions
- Full interoperability between IEC 61850 Editions 1 and 2
- Highly available Ethernet communication due to integrated Ethernet redundancy protocols PRP and HSR

Functions

DIGSI 5 system: all functions to be configured and combined as required

- Up to 45 analog channels
- Fast Scan Recorder
- Up to 2 slow scan recorders
- Up to 4 sumer boot recorders and 2 limit recorders
- Power Quality recordings according to IEC 61000-4-30 (harmonics, THD, TDD – in preparation)
- Sequence of events recorder for continuous recording of binary states changes and IEC 61850 GOOSE messages
- Scalable Phasor Measurement Unit (PMU) according to IEEE C37.118 protocol
- Transmission of the records and supporting via IEC 61850 GOOSE messages
- Variable sampling frequencies parameterizable between 1 kHz and 16 kHz
- Expansion of the mass storage of 16 GB in the central recorder by the user as desired
- Intelligent monitoring routines of the storage medium ensure a high level of availability and integrity of archived data
- Lossless data compression
- Time synchronization via Precision Time Protocol (PTP) IEEE 1588 protocol, IRIG-B, GPS, SNTP, and SNTP
- Binning of the measured values to n individual recorders as desired
- Combination of the measuring groups for the power calculation as desired
- Quality information for supervising the measurement signal quality at the input signal level
- Trigger functions of a function block are fundamental (single point value, RMS value, limit sequence, pulsing sequence, relative sequence system power), comparison (phase, 3-wattmeter method, and 3-voltmeter method)
- Local trigger and manual triggers for every trigger function
- Flexible limit stages and envelope stages, manual trigger
- Function or independent trigger functions with the graphic automation editor CFC (continuous function chart)
- Trigger functions via a combination of single points, double point indications, limit values, binary signals, internal signals, and GOOSE messages
- Standalone operational concept
- Auxiliary functions for simple tests and commissioning
- Special test mode for commissioning
- Integrated electrical Ethernet RJ45 for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- Redundancy protocols PRP and HSR
- Cyber security in accordance with NERC CIP and BDEW White paper requirements

SIPROTEC 5 Devices and Fields of Application

Fault Recorder – SIPROTEC 7KE85

- Up to 4 pluggable communication modules usable for different and redundant protocols
- Intelligent terminal technology enable pre-wired and a simple device replacement

Applications

The fault recorders for use in medium, high and extra high voltage systems and in power plants with comprehensive trigger and recording functions. With the fault recorder SIPROTEC 7KE85, you receive a clearly organized and event related evaluation and documentation of your power system processes. You can thereby able to analyze failures in a targeted manner and optimize your power systems.

Typical processes to be monitored and documented

- System incidents, such as critical load cases or short circuits
- Failures of the quality of supply
- Dynamic behavior of generators
- Closing and breaking operations of transformers (saturation response)
- Power fluctuations and power swing cycles
- Test runs during commissioning

Application Templates

Application templates are available in DIGSI for standard applications. They comprise basic configurations and default settings.

The following application templates are available:

Fault Recorder 4 V, 7 I, 1 B

- Application templates tailored to the monitoring of a feeder or current/voltage transformers

Fault Recorder 8 V, 11 B

- Application templates tailored to the monitoring of a busbar voltage transformers

Fault Recorder 8 V, 8 I, 10 B

- Application templates tailored to the monitoring of a busbar 16 current/voltage transformers

Fault Recorder 20 V, 20 I, 20 B

- Application templates tailored to the monitoring of a busbar of six current/voltage transformers

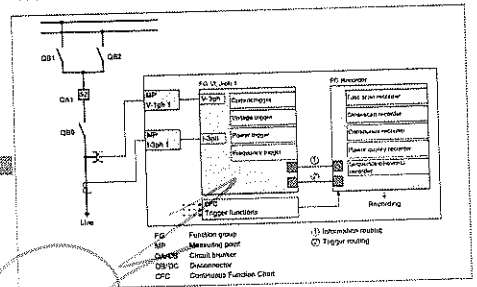


Figure 2.163 Application example: Fault Recorder SIPROTEC 7KE85 for monitoring a busbar

Fault recorder for monitoring feeders

Figure 2.163 and *Figure 2.164* show simple applications with one SIPROTEC 7KE85, which is connected for monitoring a busbar. In these examples, four current triggers are provided via function group "FG V, 3ph 1" (phase-of-3-wire-system) in the function group "FG Recorder" and, thus, in the event triggered recorder in parallel, individually parameterizable current and voltage channels are recorded.

SIPROTEC 5 Devices and Fields of Application

Fault Recorder – SIPROTEC 7KE85

of GOOSE messages, single-point/double-point indications, binary signals, etc.) can start a recorder via the CFC and thus generate a fault record.

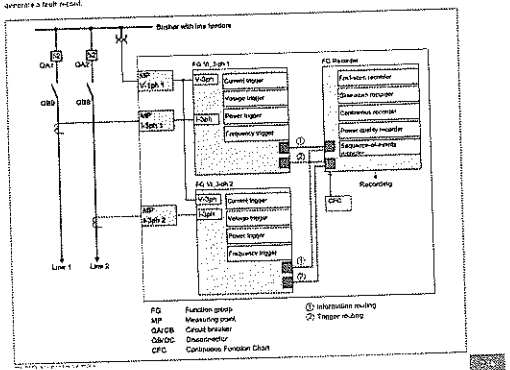


Figure 2.164 Application example: Fault Recorder SIPROTEC 7KE85 for monitoring a busbar

SIPROTEC 5 Devices and Fields of Application

Fault Recorder – SIPROTEC 7KE85

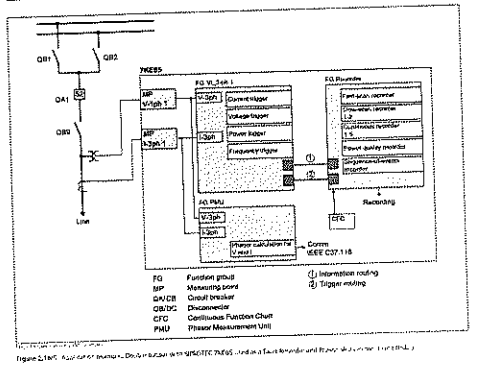


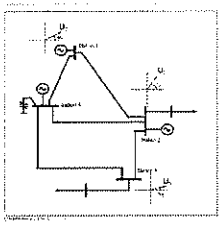
Figure 2.165 Application example: Device structure of the SIPROTEC 7KE85 – Fault Recorder and Power Quality Recorder

Fault Recorder with PMU

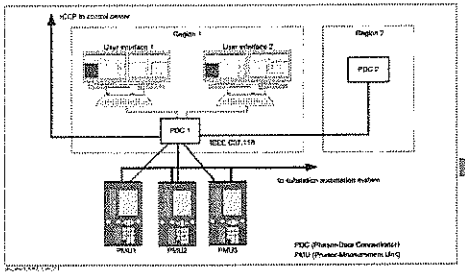
When the PMU function is used, a TG PMU function group is created in the device, see *Figure 2.165*. This function group includes one phasor and analog values. Performs the transmission of synchrophasor data with the protocol IEEE C37.118 via the selected Ethernet interface. There, they can be received, made available, stored and processed. Up to three IP addresses can be assigned to the device.

Phasor Measurement Unit

PMU: calculate current and voltage by amplitude and phase in selected stations of the transmission system. The high precision time synchronization (via GPS) allows comparing measured values from different substations to a joint and showing complex events in the system state and dynamic events such as power swing conditions.



When using the optional Power Measurement (P, Q), the device determines active and reactive powers, provides them with limit values and counters, and transmits these to analog inputs and other measured values (powers, speed of the power change) using the IEEE C37.118 communication protocol, see Figure 2.30. User-specific measured value calculations (for example, DIGRAM PDP) is available as an individually developed option and supplied upon request to the customer, for example.



When using the PMU functions, a function group "PG PMU" is created in the device. This function group establishes the phasors and analog values, conducts the time stamping and sends the data in the selected Ethernet interface using the IEEE C37.118 protocol. These, the data can be received, stored and processed by one or more clients. Up to three client IP addresses can be assigned in the device.

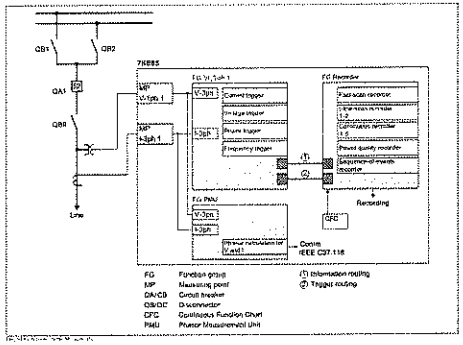


Figure 2.164 Application example for the fault recorder and Phasor Measurement in 7KE85

Binary changes are recorded as a resolution of 1 ms. The input signal is also analyzed according to the specified trigger conditions and recorded if the limiting values are violated. The recorded fault record includes the pre-trigger time, the trigger point and the fault secondary. In addition, the cause that made the trigger is stored. The trigger limiting values and record times can easily be set with DIGSI 5.

Slow scan recorder

The function principal corresponds that of the fast scan recorder, but the values are calculated every 10 ms and communicated over a configurable interval. The averaging interval can be configured from a minimal period up to 3000 minimal periods. The averaged values are stored by the slow scan recorder as a recording of mean values. Binary changes are recorded, similar to the fast scan recorder, at a resolution of 1 ms.

Slow scan recording can be performed very much quicker by comparison, for example, the load connection behavior, during and after a failure and, thus, also power-swing cycles.

The slow scan recorder can record the history of sampled values from all analog points, internally calculated measured values and binary signals of the protection functions over 49 minutes with a pre-trigger time of 30 seconds. Here, too, the input signals are analyzed according to the specified trigger conditions and recorded if the limiting values are violated. These fault records include the pre-trigger time, the trigger point and the fault recording. In addition, the cause that triggers is saved. The user sets trigger values and record times in DIGSI 5.

Fast scan recorder	1	8	200	1 kHz to 1 kHz		
Slow scan recorder	1	32	4	1 Hz	1 s to 3000 s	
Continuous recorder	1	32	4	1 Hz	1 s to 3000 s	

FAST = Sampling interval for fast scan recorder; SLOW = Sampling interval for slow scan recorder; CONT = Sampling interval for continuous recorder

Table 2.167 Overview of the recorders

Recorder

Fast scan recorder

Transient processes, which occur on special faults and also the behavior of protection devices can be analyzed by using the fast scan recorder. Transient processes can be triggered, for example, by switching operations. The fast scan recorder can record the history of the sampled values of all analog inputs, internally calculated measured values and binary signals when an error occurs for up to 40 seconds with a pre-trigger time of 4 seconds. The sampling rate can be set between 20 and 1200 sampled values per cycle. This corresponds to a sampling frequency of 1 kHz to 16 kHz.

Binary changes are recorded at a resolution of 1 ms. The input signal is also analyzed according to the specified trigger conditions and recorded if the limiting values are violated. The recorded fault record includes the pre-trigger time, the trigger point and the fault secondary. In addition, the cause that made the trigger is stored. The trigger limiting values and record times can easily be set with DIGSI 5.

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Continuous recorder

The SIPROTEC 7KE85 has up to four continuous recorders that are used for data acquisition of the analog quantities and internally recorded measured values over seven days history. This makes it possible to investigate even long time changes of the system behavior.

Every 15 seconds (configurable) the recorder records an average value of a freely chosen or adjustable measured point and stored in memory. A set of these recorders can be separately activated. The user can set the available memory space of the ring and the periodicity for each recorder.

Trigger functions

In a event, triggered recorders (fast scan and slow scan) have a large number of analog and binary triggers that enable the user to record all potential system problems exactly and avoid unnecessary recordings. The trigger signals are thus avoided

- independently of the trigger conditions and start the fault record recording. In the SIPROTEC 7KE85, all recorders can also be started manually by the service technicians.

Analog trigger

There are four analog trigger elements available per level and gradient (signal). Level triggers monitor measurands for compliance with the configured limiting values (thresholds). As soon as the measurand exceeds or falls below the respective limiting value, the trigger is tripped. Gradient triggers respond to the level change over time.

Each analog trigger can be configured as primary, secondary or secondary high value. A distinction is made here between frequency, voltage, current and power triggers. With current and frequency trigger variables, it is possible to select between fundamental, RMS or symmetrical components.

Binary trigger

A binary trigger starts a recording via the logical status change of a binary signal. Along with the manual trigger, which can be triggered via the device keypad, DIGSI 5 or any IEC 61850 client (for example, DIGRAM PDP05), the telegram-driven external via

Binary input (external trigger or IEC 61850 GOOSE messages via the communication network). The logic triggers are implemented via the powerful graphical logic editor (CFC). In this case, the free combination of all available analog values (analog values or phasors), binary signals, Boolean signals, GOOSE messages, single-point and double-point indications is possible via Boolean or arithmetic operations.

As a user, you can thus set the trigger conditions appropriate for your problem and start the recording.

Functions, application templates

	Hardware quantity structure and slots	HQ	●	●	●	●
PMU	32 configurable measurands per PMU (up to 4 per PMU for max. 8 voltages and 8 currents)	PMU	●	●	●	●
	Synchrophasor, analog, frequency, rate of change of frequency		●	●	●	●
	Measured values, extended (min, max, avg)		●	●	●	●
	IEC 61850 Ed. 2 PMU		●	●	●	●
	IEEE C37.118		●	●	●	●
	Time synchronization via Ethernet (PTP, NTP)		●	●	●	●
	Statistics and supervision		●	●	●	●
FAN	Fast scan recorder	FAN	●	●	●	●
SCR	Slow scan recorder	SCR	●	●	●	●
CR	Continuous recorder	CR	●	●	●	●
TR	Trend recorder	TR	●	●	●	●
PQR	Power quality recording function	PQR	●	●	●	●
	Sequence of events recorder	SER	●	●	●	●
FLOC	Fault locator	FLOC	●	●	●	●
Synchronous clock			●	●	●	●

The configured number of functions can be increased with the DIGSI 5 license (chargeable license).

Table 2.167 SIPROTEC 7KE85 – Functions and available licenses

1	Fault recorder 7KE85 FE
2	Fault recorder 7KE85 FE
3	Fault recorder 7KE85 FE
4	Fault recorder 7KE85 FE

Standard variants

Standard variants for SIPROTEC 7KE85		
FE	1/6 x 19", 4U, 4 x I, 11 x U, 7 BI, 8 BO Housing width 1/6 x 19" 4 voltage transformer inputs 4 current transformer inputs 11 binary inputs 7 binary inputs, 4 x fast switching, 3 standard, 4 BO Suitable for surface-mounted housing with two-tier terminals Suitable for flush-mounted housing with detachable terminals	
FE	1/3 x 19", 4U, 4 x I, 8 BI, 5 BO Housing width 1/3 x 19" 4 voltage transformer inputs 4 current transformer inputs 8 binary inputs 5 binary outputs (1 life contact, 2 standard, 2 BO) Suitable for surface-mounted housing with two-tier terminals and with detachable terminals	
FE	1/6 x 19", 4U, 4 x I, 11 x U, 7 BI, 8 BO Housing width 1/6 x 19" 4 voltage transformer inputs 4 current transformer inputs 11 binary inputs 7 binary outputs (1 life contact, 3 standard, 3 BO) Suitable for surface-mounted housing with two-tier terminals and with detachable terminals Ethernet module: RJ45	
FE	1/3 x 19", 4U, 4 x I, 8 BI, 5 BO Housing width 1/3 x 19" 4 voltage transformer inputs 4 current transformer inputs 8 binary inputs 5 binary outputs (1 life contact, 2 standard, 2 BO) Suitable for surface-mounted housing with two-tier terminals and with detachable terminals Ethernet module: RJ45	

The technical data of the device can be found in the device manual (basic, standard, comfort).

SIEMENS

www.siemens.com/siprotec

SIPROTEC 5 System

	Chapter
Functional integration	3.1
Protection	3.2
Control	3.3
Automation	3.4
Monitoring	3.5
Data acquisition and recording	3.6
Communication	3.7
Safety and Security Concept	3.8
Test	3.9
Engineering	3.10
Hardware	3.11

The SIPROTEC 5 devices include:

- Protection
- Control and automation
- Supervision and monitoring
- Data acquisition and logging
- Communication and cyber security
- Test and Diagnosis

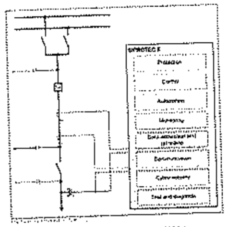
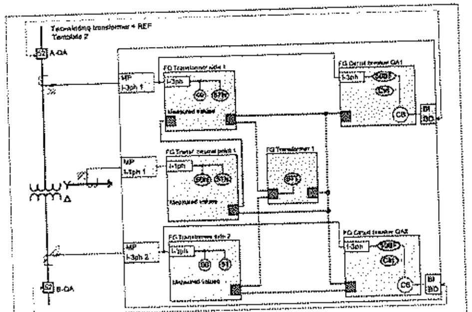


Figure 3.1/1

SIPROTEC 5 System

Functional integration – Instrument and protection-class current transformers



FG	Function group	49	Overload protection
MP	Measuring point	50BF	Circuit-breaker failure protection
BI	Binary input	50/51	Overcurrent protection
BO	Binary output	50N/51N	Overcurrent protection, ground
QA/CB	Circuit breaker	87T	Transformer differential protection
Ctrl	Control	87N	Restricted ground-fault protection

Figure 3.1/2

SIPROTEC 5 System

Functional integration – Instrument and protection-class current transformers

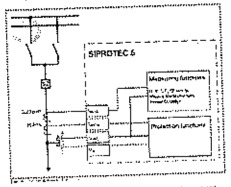


Figure 3.1/3

SIPROTEC 5 System

Protection – The distance-protection function (ANSI 21, 21N) – classical method

Protection

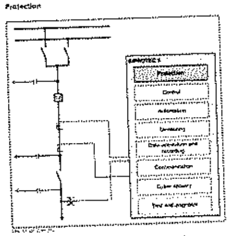


Figure 3.2/1

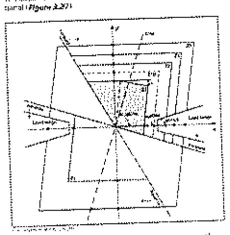


Figure 3.2/2

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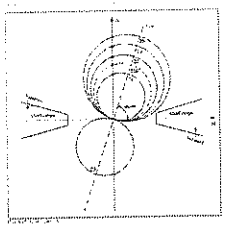

Figure 3.203 RMD-type characteristic, forward direction, example

Arbitrary quadrilateral characteristic

The number of distance zones can be freely adapted according to the application requirements. The numbers that use a shape other than circle or the parallelogram (overload) cannot be achieved, all parameterized zones from the distance protection are available (the use of the zone in the distance protection itself is not affected by this). Each distance zone has its own timer, separately dedicated to 1-phase and multi-phase errors. The flexibility of the SIPROTEC 5 device family provides optimal adaptation to each application. The distance protection 4-48 always provides exactly the right number of distance zones.

Load zone

In order to guarantee reliable discrimination between load operation and short circuit – especially on long lines under large loads – an adjustable load zone is used. Impedances within this load range do not result in unwanted tripping in the distance zones.

Four-quadrant method

The following setup methods can be employed optionally:

- Overcurrent pickup Z
- Voltage dependent overcurrent pickup V/Z
- Voltage dependent and phase angle dependent overcurrent pickup V/Z [ ]
- Impedance pickup Z

Absolute phase selectivity

The distance protection function is equipped as well proven, highly sophisticated phase selection algorithm. The pickup reliability of users due to the negative effect of the short-circuit currents and voltages or noise phases is reliably integrated. The phase selective algorithm makes approximate tripping decisions and ensures correct distance measurements in a wide field of application.

Arbitrary network, for example, with a load infeed

With the help of the two current transformers that are connected in parallel, the smaller measurement error will be the sum of the two errors, caused by the different transformer. This common current is compared, but the current flowing only in the feeder and is therefore used for the precise measurement of the distance to the fault. The protection is commercially used. SIPROTEC 5 devices also provide sufficient measuring inputs to connect two or several sets of current transformers separately to the device. In this case, the summation is carried out in the device internally. If a distance protection function detects possible compensation of influence of the current transformers or other flow patterns, special pickup criteria or an increased measuring range can be activated. Finally, the separately measured currents, separate phase, flexible values per zone, can be calculated to the distance protection function. Moreover, the separately measured currents allow a full-fledged differential protection for the feed zone, because the current transformers of the feeder is switched off (see 7SD6 differential protection, ANSI 87-1/87-3).

Parallel line compensation

Using a separate power system measurements due to the effect of parallel lines can be compensated by balancing the parallel line ground current. Parallel line compensation can be used for distance protection as well as for load protection.

Load compensation

The distance protection function provides options to compensate the load influences on the static measurement.

Elimination of distortion in a pickup

Digital filters render the device immune to disturbances contained in the measured values. In particular, the influence of DC components, capacitive voltage transformer and frequency changes is considerably reduced. A special method of measurement is employed in order to realize selectivity at maximum speed, even under transformer saturation.

Measuring voltage failure detection

Tripping by the distance protection is blocked automatically in the event of a measuring voltage failure, thus preventing unwanted tripping. Distance protection is blocked if one of the voltage transformer fuses or the auxiliary contact of the voltage transformer circuit breaker picks up and, in this case the EMER GENCY distance zone overcurrent protection can be activated.

Distance protection with reactance method (RMD) (ANSI 21, 21N)

Under extreme conditions, load swings and high fault resistances can influence the selectivity. The distance protection with reactance method (RMD) function reduces the unfavorable influences of high fault resistances at high loads.

Load compensation in the case of the reactance

If the electrical power system shows unfavorable conditions, for example, different impedance angles of the infeeds, this can also affect the results of the distance protection. The reactance method compensates this influence via adjustable reactance line angles.

Arbitrary quadrilateral characteristic and load zone

The characteristic is identical to the RMD function. The load zone can be configured separately to operate for ground faults only, for phase faults only or for all fault types. All distance zones can be configured forward, backward or non-directional.

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Under extreme conditions, load swings and high fault resistances can influence the selectivity. The distance protection with reactance method (RMD) function reduces the unfavorable influences of high fault resistances at high loads.

Load compensation in the case of the reactance

The distance protection function with reactance method (RMD) includes a highly sophisticated algorithm for the adaptive loop selection. Sufficient loop selection criteria are processed in parallel. The loop selection criteria work with loop selection, delta value detection, symmetrical components and current, voltage and impedance comparison methods. The package of passive phases due to the negative influences of short-circuit currents and voltages or other phases is thus reliably eliminated. This adaptive loop selection algorithm makes appropriate tripping decisions and ensures correct distance measurement in a wide field of application.

Th – distance-protection function with reactance method (RMD)

- Speed in power systems with a meshed infeed system
- It is unaffected by the load power flow between the two substations
- Is suited as a backup protection for busbars, line stubbers, and cable lines
- Is suitable for use in all voltage levels

The distance protection function with reactance method (RMD) can, as an alternative or additionally, be used for the distance protection function with the classical method.

Overcurrent zone characteristic

The quadrilateral-separate zone primary separate setting for the resistance R and the fault resistance RF. Each distance zone can be configured separately to operate for ground faults only, for phase faults only or for all fault types. All distance zones can be configured forward, backward or non-directional.

The RMD function calculates up to 7 impedance loops A and, B and, C and, A-B, B-C, C-A and A-B-C. The pickup methods, the impedance pickup Z. The evaluation of faulty voltages, the use of a voltage memory and the evaluation of delta values and symmetrical components make optimal direction detection always possible.

MHO zone characteristic

With the MHO characteristic, the MHO circle expansion values were set to direction correction behavior. The circle expands in the source impedance but never more than the selected impedance radius. As an alternative to the quadrilateral zone characteristic, the MHO characteristic can be used. If there are requirements for the compatibility with earlier generations protective systems.

Selectable number of distance zones

The number of distance zones can be freely adapted according to the application requirements.

Load zone

In order to guarantee reliable discrimination between load operation and short circuit – especially on long lines under large loads – an adjustable load range is used. Impedances within this load range do not result in unwanted tripping in the distance zones.

Absolute phase selectivity

The distance protection function with reactance method (RMD) includes a highly sophisticated algorithm for the adaptive loop selection. Sufficient loop selection criteria are processed in parallel. The loop selection criteria work with loop detection, delta value detection, symmetrical components and current, voltage and impedance comparison methods. The package of passive phases due to the negative influences of short-circuit currents and voltages or other phases is thus reliably eliminated. This adaptive loop selection algorithm makes appropriate tripping decisions and ensures correct distance measurement in a wide field of application.

Use in operation in parallel or with transformer

The distance protection function with reactance method (RMD) can be used in parallel or with transformer. In addition, the influences of parallel lines can be compensated by balancing the parallel line ground current. Parallel line compensation can be used for distance protection as well as for load function.

Digital filter characteristic

Digital filters render the device immune to disturbances contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special method of measurement is employed in order to realize selectivity at maximum speed, even under transformer saturation.

Measuring voltage failure detection

Tripping by the distance protection is blocked automatically in the event of a measuring voltage failure, thus preventing unwanted tripping. The EMERGENCY distance zone overcurrent protection can be activated.

Impedance protection for transformers (ANSI 21T)

SIPROTEC 5 offers a 6-system impedance protection with up to 4 impedance zones, especially for use as backup protection on power transformers.

Th – function

- protects transformers as backup protection for short-circuit differential protection
- is used as backup protection for the generator transformer and the generator in power plant units
- functions as backup protection in the event of energy power flow to faults in the positive electrical power network point of a transformer

Depending on the application, the loop selection can be combined. In active grounded power systems, all 6 measuring loops work independently of each other. The general release is performed via the minimum current criterion. In non-active grounded power systems (for example, overvoltage protection), the measuring loop selection is controlled by an overcurrent pickup with undervoltage stability.

By using the frequency tracking sampled values, the impedance is measured over a broad frequency range. Thus, all the relevant components of power plant units, for example, the startup operations.

Operating time characteristics

The quadrilateral operate zone permits separate setting of the reactance X and the resistance R for phase-to-ground and phase-to-phase loops. The quadrilateral characteristic is rectangular in the impedance plane. Within the function, a minimum of 3 impedance zones can be operated simultaneously. They can be set forward, backward or non-directional. Each impedance zone has its own timer.

Speed and direction detection

The direction of shaft rotation and speed (voltage vectors) are measured by power system variables.

Thermal voltage history detection

Tripping by the overvoltage protection is blocked automatically in the event of a measuring voltage failure. The function prevents unwanted tripping in the event of a fault. For three-phase and two-phase faults, the voltage may extend limit values or non-available values of the voltage transformer circuit breaker picks up and the EMERGENCY distance zone overcurrent protection can be activated.

Phase-sequence voltage detection

Digital filters render the device immune to disturbances contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special method of measurement is employed in order to realize selectivity at maximum speed, even under transformer saturation.

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Undervoltage protection (with any voltage)

- Capture of any 1-phase undervoltage with 3-phase voltage measurement for special applications
- Measuring methods, optionally, measurement of the fundamental component or of the effective value (True RMS).

Undervoltage-controlled reactive power protection (QU-Protection)

The undervoltage-controlled reactive power protection protects the system by makes decoupling purposes. To prevent a voltage collapse in energy systems, the generating side, e. g. a power zone, must be equipped with voltage and frequency protection devices. An undervoltage-controlled reactive power protection is required at the supply system connection point. It detects critical power system situations and ensures that the power generation facility is disconnected from the infeed. Furthermore, it ensures the interconnection only takes place on stable power system conditions. The associated criteria can be parameterized.

Power protection (ANSI 32, 37)

The power protection works 3-phase and detects overload or underpumping of the set effective power or reactive power thresholds (see *Figure 3.207*). Five defined power limits are monitored and corresponding warning alarms are issued.

The power direction can be determined via angle measurement of the active power. The feeding back of the network or of the machine can be detected, falling overhang faults, power over are detected and can be shut down via an indicator.

The power protection can be triggered one or 2 adjustment periods, for example, to monitor very specific power limits (further logical processing in CFC). The power protection function makes use of factory as stage each for the active and the reactive power. A combination of four active power stages or 4 four reactive power stages can be operated simultaneously in the function. The stepping stages are structured identically.

The pickups for exceedance or undercurving of the power limit can be defined. The combination of the different pickups via CFC result in various applications.

Application examples

- Detection of negative active power, in the case of synchronous protection can be applied by using the CFC to link power protection outputs in the "Power [dir]" function.
- Detection of capacitive reactive power, in the case of over voltage being detected due to long lines under no load conditions it is possible to select the binary inverse capacitive reactive power is monitored.

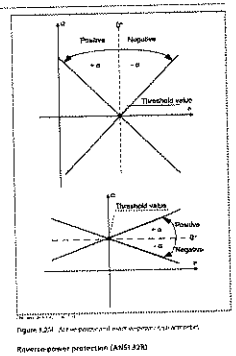


Figure 3.204 Active power and reactive power characteristics

Reverse-power protection (ANSI 32R)

The reverse power protection is used in generators and power plant units. If the "shaft-output" energy, for example, steam supply at the turbine fails, the generator absorbs the driving energy from the power system. In this operating state, the turbine can be damaged, as well. It is prevented by tripping of the reverse power protection. In order to react quickly if there is a steam outage, the pickup of the quick step value is designed additionally via binary input. It is used to switch between two time delay of the two command. Furthermore, the function is used for operational disconnection (commercial reasons) of generators.

For some applications, the "unbalanced power protection" (ANSI 32, 37) is recommended.

The reverse power protection operates on a 3-phase basis and measures the absolute active power (evaluation threshold value). By reliable clear of the positive sequence system present as well as the selection of a long time setting window, the function is used to be evaluation variables and only precise quantities setting thresholds (0.3 % Pnominal). The sequencing accuracy is considerably affected by the angle error. Because the SIPROTEC 5 devices are compensated, the primary transformers affect the measuring accuracy. The transient can contact the angle error. The angle error can be found in the technical characteristics. It can be evaluated using the primary system. The problem with the angle error is especially at high-precision instrument transformers are used as primary transformers (class 0.2 or 0.1). For this purpose, the reverse power protection it must be adapted to an independent measuring method.

Power plant decoupling (ANSI 32 dP/dt; 27, 50)*

Three phase close in short circuits result in mechanical stresses on the turbo-generator unit as well as electrical ones. The detection of the turbo-generator unit as well as electrical ones. The detection of a short-circuit is the prerequisite for the sensitive active power limit ΔP, because torque and active power are proportional to each other. The sudden force selective results in an acceleration of the rotor. At the same time, the phase position and amplitude of the synchronous-generated voltage changes. These changes result on a delayed basis corresponding to the inertia constants of the machine and the magnitude of the active power change. The longer this state persists, the more critical the stress on the generator becomes without there is a sudden voltage recovery. It is the precise to compare the effects of the subsequent opera tion or loss or a "delayed disconnection". If the power system protection does not cut off the high-current short circuit close to the power plant within the allotted quick operation time, the aforementioned stress can occur.

The power plant decoupling function (maximum) in this case and ensures the main switch or the power voltage side. Also load distribution, the block can be synchronized with the possible ring device.

The power protection function evaluates the negative active power part of the positive sequence system power. This is derived from the three-phase voltage and current measured values. After an adjustable time delay has passed, the turbo generator load shedding command is issued. The characteristic curve has a fixed, user-configurable characteristic curve. The characteristic curve is defined by two points (power/time value pairs). Additionally, the generator only be operated below a load current and a minimum active power and fall below an active power monitoring.

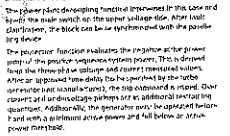


Figure 3.205 Characteristic curve of the power protection

Undercurrent protection (ANSI 37)

Undercurrent protection detects the falling edge or dropping current. Here, the main application is the monitoring by a three-level circuit breaker, or by decoupling a break, such as pumps running empty.

If load shutdown, it must be precautions to open the hydraulic brakes in order to prevent consequential damage. The undercurrent protection handles the case.

The function consists of an undercurrent stage with a current-dependent time delay. A minimum of two stages can be operated and in parallel.

Optionally, the auxiliary contacts of the local circuit breaker are monitored in order to prevent overreaction.

Temperature supervision (ANSI 38)

The temperatures (e.g. winding or coil temperatures) are captured with an external temperature monitoring device. Typical sensors are Pt 100, Ni 100 and Ni 120. The temperature are transmitted to the protection via serial interface or via Ethernet interface and the temperature monitoring function detection algorithm may exceed or limits. There are two threshold-dependent temperature monitoring point. The function is designed so that up to 12 temperature can be processed. The function also includes unbalanced broken-wire monitoring which sends alarms referring to the measuring points.

Underexcitation protection (ANSI 40)

The generator power diagram describes the stability limits. In the per unit view it can easily be transformed into an admittance diagram by changing the axis labels. The underexcitation protection monitors the stability limits and prevents damage to the generator from pulling out of synchronism (asynchronous reversal) as a result of problems with the excitation or voltage control during underexcited operation.

The protection function offers three characteristics for monitoring the stator as well as dynamic stability. A quick protection function is achieved via the very minimum of there is an active power and current time stepping is added. Alternatively, the excitation voltage can be measured by a measuring transducer and the primary signal for falling below the threshold value can be evaluated. The characteristic curve lines enable an optimal adaptation of the protection to the generator diagram (see *Figure 3.206*). The sensing values can be read directly from the per unit view of a diagram.

The calculation is calculated from the positive-sequence system quantities of the three-phase currents and voltages. This gives an less distort behavior of the protection function even under asymmetrical power system conditions. If the voltage declines from the rated voltage, the admittance characteristic curve advantage that the characteristics run in the same direction as the generated power diagram does.

Figure 3.206 Characteristic curve of the underexcitation protection

Unbalanced-load protection (ANSI 46)

An unbalanced load current loading of the rotor and then of a generator and result in heat buildup of the rotor because of the double-system frequency. The protection detects an asymmetrical loading of three of the machine. In operation on the basis of

Figure 3.207 Characteristic curve of the power protection

symmetrical components. The protection function evaluates the negative sequence current and prevents thermal overloading of the rotor of electric machines (generators, motors). The thermal asymmetrical faults, with the negative sequence system, various monitoring and protection tasks can be realized.

- Detection of 1 or 3 phase if not calculate the network with a higher cross-body fault in classic overcurrent protection
- Detection of phase-conductor interruptions in the primary system and on the current transformer secondary circuits
- Location of short circuits or reversals in the connections to the current transformers
- Indication of asymmetrical states in the energy system
- Protection of electrical machines following asymmetrical loads that are caused by asymmetrical voltages or phase failures (for example through a defective fuse).

The function comes to the on each 3 stage. A maximum of 4 stages can be operated simultaneously. If the device is equipped with the inrush current detection function, the tripping stages can be stabilized against tripping due to transformer inrush currents.

Overvoltage protection functions (ANSI 59, 47, 59N)

Overvoltages occur, for example, as long lines are run under no load. Another cause can be failure in the voltage regulator (overvoltage faults, malapropisms). The overvoltage protection monitors the permissible voltage on system equipment from unbalanced load or high overvoltages and serves to decouple systems (e.g. wind energy infeed).

Various overvoltage protection functions are available. By default, two stages are parameterized. Up to three identical stages are possible.

The following functions are available:

Overvoltage protection with 3-phase voltage (ANSI 59)

- Optionally, measurement of phase-to-phase voltages or phase-to-ground voltages
- Method of measurement: optionally, measurement of the fundamental component or of the effective value (True RMS value).

Overvoltage protection with positive-sequence system (ANSI 59)

- Detection symmetrical, optionally overvoltages with positive sequence voltage
- Selected of measurement: calculation of positive sequence voltage from the measured 3-phase or ground voltages

Overvoltage protection with negative-sequence system (ANSI 59)

- Detection of asymmetrical voltages with negative sequence voltage
- Selected of measurement: calculation of negative sequence voltage from the measured 3-phase or ground voltages

Residual voltage protection (ANSI 59N)

- Detection of displacement voltages in the event of ground faults in high-resistance grounded systems
- Selected of measurement: The protection detects the displacement voltage via the measured residual voltage or the calculated residual voltage from the 3-phase voltages.

Directional negative-sequence protection with definite-time delay (ANSI 46, 47)

This function serves as a sensitive short circuit protection for short-circuit faults, with the negative sequence system, various monitoring and protection tasks can be realized.

- Protection of 1 or 3 phase if not calculate the network with a higher cross-body fault in classic overcurrent protection
- Detection of phase-conductor interruptions in the primary system and on the current transformer secondary circuits
- Location of short circuits or reversals in the connections to the current transformers
- Indication of asymmetrical states in the energy system
- Protection of electrical machines following asymmetrical loads that are caused by asymmetrical voltages or phase failures (for example through a defective fuse).

The function comes to the on each 3 stage. A maximum of 4 stages can be operated simultaneously. If the device is equipped with the inrush current detection function, the tripping stages can be stabilized against tripping due to transformer inrush currents.

SIPROTEC 5 System

Protection – Starting-time supervision (ANSI 48)

Starting-time supervision (ANSI 48)

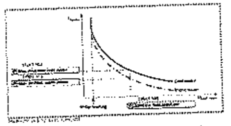


Figure 3.2/7

Hot spot calculation (ANSI 49H)

SIPROTEC 5 System

Protection – External trip initiation

External trip initiation

High speed instantaneous overcurrent protection (ANSI 50HS)

Circuit-breaker restrike protection (ANSI 50RS)

Instantaneous tripping at switch onto fault (SOTF)

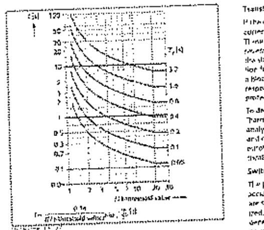
External trip initiation

Load-jam protection (ANSI 50L)

Overcurrent protection, phases and ground (ANSI 50/51, 50N/51N)

SIPROTEC 5 System

Protection – Overcurrent protection, single-phase (ANSI 50N/51N)



Overcurrent protection, single-phase (ANSI 50N/51N)

Sensitive ground protection (ANSI 50Ns/51Ns)

Intermittent ground-fault protection

Transformer inrush current detection

Switching protection (ANSI 50/27)

Shaft-current protection (ANSI 50GN)

SIPROTEC 5 System

Protection – Voltage-dependent overcurrent protection (ANSI 51V)

Voltage-dependent overcurrent protection (ANSI 51V)

Peak overvoltage protection for capacitors (ANSI 59C)

Interturn fault protection (ANSI 59N (IT))

Table 3.2/1

Arc Protection

SIPROTEC 5 System

Protection – Direct voltage / direct current protection (ANSI 59N (DC), 50N (DC))

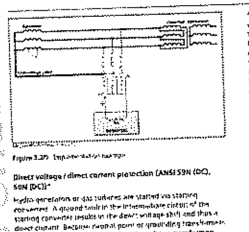


Figure 3.2/9

Direct voltage / direct current protection (ANSI 59N (DC), 50N (DC))

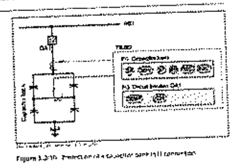
Stator ground-fault protection with 3rd harmonic (ANSI 27TH/59TH, 59THD)

90% stator ground-fault protection (ANSI 59N, 67Ns)

100% stator ground-fault protection with 20-Hz coupling (ANSI 64S)

SIPROTEC 5 System

Protection – Current-unbalance protection for capacitor banks (ANSI 60C)



Current-unbalance protection for capacitor banks (ANSI 60C)

Measuring-voltage failure detection (ANSI 60FL)

Rotor ground-fault protection (ANSI 64F)

200

[illegible]

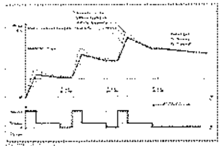


Figure 3.2/11 [illegible]

Directional overcurrent protection, phases and ground (ANSI 67, 67N)

[illegible]

Restart inhibit (ANSI 66)

[illegible]

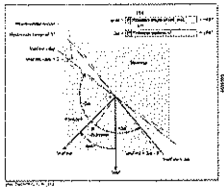


Figure 3.2/12 Direction characteristic of the directional ground-fault function

[illegible]

Directional ground-fault protection with phase selector (ANSI 67G, 50G, 51G)

[illegible]

Directional sensitive ground-fault detection (ANSI 67Ns, 51Ns, 59N)

[illegible]

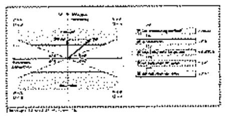


Figure 3.2/13 [illegible]

[illegible]

Power-swing blocking (ANSI 68)

[illegible]

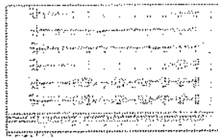


Figure 3.2/14 [illegible]

Trip circuit supervision (ANSI 74TC)

[illegible]

Out-of-step protection (ANSI 78)

[illegible]

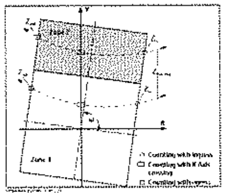


Figure 3.2/15 [illegible]

Automatic reclosing (ANSI 79)

[illegible]

[illegible]

Rate-of-frequency-change protection (ANSI 81R)

[illegible]

Weak or no infeed: Echo and tripping (ANSI 85/27)

[illegible]

Teleprotection scheme for distance protection (ANSI 85/21)

[illegible]

Teleprotection for directional ground-fault protection (ANSI 85/67N)

[illegible]

Frequency protection (ANSI 81O, 81U)

[illegible]

[illegible]

Line differential protection (ANSI 87L, 87T)

[illegible]

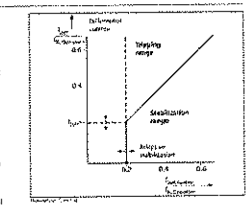


Figure 3.2/16 Tripping characteristic

[illegible]

201

Protection – Line differential protection (ANSI 87L, 87T)

Protection – STUB differential protection ANSI 87 STUB

STUB differential protection ANSI 87 STUB

Transformer differential protection (ANSI 87T)

Protection – Differential Protection for Phase-Shifting Transformers

Differential Protection for Phase-Shifting Transformers

Ground fault differential protection (on the transformer) (ANSI 87N T)

Protection – Differential motor protection (ANSI 87M)

Differential motor protection (ANSI 87M)

Protection – Generator differential protection (ANSI 87G)

Generator differential protection (ANSI 87G)

Busbar differential protection (ANSI 87B)

Capacitor bank differential protection (ANSI 87C)

Voltage differential protection for capacitor banks (ANSI 87V)

Protection – Fault locator (FL)

Fault locator (FL)

Phasor Measurement Unit (PMU)

202

Control

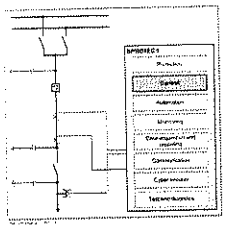


Figure 3.2-1 SIPROTEC 5 – functional integration – control

SIPROTEC 5 includes all bay level control and supervision functions that are required for efficient operation of the switchgear.

The basic, freely configurable graphic display for control displays is available for operations local control. Freigiver operating actions, such as starting switching sequences or displaying the message list, can be called up via one of the 9 function keys. The required security is guaranteed by the key switch for local/remote and interlocked/non-interlocked control.

The application templates supplied provide the full functionality of a preconfigured bay for your application. Protection and control functions always use the same logical elements. From the perspective of switching devices, protection and control are treated with equal priority.

Th = modular, scalable hardware can be optimized for the system configuration. You can easily add more than the desired hardware quantity structure. For example, a single SIPROTEC 5 device can be used to control and monitor an entire breaker-and-a-half diameter.

A high level of quality of control is achieved with the application of interlocking as standard (IEC 61850). For example, binary information from the bay can be processed only accurately and data (such as for enabling across multiple fields) can be exchanged between the devices. Cross communication via GOOSE or cable are smart solutions, since here the control is replaced with data transmission.

All devices already have up to 4 switching objects (local) as disconnector or grounding switches via the basic control package. Optionally, additional switching objects, and switching sequence blocks (CFC switching sequences) can be accessed.

Transformer voltage controller (ANSI 90V)

The automatic voltage controller for single (ANSI 90V) is used to control power transformers (two winding transformers, three winding transformers, 2 winding parallel transformers, 3 winding parallel transformers) and busbars using a load-dependent control method (line drop compensation) or a voltage-dependent control via the following:

- Parallel switching transformers: the voltage of the secondary side of the power transformer
- Two winding transformers: the voltage of the secondary side of the winding 2
- Two and coupling transformers: voltage of winding 1 or winding 2, selectively depending on the power direction

It is used for either automatic voltage control, within a permissible voltage band, on the secondary side of the transformers or other parameters as a constant load point (Z-compensation or RX-compensation) of the system. To compensate voltage fluctuations in the transmission system, the LDC Z (impedance compensation) or the load control, the LDC Z (impedance compensation). For voltage drops in the line, you can use the LDC R and R procedure (IR-compensation).

The control parameter is based on the fact that an up or down command in the tap changer causes a rise or fall in voltage, depending on the voltage change up to 2 % per each step.

The voltage control routine checks in each step and compares the measured actual voltage (V_{act}) with the derived target voltage (V_{set}). If the difference is greater than the set bandwidth (B), an upper dead command is output to the tap changer after the defined delay (T1) has elapsed.

The voltage control function additionally monitors the current on the primary and secondary side, as well as the direction of the transmittable operating corridors (overcurrent/undercurrent, overvoltage/undervoltage, reverse power).

Automation

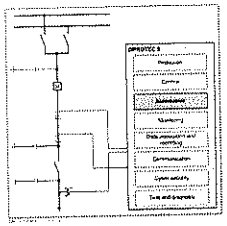


Figure 3.4-1 SIPROTEC 5 – [illegible] – automation – [illegible]

The universal CFC (Continuous Function Chart) graphical automation editor enables you to create logic diagrams clearly and simply. DIGSI 5 supports the user with powerful logic blocks based on the standard IEC 61131-3. All devices already have a powerful base information package. This makes it easy to provide specific switchgear functions, e.g. automating a switching cell or switchgear.

Various stages of expansion for the graphical function charts are available for the combination of your solutions.

- Function chart (CFC) basic
- Function chart (CFC) arithmetic

With the base package commission function chart, you can graphically link all internal digital information, such as external protection signals or operation states, directly to the logic blocks and process them in real time. With the arithmetic function chart (CFC) package you can also link measured values or minimal limits with respect to limiting values.

Examples of automation applications are:

- Interlocking checks
- Switching sequences
- Message conversions or the tripping of switching operations
- Messages or alarms by linking available information
- Load shedding in a feeder
- Management of decentralized energy feeds
- Switch transfers depending on the network status
- Automatic power system reconfigurations in the event of power system stability problems

Monitoring

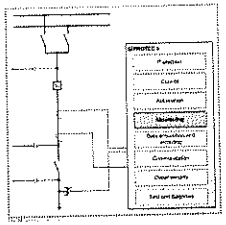


Figure 3.3-1 SIPROTEC 5 – [illegible] – monitoring – [illegible]

SIPROTEC 5 devices can achieve a wide variety of monitoring tasks.

They can be divided up to the following groups:

- Self-supervising
- Supervising a power system variable
- Monitoring a Power Quality
- Maintenance of equipment (condition-based control)

Self-monitoring

SIPROTEC 5 devices are equipped with many monitoring procedures. These detect faults, internal as well as external in secondary circuits, store them in logs, and report them. This information is used to recognize device faults and helps to determine the cause or the steps in order to take appropriate corrective actions.

Power system variables

Grid monitoring combines all of the monitoring systems that are necessary to ensure power system stability during normal operation. SIPROTEC 5 provides all the necessary functionalities, such as limit exceeded, communication interfaces, fault recorders and synchrophasor measurement (Phasor Measurement Units, PMU) for load monitoring. This functionality allows you to monitor power system limit violations such as dynamic stability issues, and to load shed in advance and actively trigger the appropriate responses. This data in the network control system can also be used as input variables for online power flow calculations and enable significantly faster response if changes in the power system occur.

Power Values

In addition to values, the influence on the load is determined by the electrical energy consumed. With additional counters for the energy (forward, reverse, active, reactive), the operating hours of connected consumers can be recorded. Power quality can be monitored, e.g. using limit values for voltage, current, frequency, power factor, and harmonics. Power quality values are recorded as defined in EN 50160.

For this, SIPROTEC 5 provides many recording and Power Quality functions, for example SIPROTEC PQREC. These can be used to detect weak points early on. For corrective measures can be taken. The large volume of data is archived centrally and analyzed locally, such as DIGSI PQS Viewer.

Equipment

For driver maintenance is an important tool in asset management and operational support. Even with the environment and the company can benefit. Equipment that typically requires monitoring includes, for example: Circuit breakers, transformers and cast compartments (gas insulated switchgear (GIS)).

The integration of transducer inputs (0 mA to 20 mA) enable monitoring of various sensors, and even tracking of the actual variables, such as gas pressure, gas density, temperature. Thus, SIPROTEC 5 enables a wide range of monitoring tasks to be carried out.

SIPROTEC 5 provides the process, operation, logs, recordings and supervision functions necessary for maintenance management:

- Process values are stored together with a date stamp in the operational log
- The circuit breaker statistics provide essential data for cut-off and based on the number of switchgear
- Process variables like overcurrent, pressure, SF6 loss, speed, and temperature are monitored for limit violations via measuring transducers connected to the sensors.
- Using external I/O with an integrative measurements devices that can be connected carefully or by Ethernet, other measured values can be captured and processed.

Data Acquisition and Recording

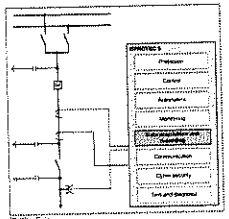


Figure 3.4-1 SIPROTEC 5 – functional integration – data acquisition and recording

Th = recorded and logged bay data is comprehensive. It depends, the usage and security of the bay. It is also used by the operation, in the SIPROTEC 5 devices for real-time, event log and disturbance recorder (DR). Th etc. they represent the basis both for the functions available today and for future applications.

Measurement methods

A large number of measured values are derived from the analog input variables, which supply a current image of the process. Depending on the device type, the following basic measured values are available:

- Operational measured values
- Fundamental, phasor and symmetrical components
- Protection specific measured values, for example differential and restraint currents for differential protection
- Mean values
- Minimum values and maximum values
- Energy measured values
- Statistic values
- Limiting values

Besides th = basic measured values, synchrophasor measured values can also be activated in the devices specifically as PMU. (Phasor Measurement Unit).

Synchrophasor measurements support a range of applications for wide-area monitoring. For this purpose, SIPROTEC 5 devices offer the necessary PMU data. These data (such as, time-stamped phasors in relation to a reference, frequency and the change in the power frequency). They can be transmitted to central analysis systems via the high-performance communication system.

Measured values are displayed in primary quantity both in primary and secondary values, and also in reference values. These values are also made available to other applications, for example, transferred to the systems control or automation tasks.

Up to 90 analog inputs can supplied to each device. Up to 40 binary inputs are supported via the busbar protection SIPROTEC 7SS85.

The analog inputs of the SIPROTEC 5 devices can be selected with a correspondingly accuracy class and dynamic range suitable for connection to both conventional and transformer cores. The innovative current terminal technology enables these to be simply changed between class 5 and 1. All analog inputs are factory calibrated and thereby ensure maximum accuracy.

The following accuracies are typical:

- $V, I < 0.1\%$ at I_{rated}
- $V, I < 0.3\%$ of the expanded frequency range (I_{min} 10Hz, I_{max} 10Hz)
- $P < 0.3\%$ at I_{rated}
- $P < 0.5\%$ in the expanded frequency range (I_{min} 10Hz, I_{max} 10Hz)
- $D = 1.0\%$ at I_{rated}
- $D = 1.5\%$ in the expanded frequency range (I_{min} 10Hz, I_{max} 10Hz)

Separate, secondary transducers (analog inputs) are available if necessary. The high-precision measured data enable extended energy management and makes commissioning much easier. SIPROTEC 5 also provides the following measured values for analysis and further processing:

- The base measured values with high dynamic range and high accuracy (protection class current transformer)
- The basic measured values with very high accuracy (protection transformer)
- Synchrophasor measured values with high precision time assigned for subsequent wide-area and stability monitoring
- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (for example, thermal overload protection, peak overvoltage protection for capacitors) and operational measured values

Recorders

In SIPROTEC 5, various data logs and recorders provide recording large volumes of data. They include a large number of analog and binary inputs, and a high sampling frequency. An economically wide-ranged records can be completed. Either continuously or as determined by various trigger criteria.

Besides storing the data for subsequent analysis in device, SIPROTEC 5 devices can also transfer the data to central archive systems. Consequently, you are able to archive the records in different types of transmission.

Fault recorder

The fault recording in protection devices and bay controllers stores analog and binary data during a fault event. For example, in the event of short circuit or ground faults, and protection the network. Including high-precision timestamps for subsequent analysis. Calculated measurands, for example powers or impedance, can also be precalculated into the fault recording function. Analysis takes place after the data is read out from the device by DIGSI using SICRA. Recorded data is archived to prevent data loss in the event of totally voltage failure. Analog and binary signal traces for recording are freely configurable, and the trigger period duration and level or time can be predetermined within a very wide range. SIPROTEC 5 fault recording provides long recording times with outstanding accuracy:

- Recording of all analog channels
- Sampling frequencies from 1 kHz to 6 kHz
- High recording capacity for individual records of 20 s for 24 channels, or at 6 kHz sampling frequency
- Storage capacity for up to 128 fault records
- The recording duration for all records is limited by the available storage capacity of the device, and depends on the number of configured channels and sampling frequency. Example:
  Line protection with 8 analog channels (4 I, 4 V), sampling frequency 8 kHz, 4 measured value and 20 binary channels, resulting recording capacity of the device about 400 s!
- Up to 100 freely configurable binary and 50 additional measured value MAVs
- Due to the high number of up to 128 maximized values, a different record duration results for SIPROTEC 7SS85
- The SIPROTEC 7KE85 Fault Recorder has yet more properties:
  - Expanded trigger criteria: Gradient trigger (dU/dt), binary message, measured value, etc.
  - Higher sampling frequency of 16 kHz for up to 40 analog channels
  - Total recording time per record duration due to the additional 16 added fault records.

The devices are synchronized via the following interfaces and components provided as well as for the highest precision are in the "SIPROTEC 7KE85 Fault Recorder".

Time synchronization

In order to be able to compare the recordings or trade recordings of different devices to each other, a synchronization of the internal clocks is necessary. Thus, the time synchronization of an important property and must be done with a high degree of accuracy. In particular the use of the Precise Measurement Unit (PMU) further requires a precise time stamped (Figure 3.4-2).

The time synchronization can be done using 3 or 2 times. Depending on the number of accuracy steps 1 ms to 1 µs is obtained. Events are stamped with a date and time with 1 ms time frame.

The time synchronization is optionally realized via:

- IEEE 1588 v2 (PRP)
- IRIG-B signal
- SNTP protocol
- Substation automation protocol (for example, IEC 60870-5-103, IEC 61850)
- IEEE 1588 protocol (annex C, P2)
- Seconds pulse (for special high precision applications)
- DIGSI 5 protocol (cyclically)
- Timing master of a protection interface
- Internal time with integrated quartz crystal

Time synchronization in the device has a battery back up. Thus, the internal clock continues to run when the quartz accuracy of the device even in case of outages of the auxiliary voltage.

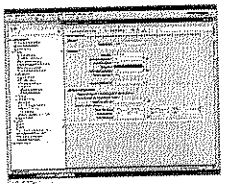


Figure 3.4-2 Time synchronization in SIPROTEC 5

GPS time synchronization for SIPROTEC 5 DCF77

To recommending GPS time external receiver from Meinberg (Figure 3.4-2) serves the synchronism of all connected protection devices. The external clock of the protection devices are receiving using the protection telegram (IRIG-B, DCF77). Optical fiber can also be used to transmit time signals. Data power or record intensity, protect and reference even over larger distances and in electromagnetically polluted environments. SIPROTEC 5 devices generally support redundant time synchronization. The time information can be provided by two external sources. One synchronizes in the primary time system. If it fails, switchover to the second (redundancy mode) is performed.

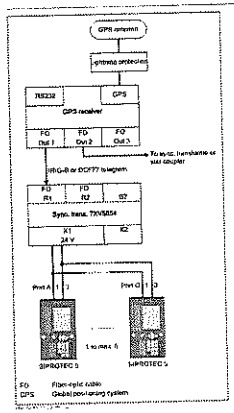


Figure 3.4-3 SIPROTEC 5 device with IRIG-B/DCF77 clock synchronization

Event log buffer

Event log buffers share important events with a time stamp (resolution 1 ms) for subsequent analysis.

The log are capacity depends on the event and limit-stage event log numbers and operation logs for different users categories. The events to be logged are freely configurable and provide improved maintainability. For operation of time specific event log buffers, if a circuit breaker event occurring is also supported.

Equipment monitoring (optional)

Event log buffers of different categories are also available, triggering as well. Changes to parameters and event protocol data are recorded.

Maintenance

Hardware and software are constantly monitored and immediately declared. In the case, extremely high levels of security, reliability and availability are achieved at the same time. Moreover is formation about essential maintenance measures (for example, battery supervision). Hardware defects detected by internal monitoring or compatibility problems are separately recorded in the diagnostic log. All events include relevant data, action instructions. The following table provides an overview of the typical log.

The log names, and fault records are listed. Event of them is an outage of the auxiliary and battery voltage.

Operational log	Fault recorder	Statistics (counting of operational and protection events)
Event log	Fault recorder (oscillographic fault)	Counter of the number of trips, Accumulation of the I^2t, Counter of the number of starting of the device, A maximum of 128 can be stored. A maximum of 3000 messages can be recorded for each fault.
Security log	Min/max log	Storage of minimum and maximum values
Earth fault recorder	Min/max log for earth fault	Storage of minimum and maximum values. A maximum of 8 can be stored. A maximum 100 messages can be recorded for each fault.
Trip circuit supervision log	Min/max log for trip circuit supervision	Storage of minimum and maximum values
Overload log	Min/max log for overload	Storage of minimum and maximum values
Restart inhibit log	Min/max log	Storage of minimum and maximum values
Ground fault log	Min/max log	Storage of minimum and maximum values
Communication log	Min/max log for communication	Logging the communication connections with analysis options for security, polling and diagnostics, connection and redundancy fault.
Changes in the device configuration	Operation logs	Logging the configuration changes and attempts to change settings with date and time, user name, cause, type, old and new value.
Diagnostic log	Operation logs	Logging and saving of specific parameter, faults, types – cause of recovery time, error type, company, battery, current, voltage, standard, maximum deviation, temperature.

Table 3.4-1 Overview of typical logs

SIPROTEC 5 devices are equipped with high-performance communication interfaces. These interfaces are integrated or extendable via plug-in modules to offer a high degree of flexibility. The concept of plug-in modules and loadable protocols enables exchangeability and retrofitting.

Communication

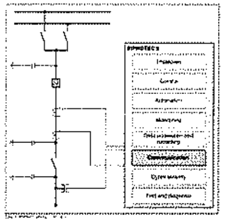


Figure 3.7/1 SIPROTEC 5 – [illegible]

SIPROTEC 5 devices are equipped with high-performance communication interfaces. These are integrated interfaces or interfaces that are extendable with plug-in modules to provide a high level of security and flexibility. There are various communication modules available. [illegible]

- Several serial and Ethernet-based communication interfaces
- A large number of serial and Ethernet-based logs (for example, IEC 60870-5-103, DNP3 serial and TCP, Modbus TCP, IEC 60870-5-104 and IEC 61850 Ed1 and Ed2)
- Full availability of the communication ring when the switching cell is enabled for servicing operations
- Ethernet redundancy protocols PRP and HSR
- A large number of plug-in modules having various communication protocols

Plug-in module positions of the device

[illegible]

Serial plug-in modules

Serial electrical plug-in modules are used for asynchronous serial protocols, e.g. IEC 60870-5-103, DNP3. Optical 820 nm [illegible] 1550 nm modules can also be configured as protection interface for the point-to-point connection.

Serial electrical RS485 module

This module has either 1 (USART-AB-1EL) or 2 (USART-AC-2EL) RS485 interfaces. [illegible] Figure 3.7/2 shows an electrical serial module with 2 interfaces on which 2 independent serial protocol applications are executed.

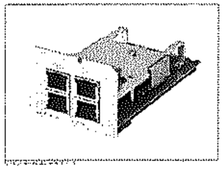


Figure 3.7/2 Serial electrical plug-in module (USART-AC-2EL)

Serial optical 820 nm module

This module exists with 1 (USART-AD-1FO) or 2 (USART-AE-2FO) optical 820 nm interfaces (Figure 3.7/3), [illegible]

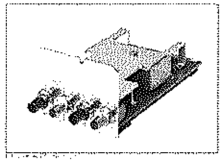


Figure 3.7/3 Serial optical [illegible] (USART-AE-2FO)

Serial optical 1300 nm/1550 nm module

Long-distance modules are used for synchronous serial data exchange of protection communication via multimode optical fibers or single-mode fibers. [illegible] (Table 3.7/1). [illegible]

[illegible]	[illegible]	[illegible]

Table 3.7/1 Long-distance modules for different distances for protection interface communication with 2 fibers

Use of modules in pairs

[illegible] (Figure 3.7/4). The optical connection is made via LC simplex plugs.

[illegible]	[illegible]	[illegible]

Table 3.7/2 [illegible]

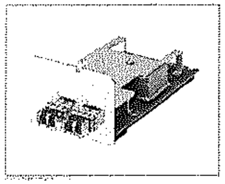


Figure 3.7/4 [illegible]

Plug-in modules for Ethernet

Ethernet modules are used for Ethernet-based protocol applications, e.g. IEC 61850, IEC 60870-5-104, DNP3 TCP, time synchronization via SNTP, network management via SNMP, DIGSI 5 via TCP, etc. [illegible]

Electrical Ethernet module

Electrical Ethernet module: The ETH-BA-2EL module has 2 RJ45 interfaces (Figure 3.7/5). It can be configured with or without an integrated switch. The maximum electrically permitted distance via CAT 5 patch cables is 20 m.

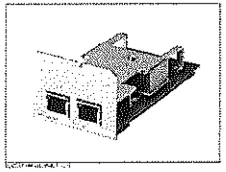


Figure 3.7/5 Electrical Ethernet module (ETH-BA-2EL)

Optical Ethernet module

The ETH-BB-2FO module has 2 optical LC duplex 1300 nm interfaces (Figure 3.7/6). It can be configured with or without an integrated switch. The maximum optically permitted distance via 50/125 µm or 62.5/125 µm multimode optical fibers is 2 km.

[illegible]

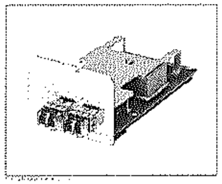


Figure 3.7/6 Optical Ethernet module (ETH-BB-2FO)

Plug-in modules for the communication

Physical Connection	[illegible]
Application	[illegible]
Additional Ethernet protocols and services	[illegible]

Table 3.7/3 [illegible]

Plug-in modules for the communication

Physical Connection	[illegible]
Application	[illegible]
Notes	[illegible]

Table 3.7/4 [illegible]

Plug-in modules for additional applications

Physical Connection		
[illegible]	[illegible]	[illegible]
Applications		
[illegible]	[illegible]	[illegible]

Table 3.7/5 Plug-in modules for additional applications

Logs

Plug-in modules are delivered without a protocol application. According to the table "Communication applications and plug-in modules", a module can be installed via DIGSI 5 with a protocol application. [illegible]

DIGSI 5 protocol

[illegible]

IEC 61850 client-server communication

[illegible]

On Ethernet modules

[illegible]

Here, Redundant solutions can be realized with 2 Ethernet modules.

IEC 61850 GOOSE

Areas of use (inside and outside switchgear)

GOOSE has been established as a worldwide standard for cross communication between devices in order to transfer messages and measured values between devices. [illegible]

[illegible]

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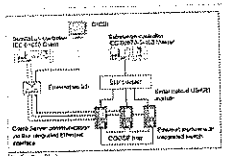

Figure 3.277 Separate connection of the COUPLE via the interface to IEC 61850-9-2 and of serial communication via IEC 60870-5-103 master

Serial IEC 60870-5-103 protocol

The serial protocol is transferred via RS485 or an optical 820 nm interface. The compatible or device-specific extended IEC 60870-5-103 protocol is supported. The implementation is compatible with existing solutions, and with SIPROTEC 4 devices, which will enable a trouble-free exchange and expansion of devices even in the very long term. In addition to indications, measured values and fault records, extended values and customer-specific data and parameters of connection functions are also available at personal workstations. Control commands for switching devices can also be transferred via the protocol. Setting values of the device can also be read or changed via the generic services of the protocol. Information about the device can be routed to the protocol interface by the user with DIGSI 5. In compatible types and function numbers can be freely configured and. This enables adaptation to existing solutions and the interchangeability of devices without changes in the substation controller. This is an important contribution to investment security.

IEC 60870-5-104 protocol

The IEC 60870-5-104 substation and power system automation protocol is supported via the electrical and optical Ethernet interfaces. Indications (single and double), measured values, metered values can be transmitted in spontaneous or scan (cyclic) sequences. IEC 104 file transfer is also supported and fault recordings can be read out of the device by Commander Import. In the command direction, serialized switching of switching objects is possible via the protocol. Time synchronization can be supported via the IEC master or via SNTP across the network. Redundant time centers are supported. All available services on Ethernet such as the DIGSI 5 protocol, recovery redundancy or SNMP for network monitoring can be activated concurrently with IEC 104 services. GOOSE messages of IEC 61850 can be exchanged between devices.

Serial DNP3 or DNP3 TCP

DNP 3 is supported as a serial protocol via RS485 or an optical 820 nm interface, and as an Ethernet based TCP variant via the electrical or optical Ethernet modules. In conjunction with Ethernet, the switch integrated in the module can be used such that redundant ring structures for DNP 3 can be realized. In the variable and the connection to the switch is monitored. In the case of a change of interface 1, a switch is made to interface 2 within just a few milliseconds (Figure 3.2715).

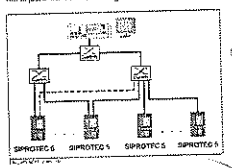

Figure 3.2717 Ethernet redundancy with ring topology: Coupling in the ring

Electrical or optical rings with a maximum of 40 devices can be established with the ring-switch (RSTP) (Figure 3.2718). Both structures of the flexible hardware and service simultaneously. Mixed operation with SIPROTEC 4 devices is possible in the ring with a maximum of 30 devices. A special ring redundancy protocol, based on RSTP, is used that actively takes in the event of the outage of a device, so that the protocol speeds does not jump during double interruptions. This can be implemented also independent of the protocol via the user on the Ethernet module.

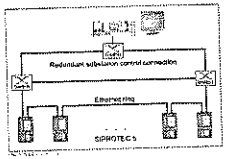

Figure 3.2718 Ethernet ring with integrated switch function

Ethernet – network topologies

Regardless of the selected protocol (IEC 61850, DNP3 TCP), the electrical and optical Ethernet modules are supported by different network topologies.

If the module works without an integrated switch, that can be achieved by means of DIGSI 5, it is connected to external switches additionally in order easily. In the case of a double ring with, for example, IEC 61850, the end interface processes the protocol applications, and, for example, IEC 61850 GOOSE messages or IEC 61850 client-server services are transmitted via the ring. For the IEC 60870-5-103 protocol, redundancy processes are supported in the device. Thus, a primary master can be set that is performed over the 2nd master in the control direction. The current process image is transferred to both masters.

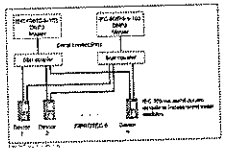

Figure 3.2719 Redundant communication of devices in IEC 60870-5-103 or DNP3 master via separate SICAM PAS

Redundancy in communication

You as the user can implement different levels of redundancy. The number of independent protocol applications running in parallel is limited by the plug-in module provided.

A serial protocol can be run 2 times on a double module. For it can also be implemented on 2 modules. Different baud rates can be run on the device simultaneously, for example, DNP3 at 4800 bit/s, communication occurs with 2 separate masters.

The Ethernet module can be plugged into the device one or more times. This allows the same or different protocol applications to be operated multiply times. For IEC 61850, several connections are possible. For example, one for client-server communication to a control center and a second one for GOOSE communication between the devices that could be assigned to the process bus (Figure 3.2720). Through the client-server mechanisms of IEC 61850, one server (device) can send spontaneously and reports to a maximum of 6 clients. The flooding of the information on the Ethernet module is within the establishment of redundant network structures, for example, optical rings or the redundant connection in 2 switches.

Figure 3.2716 Ethernet ring with integrated switch function

The Ethernet interfaces can be implemented in double. If one connection fails, a switch is made to the second connection and the device remains accessible. SNTP can also be used via the integrated Ethernet interface.

Time synchronization with IEEE 1588

For greater precision of time synchronization via Ethernet, the IEEE 1588 protocol is available. It can be applied for electrical or optical Ethernet modules. The precondition is that the network components, e.g. switches, support the protocol and special IEEE 1588 time servers are present in the network. With IEEE 1588, the spatial propagation times of the time signal are taken into account in the Ethernet modules and are stored so that the highest precision can be achieved. SIPROTEC 5 devices can be the master or slave, and SIPROTEC 5 devices can be used as boundary clocks (time relay in the network).

Further Ethernet-based protocols and services

Besides the serial protocol applications, there services can run in parallel on an Ethernet module, and can be switched on and off by the user with DIGSI 5.

Ethernet redundancy with ASTP, PRP and HSR

The electrical and optical Ethernet module supports with the redundancy protocol RSTP, HSR the reconfiguration of interrupted ring structures. With HSR, uninterruptible ring redundancy is achieved with up to 50 devices in the ring. PRP enables uninterruptible communication via parallel networks. These methods can be activated via parameters. They are independent of the substation automation protocol or the chosen auxiliary services.

Time synchronization with SNTP

The device can poll the absolute time from 1 or 2 time servers via an SNTP service. e.g. in the hardwired via IEC 61850. In redundant operation, both servers are read and the time of the 1st server is used for setting the device clock with a precision of 1 ms. If the server fails, time synchronization takes place via the central server. In addition to Ethernet modules, SNTP can also be used via the integrated Ethernet interface of the basic device.

Transfer of data via the protection communication

The protection interface and protection topology enable data exchange between devices via synchronous and asynchronous

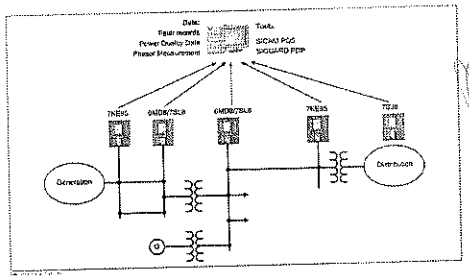

Figure 3.276 Communication of the 8 modules via SUP

SUP – Slave Unit Protocol

The Siemens specific protocol is used to read out external 20 mA devices (20 mA box) or temperature sensing devices (thermo box) serially or via Ethernet. These devices are available as accessories to expand SIPROTEC 5 devices with analog inputs or RTD inputs. The measured values of these devices can be further processed in the SIPROTEC 5 device or are used for protection functions such as overload protection or hot spot calculation in transformers.

Further Ethernet-based protocols and services

Besides the serial protocol applications, there services can run in parallel on an Ethernet module, and can be switched on and off by the user with DIGSI 5.

Ethernet redundancy with ASTP, PRP and HSR

The electrical and optical Ethernet module supports with the redundancy protocol RSTP, HSR the reconfiguration of interrupted ring structures. With HSR, uninterruptible ring redundancy is achieved with up to 50 devices in the ring. PRP enables uninterruptible communication via parallel networks. These methods can be activated via parameters. They are independent of the substation automation protocol or the chosen auxiliary services.

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Time synchronization with IEEE 1588

For greater precision of time synchronization via Ethernet, the IEEE 1588 protocol is available. It can be applied for electrical or optical Ethernet modules. The precondition is that the network components, e.g. switches, support the protocol and special IEEE 1588 time servers are present in the network. With IEEE 1588, the spatial propagation times of the time signal are taken into account in the Ethernet modules and are stored so that the highest precision can be achieved. SIPROTEC 5 devices can be the master or slave, and SIPROTEC 5 devices can be used as boundary clocks (time relay in the network).

Further Ethernet-based protocols and services

Besides the serial protocol applications, there services can run in parallel on an Ethernet module, and can be switched on and off by the user with DIGSI 5.

Ethernet redundancy with ASTP, PRP and HSR

The electrical and optical Ethernet module supports with the redundancy protocol RSTP, HSR the reconfiguration of interrupted ring structures. With HSR, uninterruptible ring redundancy is achieved with up to 50 devices in the ring. PRP enables uninterruptible communication via parallel networks. These methods can be activated via parameters. They are independent of the substation automation protocol or the chosen auxiliary services.

Time synchronization with SNTP

The device can poll the absolute time from 1 or 2 time servers via an SNTP service. e.g. in the hardwired via IEC 61850. In redundant operation, both servers are read and the time of the 1st server is used for setting the device clock with a precision of 1 ms. If the server fails, time synchronization takes place via the central server. In addition to Ethernet modules, SNTP can also be used via the integrated Ethernet interface of the basic device.

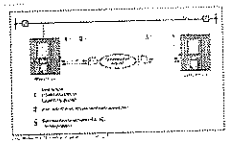


Figure 3.2711 Redundant communication of the differential protection via communication networks

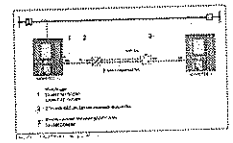


Figure 3.2712 Redundant communication of the differential protection via communication networks

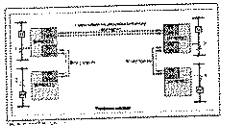


Figure 3.2710 Protection communication via IEEE C37.94 (G.703.1 with 64 kbit/s)

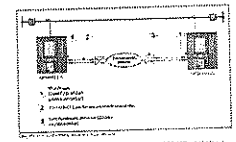


Figure 3.2711 Protection communication via IEEE C37.94 (G.703.1 with 64 kbit/s)

Protection interfaces integrated in the device have generally been used for differential protection (Figure 3.2710) and the permissible communication interface (depending on the protection). In addition to these protection applications, you can configure protection interfaces in all devices for SIPROTEC 5, at the same time, any binary information and measured values can be transferred between the devices. Even connections with low bandwidth, such as 64 kbps, can be used for this. Prerequisite information that already exists in transfer data for the differential protection via the protocol type 1 links and are used in the SIPROTEC 7SL80 and 7SJ8 devices. Connections for transferring any data that can be configured in the other devices (for example, SIPROTEC 7SA8, 7SJ8) are type 2. The protection interfaces must be of the same type on both sides.

The topology (Figure 3.2711 to Figure 3.2716) gives possible communication options for establishing protection communications.

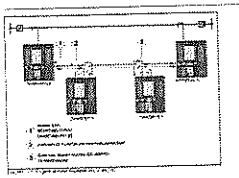


Figure 3.2714 Redundant communication via Ethernet ring topology

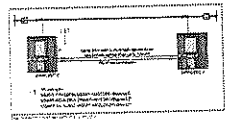


Figure 3.2715 Redundant communication via Ethernet ring topology

Figure 3.2716 Redundant communication via Ethernet ring topology

Figure 3.2716 Redundant communication via Ethernet ring topology

Figure 3.2719 Redundant communication of devices in IEC 60870-5-103 or DNP3 master via separate SICAM PAS

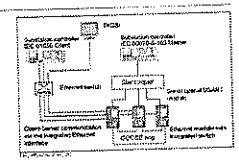


Figure 3.2720 Redundant communication of devices in IEC 60870-5-103 master

Seamless redundancy with PRP and HSR

New technologies dissolve at once the need for the selection of communication networks in the event of interruptions. These technologies include:

- PRP – Parallel Redundancy Protocol
- HSR – High Availability Seamless Ring Redundancy

Both systems operate according to the same principle and conform to the standard IEC 62439-3.

The same information (Ethernet telegram) is thus transmitted via two different information routes. The receiver utilizes the first telegram to arrive and discards the second. If the first telegram does not arrive, the second one is still available and is used. This mechanism is based on a Ethernet mark, which assigns the same MAC address to the two telegrams.

- PRP uses two independent Ethernet networks. Although this doubles the effort for installing the protocol along with the associated costs, the design is simple.
- HSR operates according to the same principle, but not all the Ethernet networks is designed in a ring-like topology. The same information (Ethernet telegram) is transmitted in both directions of the ring, and the receiver evaluates it from both sides of the ring. This design can also be used to cross-connect star couplers, but some of the costs for a special Ethernet network.

The procedures can be activated via a setting parameter and do not have any other parameters. They are therefore easy to use. The number of network nodes is limited in both procedures to a maximum of 512.

HSR and PRP can be combined solely as nodes in double. In boundary nodes, the connection between networks is made. Considered in the following scenarios:

- 2 switches in the control room
- 2 switches in the bay
- 2 redundant ports on IEC ring

- Up to 40 devices per HSR ring
- Easy expansion using two additional PRP switches

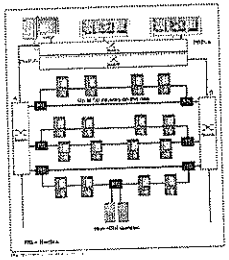


Figure 3.2721 Ethernet network architecture

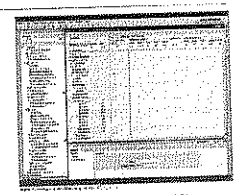


Figure 3.2722 Communication arrangement via Ethernet to the IEC 61850-9-2 test system

Integrated testing of communication in DIGSI 5

A common test can be carried in combination with DIGSI 5. According to available type, DIGSI 5 offers the user the selection of the respective permissible protocol applications. The protocol parameters are set e.g. baud rate, IP address etc.). Then the interface is activated and the protocol application and, for example, control possible with the IEC 60870-5-103 and DNP3 protocol and the communication parameters are loaded.

For an application, a configured device is set as an appropriate communication assigning (Figure 3.2723). In a communication matrix, the user can then do mapping and assess and configure the new information. This mapping file is easily loaded by DIGSI 5 into the device, and determines the scope of information that is processed via the protocol. Protocol mappings can be copied between devices, if they contain the same functions, and can be exported into tabular user control applications.

Process bus – IEC 61850-9-2

The process bus transfers current and voltage of a device (merging unit). The measured values are digitalized in the merging unit and transferred to the protection devices via optical Ethernet connections with help of the IEC 61850-9-2 communication protocol. The protection devices no longer need with analog measured values. For example, use the digitalized measured values from the sampled values data stream.

The merging units are possessed of three-phase voltage transformers to transform voltage and. The sampled values data streams generated by the merging units can be transmitted to one or several protection devices.

The 8PA01 Expansion Module for SIPROTEC 5 enables subsequent upgrading from SIPROTEC 5 devices to process bus capability.

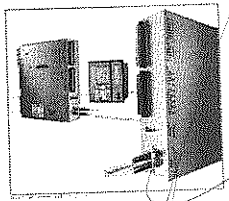


Figure 3.2724 Process bus with the 8PA01 Expansion Module for SIPROTEC 5 devices

arrangement solution to parallel operation of the feeder with process bus.

Figure 3.2/3a Example of two devices operating in parallel with process bus

Figure 3.2/3b Example of two devices operating in parallel with process bus

Figure 3.2/4 Example of a substation automation system with process bus

Safety for protection and for control: Plants, their availability is also critically important. And it is the plant itself that is supposed to be protected. Safety is the prevention of dangers that can arise from the plant itself or from the environment in the event of a fault. Safety and security are closely linked in the SIPROTEC 5 device architecture. It is the purpose of the multifunctional safety mechanisms to protect the environment of the plant from dangers that can arise from the plant itself in the event of a fault.

Safety and Cyber Security Related

- Security concept of device design
- Information security related to causes of threats from the environment

Safety

Multifunctional safety mechanism

Safety comprises all aspects of protection for persons and property equivalent in all phases. The device meets SIPROTEC 5 helps the functional standards. Failed security measures in safe service operations is minimized. The main aim here can support the user with these measures. The purpose of help to implement a comprehensive cyber security concept has with the operational system. The concept must consider all system components and requires all technical aspects of cyber security.

Safety of the hardware design

- The device system consisting of configured hardware building blocks, each with its own cooling system, reduces thermal

Figure 3.2/1 Example of integrated safety and security

Monitoring functions

Comprehensive monitoring functions enable secure operation by fast detection of irregularities and automatic initiation of appropriate measures. In most protection functions. Depending on the severity of the irregularity detected, a warning may be issued, the functions concerned be blocked, or the entire device may be isolated by disconnecting the line contacts. In all cases, the event is logged, the operator informed, and appropriate take action is enabled.

Maintenance monitoring

All of software in the device is continuously monitored. This includes, for example the CPU, the auxiliary voltage, the battery status, the internal clock, the storage modules, the proper function of the bus connections, the expansion and communication modules.

Monitoring of the analog circuit

As a data source for the protection functions, monitoring of the analog inputs is ensured in multiple stages. Some may routing

- Single-point faults in the device do not lead to the loss of the safety function.
- Multiple-point faults in the device are detected in the monitoring circuit (or at the latest when requesting a safety function) and result in a safe device state. These include
  - Current and voltage balance
  - Current and voltage sums
  - Phase rotation supervision

Other monitoring functions depend on type, design, operation and correct operating conditions of the selected functions:

- Flow, pattern monitor (loss of voltage)
- Fast current rate supervision and breaker wear monitoring for the power circuits.

In addition, the primary working method of the analog digital conversion is ensured by plausibility monitoring at the sampling level.

Tripping circuit supervision (ANSI 74TC)

If a circuit breaker coil or its feed lines are interrupted, the trip circuit supervision is activated by plausibility monitoring at the sampling level.

Communication supervision

Telegrams are short-term monitored. Faulty or delayed telegrams are withheld messages. Data sensitized with protection and control is transmitted via protection interfaces and IEC 61850 GOOSE messages. The transmitted information is also monitored constantly on the receiving side.

Load management

The flexible configuration of protection functions and function charts (CFC) enables them to be adapted to an enormous range of applications. During engineering with DIGSI 5, the designer can load model calculate the resulting device load. The versions that only suitable configurations can be loaded into the device.

Standardized management of device modes

The modes and the health status of all modules are forwarded and handled uniformly and consistently throughout the entire system. Analysis functions take the modes into consideration and quarantine secure operation. This is particularly efficient when protection and control related data is transmitted via protection interfaces and IEC 61850 GOOSE messages. Both applies equally for signal processing in the function charts (CFC).

Figure 3.2/2 Monitoring of analog input values and [illegible]

Cyber Security

Figure 3.2/1 SIPROTEC 5 – Cyber Security

With the increasing interconnection of key devices in Ethernet-based communication networks, measures to protect networks against external disturbances and attacks have become indispensable. Such attacks and disturbances such as NERC CIP (North American Electric Reliability Corporation – Critical Infrastructure Protection) and the BDEW white paper (Requirements for Secure Control and Telecommunications Systems of the Bundesverband der Energie- und Wasserwirtschaft) define certain requirements for the safe operation of facilities of the critical infrastructure sector, consumers, and are directed at both manufacturers and operators.

Cyber Security must be incorporated into the operation devices right from the start. The following central cyber security functions of the SIPROTEC 5 Modules of the application ensure the key material for protecting the communication and data that is stored in encrypted security. Communication data is in an authenticated, encrypted and integrity-protected manner. Role-based access control (RBAC) in conjunction with password management enables authorized access to the device. Logging of security events ensures traceability of all changes.

By default only the essential functions of DIGSI 5 are activated in the device. All additional functions as well as the port numbers used can be activated as required. Unused ports can be configured. For example, only the ports necessary for PROFINET IO are enabled. Access to the device via serial interfaces is also possible. Disabling unused services further reduces the attack surface.

Authentication

Secure communication takes place between the device and DIGSI 5. This provides another mapping from browser to devices and making an entire data flow. Through this secure transmission protocol, the integrity and confidentiality of the transmitted data are ensured. This hinders manipulation and unauthorized access of the data.

Employment of connection after password verification

Optionally, a connection password can be set up on the device. Separate access via the Ethernet cannot take place until the user enters this password. Only after the connection has been established does the user have read/write access to the device. This connection password conforms to the cyber security requirements for assigned passwords defined in NERC CIP. It has to have a minimum length and must include upper and lower case letters, numbers and special characters. Through this secure transmission protocol, the integrity and confidentiality of the transmitted data are ensured. This hinders manipulation and unauthorized access of the data.

Central reference configuration IP

Safety prompts must be answered for safety-relevant actions, such as changing parameters, in order to obtain write access to the device. These safety prompts can be configured by the user, and may be different for different fields of application.

Secure logging

Unauthorized and unauthorized access attempts are also recorded and an alarm can be triggered by an independent safe message unit. The execution of safety critical actions is logged. These log entries are safeguarded against deletion. It may be transmitted to the substation automation unit and archived there.

Network protection for filter

Access that can be loaded into the device via DIGSI 5 can also be safeguarded, in the way, computer from outside to prevent its targets. An example with additionally manipulated firmware files, is reliably prevented.

Secure standard configuration

By default only the connection of DIGSI 5 is enabled in the device. All other Ethernet services of these ports are disconnected by default in the device and can be enabled with DIGSI 5, if, for example, only the ring redundancy protocol RSTP is used, then all the other ports enable this with DIGSI 5 (Figure 3.2/1). The secure standard configuration provides a potential attacker no open interfaces and only services that are really in use are still offered in a network.

Authentication

If, however, it is desirable to limit access connection passwords at the administrator IDs during the configuration at a later phase. During operation, however, the device must be capable of this. Comprehensive user access security can be guaranteed in the device and comprehensively has been completed and then deactivated for operation.

Figure 3.2/4 Example of a communication network using protocol [illegible]

Figure 3.2/5 Example of devices with integrated communication modules

Product Security Blueprint

The Product Security Blueprint in conjunction with the "Application Note – SINC APP 0010" for SIPROTEC 5 devices provides you with valuable hints for integrating devices in your network and operating them securely. An overall security concept should be drawn up and maintained in a "Operating Security Blueprint". This document typical network configurations, the devices used, and their ports. Main users for updating the components that are central for cyber security, password protection and also what protection are also described.

Figure 3.2/5 shows a recommendation on this. Here for connecting switchgear. The SIPROTEC 5 devices are integrated in optical Ethernet rings via switches. In these rings, each Ethernet based substation automation protocol, for example, IEC 61850 or DNP3 TCP and the devices required run with full line of performance. Accesses from a non-secure external network are allowed via a gateway that is responsible for encryption and protocol. The gateway ports is authenticated, for example, by SIDES 5, in the gateway, and communication is encrypted as VPN. This is fully supported by the commercial time protocol DIGSI 5.

The technical control network and the network for security access can also be separated strictly by appropriate selection of an independent Ethernet port for communication between the devices and DIGSI 5. This falls within the scope of the operator's philosophy. With their concept of pluggable modules, the devices also enable solutions with separate networks. An example can be of cyber security features have been presented in SIPROTEC 5 and DIGSI 5, and these are described in the next section.

Security patch management (security updates) for DIGSI 5

In response to the regulations for protecting power plants, many power system operators are interested for DIGSI 5. This means that regular security updates for the software components from third party providers integrated with DIGSI 5 is met by DIGSI 5 are tested for compatibility with DIGSI 5. A list of available security updates and compatibility notes is made available for download loading at the Internet and is updated at monthly intervals.

Figure 3.2/1 SIPROTEC 5 – Test Suite – Overview

DIGSI 5 Test Suite

The objective of the extensive test and diagnostic functions that are made available to the user with SIPROTEC 5 together with DIGSI 5 is to offer service, testing and commissioning tasks. All test functions are integrated in DIGSI 5. This enables engineering including the device test to be carried out with one tool. The most important functions should be listed as examples here. There are also other specific tests for others depending on the device type.

In a simulation mode: For this, the analog and binary inputs are decoupled from the process and connected to the integrated test sequencer.

The sequences DIGSI 5 to create a test sequence, for example, a commissioning sequence, loads it into the device and runs it in simulation mode. The test sequences in DIGSI 5 is capable of running up to ten tests in one test sequence. When numbering up to ten tests in one test sequence. When loaded into the device, the test sequence is run in real time and simulates the fault cases of the device like a real process as binary and analog inputs. Protection functions, control, logic functions, and communication can then be tested in real time without necessary test equipment.

The test sequence is started manually from DIGSI 5 or controlled via a binary input. This also makes it possible to test the interaction between several devices.

Hardware and wiring test

In the hardware test, the state of the binary inputs can be read out by DIGSI 5, and contacts and LEDs can be switched or tested through DIGSI 5 for test purposes.

The parameters monitored as voltage and current inputs are represented in phase diagrams – divided according to measured size and phase angle (Figure 3.2/2). Thus it is easy to detect and check if the connections of the measured sensing are correct and if the connections of the direction between connected and voltage. In devices that are connected via protection interfaces, even analog measurement points of remote ends can be represented at a glance. This makes it easy to check the validity of a differential protection.

In the same test, the analog connections between devices are tested. If the device is connected to a remote via Ethernet, the test can be combined with an end-to-end test. For this, the protection devices at both ends are connected via test equipment. The test is controlled by a binary input of one or more SIPROTEC 5 devices or a user connection. These automatically send a signal to DIGSI 5 or the other. Then the binary input has been picked up by a change of the output. The better can then check the signal times and check if an analog between the devices

Figure 3.2/2 [illegible]

Testing of protection functions and protection functions

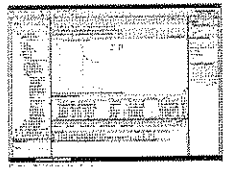


Figure 3.94 Test of protection functions in case of a symmetrical fault

Circuit-breaker test and AR test function

Switching sequences can be defined via DIGSI 5 as per the automatic reclosing (AR). However, this is only possible if remote switching via the key switch is permitted. In addition, a safety prompt (confirmation) is most commonly used for executing authentication via DIGSI 5.

There are additional safety prompts in non-activated switching. The possible protection signal interruption via interlocking principles during operation. A circuit-breaker test can also be deactivated and activated without an interlocking check.

Communication testing

Since communication is an integral component of the devices and they are interconnected either directly or via substation control systems, they must be thoroughly tested at routine testing and monitored continuously during operation. The integrated test tools assist the user in ensuring that the communication routes are tested and working efficiently.

<u>Loop test for the communication connections</u>

To do this, launched by DIGSI 5 via a communication module and a valid test interface, a protection interface is configured as a remote file end. It is used to detect disturbances in transmission when importing the physical connection of the communication route (Figure 3.95). Two telegrams are sent from the local terminating side to the remote end and back. The telegrams are sent in both directions via the two communication paths. The runtime is determined based on these telegrams and the asymmetry of the transmission path. The symmetrical telegram runtime, recorded and compared in digital form, is evaluated in DIGSI 5, so that the quality of the communication can be monitored.

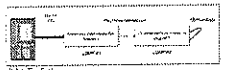


Figure 3.95 Loop test via protection interfaces

<u>Online monitoring of communication connection</u>

The data flow at communication interfaces can be continuously monitored. To do this, a number of telegrams that are sent, received and transmitted per time unit by communication and protection interfaces during operation are constantly measured and displayed. If faults occur, an alarm can be issued. A comparison between and assignment of system-specific detailed fault codes of Ethernet modules via the SNMP protocol.

For protection interfaces, the delay time of the signals is also monitored, and is calculated during synchronization by means of a half-by-device-specific pulse in the transmit and receive directions. Additionally, the communication topology is also monitored for clarity then and displayed in DIGSI 5. GOOSE connections can be monitored permanently at the receiving site during operation. This means that an outage is detected within a few seconds.

<u>Protocol test</u>

For the protocol test, specific signal values can be set and reset using DIGSI 5 (Figure 3.96). The test mode itself is manageable. The device sends the selected value to the client using the corresponding communication protocol. For example IEC 61850. In this case, a report is generated or a GOOSE message is sent automatically when this information is switched correspondingly.

The device can be used to test various control information for all protocols. For example, IEC 61850, IEC 60870-5-103, serial (DNP3, DIGS TCP) without the wiring through the plotters of generating signal states with test equipment. Signals that that are transmitted across protection interfaces can also be tested.

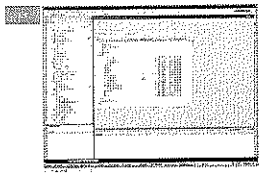


Figure 3.97 Display of external inputs

Test and display of external inputs

If the system data of the device is not externally valid or is absent, this state can be read out in the operation with DIGSI 5 (Figure 3.97). The time process between these values is indicated when there is setting the system time and device assignment regarding the quality of the time source. Synchronization via external inputs can also be supervised and displayed during operation (Figure 3.98).

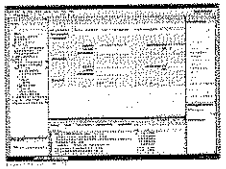
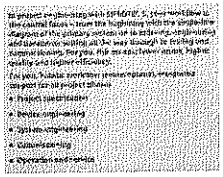


Figure 3.98 Test of external inputs

Analysis of logic diagrams (CFC debugging)

Logic diagrams prepared in the form of function charts (CFCs) can be tested online in DIGSI 5. To this end, test sequences can be generated with the DIGSI 5 sequencer to set logical inputs of the function chart in the working and binary inputs of the device. This makes it possible to test not only the function chart but also the interface and upstream and downstream functions. During this test, the values of variables are displayed and their changes over time are logged in records that can be analyzed later, for example, with SIGRA. This enables even complex temporal dependencies to be analyzed with ease. Functional checks, stable signal propagation times in the system configuration (routings), implementation of user-specific logic with function charts (CFC) and the parameterization must also be performed.



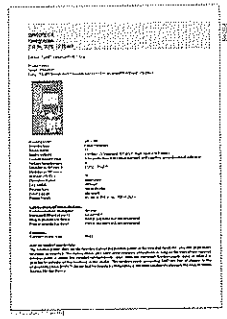


Figure 3.101 Representation of configuration result (hardware details)

Product selection via the order configurator

The online configurator assists you in the selection of SIPROTEC 5 products. The online configurator is a Web application that can be used with all common web browsers. The SIPROTEC 5 configurator can be used to configure complete devices or individual components, such as communication modules or expansion modules.

As the result of the configuration process, the product code and a detailed presentation of the configuration result are provided. It clearly describes the module and also serves as the order number.

All functions from the library

The SIPROTEC 5 devices also in future will be operated by a high dependency on device type. You can unleash these flexibly with any desired functions from the library. Additional functions are held with overloads because which is reflected in function points. The function point calculation assists you in finding the correct function point value for your application. This means that the selected device is the required functionality.

In the SIPROTEC 5 system, the major function is determined by the selection of the device type, consider the scope of the additional functionality is determined by a single property, the "basic one point value". This means that the functionality does not have to be fixed in detail during product selection. In the later engineering phase, you can then add additional functions can be selected from the device specific function library. You must simply ensure that your full one of function points ordered for the device is not exceeded. Extra function points can simply be purchased at any time.

Clearly presented result representation

The successful configuration of a device is represented on a clearly organized result page. You can also view the result as a .pdf file type (Figure 3.101). The specified product code can then be adopted directly into the ordering system or the ordering system of DIGSI 5 (www.siemens.com/siprotec).

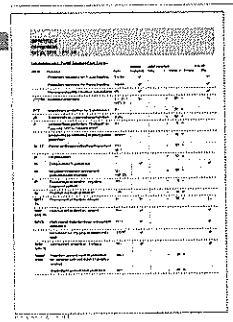


Figure 3.102 Representation of configuration result in detailed view (output)

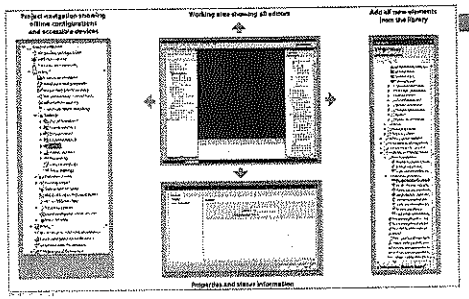


Figure 3.103 Structure of DIGSI 5 – overview

DIGSI 5

The product code calculated with the SIPROTEC 5 configurator can be selected directly with the engineering program DIGSI 5. In this case, the device-specific selected features directly in DIGSI 5 in all device characteristics are automatically shortened via the product code, engineering work with DIGSI 5 starts on a correct basis, without the need for a time-consuming re-entry of the device characteristics.

From planning to engineering up to testing – DIGSI 5

The engineering tool DIGSI 5 covers your workflow from planning to commissioning of substations and SIPROTEC 5 devices. With DIGSI 5 you have full control over the engineering. The individual stages of the workflow all tasks – from device configuration and parameter setting to communication and creation of user data.

This is how a modular, efficient engineering process is ensured.

In the initial planning, the system topology is represented using CAD. The system topology is designed for a new project. Detail planning in the SCD file (SCL Editor). Depending on the application the required functionality is selected for the device control and protection. Once all tasks and functions are defined and a device is selected. In the next step, the device is assigned or added to the project created in the workflow. Function-by-function is possible or you assign the whole device at the project owner template. The right performance for the functions can

for changed protective parameters, for configuring customer-certain mappings or for creating function charts (CFC).

In the device area of the screen view, you can quickly and conveniently access the properties of all elements (for example, with circuit breakers or signals). The same also applies to tests with warnings and errors.

The libraries are particularly important in DIGSI 5. They are beyond the right and context-sensitive that is offered in the editors. Here you select the required device and integrate into your project. When configuring the hardware, you can select different hardware components, for example, a communication module. On the other hand, if you are working with function charts (CFC), you select the corresponding logical building blocks and select the required function library when configuring the connection scope. For this purpose, you move the elements or the position of the editor where you need them.

Visual definition of the primary topology in single-lines

The single-line diagram designer, the primary topology of your system. (Figure 3.104). For this, simply select the required single-line templates from the library. Further processing, for example, as an overview, is possible without difficulty. DIGSI 5 contains a library with elements that are familiar to you from the ANSI and IEC standards.

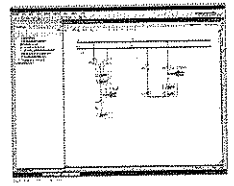


Figure 3.104 Creation of a single-line diagram in the Graphic Editor

From the application to the solution. Application templates and their modification

After the topology has been defined, the next step is to add the required devices. You simply take the ordering code from the configurator in DIGSI 5 or a new single-line editor is already known. In the next step, you select the application template appropriate for your application and adapt it according to your requirements. Remove functions that are not needed and add the desired functions. The user-friendly and intuitive editor ensures that you are successful. The connection of the devices and assignment is carried out, tested. Finally, you can additionally create the graphic user templates are previously elements of the single-line diagram (voltage or current measurement as well as circuit breakers). Thus, a topological reference is created. Getting values of the transformers (power) and secondary signal values, as well as the control point "substation with different feeders" can then be adopted into the single-line diagram.

Design of user-defined control displays

With the display editor you can create or change the factory set displays, known as control displays. The editor assists you in a typical workflow. You simply decide which fields of your already created single-line diagram are to be used for the display pages – and that is all there is to it. Naturally, the display can also be completely newly created or expanded. To do this, drag a signal from the library to a dynamic element in the display and the connection is created. Besides the use of icons in accordance with the IEC and ANSI standards, you can create your own static or dynamic icons in an icon editor.

Routing and assignment

The routing matrix is one of the most important hardware tools of DIGSI 5. It is conveniently divided between 2 editors, "Interconnection" and "Communication mapping". Both views are designed such that you can quickly complete your task. With pre-defined or user-defined filters, you reduce the displayed information to a minimum. As an option, you can select which information is to be displayed for each receiver (Figure 3.105).

In the matrix, all signals are sorted according to function and further groups. Sources and targets are displayed as columns. This example results from the compressed form of representation to a detailed representation of information in which you can view and change each point of information (routing to binary inputs and outputs, LEDs, logs, etc.) in different columns. In this way, all information can be configured very simply.

For communication mapping all necessary settings are already regulated for the selected protocol. You can adapt these simply and quickly to your needs.

With a large selection of filters and the option to open and close rows and columns, you will find it easy to display only the information you need.

Routing matrix is possible, with DIGSI 5. All table-based data displays furnish the functionality to fill all user cells with a single mouse click – in the same way you know from Excel.

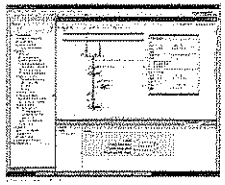


Figure 3.1605 Graphical sequencing of interlocking check

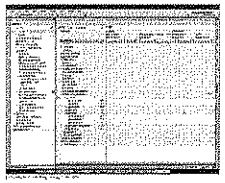


Figure 3.1606 Operation flexibility at the information matrix editor

Protecting your plant better against invalid operations

A PLC (Programmable Logic Controller) where, for example, standard interlockings can be executed, is integrated in SIPROTEC 5 devices. If you want to change or adapt the CFC, use the function chart (CFC) editor that is included as a component in DIGSI 5 Standard and Premium. Thanks to the fully graphical user interface, even users without programming knowledge can fully utilize the functional scope and thus flexibly adapt the functionality of the device (*Figure 3.1607*).

For this, an extensive library is available to work with building blocks that are compatible with IEC 61131-3. This library contains simple logical operators, such as AND, but also complex functions, such as timers, command chains for switching sequences, and many more.

The use of the editor is more efficient than ever before: You thus need fewer building blocks in order to achieve your objectives. This decisively improves the readability of the function chart (CFC). New display modes also enhance clarity. The creation, modification and test of expansions work of the building blocks and creation of plants – all that you can use all the application functions without having to install it yourself.

Each function or device in the plant that CFC is assigned to becomes live. During operation and downtimes, the logical library in the respective project or a building block – and you are creating. Created logic plans can be assigned over several devices defined with DIGSI 5. This ensures the necessary quality in communication and saves you a time and effort.

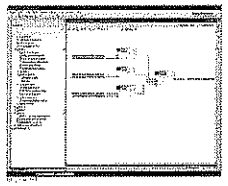


Figure 3.1607 Customization of automation with the CFC editor

Setting the parameters of the device

All parameter settings are represented in the same way. The creation of the parameter values, which displays all parameters of a function, lets you have the choice between different views of the settings. On the one hand there is a primary view where you can directly enter the primary setting values.

In this way, you can avoid using conversion factor errors, which can lead to setting errors. The same applies for the "per unit" view where setting parameters refer to object rated values. If you decide on the secondary view, the setting parameters must be converted to secondary values.

For setting special protection characteristics, the graphical representation of the characteristics is of advantage. In the parameter editor, all characteristic curves of the function are represented. Through this, you can graphically check the effects of changes in the settings immediately. Existing values of different setting groups can quickly and easily be compared in a common window, differences can be detected and compensated for (*Figure 3.1608*).

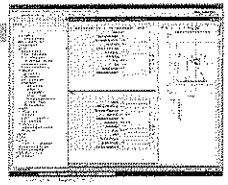


Figure 3.1608 Easy comparison setting

Cooperating in teams

Improve plant engineering performance by cooperating in teams. Using extensive export and import functions, you create or define the protection parameters and work on the routing sections while others set system interface parameters. The individual areas can be updated at any time with new versions of e-diagrams. For example, when the protection parameter group has updated its data, this data can be mapped in the project.

Comprehensive testing support during commissioning and operation

The testing and diagnostic functions assist you in the commissioning phase. You can thus quickly and simply test the wiring and observe the effect that a message caused over the system interface, on the operator station. The error messages that are recorded in the event of a disturbance of the protected object in the relay are listed in DIGSI 5 and can be displayed, saved and printed for documentation purposes.

The new testing options are an innovation. Multi level test equipment can be defined down to the phase sections via a sequence functionality. These are loaded into the device with DIGSI 5 at the click of the physical inputs there. There are then simulation in the device via the integrated test sequencer, which simulates the analog process values. In this way, you can define all disturbance cases and check for passing your project engineering and logic at an early stage.

With the new and diagnostic functions, extensive test equipment is not longer necessary or needs are reduced to a minimum. Processes that were made for testing special protection principles, such as for line differential protection, can be found in the operation device manual. The function chart (CFC) editor also offers new analysis functions. DIGSI 5 thus enables offline debugging of logic plans as well as tracing of measured values – both in the representation of the logic plan and in the representation of logs. The indices overall testing effort during commissioning. The results of the function chart (CFC) analysis can also be represented after completion of the test sequence, for example, with the assistance of SIGRA. Thus, even complex sequence relations can easily be analyzed.

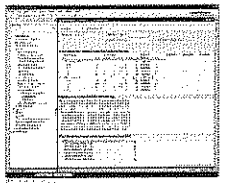


Figure 3.1609 Graphical testing of the device with all device signals, states

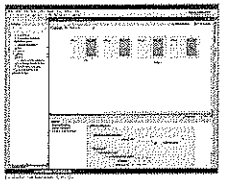


Figure 3.1610 Graphical testing of the device with all device signals, states

Direct online access of all accessible devices

DIGSI 5 also assists you in your workflow if your devices already offline are connected or is a device in your plant in your system. In DIGSI 5, all devices accessible via communication interfaces are displayed automatically in your offline device. The preferred communication in networks is Ethernet. Fortunately, you can individually select devices via a USB interface. In order to work with a physical device, connect the online device and offline configuration via drag and drop, and you are done.

Besides transferring the device configuration to individual devices, you can also automatically transfer all device configurations in your devices.

Besides online access, in addition to reading fault records and message logs, you can also display measured values and

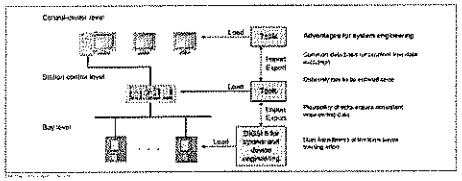


Figure 3.1611 Open, non-proprietary communication via Ethernet at all levels

IEC 61850 - Ethernet-based substation automation protocol

IEC 61850 is known that just a substation communication protocol. The standard comprehensively defines data types, functions and communication in station networks. In Edition 2, the definition of the standard is extended to open systems of the energy supply industry. Siemens actively participated in designing the process of updating Edition 1 to Edition 2 for the purpose of the standardized "plug-and-play". Edition 2 follows various omissions and defines additional applications. As a global market leader with Edition 2 SIPROTEC 5 devices have resolved the issues of interoperability, flexibility and compatibility between Editions 1 and 2. Compression with Edition 1 devices is possible without restriction.

IEC 61850

- Connecting the complexity of the IEC 61850 data models in your familiar user language
- Integrated, consistent system and device engineering from the single line of the plant to device parameterization on the basis of the IEC 61850 data model
- Flexible object modeling, freedom in addressing objects and flexible communication services allow the highest possible degree of interoperability and effective exchange and separation concepts.
- Full compatibility and interoperability with IEC 61850 Editions 1 and 2

The internal structure of SIPROTEC 5 devices conforms to IEC 61850. The user profit is that for the first time an integrated, end-to-end system and device engineering, from the single plant line to device parameterization, conforming to the guiding principles of IEC 61850 is possible.

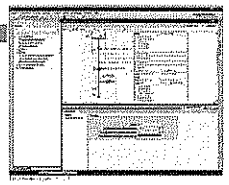


Figure 3.1612 System-specific adaptation of DIGSI 5 – the complexity of IEC 61850 is transparent

DIGSI 5 with integrated IEC 61850 engineering covers the complexity of the standard with a sophisticated user interface. In standard engineering, you as the user will not be required to deal with the details of IEC 61850; you get to use your user language.

In the user language, distance protection is distance protection with zones and dependent functions, not a collection of logical nodes. Reports are message lists in which it is known also about the system context is configured. In the system configuration, GOOSE connections are simply configured in a multi-point source and target information. You work in your language, with functions and messages associated with a device. If you wish, you can view the structured IEC 61850 objects in the IEC 61850 protocol language. This bilingualism is supported throughout the user interface by DIGSI 5 and it is easy to "live in the substation" control system. At the user you can over and Publish rules in the data sheets you define in your language and then export them for data purposes in the ICD and SCD description.

Figure 3.1613 Create your IEC 61850 name

Flexible engineering offers IEC 61850 experts a wide range of freedom to design the new IEC 61850 systems, including their own tailored functions and objects. Flexible object modeling, freedom in addressing objects and flexible communication services across the highest possible degree of interoperability and effective exchange and separation concepts.

The name of the logical device (LD Name) is freely editable. For example, the standard configuration name CTRL can be changed to CONTROL. Structural changes can also be made by changing the logical device (LD), so that the interface structure can be flexibly adapted to the user's own requirements. Rigid manufacturer specifications are a thing of the past. Prefix and ordering of the logical node (LN) can also be edited.

The standard prescribes the length and rules that are checked by DIGSI 5 when they are entered.

Function levels of a device, which the standard maps in logical nodes (LN), can be deleted, copied, and regarded with the user's own objects. Messages can be added to a switching object such as the LN XCBR, for example, monitoring messages for a circuit breaker that have not been defined in the original LN. As the user, you can make all of the information associated with a given switching object into a logical node (LN).

Logical nodes (LN) can be added from a library. These instances can be supplanted and with your own objects. You can also define and create generic nodes. For example, these are logical nodes (LN) whose functionality you as the user create for yourself through a specification. These user-defined functions can be loaded into the device and run there. Real-time functions can be created and supervised as required.

A high degree of flexibility in communication is offered for configuration of GOOSE messages and inputs.

Addresses, datatype names, etc., can be set by you, the user.

Flexible engineering offers a high degree of design freedom on every level, ensuring interoperability for multi-vendor communication and the possibility. This in turn safeguards investments in models created in accordance with IEC 61850.

With the single-line diagram, you as the customer can view the topological structure of the system. DIGSI 5 has been prepared so that a customer's topological structure of a system to the IEC the performance to the standard. The description, as an interface in the SCD file, represents the primary system for technical data purposes. In the future, the objects of the device with which processes of the primary system are controlled can be adapted flexibly to reflect the customers' specifications. Flexibility in the key to bringing the systems one into harmony with the IEC 61850 structure of the device.

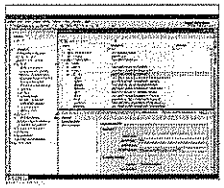


Figure 3.1614 Editor for adapting the IEC 61850 structure in the SIPROTEC 5 view

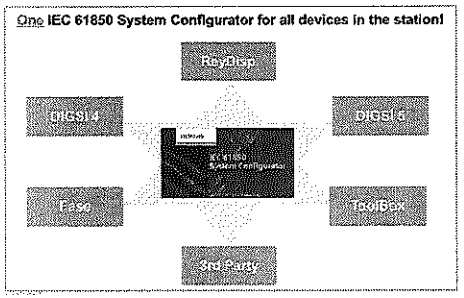


Figure 3.1615 A IEC 61850 system configurator for all devices in a station

IEC 61850 system configurator

The IEC 61850 system configurator is the manufacturer-neutral editor for the implementation of engineering of IEC 61850 products in substations and supports all devices with IEC 61850, e.g. with Siemens products like SIPROTEC 5, SIPROTEC 4, SIPROTEC Compact, Reyrolle, SICAM RTUs, SICAM PAS/PAS CC (IEC 61850 devices from other suppliers (such as KEMA's IPCI) or from third parties.

It is used to create the ICD (substation configuration description) and SCD (system configuration description) files in accordance with IEC 61850 Edition 2.

Import or export of all formats (COMTRADE, PSDAT, DAT, etc.). Thus, IEC 61850 devices can be added and compared in IEC 61850 Edition 2 is available for the substation automation technology.

IEDs from the IEC 61850 standard of Edition 1 or Edition 2 are supported. The possible engineering therefore includes not only the GOOSE recommendations and the client-server configuration via MMS reporting but also the process logic of a process bus communication with SAV (sampled measured values) and the IEC 60870-5-104 addresses for the gateway to the network control center via IEC 61850 ed. 1.

Simple and powerful thanks to customer-friendly workflows and the universal display of IEC 61850 addresses as well as customer-defined texts, users with IEC 61850 basic or expert knowledge find the desired level of detail. For documentation purposes, the engineering can be displayed in the web browser in a customer-friendly form.

Structured interfaces of the tool, such as with DIGSI 4 and DIGSI 5, reduce the engineering effort for Siemens engineering even more.

Effective fault analysis with SIGRA

After a protection trip followed by a system incident, it is important for the fault to quickly and completely analyzed. With the fault records saved in the SIPROTEC 5 devices, you can always quick and reliable even complicated fields. The high performance tool SIGRA stands you in your evaluation. Besides the usual time signal representation of the recorded measurands, it is also designed to display vector diagrams, limit diagrams and fault charts in order to represent harmonics and data tables. From the measured values recorded in the fault records, SIGRA calculates additional values, such as mixing quantities in the 3-phase current system, impedance, admittance components, etc. Derived signals can be synthesized easily and conveniently using a measuring concept.

You can also add to evaluate several fault records in parallel with SIGRA. For example, the record from the end of a line differential protection. You can synchronize these two measurement files, they (zoom, as usual and save as a new overall representation in a diagram). Thus, the detect overlaps as well as disconnects.

SIGRA also runs as an offline fault viewer. If the compact, the fault records have also been evaluated. Through the graphic display of the fault behavior you save time, which you can then use in knowledge the fault or else.

SIGRA can be used for all fault records present in the COMTRADE or SIPROTEC 5 formats. The software product is available in an optional package or additionally in DIGSI 5 Standard, as a stand alone version or as a component of DIGSI 5 Premium.

Figure 3.1616 SIGRA overview

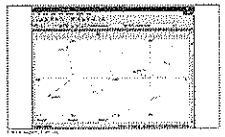
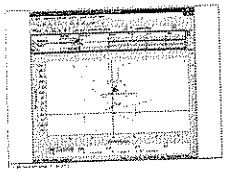
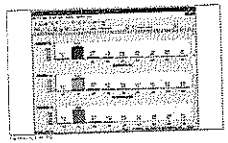


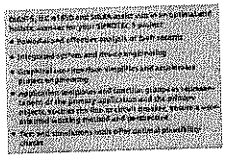
Figure 3.1617 SIGRA overview

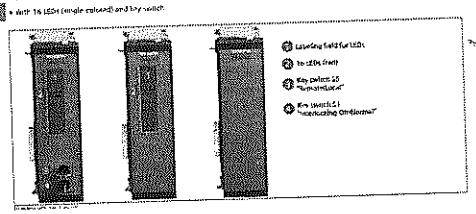
Overview of functions

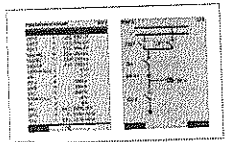
- 6 diagram types
  - Time signal representation (standard)
  - Circle diagrams (for example for PQ)
  - Vector diagrams (pointing of angles)
  - Bar chart (for example for evaluating harmonics)
  - Table (with values of selected signals in the time point in level)
  - Fault location determination (display of fault location)
- Calculation of additional values, such as e. positive sequence, negative sequence, RMS values, various neutral components, phases etc.
- 2 measuring cursors that are synchronized in all views
- High performance processing across functions (e.g. session management)
- User friendly program operating via drag & drop
- Innovative signal naming as a result, customized names
- Time saving presetting, which can be assigned to individual fault types, as users
- Addition of further fault records and synchronization of multiple fault records with a common time base
- Simple documentation through copying of the diagrams e.g. into MS Office applications
- Efficient fault location determination

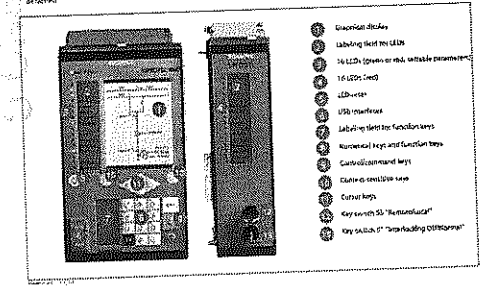


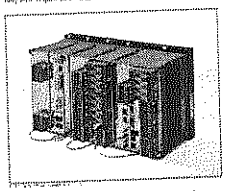


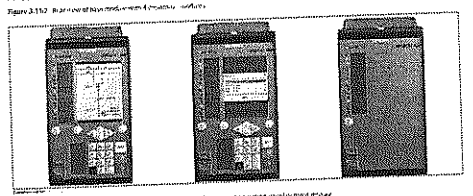


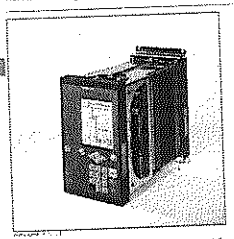


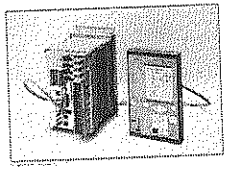












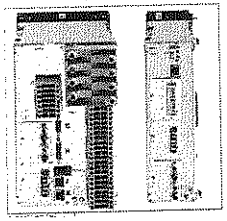


Figure 3.1.1.01 Basic connection between two communication interfaces and the module rack (with base module, e. g. size C or D)

Integrated Ethernet interface (EN100)

This electrical RJ45 interface serves to connect SIPROTEC 5 via a local Ethernet network. In this way, several devices can be operated from DIGSI 5 via one electrical cable. DIGSI 5 detects the devices over software and configuration or the local network and can assign them network addresses.

Optionally, the protocol IEC 61850 can be activated on this interface for connections up to 6 clients. With the 7SA82 devices and SIPROTEC 5 with CP300, GOOSE messages are also supported on the interface.

Time synchronization interface (port G)

Via the 9-pole Sub-D socket (connection compatible with SIPROTEC 4), the time in the device can be synchronized. The set clock telegram IRIG B005 (B02) of a GPS receiver can be fed with 5 V, 12 V or 24 V levels. In addition, the format Sinaucron DCF77 format with summer and winter time changes is supported. An additional second pulse input enables microsecond-precise synchronization of the device from a highly precise time source, e. g. a special GPS receiver. The accuracy needed for special protection and measuring tasks in this way, devices can be precisely synchronized to the microsecond using a receiver, for example, from Siemens. Suitable pre-fabricated complete solutions with time receiver, optical fiber converter and appropriate connection cables.

Connection of detached operation panel (port H)

A detached operation panel provided together with the control display can be connected to this interface. The maximum distance is 2.5 or 5 meters.

Connecting the expansion unit CB202 (port K)

The base module offers slots for 2 plug-in modules. If more plug-in modules are needed, these can be installed via a special expansion module CB202. The module is connected via RJ45. The expansion module is delivered with an appropriate cable and is connected to the base module with the CB202 interface module. The CB202 interface module is connected to the base module with the CB202 interface module. The CB202 interface module is connected to the base module with the CB202 interface module.

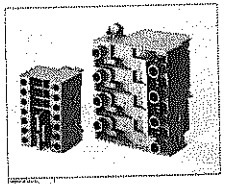


Figure 3.1.1.02 Installation of communication interfaces at 1/3 module

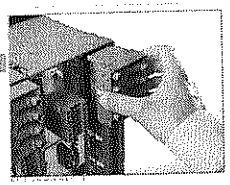


Figure 3.1.1.11 Removed current module base

Current transducer

The 8-pole connection terminal with 4 integrated current transformers is available in 1 version:

- 4 protection current transformers
- 4 protection plus current transformers + 1 sensitive protection class transformer
- 4 transducer transformers

The terminal design provides the following advantages for the connection of current:

- Exchange of the current transformer type also possible on the already installed device, for example, protection class current transformer for standard transformer, sensitive for normal ground current transformers or types of transducer connections
- Additional safety during test or device replacement, since the secondary current transformer circuits always remain closed

Voltage terminal

The voltage transformers and the binary inputs and output signals are connected via the 14-pole voltage terminal. The cable route away from the device enables clear terminal wiring. Jumpers, precisely matching the current and voltage terminals are available for connecting contacts in common potential (see also Jumper Assignments, chapter **Attachment**).

Modules

Selection of the input/output modules

Which and how many process connections a base or expansion module has depends on the choice of a particular input/output module. The modular building block concept includes different input/output modules.

The IO202 input/output module is used, for example, as a base measuring module. By equipping several modules with IO2, you can achieve up to 20 measuring channels per SIPROTEC 5 device.

- 8 binary inputs
- 4 high-speed binary outputs
- 4 current transformers, optional protection class current transformer, sensitive protection class current transformer or transducer transformer
- 4 voltage inputs (U)
- 4 binary outputs (BO), designed as 1 fast and 3 high-speed contacts and 2 fast and 2 high-speed contacts

The connectors are distributed over:

- 1 x 8 pole current terminal block
- 1 x 14 pole voltage terminal block

Select the modules suitable for your purposes on the web for build the SIPROTEC 5 device that precisely matches your application. An overview of the modules and their possible structures can be found in Table 3.1.1.1.

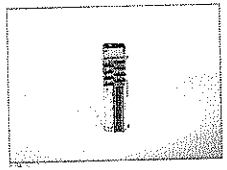


Figure 3.1.1.12 Removed current module

Control terminal

To add the quantity structure of a device with 4 parallel modules or more, it can be expanded by a control row. A PS201 power supply is required for one of the two mounting positions of the control row. The two remaining positions can be filled with parallel modules from the SIPROTEC 5 building block. Exception: The CB202 must always be positioned in the last row and can only be used once per device.

Module CB202

Module CB202 represents a special case. The CB202 provides 2 plug-in module positions for up to 2 communication modules or up to 2 measuring transducer modules. Combinations are also possible, for example, 2 communication modules and one measuring transducer module.

The power supply is not required, so that the CB202 can be powered independently of the master unit. Communication with the master unit is passed via an RJ45 connector and the bus connection on the front of the module.

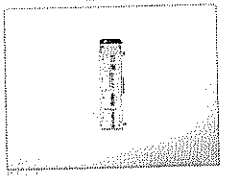


Figure 3.1.1.13 Type current module CB202

Measuring ranges of current transformer modules

The measuring ranges (full modulation) of the current transformers can be set to different values electronically. Depending on the base or application, in addition, you can choose between protection and instrument transformers. Due to the wide dynamic range, only protection class current inputs should be considered for fault recording. In protection class, wide ranges provide a rounded current up to a max. of 700 A & 1/5 A measure of range across and beyond.

A large dynamic range is necessary for metering power applications, so that all necessary currents can be recorded without distortion. A value of 100 % $I_{n,sec}$ has the same primary load in all transformers, this corresponds to a transformer rated primary current of 5 kA, and consequently of 1000 A for 1 A rated current. For applications in generator protection, where it can occur that there are very large primary currents, a dynamic range of 20 x $I_{n,sec}$ is sufficient. Thus, a primary value of 100 kA is obtained for a rated current of $I_{n,sec}$ = 5 and a maximum range of 20 A for $I_{n,sec}$ = 1 A.

A smaller dynamic range means that in general measuring error may be achieved at the rated current range. Consequently, the dynamic range for instrument transformers and sensitive protection current transformers (ground fault) should not, as is frequently limited, in this case, limited more than the input currents is increased to 8 x rated value. If necessary, the input circuits are protected against overloading.

	Protection current transformer	Sensitive protection current transformer	Instrument transformer
Rated current I_n	1 A 5 A	1 A 5 A	1 A 5 A
Thermal rating (r.m.s. value)	500 A for 1 s 100 A for 10 s 30 A continuous	300 A for 1 s 100 A for 10 s 30 A continuous	300 A for 1 s 100 A for 10 s 30 A continuous
Dynamic current overload capability (peak value)	1250 A 250 A	750 A 250 A	750 A 250 A
Burden	0.05 VA 0.3 VA	0.05 VA 0.3 VA	0.05 VA 0.3 VA
Overload capability	4 x I_n continuous 20 x I_n for 1 s	4 x I_n continuous 20 x I_n for 1 s	4 x I_n continuous 20 x I_n for 1 s

Table 3.1.1.01 Measuring ranges and load capacity

Plug-in Modules

Plug-in modules are available for many applications in the 1/3 inputs and are protected. The communication modules are described in the "Communication" chapter.

Measuring transducer module ANAI CA, EL

The module has four 20 mA inputs. It can be plugged into any of the slots in the PS201 or CB202. Multiple installed value modules can be used with each device (one per slot). In addition, the connections are created via an 8-pole screw terminal block (Figure 3.1.1.13).

The technical data for the measuring transducer modules is provided in the Accessories "Summary of Technical Data".

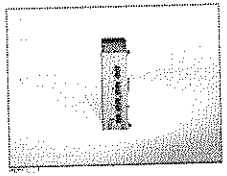


Figure 3.1.1.14 Power module PS201

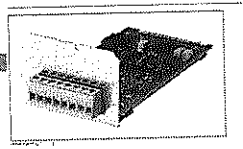


Figure 3.1.1.15 ANAI CA, EL Measuring Transducer Module

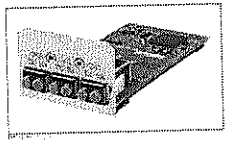


Figure 3.1.1.16 Arc protection module ARC CD 3PO

Arc protection module ARC CD, CP0

Up to 3 optical point sensors per arc protection plug-in module (Figure 3.1.1.16) can be connected. This yields a maximum number of up to 15 sensors for modular SIPROTEC 5 devices. The point sensors can be ordered with connection cable lengths from 2 m to 35 m.

Quantity structure of the modules for 7xx82 devices

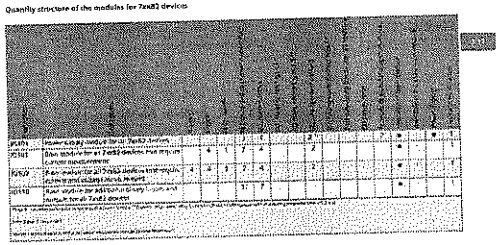
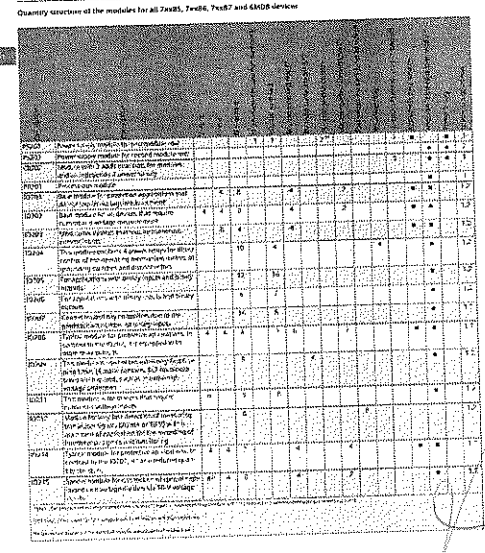


Table 3.1.1.03 Quantity structure of the modules for 7xx82 devices

Quantity structure of the modules for all 7xx85, 7xx86, 7xx87 and 6MD8 devices



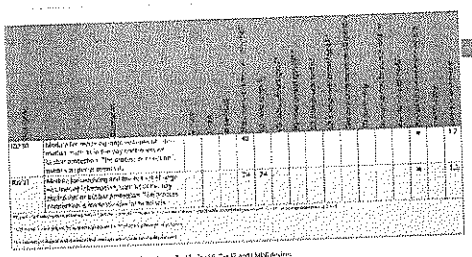


Table 3.11/4 Standard variants of the 1/3 x 19" device (housing width = 103.2 mm)

Standard variants

To make it easier to select the correct devices, Siemens offers you pre-configured devices called standard variants. These are combinations of a base module and one or more expansion modules are intended for specific applications. In this way, you can order exactly the right device with a single order number. The standard variants can also be modified easily and quickly with additional expansion modules. Thus, it is just as easy to add modules as it is to replace master modules with others. The available standard variants are listed in the order information.

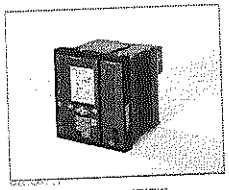


Figure 3.11/17 Standard variant SIPROTEC 7SJ87

Figure 3.11/17 shows one possible standard variant for SIPROTEC 7SJ87. This variant describes a 1/3 x 19" wide device having the following hardware properties:

- 15 binary inputs
- 28 binary outputs
- 8 current inputs
- 8 voltage inputs.

The modules used in the device can be seen on the rear view page of the SIPROTEC 5 configurator (see chapter "Engineering" for more details).

In our example, the following modules are used in position 1 to 3:

- Position 1: 1020d
- Position 2: PS201
- Position 3: 1020d

The individual terminals are defined by the mounting position of the module and the terminal design (dots) of the module (see the Attachment, "Connection variations").

As an example, the terminals of the four current inputs, which are on the 1020d at position 1, are designated as follows:

- I1: 1A1 and 1A2
- I2: 1A3 and 1A4
- I3: 1A5 and 1A6
- I4: 1A7 and 1A8

- 1: 1A1 and 1A2
- 2: 1A3 and 1A4
- 3: 1A5 and 1A6
- 4: 1A7 and 1A8

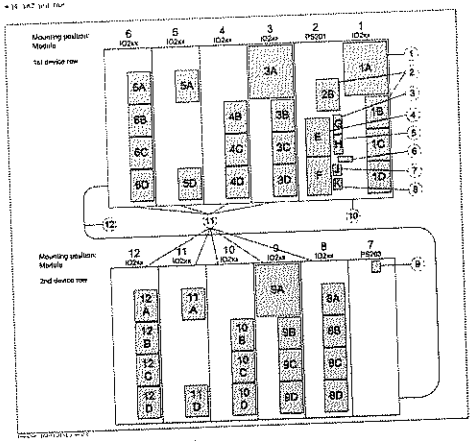


Figure 3.11/18 Terminal configuration and numbering method

(1) Current terminal A
(2) Voltage terminal A, B, C, D
(3) Terminal for slave type2 connection G
(4) Plug-in modules E, F

(5) Terminal for detached or the operator panels
(6) System connections
(7) Terminal for ethernet interfaces
(8) Terminal for COM serials
(9) 2 pole terminal for current power supply
(10) Base module in 1/3 19"
(11) Expander modules 1/6 - 1/2 19"
(12) Connecting cable between terminal 2 of device sets

A maximum of the flexible hardware modules can be individually configured and applied hardware types for your application.

- For many applications, the appropriate device specification can be directly performed in a standard variant.
- The hardware extension can be done by the user himself.
- The combination SIPROTEC 5 device with Siemens current transformers offers decreased space in switchgear racking and modelling when exchanging the transformer type.

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Appendix

DIGSI 5 – Variants and system requirements – Description

Description

DIGSI 5 is the versatile engineering tool for protection, control, bay and substation devices of SIPROTEC 5 and 7SX800. It offers convenient access to individual settings as well as powerful solutions for complex projects. The graphical user interface guides you efficiently and intuitively through the workflows. DIGSI 5 provides online access and topology recognition of the devices via Ethernet. The offline abilities of DIGSI 5 enable you to work independently of the devices and to create settings in advance. Time-saving tools and wizards assist in all tasks.

DIGSI 5 software is modular and is configured for your tasks and your devices. Therefore you can install only the components you need. Simply add a license key to activate additional functions. Different user authorizations and standardized workflows increase efficiency, support quality and training.

Overview of functions

DIGSI 5 is tailored to specific requirements. The base software variant DIGSI 5 Compact offers everything that is required for a single device. The DIGSI 5 Standard Version is suitable for complex operation and visualization. DIGSI 5 Premium contains the full functionality and helps you make your project fully scalable and safe. The functionalities of the various DIGSI 5 variants are listed in the table "Features of the various DIGSI 5 variants".

The available DVD contains all components in English (International), German, French, Portuguese, Spanish, Turkish, Russian and Italian. More languages will be added at a later time. The delivered package includes a USB cable for connecting directly to the PC and a license card with the license for activating the program.

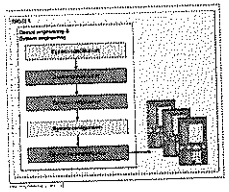


Figure 4.101 Structure of DIGSI 5 (power system)

Hardware requirements

- Intel® Celeron™ Dual Core, 2.2 GHz (Sandy Bridge)
- 5 GB available hard disk space (Solid state disk (SSD) recommended)
- 4 GB RAM (8 GB recommended)
- HD ready graphic display ready with a resolution of 1,280×1024 or 1,377×768

Software requirements

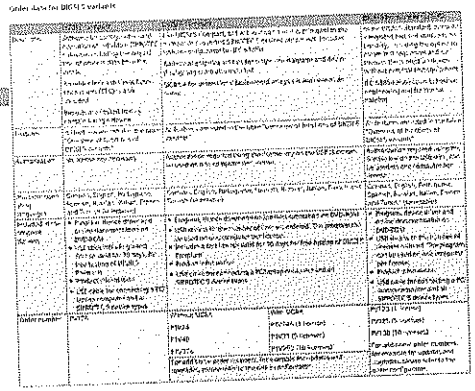
The following operating systems are supported:

- MS Windows 7
- MS Windows 8.1
- MS Windows Server 2012 R2
- VMware support for stated operating systems running under one of the supported Windows operating systems

A complete list of supported operating systems is archived in the product information for DIGSI 5. The detailed requirements, restrictions and an update manual, including version descriptions of updates and the Release Notes for DIGSI 5, are contained in the online help.

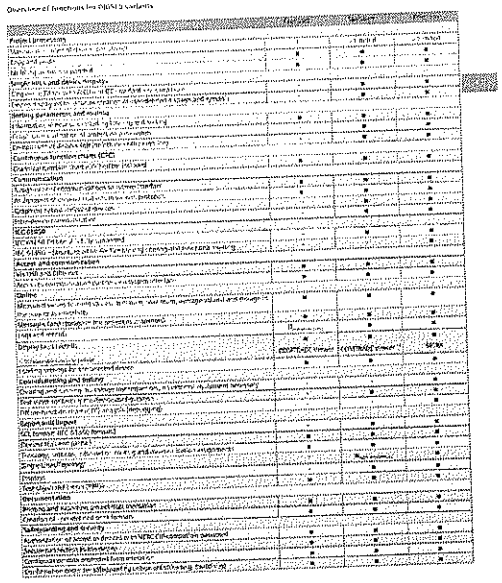
DIGSI 5 – Variants and system requirements – Order data for DIGSI 5 variants

Order data for DIGSI 5 variants



DIGSI 5 – Variants and system requirements – Overview of functions for DIGSI 5 variants

Overview of functions for DIGSI 5 variants



Spare parts and accessories

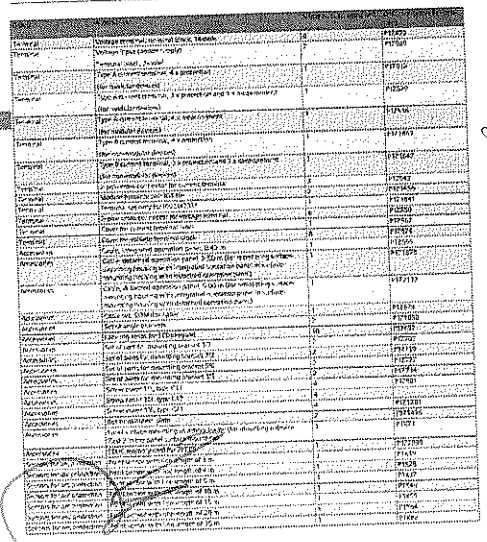


Table 4.201 Spare parts

Connection diagrams

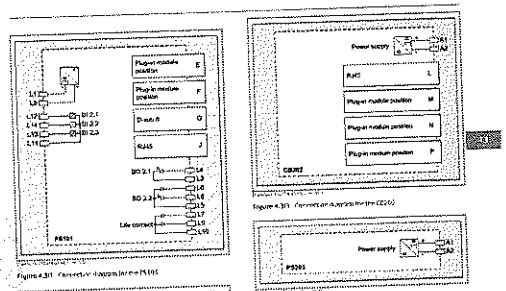


Figure 4.201 Connection diagram for the PS101

Figure 4.202 Connection diagram for the CB202

Figure 4.203 Connection diagram for the PS201

Figure 4.204 Connection diagram for the IO201

Figure 4.205 Connection diagram for the IO202

Connection diagrams

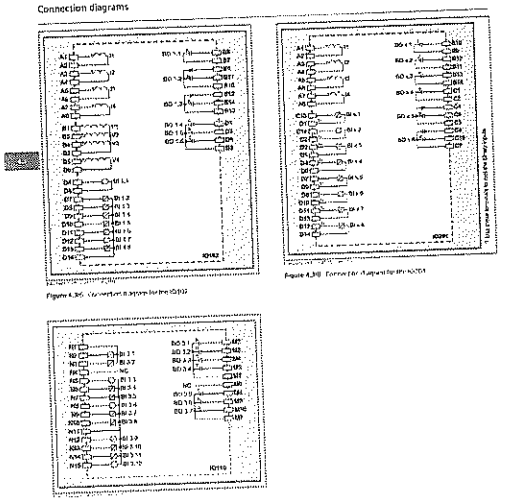


Figure 4.206 Connection diagram for the IO203

Figure 4.207 Connection diagram for the IO204

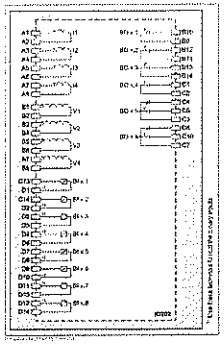


Figure 4.3/9 Connection diagram for 7SD610

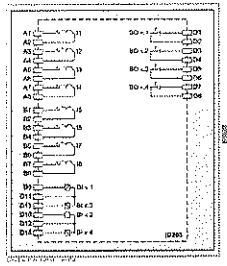


Figure 4.3/10 Connection diagram for 7SD610

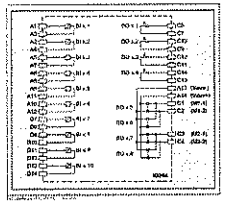


Figure 4.3/11 Connection diagram for 7SD610

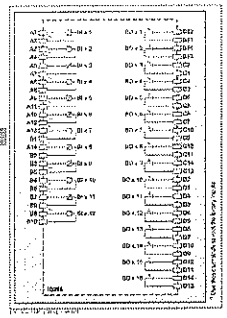


Figure 4.3/12 Connection diagram for 7SD610

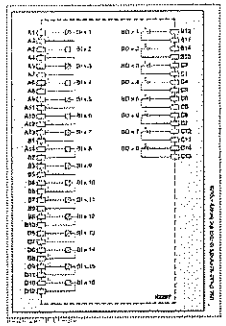


Figure 4.3/13 Connection diagram for 7SD610

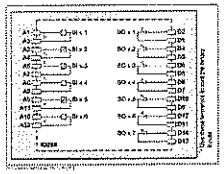


Figure 4.3/14 Connection diagram for 7SD610

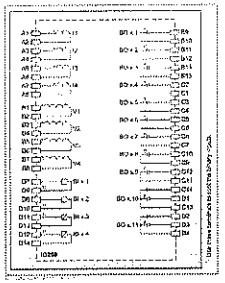


Figure 4.3/15 Connection diagram for 7SD610

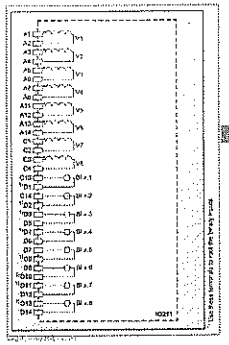


Figure 4.3/16 Connection diagram for 7SD610

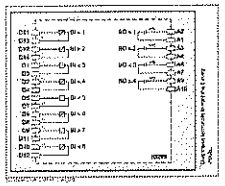


Figure 4.3/17 Connection diagram for 7SD610

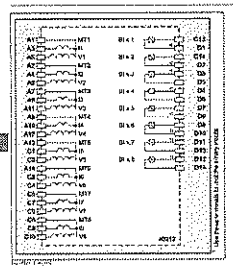


Figure 4.3/18 Connection diagram for 7SD610

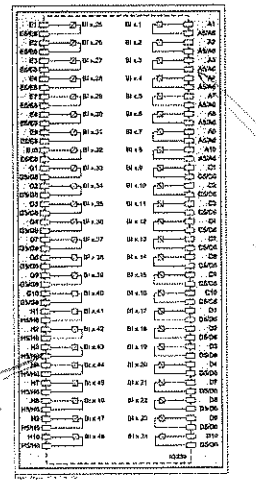


Figure 4.3/19 Connection diagram for 7SD610

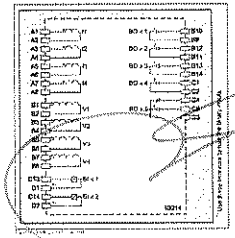


Figure 4.3/20 Connection diagram for 7SD610

The connection designations identical to the input and output modules (7XP20) of the analog input models

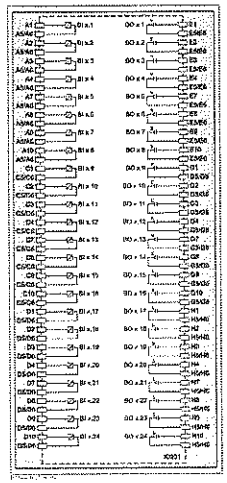


Figure 4.3/21 Connection diagram for 7SD610

Flush-Mounting Device

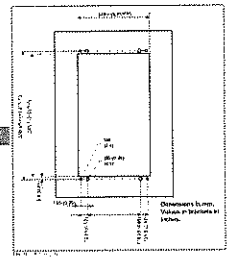


Figure 4.4/1 Flush-Cut Widths and Drilling Patterns – 1/3 Device, Front View

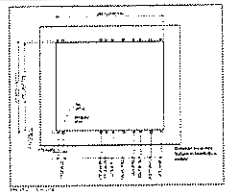


Figure 4.4/2 Flush-Cut Widths and Drilling Patterns – 1/3 Device, Front View

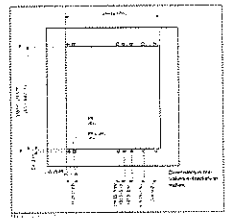


Figure 4.4/3 Flush-Cut Widths and Drilling Patterns – 1/2 Device, Front View

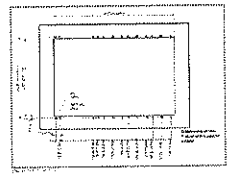


Figure 4.4/4 Flush-Cut Widths and Drilling Patterns – 1/2 Device, Front View

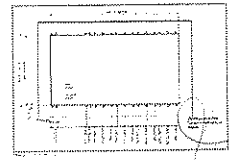


Figure 4.4/5 Flush-Cut Widths and Drilling Patterns – 1/1 Device, Front View

Dimension drawings – Flush Mounting Device

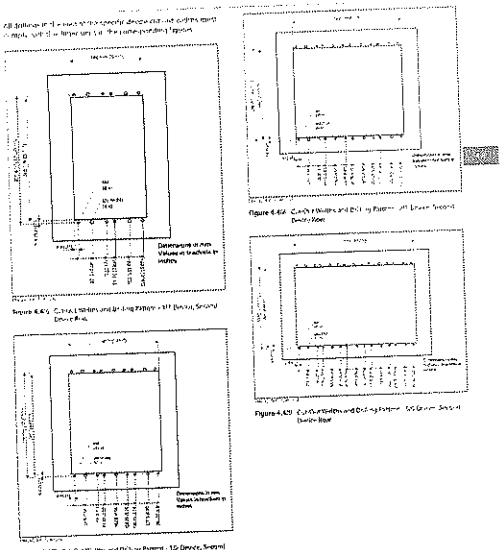


Figure 4.4/6 Cut-Out Widths and Drilling Pattern – 1/1 Device, Second Device Row

Figure 4.4/7 Cut-Out Widths and Drilling Pattern – 1/2 Device, Second Device Row

Figure 4.4/8 Cut-Out Widths and Drilling Pattern – 1/1 Device, Second Device Row

Figure 4.4/9 Cut-Out Widths and Drilling Pattern – 1/2 Device, Second Device Row

Dimension drawings – Surface-Mounting Devices with Detached On-Site Operation Panel

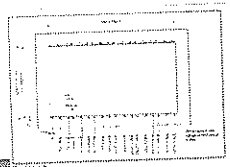


Figure 4.4/10 Cut-Out Widths and Drilling Pattern – 1/1 Device, Second Device Row

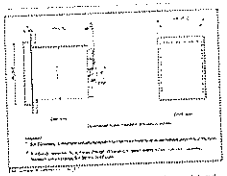


Figure 4.4/11 Cut-Out Widths and Drilling Pattern – 1/2 Device, Second Device Row

1/1 device (cut-out width)	140 mm (5.51 in)
1/2 device (cut-out width)	273 mm (10.75 in)
Height (all)	236 mm (9.29 in)
Side spacing (minimum width)	5 mm (0.20 in)
Top spacing (minimum width)	5 mm (0.20 in)
Bottom spacing (minimum width)	5 mm (0.20 in)
1/1 device (cut-out depth)	140 mm (5.51 in)
1/2 device (cut-out depth)	140 mm (5.51 in)

Table 4.4/1 Cut-Out Width

1/1 device	140 kg (309 lb)
1/2 device	270 kg (595 lb)
2/1 device	280 kg (617 lb)
2/2 device	540 kg (1190 lb)
3/1 device	420 kg (926 lb)
3/2 device	810 kg (1786 lb)

Table 4.4/2 Permissible Weights

Surface-Mounting Devices with Detached On-Site Operation Panel

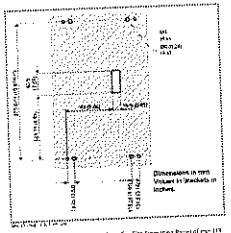


Figure 4.4/12 Drilling Pattern of the On-Site Operation Panel of the 1/1 Device

Dimension drawings – Surface-Mounting Devices with Detached On-Site Operation Panel

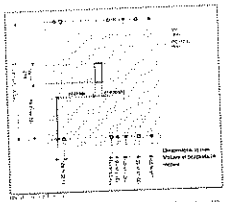


Figure 4.4/13 Drilling Pattern of the On-Site Operation Panel of the 1/1 Device

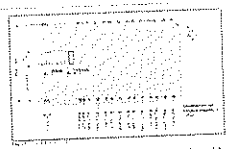


Figure 4.4/14 Drilling Pattern of the On-Site Operation Panel of the 2/1 Device

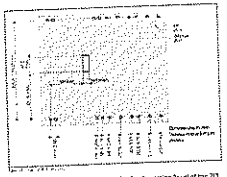


Figure 4.4/15 Drilling Pattern of the On-Site Operation Panel of the 1/1 Device

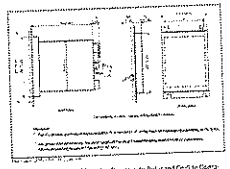


Figure 4.4/16 Surface-Mounting Device with Detached On-Site Operation Panel – Dimensions and Side-by-Side Views

The drilling patterns correspond to the following graphics:
Figure 4.4/13 in *Figure 4.4/15*

The cable length for the detached operator panel is up to 5 m (196.9 in).

Dimension drawings – Surface-Mounting Devices with Integrated On-Site Operation Panel (Non-Modular Device)

Surface-Mounting Devices with Integrated On-Site Operation Panel (Non-Modular Device)

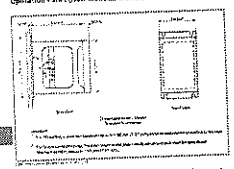


Figure 4.4/18 Non-Modular Surface-Mounting Device with Integrated On-Site Operation Panel, Dimensions and Side-by-Side and Front Views

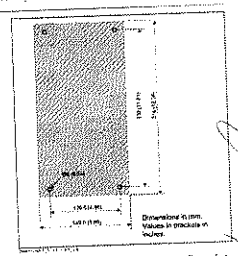


Figure 4.4/19 Drilling Pattern of a 1/1 Surface-Mounting Device – First Device Row

Surface-Mounting Devices with Integrated On-Site Operation Panel (Modular Device)

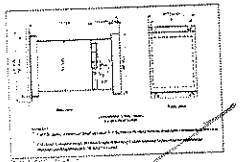


Figure 4.4/20 1/1 Surface-Mounting Device Integrated On-Site Operation Panel, Dimensions and Side-by-Side and Front Views

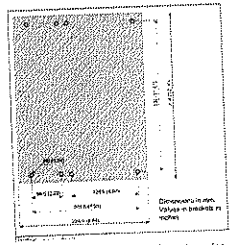


Figure 4.4/21 Drilling Pattern of a 1/2 Surface-Mounting Device – First Device Row

Dimension drawings – Surface-Mounting Devices with Integrated On-Site Operation Panel (Modular Device)

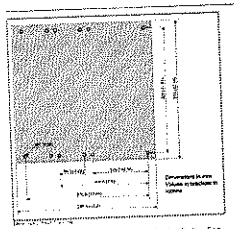


Figure 4.4/22 Drilling Pattern of a 1/1 Surface-Mounting Device – First Device Row

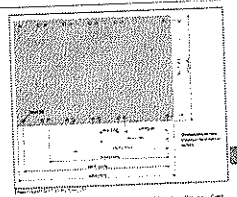


Figure 4.4/24 Drilling Pattern of a 1/1 Surface-Mounting Device – First Device Row

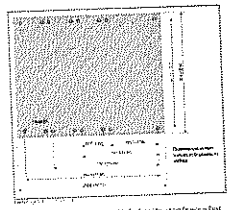


Figure 4.4/23 Drilling Pattern of a 1/2 Surface-Mounting Device – First Device Row

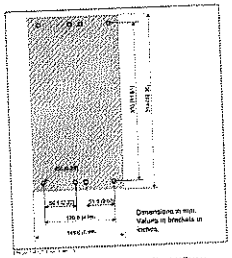


Figure 4.4/25 Drilling Pattern of a 1/2 Surface-Mounting Device – Second Device Row in Rim

Dimension drawings – Surface-Mounting Devices with Integrated On-Site Operation Panel (Modular Device)

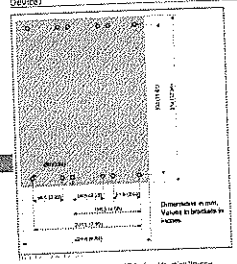


Figure 4.4/26 Drilling Pattern of a 1/1 Surface-Mounting Device – Second Device Row

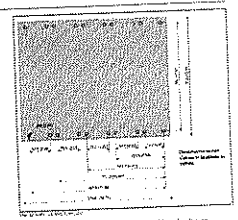


Figure 4.4/28 Drilling Pattern of a 1/1 Surface-Mounting Device – Second Device Row

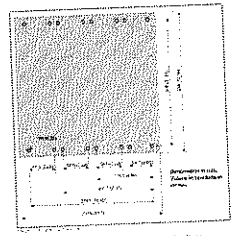


Figure 4.4/27 Drilling Pattern of a 1/2 Surface-Mounting Device – Second Device Row

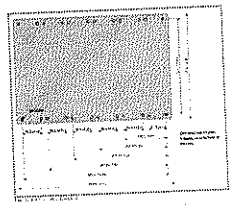
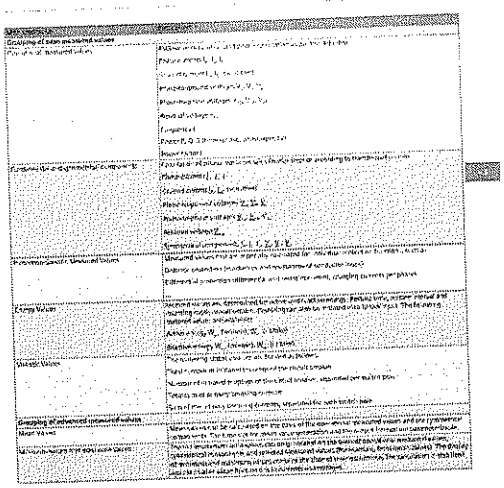


Figure 4.4/29 Drilling Pattern of a 1/2 Surface-Mounting Device – Second Device Row

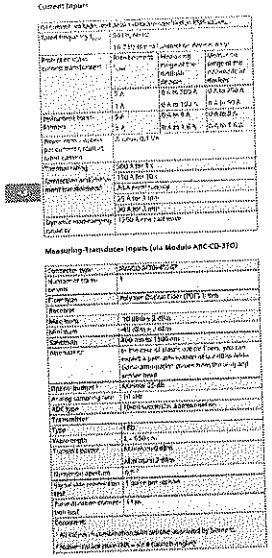
Appendix

Grouping of measured values



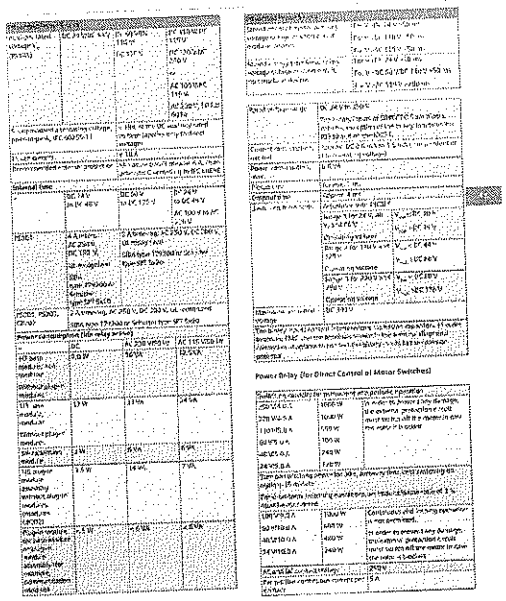
Appendix

Technical data – Current Inputs



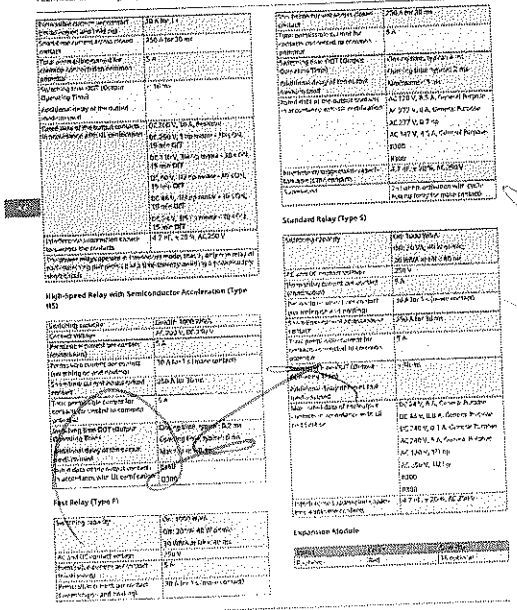
Appendix

Technical data – Power Relay for Direct Control of Motor Switches



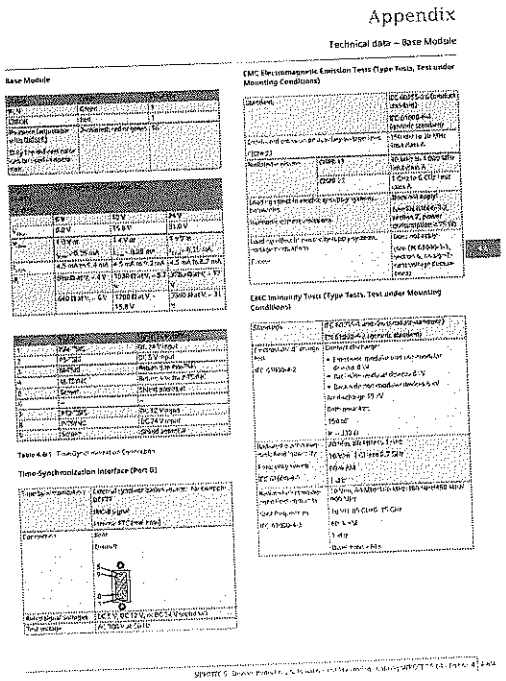
Appendix

Technical data – High-Speed Relay with Semiconductor Acceleration (Type HS)



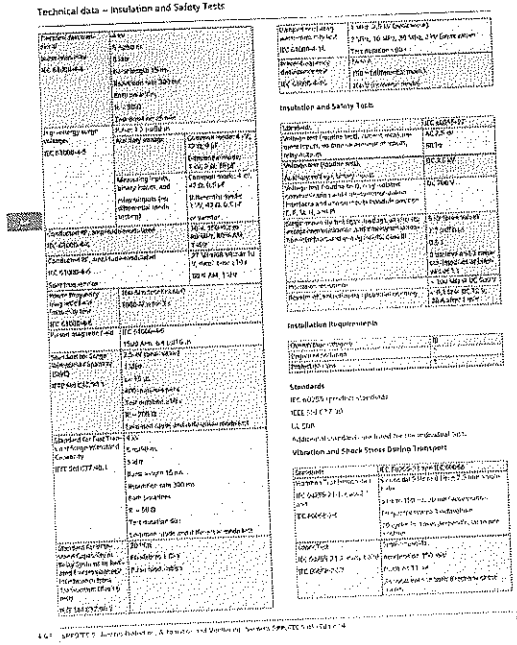
Appendix

Technical data – Base Module



Appendix

Technical data – Insulation and Safety Tests



Appendix

Technical data – Vibration and Shock Stress in Stationary Use

Frequency range	5 ... 150 Hz
IEC 60255-21-1, class 1 or IEC 60068-2-6	Acceleration 5 g
	Amplitude 3.5 mm
	5 ... 9 Hz
	10 ... 150 Hz
Duration	10 frequency sweeps per axis in each of the 3 perpendicular axes

Vibration and Shock Stress in Stationary Use

Standard	IEC 60255-21-2 and IEC 60068-2-27
Acceleration / amplitude	5 g, corresponding to 50 m/s² (164 ft/s²)
Duration	11 ms
Number of shocks	3 per direction and polarity
IEC 60255-21-3, class 2 and IEC 60068-2-6	Sweep rate 1 octave/min
	20 cycles in 3 perpendicular axes
	Frequency range 10 ... 150 Hz
	Acceleration 2 g
Device test	Test as per IEC 60255-5 and IEC 60870-2-1
	Test voltage 5 kV (peak value), polarity alternating
	100 kΩ, 0.5 J, 3 positive and 3 negative surges in each direction
IEC 60255-22-1, class III and VDE 0435 Part 303	Frequency 2.5 MHz
	Test voltage 2.5 kV (peak value)
	Polarity alternating
	200 surges per second
	Duration 2 s
	Source impedance 200 Ω
Device test	Test as per IEC 60255-5 and IEC 60870-2-1
	Test voltage 5 kV (peak value), unipolar
	1.2/50 µs, 0.5 J, 3 positive and 3 negative surges in each direction
IEC 60255-22-2, class IV and VDE 0435 Part 303	Frequency 1 MHz and 10 MHz
	Test voltage 200 V
	Duration > 2 s
	Source impedance 200 Ω
Device test	Test as per IEC 60255-5 and IEC 60870-2-1
	Test voltage 2.5 kV (peak value), unipolar
	1.2/50 µs, 0.5 J, 3 positive and 3 negative surges in each direction
IEC 61000-4-3	Frequency range 80 ... 1000 MHz
	Test field strength 10 V/m
	Test using AM 80 % 1 kHz
	80 ... 960 MHz, 1.4 ... 2.0 GHz, 2.0 ... 2.7 GHz
IEC 61000-4-6	Frequency range 150 kHz ... 80 MHz
	Test voltage 10 V
	Test using AM 80 % 1 kHz
	Source impedance 150 Ω
IEC 61000-4-2, class III	Discharge through air, 10 kV
	Contact discharge, 8 kV
	Number of discharges 10
IEC 61000-4-4, class IV	Burst length 2.5 kHz
	Repetition rate 300 ms
	Duration 1 min
	Source impedance 50 Ω
IEC 61000-4-5, class III	Pulse: 1.2/50 µs
	Source impedance: Between wires: 2 Ω, Between wire and ground: 12 Ω
	Test voltage: Between wires: 1 kV, Between wire and ground: 2 kV
	Number of pulses: 5 positive and 5 negative
	Test duration: 1 min
	Interval: 1 s
IEC 60255-25	Limit class A
	Limit curve according to Table 3
	Measured at 10 m distance
IEC 60255-25	Limit class A
	Limit curve according to Table 4
	Measured at 10 m distance

Other Environmental Information

Ambient temperature during storage	-25 °C to +55 °C	-13 °F to +131 °F
Ambient temperature during shipment	-25 °C to +70 °C	-13 °F to +158 °F
Humidity	Permissible humidity stress; it is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	

Humidity

Permissible humidity stress	75 % annual average
According to IEC 60068-2-30	On 30 days in the year up to 95 % relative humidity; otherwise no condensation

Temperatures

Type test temperature	-25 °C to +55 °C	-13 °F to +131 °F
Temperature according to IEC 60068-2-1 and IEC 60068-2-2, test Bd for dry heat and test Ab for cold		
Permanent permissible operating temperature (steady-state)	-20 °C to +55 °C	-4 °F to +131 °F
Limit temperatures for operation	Limit temperatures below which or above which the functional capability of the display is impaired. These temperatures are not tested.	
Recommended for permanent operation	-5 °C to +55 °C	23 °F to +131 °F
Limit temperatures for storage and transport	-25 °C to +55 °C	-13 °F to +131 °F
Storage		
Type test temperature and storage duration	+85 °C for 96 h	+185 °F for 96 h

Temperatures

Temperature changes	Temperature changes that are not expected to occur more than 2 times per day		
Range of temperature changes	20 °C	68 °F	
Rate of temperature change	1 °C/min	1.8 °F/min	
Humidity changes	Humidity changes that are not expected to occur more than 2 times per day		
Range of humidity changes	10 %	10 %	
Rate of humidity change	5 %/h	5 %/h	

Appendix

Technical data – Degree of Protection to IEC 60529

Degree of protection according to IEC 60529	IP20	IP20	IP20
Type of protection	Protection against solid foreign objects greater than 12.5 mm	Protection against solid foreign objects greater than 2.5 mm	Protection against solid foreign objects greater than 1 mm
	Protection against touch with fingers	Protection against touch with tools	Protection against touch with wires
	No protection against water	No protection against water	No protection against water
Degree of protection, IEC 60255-27	IP20	IP20	IP20

Minimum Permissible Radii of the Connecting Cables between the Operator Operation Panel and the Base Module

Permissible radius	5 ... 50 mm
	The connection cable must be at least as long as the cable between the operator control panel and the base module.
Recommended radius	10 ... 50 mm (0.39 ... 1.97 in)

Plug-in Module Dimensions

Width of the plug-in module	61 mm (2.40 in)	122 mm (4.80 in)
Height of the plug-in module	13 mm (0.51 in)	13 mm (0.51 in)
Depth of the plug-in module	61 mm (2.40 in) + 13.5 mm (0.53 in) = 74.5 mm (2.93 in)	61 mm (2.40 in) + 13.5 mm (0.53 in) = 74.5 mm (2.93 in)

Expansion Module Dimensions

Type of expansion module	1/3	1/2	1/1
Width	61 mm (2.40 in)	92 mm (3.62 in)	184 mm (7.24 in)
Height	176 mm (6.93 in)	176 mm (6.93 in)	176 mm (6.93 in)
Depth	74 mm (2.91 in)	74 mm (2.91 in)	74 mm (2.91 in)
Weight	0.5 kg (1.1 lb)	0.8 kg (1.8 lb)	1.6 kg (3.5 lb)

Dimensions of Device Rows

Type of housing	1/3	1/2	2/3	1/1	1/1
Width	61 mm (2.40 in)	92 mm (3.62 in)	123 mm (4.84 in)	184 mm (7.24 in)	184 mm (7.24 in)
Height	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)
Depth	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)
Weight	1.5 kg (3.3 lb)	2.0 kg (4.4 lb)	2.5 kg (5.5 lb)	3.0 kg (6.6 lb)	3.0 kg (6.6 lb)

Appendix

Technical data – Dimensions of the Basic and 1/3 Modules

Type of housing	1/3	1/2	2/3	1/1	1/1
Width	61 mm (2.40 in)	92 mm (3.62 in)	123 mm (4.84 in)	184 mm (7.24 in)	184 mm (7.24 in)
Height	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)
Depth	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)
Weight	1.5 kg (3.3 lb)	2.0 kg (4.4 lb)	2.5 kg (5.5 lb)	3.0 kg (6.6 lb)	3.0 kg (6.6 lb)

Dimensions of the Basic and 1/3 Modules

Type of housing	1/3	1/2	2/3	1/1	1/1
Width	61 mm (2.40 in)	92 mm (3.62 in)	123 mm (4.84 in)	184 mm (7.24 in)	184 mm (7.24 in)
Height	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)
Depth	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)
Weight	1.5 kg (3.3 lb)	2.0 kg (4.4 lb)	2.5 kg (5.5 lb)	3.0 kg (6.6 lb)	3.0 kg (6.6 lb)

Masses

Type of housing	1/3	1/2	2/3	1/1	1/1
Width	61 mm (2.40 in)	92 mm (3.62 in)	123 mm (4.84 in)	184 mm (7.24 in)	184 mm (7.24 in)
Height	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)	266 mm (10.47 in)
Depth	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)	229 mm (9.02 in)
Weight	1.5 kg (3.3 lb)	2.0 kg (4.4 lb)	2.5 kg (5.5 lb)	3.0 kg (6.6 lb)	3.0 kg (6.6 lb)

Appendix

Technical data – UL Note

Appendix

Legal notice

Indication of conformity

CE

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2006/95/EC).

This conformity has been proved by tests performed according to the Council Directive in accordance with the generic standards EN 61000-6-2 and EN 61000-6-4 (for EMC directive) and with the standard EN 60255-27 (for Low Voltage Directive) by Siemens AG.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standards of IEC 60255 and the

German standard VDE 0435.

Disclaimer of liability

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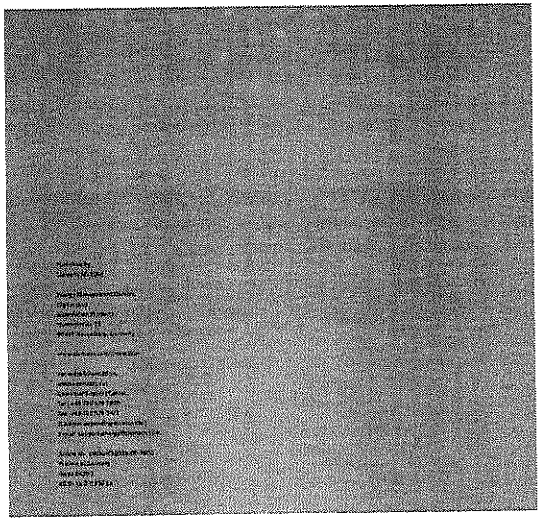


www.siemens.com/protection

SIEMENS

SIPROTEC 5
High-Voltage Bay Controller
6MD85/86

V7.30 and higher

Manual

C53000-G5040-C015-8

NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

Preface

Purpose of the Manual

This manual describes the functions of SIPROTEC 5 high-voltage bay controllers.

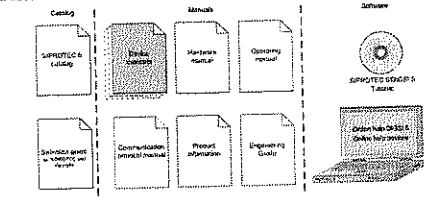
Target Audiences

Protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, switchgear interlocking and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the SIPROTEC 5 device family.

Further Documentation



- Device manuals
  Each DIGSI manual describes the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.
- Hardware manual
  The Hardware manual describes the hardware building blocks and device combinations of the SIPROTEC 5 device family.
- Operating manual
  The Operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.

- Communication protocol manual
  The Communication protocol manual contains a description of the protocols for communication within the SIPROTEC 5 device family and to higher level network control centers.
- Product information
  The Product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.
- Engineering Guide
  The Engineering Guide describes the essential steps when engineering with DIGSI 5. In addition, the Engineering Guide shows you how to load a powered configuration to a SIPROTEC 5 device and update the functionality of the SIPROTEC 5 device.
- DIGSI 5 online help
  The DIGSI 5 online help contains a help package for DIGSI 5 and CFC.
  The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles, and editors. The help package for CFC includes an introduction to CFC programming, basic examples of working with CFC, and a reference chapter with all the CFC blocks available for the SIPROTEC 5 range.
- SIPROTEC 5 DIGSI 5 Tutorial
  The tutorial on the DVD contains brief information about important product features, more detailed information about the individual technical areas, as well as operating sequences with tasks based on practical operation and a brief explanation.
- SIPROTEC 5 catalog
  The SIPROTEC 5 catalog describes the system features and the devices of SIPROTEC 5.
- Selection guide for SIPROTEC and Reyrolle
  The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

Indication of Conformity

CE

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the product standard EN 60255-26 (for EMC directive) and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens AG.

The device is designed and manufactured for applications in an industrial environment.

The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

Other Standards

IEEE Std C37.90

The technical data of the product is approved in accordance with UL.

For more information about the UL database, see www.ul.com/database.

Select Online Certification Directory and enter E194016 as UL File Number.

cULus LISTED IND.CONT.EQ. 85CA

Additional Support

For questions about the system, please contact your Siemens sales partner.

Support

Our Customer Support Center provides a 24 hour service.

Phone: +49 (180) 524-7000
Fax: +49 (180) 524-2471
E-Mail: support.ptd@siemens.com

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

Siemens AG
Siemens Power Academy TD

Humboldtstraße 59
90459 Nürnberg
Germany

Phone: +49 (911) 433-7415
Fax: +49 (911) 433-7929
E-Mail: poweracademy.ptd@siemens.com
Internet: www.siemens.com/poweracademy

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it contains important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger.

DANGER

DANGER means that death or severe injury will result if the measures specified are not taken.

- Comply with all instructions, in order to avoid death or severe injuries.

WARNING

WARNING means that death or severe injury may result if the measures specified are not taken.

- Comply with all instructions, in order to avoid death or severe injuries.

CAUTION

CAUTION means that medium-severe or slight injuries can result if the specified measures are not taken.

- Comply with all instructions, in order to avoid moderate or minor injuries.

NOTICE

NOTICE means that property damage can result if the measures specified are not taken.

- Comply with all instructions, in order to avoid property damage.

NOTE

Important information about the product, product handling or a certain section of the documentation which must be given particular attention.

Qualified Electrical Engineering Personnel

Only qualified electrical engineering personnel may commission and operate the equipment (module, device) described in this document. Qualified electrical engineering personnel in the sense of this manual are people who can demonstrate technical qualifications as electrical technicians. These persons may commission, isolate, ground and label devices, systems and circuits according to the standards of safety engineering.

Proper Use

The equipment (device, module) may be used only for such applications as are set out in the catalogs and the technical description, and only in combination with third-party equipment recommended and approved by Siemens.

Problem-free and safe operation of the product depends on the following:

- Proper transport
- Proper storage, setup and installation
- Proper operation and maintenance

When electrical equipment is operated, hazardous voltages are inevitably present in certain parts. If proper action is not taken, death, severe injury or property damage can result.

- The equipment must be connected to the grounding terminal before any connections are made.
- All circuit components connected to the power supply may be subject to dangerous voltage.
- Hazardous voltages may be present in equipment even after the supply voltage has been disconnected (capacitors can still be charged).
- Operation of equipment with exposed current transformer circuits is prohibited. Before disconnecting the equipment, ensure that the current transformer circuits are short-circuited.
- The limiting values stated in the document must not be exceeded. This must also be considered during testing and commissioning.

Open Source Software

The product contains, among other things, Open Source Software developed by third parties. The Open Source Software used in the product and the license agreements concerning this software can be found in the Readme_OSS. These Open Source Software files are protected by copyright. Your compliance with those license conditions will entitle you to use the Open Source Software as foreseen in the relevant license. In the event of conflicts between Siemens license conditions and the Open Source Software license conditions, the Open Source Software conditions shall prevail with respect to the Open Source Software portions of the software. The Open Source Software is licensed royalty-free. Insofar as the applicable Open Source Software License Conditions provide for it, you can order the source code of the Open Source Software from us at Siemens sales conditions against payment of the shipping and handling charges - for a period of at least 3 years since purchase of the Product. We are liable for the Product including the Open Source Software contained in it pursuant to the license conditions applicable to the Product. Any liability for the Open Source Software beyond the program flow intended for the Product is explicitly excluded. Furthermore any liability for defects resulting from modifications to the Open Source Software by you or third parties is excluded. We do not provide any technical support for the Product if it has been modified.

When using DIGSI 5 in online mode, you are provided with the option to go to the menu item **Show Open source information** and read and display the Readme_OSS file containing the original license text and copyright information.

To do this, the following steps are necessary:

- Switch to online mode
- Select the device.
- Select online in the menu bar.
- Click **Show Open source information**

NOTE

To read the Readme_OSS file, a PDF viewer must be installed on the computer.
In order to operate SIPROTEC 5 devices, a valid DIGSI 5 license is required.

8 Supervision Functions 809

9 Measured Values, Energy Values, and Supervision of the Primary System 869

1 Introduction

1.1 General

The digital multifunctional protection and bay controllers of the SIPROTEC 5 device series are equipped with a powerful microprocessor. As a result, all tasks, from acquiring measurement to entering commands to the circuit breaker, are processed digitally.

Analog Inputs

The measuring circuits transform the currents and voltages sent by the instrument transformers and adapt them to the internal processing level of the device. A SIPROTEC 5 device has a current transformer and, depending on the device type, a voltage transformer. The current inputs are therefore intended for the detection of phase currents and ground currents. The ground current can be detected very sensitively using a core balance current transformer. In addition, phase currents can be detected very sensitively for a particularly precise measurement. The voltage inputs detect the measuring voltage of device functions requiring current and voltage measured values.

The analog values are digitized in the internal microcomputer for data processing.

Microcomputer System

All device functions are processed in the microcomputer system.

This includes, for example:

- Filtering and preparation of the measurands
- Constant monitoring of the measurands
- Monitoring of the circuit conditions for the individual protection functions
- Querying of binding values and time-outs
- Controlling of signals for the logic functions
- Decision about the trip and close commands
- Storage of indications, fault data, and fault values for fault analysis
- Administration of the operating system and its functions, such as data storage, real-time clock, communication, interfaces, etc.
- External distribution of information

Binary Inputs and Outputs

Using the binary inputs and outputs, the device receives information from the system or from other devices (such as locking commands). The most important outputs include the commands to the switching devices and the indications for remote signaling of important events and states.

Front Elements

For devices with an integrated or offset operation panel, LEDs and an LC display on the front provide information on the device function and important events, states, and measured values. In conjunction with the LC display, the integrated keypad enables an easy operation of the device. All device information such as setting parameters, operating and fault indications or measured values can be displayed, and setting parameters changed. In addition, system equipment can be controlled via the user interface of the device.

Serial Interfaces

The serial interface in the front panel enables communication with a personal computer when using the DIGSI operating program. As a result, the operation of all device functions is possible. Additional interfaces on the back are used to realize various protection concepts.

Power Supply

The individual functional units of the devices are supplied by an extensive power supply, both from stations on the substation battery, which can occur during short circuits in the system, as well as supply are generally ensured by extensive storage (see also the Technical Data).

1.2 Properties of SIPROTEC 5

The SIPROTEC 5 devices, at the bay level, are compact and can be installed directly in medium and high-voltage switchgear. They are characterized by comprehensive independent of protection and control function.

General Properties

- Powerful microprocessor
- Fast, digital signal processing and control. Fast reception and distribution of information via binary inputs and outputs
- Complete galvanic and interference-free isolation of the internal processing electronics from the system measuring, control, and supply circuits through instrument transformers, binary input and output modules, and DC and AC voltage converters
- Easy operation using an integrated operation and display panel, or using a connected personal computer with user interface
- Continuous display of measured and metered values at the front
- Storage of minimum/maximum values (user-definable function) and storage of long-term average values
- Storage of fault indications for system incidents (faults in system) with high-level assignment and instantaneous values for fault recording
- Continuous monitoring of the measurands as well as the device hardware and software
- Communication with central control and storage devices possible via the device interface
- Battery-buffered, synchronizable clock

Modular Concept

The SIPROTEC 5 modular concept ensures the consistency and integrity of all functionalities across the entire device range. Significant features here include:

- Modular system design in hardware, software, and communication
- Functional integration of various applications, such as protection, control, and fault recorder
- The same expansion and communication modules for all devices in the family
- Innovative terminal technology with easy assembly and interchangeability and the highest possible degree of safety
- The same functions can be configured individually across the entire family of devices
- Ability to upgrade with innovations possible at all times through libraries
- Open, scalable architecture for IT integration and new functions
- Multi-layered security mechanisms on all links of the security chain
- Self-monitoring routines for reliable localization and indication of device faults
- Automatic logging of access attempts and safety-critical operations on the devices and software

Redundant Communication

SIPROTEC 5 devices maintain complete communication redundancy:

- Multiple redundant communication interfaces
- Redundant and independent protocols to control centers possible (such as IEC 60870-5-103 and IEC 61850, either single or redundant)
- Redundant time synchronization (such as IRIG-B, SNTP, or IEEE 1588)

2 Basic Structure of the Function

2.1 Function Embedding in the Device

General

SIPROTEC 5 devices offer great flexibility in the handling of functions. Functions can be individually loaded into the device. Additionally, it is possible to copy functions within a device or between devices. The necessary integration of functions in the device is illustrated by the following example.

NOTE

The availability of certain settings and setting options depends on the device type and the functional scope available on the device.

EXAMPLE

A 1 1/2 circuit breaker layout of the 6MD86 series as an example. The following protection functions are required for implementation (simplified and complete):

- Automatic reclosure (79)
- Circuit breaker failure protection (50BF), for circuit breakers 1 and 2
- Basic functionality (emergency/overcurrent protection, control, etc.)

Several predefined function packages that are tailored to specific applications exist for each device family. A predefined functional scope is called an application template. The existing application templates are offered for selection automatically when you create a new device in DIGSI 5.

EXAMPLE

When creating the device in DIGSI 5, you must select the appropriate 6MD86 application template. In this example, select the application template 1 1/2 circuit breaker layout configuration type 2. This application template covers the required functional scope. Selecting the application template determines the preassigned functional scope. This can be changed as necessary (refer chapter 2.2 Adjustment of Application Templates/Functional Scope).

Function Groups (FG)

Functions are arranged in function groups. This simplifies handling of functions (adding and copying). The function groups are organized in primary objects, such as transformers, or circuit breaker.

The function groups handle functions with regard to the following basic tasks:

- Assignment of functions to current and/or voltage transformers (assignment of functions to the measuring points) and thus to the protected object
- Exchange of information between function groups

When a function is copied into a function group, it automatically works with the measuring points assigned to the function group. Their names appear and also automatically included in the configured interfaces of the function group.

The number and type of function groups depend on the respective application template, depending on the type of the device and application. You can add, copy, or even delete function groups for a specific application. You can also adapt the functional scope within a function group according to the use case. You can find detailed information on this in the DIGSI 5 online help.

Interface Between Function Groups and Measuring Points

The function groups receive the measurands of the current and voltage transformers from measuring points, and, in turn, the function groups are connected to one or more measuring points.

The number of measuring points and the assignment of function groups to the measuring points are preset in the selected application template in accordance with the specific applications. However, this can also be changed.

measuring point(s) and the corresponding measurands have to be used by which function within the function group.

The user can change the assignment as needed, that is, function groups can be assigned to any available measuring points of the device.

To check or change the assignment of measuring points to the function groups, double click Function-group connections in the DIGSI 5 project tree.

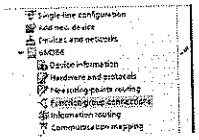


Figure 2-1 Project Tree in DIGSI 5 (Detail)

The window for routing of the measuring points opens in the working area (see the following figure, does not correspond to the example).

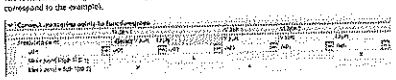


Figure 2-2 Connecting Measuring Points and Function Groups

2.2 Adjustment of Application Templates/Functional Scope

Application Template

The application template defines the now-configured functional scope of the device for a specific use case. A certain number of application templates is predefined for each device type. DIGSI 5 automatically offers the application templates for selection when a new device is installed. The available application templates with the respective functional scope are described in more detail in /A Applications/.

The selection of the application template first predefines which function groups and functions are present in the device.

You can adjust the functional scope to your specific application.

Adjusting the Functional Scope

Adjust the functional scope based on the selected application template. You can add, copy or delete functions, stepping levels, function blocks, or complete function groups.

In the DIGSI 5 project tree, this can be done via the following Editors:

- Single-line configuration
- Information routing
- Function settings

Siemens recommends the Single-line configuration Editor to adjust the functional scope.

Complete missing functionalities from the Global DIGSI 5 Library. Then, the default settings of the added functionality are active. You can copy within a device and between devices as well. Settings and routings are also copied where applicable.

NOTE

If you delete a combination of function group, function, or level from the device, all settings and routings will be lost. The function group, function, or stepping stage can be added again, but then the default settings are active.

In most cases, the adjustment of the functional scope consists of adding and deleting functions, stepping stages, and function blocks. As previously described, the functions, stepping stages, and function blocks automatically connect themselves to the measuring points assigned to the function group.

In few cases, it may be necessary to add a protection or circuit breaker function group. These newly added function groups do not contain protection functions. You must individually load the (protection) functions for your specific application. You must also connect the protection or circuit-breaker function group to one or more measuring points (see chapter 2.1 Function Embedding in the Device). You must connect newly added protection function groups to a circuit breaker function group (see chapter 2.7 Function Embedding in the Device).

Function, stepping stages, function blocks, and function groups can be added up to a certain maximum number. The maximum number can be found in the respective functional and function-group descriptions.

Function Points

Function points (FP) are assigned to specific functions, but not to other functions. Further information can be found in the description of application templates, in the chapter /Applications/.

The device is supplied with the assigned function point credit. Functions with function points can be loaded into the device as long as the available function point credit. The functional scope cannot be loaded into the device if the required number of points of the functional scope is higher than the function point credit. You must either delete functions or upgrade the function point credit of the device.

No function points are required to add additional stages or functions.

Extending the Function Point Credit

You can order additional points if the function point credit for the device is not enough.

Proceed as follows:

- Determine the function point requirements of certain functions, for example, with DIGSI 5 or the SIPROTEC 5 Configurator.
- Order the additional function points from your local distributor at a supplier-neutral service case.
- Service will provide you with a signed license file for your device, either via e-mail or for downloading.
- Use DIGSI 5 to load the signed license file into your device. The procedure is described in the Online Help of DIGSI 5.

2.3 Function Control

Function control is used for:

- Functions that do not contain stages or function levels
- Stages within functions
- Function levels within functions

NOTE

Simplified Functions and Function control will be discussed in the following. The description also applies to Trigger stage control and function block control.

Functions can be switched to different operating modes. You use the parameter Mode to define whether you want a function to run (On) or not (Off). In addition, you can temporarily block a function or switch it into test mode for the purpose of commissioning (parameter Mode = Test).

The function shows the current state – such as an Alarm – via the Health signal.

The following outlines the different operating modes and mechanisms and how you set the functions into these modes. The function control is shown in Figure 2-3. It is standardized for all functions. Therefore, the control is not discussed further in the individual function descriptions.

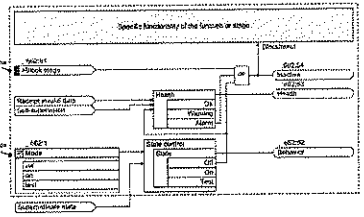


Figure 2-3 General Control of a Function

State Control

You can control the state of a function via the parameter Mode and the signal Superordinate state.

You set the specified operating state of the function via the parameter Mode. The function mode can be set on, OFF, and Test. The operating principle is described in Table 2-2. You can set the parameter Mode via:

- DIGSI 5
- On-site operation at the device
- Certain systems control protocols, IEC 61850, IEC 60870-5-103)

The possibility to adjust the superordinate state is limited. For test purposes, the complete device can be set into test mode.

The output of the state control is the parameter Mode and the superordinate state is shown in the following table.

Table 2-1 Resulting State of the Function (From Linkage of Parameter Mode and Superordinate State)

Inputs		Function State
Mode Parameter (of the function)	Superordinate State	
Off	Don't care	Off
Don't care	Off	Off
On	On	On
On	Test	Test
Test	On	Test
Test	Test	Test

The following table shows the possible function states:

Table 2-2 Possible Function States

Function State	Explanation
On	The function is activated and operating as defined. The prerequisite is that the health of the function is OK
Off	The function is turned off. It does not create any information. The health of a disabled function always has the value OK.

Function State	Explanation
Test	The function is set to test mode. This state supports the commissioning. All outgoing information from the function (indications and, if present, measured values) is provided with a test bit. This test bit significantly influences the further processing of the information, depending on the target. For instance, among other things, it is possible to implement the functionality **Blocking of the command relay** in the system SIPROTEC 5.

Target of the information	Processing
Log	The indications are provided with the identification Test in the log
Control	An indication routed as control is not triggering the control
Light emitting diode (LED)	An indication routed to the LED triggers the LED (normal processing)
CFC	Here, the behavior depends on the **state** of the CFC chart. ▪ CFC chart itself is not in test state The CFC chart is not triggered by a state change of information with a set test bit. The initial state of the information (state before test bit was set) is fed processed during execution of the CFC chart. ▪ CFC chart itself is in test state The CFC chart continues to process the information (indication or measured value) normally. The CFC outputs information is provided with a test bit. The definitions in this table apply to its continued processing. A CFC chart can be set to the test state only by switching the entire device to test mode.
Protocol	Indications and measured values are distributed with set test bit, provided that the protocol supports this functionality. If an object is transferred as a GOOSE message, the test bit is set spontaneously and the GOOSE message is transmitted immediately. The receiver of the GOOSE message is automatically notified of the sender test mode. If an object is transmitted via the protection interface, the test bit is not transmitted. The Test state must also be transmitted as information for this state to be taken into account at the application on the receiver end. You must route the Test signal in the DIGSI 5 Project tree → Device → Communication routing. The test mode of the differential protection will be dealt with separately in the application.

Health

Health signals if a switching function can perform its operation functionally. If so, the Health is OK. In case the functionality is only available in a limited way, or not at all, due to state or problems within the device, the Health will signal warning (limited functionality) or Alarm (no functionality).

Internal self supervision can cause the functions to assume the health Alarm. See chapter 6 Supervision Functions. If a function assumes the health state Alarm, it is no longer active (indication Oper. Active is disappears).

Only a few functions can signal the health state warning. The health state is not representative for function specific supervision and values / process data as explained in the function description. If a function assumes the status Diagnosis, it will remain active, that is, the function can continue to work in a conditioned manner and trip in the case of a protection function.

Not Active

The indication Oper. Active signals that a function is currently not working. The indication Oper. Active is active in the following cases:

- Function is switched off
- The function is in the Health state Alarm
- Function is blocked by an Input signal (see Figure 2-3)

Blocking of the Operate Indication, No Fault Recording at Pickup

You use the parameter Blk. Op. Ind. & Fault Rec. to define whether a function works as a protection or supervision function. Further, you use this to determine the type and scope of the logging (see following table).

Parameter Value	Description
No	The function works as a protection function. It generates an operate indication and starts fault recording with pickup. During fault recording, a fault is entered and logged as a fault event in the fault log.
Yes	The function works as a supervision function. The local operate indication is still generated and can be processed further if necessary. No fault recording starts with pickup.

2.4 Text Structure and Reference Number for Settings and Indications

Each parameter and each indication has a unique reference number within every SIPROTEC 5 device. The reference number gives you a clear reference, for example, between an indication entry in the buffer of the device and the corresponding description in the manual. You can find the reference numbers in this document, for example, in the applications and setting notes in the logic diagrams, and in the parameter and information lists.

In order to form explicit texts and reference numbers, each function group, function, function block/stage, and indication or parameter has a text and a number. This means that structured overall texts and numbers are created.

The structure of the texts and the reference numbers follows the hierarchy:

- Function group/Function/Stage/Function block/Indication
- Function group/Function/Stage/Function Block/Parameter

The texts serve as a structure element to separate the hierarchy levels. Depending on the functionality, not all hierarchy levels are always available. Function group and Unsymmetrical block are optional. Since the function groups, functions as well as existing stages/function blocks of the same type can be created multiple times, a so-called instance number is added to these elements.

2.5 Information Lists

For the function groups, functions, and function blocks, settings and signal inputs/outputs are defined that are stored in the following data information lists.
The information lists summarize the signals. The data type of the information may differ. Possible data types are BOOL, ACTI, ACT, DPS and MV, etc.
A type is assigned to the individual data types. The following table shows the possible types:

Type	Meaning
SI	Input – Input signal
O	Output – output signal
C	Controllable – control signal

EXAMPLES:

The following table shows the types for some data types as examples:

Data Type	Type
BOOL	O
SPS	O
ACT	O
SPC	C or O
SPC	C
MV	O

3.1 Indications

3.1.1 General

During operation, indications deliver information about operational states. These include:

- Measured data
- Power system data
- Device supervision
- Device functions
- Function processes during testing and commissioning of the device

In addition, indications give an overview of important fault events after a failure in the system. All indications are furnished with a time stamp at the time of their occurrence.
Indications are saved in logs inside the device and are available for later analyses. The following number of indications are saved as fixed in the respective buffer depending on the scope of the application:

- Ground-fault log 500 indications
- Fault log 1000 indications
- User-defined log 200 indications
- Operational log 2000 indications

If the maximum capacity of the user-defined log or of the operational is exhausted, the oldest entries drop-ping below the lowest margin. If the maximum capacity of the fault log or of the ground-fault log is reserved, the number of the last fault is saved via the signal Fault log is full. During a supply voltage failure, recorded data are securely held by means of battery buffering in storage in the fault memory. You can read and analyze the log from the device with DIGSI 5. The device display and navigation inner keys allow you to read and analyze the logs on site.
Indications can be output spontaneously via the communication interfaces of the device and through referral defined via general interrogation. In DIGSI 5 indications can be tracked spontaneously in online operation in a special indication window. Indications can be made accessible on higher-level control systems through mapping on various communication protocols.

NOTE

All indications are assigned to certain device functions, the text of each indication contains the corresponding function designation. You will find explanations of the meaning of indications in the corresponding device functions. However, you can also define indications yourself and group them into your own function blocks. These can be cut by binary inputs or CFC logic.

Reading Indications

To read the indications of your SIPROTEC 5 device, you can use the operation panel of the device or a PC on which you have installed DIGSI 5. The following section describes the general procedure.

3.1.2 Reading Indications on the On-Site Operation Panel

Procedure

The menus of the logs begin with a header and 2 numbers at the top right corner of the display. The number after the slash specifies the quantity of indications that are available. The number before the slash indicates how many indications are just selected or viewed. The end of the indication list is closed with the entry "END".

Figure 3-1
On-Site Display of an Indication List (Example: Operational Indications)

Menu Path	Log
Main menu → Indications →	Operational log Fault log Ground-fault log Setting changes User indications 1 User indications 2
Main menu → Test & Diagnosis → Indications →	Security indications Device diagnosis Communication indications

- To reach the desired log from the main menu, use the navigation keys of the on-site operation panel.
- Navigate inside the log using the navigation keys (single-click). You will find the most current indication at the top of the list. The selected indication is shown with a dark background.
- Which indications can be shown in the selected log depends on the assignments in the DIGSI 5 Informa-tion matrix and is predefined. You will find information about this in chapter 2.3.5.1 General.
- Every indication contains date, time and its state as additional information.
- In some logs you can select the option of deleting the entire indication list by softkey in the footer of the display. To know more about this, read chapter 3.1.4 Displaying and Deleting the Logs.

NOTE

No password entry is necessary to read indications from the device.

3.1.3 Reading Indications from the PC with DIGSI 5

Procedure

Menu Path (Project)	Log
Project → Device → Online data → Log →	Operational log Fault log Ground-fault log Setting changes User indications 1 User indications 2

Menu Path (Project)	Log
Project → Device → Online information → Log →	Security indications Device diagnosis Communication indications

- To read the indications with DIGSI 5 your PC must be connected via the USB user interface of the on-site operation panel or via an Ethernet interface of the device. A direct connection to your PC can be estab-lished via the Ethernet interfaces, it is also possible to access all connected SIPROTEC 5 devices via a data network from your DIGSI 5 PC.
- To reach the desired logs of the SIPROTEC 5 device, use the project tree window. If you have not set up the device within a project, you can also start this via Online access.
- After selecting the desired log, you are shown the last state of the log loaded from the device. To update, it is necessary to synchronize with the log in the device.
- To execute a synchronization with the logs, click the respective button in the toolbar of the log (via example of ground-fault log in Figure 3-2).

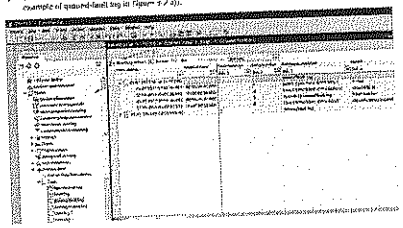


Figure 3-2 DIGSI 5 Display of an Indication List (Example of Ground-Fault Log)

- You will find additional information about the data fetch and saving of logs in chapter 3.1.5 Saving and Deleting the Logs.
- To determine a relative time for all other indications, you can reference the entries of log entries, if needed, to the real time of a certain entry. The real time stamps of events remain unaffected.
- For this purpose click the respect ve button in the headline of the log (via example of ground-fault log in Figure 3-2 a).

Setting Relative Time Reference

- Which indications in the selected log can be displayed depends on the assignments in the DIGSI 5 Infor-mation routing matrix or is predefined. You will find information about this in chapter 2.3.5.1 General.

3.1.4 Displaying Indications

Displayed indications in DIGSI 5 and on the on-site operation panel are supplemented with the following infor mation:

3 System Functions

Table 3-7 Overview of Additional Information

Indications in	DIGSI 5 Information	Device Display Information
Log for operational indications and log for user-defined status bars	Time stamp (date and time), Relative time, Error number, Increasing entry number, Value, Intermediate number, Quality, Cause	Time stamp (date and time), Error number, Value
log for fault indications	Time stamp (date and time), Relative time, Error number, Increasing entry number, Value, Intermediate number, Quality, Cause	Time stamp (date and time), Error number, Value
Log for general fault indications	Time stamp (date and time), Relative time, Error number, Increasing entry number, Value, Intermediate number, Quality, Cause	Time stamp (date and time), Error number, Value
Spontaneous information window (DIGSI 5)	Time stamp (date and time), Error number, Increasing entry number, Value, Intermediate number, Quality, Cause	Time stamp (date and time), Error number, Value

DIGSI 5: Quality Indication Column

Quality	Meaning
Good	Indication is valid
Invalid	Indication is invalid

DIGSI 5: Additional Information Indication Column

The entries in the column for additional information are in the format Cause/Originator/Additional Cause:

- Cause → What was the cause?
- Originator → Who was the originator?
- Additional Cause → Supplementary reason

Cause	Meaning
Date/Time	Value changed as an indication
Data update	Update of indication table
General interrogation	General interrogation

Cause	Meaning
Cyclic	Cyclical general update
Spontaneous	Change of transmission status

Initiator	Meaning
Bay	Control local
Substation	Control via the substation
Remote terminal	Control via the remote control center
Auto (auto)	Control local via automatic function
System (auto)	Control via the station via automatic function
Gateway (auto)	Control via the network, remote control command
Maintenance	Function
Process	Maintenance
	Device operating (normal)

Additional Cause	Meaning
Switching authority (DIGSI) failed	Switching authority check failed
Selection failed	Selection failed
Invalid position	Invalid position
Position attained	Position attained
Settings change running	Settings change running
Final position attained	Final position attained
Implementation mode	Implementation mode
Blocking through process	Blocking by the present
Interlocked	Interlocked
Synchronism failed	Synchronism failed
Command already running	Command already running
Not ready	Not ready
1 out of N control failed	1 out of N control failed
Command cancellation	Command cancellation
Monitoring time expired	Monitoring time expired
Cancellation due to stop command	Cancellation due to stop command
Object not selected	Object not selected
No access right	No access right
Final position exceeding	Final position exceeding
Target value not allowed	Target value not allowed
Loss of connection	Loss of connection
Unknown	Unknown
Blocking through command	Blocking through command
Object already selected	Object already selected
Inconsistent parameter(s)	Inconsistent parameter(s)
Blocked by foreign access	Blocked by foreign access
Select time-out	Select time-out
CB not open	CB not open
Communication is interrupted	Communication is interrupted
Hardware not stable	Hardware not stable
FUP in process	Fault locator in processing
Trigger command active	Trigger command active
Close command active	Close command active

Additional Cause	Meaning
Blocked through protection	Blocked through protection
Close request	Close request
Close command	Close command
CB not closed	CB not closed
Open request	Open request
Open command	Open command
CB open	CB open

3.1.5 Logs

3.1.5.1 General

Indications are saved in logs inside the device and are available for later analysis. Different logs allow categorization of indication logging based on operating states (for example, operational and fault logs) and based on times of application.

Table 3-8 Log Overview

Log	Designation
Operational log	Operational indications
Fault log	Fault indications
Spontaneous fault log	Ground-fault indications
Setting-history log	Setting changes
User-defined log	User-defined indication scope
Security log	Access with safety relevance
Device-alive-graphic log	Error of the device (software, hardware) and the connection circuits
Communication log	Status of communication interfaces
Motor startup log	Information on the motor starting

Managing Logs

Logs, since they are sometimes also incrementally managed, if the maximum capacity of a log is exhausted, the oldest entries disappear when the newest entries. If the maximum capacity of the fault or ground-fault log is reached, the number of the last fault is generated via the signal Fault log is full. You can route this signal in the information matrix. If indications in the information routing of DIGSI 5 are routed to a log, then they are also stored. During a supply voltage failure, recorded data are currently held by means of battery buffering or storage in the flash memory. You can read out, analyze the log from the device with DIGSI 5. The device display and the navigation allow you to read and evaluate the logs on the using keys.

Configurability of Logs

The operation capacity to be recorded in configurable logs (for example, ground-fault log) is laid down in columns of the information routing (matrix) of DIGSI 5 specifically defined for this purpose.

Procedure

- To check the information routing of your SIPROTEC 5 device, use the project tree window. Access it only through the project:
  Project → Device → Information routing
- Select the associated routing column in the matrix from:
  Target → Log → Column ground-fault log

- The routing of the selected indication is done via right click. Select one of the options in the list box shown:
  - Routed (R)
  - Unrouted

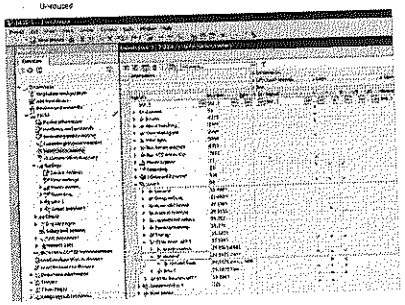


Figure 3-3 Indication Configuration in DIGSI 5 (Example, Ground-Fault Log)

For non-configurable logs (for example, setting-history logs) scope and type of logged indications are described separately (see following chapter about logs).

3.1.5.2 Operational Log

Operational indications are information that the device generates during operation. This includes information about:

- State of device functions
- Measured data
- Power-system data

Exceeding or dropping below limiting values is output as an operational indication. User circuits in the millibreak are indicated as an operational indication Fault with sequential fault number. For detailed information about the operations of system incidents, please refer to the description of the fault log (chapter 3.1.5.3 Fault Log). Up to 2000 indications can be stored in the log.

Reading from the PC with DIGSI 5

- To read the operational log of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Process Data → Log → Operational log
- The entries of the operational log last loaded from the device is shown to you. To update synchronization with the device click the button Read log entries in the headline of the indication list (Figure 3-4 ②).

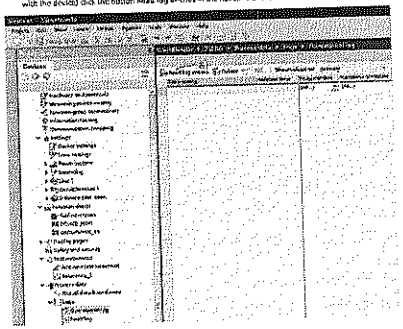


Figure 3-4 Reading the Operational Log with DIGSI 5

Reading on the Device Through the On-Site Operation Panel

- To reach the operational log via the main menu, use the navigation keys of the on-site operation panel.
  Main menu → Indications → Operational log
- You can navigate within the displayed indication list using the navigation keys (buttons) on the on-site operation panel.

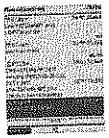


Figure 3-5
On-Site Display of an Indication List (Example, Operational Indications)

Deletability

The operational log of your SIPROTEC 5 device can be deleted. This is done usually after testing or commissioning the device. To know more about this, read chapter 3.1.6 Saving and Deleting the Logs.

Configurability

The indication scope of the operational log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:
Target → Log → Operational log column
Selected application templates and functions from the library bring with them a predefined set of operational indications which you can adjust individually at any time.

3.1.5.3 Fault Log

Fault indications are events which arise during a fault. They are logged in the fault log with real-time stamp and detailed time-stamp reference point (fault incremental). Faults are numbered consecutively in rising order. With the 65 increasing endpoint, a corresponding fault record with the same number exists for every fault logged in the fault log. A maximum of 128 fault logs can be stored. A maximum of 1000 indications can be recorded in each fault log.

Fault Definition

In general, a fault is caused by the picking picking of a protective function and ends with the cleared pickup after the trip command.
When using an automatic reclosing function, the complete reclosing cycle (successful or unsuccessful) is considered as one fault. If evolving faults appear within reclosing cycles, the entire clearing process is logged under one fault number even in multiple pickup cycles. Without automatic reclosing function every pickup is also recorded as its own fault.
Laborative configuration of a fault is also possible.

NOTE

The definition of the fault is done through settings of the fault recording (see Device manual). Please see Related in the fault log even when fault recording is switched off.

Apart from the recording of fault indications in the fault log, spontaneous display of fault indications of the last fault on the device display is also done. You will find details about this in chapter 3.1.8 Spontaneous Fault Display on the On-Site Operation Panel.

Reading from the PC with DIGSI 5

- To reach the fault log of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Process Data → Log → Fault logs

The status of the fault log last loaded from the device is shown to you.

- To update (synchronization with the device), click the button Read log entries in the headline of the indication list.

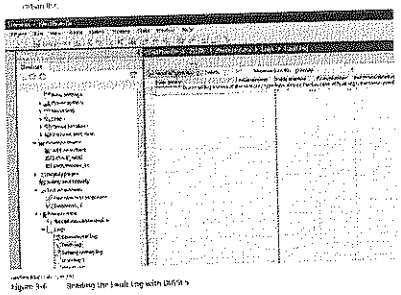


Figure 3-6 Reading the Fault Log with DIGSI 5

Deletability

The fault log of your SIPROTEC 5 device can be deleted. Read about it in chapter 3.1.6 Saving and Deleting the Logs.

Reading on the Device through the On-Site Operation Panel

- To reach the fault log from the main menu, use the navigation keys of the on site operation panel.
  Main Menu → Indications → Fault logs
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on site operation panel.

Target → Log → Columns Ground-fault log

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

3.1.5.5 Setting-History Log

All individual setting changes and the downloaded files of entire parameter sets are recorded in the log for setting changes. This enables you to determine setting changes made are associated with events logged (for example, faults). On the other hand, it is possible to prove with fault analyses, for example, that the current status of all settings truly corresponds to their status at the time of the fault. Up to 200 indications can be stored in the setting-history log.

Reading from the PC with DIGSI 5

- To reach the log for setting changes of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Process Data → Log → Setting changes

The status of the setting history log last loaded from the device is shown to you.

- To update (synchronization with the device), click the Read log entries button in the headline of the indication list (Figure 3-10).

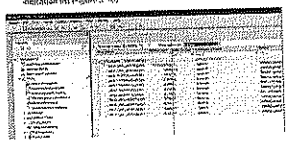


Figure 3-10 Reading the Setting-History List with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the setting-history log from the main menu, use the navigation keys of the on-site operation panel.
  Menu → Indications → Setting changes
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on site operation panel.

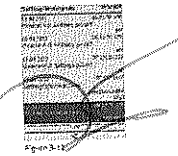


Figure 3-11

Figure 3-7
Reading the Fault Log on the On Site Operation Panel of the Device

Configurability

The indication scope of the fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → Fault log column

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

The operational measured values and the measured values of the fundamental components and symmetrical components (see Equipment Manual) are calculated every 5 cycles (at 50 Hz, this is every 100 ms). However, this can mean that the data are not corresponding with the sampled values of the analog channels. The recording of these measured values can be used to analyze the closely cyclic processes.

3.1.5.4 Ground Fault Log

Ground-fault indications are events which arise during a ground fault. They are logged in the ground fault log with real time stamp and millisecond stamp (sequence point ground-fault occurred). Ground faults are numbered consecutively in rising order. A maximum of 10 ground fault logs are stored and for each ground fault log, it is guaranteed that at least 100 indications are recorded.

The following functions can start the logging of a ground fault with the raising ground fault indication:

- Directional sensitive ground-fault protection for isolated and isolated systems (67Ns)
- Sensitive ground current protection with IE (50/51/67Ns)
- Intermittent ground-fault protection

The logging ends with the going ground fault indication.

Reading from the PC with DIGSI 5

- To reach the ground-fault log of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Process Data → Logs → Ground-fault log

The status of the device-diagnosis log last loaded from the ground-fault log is shown to you.

- To update (synchronization with the device) click the button Read log entries in the headline of the indication list (Figure 3-8 a).

Reading the Setting-History Log on the On-Site Operation Panel of the Device

Indication Categories in the Setting-History Log

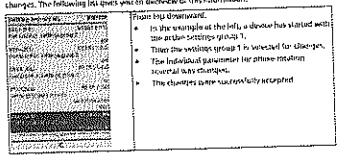
For this log, there is entered information that is stored in case of successful as well as unsuccessful setting changes. The following list gives you an overview of this information:

Table 3-2 Overview of Indication Types

Displayed Information	Explanation
Selection setting-group	Selection of settings group to be edited
Recycle	Rejection of all changes successful
PC activation+	PC activation via command successful
PC activation-	PC activation via command failed
Par. activation	Parameter value was changed
Acceptance+	Acceptance of change successful
Acceptance-	Acceptance of change failed
DCF loaded	DCF loaded into device
SG 1	Settings group 1
SG 2	Settings group 2
SG 3	Settings group 3
SG 4	Settings group 4
SG 5	Settings group 5
SG 6	Settings group 6
SG 7	Settings group 7
SG 8	Settings group 8

Example of Logging in Setting-History Log

For this log, there is entered information that is stored in case of successful as well as unsuccessful setting changes. The following list gives you an overview of this information.



From top downward:

- In the example at the left, a device has started with the active Settings group 1.
- Then the settings group 5 is selected for changes.
- The individual parameter for phase rotation reversal was changed.
- The changes were successfully accepted

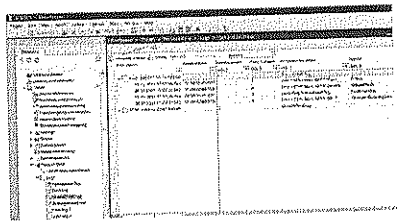


Figure 3-8 Reading the Ground-Fault Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the ground-fault log from the main menu, use the navigation keys of the on site operation panel.
  Main Menu → Indications → Ground fault indication
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on site operation panel.

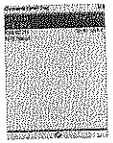


Figure 3-9
Reading the Ground Fault Log on the On Site Operation Panel of the Device

Deletability

The ground fault log of your SIPROTEC 5 device can be deleted. Read about it in chapter 3.1.6 Saving and Deleting the Logs.

Configurability

The indication scope of the ground fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5

NOTE

- The logged indications are preconfigured and cannot be changed.
- The log, which is organized as a ring buffer, cannot be deleted by the user itself.
- If you want to archive currently relevant information without loss of information, you must regularly read this log.
- You cannot route additional indication objects to the setting history log.

3.1.5.6 User Log

With the user-defined log (up to 3), you have the possibility of individual indication logging suited to the operational log. This is helpful, for example, in special monitoring tasks but also in the classification into different areas of responsibility of the logs. Up to 200 indications can be stored in the user-defined log.

Reading from the PC with DIGSI 5

- To reach the user-defined log of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Process Data → Logs → User log 1/2

The status of the user-defined log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button Read log entries in the headline of the indication list (Figure 3-12 a).

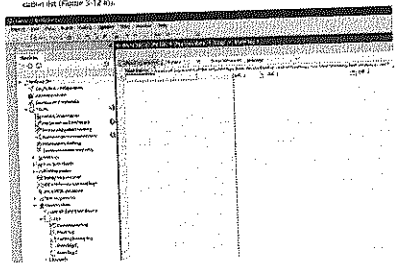


Figure 3-12 Reading the User-Defined Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach user-specific logs from the main menu, use the navigation keys of the on site operation panel.
  Main Menu → Indications → User-defined log 1/2

You can navigate within the displayed indication list using the navigation keys (up/down) on the on site operation panel.

Figure 3-12
Reading the User Defined Log on the On Site Operation Panel of the Device

Deletability

The user defined log of your SIPROTEC 5 device can be deleted. Read about it in chapter 3.1.6 Storing and deleting the Logs.

Configuration of a User Defined Log

The indication capacity of a created user defined log can be configured freely in the associated column of the indication routing (routing) of DIGSI 5:
Target → Log → U1 or U2

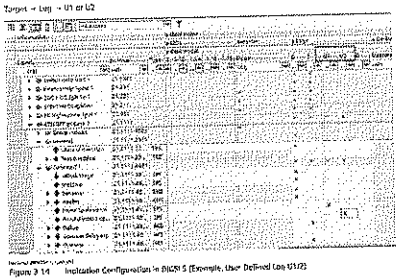


Figure 3-14 Indication Configuration in DIGSI 5 (Example, User Defined Log U1/U2)

3.1.5.7 Security Log

Access to areas of the device with restricted access rights is recorded in the security log. Unsuccessful and unauthorized access attempts are also recorded. Up to 500 indications can be stored in the security log.

Figure 3-13
Reading the Device Diagnosis Log on the On-Site Operation Panel of the Device

NOTE

- The device-diagnosis log cannot be deleted!
- The logged indications are preconfigured and cannot be changed!

3.1.5.8 Communication Log

The logging of the ring/redundancy status such as arriving faults, test and diagnostic operation, and communication capacity utilization is done for all hardware based configured communication interfaces. Up to 500 indications can be stored in the communication log. Logging occurs separately for each communication port of the configured communication modules.

Reading from the PC with DIGSI 5

- Use the project tree window to reach the communication logs of your SIPROTEC 5 device.
  Online access → USB → Project → Test suite → Communication module
- Then select:
  Ethernet → Communication log

The status of the communication log last loaded from the device is shown to you under the item Time stamp from.

- To update (synchronization with the device) click the button Update in the headline of the indication list.

Reading from the PC with DIGSI 5

- To reach the security log in your SIPROTEC 5 device, use the project tree window.
  Project → Device → Device information → Log → Security log

The status of the security log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button Update in the headline of the indication list.

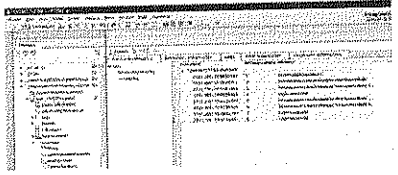


Figure 3-15 Reading the Communication Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the security log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → Security log
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-16
Reading the Security Log on the On Site Operation Panel of the Device

NOTE

- The logged indications are preconfigured and cannot be changed!
- This log, which is organized as a ring buffer, cannot be deleted by the user!
- If you want to archive security-relevant information without loss of information, you must regularly read this log.

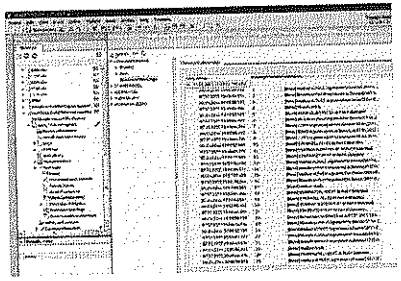


Figure 3-19
Reading the Communication Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the communication log from the main menu, use the navigation keys on the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → Communication log
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-20
Reading the Communication Log on the On-Site Operation Panel of the Device

3.1.5.8 Device Diagnosis Log

The logging and the display of device interruptions or errors in the device diagnosis log during

- Ill-tested environment (for example, thermal, mechanical)
- Identified hardware defects
- Compatibility problems

up to self-intervention, can be stored in the device diagnosis log. A normal operation of the device, it is sufficient for diagnostic purposes to follow the entries of the operational log. This specific significance is assumed by the device diagnosis log when the device is no longer ready for operation due to hardware defect or compatibility problems and the fallback system is active.

Reading from the PC with DIGSI 5 in Normal Operation

- To reach the device diagnosis log of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Device information → Log → Device-diagnosis log

The status of the device diagnosis log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button Update in the headline of the indication list.

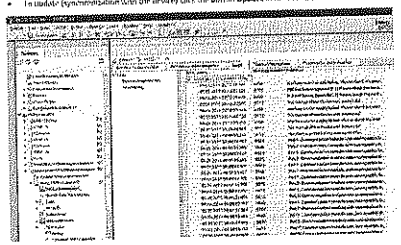


Figure 3-17 Reading the Device-Diagnosis Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel in Normal Operation

- To reach the diagnosis log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → Device diagnosis
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Deletability

The communication logs of your SIPROTEC 5 device can be deleted. Read details about this in chapter 3.1.6 Storing and Deleting the Logs.

Configurability

The communication logs are not freely configurable. The entries are preconfigured.

3.1.5.10 Motor Starting Log

The motor starting log records the starting current, starting voltage and the start duration each time a motor starts. The motor starting current and the motor starting voltage are displayed as primary values. Up to 200 indications can be stored in the motor starting log.
Measurement of the motor statistics starts when the motor state changes to **Start**. Measurement of the motor starting time ends as soon as the motor state changes to **Standstill** or **Running**. The motor state is obtained from the Motor state detection function.
No entry is recorded in the motor starting log if the motor state changes to Start and the current drops below the motor starting current within 300 ms.

Table 3-4 Motor Starting Log

		Primary
Measured Values		
Start duration	Motor starting time	s
Starting current	Motor starting current (primary)	A (or kA)
Starting voltage	Motor starting voltage (primary)	V (or kV)

Reading from the PC with DIGSI 5

- Use the project tree window to reach the motor starting log of your SIPROTEC 5 device.
  Project → Device → Device information → Log → Motor starting log

The state of the motor starting log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button Update in the headline of the indication list.

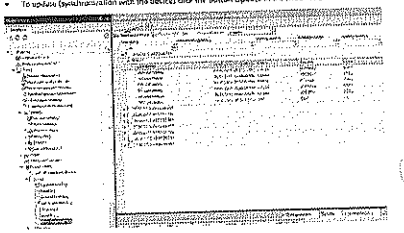


Figure 3-21 Reading the Motor Starting Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the motor-starting log from the main menu, use the navigation keys of the on-site operation panel:
  Main Menu → Indications → Motor starting log
- You can navigate within the data pages and cancel out using the navigation keys (optional) on the on-site operation panel.

Figure 3-22 Reading the Motor Starting Log on the On-Site Operation Panel of the Device

Deletability

The motor starting log of your SIPROTEC 5 device can be deleted. Read details about this in Chapter 3.1.6 Saving and Deleting the Logs.

Configurability

The motor starting log is set, preset in the Master function group. There is no column for the motor starting log in the DIGSI Information matrix. The entries in the motor starting log are preconfigured and cannot be changed.

3.1.6 Saving and Deleting the Logs

Deleting the logs of the device in the operating mode is unnecessary, if storage capacity is no longer sufficient for new indications, the oldest indications are automatically overwritten with new incoming events. In order for the memory to contain information about the new faults in the future, for example, after an inspection of the system, a deletion of the log makes sense. Reading the log is done separately for the various logs.

NOTE

Before you delete the contents of a log on your SIPROTEC 5 device, save the log with DIGSI 5 on the hard disk drive of your PC.

NOTE

Not all logs of your SIPROTEC 5 device can be deleted. These limitations apply especially to logs with relevance for security and after sales (security log, device diagnosis log, motor history log).

NOTE

Upon deletion of the fault log, the associated fault records are also deleted. In addition, the memory for fault number and fault record number are reset to 0. In contrast, if you delete fault records, the content of the fault log, including the deleted fault numbers, remains.

NOTE

If the device operates an inactive state, for example, after a restart of the device software, the following logs are automatically deleted:

- Operational log
- Fault log
- Ground fault log
- Setting history log
- User log
- Motor starting log

Back up the deletable logs using DIGSI 5.

NOTE

If a ground fault is currently active, the ground fault log cannot be deleted.

Deleting Logs on the On-Site Operation Panel

- To reach the operating log from the main menu, use the navigation keys of the on-site operation panel (example operational log):
  Main Menu → Indications → Operational log

Figure 3-23 Deleting the Operational Log on the On-Site Operation Panel

- You can navigate within the displayed indication list using the navigation keys (optional) on the on-site operation panel.
- The option to delete the entire log is offered to you in the footer of the display at the bottom left. Use the softkey selected under the display to activate the command prompt. Confirm the request to **Delete**.
- After being prompted, enter the password and confirm with **Enter**.
- After being prompted, confirm the **Deletion of all entries with Ok**.

Deleting Logs from the PC with DIGSI 5

- To open the operating log of your SIPROTEC 5 device, use the project tree window, for example, select:
  Project → Device → Process data → Logs → Operational log

3.1.7 Spontaneous Indication Display in DIGSI 5

With DIGSI 5 you have the possibility of displaying all currently transmitted indications of the selected device in a special indication window.

Procedure

- Call up the spontaneous indications of your selected device in the navigation window Online Access (online access).
- Click Indications in the path:
  Online access → Interface → Device → Indications
- The arising indications appear immediately without you having to wait for a cyclical update or execute the manual update.

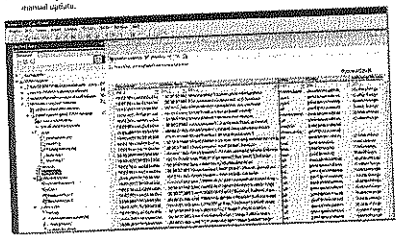


Figure 3-24 Displaying Spontaneous Device Indications in DIGSI 5

3.1.8 Spontaneous Fault Display on the On-Site Operation Panel

After a fault, the most important data of the last fault can be displayed automatically on the device display without further operational measures. In SIPROTEC 5 devices, protected objects and even circuit breakers can be freely created and configured (dependent on the application) (multi-channel instances). In DIGSI 5, several spontaneous fault displays can be configured, depending on the application, with each individual one being assigned a particular circuit breaker. These displays remain stored in the device until they are manually confirmed or reset by LED reset.

Configuration of a Spontaneous Fault Display with DIGSI 5

- To reach the **Fault display configuration** of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Device page → **Fault display configuration**
- In the main window, all configured circuit breakers are displayed. A list of a maximum of 6 configurable display lines is offered for each circuit breaker. The activation of a spontaneous fault display occurs for each circuit breaker by selection via checkmark in the column **Display**.
- With the parameter **Fault-display behavior** → **Parameter** → **Device settings** you determine whether spontaneous fault displays should be displayed for each pickup or only pickups with the off command.

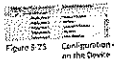


Figure 3-25 Configuration of the Spontaneous Fault Display on the Device

For every display line the following display options can be selected:

Table 3-5 Overview of Display Options

Displayed Information	Explanation
Pickup indication	Display of the first function stage picked up in a fault, as needed with additional information (phases, ground, start, fwd).
Pickup time	Display of the return pickup duration of the fault.
Operate indication	Display of the first function stage triggered in a fault, as needed with additional information (phases).
Trip time	Display of the operate time related to the beginning of the fault (pickup start).
Fault distance	Display of the measured fault location distance.

Acknowledgement of the Spontaneous Fault Display on the Device

After tests, the last received fault is always displayed so you, in cases where tests then are carried out, is configured, several stored fault displays can be present after this, with the latest being displayed. These displays remain stored in the device until they are manually acknowledged or reset by LED reset.

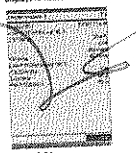


Figure 3-26 Spontaneous Fault Display on the Device

Method 1: Manual acknowledgement

- Press the softkey button **Quit** in the base bar of the display. The display is not immediately cleared. Repeat this step until no spontaneous fault display appears anymore.
- After completion of all confirmations the last display view is showed before the faults.

Method 2: Acknowledgement via LED reset

- An LED reset (device) causes the reset of all stored LEDs and binary output contacts of the device and also to the confirmation of all fault displays stored in the display.

You can find more details on the topic of LED reset in Chapter 3.1.9 Stored Indications in the SIPROTEC 5 Device.

3.1.9 Stored Indications in the SIPROTEC 5 Device

In your SIPROTEC 5 device, you can also configure indications as stored. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is activated until it is acknowledged. Acknowledgement occurs via:

- On-site operation panel
- DIGSI 5
- Binary input
- Protocol of substation automation technology

Configuration of Stored Indications with DIGSI 5

- In the Information Routing of each device set up in DIGSI 5, you can route binary signals, among others, to LEDs and output contacts. For this, go to the project tree.
  Project → Device → Information routing
- Right-click the routing field of your binary indication in the desired LED or binary output columns in the routing matrix of the targets.

You are offered the following options:

Table 3-6 Overview of Routing Options

Routing Options	LEDs	BOs	Blk	Description
H	(active)		Y	The signal is routed as active with voltage.
L	(active)		Y	The signal is routed as active without voltage.
V	(latched)	Y		The signal is routed as unlatched. Activation and reset of the output (LED, BO) occurs automatically via the binary signal value.
S	(latched)	Y		The binary signal is latched when the output (LED) is activated. To reset, a targeted confirmation must occur.
NI	(stored mode) with (tripping)	Y		Fault indications are stored when the output (LED) is activated. If the fault is ended via a trip command from the device, the stored state is maintained. In case of absence of the pickup (without the command from the device for example, external fault), the state displayed before the fault is restored. Note: Observe here the parameter **Fault-display behavior** with the setting options **with trip** or **with pickup**. For the routing option, select the setting **with trip**.

Routing Options	LEDs	BOs	Blk	Description
(tripping)		X		Binding output (tripping coord) is only possible for the switching object circuit breaker. The output is saved with protection tripping. The contact remains activated until acknowledged. General commands are not affected. A control command is possible during the parameterized command period until feedback has been successfully received. Note: You can activate the functionality of the Lockout (ANSI 86) by storing the control relay with the routing option TI.

Acknowledgement of Stored Indications on the On-Site Operation Panel

Acknowledgement via LED Reset

Operating the button first causes the activation of all LEDs (LED test) when pressed, and when releasing the resetting of all stored indications. Stored LEDs, output contacts and spontaneous fault displays are reset.

Acknowledgement via the operating menu

Use the navigation buttons on the on-site operation panel, in order to reach the reset function from the main menu.

- Select: Main menu → **Device functions** → **Reset functions**
  You see different reset options.
- Open the corresponding submenu.

Figure 3-27 Reset Functions on the On-Site Operation Panel

- Use **Yes**, binary outputs to reset stored output contacts.
- Activate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.
- Use **Reset LEDs** to reset stored LEDs that are not assigned to a special function group.
- Activate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.

Depending on device configuration, the protection function group(s) are displayed to you as submenus for which separately corresponding, stored LEDs can be reset.

- Go to the submenu of the selected function group (for example, Line 1).
- Use **Reset LEDs** to reset stored LEDs in the selected function group.
- Activate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.

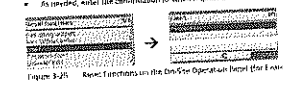


Figure 3-28 Reset Functions on the On-Site Operation Panel (for Example, Line FG)

Acknowledgment of Stored Indications via Binary Inputs

Acknowledgment via Only >LED Reset
Acknowledgment via binary input >LED Reset brings about the activation of all LEDs (LED Reset), and, in case of program of signal, the resetting of all stored indications. Stored LEDs, output contacts and spontaneous fault displays are reset.

Acknowledgment of Stored Indications with DIGSI 5

You can acknowledge stored indications via DIGSI 5 in online mode. For this, go to the project tree.

- Select Online access → Interface → Device → Device information

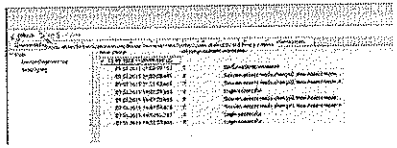


Figure 3-29 LED Reset via DIGSI 5

- Click the LED reset button.
- Enter the confirmation ID
- Confirm the process with OK.

Stored LEDs, output contacts and spontaneous fault displays are reset on the assigned device.

Acknowledgment of Stored Indications via Log

Initiation of remote retrieval of stored indication can also occur through communication via a connected substation automation technology. This can occur in conformance to standards (IEC 61850, IEC 60870-5-103) or via configuration (mapping) of the LED reset input signal to any general Stored LEDs, output contacts and spontaneous fault displays are reset.

NOTE

The acknowledgment of stored indications then leads to the resetting of configured LEDs and output contacts, as long as these actually unstored indications are not present in parallel. That is, indications configured as unstored are not affected by the acknowledgment process.

3.1.10 Resetting Stored Indications of the Function Group

You can configure indications of individual functions as "stored" in a function group. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is retained until it is acknowledged.
The protection and the circuit-breaker have an option to receive the block **Reset LED FG**. The block **Reset LED FG** is visible only in the information routing under the corresponding function group in DIGSI 5. You use the binary input signal *>Reset LED* to reset the stored LEDs in the respective function group. The configured contacts (contacts) are not reset.

The 20 samplings per cycle will be made available to the algorithms processed in the function groups, in 2 variants:

- Fixed (not resampled)
- Resampled (frequency range from 10 Hz to 80 Hz)

Depending on the algorithms (see function descriptions), the respective data flow is considered. A higher sampling frequency is used for selected methods of measurement. Detailed information can be found in the corresponding function description.

NOTE

The measuring points for current and voltage are in the Power-system data (filtering in chapter 5.1 Power-System Data). Each measuring point has its own parameters.

3.1.11 Test Mode and Influence of Indications on Substation Automation Technology

If the test mode of the device or of individual functions is switched on, the SIPROTEC 5 device enters a defined state in substation automation technology station control system with an additional test bit. This way it makes it possible to determine that an indication was not issued in real operation but in test mode. Furthermore, it can be determined from the bit in the indication on how to be subsequent.

3.2 Measured-Value Acquisition

Basic Principles

Synchronized measurement is a key requirement for many power system management functions. Synchronized measurement is the only way to correctly acquire current and voltage values during dynamic power system conditions. Sampling of the analog input variables is the conversion of continuous analog quantities into discrete analog values. The first step in this conversion process is the sampling of input voltages and currents. Sampling is carried out at a constant clock pulse rate. The sampling frequency determines how many times per second the analog values are sampled. The sampling theorem must be observed during sampling. The sampling theorem states that sampling must be carried out at a frequency that is more than twice the highest frequency component in the sampling signal. Otherwise, overlapping occurs, which means that high-frequency components are displayed as low-frequency components in the sampled signal. This leads to misinterpretations in the digital further processing.

Sampling frequency and adaptation

The sampling frequency specifies how many times per second the analog values are sampled. The sampling theorem must be observed during sampling. The sampling theorem states that sampling must be carried out at a frequency that is more than twice the highest frequency component in the sampling signal. Otherwise, overlapping occurs, which means that high-frequency components are displayed as low-frequency components in the sampled signal. This leads to misinterpretations in the digital further processing.

In digital systems, deviations from the rated frequency lead to additional errors, because in such cases, also non-fundamental components are sampled. Therefore, a precise adaptation of the sampling frequency to the input frequency is necessary. SIPROTEC 5 devices are equipped with a powerful measured-value acquisition function in addition to a high sampling frequency. They have a high measurement resolution. This ensures a high degree of accuracy across a wide dynamic range. The 24 bit sigma-delta analog-digital converter represents the core of measured-value acquisition. In addition, the oversampling function ensures the high measurement resolution. Depending on the requirements of the individual method of measurement, the sampling frequency is reduced (Downsampling).

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- Sampling frequency tracking
  The analog input channels are scanned for valid signals in cycles. The current power frequency is determined and the corrected sampling frequency is applied by using a resampling algorithm. The tracking is effective in the frequency range between 10 Hz and 69 Hz.
- Fixed sampling frequency – correction of the filter coefficients
  This method operates in a limited frequency range (f_{nom} ± 5 Hz). The power frequency is determined and, depending on the degree of the frequency deviation, the filter coefficients are corrected.

Dynamic measuring point switching is also implemented for 1.5 circuit breaker or double busbar applications that require dynamic selection of voltage measuring points.

The following figure shows the basics of dealing with sampled values (SVs) in the measured value acquisition chain. Figure 3-30 shows to which the various sampling frequencies are made available. In order to limit the bandwidth of the input signals, a low-pass filter (anti-aliasing filter to minimize the sampling theorem) is installed downstream. After sampling, the current input channels are adjusted. This means the magnitude, phase, as well as the transformer time constant are corrected. The compensation is designed to ensure that the current transformer nominal loads can be exchanged randomly between the devices.

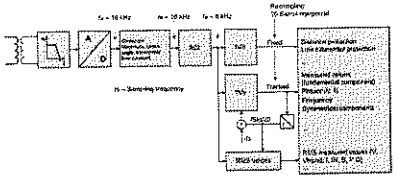


Figure 3-30 Measured-Value-Acquisition Chain

The internal sampling frequency of the SIPROTEC 5 devices is fixed at 16 kHz (sampling rate: 320 samplings per 50-Hz cycle). All current and voltage inputs are sampled, if the magnitude, phase, and transformer time constant are corrected, the sampling frequency is reduced to 8 kHz (160 samplings per 50-Hz cycle). This is the basic sampling frequency to which various processes, such as fault recording, RMS measured values, refer. For the RMS measurement, the measured-value window is adjusted on the basis of the power frequency. For maximum measurement and protection applications, 20 samplings per cycle are sufficient ($f_{sampling}$ = 50 Hz · sampling every 1 ms, at f_{nom} = 60 Hz sampling every 0.833 ms). This sampling rate is an adequate compromise between accuracy and the parallel processing of the functions (multi-functionality).

3.3 Processing Quality Attributes

3.3.1 Overview

The IEC 61850 standard defines certain quality attributes for data objects (DO), the so-called Quality. The SIPROTEC 5 system automatically processes some of these quality attributes. In order to handle different application cases, you can influence certain quality attributes and also the values of the data objects on the basis of these quality attributes. This is how you can ensure the necessary functionality.
The following figure describes roughly the general data flow within a SIPROTEC 5 device. The following figure also shows at which points the quality can be influenced. The building blocks presented in the figure are described in more detail in the following.

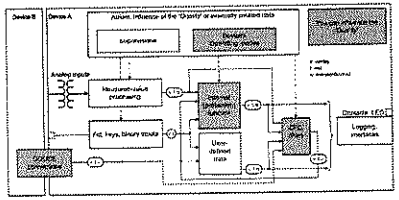


Figure 3-31 Data Flow within a SIPROTEC 5 Device

Supported Quality Attributes

The following quality attributes are automatically processed within the SIPROTEC 5 system.

- Validity using the values *good*, *invalid*
  The Validity quality attribute shows if an object transferred via a GOOSE message is received (valid, invalid) or not received (invalid). The *invalid* state can be suppressed in the receiver device by also setting a substitute value for the object that is not received (see Figure 3-32). The substitute value is transmitted in the transfer.
  If the device receives one of these values, it is replaced by the configured substitute and then processed further as *invalid*.
  If one of the detailed quality attributes (questionable) has the value *TRUE*, then Validity is set to the *invalid* value, unless this was already done at the transmitter end.
- Test using the values *TRUE*, *FALSE*
  The Test quality attribute indicates to the receiver device that the object received via a GOOSE message was created under test conditions and not operating conditions.

- Operator=Blocked using the values *TRUE*, *FALSE*
  The Operator=Blocked quality attribute indicates whether an object transferred via GOOSE message originates from a device that is in *Functional Test* mode. When the sending device is switched off, the object is no longer being switched and assumes the value *TRUE*. However, however, since the Operator-Blocked quality was previously identified on the sending device, the object can be treated differently at the receiving end (see chapter 3.3.2 Quality Processing/Reaction) by the User the Received (GOOSE) values).
  At the receiving end, the object may be treated like a dropped signal.
- Source using the values *process*, *substituted*
  The Source quality attribute indicates whether the object was updated in the sending device.
  You can find more detailed information in chapter 4.8.2 Acquisition Blocking and Manual Updating.

Influencing Quality by the Operating Modes

In addition to the normal operation, the device also supports further operating modes that influence quality:

- Test mode of the device
  You can switch the entire device to test mode. In this case, all data objects generated in the device (state values and measured values) receive the quality attribute Test = *TRUE*.
  For IEC others are also in test mode and all output data receive the quality attribute Test = *TRUE*.
- Test mode for individual functions, stages, or function blocks
  You can switch individual functions, stages, or function blocks into test mode. In this case, all data objects generated by the function, stage, or function block (state values and measured values) receive the quality attribute Test = *TRUE*.
- Functional logoff of the device
  If you take the device out of operation and want to isolate it from the supply voltage, you can functionally log off the device ahead of time. Once you functionally log off the device, all data objects generated in the device (state values and measured values) receive the quality attribute Operator-Blocked = *TRUE*. This also applies to the output from CFC charts.
  If objects are transferred via a GOOSE message, the receiving devices can assess the quality. The receiver device detects a breakdown of the transmitting device. After shutting down the sending device, the receiver device identifies that the sending device has been logged off operationally and did not fail. Now the receiving objects can automatically go to a defined status (see chapter 3.3.2 Quality Processing/Reaction) by the User (or Received (GOOSE) Values).
- Switching off individual functions, stages, or function blocks
  You can switch off individual functions, stages, or function blocks. In this case, all data objects generated by the function, stage, or function block (state values and measured values) receive the quality attribute Validity = *Invalid*.

Influencing the Quality through Hardware Supervision

Supervision functions monitor the device hardware (see chapter 8.4 Supervision of the Device Hardware), if the supervision function identify failures in the data acquisition of the device, all transient data will receive the quality attribute Validity = *Invalid*.

Influencing the Quality through Voltage-Transformer Circuit Breakers

If tripping of the voltage transformer circuit breaker is detected (see chapter 7.3.4 Voltage Transformer Circuit Breaker), all recorded data will receive the quality attribute Validity = *Invalid*.

Influencing the Quality by the User

You can influence the processing of data and their quality differently. In DIGSI 5, this is possible at the following 3 locations.

- In the information routing editor for each individual signal of GOOSE connections
- In the CFC chart
- In the information routing editor for binary and digital of device-internal functions

The following chapters describe in more detail the options regarding the influence of and the processing quality evaluation.

If a GOOSE connection is the data source of a binary input signal of a device internal function, you can influence processing of the quality of 2 functions at the GOOSE connection and at the input signal of the function. That is based on the following: A GOOSE data can be received when the receiving device is ready for operation. The GOOSE connection sending (publishing) device will, however, interrupt, if different functions require outdated settings, these are then set directly at the binary input signal of the function.

3.3.2 Quality Processing/Affected by the User for Received GOOSE Values

In the Information Routing editor, you can influence the data value and quality of all data types. The following figure shows the possible influences using the example of an SPC data type:

- In the DIGSI 5 project tree, double-click Information Routing.
- Select the device signal in the External Signals group.
- Open the Properties window and select the Processing Quality Attributes check.

Figure 3-32 Influence Option When Linking an SPC Type Data Object

The following options work for the device receiving the data.

Quality Attribute: Validity	
The validity value *reserved* and *questionable* are replaced at the receiving end by the *invalid* value.	
• Check box is not set • Check box is set and receipt of Validity = *good*	The validity attribute and data value are forwarded without change.
Check box is set and receipt of Validity = *invalid* or (also applies to values *reserved* and *questionable*).	• The validity attribute is set to *good* and processed further using this value • The data value is set to the defined substitute value and processed further using this substitute value.

Quality Attribute: OperatorBlocked (opBlk)	
• Check box is not set. • Check box is set and received OperatorBlocked = *FALSE*	The OperatorBlocked attribute and data value are forwarded without change.

Quality Attribute: OperatorBlocked (opBlk)	
Check box is set and received OperatorBlocked = *TRUE*	• The OperatorBlocked attribute is set to *FALSE* and processed further using this value • The data value is set to the defined substitute value and processed further using this substitute value

Interaction of the Quality Attribute Validity and OperatorBlocked	
OperatorBlocked check box is set and receipt of OperatorBlocked = TRUE	Regardless of whether the validity check box is set or not, or regardless of the current validity, the validity attribute is set to good and the substitute value of the OperatorBlocked data object is set. That is, the operator has made changes outside the validity settings.
OperatorBlocked check box is not set and receipt of OperatorBlocked = *TRUE*	The OperatorBlocked attribute remains set and is forwarded. If the Validity check box is set and the receipt of validity = *invalid* is set, the respective data object substitute value is used. For input signal processing and influences, it must be taken into account that in the reading-order the data object substitution value for validity = *invalid* is set, but the quality attribute OperatorBlocked is not set/set.

Data Substitute Values

Depending on the data type, different data substitute values must be used.

Data Type	Possible Data Substitute Values	
ACD, ACT	general, dirA, dirB, dirC, dirN	0 (none) ... 1 (true)
only ACD	dirUnk	0, 1, 2, 3 (Unknown, Forward, Backward, both)
	dirFrwd, dirBckw, dirBoth, dirNone	0, 1, 2 (Forward, Backward, Both)
INC, APC	stVal	-1.012268 · 10^38 to 7.623 · 10^37
	stVal	0 (false), 1 (true)
	ctlVal	0 to 255
BCR	actVal, frVal, orVal	0 to 1 073 741 824
CMV	mag.f	-1.012268 · 10^38 to 7.623 · 10^37
DPC, EPS	stVal	0, 1, 2, 3 (intermediate-state, off, on, bad-state)
BH483 type (for example, EN, CN, INC)	CPC output	0 (false), 1 (true)
	TFS output	The qualities of the object of the sending device are updated.
INC	stVal	0 to 1 073 741 824
	mxVal	0 (false), 1 (true)
INS	stVal	0 to 1 073 741 824
IPC, BSC	ctlVal	0 to 1
	oprTout	60 to 64
	cxlVal	0 (false), 1 (true)
SEC	cnt	0 to 1 073 741 823
SPC, SPS	stVal	0 (false), 1 (true)
SPG	setVal	0 (false), 1 (true)

Data Type	Possible Data Substitute Values	
MV	mag	-1.012268 · 10^38 to 7.623 · 10^37

3.3.3 Quality Processing/Affected by the User in CFC Charts

In DIGSI 5, you can control the quality processing of CFC charts. In a project tree, you can find the CFC block (see the following figure) under Device name → Settings → Device settings in the editor.

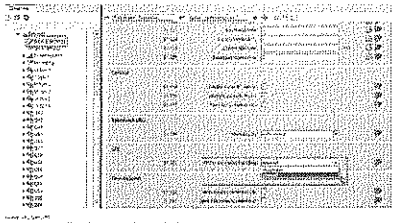


Figure 3-33 Influencing CFC Quality Handling in DIGSI 5

With the CFC chart quality handling parameter, you control whether you want to influence the quality of CFC charts in a manual or automatic (default setting) manner.

If you select manual, the quality attribute of the CFC chart is always valid regardless of the quality of individual signals (Validity = *good*).

Only the Test quality attribute of the CFC chart is processed, if the device is in test mode or the input TEST of the CHART_STATE CFC block is set, the quality attribute of the CFC chart is set to Test.

If you select automatic, the quality processing of the CFC charts is influenced as follows.

In the case of CFC charts, a distinction has to be made between the general quality processing and certain CFC blocks that are specifically designed for quality processing.

General Processing

Most of the CFC blocks do not have an explicit quality processing. For these blocks, the following general mechanisms shall apply.

Quality Attribute: Validity
If one *invalid* signal is received in the case of CFC input data, then all CFC output data will also be set to *invalid* if they originate from building blocks without explicit quality processing. In other words, the quality is not processed sequentially from building block to building block but the output data are set globally. (this does not apply to CFC output data that originate from building blocks with explicit quality processing (see next section).

Quality Attribute: Test	
CFC chart is in normal state.	CFC input data with the Test = *TRUE* attribute are ignored. When the CFC chart is executed, then the data value that was used before the Test = *TRUE* attribute is used. The quality of this old value is also processed. This means that on the output side, the attribute Test = *FALSE*.
CFC chart is in "Test" state.	If the CFC chart is executed, then the attribute Test = *TRUE* is set for all data leaving the CFC chart. This does not depend on whether the data are formed via CFC blocks with or without quality processing.

*) A CFC chart can be switched to the test state by switching the entire device to test mode or the input TEST of the CFC block CHART_STATE is set.

Quality Attribute: OperatorBlocked	
CFC chart is in normal state.	In CFC charts for incoming data, the OperatorBlocked attribute is ignored.
CFC chart is in functionality logged off"state .	In CFC charts for incoming data, the OperatorBlocked attribute is ignored. All CFC output data are labeled as functionally logged off.

*) This state only occurs if the device is functionally logged off. In this case, the quality attribute of all CFC outputs are labeled as functionally logged off.

Quality Processing Building Blocks (Condition Processing)

The first 3 blocks (* _SPS) process the quality information according to the stated logic. The other blocks are used to isolate the quality from a data object and add them back after separate logical processing.

Building Blocks	Description
OR_SPS AND_SPS NEG_SPS	The blocks also process the supported quality attributes according to their logic. The following rules describe the logic using input values in connection with the quality attribute Validity. The input values are 0 or 1, the quality attribute Validity can have the value *good* (=0) or *invalid* (=1). x = placeholder for the input value and quality attribute Validity

OR_SPS

A (Value, Attribute)	B (Value, Attribute)	Q (Value, Attribute)
0, i	0, x	i, i
0, x	1, g	1, g
1, g	x, x	1, g
1, i	x, x	1, i
x, i	0, x	1, i

The output then has the logical value 1 with Validity = *good* as soon as at least 1 input has the logical value 1 with Validity = *good*. Otherwise, the inputs are treated according to the OR operation and the INVALID bit is OR-gated for the quality.

AND_SPS

A (Value, Attribute)	B (Value, Attribute)	Q (Value, Attribute)
0, g	x, x	0, g
0, i	1, x	0, i
1, i	1, x	1, i
1, g	1, g	1, g

The output then has the logical value 0 with Validity = *good* as soon as at least 1 input has the logical value 0 with Validity = *good*. Otherwise, the inputs are treated according to the AND operation and the INVALID bit is OR-gated for the quality.

NEG_SPS

A (Value, Attribute)	Q (Value, Attribute)
0, i	1, i
0, q	1, q
1, i	0, i
1, q	0, q

SPLIT_SPS SPLI_BPS SPLI_MV	This blocks isolates the data value and quality of a data object. The requirement is that the quality is available from the input end. This is the case if the block is interconnected with CFC input data, or if a connected downstream block is quality processing building block (e. SPS), in other cases, the CFC editor does not allow a connection.
SPLIT_Q	The block performs a bitwise separation of the quality into *good*, *bad* (= *invalid*), *test*, *oflnd* and *operatorBlocked*. These 5 attributes can then be processed individually, in a binary operation. The block must be connected downstream to a SPLIT_BOO block.
BUILD_Q	The building block enters a secure value for *good* and *bad* (= *invalid*) in each quality structure. Thus, with this building block the quality attributes *good* and *bad* (= *invalid*) can be set explicitly, for example, as the result of a monitoring task. All other quality attributes are set to the default state, for instance, Test = *FALSE*. If, for example, the entire CFC chart is in the test state (see Quality Attribute: Test Under General Processing), this default status can again be overwritten in the CFC output side. The building block is normally connected downstream to a BUILD_QBO multibinary block.

Building Blocks	Description
BUILD_ACD	These blocks merge data value and quality. The block output is generally used as a CFC output. Exception: the BUILD_Q block is connected upstream from these building blocks.
BUILD_ACT	
BUILD_BSC	
BUILD_DPS	
BUILD_ENS	
BUILD_SPS	
BUILD_XMV	

CFC charts have a standard behavior in the processing of signals. If no other signal at the CFC chart has the quality *invalid*, all output signals of the CFC chart also get the quality *invalid*. This standard behavior is not desirable in some applications. If you use the building blocks for quality processing, the quality attributes of the input signals in the CFC chart are processed.

EXAMPLE: Switchgear Interlocking via GOOSE

The following conditions apply to the example:

- The interlocking condition for bay/generator interlocking protection is stored in the device as a CFC chart.
- The remote device sends the release signal for the interlocking condition via a GOOSE telegram.

If the communication connection has been interrupted, the release signal (GOOSE data) incoming via the GOOSE telegram gets the quality *invalid*. If the CFC chart detects an invalid input signal, there are the following possibilities: The last signal value before the communication interruption is used (quality = *good*) or a substitute data value with the quality *good* is used (*true*, *false*).

To do this, you have to create a separate CFC chart in addition to the interlocking part of the switchgear interlocking. Use the building blocks for quality processing in a separate CFC chart. With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. You can then continue to process these signals separately in the CFC chart. Use the quality information at an input signal for a BUILD_SPS building block and assign the quality *good* to the signal. You obtain an SPS signal as a result, with the quality *good*. You can use this to process release messages correctly. You can process the release messages with the quality *good* in the CFC chart of the actual interlocking. Therefore, the release signal for a switch illustrated in the interlocking logic is available as a valid result with the quality *good*. The following figure shows an example of the CFC chart with the building blocks for quality processing:

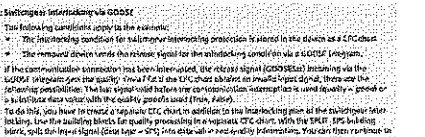


Figure 3-34 CFC Chart with Building Blocks for Quality Processing (Interlocking Interlocking via GOOSE)

If you do not want to convert the invalid release signal to a valid signal, as described, during the communication interruption, you can also assign a different data value to the relevant signal. Proceed as follows: With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. Use the stVal output of the SPLIT_SPS building block with the data type of the input signal (BOOLean). This way, you can set the value in a way that differs from the valid input signals, in this example, the output of the CFC chart is set to the value *FALSE* when the input signal is invalid.

3.3.4 Quality Processing/Affected by the User in Internal Device Functions

Figure 3-25 provides an overview for processing the quality of data objects with a device-internal function. A function can receive internal data or internal data that is available to the user (binary input signals or display commands). The respective quality attributes supported are checked by the function on the input side. The evaluation can be parameterized through the specific algorithm-like specifications of the function. The output data are supplied with a quality that is specified by the function, state and device-operating mode.

NOTE

Take into account that pickup of counter blocking (see chapter 3.6.3 Signal Filtering and Counter Blocking) for quality bit Test sets the corresponding Validity attribute to *Invalid*.

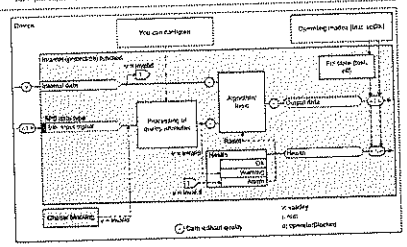


Figure 3-25 Overview for Processing Quality within an Internal Function

Internal Input Data

The quality processing is automatic for internal input data.

Supported Quality Attributes	Description
Validity	▪ All the time, and internal values can only be *Invalid* or good. ▪ If *Invalid* for the function health is set to Alarm and the function is reset. Causes for invalid internal data are, for example: ▪ The frequency operating range of the device was left. ▪ The device is not calibrated. ▪ The A/D converter malfunction identified an error.

Routable Binary Input Signals (SPS Data Type)

Figure 3-26 shows the possible sources for connecting a binary input signal. Depending on the source, different quality attributes can be set.

- ETC client. See description in chapter 3.3.3 Quality Processing/Affected by the User in ETC Clients
- GOOSE connection. See description in chapter 3.3.2 Quality Processing/Affected by the User for Received GOOSE Values
- Device hardware: No quality attributes are set and supported.

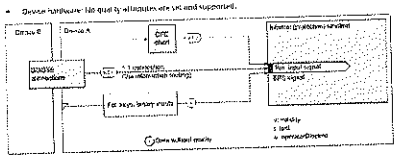


Figure 3-26 Sources for Connecting a Binary Input Signal

For the signal type (SPS), you can influence the processing of the quality, see overview in Figure 3-26. The following figure shows the possible influences on a binary input signal of a protection stage:

- In the DIGSI 5 project tree, routing/static information routing.
- In the operating graph, select the desired binary input signal.
- In the Properties window, select the Details entry. There, you will find the item Processing quality attributes.

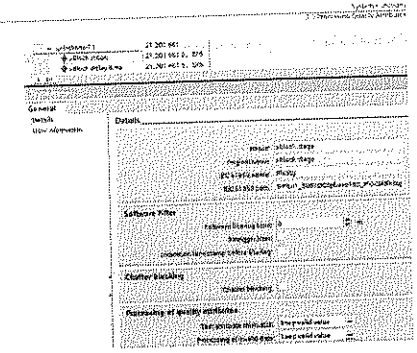


Figure 3-27 Influence Options for a Binary Input Signal (SPS Input Signal)

Quality Attribute: Validity The Validity attribute can have the values *good*, *Invalid*, *oscillatory*, or *questionable* were already initiated at the input end of the device by the value *Invalid*.	
The input signal source is *Invalid*.	The current data value of the source signal is ignored. You can select between the following options: ▪ Further process last valid data value at the source signal (this is the default setting with only a few exceptions) ▪ Set the binary value to be processed further to 0. ▪ Set the binary value to be processed further to 1. The configuration option is necessary to satisfy different applications. The function health switches to Warning.
The input signal source is good.	The source signal data value is processed further.

Quality Attribute: Test	
▪ The input signal source and processed function are in test state. ▪ The input signal source is not in test state and the function to be processed is in test state.	The source signal data value is processed further.

Quality Attribute: Test	
The input signal source is in a test state and the function to be processed is in internal state.	The data value of the source signal is ignored. You can select between the following options: ▪ Further processing of the last valid source signal data value, before the source switched to the test state (that is the default setting) ▪ The binary value to be processed further is set to 0. ▪ The binary value to be processed further is set to 1. This configuration option is necessary, in order to satisfy different applications.

Quality Attribute: Operator blocked	
The quality cannot be influenced at this position and does not lead to a response within the logic.	

Output Data

The quality is not processed through the actual algorithm logic of the function, the following table displays the conditions required to set the quality of output signals of a function.

Cause	DO Value	Quality Attribute	
		After internal (in the SIPROTEC 5 system, for example, in the direction of > (ETC client)	To the IEC 61850 interface, in addition
Functional State = Test (thus, result of device operating mode = Test or function mode = Test)	Unchanged	Test = TRUE	Test = TRUE
Functional State = Off (thus, result of device operating mode = Off)	Function-specific, corresponding to the definition for switched off	Validity = good	Validity = Invalid
Function Health = Alarm (for example, result of invalid sensor data)	Function specific, corresponding to the definition for reset	Validity = good	Validity = Invalid
Device operating mode = temporarily logged off	Unchanged	Validity = good OperatorBlocked = TRUE	Validity = good DetailQual = oldData OperatorBlocked = TRUE

3.4 Fault Recording

3.4.1 Overview of Functions

All SIPROTEC 5 devices have a fault memory in which fault recordings are kept securely. Fault recording documents operations within the power system and can keep in which protection devices respond to them. You can read out fault recordings from the device and analyze them afterwards using evaluation tools such as SIGRA.

A fault record contains the following information:

- Sample values of the analog input channels
- Operational values calculated internally
- Any binary signals (for example, pickup signals and trip signals of protection functions)

You can individually configure the signals to be recorded. Furthermore, you can define the starting conditions, the record duration, and the saving criterion of a recording. Fault records saved in the device are also available after a loss of auxiliary voltage.

3.4.2 Structure of the Function

The Fault recorder function is a central device function. Both the recording criterion and the measured value and binary channels, to be recorded are functionally uncoupled through the application templates. You are able to individually adapt the configuration in DIGSI 5. The fault recording and the fault log are subject to the same control. This ensures that real time, relative time, and numbering of the fault data are synchronized. This means that all fault recordings function on the same real time and relative time basis.

The data that are via the DIGSI PC are saved in COMTRADE format. Fault recording data can be transferred via the substation automation technology by request in accordance with the standards via existing communication connections (such as IEC 61850, IEC 60870-5-103). The central device analyzes the data using appropriate programs.

3.4.3 Function Description

The Fault recorder function records the sampled values, specific in each device, of all analog inputs, the internally calculated measured values and the binary signals. The configuration, which is predefined for each device via an application template, can be adapted individually.

NOTE

You can find detailed information about selecting and deleting fault records in the Operating Manual (C53000-G5000-C010).

The fault memory of the device is automatically updated with every recording. When the fault memory is filled completely, the oldest records are overwritten automatically. Thus, the most recent recordings are always stored safely. The maximum number of recordings is 128.

Sampling Frequency

The analog measuring channels are sampled at a different sampling rate for fault recording. The Sampling Frequency parameter is used to set the desired sampling frequency. Possible setting values are 1 kHz, 2 kHz, 4 kHz, and 8 kHz. This setting value applies only to fault recording and does not affect protection functions or calculated measured values.

Record Duration

The overall duration of a single fault recording comprises the total duration of the configured recording criterion, the Pre-trigger time and the Post-fault time. You can set the parameters for these components individually.

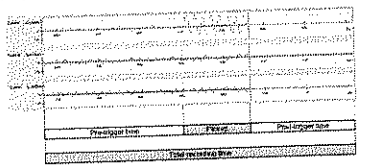


Figure 3-28 Example of a Fault Recording

With the Fault recording parameter, you specify the start criterion of the recording.

You can set the following values:

- with pickup
  The fault recording records the complete fault until dropout. The resulting pickup signals of all function groups are taken into account.
- manual only
  With this setting value, you can individually specify the recording criterion for the fault recording in DIGSI 5. Function-specific recording criteria can be realized in this way.

If a recording criterion recurs during the pre-trigger time and post-trigger time, the recording which is currently active is extended to include a new post-trigger time.

For a sampling frequency of 8 kHz and 24 analog channels to be recorded, the maximum of one individual fault recording can be up to 20 s.

The maximum record duration can be limited by the Maximum record time parameter.

In addition to starting the fault recording via the criterion, the following alternatives are possible:

- Externally via binary input signal >Start record (start file for example, from an external protection device without fault recording) or an object (command via CAESAR message)
- By way of a configurable input signal >Manual start, you can start fault records with a configurable length (parameter Manual record time).
- With DIGSI 5, you can start any fault record with a time length of 1 s.
- With a command from a central device via an existing communication connection (IEC 61850, IEC 60870-5-103)

NOTE

If a pickup signal is present continuously, the fault recording is cured after the Maximum record time expires and the fault record cannot be maintained!

Saving the Recording

Not every fault recording that is started actually needs to be saved. With the Scope/save parameter, you specify whether or not you want to save the fault recording after it has started. You can also save only fault data for which the pickup of a protection function also caused a tripping. With this setting, faults beyond the selected protection range will not lead to replacing fault recordings that have already been made.

Configuration of Signals to be Recorded

All analog inputs of the device that have been configured (current and voltage) are recorded as sampled channels. Function symbols (Limit Symbol) (for example, pickup and trip signals) and measured value channels can be configured individually for recording in the SIGRA differential recording mask. For this purpose, a separate Connect column is available.

The symmetrical measured values are the measured values of the fundamental components and symmetrical components (per the Power System Data 1 dialog box, addresses 214 and 215). Fundamental and symmetrical components are calculated every 5 cycles for 50 Hz, this is every 100 ms. However, this can mean that the data will not synchronize with the sampled values of the analog channels. The recording of these measured values can be useful in analyzing the slowly changing processes.

Numbering and Time Stamping

All fault recordings saved are automatically numbered in ascending order and assigned a real time stamp for the start time. The fault recording logs the fault with a relative time. The reference time point is the start of the recording. Every fault record has a correspondent fault log with the same number. This ensures that the fault recording can be uniquely assigned to the event log.

Fault Memory

The device manages its available fault memory dynamically, so that the maximum recording capacity is always available. When exceeding the limits of the fault memory, the oldest recordings are automatically overwritten. This means that the most recent records are always available. The sampling rate, type, and number of measured value trends to be recorded are the crucial variables when it comes to restricting the length and number of records possible. Parallel to the sampled traces, up to 50 traces with function specific measured values and up to 385 binary traces can be recorded. The following table provides an overview of the maximum storage capacities, in seconds, for different connection variations of the protection devices.

Table 3-7 Maximum Length of all Stored Records

Connection Examples	Sampling 1 kHz	Sampling 2 kHz	Sampling 4 kHz	Sampling 8 kHz
Feeder: 31, 4 measured values, 20 binary tracks	1365 s	815 s	455 s	241 s
Feeder: 41, 4V, 20 binary tracks	1120 s	566 s	284 s	142 s
Feeder: 41, 4V, 6 measured values, 28 binary tracks	890 s	508 s	266 s	137 s
Feeder 1.5 CB: 81, 8V, 6 measured values, 70 binary tracks	525 s	281 s	149 s	76 s

Input and Output Signals

The Fault recorder function provides several input signals that allow the precise starting, deleting of records. The output signals provide information about the function status.

In the following table, you can find input signals of the Fault recorder function:

Name	Type	Description
Control: Start recording	SPC	Start recording via the function key
Control: Reset memory	SPC	Delete all recordings via the function key. The error numbers are reset.
Control: Delete memory	SPC	Delete all recordings via the function key. The error numbers remain as is.

3.4.6 Information List

No.	Information	Data Class (Type)	Type
Binary IO			
_2731:51	General Mode (emulation)	ENC	C
_2731:52	Behavior	ENC	O
_2731:54	Health State	ENS	O
Recorder IO			
_2761:300	Control Start Record	SPC	C
_2761:305	Control Reset memory	SPC	C
_2761:306	Control Delete memory	SPC	C
_2761:502	Control_External start	SPS	I
_2761:501	Control>Manual start	SPS	I
_2761:310	Control Fault number	INS	O
_2761:311	Control Error number	INS	O
_2761:314	Control Record mode	SPS	O
_2761:327	Control Time overload	SPC	C

Name	Type	Description
Control: External start	SPC	Start recording by an external binary signal, for example, by the trip command of an external protection device which is set to pause recording. The set pre- and post-trigger time are taken into account.
Control: Manual start	SPC	Start of recording in Time dial out (parameter Manual record time) by way of an external binary signal, for example, manually via the function key or by an internal binary signal.

In the following table, you can find control signals of the Fault recorder function:

Name	Type	Description
General: Mode	ENC	Status feedback of the fault recording according to chapter 3.3 Function control
General: State	ENS	
General: Health	ENS	
Control: Error number	INS	The indication of the current error number allows a unique allocation of errors in the message buffer for the recorded fault records.
Control: Record in started	SPS	Fault recording running

3.4.4 Application and Setting Notes

Parameter: Fault recording

- Recommended setting value (_:27761.136) Fault recording = with pickup

With the Fault recording parameter, you define the time interval at which faults are recorded. The total record duration is defined as the duration of the fault plus the time of the parameters Pre-trigger time, Post-trigger time and is limited by the maximum record duration.

Parameter Value	Description
with pickup	The fault recording time is determined by the total number of all protection pickups. The resulting pickup signals of all function groups are taken into account. Note: When the post-trigger time has expired, the indications of an automatic reclosing function are not recorded. Switching faults after expiry of the post-trigger time can result in the opening of a new fault with its own recording.
user-defined	The fault recording time is entered user-specific. Note: You must specify all signals for individual definition of the fault recording time in the DIGSI 5 information-routing matrix. In the information routing matrix in the DIGSI 5 information-routing matrix, in the information routing matrix in the DIGSI 5 information routing matrix, the Fault recording has for this purpose a receive volume Trigger. The record duration is calculated from the logical OR operation of all initiated, configured signals.

Parameter: Storage

- Recommended setting value (_:27761.131) Storage = always

With the storage parameter, you define the storage criterion for a fault recording that has already started.

Parameter Value	Description
always	Each fault recording that has been started is saved.
with trip	If at least one protection function issues an operate indication during the record time, any fault recording that has been started will be saved.

Parameter: Maximum record time

- Default setting (_:27761.112) Maximum record time = 5.00 s

With the Maximum record time parameter, you configure the maximum record duration for an individual fault recording. When the time configured expires, an ongoing fault recording is terminated. The parameter does not have to be set to the fault time exactly. It does not affect the capacity of fault in the device.

Parameter: Pre-trigger time

- Recommended setting value (_:27761.127) Pre-trigger time = 0.50 s

With the Pre-trigger time parameter, you configure the pre-trigger time for an individual fault recording. The pre-trigger time is proceeded to the actual recording criterion for the fault recording.

Parameter: Post-trigger time

- Recommended setting value (_:27761.113) Post-trigger time = 0.50 s

With the Post-trigger time parameter, you configure the post-trigger time for an individual fault recording. The post-trigger time that has been configured is added to the actual recording criterion for the fault recording after the dropout.

Parameter: Sampling frequency

- Recommended setting value (_:27761.130) Sampling frequency = 2 kHz

With the Sampling frequency parameter, you define the sampling frequency of the fault recording. Possible setting values are 8 kHz, 4 kHz, 2 kHz, and 1 kHz.

Parameter: Manual record time

- Recommended setting value (_:27761.116) Manual record time = 0.50 s

With the parameter Manual record time, you set the duration of a recording if the fault record is activated dynamically (edge triggered) via a separately configured input signal >Manual start external. In this case, pre-trigger and post-trigger times do not take effect.

3.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_2731:1	General:Mode		• on • test	on
General				
_2761:130	Control:Fault recording		• with pickup • with pickup & AR cyc. • user-defined	with pickup
_2761:131	Control:Storage		• always • with trip	always
_2761:111	Control:Maximum record time		0.30 s to 20.00 s	5.00 s
_2761:112	Control:Pre-trigger time		0.05 s to 0.50 s	0.50 s
_2761:113	Control:Post-trigger time		0.05 s to 0.50 s	0.50 s
_2761:116	Control:Manual record time		0.30 s to 20.00 s	0.50 s
_2761:140	Control:Sampling frequency		• 8 kHz • 4 kHz • 2 kHz • 1 kHz	2 kHz

3.5 Protection Communication

3.5.1 Overview

Protection communication includes all functionalities required to exchange data via the protection interface (PI). It manages one or a maximum of 2 protection interfaces. The Protection communication is generated with the configuration of the channels as protocol.

You can find detailed information in the section Protection Interface in chapter 4.3.2.1 Overview of Connections.

3.5.2 Protection Interface and Protection Topology

3.5.2.1 Overview of Function

The Protection topology and protection interface function enables data exchange between the devices via synchronous serial point-to-point connections from 64 kbits/s to 2 Mbit/s. These connections can be established directly via optical fibers or via other communication media, for example, via dedicated lines or via communication networks.

A protection topology consists of 2 to 6 devices solely communicate via protection interfaces. It can be set up either as a redundant ring or as a chain structure. Within a topology, the protection interfaces can have a different bandwidth. Depending on the bandwidth, a certain amount of main information and measured values can be transmitted bidirectionally between the devices. The connection with the lowest bandwidth defines the amount of binary information and measured values).

The following information that is significant for the function of the protection interface is also transferred. You cannot change this information:

- Topology data and values are exchanged for synchronizing and testing the connection.
  The results are displayed on the device or with DIGSI 5.
- Protection data. For example, differential protection data or teleprotection scheme binary data, are transferred for distance protection and ground fault protection.
- The devices can be synchronized in time via the connection, whereby a device of the protection topology assumes the role of the timing master.

The connection is continuously monitored for data faults and outages, and the time delay of the data is measured.

The protection interfaces are typically used for differential protection and the teleprotection scheme. In SIPROTEC 5 you can configure protection function data of devices and then use them for further applications. At the same time, any binary information and measured values can be transferred between the devices. The measured values are transferred at a high transmission rate (typically, 200 values per second) as phasors with a time stamp.

Access to devices at the remote ends is possible via the protection interface with DIGSI 5. For this, the protection data connection is interrupted and the communication channel reserved exclusively for DIGSI 5. After remote access with DIGSI 5, the protection connection is restored.

3.5.2.2 Structure of the Function

The protection interfaces of a device are located in the Protection communication function group. A device has 1 or 2 symmetrically parameterizable protection interfaces.

The protection topology is used for administration of that topology data relevant to the respective interfaces and containing data from other devices in the protection topology.

Figure 3-28 Structure of the Protection Interfaces in a Device

The protection communication represents only a logical subset communication module, that usually can have 1 or 2 channels. The protection communication can take place via various modules. This depends on the type of interface and the application. DIGSI 5 is used to configure 1 or 2 channels of a serial optical module as a protection interface. The enables communication with the values set at the protection interface on this channel.

3.5.2.3 Function Description

Topology and Type of Protection Communication

The protection interfaces (PI) establish a direct point-to-point connection between devices via different communication media. Data can be transferred within the switchgear or between switchgears.

Devices connected to one another with protection communications form a protection topology. Refer to Figure 3-29.

The protection communication in a device can be either type 1 or type 2. In the case of devices with differential protection function (7SD and 7SL), a protection communication of type 1 is automatically created. Type 2 is created for other devices, and is used for either data communication. A device can contain only the same types of protection communication. Type 1 and type 2 protection communication do not combine together or pass via a mediation function.

Types	Description
Type 1 Application using differential protection	With type 1, the differential protection function is the primary application. This application requires the greatest portion of the bandwidth, so that with type 1 the number of signals additionally available is lower. The transmission rate is 64 kbps (protection connection via a 7XR61 or 7XV1 router). If a multiple-end differential protection application is installed, all protection communications must be of type 1. A maximum of 6 line ends is possible. If the differential protection and teleprotection scheme functions are to operate in parallel in the device, the bit rate must not be less than 512 kbps!
Type 2 Application without using differential protection	Type 2 has a significantly higher amount of information that can be transferred as the differential protection application is now used here. The transmission of protection data and other data, for example, measured values, is predominant here. Using type 2 protection communication, a maximum of 6 devices can be connected to one another and different device types (for example, 6MD, 7SJ, 7SA, and 7SJ) can exchange data.

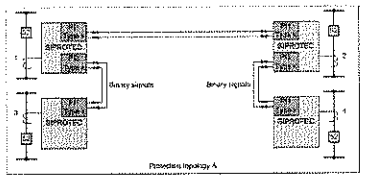


Figure 3-40 Data Exchange between 2 Devices with Protection Communication of Type 1 or Type 2 in a Protection Topology

2-Device Topology: Simple or Redundant Transfer

In the case of a simple 2-device topology, one protection communication line (device to device) is required (see next figure).

The most frequent application is the two-end differential protection (line protection communication is of type 1) or the point to point exchange of data between 2 devices (the protection communication is of type 2), as performed by protection transmission devices.

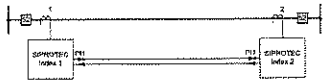


Figure 3-41 Data Exchange for 2 Devices, Each Having Protection Communication

NOTE

The index specifies the consecutive numbering of the devices in a protection topology (see parameter [addr] Device address).

A combination of 2 protection communications can be integrated in one device (see next figure). If 2 protection communications of the same type are connected to one another, the result is 100 % redundancy regarding the transmission route. The devices then search for the communication connection with the highest bandwidth (for example, optical fiber). If this connection fails, the system switches over automatically in the 2nd connection until the 1st connection is available again. As the connection with lower bandwidth defines the maximum amount of transferable information, the same information is exchanged via both connections. Only application of this is differential protection routed via a redundant communication connection. Both protection communications in the device are then of type 1.

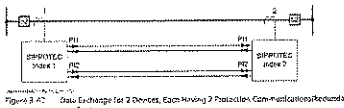


Figure 3-42 Data Exchange for 2 Devices, Each Having 2 Protection Communications/Redundant Transmission Route

Multi-Device Topology: Ring or Chain Topology

When there are more than 2 devices, a communication chain or a communication ring can be established. An arrangement with a maximum of 6 devices is possible.

To enable the devices in a topology to communicate with one another, the devices automatically detect the type of topology and their position within the topology. All devices in the topology must contain protection communications of the same type. In the case of devices with differential protection functions (7SD and 7SL), a protection communication of type 1 is automatically created. Multiple-end configurations are also option. In the case of other devices, a protection communication of type 2 is created, which can be present one or 2 times.

A distinction is made between the following types of topology:

- Chain topology
- Ring topology

The chain topology is shown in the following figure.

The protection communications must be of the same type to belong to a topology. All protection communications are of type 1 in a multiple-end differential protection configuration.

The configuration shows that the indexing of the devices does not have to correspond to the order of the communication chain.

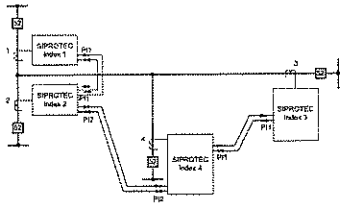


Figure 3-43 4 SIPROTEC Devices in a Chain Topology

The ring topology is shown in the following figure.

The communication ring has the advantage over the chain topology that the entire communication system and, for example, the differential protection function also work, if one of the communication connections or one device fails. In the topology is taken out of operation.

You can find more detailed information in chapter 3.5.2.5 Device Configuration Settings.

The devices detect failure or tripping off, and switch over automatically to the remaining communication routes.

The following figure shows, for example, a four-terminal differential protection application. All protection communications are of type 1. A typical application with protection communications of type 2 is the exchange of indications and measured values between 2 devices (for example, between substations), whereby the connection can occur via different communication routes. This is the application for a protection data transmission device.

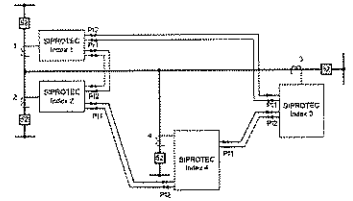


Figure 3-44 4 SIPROTEC Devices in a Ring Topology

NOTE

If a connection fails in the ring topology, this configuration continues to function as a chain topology. In addition, a device in the constellation can be logged off from the topology.

Protection-Interface Information Transfer

With the protection-interface information transfer, customer-specific indications and measured values can be communicated via the protection interface with settable update cycles (priorities).

There are 3 different priorities when transferring protection-interface information:

- **Priority 1:** Use Priority 1 for the transmission of fast protection signals that are transferred and updated at a maximum of every 20 ms in a telegram.
- **Priority 2:** Use Priority 2 for the transmission of fast single-point or double-point indications that are transferred and updated at a maximum of every 40 ms.
- **Priority 3:** Use Priority 3 for all indications, measured, and metered values that are transferred and updated a maximum of every 100 ms.

The number of customer-specific signals, indications, and measured values conform with the remaining bandwidth. The remaining bandwidth is fewer than with all other protection functions (type 2) when using a differential protection (type 1). Customer-specific measured values consume more bandwidth than single-point indications.

Communication Media

The communication takes place via direct fiber-optic connections, via communication networks or via 2-wire copper connections. Siemens recommends a direct fiber optic connection, as this offers the highest transmission rate of 2 Mbps and is immune to failures in the communication route while offering the shortest transmission time. This also enables the transmission of a large amount of additional information on differential protection relays and the average period of deviation at the remote end with GPS synchronization.

The distance to be bridged and the transmission paths available determine the settings of the protection interface. External communication converters are used for the connection to communication networks via G703.1, X21, or G.703.6 interfaces. The connection to 2-wire copper cables also takes place via a communication converter. The C37.94 interface, for example, with 2 Mbps, offers a direct fiber-optic connection to a multiplexer with the corresponding interface.

Table 3-8 to Table 3-9 show examples of communicable connections.

In the case of a direct connection, the transmission distance depends on the fiber type of the optical fiber. This distance can also be extended via external repeaters.

The modules in the device can be replaced from outside, so that adaptation to a transmission route is possible. In the case of the 820-nm double module USART-AE-2FO with 2 channels, 2 protection interfaces can be operated on one module.

The modules can be located at slots E and F in the base module, and at slots N and P in the plug-in module assembly with integrated power supply.

When using communication converters, the connection from the device to the communication converter by a module is established via optical fibers.

Table 3-8 Plug-in Modules for Applications with the Protection Interface

Plug-in Modules	Module Type USART-AP-1LDFO	Module Type USART-AW-2LDFO	Module Type USART-AG-1LDFO	Module Type USART-AH-2LDFO	Module Type USART-AK-1LDFO	Module Type USART-AN-1LDFO	Module Type USART-AJ-1LDFO	Module Type USART-AQ-2LDFO	Module Type USART-AR-2LDFO
Physical Connection									
1 x optical serial, 1 300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fibers, 4 km via 62.5/125 µm multimode optical fibers	•								
2 x optical serial, 1 300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fibers, 4 km via 62.5/125 µm multimode optical fibers		•							
1 x optical serial, 1 550 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fibers			•						
2 x optical serial, 1 550 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fibers				•					
1 x optical serial, 1 550 nm, duplex LC plug, 100 km via 9/125 µm singlemode optical fibers					•				
2 x optical serial, 1 550 nm, duplex LC plug, 100 km via 9/125 µm singlemode optical fibers						•			

Plug-in Modules	Module Type USART-AP-1LDFO	Module Type USART-AW-2LDFO	Module Type USART-AG-1LDFO	Module Type USART-AH-2LDFO	Module Type USART-AK-1LDFO	Module Type USART-AN-1LDFO	Module Type USART-AJ-1LDFO	Module Type USART-AQ-2LDFO	Module Type USART-AR-2LDFO
Physical Connection									
1 x optical serial, bi-directional via 1 optical fiber, 1300/1550 nm (Telfa), simplex plug LC, 40 km via 9/125 µm singlemode optical fiber							•		
1 x optical serial, bi-directional via 1 optical fiber, 1550/1300 nm (Telfa), simplex plug LC, 40 km via 9/125 µm singlemode optical fiber								•	
2 x optical serial, bi-directional via 1 optical fiber, 1300/1550 nm (Telfa), 2 x simplex LC plug, 40 km via 9/125 µm singlemode optical fibers								•	
2 x optical serial, bi-directional via 1 optical fiber, 1550/1300 nm (Telfa), 2 x simplex LC plug, 40 km via 9/125 µm singlemode optical fiber									•

Table 3-9 Plug-in Modules USART-AD-1FO and USART-AF-1FO

Plug-in module	Plug-in Module USART-AD-1FO USART-AF-1FO
Physical Connection	
1 x optical serial, 820 nm, ST connector, 1.5 km via 62.5/125 µm multimode optical fibers	•
2 x optical serial, 820 nm, ST connector, 1.5 km via 62.5/125 µm multimode optical fibers	•
Application	
Protection interface (sync, HOLC, IEEE C37.94)	1, 2

NOTE

The USART plug-in module types can be used in slots E and F in the base module as well as in slots N and P in the CB202 expansion module. They are not suitable for use in slot M in the CB202 expansion module.

Figure 3-45 Connection over Short Distances, 2.5 km to 2.1 km via Multimode Optical Fiber

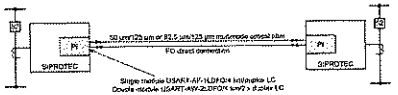


Figure 3-46 Connection over Medium Distances, 4 km via Multimode Optical Fiber

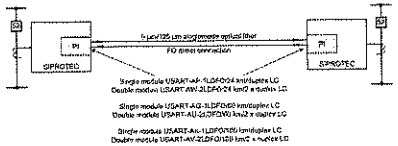


Figure 3-47 Connection via Long Distances, via Singlemode Optical Fiber

NOTE

In order to prevent optical overload of the receiver, a 7XV5107-0AA00 attenuator must be used on one side in the fiber-optic modules USART-AJ, USART-AG, USART-AH, USART-AK, and USART-AV for distances of less than 25 km/50 km.

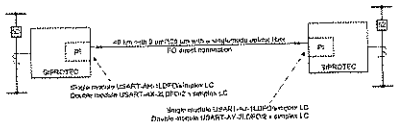


Figure 3-48 Connection via Singlemode Optical Fiber

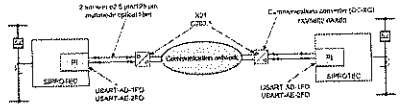


Figure 3-49 Connection via Communication Network with a G703.1 Interface

The connection to the multiplexer is established via a communication converter with a G703.1 interface (64 kbps) or X21 interface (64 kbps to 512 kbps). You can set the bit rate for the KU XG 512 (for A213, KU XG 256 (for A212, KU XG 128 (for A213, and KU XG 64 (for A21 or G703.1) with the parameter Connection data.

You can find more detailed information in Table 3-10.

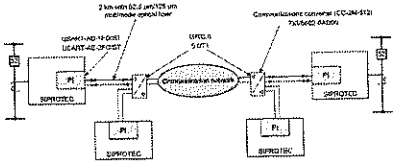


Figure 3-50 Connection via Communication Network with a G703.6 Interface

The connection to the multiplexer is established with 512 kbps via a communication converter with a G703.6 interface (E1 with 2 Mbps or T1 with 1.44 Mbps). The communication converter offers a 2nd interface for connecting an additional protection interface.

Make the setting for the bit rate with KU-2M 512 with 512 kbps in accordance with Table 3-10 with the parameter Connection data.

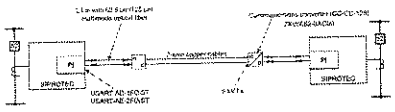


Figure 3-51 Connection via 2 Wire Copper Cables

The connection in a communication converter with an interface for isolation voltage is established with 128 kbps (KU for 128 variable in accordance with Table 3-10). A 20 kV isolation of the 2 wire connection is available via an external 7XR8567 isolating transformer.

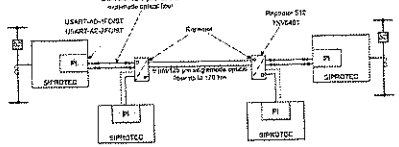


Figure 3-52 Direct Fiber-Optic Connection via an External Repeater

The repeater offers an interface for connecting an additional protection interface. The connection to a repeater is established with 512 kbps (repeater 512 setting in accordance with Table 3-10).

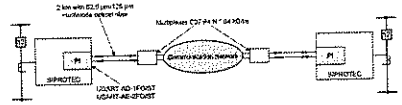


Figure 3-53 Direct Optical Connection to a Multiplexer with a C37.94 N * 64 kbps Interface (Time Slot N = 1, 2 or 8)

NOTE

For redundancy of different communication connections (for the ring topology) requires separation of all devices involved in the communication. Therefore, avoid different communication routes via the same multiplexer board, as no more substitute paths are possible if the board fails.

Supervision of the Communication

The communication is continuously monitored by the devices.

For a number of defects in data telegrams, or no data telegrams at all, one can specify, which response in case of a failure in the communication as well as a failure time of 100 ms default setting can be changed as required. A list of the measured values is shown in a window in DIGSI 5 (detailed telegrams per minute/hour, transmitted and received telegrams per minute/hour, percentage fault rate per minute/hour). A corresponding error message counter is always available. If an alternative communication route exists (as in the ring topology), the primary (the function operating with the protection interface 1) is not switching over the remote signals are not updated as the new one.

If the communication is interrupted for longer than an adjustable time Data-connection failure, this is regarded as a communication failure. A corresponding fault indication is shown in addition.

Time Synchronization via the Protection Interface

All devices of a topology can be time-synchronized with one another. Synchronization is carried out with millisecond accuracy. The synchronization works independently of the protection function and is exclusively for simultaneous time keeping in the device of a protection topology.

The master can be in the parameter Address of device 1 in the device settings 1. This device functions as the timing master in a protection topology. If the timing master is turned off and switched off, the device with the next highest device index takes on the function of the timing master. The timing master synchronizes the clocks of the other devices of this topology via the protection interfaces. The time of the timing master is specially synchronized via a substation automation protocol (for example, Ethernet or SNTP or via IRIG-B. For this, these time sources must be set as the 1st time source and additionally as the 2nd time source in the timing master. If available, the system switches over to the 2nd time source in the timing master. This time is communicated with millisecond accuracy to the other devices of the topology.

Set the protection interface as the 1st time source in the other devices of the topology. In this way, all events in the devices of the protection topology are recorded with the same time and are time-synchronized even across different substations. This simplifies fault analysis and the tests can be carried out with the same time in all devices.

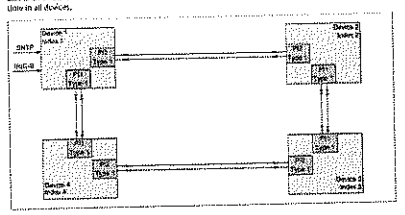


Figure 3-54 Time Synchronization in a Protection Topology

Figure 3-54 shows, how device 1 with index 1 is synchronized with the devices 2, 3, and 4 via the protection interfaces. Device 1 is synchronized externally from 2 sources (IRIG-B and SNTP via Ethernet).

Time Synchronization of the Line Differential Protection Measured Values with Millisecond Accuracy

The measured values of the line differential protection for the various line ends are synchronized with each other with millisecond accuracy via the mechanisms of the protection interface. The protection interface displays this state with the MISYNC indication *Protection interface synchronized*.

If communications problems occur, it is possible that the measured values may not be properly synchronized. In this case, the protection interface generates the CLEARED indication *Protection interface synchronized*. The line differential protection is blocked. This state can be corrected only by manual intervention.

NOTE

You can reset the synchronization of the protection interface directly in the device. Proceed as follows: **Device functions > ≡ Device protection comm. > Protection interface y > Reset synchron.**

Synchronization via GPS Second Pulse

Millisecond accurate synchronization of the devices (1 PPS (DCF), connected via protection interfaces, can take place via a high-precision GPS second pulse at the time-synchronous port B (for special differential protection applications or synchronous operating devices). As a result, the transmission time of the communication route can be measured and displayed separately, in the forward and reverse directions. This enables that the maximum asymmetry, can be obtained during differential protection, even if transmission times are unbalanced in the communication networks. Different transmission times are insignificant for the transmission of protection data with a protection communication of type 2.

3.5.2.4 Installation and Configuration of the Protection Interface in DIGSI 5

If the device is provided with modules, proceed as follows:

- Select the desired communication module in the rear view of the device.
- Use the Communication protocols text box to select the protection interface. A text box entitled Protection interface will then appear:

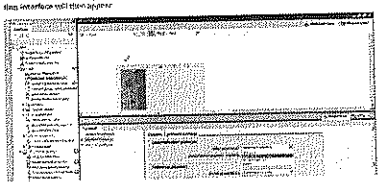


Figure 3-55 Selection of the Communication Protocol

- Then select the **Select constellation** text box to select the number of devices (see next figure). Depending on the choice, the selection of constellations can be restricted to 2 or 3 devices.

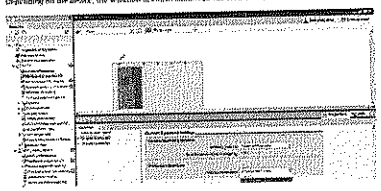


Figure 3-56 Selecting the Constellation

NOTE

You have the option of changing the number of devices (for example 2 protection communication devices) depending on the product code any way you like via the **Select constellation** text box. If you change the number of devices via the **Select constellation** text box, all settings and constellation settings are lost.

If the module slot is not yet provided with modules, proceed as follows:

- Select the desired communication module in the rear view of the device.
- Select the module from the catalog and drag it to a channel. This is the channel configured with a module. DIGSI 5 indicates whether the module can be used for protection communication under **Device information**.
- Use the **Communication protocols** text box to select the protection interface. A text box entitled Protection interface will then appear (see Figure 3-55).
- Then use the **Select constellation** text box to select the number of devices (for example 2 devices protection comm.) (see Figure 3-56).

3.5.2.5 Device-Combination Settings

Make the device-combination settings and the settings for protection communication (see next figure)

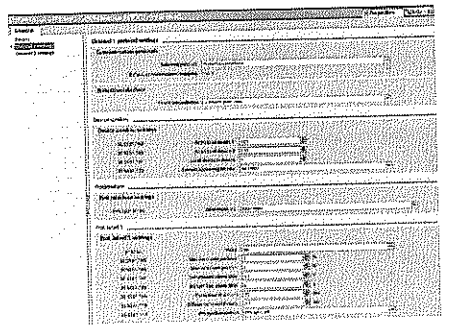


Figure 3-57 Protection Interface Initialization and Configuration

Changes in a channel are visible on the other channel as well. All further parameters can be set separately, for individual channels.

Setting Device-Combination Settings

- Default setting (_:51:51:107) Address of device 1 = 101
- Default setting (_:51:51:103) Address of device 2 = 102
- Default setting (_:51:51:104) Address of device 3 = 103
- Default setting (_:51:51:105) Address of device 4 = 104
- Default setting (_:51:51:106) Address of device 5 = 105
- Default setting (_:51:51:107) Address of device 6 = 106

The parameters Address of device 1 to Address of device 6 can be used to give an address to each device. Set a unique and unambiguous address for each device.

- Default setting (_:51131:101) Local device is device = 1

With the Local device is device parameter, you set the index (number) of your device in the topology. A maximum of 6 devices can be present in one topology.

APPLICATION EXAMPLE

You have a topology with 3 devices.

For example, a DIGSI 5 project the parameter setting address of device 1 with the parameter value 102 for device 1 and the parameter setting address of device 2 with the parameter value 102 for device 2.

Then use the Local device ID domain parameter to set the index of the local device.

The addresses must be configured identically for all switching levels in the constellation. A fault-free protection communication only results if you also assign the same index in all devices of a constellation to a device with a unique address.

- Default setting (_:52:2:1223) Lowest appearing bit rate = 64 kBit/s

Use the Lowest appearing bit rate parameter to set the lowest occurring bit rate in the device group. Set the smallest value if each device with a three-end constellation with 2 fiber optic connections (2 kBit/s) and a 64-kBit/s connection with the lowest value (64 kBit/s). This value determines the maximum signals and measured values within a constellation.

Apart from the default value, you can also set the following bit rates:

- 128 kBit/s
- 512 kBit/s
- 2048 kBit/s

NOTE

If you use fiber optic cables for the connection between the devices, set the value to 2048 kBit/s .

3.5.2.6 Selecting the Connection

- DIGSI 5 setting (_:100) Connection via : Fiber optic

The Connection via parameter is used to set the bit rate required for the protection interface. Different device values can be selected depending on the means of communication (see following table).

Table 3-10 Means of communication

Means of Communication	See	Setting Value	Bit Rate
Fiber optic direct connection	Figure 3-4 on Figure 3-5	Fiber optic	2 MBit/s
FO G.703.1 communication converter	Figure 3-6	FO G.703.1	512 kBit/s
FO 820 128 communication converter	Figure 3-6	FO 820 128	128 kBit/s
FO 64 kBit/s communication converter	Figure 3-6	FO 64 kBit/s	64 kBit/s
Repeater 512 communication converter	Figure 3-5	Repeater 512 kBit/s	512 kBit/s
FO 820 128 Communication converter	Figure 3-5	FO 820 128	128 kBit/s
FO 820 512 Communication converter	Figure 3-5	FO 820 512	512 kBit/s
Multiplexer with C37.94 interface	Figure 3-5	C37.94 1 × 64 kBit/s C37.94 2 × 64 kBit/s C37.94 8 × 64 kBit/s	64 kBit/s 128 kBit/s 512 kBit/s
Direct (freely adjustable) interface for a direct connection for special applications		64 kBit/s 128 kBit/s 512 kBit/s 2048 kBit/s	64 kBit/s 128 kBit/s 512 kBit/s 2048 kBit/s

3.5.2.7 Routing Information to DIGSI 5

protection system disturbance at the same time in a topology.

For more information on this, see Chapter 3.5.2.8 Time Synchronization .

A data bar is exchanged between the devices in a topology connected via protection communication wires. The data bar contains bits or words from up to 3 devices. This can be bits for the changing warning signals between the devices. In this case, each signal demands a certain number of data fields.

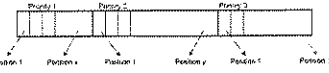


Figure 3-58 Data Bar Exchanged Between Devices

The data bar is divided into 3 protection, which also have different transmission rates and data volumes.

The following basic principle applies for all messages: Only pure data contents are transmitted. The quality (for example, bad) of a value is generally not transmitted as well. If the user wants to transmit the quality as well (for example, for further processing of GOOSE messages), the quality must be transmitted separately (for example, by using CFC). If a signal that has a text flag is transmitted between 2 devices (e. g. in text mode, for example), all signals are provided with a text flag on the receiving side. If the connection is broken, all received signals are flagged with the quality Device fail. If desired, the relay can also be set to a secure state after a selectable dropout time, or the last value received can be retained (Last setting). This can be configured separately, for each received signal (see Table 3-12).

NOTE

For ACT type signals, only the phase information is transmitted.

Indications that are transferred data fields of priority 1 are sent with every telegram. They are preferably used for the transmission of critical signals, for example, release for circuit breaker interlocking. A strictly deterministic, rapid transmission is required there.

Signals of priority 2 are transmitted with at least every 2nd telegram, for bit rates >256 kBit/s, there are no differences between priority 1 and priority 2.

Priority 3 information is transmitted at least every 100 ms. This priority is used for transmission of measured and metered values. Complex values must be routed separately as the real and the imaginary part for transmission. Measured-value thresholds that lead to an updating of a device and value are not strictly to a proportion of the measured value. These measured-value thresholds apply with the corresponding repeating, for example, also for the transformer IEC 61850 to a substation automation technology.

Indications which are written to a data area under a priority on the data bar must be routed to an indication at the same type in the device receiving the information. Otherwise, they are processed incorrectly on the receiving side. The data bar is organized in fields of bits. For information on the bit requirement of each signal type, refer to Table 3-12 .

Table 3-11 and Table 3-12 show the number of data areas in the data bar in relation to the available baud rate.

NOTE

The Lowest appearing bit rate parameter, which has to be set in each device for the protection interface, of a topology, defines the number of data areas as well as the topology type

E. for example, in a three-end constellation with a type 2 chain topology two devices are connected via direct optical fibers and 2 devices via the 64-kBit/s worst link, the 64-kBit section is the limiting factor for the entire constellation.

Table 3-11 Available Bits - Minimum Communication Baud Rate 512/2048 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	96 Bits	96 Bits	192 Bits
Type 2	32 Bits	64 Bits	256 Bits

Table 3-12 Available Bits - Minimum Communication Baud Rate 512/2048 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	128 Bits	384 Bits	384 Bits
Type 2	256 Bits	768 Bits	1024 Bits

Table 3-13 Requirement in Bits

Signal Type	Size in Bits
SP (single-point indication)	1 Bit
DP (double-point indication)	2 Bits
IN (metered value)	32 Bits
MV (measured value)	32 Bits
ACT	4 Bits

Table 3-14 Possible Dropout Values

Signal Type	Dropout Value
SP (single-point indication)	Outgoing, Incoming, Hold
DP (double-point indication)	Ein, Off, Intermediate Position, Disturbed Position, Hold
IN (metered value)	0, Hold
MV (measured value)	0, Hold
ACT	Hold

NOTE

If the protective link fails, these values can be set via the receiver side.

EXAMPLE

2 devices are connected with differential protection via a 64 kBit/s channel. The data type 1 topology, 8 bits are freely available for priority 1. Now, for example, 4 DPS and 2 SPS can be routed:
4 x 2 Bit + 2 x 2 Bit = 8 Bit

NOTE

Measured values are transmitted as primary values.

Remote Data Transmission: Routing of the Indications and Measured Values to the Protection Interface

The transmission is organized in the form of a data bar which is continuously exchanged between the devices. For this, see Figure 3-58 .

A double indication or measured value is allocated to a definite data area of the bar.

Figure 3-59 to Figure 3-67 show the routing for a communication topology of protection interface type 1.

* The available options of the routing page are described

To transmit signals to other devices, these signals must be routed in the communication matrix under Transmit. Binary inputs 1 and 2 are single-point indications (SPI) and are routed to position 1 and position 2 of the transmission with the highest priority (priority 1). For 64 kBit/s, for example, only 8 of these data areas are available for type 1, they are exchanged between the transmission routes with each telegram. Signals 3 and 4 are double-point indications (DPI), for example, a switch position that is transmitted by a device 1. A double-point indication occupies 2 positions on the data bar. In addition, a measured and metered value are communicated via priority 3.

As a measured or metered value uses 32 bits, value 2 starts at position 33. DIGSI 5 indicates the next available position.

Figure 3-59 Routing of Single-Point Indications to the Protection Interface in Device 1

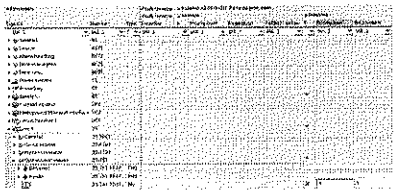


Figure 3-60 Routing of Measured Values to the Protection Interface in Device 1

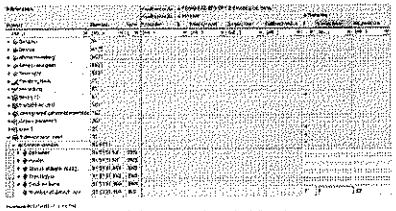


Figure 3-61 Routing of Metered Values to the Protection Interface in Device 1

This device also receives information (in the device under Receive). This must have been routed as a target for other devices (see next figure). The binary outputs 1 and 2 in device 1 receive their information via the protection interface. This is a priority 1 information, which has been routed in another device to position 3 and 4 of the data bar. The main state is defined in the fallback value column. If the data connection fails, the single-point indication is reset to Good (signal nothing or its value is retained (Last)). For data of the various priorities, you can also set a dropout time after which the switching (see Figure 3-61) to the fallback value occurs. In order to ensure the original state for a short time in the event of brief interruptions, these 3 dropout times apply for all data of one transmission priority and are set as parameters.

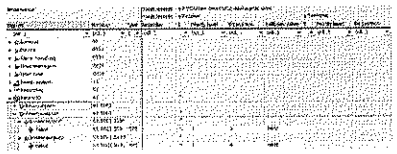


Figure 3-62 Routing of Single-Point Indications (Receive) to the Protection Interface in Device 1

The following figure shows the routing in the 2nd device. Binary input 1 and 2 are routed with priority 3 to positions 3 and 4 there. In device 1, positions 1 and 2 are already occupied (see Figure 3-59). If you also route the signals to positions 1 and 2, the signals of the devices can then connected to the corresponding position with a logical OR operation. If measured and metered values are routed in the same data areas, this results in impossible values for the receivers that read the data. As a user, you are therefore responsible for the correct routing.

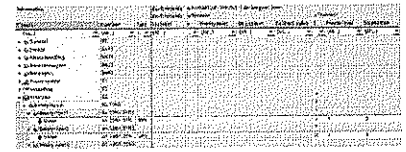


Figure 3-63 Routing of Single-Point Indications to be Sent to the Protection Interface in Device 2

The binary outputs 1 and 2 (Backstop) in the 2nd device are connected to priority 3 signals 1 and 2 from the 1st device. This takes place via the data areas at positions 1 and 2 of the data bar, which transfer the state of the indications. Other devices can also read this information and link it to their internal signals. Note, too, the receive-state, which is assumed when the protection connection is interrupted, if entered. The state depends on the information. In the case of single-point indications, the state 0 or 1, in the case of double-point indications, the bit combinations 00, 01, 10, or 11 are possible, in order to directly signal a disturbed position upon failure of the data connection, for example.

Device is used to switch the state

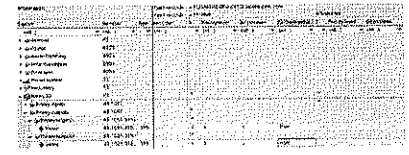


Figure 3-64 Routing of Received Single-Point Indications to the Protection Interface in Device 2

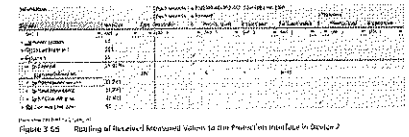


Figure 3-65 Routing of Received Measured Values to the Protection Interface in Device 2

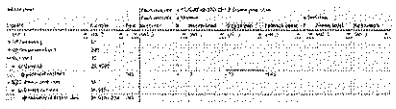


Figure 3-66 Routing of Measured Values to the Protection Interface in Device 2

3.5.2.8 Diagnostic Measured Values of the Protection Interface

The following diagnostic data is provided via the protection interfaces, by the devices in the constellation:

- Address of the device in the constellation
- Circuit-breaker switch position (open/ blocked/unspecified) (only for protection interfaces of type 7)
- Availability of protection-interface communication within the last minute, as percentage
  Availability of protection-interface communication within the last hour, as percentage
- Time delay in the send and receive direction of the telegrams between local and remote-end device

You can find the diagnostic data in DIGSI under the following menu structure (see Figure 3-67):

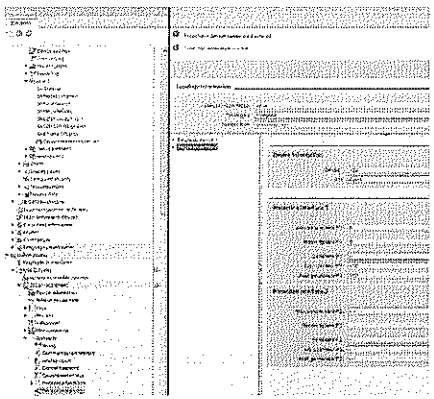


Figure 3-67 Protection-Interface Channel Diagnostic Data - Device Address

NOTE

You can use the following procedure to reset the measured values for the protection interface directly in the device:
Device functions > x Device protection comm. > Protection interface y > Reset measured values.

Output Signals of the Protection Interface

Each individual protection interface provides the following indications for commissioning and diagnosing communication.

Indication	Description
(_:52612:302) Status of Lay. 2 and 2	The output signal gives you information about the state of communication layers 1 and 2 (1: Physical Layer, 2: Data Link Layer). The following indications values are possible: • *Initialized* The protection interface is not connected and is in the initial state. • *Protection interface connected* The protection interface is connected to the protection interface of a device. • *Protection interface failure* The protection interface has not received any valid telegrams for the time set in parameter *(_:5161:107) Threshold value alarm after* . • *Protection interface failure* The protection interface has not received any valid telegrams for the time set in parameter *(_:5161:109) Timeout fail. alarm after* . • *not present* The protection interface has not been assigned to a communication channel.
(_:52612:303) Status of Lay. 3 and 4	The output signal gives you information about the state of communication layers 3 and 4 (3: Network Layer, 4: Transport Layer). The following indications values are possible: • *no error* The protection interface is operating correctly. • *Software versions incompat.* The firmware versions of the connected devices are incompatible. Update the firmware. • *System error/config* The protection interface is receiving its own data. Check the wiring. • *Dev. addr. incorrect* The device address of the partner device is incorrect. Check the settings for parameters *Address of domain 1* to *Address of device n* (*_:5131:107* and following). • *Constell. incorrect* The constellation settings of the devices are different. Check that the setting for the parameter *Select constellation* is identical in all devices. • *Channel, param. incorrect* Check that the same setting has been made for parameter *(_:5131:102) Lowest appearing bit rate* in all devices. • *Diff. param. error* The two differential protection settings for the connected devices are incompatible. Check whether both devices are set to operate with or without line differential protection. The rated value of the line (parameter *(_:9001:103) Rated voltage*) must match the interface setting at both ends of the line. If a transformer is installed in the line, both patterns must be set such that the rated apparent power is the same at both ends of the line (parameter *(_:9001:102) Rated apparent power*)

In order to clarify faults, each individual protection interface provides the following binary signals:

Binary Output Signal	Description
(_:5161:309) Connection broken	Signal *Connection broken* indicates that during a parameterized time (parameter *(_:5161:107) Disturbance alarm after*) faulty or missing telegrams were continuously received. If the "connection interrupted" condition occurs, the affected protection interface link will be terminated. This may cause the blocking of an active differential protection or a ring topology may change to a chain topology.
(_:5161:310) Error rate / min exc.	Signal *Error rate / min exc.* indicates that the set maximum error rate per minute (parameter *(_:5161:106) Max. error rate per min*) has been exceeded.
(_:5161:317) Error rate / hour exc.	Signal *Error rate / hour exc.* indicates that the set maximum error rate per hour (parameter *(_:5161:105) Max. error rate per hour*) has been exceeded.
(_:5161:318) Time delay exceeded	Signal *Time delay exceeded* indicates that the threshold value for the set signal-transit time (parameter *(_:5161:109) Delay time threshold*) has been exceeded.
(_:5161:319) Time delay different	Signal *Time delay different* indicates that the threshold value for asymmetrical transit times has been exceeded. The setting value results from the setting value of the parameter *(_:5161:110) Difference Tx and Rx time* .
(_:5161:320) Time delay jump	Signal *Time delay jump* indicates that the data transit times changed abruptly. This is caused by switching the communication path in the communication network.
(_:5161:321) PI synchronized	Signal *PI synchronized* indicates that the protection interface connection is synchronized with the opposite end.
(_:5161:340) Telegram Test	Signal *Telegram Test* indicates that an expected telegram has failed to arrive or a faulty telegram has been received. If you would like to allocate the communication failures or faults to single events, route the signal *Telegram Test* temporarily into the operational log. Such events may be switching operations in the primary system or operations on the components of the communication network. Note: If the signal is constantly routed the operational log may overflow. Siemens recommends routing the signal only for clarification of faults.

Measured Values of the Protection Interface

The protection interface provides the following measured values to diagnose the protection interface connection:

Measured Value	Description
(_:5161:306) Tx tel/h	Telegrams sent during the last hour
(_:5161:305) Rx tel/h	Telegrams received during the last hour
(_:5161:302) Tx tel/min	Telegrams sent during the last minute
(_:5161:312) Rx tel/min	Telegrams received during the last minute
(_:5161:312) Tx err/h	Transmission failure rate during the last hour
(_:5161:311) Rx err/h	Reception failures during the last hour
(_:5161:314) Err/min	Transmission failure rate during the last minute

Measured Value	Description
(_:5161:315) Rx errors/min	Reception failure rate during the last minute
(_:5161:223) Average	Mean signal-transit time (average value of the transit time in transmission and reception direction divided by 2, without GPS synchronization)
(_:5161:326) Rec. st	Signal-transit time in reception direction (with GPS synchronization)
(_:5161:327) Sen. st	Signal-transit time in transmission direction (with GPS synchronization)
(_:5161:334) Miss.tel/min	Number of telegram failures within the last minute
(_:5161:335) Miss.tel/h	Number of telegram failures within the last hour
(_:5161:336) Miss.tel/d	Number of telegram failures within the last day
(_:5161:339) Miss.tel/w	Number of telegram failures within the last week
(_:5161:338) M. Tele/d	Longest lasting telegram failure within the last day
(_:5161:339) M. Tele/w	Longest lasting telegram failures within the last week

NOTE

You can read the measured values of the protection interface directly in the device. Proceed as follows:
Device functions > x Device protection comm. > Protection interface y > Reset measured values.

3.5.2.9 Diagnostic Data for the Protection Interface

Diagnostic Data of the Channel in DIGSI 5

Different diagnostic data can be read with DIGSI 5.
For this, connect with the device via DIGSI 5 and query the device information. Diagnostic data for a module whose channel is configured with the protection interface can be received by selecting the module view (for example, F) and the corresponding channel (1 or 2). The following figure shows the available diagnostic data for the protection interface. It is particularly helpful if data failures occur or other irregularities in a communication connection (for example, transmission time fluctuations).

NOTE

The diagnostic data can also be read via the device control on the display of the device. The communicated DIGSI 5 does not offer this option, however.

The following table describes the displays.

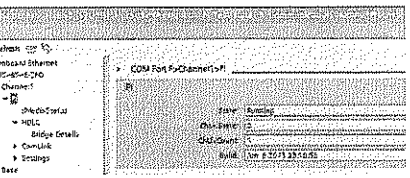


Figure 3-68 Diagnostic Data of a Channel Configured with the Protection Interface

Table 3-15 Description of the Diagnostic Data under Protection Interface

Channel Type	Name	Values	Description - Diagnostic Information for Log F1
Protection interface - log	Status	Online, Running, Error	Runtime status of the log
Protection interface - log	Build	Date/time	Date and time of the log version

Diagnostic Data of the Protection-Interface Log in DIGSI 5

The following figures and tables describe the displays of the protection-interface log.

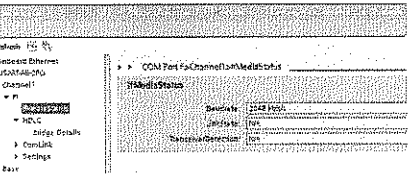


Figure 3-69 Diagnostic Data of the Protection-Interface Log - Media Status

Table 3-17 Description of Diagnostic Data under Media Status

Protection Interfaces - Log Type	Name	Values	Description - Media Status interface (in Direction of Outside Interface)
Media Status	Baud rate	64 kbps: LSA values 512 kbps: 2048 kBit/s; -30 dBm/0 dBm (CRC4)	HDLC baud rate: FO: 64 kBit/s to 20 MBit/s for IP/Ethernet: UART modules LDFO: 30 MBit/s or 130MBit/s for two fiber optic modules Error case: unknown
Media Status	Link State	FO: UP, DOWN	FO: UP, DOWN
Media Status	Transceiver Direction	N/A, as FO transceiver (bidirectional, Transceiver directed), (directed)	FO: N/A (always N/A) (FO transceiver directed, Transceiver directed), Error case: N/A

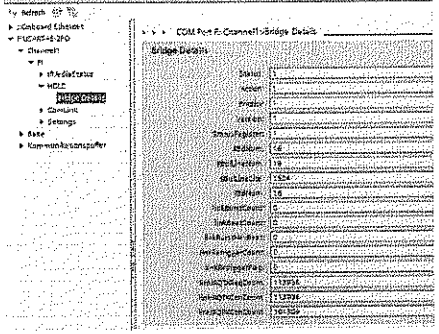


Figure 3-70 Diagnostic Data of the Protection Interface Log - HDLC (Log - Layer)

Table 3-17 Description of Diagnostic Data under Media Status (Log - Layer)

Protection Interfaces - Log Type	Name	Values	Description - HDLC Link Layer Diagnostic Information (in Direction of Outside Interface)
HDLC	RXFPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, OK
HDLC	RXLPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, OK
HDLC	RxHiFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, faulty
HDLC	RXLPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, faulty
HDLC	TXHPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, OK
HDLC	TXLPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, OK
HDLC	TXHPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, faulty
HDLC	TXLPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, faulty
HDLC	Bridge Details Sub-nodes	Sub-nodes	Elements internal special diagnostic for fault search

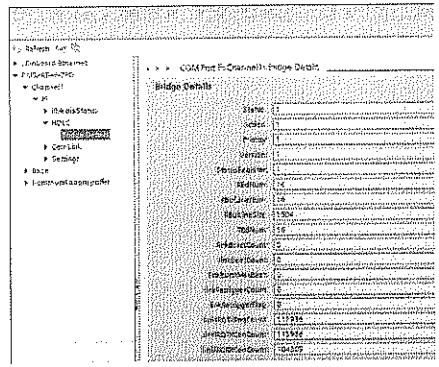


Figure 3-71 Diagnostic Data of the Protection Interface Log - COM Interface (Internal COM Link Interface Between Module and Mainboard)

Table 3-18 Description of Diagnostic Data of the COM Interface (Internal COM Link Interface Between Module and Mainboard)

Protection Interfaces - Log Type	Name	Values	Description - COM Interface Layer Diagnostic Information (Internal COM Link Interface in Mainboard Direction)
COM Interface	TXHPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, OK
COM Interface	RXLPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, OK
COM Interface	RxHiFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, faulty
COM Interface	RXLPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, faulty

Protection Interfaces - Log Type	Name	Values	Description - COM Interface Layer Diagnostic Information (Internal COM Link Interface in Mainboard Direction)
COM Interface	TXHPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, OK
COM Interface	RXLPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, OK
COM Interface	TXHPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, faulty
COM Interface	TXLPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, faulty
COM Interface	Bridge Details Sub-nodes	Sub-nodes	Elements internal special diagnostic for fault search

Table 3-19 Description of Diagnostic Data of some Setting Values of the Protection Interface

Protection Interfaces - Log Type	Name	Values	Description - Protection Interface Setting Values
Settings	Connection Via	Integer number - display of the internal coding of the settings variant	Protection interface is connected via
Settings	PDI Transmit Data	Bit rate display	Bit rate (b/s) for protection telegrams based on the parameter Connection via
Settings	PDI Transmit Signature	Display of bits	Checksum for every protection telegram in bit

3.5.2.10 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device combin.				
_0131:102	Device combin.:Address of device 2		1 to 65534	101
_0131:103	Device combin.:Address of device 3		1 to 65534	102
_0131:104	Device combin.:Address of device 4		1 to 65534	103
_0131:105	Device combin.:Address of device 5		1 to 65534	104
_0131:106	Device combin.:Address of device 6		1 to 65534	105
_0131:107	Device combin.:Address of device 7		1 to 65534	106
_0131:108	Device combin.:Local identification in ring		1 to 6	1
_0131:122	Device combin.:Channel bandwidth (send)		64 kBit/s 128 kBit/s 512 kBit/s 2048 kBit/s	64 kBit/s

Addr.	Parameter	C	Setting Options	Default Setting
Param. channel 1				
_0161:1	Prot. Intert.1:Mode		• on • off	on
_0161:105	Prot. Intert.1:Max. error rate per hour		0.000 % to 100.000 %	1.000 %
_0161:106	Prot. Intert.1:Max. error rate per min		0.000 % to 100.000 %	1.000 %
_0161:107	Prot. Intert.1:Disturbance alarm after		0.05 s to 2.00 s	0.10 s
_0161:108	Prot. Intert.1:Time, fail. alarm after		0.0 s to 60.0 s	6.0 s
_0161:109	Prot. Intert.1:Delay time threshold		0.1 ms to 30.0 ms	30.0 ms
_0161:110	Prot. Intert.1:Difference to last fa time		0.000 ms to 3.000 ms	0.100 ms
_0161:112	Prot. Intert.1:PPS synchronization		• telegr. and PPS • telegr. or PPS • PPS sync. off	PPS sync. off
Ext. Synchron.				
_0181:50	Ext. Synchron.:PPS pulse time alarm at		2.5 s to 30 s	2.5 s

3.5.2.11 Information List

No.	Information	Data Class (Type)	Type
Device combin.			
_0131:102	Device combin.:Status	ENS	O
_0131:1	Device combin.:Reset	IMS	O
_0131:301	Device combin.:Status of time, config.	ENS	O
_0131:302	Device combin.:Topology is	ENS	O
_0131:303	Device combin.:Broken from	ENS	O
_0131:304	Device combin.:Number of detect. dev.	INS	O
_0131:305	Device combin.:Fct. logoff device 1	SPS	O
_0131:306	Device combin.:Fct. logoff device 2	SPS	O
_0131:307	Device combin.:Fct. logoff device 3	SPS	O
_0131:308	Device combin.:Fct. logoff device 4	SPS	O
_0131:310	Device combin.:Fct. logoff device 5	SPS	O
_0131:311	Device combin.:Fct. logoff device 6	SPS	O
_0131:312	Device combin.:Device 1 available	SPS	O
_0131:313	Device combin.:Device 2 available	SPS	O
_0131:314	Device combin.:Device 3 available	SPS	O
_0131:315	Device combin.:Device 4 available	SPS	O
_0131:316	Device combin.:Device 5 available	SPS	O
_0131:317	Device combin.:Device 6 available	SPS	O
Param. channel 2			
_0161:81	Prom. Intert.1:Block stage	SPS	I
_0161:500	Prot. Intert.1:Sync. level	LV	O
_0161:301	Prot. Intert.1:Reset synchronized	SPS	O
_0161:342	Prot. Intert.1:Error measurement	MV	O

No.	Information	Data Class (Type)	Type
_0161:0	Prot. Intert.1:Behavior	ENS	O
_0161:53	Prot. Intert.1:Health	ENS	O
_0161:301	Prot. Intert.1:Status of Sys. 1 and 2	ENS	O
_0161:302	Prot. Intert.1:Status of Sys. 3 and 4	ENS	O
_0161:303	Prot. Intert.1:Connection params	MV	O
_0161:316	Prot. Intert.1:Error rate / min exc.	SPS	O
_0161:317	Prot. Intert.1:Error rate / hour exc.	SPS	O
_0161:318	Prot. Intert.1:Time delay exceeded	SPS	O
_0161:319	Prot. Intert.1:Time delay difference	SPS	O
_0161:320	Prot. Intert.1:Time delay jump	SPS	O
_0161:321	Prot. Intert.1:Is synchronized	SPS	O
_0161:340	Prot. Intert.1:Telegram fail	SPS	O
_0161:308	Prot. Intert.1:Err bits	MV	O
_0161:309	Prot. Intert.1:Err bps	MV	O
_0161:310	Prot. Intert.1:1s telegr.	MV	O
_0161:311	Prot. Intert.1:1s errors	MV	O
_0161:312	Prot. Intert.1:1s err min	MV	O
_0161:313	Prot. Intert.1:Rx errors	MV	O
_0161:314	Prot. Intert.1:Rx errmin	MV	O
_0161:315	Prot. Intert.1:Rx errbits	MV	O
_0161:336	Prot. Intert.1:Max.reconn	MV	O
_0161:335	Prot. Intert.1:Diagnostic	SPS	O
_0161:336	Prot. Intert.1:Max.telid	MV	O
_0161:337	Prot. Intert.1:Min.telid	MV	O
_0161:338	Prot. Intert.1:Id. telid	MV	O
_0161:339	Prot. Intert.1:Id. err.tel	MV	O
_0161:331	Prot. Intert.1:Recnct	MV	O
_0161:333	Prot. Intert.1:PPS: time det. timers	SPS	O
_0161:334	Prot. Intert.1:Pi with PPS sym-thresh.	SPS	O
_0161:324	Prot. Intert.1:Err.cr	MV	O
_0161:326	Prot. Intert.1:Rec. Al	MV	O
_0161:327	Prot. Intert.1:Rec. Al	MV	O
Ext. Synchron.			
_0181:500	Ext. Synchron.:Alarm stage	SPS	I
_0181:501	Ext. Synchron.:PPS pulse lens	SPS	I
_0161:301	Ext. Synchron.:PPS pulse rec.	SPS	O
_0161:302	Ext. Synchron.:PPS pulses	SPS	O

3.6 Date and Time Synchronization

3.6.1 Overview of Functions

Timely recording of process data requires precise time synchronization of the devices. The integrated date/time synchronization allows the exact chronological assignment of events to an internally managed device time base that is used to time stamp events in logs, which can then be transmitted in a substation automation environment or transferred via the protection interface. A clock monitor ensures the device and battery backup are synchronized correctly with the current device time so that the right device time is available and used even in case of auxiliary voltage failure. At the same time, the powerful hardware supports monitoring of the device time.

3.6.2 Structure of the Function

The integrated substation synchronization is a supervisory device function. Setting parameters and indications can be found in the following format for the DIGSI and the device:

Set date and time:

- DIGSI: Online access -> Interface -> Device -> Device information -> Time information
- Device: Main menu -> Device functions -> Date & Time

Parameter:

- DIGSI: Project -> Device -> Parameter -> Time Settings

Indications:

- DIGSI: Project -> Device -> Information routing -> Time keeping or Time Sync.

3.6.3 Function Description

Every SIPROTEC 5 device maintains an internal device time with date. The date and time can also be set on the device via the operator operation panel or via DIGSI 5. Within a system, or even beyond, it is usually necessary to record the time of process data accurately and to have exact time synchronization of all devices. For SIPROTEC 5 devices, the sources of time and synchronization options can be configured.

Configurable Synchronization Options:

- **None (default setting)**
  The device functions without any external time synchronization. The internal time synchronization continues to work with the help of the back-up battery even when the auxiliary voltage is shut down temporarily. The time can be adjusted manually.
- **Telegram**
  The time is synchronized via a telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 or DNP3 protocol.
- **Connection to a radio clock**
  The time synchronization takes place with the set time telegram from an external radio or DCF 77 receiver via the time synchronization interface of the device.
- **Ethernet**
  The time synchronization is done via Ethernet-based SNTP protocol (Simple Network Time Protocol), for example with IEC 61850 stations or via IEEE 1588, if you enable both services during configuration of Ethernet interfaces. These protocols are available as an option for the time synchronization.
- **Protection interface**
  The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management.

Configurable Time Sources:

- 2 time sources can be taken into consideration with the SIPROTEC 5 devices. For each time source, the synchronization type may be selected based on the options provided.
- Time source 1 takes precedence over time source 2. Status, time, position 2 will be effective for the synchronization of the device time only if time source 1 fails. If only one time source is available and it fails, then only the internal clock continues to synchronize. The status of the time source is evaluated.
- For every time source it is possible to define via the time zone setting parameter for time zone time source 2 if this source transmits its time in UTC (universal time) or if the setting takes regard to the local time zone of the device.

NOTE

Make sure that the settings for the time sources coincide with the actual hardware configuration of your SIPROTEC 5 device. In any event, incorrect settings cause the status indications of time sources to pick up.

Configurable Date Format

Regardless of a time synchronization source, a uniform format is available and internally within the device. The following options are available for the customary text representation of the date format:

- Day.Month.Year: 24.12.2010
- Month/Day/Year: 12/24/2010
- Year-Month-Day: 2010-12-24

Taking Local Time Zones into Account

The internal device time is maintained in universal time (UTC). To display time stamps in DIGSI and on the device display, you can define the local time zone of the device (parameter Time zone time source 1/2), including the applicable daylight saving times (start, end, and extent of daylight saving time) using parameters. This allows the display of the local time.

NOTE

- For time sources that transmit the status of the switch to daylight saving time, this will be taken into account automatically when creating the internal device time in the UTC format. The differential time of the daylight saving time set in the device (parameter Offset daylight saving time) is taken into consideration. However, in contrast, the settings of the start of daylight saving time and end of the daylight saving times are ignored when converting into the device internal UTC format.
- For active time sources, it is not possible to set the time via the device display or DIGSI 5. An exception is setting the calendar year for active time protocol IRIG-B.

Status, Supervision, and Indications of Time Management

Your SIPROTEC 5 device generates status and monitoring indications that provide important information regarding the current configuration of the time source and the status of the internal time management during start-up and device operation.
If external time synchronization is monitored cyclically, important synchronization processes, the status of the time sources and errors detected are reported. A whole time error has occurred (fault) will be marked as long only as that affected functions can go to a safe state.

Indication	Description
Device clock fail	This indication signals a high difference between the internally managed time and the time of the clock module that is not permissible. The triggering of the indication can point to a defect in the clock module or to an unacceptable high drift of the system source crystal. The time maintained internally is marked as invalid.
Time synchronization: daylight saving time	This indication signals whether the daylight saving time has been enabled.
Time management: clock set manually	This indication signals that the device time has been set manually via the on-site operation panel or via DIGSI 5.
Time synchronization: status time source 1 status time source 2	These 2 indications signal whether the set time sources are recognized as valid and active from the device point of view. When the indications get triggered, it can also be an indication that an incorrect configuration of the port or channel numbers was done at the on-site operation panel.
Time synchronization: time sync. error	This indication signals after the parameterized time fault indication after that synchronization using an external time source has failed.
Time synchronization: high accuracy	This indication signals that the device is synchronized with an accuracy better than 1 µs. The indication is only of significance when the PRU has had a load.

NOTE

In case of a missing or discharged battery, the device starts without active external time synchronization with the device time 2011-01-01 00:00:00 (UTC).

For the device, DIGSI 5 provides a compact overview of the status of the time synchronization of your SIPROTEC 5 device in online mode. All displays are updated continuously. You can access the overview in the project tree window via Online access.
DIGSI: Online access -> Interface -> Device -> Device information -> Time information

Figure 3.72 Time information in DIGSI

For every time source, you see the following:

- Last received time (with date)
- Receive time of the last received time telegram

- Configured type of timer
- Indication of timer outage or failure
- Whether the device time is currently synchronized from the time source

The lower section displays the device time, which is continuously updated, if the internal device time and the linked time source were synchronized at the time of telegram receipt, both displayed times are identical.

NOTE

All times displayed (also the time source) take into consideration the local time settings (zone and daylight saving time of the device) in the form of a numerical offset for UTC (universal time).

3.6.4 Application and Setting Notes

Parameter: Date Format

- Default setting Date format = YYYY-MM-DD

With the Date format parameter, you define the local customary format of the date display.

Parameter Value	Description
DD.MM.YYYY	Day.Month.Year: Typical European display Example: 24.12.2010
MM/DD/YYYY	Month/Day/Year: Typical US representation Example: 12/24/2010
YYYY-MM-DD	Year-Month-Day: Typical Chinese display Example: 2010-12-24

Parameter: Time zone time source 1,Time zone time source 2

- Default setting Time zone time source 1 = local, Time zone time source 2 = local

With the Time zone time source 1 and Time zone time source 2 parameters, you define the handling of time zones of the external timer.

Parameter Value	Description
local	Local time zone and daylight saving time are evaluated as time zone offsets to GMT.
UTC	Time format according to UTC (universal time)

Parameter: Time source 1,Time source 2

- Default setting Time source 1 = none, Time source 2 = none

With the Time source 1 and Time source 2 parameters, you configure an external timer. The prerequisite is to match the corresponding hardware configuration of the communication interfaces of your SIPROTEC 5 device. This is done as a prefix when making a selection in DIGSI 5.

Parameter Value	Description
none	The time source is not configured.

Parameter Value	Description
IRIG-B	Time synchronization by an external GPS receiver SIPROTEC 5 devices support several protocol variants of the IRIG-B standard: • IRIG-B 002(IRIG) The control function bits of the signal are not occupied. The missing year is formed from the current device time. In this case, it is possible to set the year via the on-site access in DIGSI 5. • IRIG-B 003(IRIG) The bits for the calendar year are not equal to 00. The calendar year is set automatically by the time protocol. • IRIG-B 005(IRIG) with extension according to IEEE C37.118-2005 If, in the time signal, other control functions bits are occupied in addition to the calendar year, then the device takes the additional information into consideration for leap seconds, daylight saving time, time offset (zone, daylight saving time) and time accuracy. Time zone time source 1 or Time zone time source 2: The value of this setting is not evaluated by the device, since this protocol either transmits or is the case of local time, specifies the appropriate offset to UTC in each set time telegram.
DCF77	Time synchronization by an external DCF 77 receiver Time zone time source 1 or Time zone time source 2 = local Please note: There are also clocks that generate a DCF 77 signal representing UTC. In this case, UTC must be set.
PI	The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management. Signal-transit times of the protection interface communication are calculated automatically. Time zone time source 1 or Time zone time source 2 = UTC A slave that receives a time of a SIPROTEC 5 master, receives its system time in UTC.
SNTP	The time synchronization is done via the Ethernet service SNTP (SNTP server or via IEC 61850). SIPROTEC 5 devices support both Edition1 and Edition2 in accordance with IEC 61850-7-2, in Edition2, the logical attributes LeapSecondsKnown, ClockFailure, ClockNotSynchronized, and the value TimeAccuracy are maintained in each time stamp. For Edition1, these signals contain default settings. Thus, the time information for substation automation technology is ensured for both editions. The SNTP service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. Time zone time source 1 or Time zone time source 2 = UTC
IEC 60870-5-103	The time is synchronized via telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 protocol. However, there are also HMI systems that send the UTC

Parameter Value	Description
SNTP	The time is synchronized via telegram with the appropriately configured communication interface in accordance with the SNTP protocol. Two characteristics are supported in this process: • Time synchronization via UTC • Time synchronization with local time The daylight saving time stages is not considered. The device assumes that the SNTP server follows the same rules for the start and end of the daylight saving time as there that store set for the device Time zone time source 1 or Time zone time source 2 = TZ(n)h The correct implementation (local) incorrect under implementations.
IEEE 1588	Time is synchronized in an IEEE 1588 timing master. In this case, SIPROTEC 5 devices operate as slave-only clocks. IEEE 1588 v2 is supported with PTP and Ethernet Transport. The IEEE 1588 service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. Time zone time source 1 or Time zone time source 2 = UTC

Parameter: Fault indication after

- Default setting Fault indication after = 600 s

With the Fault indication after parameter you set the time delay after which the unsuccessful attempts of time synchronization with external time sources configured are indicated.

Parameter: Time Zone and Daylight Saving Time

This parameter block contains all the settings for the local time zone and daylight saving time of your SIPROTEC 5 device. In addition to the individual parameters, configure the basic settings by parameterizing via the radio buttons or check box.

Figure 3.73 Settings for Time Zone and Daylight Saving Time in DIGSI

Selection Button	Description
Manual settings (local time zone and daylight saving time management)	This (default) mode. No selection if you want to select the local time zone and daylight saving time manually. None of your SIPROTEC 5 device properties at the DP settings: Input: Offset time zone to GMT [mm] Selection: Switch over to daylight saving time (period) via check box ✓ Switch daylight sav. time • Input: Start of daylight saving time [Day and time] • Input: End of daylight saving time [Day and time] • Input: Offset daylight saving time [min] • Default settings as in the picture shown

3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Time sync.				
_1102	Time sync. Time source 1		• none • PPM • IRIG B • DCF77 • Synchbox • PI • SNTP • IEC 61850-9-3 (1) • PROFINET IO • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-103	none
_1301	Time sync. Time source 3 port		• port F • port E • port B • port P • port N • port G	
_1104	Time sync. Time source 1 channel		• CH1 • CH2	

Addr.	Parameter	C	Setting Options	Default Setting
_1103	Time sync. Time source 2		• none • PPM • IRIG B • DCF77 • Synchbox • PI • SNTP • IEC 61850-9-3 (1) • PROFINET IO • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-103	none
_1105	Time sync. Time source 2 port		• port F • port E • port B • port P • port N • port G	
_1107	Time sync. Time source 2 channel		• CH1 • CH2	
_1108	Time sync. Time zone time source 1		• UTC • local	local
_1109	Time sync. Time zone time source 2		• UTC • local	local
_1101	Time sync. Fault indication after		0 s to 3600 s	600 s

3.6.6 Information List

No.	Information	Data Class (Type)	Type
Clock Management			
_1300	Time management: Daylight saving time	SPS	O
_1301	Time management: Clock set manually	SPS	O

No.	Information	Data Class (Type)	Type
Time sync.			
_1302	Time sync. Status time source 1	SPS	O
_1304	Time sync. Status time source 2	SPS	O
_1305	Time sync. Time sync. error	SPS	O
_1306	Time sync. Leap second	SPS	O
_1307	Time sync. High accuracy	SPS	O

3.7 User-Defined Objects

3.7.1 Overview

Within a user-defined function group, you can use the User-defined function block and the User-defined function block [Control] to group user-defined objects that you create. In DIGSI 5 library tests I user-defined functions.

With user-defined function groups and user-defined functions, a grouping of user-defined objects for example, user-defined function blocks, can be performed. 7 user-defined function blocks are available (see following figure).

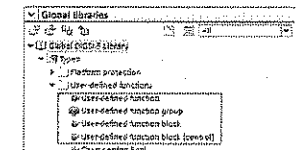


Figure 3-74 User-Defined Objects in the DIGSI 5 Library

You can insert single-point indications, pulses and operate indications (SI 1), SP (), single or double commands, commands with a controllable whole number as well as measured values in the User-defined function block (see following figure). You can assign a subscription name to the grouping (for example, Process indications, for a group of single-point indications that are read in as binary inputs). This function can be deactivated via the mode. Readiness is also evaluated and represented.

The user-defined function can be instantiated both at the highest level (in parallel to other function groups) and within the function groups and functions.

A User-defined function block [control] is also available. In addition to the mentioned option of a general User-defined function block, this block offers additional tests for user-defined control signals, for example, SPC or DP.

You can find more information in chapter 4.8.1 Overview of functions.

Figure 3-75 Information Routing Through the Id Added User-Defined Function Block: Process Indications and Single-Point Indications

3.7.2 Basic Data Types

The following data types are available for user-defined objects in the DIGSI 5 library under the heading User-defined signals.

Single-Point Indication (Type SPS; Single-Point Status)

The status of a binary input can be registered in the form of a single-point indication or forwarded as the binary result from a CFC chart.

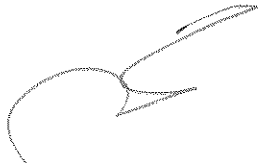
EXAMPLE

Acquisition using binary input, further processing in a CFC and/or display using an LED.

Single-Point Indication (Type SPS unsaved; Single-Point Status Unsaved)

In contrast to SPS single-point indications, the state of the SPS unsaved indication is not maintained after the device restarts.

For this purpose, go to Properties > Details > Initialization > Restart and set the value.



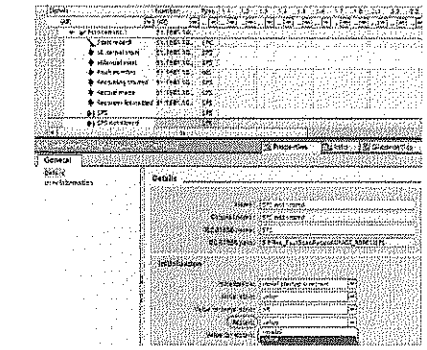


Figure 3-76 Single-Point Indication SPS unsaved (Example: 2YE81 Fault direction)

Double-Point Indication (Type DPS; Double-Point Status)

When using a double-point indication, the status of 2 binary inputs can be registered simultaneously and mapped as an indication with 4 possible conditions, e.g., Intermediate = position, OFF, Disturbed position).

EXAMPLE

Acquisition of a disconnector or circuit breaker switch position.

Marker Command (Type SPC, Single-Point Controllable)

This data type can be used as a command without feedback for simple signalling or as an internal variable (marker).

State of a Whole Number (Type INS)

The data type INS is used to create a whole number that represents a CFC result.

EXAMPLE

The output of the CFC block ADD_D can, for example, be connected with the data type INS. The result can be shown on the display of the device.

State of an Enumeration Value (Type ENS)

The data type ENS is used to create an enumerated value that represents a CFC result.

Controllable Single-Point Indication (SPC, Single-Point Controllable)

This can be used to issue a command (to one or several relays, selectable under Information routing) that is monitored via a single feedback.

Command with Double-Point Feedback (DPC, Double Point Controllable)

This can be used to issue a command (to one or several relays, selectable under Information routing) that is monitored via double-point indication as feedback.

Command with a Whole Number (INC, Controllable Integer Status)

This can be used to issue a command (to one or more relays, selectable under Information routing) that is monitored via a whole number as feedback.

Complex Measured Values (CMV)

This data type provides a complex measured value that can be used as a CFC result, for example.

Measured Values (MV)

This data type provides a measured value that can be used as a CFC result, for instance.

NOTE

Additional data types can be found under other headings in the DIGSI 5 library, as well as in the corresponding function blocks. This applies to the following data types:

- Pulse-measured values (see User-defined functions in the DIGSI 5 library)
- Transformer taps
- Metered values

Phase-to-Ground Measured Values (WYE)

This data type represents the phase-to-ground measured values of a 3-phase system.

Phase-to-Phase Measured Values (DEL, Delta)

This data type represents the phase-to-phase measured values of a 3-phase system.

Protection Activation Information (ACT)

This object type is used by the protection functions for Tripping. It is available in the library for receiving protection information via the protection interface, which could also indicate Tripping.

Protection Activation Information with Direction (ACD)

This object type is used by the protection functions for Pickup. It is available in the library for receiving protection information via the protection interface, which could also indicate Pickup. In addition, both ACD and ACT can be evaluated and processed by CFC charts.

3.7.3 Pulse- and Energy- Metered Values

Pulse-Metered Values

Pulse metered values are available as data type **BCR** (Binary Counter Reading) in the DIGSI library under User defined Functions.

The functionality and the settings of the pulse metered values can be found in chapter 6.10.1 Pulse Metered Values, Function Description.

Energy-Metered Values

Energy metered values are no longer need to be created by the user separately. They are available as active and reactive power in each Line function group for reference and output direction. The calculation is based on the current and voltage transformer associated with the protected object.

You can find more detailed information in chapter 6.11 Synchrophasor Measurement Values.

3.7.4 Additional Data Types

The following data types are also used in the system but are not available for general use as user defined types in the library:

- **ENC** (Enumerated Setting Controllable)
  The data type **ENC** includes a command with which the user can set predefined values.
- **SEQ** (Sequence)
- **BSC** (Binary Controlled Step Position)
  The data type **BSC** can, for example, be used to control a transformer tap changer. The commands up, down can be given.

NOTE

Transformer taps are included in the Transformer tap changer switching element. If the switching element is created in the device, the transformer tap position is available as a data object of type BSC (binary controlled tap changes with information information).

3.8 Other Functions

3.8.1 Signal Filtering and Chatter Blocking for Input Signals

Input signals can be filtered to suppress fast changes at the binary input. Chatter blocking can be used to prevent faster-than-expected changing indications from flagging the event list. After an adjustable number of changes, the indication is blocked for a certain period.

The settings for application filtering can be found at the marshalling stages. The next figure shows the setting using the example of a centrifugal circuit breaker switch position.

NOTE

For the circuit breaker switch position, the settings of the software filter for spontaneous position changes are available only in the Control/Command with feedback function block. These settings are not available in the Circuit breaker or Disconnector function blocks where three function blocks contains the setup-conditioned positions of the switch in the bay.

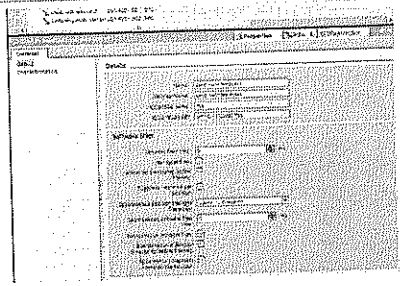


Figure 3-77 Settings for Circuit Breaker Switch Position

The setting range for the **Software filtering time** parameter ranges from 0 ms to 86 400 000 ms (1 day) in ms increments. The **Extrapper filter** check box can be used to select whether the software filter should be restarted by a change from 1 to 0 and back. When activated, the **Indication on timestamp before filtering** check box adds the time stamp by the set software filtering time and the fixed hardware filtering time. In this case, the time stamp corresponds to the actual status change of the signal. If you activate the **Suppress intermediate positions** check box, the intermediate position is suppressed for the duration of the software filter time.

With the parameter **Spontaneous position changes filtering**, you set how switch position changes are to be filtered. Spontaneous position changes are caused by external switching commands, for

example, if the general reference filtering setting is selected, the spontaneous and unwanted flickering of spontaneous position changes and the position changes caused by a switching command apply. The spontaneous position changes can then not be recorded. A separate filtering for spontaneous position changes is activated with the **Spontaneous** and **Pulse filtering** setting and you can set the settings for this.

Chatter blocking can be activated or deactivated as a parameter of the position in the General breaker or Disconnector function block.

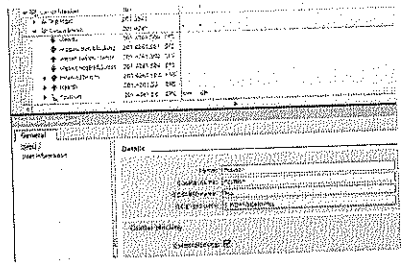


Figure 3-78 Setting Chatter Blocking

The settings for the chatter blocking functions are set centrally, for the entire device in DIGSI. They are active alike on settings in the General function group (see the following figure).

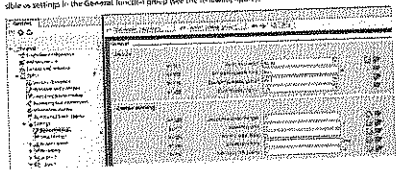


Figure 3-79 Chatter Blocking Settings

The chatter blocking settings have the following meaning (see also Figure 3-80 and Figure 3-81 in the examples shown in the following):

- **No. permis. state changes**
  This number specifies how often the state of a signal may toggle within the chatter-test time and the chatter checking time. If this number is exceeded, the signal will be or remains blocked.
  Enter a number from 0 to 65535 in this field. If the entry is 0, chatter blocking is essentially inactive.
- **Initial test time**
  During this time, the number of times a signal changes its status is checked. This time is started if chatter blocking is configured for at least one signal and this signal changes its status. If the configured number of permissible state changes is exceeded during the initial test time, the signal is temporarily blocked and the indication *Chatter Blocking* is set.
  Enter a number between 1 and 65535 in this field. The number entered corresponds to the time in seconds, when the set time has expired, the timer restarts automatically (cycle time).
- **No. of chatter tests**
  This number specifies the maximum number of test cycles to be run. If the number of permissible state changes stays exceeded during the initial test time of the last test cycle, the signal is finally blocked. In this case, the indication *Group warning* (Alarm handling group) and (Device group) are set. In addition to the *Chatter Blocking* indication after expiry of the set number, Restarting the devices removes this block again.
  Enter a number from 0 to 32767 in this field. The value Infinity (∞) is also permissible here.
  Enter this value as standard setting on.
- **Chatter idle time**
  If the number of permissible status changes for a signal is exceeded during the initial test time or the subsequent test time, the **Chatter idle time** starts. Within this time, the signal is blocked temporarily and the *Chatter Blocking* indication is set. The constant input signal is assigned the oscillatory quality.
  Enter a number between 1 and 65535 in the field. The number entered corresponds to the time in minutes. An entry here is only considered if the number of chatter tests does not equal 0.
- **Subsequent test time**
  During this second test time, the number of times a signal changes its status is checked once again. The time begins when the **Chatter idle time** expires. If the number of state changes is within the permissible limit, the signal is released. Otherwise, an additional idle time begins, unless the maximum number of chatter tests has been reached.
  Enter a number between 2 and 65535 in the field. The number entered corresponds to the time in seconds. An entry here is only considered if the number of chatter test does not equal 0.

Example 1: Permanent Blocking

The chatter-blocking settings are set as follows:

- **No. permis. state changes** = 4
- **No. of chatter tests** = ∞

After more than 4 state changes within the **Initial test time**, the input signal is set to the original state by the chatter blocking and the oscillatory quality is assigned. Additionally, a corresponding indication is added to the operational log. If the new, slowly *Chatter Blocking* indication is set. After expiry of the settable **Chatter idle time**, during the following **Subsequent test time**, it is checked whether the input signal is still chattering. This check is repeated, as the **No. of chatter tests** is set to ∞ in the example.

If, during the 2nd **Subsequent test time**, it has been detected that the number of state changes of the input signal remains below the **No. permis. state changes**, the chatter blocking detects a persistent indication of the signal stability and sets the *Group warning* indication. The original state of the signal is permanently locked. Only a device restart removes the chatter blocking again.

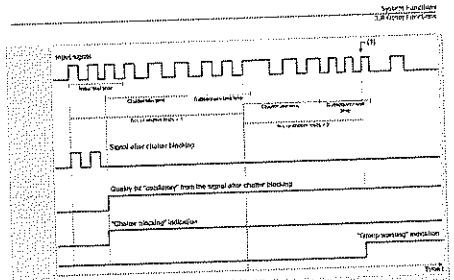


Figure 3-80 Signal Change during Chatter Blocking with one Impermissible Number of Signal State Changes during 2nd Subsequent Test Time

(1) The input signal is permanently blocked contrary from this point in time.

Example 2: Temporary Blocking

The chatter blocking settings are set as follows:

- **No. permis. state changes** = 4
- **No. of chatter tests** = 2

After more than 4 state changes within the **Initial test time**, the input signal is set to the original state by the chatter blocking and the oscillatory quality is assigned. Additionally, a corresponding indication is added to the operational log. At the same time, the *Chatter Blocking* indication is set. After expiry of the settable **Chatter idle time**, during the following **Subsequent test time**, it is checked whether the input signal is still chattering. This check is repeated, as the **No. of chatter tests** is set to 2 in this example.

If, during the 2nd **Subsequent test time**, it has been detected that the number of state changes of the input signal remains below the **No. permis. state changes**, the temporary blocking of state changes of the signal is removed and the actual signal state is released.

The quality bit oscillatory is removed and the *Chatter Blocking* indication is reset. As the temporary blocking of the signals remains, the *Group warning* indication is not set. The chatter test starts again.

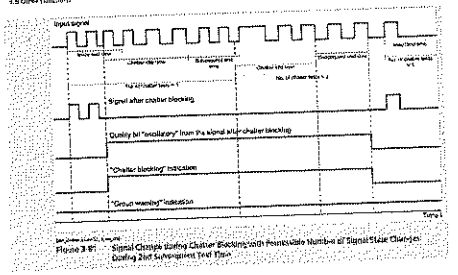


Figure 3-81 Signal Change during Chatter Blocking with Permissible Number of Signal State Changes during 2nd Subsequent Test Time

3.8.2 Acquisition Blocking and Manual Updating

During commissioning, maintenance, or testing, a brief interruption of the connection between the logical signals and binary inputs may be needed. It allows you to manually update the status of a switching device that is not processing live data currently. Before this can take place, you must set up acquisition blocking. Set the Acquisition blocking function in the menus of the device display Commands > Equipment > Acquisition state, update. If several switching devices are available, select the appropriate switching device. When prompted for, Change to, the combination ID will be required. After entering the combination ID, the acquisition blocking function is switched on when OK is pressed.

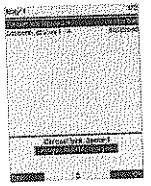


Figure 3-82 Activating the Acquisition Blocking

Manual updating of the switching device is possible from within the same menu. For the Operation Control to select the Manual updating function, Substation only, select the updating point of the switching device manually, and confirm/reject the selection by pressing OK. The manually updated position of the switching device will be displayed.

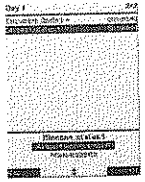


Figure 3-83 Activate Manual Updating

Figure 3-84 Selecting Position

NOTE

For safety reasons, manual updating is possible only directly through the on site operation panel of the device and not through DIGSI 5.

NOTE

Setting acquisition blocking and the subsequent manual updating are also possible via the IEC 61850 system interface.

Acquisition blocking can also be set via a binary input. This way, acquisition blockings can be set for an individual or several switching devices in a feeder simultaneously with an external single switch in order to

3.9 General Notes for Setting the Threshold Value of Protection Functions

3.9.1 Overview

You can set the threshold values of protection functions directly on the device or by using DIGSI 5.
An innovative design was implemented for the parameter settings.
You can switchover the edit mode between the following setting views:

- Primary
- Secondary
- Percent

If you change settings in a setting sheet, DIGSI 5 calculates the settings of the 2 inactive views in the background. If you wish to view, for example, conversion to secondary values, then select the primary view. Configure all the settings and switchover to the secondary view.

Edit Mode: Primary

The parameters are set as primary values and then refer directly to the primary system. The manual corresponds to the secondary circuit entered.

Edit Mode: Secondary

The settings refer to the secondary circuits of the transformer. This means that the settings must be converted. The secondary setting is the customary setting view. For secondary tests, the pickup values can be read directly.

Edit Mode: Percent

This setting type is beneficial for electric machines (generators, transformers, motors, and busbars). The setting values can be standardized regardless of the machine size. The reference values for the percentage settings are the rated values of the function groups, for example, rated voltage and rated currents or rated apparent power . The setting values are, thus, related exclusively to the primary settings. If other reference values are used, then they are documented for the respective protection function in the application and setting notes.

If parameter are changed it may happen that they are set only in percent in all 3 setting views.

Recommendation for Setting Sequence

When setting the protection function, Siemens recommends the following procedure:

- First set the transformation ratios of the transformers. You can find these under Power-system data.
- In addition, set the relevant parameters for the percent settings. You will find these parameters in function groups .
- Next, set the parameters of the protection functions.

If the transformer data have changed after completing the protection settings, perform in the setting sheet (for example, primary setting) that changed the transformer data. In the last instant, DIGSI 5 obtains the new settings in the inactive setting views the example, now secondary values).

The following section explains, by way of an example, how to modify the transformer ratios in DIGSI 5 using the corresponding alternatives.

3.9.2 Modifying the Transformer Ratios in DIGSI 5

In the following setting, DIGSI 5 is set to the Secondary edit mode.

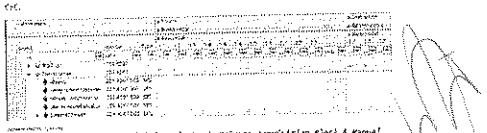


Figure 3-85 Input signals >Acquisition Blocking, >Release Acquisition Block & Manual Updating on the Switching Device

NOTE

Interlocks are carried out with the status changes of the switching device. Remove acquisition blocking again manually. However, position changes of the switching device are not observed and interlockings are ineffective.

If the acquisition blocking and the manually updated position are released, the operation panel of the device or the system interface IEC 61850, these are retained until the acquisition blocking is manually deactivated. When you initially start the device, the acquisition blocking is deactivated.
Except for a restart, the acquisition blocking and the manually updated position are retained.
If the acquisition blocking is activated via the input signal >Acquisition Blocking, it is retained as long as the binary input is active.
To set the acquisition blocking of a switching device, the following sources are possible:

- Operation panel of the device
- System interface IEC 61850
- Input signal >Acquisition Blocking

All sources undergo OR operations, that is, the acquisition blocking remains set until all the sources are deactivated.
After deactivation of the acquisition blocking, the actual position of the switching device is adopted and displayed in the operation panel of the device.

NOTE

When the acquisition blocking is activated or the switching device updated manually while the entire device or the switching device is in test mode, these states are not stored. The acquisition blocking and the manual updating are not retained after a restart.

Acquisition blocking and manual update for the circuit breaker, the disconnector and the earthing switch are made by way of the General: Acquisition Block Binary Input. Certain acquisition blockings and manual update is blocked with the input activated.

3.8.3 Persistent Commands

In addition to the switching commands, which are issued as pulse commands, and stored for the standard switching devices (circuit breaker, disconnector, earther), persistent commands are also possible. In this case, a

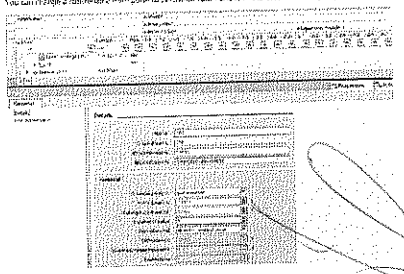


Figure 3-86 Setting the Command Type in DIGSI 5

Select the two outputs or Continuous output for the command output type. If a persistent command is selected, the pulse parameter is irrelevant.

The following setting example shows how you can change the transformer ratio in DIGSI 5, and what impact this has on the settings in the setting views Primary and Secondary. The protection setting is observed in the example of the Overcurrent protection function.
The following output data are assumed.

Current transformer: 1000 A/1 A
Protection pickup value: 1.5 A

The following figure shows the protection setting of the Overcurrent protection function in the secondary view. The threshold value of the stage is set to 1.5 A.

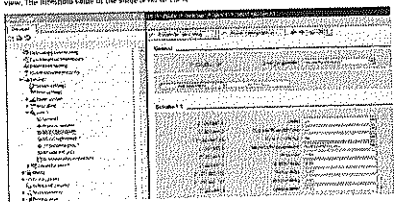


Figure 3-87 Protection Setting, Display of the Active Setting Sheet

When you click the green arrow in the setting sheet at the upper left, you get to the window for switching over to the setting view (see the following figure). Select the setting view you prefer.

Figure 3-88 Switchover to the Desired Setting View

The following figures show the setting sequence in the Primary edit mode. See the transformer data. In the example, the current transformers use a transformation ratio of 1000 A/1 A.

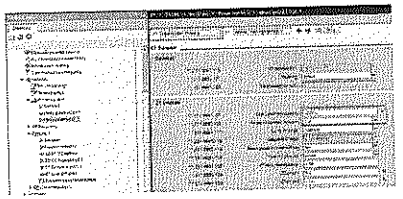


Figure 3-89 Setting Sheet Transformer Data

In the Voltage/current 3-phase function group, you set the rated current and rated voltage (see the following figure). Rated current, rated voltage are the reference variables for the percent setting.

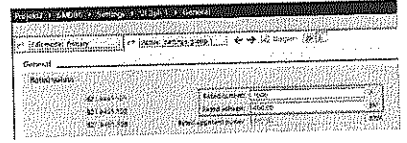


Figure 3-90 Reference Data for Percentage Settings

The following figure shows the threshold value of the Overcurrent protection function in the primary view at 1500 A.

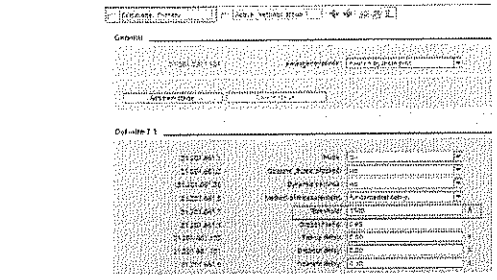


Figure 3-91 Example of the Threshold Value of the Definite-Time Overcurrent Protection (Edit Mode: Primary)

When switching over to the general view, the result should be the following value:
150A A/100A A · 100 % = 150 %

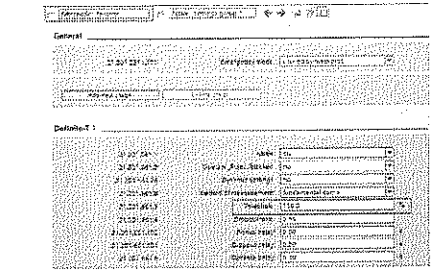


Figure 3-92 Example of the Threshold Value of the Definite-Time Overcurrent Protection (Edit Mode: Percent)

When switching over to the secondary view, the result should be the following value:
1500 A/(2000 A/1 A) · 1 A

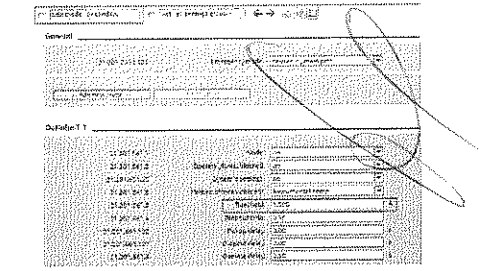


Figure 3-93 Example of the Threshold Value of the Definite-Time Overcurrent Protection (Edit Mode: Secondary)

If you only want to work in the secondary view, DIGSI 5 supports you if the transformation ratio changes during the project phase.
In the example, the current transformer ratio changes from 1000 A/1 A to 1600 A/5 A. Change the secondary rated current of the current transformer in the setting sheet of the transformer data from 1 A to 5 A (Edit mode: Secondary). If you change the transformer data, a window will appear (see the following figure) that will ask you for the action desired.

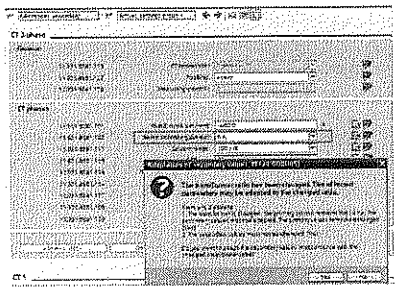


Figure 3-94 Query after Changing the Transformer Data (Setting View: Secondary)

If you answer the question with Yes, then DIGSI 5 will recalculate the pickup values (threshold values) in the active secondary view. For the new secondary transformer current 5 A, the new secondary threshold value obtained is 7.5 A (1.5 A * 5 = 7.5 A). The primary and percent values remain unchanged.
The following figure shows the newly calculated threshold value in the secondary view:

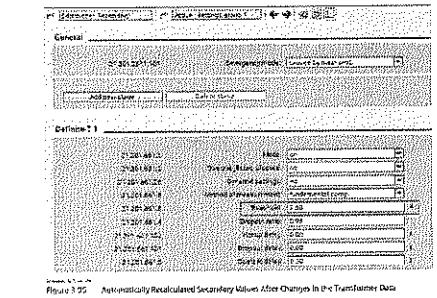


Figure 3-95 Automatically Recalculated Secondary Values After Changes in the Transformer Data

If you have already set the settings in the secondary view by including the new transformation ratio of the transformer in the calculation, then you answer the question with No. In this case, the protection settings in the secondary view remain unchanged. DIGSI 5 recalculates the settings (threshold values) at the primary view. In the example, the primary threshold value is then 300 A (1.5 A * 1000 A/5 A = 300 A).
In the example, the current transformer ratio changes from 1000 A/5 A to 1000 A/5 A. The following table summarizes the pickup values that DIGSI 5 will recalculate in the setting view. The new values (in bold) depend on the answer of your inquiry (see Figure 3-94).

	Reply to the Question	
	Yes	No
Threshold value secondary (active setting view)	7.5 A	7.5 A
Threshold value primary (activated setting view)	1500 A	300 A

3.9.3 Changing the Transformation Ratios of the Transformer on the Device

The device is preset to rated secondary values at the time of delivery. Only secondary values can be set directly on the device.
If you change transformer data directly on the device, it is not followed by a query, like in DIGSI 5 (see Figure 3-94), instead, the device assumes that all settings remain unchanged in the secondary view.

NOTE

If the device works with IEC 61850 protocol, you change the transformer data only via DIGSI 5 and not directly on the device. If you change the transformer data directly on the device, the IEC 61850 configuration of the measurement and metered values can be faulty.

3.10 Device Settings

3.10.1 Settings-Group Switching

3.10.1.1 Overview of Functions

For different applications you can save the respective function settings in so-called Settings groups, and if necessary enable them quickly.
You can set up to 8 different settings groups in the device. In the process, only one settings group is active at any given time. During operation, you can switch between settings groups. The source of the switchover can be selected via a parameter.
You can switchover the settings groups via the following alternatives:

- Via the onsite operation panel directly on the device
- Via an online DIGSI connection to the device
- Via binary inputs
- Via a communication connection to the substation automation technology.
  The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups.

A settings group includes all switchable settings of the device. Except for a few exceptions (for example, general device settings, such as rated frequency), all device settings can be switched.
Detailed information about the settings groups can be found in the Operating Manual and DIGSI 5 Online Help.

3.10.1.2 Structure of the Function

The function of the Settings group switching is a supervisory device function. Accordingly, the settings and indications of the settings group switching can be found in DIGSI 5 and in the on-site operation panel of the device, below the general device settings respectively.
If you want to switchover a settings group manually in DIGSI 5 or proceed on the on-site operation panel of the device, as follows:

- Via the project tree in DIGSI 5:
  Project → Device → Settings → Device settings
- Via the on-site operation panel of the device:
  Main menu → Settings → General → Group switchover

The indications for the settings group switchover can be found in the DIGSI 5 project tree under:
Project → Device → Information routing → General

3.10.1.3 Function Description

Activation

If you want to use the Settings group switching function, you must set at least 2 settings groups in DIGSI 5 (parameter Number of settings groups = 2). You can set up a maximum of 8 settings groups. The settings group, set in DIGSI 5 are subsequently loaded into the device.

Mechanism of the Switchover

When switching over from one settings group to another, the device operation is not interrupted. With the exception settings group pickup/dropout, you are not specifying a certain settings group or you allow switching via command (for example, IEC 61850) or via binary input.

Switching via Control

When using the **General** function for switching, the control device with the switching command sends the command via the substation automation technology or via a CFC chart.

The command can be sent via IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP. Set the signal for switching the settings groups via the communication protocol first.

In order to use a CFC chart for switching, you must create a new CFC chart in DIGSI 5. Open the CFC chart in the DIGSI 5 project tree under **Name of the device** → **Charts** → **Add new chart**. Link the signals that control settings group switching in the CFC chart.

Switching via Binary Input

There are 4 appropriate input signals available for switching via binary inputs. These input signals allow selection of the settings group via a binary code. If one of the 4 signals changes, the signal is only present still, after 100 ms (stabilization time), result in switching over to the appropriate settings group. If only 2 settings groups must be switched over, only 1 binary input is required. The following table shows the possible binary codes (BCD) and applicable settings groups (PG).

Table 3-20 Binary Codes of the Input Signals and Applicable Settings Groups

BCD Code via Binary Inputs	PG 1	PG 2	PG 3	PG 4	PG 5	PG 6	PG 7	PG 8
>PG selection bit 3	0	0	0	0	1	1	1	1
>PG selection bit 2	0	0	1	1	0	0	1	1
>PG selection bit 1	0	1	0	1	0	1	0	1

Copying and Comparing Settings Groups

In DIGSI 5, you can copy or compare settings groups with each other.

If you want to compare settings groups, select a source and target parameter group in DIGSI 5 in the device editor and then start the comparison. The device settings can be found in the DIGSI 5 project tree under **Project** → **Device** → **Settings** → **Device settings**.

If you want to compare settings groups, it is possible to go to all existing sheets for settings. You can then select in addition to the active settings group, a 2nd settings group for comparison. Active setting values and the comparison values are displayed next to each other. For settings that cannot be switched over, no comparison values are displayed.

Indication of Settings Group Switchings

Every settings group change or applicable binary information as well as its activation and deactivation. The process of settings group switching is also logged in the log for settings changes.

3.10.1.4 Application and Setting Notes

Parameter: Number settings groups

- Default setting (_:113) **Number settings groups** = 2

With the **Number settings groups** parameter, you can set the number of available settings groups, you can switch between three.

Parameter: Activat. of settings group

- Default setting (_:114) **Activat. of settings group** = **settings group 1**

With the **Activat. of settings group** parameter, you specify the settings groups that you want to activate, or the mechanism via which the switchover is allowed. You can switch over only between the settings groups specified with the **Number settings groups** parameter. Parameter Value

Parameter Value	Description
via control	The switchover between the settings groups can only be initiated via a communication connection from a substation control or network control via a CFC chart. The communication protocols IEC 61850-8-1, IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups via a communication connection.
via binary input	The switchover between the settings groups is carried out via the binary input signals routed to the settings group switching.
settings group 1 ... **settings group 8**	The, define the active settings groups. You can define the active settings groups in DIGSI 5, or directly on the device via the device operation.

3.10.1.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Change groups				
_:113	Number settings groups		1 to 8	1
_:114	General.Activat. of settings group		• via control • via binary input • settings group 1 • settings group 2 • settings group 3 • settings group 4 • settings group 5 • settings group 6 • settings group 7 • settings group 8	settings group 1

3.10.1.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:SG choice bit 1	SPS	
_:501	General:SG choice bit 2	SPS	
_:502	General:SG choice bit 3	SPS	
_:300	General:Act. settings group 1	SPC	C
_:301	General:Act. settings group 2	SPC	C
_:302	General:Act. settings group 3	SPC	C
_:303	General:Act. settings group 4	SPC	C
_:304	General:Act. settings group 5	SPC	C
_:305	General:Act. settings group 6	SPC	C
_:306	General:Act. settings group 7	SPC	C
_:307	General:Act. settings group 8	SPC	C

3.10.2 General Device Settings

3.10.2.1 Overview

In **Device** settings in DIGSI 5, you find the following general settings.

3.10.2.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device				
_:100	General:Rated frequency		• 50 Hz • 60 Hz	50 Hz
_:102	General:Minimum operate time		0.00 s to 30.00 s	0.00 s
_:138	General:Block monitoring dir.		• off • on	off
Spontan. faults				
_:139	General:Fault display		• with pickup • with trip	with pickup
Test support				
_:198	General:Activate device test mode		• 0 • 1	false
_:153	General:Oper.fun.outp. under test		• 0 • 1	true

3.10.2.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:519	General:Test mode on	SPS	I
_:511	General:Test mode off	SPS	I
_:507	General:Device failed, logoff on	SPC	F
_:508	General:Dev. hard logoff on	SPC	F
_:512	General:LED reset	SPS	I
_:502	General:Blk.mon	ENS	O
_:53	General:Health	ENS	O
_:57	General:Test mode	SPC	F
_:201	General:Protection on	SPC	C
_:54	General:Protection inactive	SPS	O
_:121	General:LED reset	SPC	F
_:120	General:LED have been reset	SPS	O

With the **Test support**, indications issued via communication interfaces are labeled with an additional test bit if this is supported by the protocol. With this test bit, you can determine that an indication is generated as a test and does not as individual functions of the device are in test mode. In this way, the reactions that are associated with normal operation due to an indication can be suppressed in other devices that receive these indications. You can also permit, for example, a trip command to close an interlocking binary output for test purposes. Siemens recommends deactivating the Test support again after the test phase.

3.10.2.2 Application and Setting Notes

The major part of the settings is described in the chapters cited above. In the following sections, you can find a description of the parameters of the sections **Device**, **Spontaneous indications**, and **Test support**.

Parameter: Rated frequency

- Default setting (_:101) **Rated frequency** = **50 Hz**

With the **Rated frequency** parameter, you set the rated frequency of the electrical power system.

Parameter: Minimum operate time

- Default setting (_:102) **Minimum operate time** = ...

With the **Minimum operate time** parameter, you set the minimum duration for the trip command of the functions. The trip command is maintained for the set duration.

Parameter: Blink monitoring dir.

- Default setting (_:138) **Block monitoring dir.** = **off**

With the **Block monitoring dir.** parameter, you set whether indications are issued via the system interface of the SIPROTEC 5 device or not.

If transmission blocking is switched on, no indications are issued via the system interface of a SIPROTEC 5 device.

Parameter: Fault display

- Default setting (_:139) **Fault display** = **with pickup**

With the **Fault display** parameter, you set whether spontaneous indications are issued for a pickup or for a tripping. Keep the DIGSI 5 routing options in chapter 4.3.2 Spontaneous Indications Display in DIGSI 5 and Table 2-6 in mind.

Parameter: Activate device test mode

- Default setting (_:198) **Activate device test mode** = **inactive**

With the **Activate device test mode** parameter, you activate the test mode that sets a test bit to the issued indications.

Parameter: Oper.fun.outp. under test

- Default setting (_:153) **Oper.fun.outp. under test** = **inactive**

If you activate the parameter **Oper.fun.outp. under test**, you can allow the closing of a binary output for test purposes. In this way, indications are issued during a device-wide test mode and the relays are visibly activated or not. If an individual function is in test mode, only indications are issued and the relays are not activated.

NOTE

The device remains in test mode during every startup until you set the device back into operation mode intentionally. You switch on the process mode by switching the parameter **Activate device test mode** in location mode from the check mark.

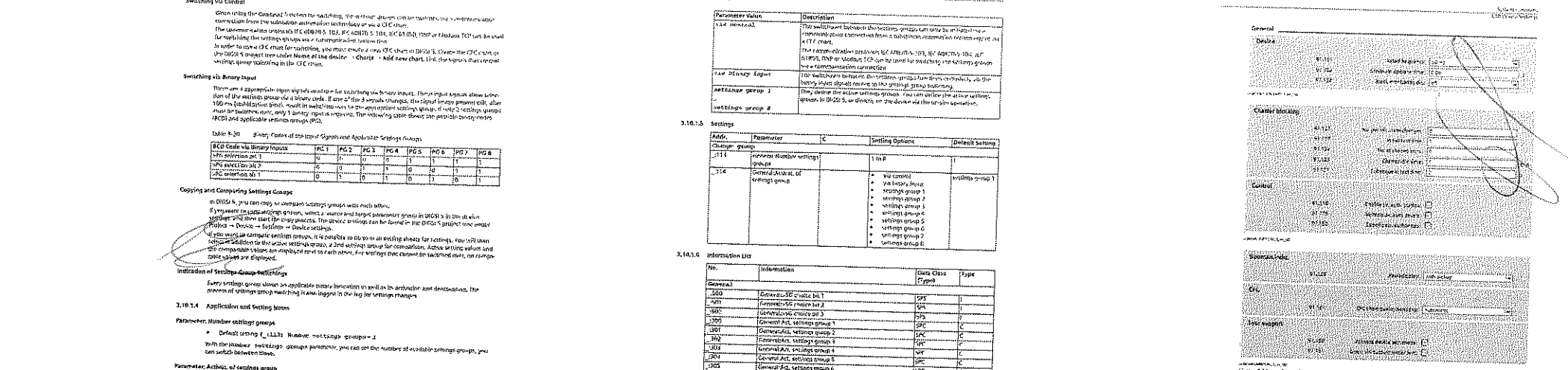


Figure 3-96 General Device Settings

The following set values are the chapters mentioned in the present information.

You can find more about

- **Chatter blocking** in chapter *3.2.7 Signal Filtering and Chatter Blocking for Input Signals*,
- **Control** in chapter *6.3 Control Functionality*,
- **Spontaneous indications** in chapter *3.1.3 Spontaneous Indications Display in DIGSI 5*,
- **CFC Quality Processing** in chapter *4.3.3 Quality Processing/Reflection by the User in CFC Charts*.

Under **Device**, you set the parameters for the device that are valid across functions.

4 Applications

4.1 Overview

The function library, in DIGSI 5, provides application templates for the standard applications of the devices. The application templates:

- Supports the installation of complete protection solutions for standard applications
- Contains the basic configuration for the application
- Contains functions and default settings for the application

When using an application template, please note the following:

- Adapt the application template to your specific application (check/adapt primary settings, delete/add functional). You can find more detailed information in Section 2.2.
- Check the routing of binary and post information to test and control device
- Check the logic, block chart for the circuit breaker interaction

The following describes the application templates for the 6MD85 and 6MD86 devices.

NOTE

The availability of certain settings and routing options depends on the ordering type and the functions available on the device!

4.2 Application Templates and Functional Scope for Device 6MD85

Application templates are available in DIGSI 5 for the applications of the device 6MD85.
The application templates contain:

- Basic configurations
- Required functions
- Default settings

The following application templates are available for the device 6MD85 in the DIGSI 5 function library:

- Not preconfigured
- Standard
- Control expanded

To load the application templates to the device, the following minimum hardware configuration requirements must be met:

Application Templates		Hardware Configuration
Template 1	Standard	28 binary inputs (BI), 12 binary outputs (BO), 4 I, 4 V
Template 2	Control expanded	36 BI, 15 BO, 8 I, 8 V

The following table shows the functional scope and the function-point requirements of the application templates:

Table 4-1 Functional Scope of the Application Templates for Device 6MD85

ANSI	Function	Abbr.	Points	Template 1	Template 2
			10		
25	Synchrocheck, synchronizing function		5		
27	Undervoltage protection, 3-phase	3Ph.	3		
27	Undervoltage protection, 3-phase, universal, Vx	3Ph.	3		
P,Q 27	Power protection undervoltage power	P<>, Q<>	10		
38	Temperature supervision	θ>	10		
46	Negative-sequence protection, non-directional	I2>	9		
49	Thermal overload protection	θ, I²t	20		
50/51 TD	Overcurrent protection, phases	I>	20		
50N/51N TD	Overcurrent protection, ground	3I0>	35		
67	Directional time-overcurrent protection, phases	I>, ∠ (V,I)	35		
67N	Directional time overcurrent protection, ground		35		
51V	Overcurrent protection, voltage-dependent	I> = f(V,I)	10		
50HS	Instantaneous high-current tripping	50HS	5		
59	Overvoltage protection, 3-phase	V>	5		
59	Overvoltage protection, positive-sequence system	V1>	5		
59	Overvoltage protection, 3-phase, universal, Vx	3Ph.	6		
74TC	Trip circuit supervision	TC	5		
81O	Overfrequency protection	f>	5		

ANSI	Function	Abbr.	Points	Template 1	Template 2
81U	Underfrequency protection	f<	5		
81R	Frequency change protection	df/dt	5		
86	Lockout		0		
47U	Two-winding transformer voltage controller		150		
90V	Three-winding transformer voltage controller		250		
90V	Grid coupling transformer voltage controller		175		
PMU	Load coupling transformer voltage controller		40		
PMU	Phasor measurement unit	PMU	10		
	Circuit breaker supervision	ΣIx, Ix², 2P, Mean time			
CCFF	Instantaneous tripping at switch onto fault	SOTF	0		
	Arc protection		0		
	Signaling voltage supervision		0		
	External synchronization		0		
	External trip initiation		0	1	1
	Command interlocking, standard		3a		4
	Measured values, extended, multiple/derivative values		3a		
	Switching statistic counters		0	x	x
	CFC standard		0	x	x
	CFC arithmetic		5		2
	Switching sequences		0		
	Inrush-current detection		0		
	External trip initiation		0		
	Control		0		
	Fault recording of analog and binary signals		0	x	x
	Supervision		0		
	Protection interface, serial		3a		
	Circuit breaker		3a	1	1
	Circuit breaker control		3a		
	Circuit breaker status		3a		
	Disconnector/grounding combination		3a	3	3
	Disconnector/grounding combination status		3a		
	Function points:			9	52

a) Points apply beginning with the 5th element
b) 3 function points per type used

Application Template: 6MD85 Not configured

The unconfigured application template is available for all applications that cannot be built on other application templates or for which deletion would be too complex.

Application Template: 6MD85 Standard

The 6MD85 standard application template is preconfigured for the following applications:

- Double busbar feeder with multifunctional reverse interlocking protection

4.3 Application Templates and Functional Scope for Device 6MD86

Application templates are available in DIGSI 5 for the applications of device 6MD86.
The application templates contain:

- Basic configurations
- Required functions
- Default settings

The following application templates are available for the device 6MD86 in the DIGSI 5 function library:

- Not preconfigured
- Double busbar
- 1.5 circuit breaker, type 1
- 1.5 circuit breaker, type 2

To load the application templates to the device, the following minimum hardware configuration requirements must be met:

Application Templates		Hardware Configuration
Template 1	Double busbar	8 binary inputs (BI), 16 binary outputs (BO), 4 I, 4 V
Template 2	1.5 circuit breaker, type 1	42 BI, 28 BO, 8 I, 8 V
Template 3	1.5 circuit breaker, type 2	42 BI, 27 BO, 8 I, 8 V

The following table shows the functional scope and the function-point requirements of the application templates described below:

Table 4-2 Functional Scope of the Application Templates for Device 6MD86

ANSI	Function	Abbr.	Points	Template 1	Template 2	Template 3
			0	x	x	x
25	Synchrocheck, synchronizing function		5			
27	Undervoltage protection, 3-phase	3Ph.	3			
27	Undervoltage protection, 3-phase, universal, Vx	3Ph.	3			
P,Q 27	Power protection undervoltage power	P<>, Q<>	10			
38	Temperature supervision	θ>	9			
46	Negative-sequence protection, non-directional	I2>	10			
49	Thermal overload protection	θ, I²t	11			
50/51 TD	Overcurrent protection, phases	I>	20	2	2	2
50N/51N TD	Overcurrent protection, ground	3I0>	10			
67	Directional time-overcurrent protection, phases	I>, ∠ (V,I)	35			
67N	Directional time-overcurrent protection, ground		35			
51V	Overcurrent protection, voltage-dependent	I> = f(V,I)	10			
50HS	Instantaneous high-current tripping	50HS	15			1
79AR	Circuit breaker failure protection		11			
59	Overvoltage protection, 3-phase	V>				

ANSI	Function	Abbr.	Points	Template 1	Template 2	Template 3
59	Overvoltage protection, positive-sequence system	V1>	5			
59	Overvoltage protection, 3-phase, universal, Vx	3Ph.	6			
74TC	Trip circuit supervision	TC	5			
81O	Overfrequency protection	f>	5			
81U	Underfrequency protection	f<	5			
81R	Frequency change protection	df/dt	5			
86	Lockout		0			
47U	Two-winding transformer voltage controller		150			
90V	Three-winding transformer voltage controller		250			
90V	Grid coupling transformer voltage controller		175			
PMU	Load coupling transformer voltage controller		40			
PMU	Phasor measurement unit	PMU	10			
	Circuit breaker supervision	ΣIx, Ix², 2P, Mean time				
CCFF	Instantaneous tripping at switch onto fault	SOTF	0			
	Arc protection		0			
	Signaling voltage supervision		0			
	External synchronization		0			
	External trip initiation		0	1	1	1
	Command interlocking, standard		3a		4	4
	Measured values, extended, multiple/derivative values		3a			
	Switching statistic counters		0	x	x	x
	CFC standard		0	x	x	x
	CFC arithmetic		5		2	2
	Switching sequences		0			
	Inrush-current detection		0			
	External trip initiation		0			
	Control		0			
	Fault recording of analog and binary signals		0	x	x	x
	Supervision		0			
	Protection interface, serial		3a			
	Circuit breaker		3a	1	1	1
	Circuit breaker control		3a			
	Circuit breaker status		3a			
	Disconnector/grounding combination		3a	3	3	3
	Disconnector/grounding combination status		3a			
	Function points:			9	52	52

a) Points apply beginning with the 5th element
b) 3 function points per type used

Application Template: 6MD86 Not configured

The unconfigured application template is available for all applications that cannot be built on other application templates or for which deletion would be too complex.

Application Template: 6MD86 Standard

The 6MD86 standard application template is preconfigured for the following applications:

- Double busbar feeder with multifunctional reverse interlocking protection (but also contains the CFC blocks for switching sequences)
- Switching sequence for automatic busbar switchover (triggered by function key)

ANSI	Function	Abbr.	Points	Template 1	Template 2	Template 3
27	Undervoltage protection, positive-sequence system	V1<	9			
59	Overvoltage protection, 3-phase, with at least V>	V>	9			
74TC	Trip-circuit supervision		3			
79	Automatic reclosing	AREC	49			x
81O	Overfrequency protection	f>	9			
81U	Underfrequency protection	f<	9			
81R	Frequency change protection	df/dt	9			
86	Lockout		0			
90V	Two-winding transformer voltage controller		150			
90V	Three-winding transformer voltage controller		200			
90V	Grid coupling transformer voltage controller		175			
PMU	Phasor measurement unit	PMU	48			
	Circuit-breaker supervision time	CB, I²t, 2P, trd, tre, tse	18			
SOTF	Switch-onto-fault	SOTF	0			
	Fuse protection		0			x
	Signaling voltage supervision		0			x
	External synchronization		0			x
	External 1 of n check		0			
	CFC arithmetic		0			
	Switching sequence		0	x		
	Interlocked operation		0			
	Operating hours counter		0			
	Control		0	x	x	x
	Fault recording of analog and binary signals		0			
	Supervision and monitoring		0	x	x	x
	Protection interface, serial		0			
	Circuit breaker		0	1	2	3
	Disconnector control		0		1	
	Circuit-breaker status		0			2
	Disconnector/grounding conductor		0	3	16	7
	Disconnector/grounding conductor status		0		2	11
	Function points:			9	0	49

Application Template: 6MD85 Unconfigured

The unconfigured application template is available for all applications that cannot be built on other application templates or for which creation would be too complex.

Application Template: 6MD86 Standard Double Busbar

The 6MD86 standard double busbar application template is preconfigured for the following basic scope:

- Busbar busbar (multi-phase switchgear manufacturing protection
- Synchronizer for circuit breaker
- Switching sequence for automatic busbar transformer (triggered by function key)
- Logic block chart for external voltage transformer selection for synchronizer

Application Template: 6MD86 1 1/2 Circuit-Breaker Layout, Type 1

The 6MD86 1 1/2 circuit-breaker layout, type 1 application template is preconfigured for the following basic scope:

- Control of a 1 1/2 circuit breaker layout bay, (3 circuit breakers, 18 isolators / grounding contactors
- Synchronizer for the 3 circuit breakers with dynamic measuring point switchover
- Logic block chart for dynamic synchronization voltage selection

Application Template: 6MD86 1 1/2 Circuit-Breaker Layout, Type 2

The 6MD86 1 1/2 circuit-breaker layout, type 2 application template is preconfigured for the following basic scope:

- Control of two of a 1 1/2 circuit-breaker layouts
- Logic block chart for dynamic synchronization voltage selection
- Circuit breaker failure protection and automatic reclosing
- Support of concepts with multiple bay controllers per bay

5 Function-Group Types

5.1 Power-System Data

5.1.1 Overview

The **Power-system data** are provided with each SIPROTEC 5 device and cannot be deleted. You will find them in DIGSI under **Settings — Power-system data**.

5.1.2 Structure of the Power-System Data

The **Power-system data** contain the **Black General** and the **Measuring points** of the device. The following figure shows the structure of the **Power-system data**:

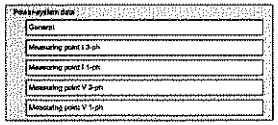


Figure 5-1 Structure of the Power-System Data

In order to adjust to functions to the application, the device requires some data about the power system. The necessary settings can be found in the Power-system data under **General** as well as in the Measuring points.

NOTE

You can find information on the supervision function parameters in chapter 6.1 Supervision of the Secondary System.

Type and scope of the required measuring points depend on the application. Possible measuring points are:

- Voltage 3-phase (measuring point V 3-ph)
- Current 3-phase (measuring point I 3-ph)
- Voltage 1-phase (measuring point V 1-ph)
- Current 1-phase (measuring point I 1-ph)

The measuring points have interfaces to the function groups requiring voltage and/or current measured values of the power system.

5.1.3 Application and Setting Notes – General Settings

Parameter: Phase sequence

- Recommended setting value (_:2311:101) **Phase sequence** = **ABC**

The parameter **Phase sequence** is used to set the phase sequence (ABC) or (ACB). The setting value applies to the entire SIPROTEC 5 device.

Use the **General** function to set the settings in the power-system data.

You can find detailed information about phase rotation reversal in chapter 7.2.2.3 Correction of the Phase

5.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)

The following example describes the settings of the voltage measuring point Measuring point V-3ph voltage 3-phase). Settings for the supervision functions are also located in the voltage measuring point. The description of these settings can be found in chapter Supervision Functions.

Parameter: Rated primary voltage

- Default setting (_:8941:103) **Rated primary voltage** = **400.000 kV**

The **Rated primary voltage** parameter is used to set the primary rated voltage of the voltage transformer.

Parameter: Rated secondary voltage

- Default setting (_:8941:102) **Rated secondary voltage** = **200 V**

The **Rated secondary voltage** parameter is used to set the secondary rated voltage of the voltage transformer.

Parameter: Matching ratio Vph / VN

- Default setting (_:8941:103) **Matching ratio Vph / VN** = **1.73**

With the parameter **Matching ratio Vph / VN**, you set the deviation between the calculated zero-sequence voltage and the residual voltage measured directly via a measuring input. The different transmission ratio of the voltage transformers is the cause for the deviation (see Figure 5-2).

The **Matching ratio Vph / VN** is equal to the ratio $M_{V_{ph}/V_{N}}$

with

V_{ph} *Calculated zero sequence voltage*

V_{N} *Measured residual voltage*

The zero voltage is calculated as phase to ground voltages. The residual voltage is measured on the open delta winding of the voltage transformer. For 3-phase voltage transformers, the residual voltage is measured in the generator or the transformer neutral point.

NOTE

The measurement residual voltage $V_{N,meas}$ is converted to a zero-sequence voltage in the device as follows:

$$V_{0,sec} = V_{N,sec} \cdot \frac{\text{Matching ratio Vph/VN}}{3}$$

EXAMPLE 1

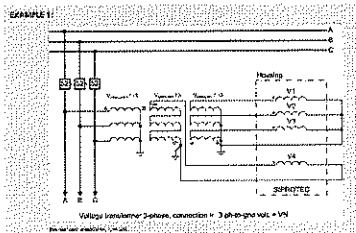


Figure 5-2 3-Phase Voltage Transformers Connection – 3 Phase-to-Ground Voltage + VN

If the connection type of the voltage transformers is 3 phase-to-ground volt. + VN (connector VT, connection 1) and the voltage input V4 is connected to the broken delta winding of the voltage transformer (open), the **Matching ratio Vph / VN** is as follows.

When changing the neutral point according to Figure 5-2, this results in the following values:

- The calculated secondary zero-sequence voltage $V_{0,sec}$ is equal to the secondary phase-to-ground voltage (converted to secondary transformer rated voltage, then $V_{0,sec} = 57.74$ V).
- The measured residual voltage on the open delta winding is the sum of the voltage drops in the 3 phases, expressed with the 3rd-multiple, the result is $V_{N,sec} = 3 \cdot V_{0,sec}$ V.

Calculate the matching ratio **Vph / VN** parameter as follows:

$$\text{Matching ratio } \frac{Vph}{VN} = \frac{3 \cdot V_{0,sec}}{3 \cdot V_{N,sec}} = \frac{3 \cdot \frac{V_{phase-gnd}}{\sqrt{3}}}{3 \cdot V_{phase-gnd}} = \frac{3}{\sqrt{3}} = \sqrt{3} = 1.73$$

with

$V_{phase-gnd}$ = 100 V

Set **Matching ratio Vph / VN** = 1.73.

In example 1 $V_{phase-gnd}$, the phase to ground voltage and the secondary voltage on the open delta winding were identical. If these voltages are different, use the actual numerical values in the calculation.

EXAMPLE 2:

Phase to ground voltage $V_{phase-gnd}$ = 100 V

Broken-delta winding (for example, grounding point formed at generator joint center) $V_{N,sec}$ = 300 V

The voltage input of the device is designed for a continuous operation using 230 V max. Therefore, you connect the open delta winding (with V) is reduced to a 3rd multiple using an ohmic divider, in order to calculate the matching factor, the secondary voltage of 300 V will be applied.

Calculate the matching ratio **Vph / VN** parameter as follows:

$$\text{Matching ratio } \frac{V_{ph}}{V_N} = \frac{3 \cdot V_{n,sec}}{V_{n,sec}} = \frac{3 \cdot \frac{V_{n,sec}}{\sqrt{3}}}{\frac{V_{n,sec}}{\sqrt{3}}} = \frac{3 \cdot \frac{100\ V}{\sqrt{3}}}{\frac{200\ V}{\sqrt{3}}} = \frac{3}{2 \cdot \sqrt{3}} = \frac{\sqrt{3}}{2} = 0.866$$

Example:

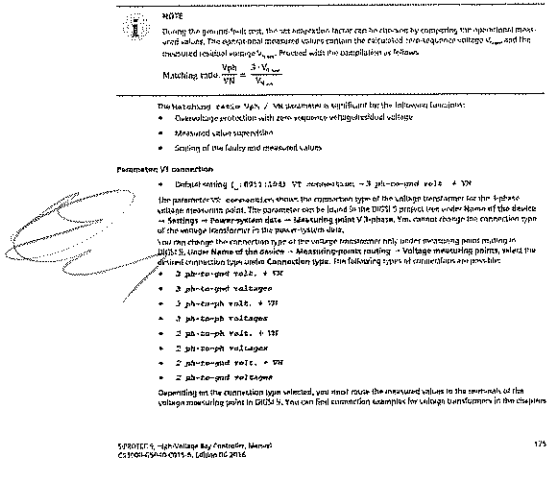
Set Matching ratio Vph / VN = 0.866

Interpretation of this result:

The zero-sequence voltage calculated from the protection voltage $= 57.73\ V\ (= 100/\sqrt{3})$. The parameterized residual voltage is 200 V. The calculated adaptation factor is 0.866. The measured residual voltage is converted to a zero sequence voltage inside the device:

$$V_{n,sec} = V_{0,sec} = \frac{\text{Matching ratio Vph/VN}}{3} = \frac{0.866}{3} = 57.73\ V$$

Recommendation:



NOTE

During the ground-fault test, the set adaptation factor can be checked by comparing the operational measured values. The operational measured values contain the calculated zero-sequence voltage $V_{0,sec}$ and the measured residual voltage $V_{n,sec}$. Proceed with the compilation as follows.

$$\text{Matching ratio } \frac{V_{ph}}{V_N} = \frac{3 \cdot V_{0,sec}}{V_{n,sec}}$$

The **Matching ratio Vph / VN** parameter is significant for the following functions:

- Overvoltage protection with zero-sequence voltage/residual voltage
- Measured value supervision
- Scaling of the faulty and measured values

Parameter: VT connection

- Default setting (_:8911:104) VT connection: 3 ph-to-gnd volt + VN

the parameter **VT connection** shows the connection type of the voltage transformer for the 3-phase voltage measuring point. The parameter can be found in the DIGSI 5 project tree under **Name of the device → Settings → Power-system data → Measuring point V 3-phase**. You cannot change the connection type of the voltage transformer in the power-system data.

You can change the connection type of the voltage transformer only under measuring point routing in DIGSI 5, under **Name of the device → Measuring-point routing → Voltage measuring points**, select the desired connection type under **Connection type**. The following types of connection are possible:

- **3 ph-to-gnd volt. + VN**
- **3 ph-to-gnd voltages**
- **3 ph-to-ph volt. + VN**
- **3 ph-to-ph voltages**
- **2 ph-to-ph volt. + VN**
- **2 ph-to-ph voltages**
- **2 ph-to-gnd volt. + VN**
- **2 ph-to-gnd voltages**

Depending on the connection type selected, you must route the measured values to the terminals of the voltage measuring point in DIGSI 5. You can find connection examples for voltage transformers in the chapters

A connection examples for voltage transformers. The connection examples provide assistance when selecting the type of connection.

Parameter: Inverted phases

- Default setting (_:8911:144) Inverted phases = none

The **Inverted phases** parameter is intended for special applications, for example, pumped-storage hydropower plants (see chapter *Phase-rotation reversal*). The default setting may be altered for special system protection applications.

Parameter: Tracking

- Default setting (_:8911:121) Tracking = active

The **Tracking** parameter is used to determine whether the measuring channels of this measuring point shall be used to determine the sampling frequency.

The sampling frequency of the device is sufficient for most power frequency. The device selects a measuring channel, through which the sampling frequency is determined. Preferably, this should be a voltage measuring channel. This is ideally at the signal is monitored (minimum level, frequency range). If these values are invalid, the device switches to another channel (e.g. current channel). In system-autonomous operation, in the channel is a voltage channel is used again.

Parameter Value	Description
active	If the parameter **Tracking = active** has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. Note: If the parameter **Tracking = inactive**, the determined sampling frequency applies to all functions in the device that do not use fixed sampling rates.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value **inactive**.

Parameter: Magnitude correction

- Default setting (_:8911:103) Magnitude correction = 1.000

When using the **Magnitude correction** parameter, the magnitude (magnitude correction) is adjusted for the voltage input. This allows you to correct the inaccuracies of the primary current transformer characteristics. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.

NOTE

The **Magnitude correction** parameter has nothing to do with the external adjustment of the input circuit.

You will find more parameters in chapter *8.2.1 Overview*.

5.1.5 Application and Setting Notes for Measuring Point Current 3-Phase (I-3ph)

The following example describes the settings for the current measuring point I 3-ph (current 3 phase). The supervision function settings are also located in the current measuring point. The description of these settings can be found in chapter *8 Supervision Functions*.

Parameter: CT connection

- Default setting (_:8881:124) CT connection = 3-phase + IN-separate

The parameter **CT connection** shows the connection type of the current transformer for the 3-phase current measurement point. The parameter can be found in the DIGSI 5 project tree under **Name of the device → Settings → Power-system data → Measuring point I 3-phase**. You cannot change the connection type of the current transformer in the Power-system data.

You can change the connection type of the current transformer only, under measuring point routing in DIGSI 5, under **Name of the device → Measuring point routing → Current measuring points**, select the desired connection type under **Connection type**. The following types of connection are possible:

- **3-phase + IN-separate**
- **3-phase + IN**
- **3-phase**
- **3-phase, 2 primary CT**
- **3ph,2pri,CT + IN-sep**
- **2ph, 2p. CT + IN-sep**

Depending on the connection type selected, you must route the measured values to the terminals of the current measuring point in DIGSI 5. You can find connection examples for current transformers in chapter *5.2.2 Connection Examples for Current Transformers*. The connection examples provide assistance when selecting the type of connection.

Parameter: Tracking

- Default setting (_:8981:127) Tracking = active

With the parameter **Tracking**, you specify whether you would like to work with the sampling frequency tracking function.

Parameter Value	Description
active	If the parameter **Tracking = active** has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. Note: If the parameter **Tracking = active**, the determined sampling frequency applies to all functions in the device that do not use fixed sampling rates.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value **inactive**.

Parameter: Rated primary current

- Default setting (_:8881:101) Rated primary current = 1000 A

With the **Rated primary current** parameter, the ratio rated primary current of the current transformer is set.

Parameter: Rated secondary current

- Default setting (_:8881:102) Rated secondary current = 1 A

With the **Rated secondary current** parameter, you set the current rated secondary current of the current transformer.

Parameter: Current range

- Default setting (_:8881:117) Current range = 100 x IN

The **Current range** parameter allows you to set the dynamic range for the current input. Please retain the default setting for power-system protection application. The current measuring range 1.6 x rated applies for the connection type **3-phase + IN-separate** and the sensitive current input or for the measuring inputs.

Parameter: Neutral point in dir.of ref.obj

- Default setting (_:8881:114) Neutr.point in dir.of ref.obj = yes

The **Neutr.point in dir.of ref.obj** parameter is used to set the direction of the neutral point of the current transformer (see following figure). Often, the neutral point of the current transformer is determined by the direction of the protected object (for example, in the direction of the line, cable, transformer). For this reason, the default setting of the parameter was defined as yes.

When switching the parameter, the direction of the phase currents and of the ground current IN or the separate is reversed electronically.

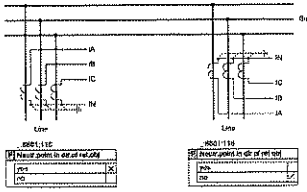


Figure 5.3 Polarity of Current Transformers

Parameter: Inverted phases

- Default setting (_:8881:114) Inverted phases = none

The **Inverted phases** parameter is intended for special applications, for example, pumped-storage plants (see chapter *Phase-rotation reversal*). The default setting may be retained for power-system protection applications.

Parameter: Magnitude correction

- Default setting (_:8881:103) Magnitude correction = 1.000

When using the **Magnitude correction** parameter, you adjust the amplitude (amplitude correction) for the current input. This allows you to correct the inaccuracies of the primary current transformer characteristics. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.

NOTE

The **Magnitude correction** parameter has nothing to do with the external adjustment of the input circuit.

You will find more parameters in chapter *8.2.1 Overview*.

Note Regarding Routable Data

Indications for the current measuring field can be found in information routing under **Power-system data → General** in DIGSI 5. The indication **Measurement of nomi. current limits** that the frequency measuring range

has been exceeded. Either the frequency is out of range (10 Hz to 80 Hz) or the input signals are too small for a manual update. Should this condition occur, the system switches the outside frequency to a sampling rate that corresponds to the rated frequency.

5.1.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_8911:101	General\Phase sequence		• ABC • ACB	ABC
General				
_8911:101	VT 3-phase\Rated primary voltage		0.20 kV to 1200.00 kV	400.00 kV
_8911:102	VT 3-phase\Rated secondary voltage		80 V to 230 V	100 V
_8911:103	VT 3-phase\Matching ratio Vph / VN		0.10 to 9.99	1.73
_8911:104	VT 3-phase\VT connection		• not assigned • 3 phase-gnd volt. + VN • 3 ph-to-gnd voltages • 3 ph-to-ph volt. + VN • 3 ph-to-ph voltages • 2 ph-to-ph volt. + VN • 2 ph-to-gnd volt. + VN • 2 ph-to-gnd voltages	3 ph-to-gnd volt. + VN
_8911:106	VT 3-phase\Inverted phases		• none • AB • BC • AB	none
_8911:111	VT 3-phase\Tracking		• inactive • active	active
_8911:130	VT 3-phase\Measuring-point ID		0 to 100	0
Voltage measurement I - 4				
_8911:103	VT 3-phase\Magnitude correction		0.010 to 10.000	1.000
_8911:108	VT 3-phase		• VA • VB • VC • VAB • VBC • VCA • VEN • VN	
General				
_8881:116	CT 3-phase\CT connection		• not assigned • 3-phase + IN • 3-phase • 3-phase + IN separate • 3 phase, 2 primary CT • Two 3phase,CT + IN-sep • 2ph, 2p. CT + IN-sep • 2 phase + IN	3-phase + IN-separate

Addr.	Parameter	C	Setting Options	Default Setting
_8881:127	CT 3-phase\Tracking		• inactive • active	active
_8881:130	CT 3-phase\Measuring-point ID		0 to 100	0
CT 3-phase				
_8881:101	CT 3-phase\Rated primary current		1.0 A to 100000.0 A	1000.0 A
_8881:102	CT 3-phase\Rated secondary current		• 1 A • 5 A	1 A
_8881:117	CT 3-phase\Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR	100 x IR
_8881:118	CT 3-phase\General CT type		• CT protection • CT measurement	CT protection
_8881:116	CT 3-phase\Invert polarity (Neutr.point in dir.of ref.obj)		• no • yes	yes
_8881:114	CT 3-phase\Inverted phases		• none • AB • BC • AB	none
_8881:107	CT 3-phase\CT error changeover		1.00 to 11.00	1.00
_8881:108	CT 3-phase\CT error I		0.5 % to 50.0 %	5.0 %
_8881:109	CT 3-phase\CT error II		0.5 % to 50.0 %	15.0 %
CT 1st				
_8881:101	CT 1-phase\Rated primary current		1.0 A to 100000.0 A	1000.0 A
_8881:105	CT 1-phase\Rated secondary current		• 1 A • 5 A	1 A
_8881:119	CT 1-phase\Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR	100 x IR
_8881:120	CT 1-phase\General CT type		• CT protection • CT measurement	CT protection
CT 2nd				
_8881:106	CT 1-phase\Rated primary current		1.0 A to 100000.0 A	1000.0 A
_8881:113	CT 1-phase\Rated secondary current		1 A to 5 A	1 A
_8881:121	CT 1-phase\Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR	1.6 x IR
_8881:122	CT 1-phase\General CT type		• CT protection • CT measurement	CT protection
CT 3				
_8881:103	CT 1-phase\Polarity		0.010 to 10.000	1.000

Addr.	Parameter	C	Setting Options	Default Setting
_1043.117	CT 1 Phase		• 1 A • 1 B • 1 C • IE • IN/sens • Ix • 50 Hz/60 Hz • 60 Hz/50 Hz	
CT 2				
_3843.103	CT 2 Amplitude correction		0.010 to 10.000	1.000
_3843.117	CT 2 Phase		• 1 A • 1 B • 1 C • IN • IN/sens • Ix • 50 Hz/60 Hz • 60 Hz/50 Hz	
CT 3				
_3843.103	CT 3 Amplitude correction		0.010 to 10.000	1.000
_3843.117	CT 3 Phase		• 1 A • 1 B • 1 C • IN • IN/sens • Ix • 50 Hz/60 Hz • 60 Hz/50 Hz	
CT 4				
_3844.103	CT 4 Amplitude correction		0.010 to 10.000	1.000
_3844.117	CT 4 Phase		• 1 A • 1 B • 1 C • IN • IN/sens • Ix • 50 Hz/60 Hz • 60 Hz/50 Hz	

5.1.7 Information List

No.	Information	Data Class (Type)	Type
General			
_2311.500	General Protection reverse	SPS	I
_2311.501	General Reset Phase	SPS	I
General			
_2311.319	General Phase sequence ABC	SPS	O
_2311.320	General Phase sequence ACB	SPS	O
_2311.321	General reset of operating	SPS	O
_2311.322	General 3ph	ACT	O
_2311.323	General 1ph	ACT	O

The function group has interfaces with

- Measuring points
- Circuit-breaker function group

Interface with Measuring Points

The function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the function group is already connected to the necessary measuring points. If you add functions to the function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring points are not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 in the Function group connections editor. You can find more detailed information in chapter 7 Basic Structure of the Function.

The function group has the following interfaces with the measuring points:

- **3-phase current**
  The measured values from the 3-phase power system are supplied via this interface. Depending on the connection type of the transformers, these are, for example, I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The function group must always be connected to the 3-ph measuring point.
  You can connect the 3-phase current interface to a maximum of four 3-phase current measuring points (for example, for 1 1/2-circuit-breaker layouts). If 2 current measuring points have been connected with the 3-phase current interface, the total current is also determined from measured values from both measuring points in the function group. All functions in the function group have access to these values.
- **3-phase voltage (optional)**
  The measurands from the 3-phase voltage system are supplied via this interface. There are various types of transformer connections possible. All values that can be calculated from the measurands are also provided via this interface. Connecting the function group to the V 3ph measuring point is optional.
  You can connect multiple measuring points with the interface. You can find more information in chapter 5.8 Voltage Measuring Point Selection.
  If you want to test or change the connection between the voltages and the V-3ph measuring point, double-click in the DIGSI 5 project tree in **Name of the device** on **Measuring point routing**. Connection type – 3-phase ground voltages. For more information, refer to the description of the power system data starting in chapter 5.1 Power System Data.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the Circuit-breaker function group. This data includes, for example, the pickup and operate indications of the protection functions and, in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

The Voltage-current 3-phase function group is connected to one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breaker(s) is/are activated by the protection functions of the protection function group
- Starting the Circuit-breaker failure protection function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the Automatic reclosing function (ARC, if available in the Circuit-breaker function group) through the protection functions of the connected protection function group

Besides the general allocation of the protection function group to the Circuit-breaker function group, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the Circuit-breaker interaction editor in the protection function group.

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions initiate the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions start the Circuit breaker failure protection function

No.	Information	Data Class (Type)	Type
General			
_3811.315	VT 3-phase Phases AB inverted	SPS	O
_3811.316	VT 3-phase Phases BC inverted	SPS	O
_3811.317	VT 3-phase Phases AC inverted	SPS	O
VT 2			
_3811.3002	VT 2 Sampled val. voltage	SAV	O
VT 2			
_3812.300	VT 2 Sampled val. voltage	SAV	O
VT 3			
_3813.300	VT 3 Sampled val. voltage	SAV	O
VT 4			
_3814.300	VT 4 Sampled val. voltage	SAV	O
Supv. balan. V			
_2921.167	Supv. balan. V offset function	SPS	I
_2921.54	Supv. balan. V blocked	SPS	O
_2921.55	Supv. balan. V behavior	ENS	O
_2921.57	Supv. balan. V dis. edit	ENS	O
_2921.171	Supv. balan. V failure	SPS	O
Supv. ph.seq. V			
_2081.82	Supv. ph.seq. V offset function	SPS	I
_2081.54	Supv. ph.seq. V blocked	SPS	O
_2081.55	Supv. ph.seq. V behavior	ENS	O
_2081.57	Supv. ph.seq. V dis. edit	ENS	O
_2081.171	Supv. ph.seq. V failure	SPS	O
Supv. sum V			
_2461.182	Supv. sum V offset function	SPS	I
_2461.54	Supv. sum V blocked	SPS	O
_2461.55	Supv. sum V behavior	ENS	O
_2461.57	Supv. sum V dis. edit	ENS	O
_2461.171	Supv. sum V failure	SPS	O
Verification V 1			
_2611.500	VT miniature circ.-Open	SPS	I
General			
_4081.319	CT 3-phase Phases AB inverted	SPS	O
_4081.320	CT 3-phase Phases BC inverted	SPS	O
_4081.321	CT 3 phase Phases AC inverted	SPS	O
CT 2			
_3841.300	CT 2 Sampled val. current	SAV	O
CT 3			
_3843.300	CT 3 Sampled val. current	SAV	O
CT 4			
_3844.300	CT 4 Sampled val. current	SAV	O

If you are using an application template, the function groups are already connected to each other, because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections editor.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

If the connection is missing, DIGSI 5 reports an inconsistency.

Protected Object/Equipment Data (FB General)

The rated voltage and rated current as well as the neutral-point treatment of the protected object or the equipment are defined here. These data apply to all functions in the Voltage-current 3-phase function group.

Equipment Data

The rated voltage and rated current as well as the neutral point treatment of the object or the equipment are defined here. These data apply to all functions in the Voltage-current 3-phase function group.

Resetting the LED Group

Using the **Reset the LED group function**, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

You can find more detailed information in chapter 3.1.10 Resetting Stored Indications of the Function Group.

Process Monitor

The process monitor is always present in the **Voltage-current 3-phase** function group and cannot be removed.

The process monitor provides the following information in the Voltage-current 3-phase function group:

- Current-flow criterion:
  Detection of an operationalized protected object/equipment based on the flow of leakage current
- Circuit direction:
  Detection of the switching on of the protected object/equipment
- Cold-load pickup detection functional, only for protection devices

These data apply to all functions in the Voltage-current 3-phase function group.

The description of the process monitor begins in chapter 5.7 Process Monitor.

Operational Measured Values

The operational measured values are always present in the Voltage-current 3-phase function group and cannot be removed.

The following table shows the operational measured values of the Voltage-current 3-phase function group:

Table 5-1 Operational Measured Values of the Voltage Current 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary values
$3I_0$	Calculated zero-sequence current	A	A	Rated operating current of the primary values
I_N	Neutral-point phase current	A	A	Rated operating current of the primary values
I_{sns}	Sensitive ground current	A	mA	Rated operating current of the primary values
V_A, V_B, V_C	Phase to ground voltages	kV	V	Operation rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase to phase voltages	kV	V	Rated operating voltage of the primary values
V_1	Zero-sequence voltage	kV	V	Operation rated voltage of primary values/√3
V_2	Negative-sequence voltage	kV	V	Operation rated voltage of primary values/√3
V_N	Neutral point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency

5.2 Function-Group Type Voltage-Current 3-Phase

5.2.1 Overview

All functions for protection and supervision of a protected object or any generic 3-phase current and voltage measurement can be used in the function group Voltage-current 3-phase. The function group also contains the operational measured values of the protected object in connection with the logic, and displays all measured values, Energy values, and Supervision of the primary System 3.

You will find the Voltage-current 3-phase function group under each device type in the Global DIGSI 5 library. You will find all protection and supervision functions that you can use for this function-group type in the function group Voltage-current 3-phase. These functions are described in chapter 7 Protection and Automation Functions.

You can find additional information on the embedding of the functions in the device in chapter 2 Basic Structure of the Function. You can find the function scope of the application templates for the various device types in the chapter 4 Applications.

5.2.2 Structure of the Function Group

The function group always contains the following blocks:

- Protected object/equipment data (FB General)
- Operational measured values
- Process monitor
- Output logic of the function group
- Reset LED group

These blocks are essential for the function group under all circumstances, so they cannot be loaded or deleted. You can load the protection and supervision functions required for your application in the function group. The functions are available in the global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

The following figure shows the structure of the function group **Voltage-current 3-phase**.

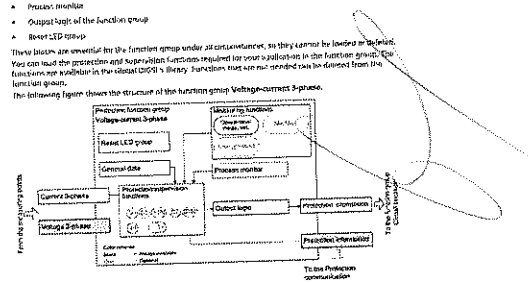


Figure 5-4 Structure of the Voltage-Current 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
P_{sum}	Active power (total power)	kW	W	Active power of the primary values $\sqrt{3} \cdot V_{nom} \cdot I_{nom}$
Q_{sum}	Reactive power (total power)	kVar	var	Reactive power of the primary value $\sqrt{3} \cdot V_{nom} \cdot I_{nom}$
S_{sum}	Apparent power (total power)	kVA	VA	Apparent power of the primary values $\sqrt{3} \cdot V_{nom} \cdot I_{nom}$
$\cos\varphi$	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase related active power	kW	W	Active power of the ph-pe $V_{nom,ph-e} \cdot I_{nom,ph}$
Q_A, Q_B, Q_C	Phase related reactive power	kVar	var	Reactive power of the phase $V_{nom,ph-e} \cdot I_{nom,ph}$
S_A, S_B, S_C	Phase related apparent power	kVA	VA	Apparent power of the phase $V_{nom,ph-e} \cdot I_{nom,ph}$

The operational measured values are explained in more detail in chapter 11.3 Operational Measured Values.

Output Logic

The output logic routes the pickup and trip signals of the protection and supervision functions that are available in the function group separately, in a pickup logic and a trip logic, respectively. The pickup and trip logic connects the corresponding indications (group indications) of the function group and are processed and transferred to the Protection Information Interface to the Circuit-breaker function group and are processed further there.

The pickup signals of the protection and supervision functions in the **Voltage-current 3-phase** function group are combined in a phase selective manner and output as a group indication.

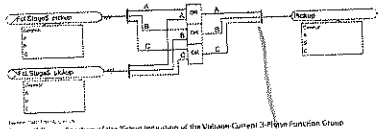


Figure 5-5 Creation of the Pickup Indication of the Voltage-Current 3-Phase Function Group

The trip signals from the protection and supervision functions of the **Voltage-current 3-phase** function group always result in 3-pole tripping of the device.

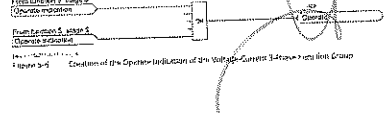


Figure 5-6 Creation of the Operate Indication of the Voltage-Current 3-Phase Function Group

5.2.3 Application and Setting Notes

Interface to the Circuit Breaker Function Group

With regard to the device which controls the circuit-breaker(s) that are affected by the protection functions of the respective function group: A feasible default setting has already been provided in the application templates. You can find more information in chapter 2.

Protected Object/Equipment Data (91 General)

The set data applies to all functions in the function group.
Set the protected object/equipment data for your specific application.

Parameter: Rated current

- Default setting (_:9451:101) Rated current = 1000 A

With the **Rated current** parameter, you can set the primary rated current of the protected object, in kilo-amps. The **Rated current** parameter is significant for protection functions, as long as the current values are set in percentages. In this case it is the reference value. In addition it is the reference value for the measured values in percent.
If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting (_:9451:102) Rated voltage = 400.00 kV

With the **Rated voltage** parameter, you can set the primary rated voltage of the protected object or equipment. The **Rated voltage** parameter is significant for protection functions, as long as the current values are set in percentages. In this case it is the reference value. In addition it is the reference value for the measured values in percent.
If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Power-sys. neutral point

- Default setting (_:9451:149) Power-sys. neutral point = grounded

With the **Power-sys. neutral point** setting you specify whether the system neutral is **grounded**, **isolated**, or **suppress. coil grounded** (optional via the application pool). Currently, this parameter does not affect any protection function; only if the **Automatic reclosing function** uses the voltage measurement.
You can find more information in Chapter 7.2.1 Overview of Functions.

5.2.4 Write-Protected Settings

Parameter: Rated apparent power

- Default setting (_:103) Rated apparent power = 492.82 MVA

With the **Rated apparent power** parameter, you can set the primary rated apparent power for the auto transformer to be protected. The **Rated apparent power** parameter is relevant for the main protection function of the device. The **Rated apparent power** set here is the reference value for the percentage-measured values and setting values made in percentages.

Figure 5-8 Connecting Measuring Points to the Voltage-current 1-Phase Function Group

The connected, calculated zero-sequence voltage or measured residual voltage from the 3-phase voltage system is available via the voltage interface (see following figure).

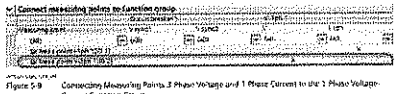


Figure 5-9 Connecting Measuring Points 3-Phase Voltage and 1-Phase Current to the 1-Phase Voltage-Current Function Group

You can connect the voltage interface with precisely one 3-phase voltage measuring point. 3 types of 3-phase voltage measuring point connections are supported. With the different connection types, the type of voltage input also changes in line with the function. The following table shows the characteristics of the voltage input depending on the types of connection

Connection Type of the 3-Phase Voltage Measuring Point	Voltage Input
3 ph to gnd voltages	The zero sequence voltage is calculated from the phase-to-ground voltages and used as a voltage input for all functions
3 ph to-gnd volt. + VN	The residual voltage VN is connected to the voltage equivalent of the zero sequence voltage. The connected voltage is used as a voltage input for all functions

Interface to the Circuit Breaker Function Group

All required data is exchanged between the protection and circuit breaker function groups via the interface with the circuit-breaker function group. In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the circuit breaker function group.

You must connect the Voltage-current 1-phase function group with the Circuit-breaker function group. This assignment can only be made in DIGSI via Project tree → Function group connections. To connect, the interface, set a cross at the intersection between the row and column in the matrix. If the interface is not connected, the functions operate as supervision functions in the Voltage-current 1-phase function group.

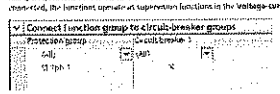


Figure 5-10 Connecting Voltage-current 1-Phase Function Group with Circuit-Breaker Function Group

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly, on the device, then the IEC 61850 configuration of the metered values can be faulty.

The setting listed here are used primarily for understanding setting configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Network data				
_:103	Connected apparent power		0.20 MVA to 5 000.00 MVA	492.82 MVA

NOTE

You can find more detailed information on the Process monitor in chapter 5.7 Process Monitor.

5.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_9451:101	General Rated current		1 A to 100000 A	1000 A
_9451:102	General Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Power-system data				
_9451:149	Power-sys. neutral point		• grounded • suppress. coil grounded • isolated	grounded
Measurement for				
_9451:159	Overcurr.P, O-Sign		• not measured • reverse	not measured

5.2.6 Information List

No.	Information	Data Class (Type)	Type
General			
_9451:27	General Behavior	ENS	O
_9451:5	General Health	ENS	O
Group Indicat.			
_9451:53	Group Indicat. Pickup	ACD	O
_9451:57	Group Indicat. Operate	ACT	O
Reset LED Group			
_7381:500	Reset LED Group: LED reset	SPS	I
7381:320	Reset LED Group: LED have been reset	SPS	O
Closure detec.			
_11.31:4681:500	Closure detec.: Disconnector open	SPS	
_11.31:4681:300	Closure detec.: Status	SPS	O

Fundamental Components

The fundamental components are always present in the Voltage-current 1-phase function group and cannot be deleted.
The following table shows the fundamental components of the Voltage-current 1 phase function group:

Table 5-2 Fundamental Components of the Voltage-current 1-Phase Function Group

Measured Values	Primary	Secondary	% Referring to
I	1-phase current	A	Rated operating current
V	1-phase voltage	kV	Rated operating voltage
V_0	Zero-sequence voltage	kV	Rated operating voltage/$\sqrt{3}$
V_{res}	Residual voltage	kV	Rated operating voltage/$\sqrt{3}$

5.3.3 Application and Setting Notes

NOTE

Prior to creation of the protection functions in the function group, three busbars should first be connected to the appropriate Circuit-breaker function group.

Parameter: Rated current

- Default setting (_:9451:101) Rated current = 1000 A

The **Rated current** parameter is used to set the primary rated current. The **Rated current** specified here is the reference value for the percentage-measured values and setting values made in percentages.

Parameter: Rated voltage

- Default setting (_:9451:102) Rated voltage = 400.00 kV

With the **Rated voltage** parameter, you set the primary voltage, which serves as a reference for all voltage-related % values within the Circuit-breaker function group.

5.3.4 Write-Protected Settings

The settings listed here are used primarily for understanding setting configuration of the function group. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_9451:104	Connected apparent power		0.20 MVA to 5000.00 MVA	492.82 MVA
Network data				
_9131:1	General:1 ph uses measuring point ID		0 to 100	0
_9131:2	General:Min time interval		0.01 to 14.00	1.00

5.3 Function-Group Type Voltage-Current 1-Phase

5.3.1 Overview

In the Voltage-current 1-phase function group, all functions can be used for protective and for maintenance purposes on objects or equipment which allow a 1-phase current and voltage measurement or a zero-sequence voltage measurement via a separate voltage measuring point. The function group also contains the operational measurement for the protected object or equipment for this type, see chapter 9 Measured Values, Energy Values, and Statistics in the relevant Manual.

5.3.2 Structure of the Function Group

The Voltage-current 1-phase function group has interfaces to the measuring points and the circuit-breaker function group

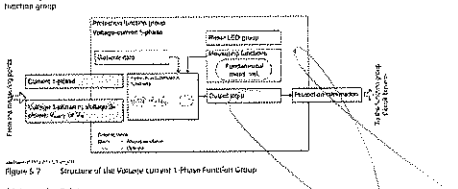


Figure 5-7 Structure of the Voltage-current 1-Phase Function Group

Interface with Measuring Points

You connect the Voltage-current 1-phase function group to the current and voltage measuring points via the interfaces to the measuring points. At least one measuring point has to be connected. The other is optional. This assignment can only be made in DIGSI via Project tree → Function group connections. To connect, the interfaces, set a cross at the intersection between the current and voltage and column in the matrix.
The function group has the following interfaces to the measuring points:

- 1-phase current
  The 1-phase current measured values are supplied via this interface.
  You can connect multiple measuring points with the 1-phase current interface.
- 1-phase voltage or 3-phase voltage
  You can connect the voltage interface of the function group with a 1-phase or a 3-phase measuring point. The calculated zero-sequence voltage or the measured residual voltage are available for connection with a 3-phase measuring point. The phase-to-ground voltages are not available in the function group **Voltage-current 1-phase**. You can use both connection types at the same time.
  You configure the 1-phase voltage measuring points via the voltage interface (see the following figure).

5.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_9451:101	General:Rated current		1 A to 100000 A	1000 A
_9451:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Power-system data				
_9421:114	General:VM 1 ph uses measr point ID		0 to 100	0
_9421:127	General:Number of meas. point, 1ph		0 to 11	0

5.3.6 Information List

No.	Information	Data Class (Type)	Type
General			
_9421:52	General:Behavior	ENS	O
_9421:54	General:Health	ENS	O
Group Indicat.			
_9451:53	Group Indicat.:Pickup	ACD	O
_9451:57	Group Indicat.:Operate	ACT	O
Reset LED FG			
_9731:500	Reset LED Group:LED reset	SPS	I
_9731:320	Reset LED Group:LED have been reset	SPS	O

5.4 Function-Group Type Voltage 3-Phase

5.4.1 Overview

In the Voltage 3-phase function group, all functions can be used for monitoring and for measuring a protected object or equipment values within a 3-phase voltage measurement. You can use this group also to evaluate the measurement results for the protection relay or equipment (not this logic, see chapter – Measured Values, Energy Values, and Supervision of the Primary System). Applicable functions are, for example, voltage, warn flag or frequency protection.

5.4.2 Structure of the Function Group

The Voltage 3-phase function group has interfaces to the measuring points and the Circuit-breaker function group:

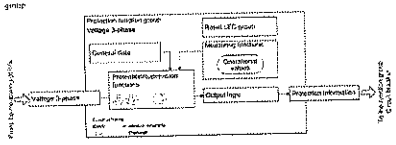


Figure 5-13 Structure of the Voltage 3-Phase Function Group

Interface with Measuring Points

You connect the Voltage 3-phase function group to the voltage measuring points via the interface to the measuring points. Your assignment can only be made in DIGSI via Project tree → Function group connections. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

Figure 5-14 Connecting Measuring Points to the Voltage 3-Phase Function Group

If you add functions to the Voltage 3-phase function group, these are connected to the measuring point automatically.
You can connect multiple measuring points with this interface. You can find more information in chapter
→ 5 Voltage Measuring-Point Selection
The measurands from the 3-phase voltage system are supplied via the 3 ph interface. Depending on the type of transformer connections, some are, for example, V_{ph}, V_{ph}, V_{ph}, V_{syn}. All values that can be calculated from the measurands are also provided via this interface.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the Circuit-breaker function group. In this example, the pickup and operate indications of the protection functions are exchanged in one direction at the Circuit-breaker function area.
You must connect the Voltage 3-phase function group with the Circuit-breaker function group. This assignment can be made in DIGSI only, via Project tree → Connect function group. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

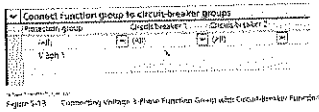


Figure 5-15 Connecting Voltage 3-Phase Function Group with Circuit-Breaker Function Group

Operational Measured Values

The operational measured values are always present in the Voltage 3-phase function group and cannot be deleted.
The following table shows the operational measured values of the Voltage 3 phase function group:

Table 5-3 Operational Measured Values of the Voltage 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
V_{ph}, V_{ph}, V_{ph}	Phase-to-ground voltage	kV	V	Operating rated voltage of primary values/√3
V_{ph-ph}, V_{ph-ph}, V_{ph-ph}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary values
V_0	Zero-sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{syn}	Reference or displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency

5.4.3 Application and Setting Notes

NOTE

Before creating the protection functions in the function group, you should first remove these functions as the appropriate Circuit-breaker function group.

Parameter: Rated voltage

- Default setting (_:9421:1621) **Rated voltage** = 400.00 kV

With the **Rated voltage** parameter, you set the primary rated voltage. The **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

5.4.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
-9421:1102	Primary Rated Voltage		38.291 V to 2302.631 kV	400.00 kV

5.4.5 Information List

No	Information	Data Class (Type)	Type
General			
-9421:52	General Behavior	ENS	O
-9421:53	General Health	ENS	O
Group Indicat.			
-9421:300	Group Indicat. Pickup	ACD	O
-9421:27	Group Indicat. Operate	ACT	O
Reset LED			
-9421:500	Reset LED Group	SPC	O
-9421:320	Reset LED Group Input	IntSP	O

5.5 Function-Group Type Circuit Breaker

5.5.1 Overview

The Circuit-breaker function group combines all the user functions that relate to a circuit breaker.
You will find the Circuit-breaker function group under each circuit type in the function library in DIGSI 5. The Circuit-breaker function group contains all of the protection, control, and supervision functions that you can use for that circuit type. The following figure shows, for example, the functional scope of the Circuit-breaker function group.

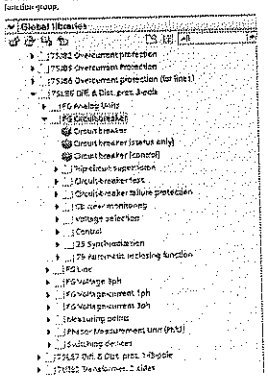


Figure 5-34 Circuit-Breaker Function Group – Example of the Functional Scope

The Circuit-breaker function group includes 3 different types of circuit breakers:

- Circuit breaker
- Circuit breaker control
- Circuit breaker [status only]

The circuit breaker type can access additional basic function blocks for protection functions along with the circuit-breaker control.

The circuit breaker [status only] is used only for acquiring the circuit-breaker switch position. This type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.
The available functions are described in the chapters → Protection and Automation Functions and → Control Functions.

5.5.2 Structure of the Function Group

Besides the user functions, the Circuit-breaker function group contains certain function blocks that are given tool for general purposes and therefore cannot be found in DIGSI:

- Trip Logic
- Mapping the physical circuit breaker
- Circuit-breaker position recognition for connection functions
- Creation of manual closure
- General settings

The following figure shows the structure of the Circuit-breaker function group. The additional function blocks in the image are described in the following chapters.

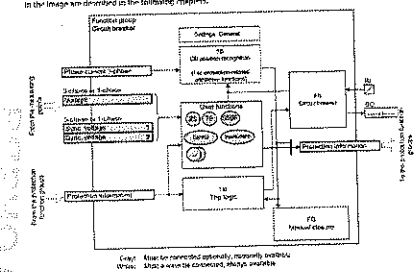


Figure 5-35 Structure of the Circuit-Breaker Function Group

The Circuit-breaker function group has interfaces with

- Measuring points
- Protection function groups

Interfaces with Measuring Points

The function group connects the measured values needed from the measuring points associated with this function group.

If an application template is used, the function group is connected to the measuring point of the 3-phase current because this connection is essential only for DIGSI 5 application templates. It can be necessary to interface additional measuring points to the function group, depending on the nature of the user function used. Configuration is carried out using the **Function-group connections** editor in DIGSI 5.
If a user function, for example, synchronization, is used in the function group but no required measuring point has not been set in DIGSI 5 reports an inconsistency. This inconsistency provides an indication of the missing measuring point connection.
The Circuit-breaker function group has interfaces with the following measuring points:

- 3-phase **3ph current**
  The measurands from the 3 phase power system are supplied via this interface. The function group must always be connected to this measuring point.
- **Voltage**
  The measurands of the 3 phase voltage system or 1-phase voltage are supplied via this interface. Depending on the connection type of the transformer, in the 3-phase voltage system there are, for example, V_{ph}, V_0, V_1 of the line or feeder.
  The connection to the corresponding measuring point is necessary only if a user function that needs the measurand of the 3 phase voltage system is used, for example, to make use of the Synchronization or Automatic reclosing function.
- **Sync. Voltage1, Sync. Voltage2**
  A 1-phase synchronization voltage (for example, voltage of the busbar with a 1 phase connection) or a 3 phase synchronization voltage (for example, voltage of the busbar with a 3 phase connection) is supplied via this interface.
  The connection to the corresponding measuring point is necessary only if synchronization is used.

Interface with Protection Function Groups

All required data is exchanged between the Protection and Circuit-breaker function groups via the interface with the Protection function group. This data includes, for example, the pickup and operate indications of the protection functions used in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.
If an application template is used, the function groups are connected to each other because this connection is essential to ensure proper operation. You can modify the connection using the **Function-group connections** editor in DIGSI 5.
If the connection is missing, DIGSI 5 reports an inconsistency.
Besides the general assignments of the Protection function groups or groups to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the automatic reclosing functions?
- Which protection functions activate the Circuit-breaker failure protection functions?

5.5.3 Application and Setting Notes

Interface with Measuring Points

The interface with the 3-phase power values must always been configured. Optionally, DIGSI 5 might as an inconsistency message (shown in the Information Assistant) that no voltage transformer (Vph, V1 and V2 of the part of the electrical power system to be protected must be connected.
You can find more detailed information in the chapter → Synchronization Function.
The Automatic reclosing function provides the auxiliary functions Dead time start and Reduced dead time. For more auxiliary functions, the 1-phase voltage system has to be connected. If you want to use these auxiliary functions, the measurand point of the 3-phase voltage system must be connected to the voltage function

group functions. This connection is also necessary if the Automatic reclosing function with adaptive dead time function type is used.

Parameter: Rated Normal Current for % Values

- Default setting (_:2311:103) Rated normal current = 2000 A

With the Rated normal current parameter, you set the primary nominal value as a reference for all current related % values within the Circuit breaker function group. This enables both for operational measured values and for setting values in %.
Enter the primary rated current of the protected object in mA.
If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the measured values can be faulty.

Parameter: Rated Voltage for % Values

- Default setting (_:2311:102) Rated voltage = 400 kV

With the Rated voltage parameter, you set the primary voltage, which serves as a reference for all voltage-related % values within the Circuit breaker function group. This applies both for operational measured values and for setting values in %.
Enter the primary rated voltage of the protected object in kV.
If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the measured values can be faulty.

Parameter: Current Threshold Circuit Breaker Open

- Default setting (_:2311:112) Current threshold CB open = 0.10 A

With the Current threshold CB open parameter, you specify the threshold value below which the circuit-breaker pole on the circuit breaker is recognized as open.
Set the Current threshold CB open parameter so that the current measured when the circuit breaker pole is open will certainly NOT below the parameterized value. If parasitic currents (for example, due to induction) are measured with the low dependable, you can make a secondary setting of the value with a high degree of sensitivity, to 0.04 A for example.
If no special requirements exist, Siemens recommends retaining the setting value of 0.10 A for secondary quantities.

5.5.4 Trip Logic

5.5.4.1 Function Description

The Trip logic function block receives the group operative indication from the Protection function groups or Protection function groups and forms the protection trip command that is transmitted to the Circuit-breaker function block.
The Circuit breaker function block activates the device contacts and thus causes the circuit breaker to open (see 5.5.2 Circuit Breaker). The command output time is also effective here.
The trip logic also decides when the protection trip command is reset (see Figure 5-17).

Figure 5-16 Trip Command

Virtual protection functions are summarized in the Trip logic function block. The trip command that causes the tripping in the Circuit breaker function block is generated there.
To operate the circuit breaker, the Circuit-breaker function block provides the output signals that must be routed to the corresponding binary outputs of the device (see Table 5-4).

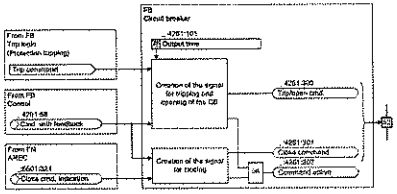


Figure 5-18 Tripping, Opening, and Closing the Circuit Breaker

Table 5-4 Description of the Output Signals

Signal	Description	Routing Options
Trip/open cmd.	This signal executes all tripping and opening operations The Output time parameter affects the signal. The signal is pending for the duration of this period, with the following exceptions: • Only when switches off by the command: The signal is canceled before expiration of the period. • Only in the event of protection tripping: The signal remains active as long as the trip command is not active after expiration of the period (see also 5.5.4.3 Tripping Description). • Only in the event of protection tripping: With the routing option Only saved in the event of tripping, the signal remains pending until it is acknowledged manually. This only applies for protection tripping.	• Unrestricted • Only saved in the event of protection tripping (not when operated)
Close command	This signal executes all closing operations The Output time parameter affects the signal. The signal is pending for the duration of this period, with the following exception: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is closed before expiration of the period.	Normal routing
Command active	This signal is active as long as, one of the binary outputs assigned to the signals Trip/open cmd. and Close command is active because a switching command is being executed by the control.	Normal routing

5.5.5.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit breaker position, the Circuit-breaker function block's receives position signals (see next figure).

Trip Command Reset

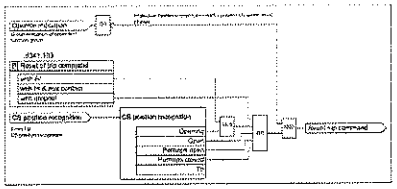


Figure 5-17 Trip Command Reset

Once a trip command is issued, it is stored (see Figure 5-16).
You determine the criteria for resetting a trip command that has been issued with the parameter Reset of trip command.

- with dropout
  The trip command is reset if the function that initiated tripping resets its operate indication. This occurs typically with dropout. Command reset of the trip command is in place regardless of confirmation of the circuit breaker condition.
- with IC
- with IC & aux.contact
  For these options, the state of the circuit breaker is also taken into account as a further criterion in addition to the dropout of the tripping function (operate indication) is reset by command. You can select whether the state is determined by means of the current (with IC) or by means of the current in conjunction with the circuit breaker auxiliary contacts (with IC & aux.contact). The behavior of these setting options only differs in one situation of the circuit-breaker state. If the circuit breaker is in the opening state, the trip command is reset in the case of the option with IC, whereas it is not reset yet in the case of the option with IC & aux.contact. The opening state is detected if the auxiliary contacts still detect the current breaker as being closed and opening is detected via the decreasing current flow.
  As long as the circuit breaker is detected unambiguously as closed (fully closed), the trip command will not be reset with these setting options.
  The information about the condition of the circuit breaker is supplied by the Circuit-breaker position recognition function block (see 5.5.6 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions). The determination of the various conditions is also described in this chapter.

5.5.4.2 Application and Setting Notes

Parameter: Reset of trip command

- Recommended setting value (_:2341:103) Reset of trip command = with IC

These signals are of the Double-point indication (DPC) type. A double-point indication can be routed to 2 binary inputs so that the open and closed circuit-breaker positions can be reliably acquired.

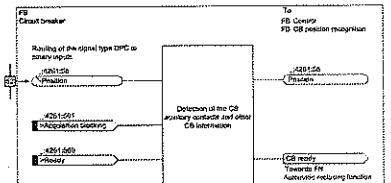


Figure 5-19 Acquisition of the Circuit Breaker Information

Signal	Type	Description
Position	DPC	Acquisition of the circuit-breaker position The position 3-pole circuit breaker open and/or the position 3-pole circuit breaker closed can be acquired by routing to 1 or 2 binary inputs.

The signals must be routed to the binary inputs that is connected with the CB auxiliary contacts. The open and closed signals do not necessarily have to be routed in parallel. The advantage of parallel routing is that it can be used to determine an intermediate or disturbed position. On the other hand, this is not possible if only one signal is routed.
In the monitoring direction, the position signals generate the following information when the open and closed positions are acquired (see following table). This information is further processed by the Circuit-breaker position recognition and Control function blocks.

Information	Type	Description
Off	SPS	Circuit-breaker position is opened.
On	SPS	Circuit-breaker position is closed.
Intermediate position	SPS	Circuit-breaker position is in intermediate position.
Disturbed position	SPS	Circuit-breaker position is in disturbed position.
Not selected	SPS	The circuit breaker is not selected for a control operation.

Other input signals are:

Signal	Type	Description
>Acquisition block blocking	SPS	This is used to activate acquisition blocking of the circuit breaker auxiliary contacts (see Other Functions, 2.8.7 Persistent Commands) for a definition of acquisition blocking).
>Manual Acquisition	SPS	This is used to start acquisition blocking and manual update of the circuit breaker. Setting of acquisition blocking and marking is blocked with the input set=and

Parameter Value	Description
with IC	With this setting, the trip command is reset as soon as the command is removed. If, however, the tripping function has remained and, for some subsequent before the recognition of the open circuit breaker via the current falling below of the value set in the parameter 4 :2311 1124 Current threshold CB open.
with IC & aux.contact	For this setting not only the current is has to be removed, but also the circuit-breaker auxiliary contact has to report that the circuit breaker is open. This setting assumes that the wiring of the auxiliary contact has been routed via a binary input (for more information, see 5.5.5 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information).
with dropout	The setting can be selected for special applications in which the trip command does not reset to complete interruption of the current in every case. In this case, the trip command is reset if the pick-up of the tripping protection function drops out. This setting is useful if the load current in the system cannot be interrupted during the protection device's test and the test current is fed in parallel with the load current.

5.5.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trip Logic				
:103	Trip logic/reset of trip command		• with IC • with IC & aux.contact • with dropout	with IC

5.5.4.4 Information List

No.	Information	Data Class (Type)	Type
Trip Logic			
:1000	Trip logic Trip indication	ACT	O

5.5.5 Circuit Breaker

5.5.5.1 Overview

The Circuit-breaker function block represents the physical switch in the SIPROTEC 5 device.
The basic tasks of this function block are the operation of the circuit breaker and the acquisition of the circuit-breaker auxiliary contacts and other circuit-breaker information.
The Circuit-breaker function block provides information about:

- Number of switching cycles
- Breaking current, breaking voltage, and breaking frequency
- Summation breaking current

5.5.5.2 Tripping, Opening, and Closing the Circuit Breaker

The circuit breaker is operated in the following situations:

- Tripping of the circuit breaker as a result of a protection trip command
- Opening of the circuit breaker as a result of control operation
- Closing of the circuit breaker as a result of automatic reclosing or control operation

To link the circuit breaker function block to the control function see 6.2.2.5 Structure of the Circuit-Breaker Switching Device. Tripping is always the result of a protection function. The operate indications of the indi-

Signal	Type	Description
>Ready	SPS	This active signal indicates that the circuit breaker is ready for an OPEN-CLOSE-OPEN cycle. The signal remains active as long as the circuit breaker is unable to trip. The signal is used in the Automatic reclosing and Circuit-breaker test functions.

Another output signal is:

Signal	Type	Description
Ext.control loc.blk	SPS	This can be used to indicate the health of the physical circuit breaker. For this, you must acquire any failure information for the circuit breaker via a binary input. This failure information can set the appropriate state at the External1 input (in signal with a CFC chart (using the #SHLD_ENS block). This signal has no effect on the health of the function block.

5.5.5.4 Circuit-Breaker Tripping Alarm Suppression

Circuit-Breaker Tripping Alarm Suppression

In certain systems, the user may wish to activate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not be "stored if the circuit breaker is to be released automatically after tripping or if it is to be closed or opened via the control. The alarm is only to be issued in the event of final tripping.
Depending on how the alarm is generated (for example, triggered by a flowing contact at the circuit breaker), the Alarm suppression input signal can be used to suppress the alarm.
This signal is generated if:

- A definitive protection tripping is not present
- The automatic reclosing function executes a reclose
- The integrated control executes a closure or opening action
- External closing is detected via the Manual close function

For further information about the use, please refer to 5.5.7.2 Application and Setting Notes.

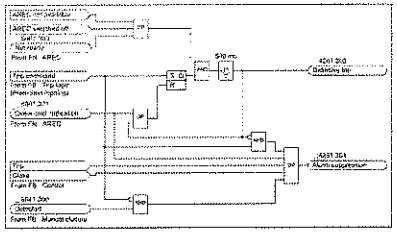


Figure 5-20 Definitive Tripping, Circuit-Breaker Tripping Alarm Suppression

5.5.5.5 Tripping and Opening Information

When a trip command is issued, the tripping information stored in the next figure is stored in the fault log.

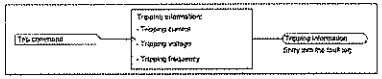


Figure 5-21 Tripping Information

The following statistics information is saved for the circuit breaker:

- Number of switching cycles
  All tripping, opening, and closing operations are counted.
- Number of closing operations by the automatic reclosing function
- Total of tripping and breaking currents

The statistics information can be individually set and reset via the device control. It is also possible to reset all values via the binary input signal >Reset switching cycles.

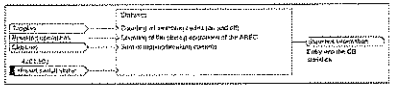


Figure 5-22 Statistics Information About the Circuit Breaker

5.5.5.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

The following figure shows the routings example:

- The device can execute 3-pole tripping (via the protection device).
- The device can execute 3-pole opening (via the control).

Furthermore, the device can switch on 3-pole (via the control / AREC).

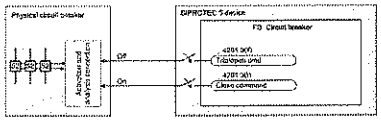


Figure 5-23 Activation of the Circuit Breaker

By routing the Trip/open cmd. signals to 1 or 3 binary outputs, you can carry out 1, 1.5, and 2-pole activations of the circuit breaker. You will find a detailed description of this in 6.2.3 Connection Variants of the Circuit Breaker.

NOTE

Do not combine these 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker with 3-pole or 3-pole tripping of the circuit breaker.

Routing for Analysis of the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. These are for example

- **Circuit-breaker position recognition** function block
- **Circuit-breaker failure protection** function
- **Control** function block

The operating principle of the auxiliary contacts is described in the individual functions.

Siemens recommends routing the *Circuit breaker is open* and *Circuit breaker is closed* via 2 auxiliary contacts (1 NO contact and 1 NC contact) for the control function. For purely protection applications, it is also enough to capture just one of the 2 circuit-breaker positions.

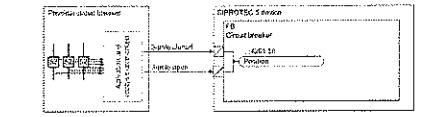


Figure 5-24 Recommended Assignment of the Circuit-Breaker Switch Position when Used as a Protection and Control Device

The following diagram shows the recommended routing, in which H stands for active with voltage.

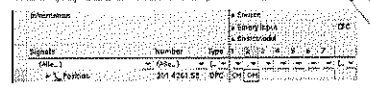


Figure 5-25 Routing for Activation of the Circuit-Breaker Switch Position via 2 Auxiliary Contacts

The device can also function without the analysis from the circuit-breaker auxiliary contacts, that is, routing of the auxiliary contacts is not absolutely necessary. However, this is a requirement for control functions.

Parameter: Output time

- Default setting (_:101) Output time = 0.20 s

The output time parameter sets up the signals for tripping, opening, and closing of the circuit breaker.

CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

- Set a time that is long enough to ensure that the circuit breaker reliably reaches its final position (open or closed) after a control operation.

Output Signal: Indication Suppression

Whereas in the case of faults without an automatic reclosing function every trip command is time due to a protection function, the use of an automatic reclosing function should only cause the motion detector of the circuit breaker (flowing current via the circuit breaker) to trigger an alarm if tripping of the circuit breaker is definitive (see next figure for more details). Likewise, a tripped alarm should not be triggered for switching operations by the control.

For this, the alarm activation circuit should be looped via a suitably routed output contact of the device (output signal **Alarm suppression**). In the idle state and when the device is switched off, this contact is permanently closed. For this, an output contact with a break contact must be routed. The contact opens whenever the output signal **Alarm suppression** becomes active, so that tripping or a switching operation

does not cause an alarm (see the logic in 5.5.5.4 Application of Circuit-Breaker Auxiliary Contacts and further information for more details).

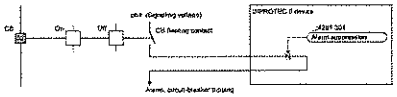


Figure 5-26 Circuit-Breaker Tripping Alarm Suppression

5.5.5.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Circuit breaker				
1105	Circuit breaker,Output time		0.02 s to 1800.00 s	0.10 s

5.5.5.8 Information List

No.	Information	Data Class (Type)	Type
Circuit breaker			
300	Circuit breaker...Ready	SPS	I
301	Circuit break...Application blocking	SPS	I
302	Circuit break...Pole discrepancy signal	SPS	O
303	Circuit breaker,Pressure monitor	SPS	I
304	Circuit breaker,External breaker	SPS	I
31	Circuit breaker...Health	WYE	O
36	Circuit break...Operation	DPC	C
300	Circuit break...Trip/open cmd.	SPC	O
301	Circuit break...Close command	SPC	O
302	Circuit break...Command action	SPS	O
303	Circuit break...Definitive trip	SPS	O
304	Circuit break...Alarm suppression	SPS	O
305	Circuit break...Intact	BYS	O
307	Circuit break...CB OFF	BCR	O
308	Circuit break...CB On	BCR	O
309	Circuit break...CB Off	BCR	O
310	Circuit break...CB On	BCR	O
311	Circuit break...Break. current ph A	MV	O
312	Circuit break...Break. current ph B	MV	O
313	Circuit break...Break. current ph C	MV	O
314	Circuit break...Break. voltage ph A	MV	O
315	Circuit break...Break. voltage ph B	MV	O
316	Circuit break...Break. voltage ph C	MV	O
322	Circuit break...CB alarm hours	INS	O
323	Circuit break...Operating hours	INS	O

5.5.6 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

5.5.6.1 Overview

This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts and the current flow.

This information is needed in the following protection-related additional functions:

- Trip logic (see)
- Detection of manual closing (see 5.5.7.1 Function Description)
- Process monitor (see)

Its use is described in the respective chapters.

The control does not use this information. The control evaluates the circuit breaker auxiliary contacts.

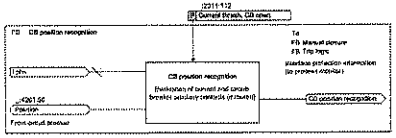


Figure 5-27 Overview of the Circuit-Breaker Condition Position Function

Based on the link between the information from the auxiliary contacts and the current flow, the circuit breaker can assume the following positions:

Circuit-Breaker Condition	Description
Open	The circuit-breaker pole is detected (meaningfully) as open according to both criteria.
Closed	The circuit-breaker pole is detected (meaningfully) as closed according to both criteria.
Possibly open, possibly closed	These conditions can occur if the information is incomplete due to the routing of the auxiliary contacts and the condition can no longer be determined reliably. These uncertain conditions are evaluated differently by certain functions.
Opening	This is a dynamically occurring condition that results when, while a trip command is active and the aux. relay contact is still closed, the current is detected to have fallen below the dropout value because the current flow continues when other faster than the auxiliary contact can open.

5.5.7 Detection Manual Closure (for AREC and Process Monitor)

5.5.7.1 Function Description

Detection of Manual Closure (for Process Monitor)

The Manual closure function block detects any closure carried out by hand. This information is used in the Process monitor (for criteria within protection function groups).

The following figure shows the logic for manual closure detection.

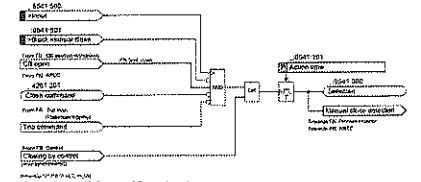


Figure 5-28 Logic for Manual Closure Detection

External Manual Closure

An external manual closure is communicated to the device via the input signal >Trigger. The input signal can also be connected directly to the control circuit of the circuit-breaker closing coil. Detection via the input signal >Trigger is also blocked if the circuit breaker is closed or if a protection trip is active.

Internal Manual Closure

Manual closure is detected in all cases if a close command is transmitted by the internal control function of the device. This is possible because the control carries out plausibility checks itself and is also subject to interlocking.

5.5.7.2 Application and Setting Notes

Input Signals: Input, >Blocking of Manual Closure

In practice, the input signal >Input is connected directly to the control circuit of the circuit-breaker closing coil (see following figure).

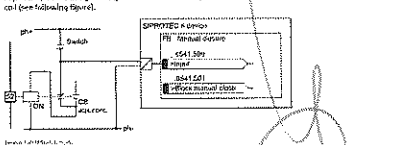


Figure 5-29 Connection of the Input Signal to the Control Circuit of the Circuit-Breaker Closing Coil

Every closure of the circuit breaker is recorded in the process

If external close command, for possible activation of the circuit breaker by other devices, which are not switched to prompt execution of a manual closure, this can be executed in 2 ways:

- The input signal is connected in such a way that it is not activated in the event of external close commands.
- The external close command is connected to the existing input signal >Manual Close to manual closure execution.

Parameter: Action time

- Recommended setting value (_:101) Action time = 200 ms

In order to ensure independence from manual activation of the input signal, the detection function is extended for a defined length of time using the parameter Action time.

Siemens recommends an action time of 200 ms.

5.6.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Manual close				
_6541:101	Manual close: Action time		0.01 s to 60.00 s ∞	0.30 s

5.6.3.4 Information List

No.	Information	Data Class (Type)	Type
Manual close			
6541:301	>Manual close: Block manual close	SPS	I
6541:300	Manual close rejected	SPS	O
6541:309	Manual close blocked	SPS	O

5.6.3 20-mA Unit Ethernet

5.6.3.1 Overview

The Ethernet 20-mA unit Ether:

- Communicates in series with a 20 mA unit via the Slave Unit Protocol (SUP) and receives the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process tags such as temperature or gas pressure
- Makes the recorded process tags available to IEC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

5.6.3.2 Structure of the Function

The function 20-mA unit Ether, can work only in the function group Analog units. A maximum of 4 function instances can work simultaneously. Each instance contains 12 preconfigured channel function blocks.

The function 20-mA unit Ether, contains input and output channels which can be configured independently of one another.

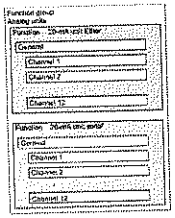


Figure 5.32 Internal Interwiring of the Function

5.6 Function-Group Type Analog Units

5.6.1 Overview

The Analog units function group is used to map analog units and communicate with them. Analog units are external devices, such as RTD units or analog sensors (pressure, etc.) or measuring transducer standards.

You will find the Analog units function group for many device types in the Global DIGSI 5 library.

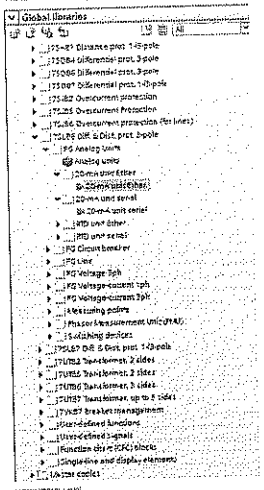


Figure 5.30 Analog Unit Function Group in DIGSI

5.6.3.3 Communication with 20 mA Unit Ethernet

Logic

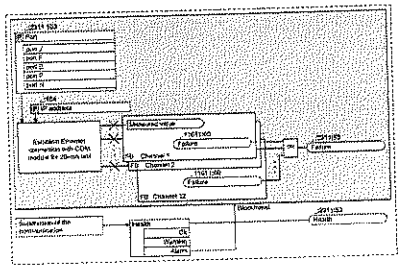


Figure 5.33 Logic of the Function 20-mA Unit Ethernet

Communication with 20 mA Unit

The function is used to communicate with a 20 mA unit connected via an Ethernet connection. When a connection of the function to an external 20 mA unit via an Ethernet interface has successfully been established, the 20-mA unit sends the measured values of all connected channels to the function 20 mA unit, Ether. For the connection to be established successfully, operator communications settings must be specified.

You can find more detailed information on in Chapter 5.6.3.4 Application and Setting Notes .

The 20-mA measurement unit 7XV5674 is supported.

Error Responses

The following table lists the conditions under which the Health device transitions to the Alarm or Warning state.

Table 5-5 Error Responses

Error Description	Status Health
The function 20 mA unit Ether, cannot establish a connection with a communication module.	Alarm
The function 20-mA unit Ether, sends TCP settings to the communication module, which ultimately would like to connect to the 20 mA unit via a serial protocol. This communication module does not establish a connection to the 20-mA unit.	Alarm
The connection fails on the communication module and the 20 mA unit senses a error but satisfactory.	Warning

5.6.2 Structure of the Function Group

If the device has a monitoring transducer, it is automatically created in the Analog units function group. If one or more RTD units are connected to the device, you have to load one or more RTD unit Ether, or RTD unit serial functions from the Global DIGSI 5 library in order to use the RTD units.

The following figure shows the structure of the function group:

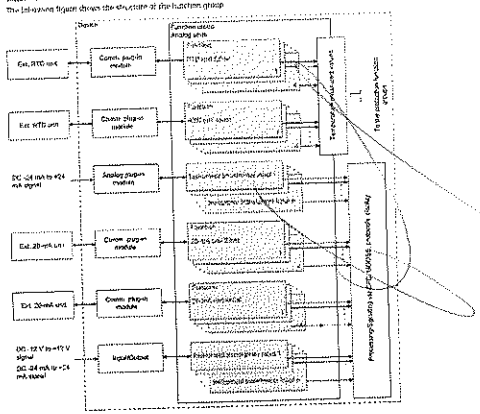


Figure 5.31 Structure of the Analog Unit Function Group

The Analog units function group has interfaces to protection function groups. The Analog units function group provides measured temperature values that come from an external RTD unit. These measured temperature values are available for all protection function groups in which a temperature monitoring function exists. The RTD unit Ether, function is not preconfigured by the manufacturer. A maximum of 20 function instances can work simultaneously.

The RTD unit serial function is set up structurally exactly in the same manner as the RTD unit Ether, function.

Error Description	Status Health
A communication module has not received any more data from the 20-mA unit for 9 sec	Warning

The Health signal is set as soon as one of the channel function blocks reports a failure.

5.6.3.4 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:103) Port = port J

Use the Port setting to define the port connecting the 20-mA unit to the SIPROTEC 5 device.

Parameter: IP address

- Default setting (_:2311:104) IP address = 10.10.40.1

With the IP address setting, you set the IP address of the 20-mA unit connected to the communication module via the TCP protocol. You must assign each 20-mA unit an unambiguous IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. First set an IP address for the 7XV5674 20-mA unit. Then specify the same IP address setting for the communication module in the same address.

Settings on the 20-mA Unit

The 7XV5674 20-mA unit is set with a web browser on the laptop computer via the latter's Ethernet interface. Set Modbus TCP as bus protocol-operating mode.

You can find detailed notes on the settings in the 7XV5674 manual that accompanies the 20-mA unit. The documents are also available in the SIPROTEC download area http://www.siprotec.siemens.com.

5.6.3.5 20-mA Channel

Logic

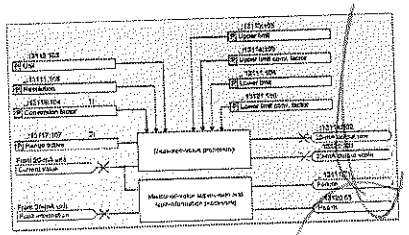


Figure 5.34 Logic Diagram of the Function 20 mA Channel

(1) If the setting Range active is set to false, the setting Transformation value 1 is displayed.

(2) If the setting Range active is set to false, the settings Upper limit, Transformation value upper limit, Lower limit and Transformation value lower are not displayed.

Measured-Value Calculation

The function 20-mA channel processes a single 20 mA current signal supplied by the 20 mA unit of the corresponding channel. The 20-mA current measured value is converted into the correct physical quantities such as temperature or pressure. In each 20 mA function unit (if they are used) there are always 12 of the 20-mA channel function blocks, even if fewer channels are connected with the 20 mA unit. The calculated values are available for further processing via CFC, GDOCS, protocols, and the display design.

Measured-Value Processing

The 20-mA unit typically transmits a value which represents a physical quantity, such as a temperature or a pressure. Therefore, the application needs a characteristic curve that maps the physical quantity to the 20-mA value. If you do not activate the **Range active** setting (so it is the check box), the function operates over the range 0 mA to 20 mA. If a value smaller than 0 mA or greater than 20 mA is active at the input of the 20-mA unit, the measured value is identified as invalid. The setting of the range for the scaled value goes from a usable range of 0 mA to 25 mA. The following figure shows an example.

Channel 1

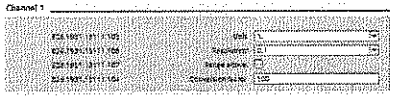


Figure 5-35 Settings for Example 1

In this example, the measured value 0 mA means a temperature of 0 °C and the measured value 20 mA means a temperature of 100 °C. To enter an **Unit = °Celsius Conversion factor = 100**, the resolution (decimal place) of the temperature value can be chosen, for a decimal place, select **Resolution = 0.1**

Temperature value [°C]

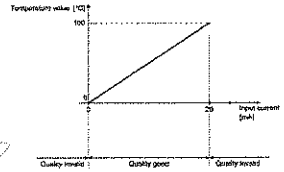


Figure 5-36 Characteristic Curve of a 20-mA Input (Example 1)

If you activate the **Range active** setting (so it is the check box), four additional parameters **Upper limit, Lower limit, Upper limit - Sensor**, and **Lower limit - Sensor** appear. The parameters **Upper limit** and **Lower limit** describe the range of the input current in mA. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value at the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value at the **Lower limit** setting. The setting of the range for the scaled value corresponds to the usable range between **Lower limit** and **Upper limit** (see following figure).

Channel 1

Figure 5-37 Settings for Example 2

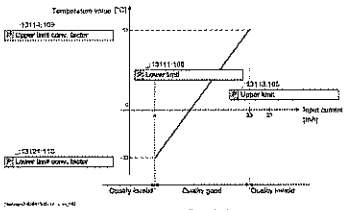


Figure 5-38 Characteristic Curve of a 20-mA Unit (Example 2)

In this example, the **Range active** setting is selected. The setting **Upper limit** is at 20 mA, the setting **Lower limit** is at 4 mA. The setting **Upper limit - Sensor** is at 95 and the setting **Lower limit - Sensor** is at -33, if the input current is smaller than 4 mA or greater than 20 mA, the quality of the scaled measured value in this example is invalid.

Each 20-mA channel makes available the scaled measured value on the information routing (these are the temperature values in the examples) and the original current measured value is not for further processing. The 20-mA values can be displayed in the display page and measured value CFC chart.

Error Responses

If the current input value is determined to be incorrect, the quality attributes of the output value is set to Invalid (for more details see the detail view).

Table 5-6 Error Responses

Error Description	Status Health	Error Status
The input value has exceeded the given limits	OK	Yes
Channel has corrupted	OK	Yes

5.6.3.6 Application and Setting Notes

Parameter: Unit

- Default setting (_:13111:103) **Unit = °C**

You use the setting **Unit** to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting (_:13111:104) **Conversion factor = 100**

The **Conversion factor** setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting (_:13111:106) **Resolution = 0.1**

The **Resolution** setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting (_:13111:107) **Range active = false**

If you do not activate the **Range active** setting (so it is the check box), the function operates over the range 0 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA.

If you activate the **Range active** setting, then 4 additional settings **Upper limit, Upper limit - Sensor, Lower limit**, and **Lower limit - Sensor** appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting (_:13111:105) **Upper limit = 20000 mA**
- Default setting (_:13111:109) **Upper limit - Sensor = 200**
- Default setting (_:13111:108) **Lower limit = 4000 mA**
- Default setting (_:13111:110) **Lower limit - Sensor = 200**

If you activate the **Range active** setting, then 4 additional settings **Upper limit, Lower limit, Upper limit - Sensor** and **Lower limit - Sensor** appear. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.6.3.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General:1				
_:2311:103	GeneralUnit		• part E • part F • part J • part N • part P	part E
Channel 1				
_:13111:103	Channel 1:Unit		• % • - • °C • °F • Ω • Ω/km • Ω/mi • h • A • As • cm² • cycles • dB • Ω/km • Ω/mi • h • Hz • Hz/s • m • / • /km • K • kA • m • m/s • mΩ • mA • Pa • parts/m • rad • rad/s • s • V • V/Hz • VA • var/h • var • varh • W • Wh • Wh/	in
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		10000 to 10000	100
_:13111:Std	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1

Addr.	Parameter	C	Setting Options	Default Setting
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		10000 to 10000	100

5.6.3.8 Information List

No.	Information	Data Class (type)	Type
General:1			
_:2311:53	GeneralHealth		O
_:2311:56	GeneralFailure		O
Channel 1			
_:13111:53	Channel 1:Health		O
_:13111:71	Channel 1:Failure		O
_:13111:301	Channel 1:20-mA output state		C
_:13111:302	Channel 1:20-mA output raw		O

5.6.4 20-mA Unit Serial

5.6.4.1 Overview

The function 20-mA unit Serial:

- Provides serial communications with a 20-mA unit via the Modbus protocol and receive the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process variables such as temperature or gas pressure
- Makes the recorded process info available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

The function 20-mA unit Serial is structured in the same way as the function 20-mA Unit Ether. The mode of operation is also identical. The only difference is that the measured values are transferred to the communication module via a serial connection instead of an Ethernet connection.

You can find more information in Chapter 5.6.1 Structure of the Function.

5.6.4.2 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:101) **Port = Port J**

With the **Port** setting, you specify the slot for the communication module that will be used for the connection with an external 20 mA unit.

Parameter: Channel number

- Default setting (_:2311:105) **Channel number = 1**

A serial communication module optionally uses 2 channels. With the **Channel number** setting, you specify the channel number (1 or 2) used to connect the 20 mA unit to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting (_:2311:106) **Slave address = 1**

Use the **Slave address** setting to define the device address of the 20 mA unit. If only one 20 mA unit is connected to the serial bus, the default value 1 can be used. Set the same device address as used with the 20-mA unit. The device address is important for distinguishing several 20-mA units that are connected to a serial bus. Set an unambiguous device address to every 20 mA unit. For example 1, 2 and 3 when connecting 3 of the 20 mA units. On every 20 mA unit, set the **Slave address** setting in the 3 directions 20 mA Unit Serial the same device address for each.

Parameter: Unit

- Default setting (_:13111:103) **Unit = °C**

You use the setting **Unit** to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting (_:13111:104) **Conversion factor = 100**

The **Conversion factor** setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting (_:13111:106) **Resolution = 0.1**

The **Resolution** setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting (_:13111:107) **Range active = false**

If you do not activate the **Range active** setting (so it is the check box), the function operates over the range 0 mA to 20 mA. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA.

If you activate the **Range active** setting, then 4 additional settings **Upper limit, Upper limit - Sensor, Lower limit** and **Lower limit - Sensor** appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting (_:13111:105) **Upper limit = 20 mA**
- Default setting (_:13111:109) **Upper limit - Sensor = 100**
- Default setting (_:13111:108) **Lower limit = 4 mA**
- Default setting (_:13111:110) **Lower limit - Sensor = 100**

If you activate the **Range active** setting, then 4 additional settings **Upper limit, Lower limit, Upper limit - Sensor** and **Lower limit - Sensor** appear. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General 1				
_2311:103	ExternalPort		• port B • port C • port J • port M • port P	port J
_2311:105	Item table channel number		1 to 1	1
_2311:106	External slave address		1 to 247	3
Channel 1				
_19111:103	Channel 1 Unit		• % • ‰ • °C • °F • K • Ω/km • Ω/mi • Hz • Ohm • A • kA • mA • µA • deg • rad • rpm • V • kV • mV • VAr • kVAr • MVAr • var • kvar • Mvar • VA • kVA • MVA • W • kW • MW	mA

Addr.	Parameter	C	Setting Options	Default Setting
_19111:108	Channel 1 Decimals		• 0 • 0.1 • 0.01 • 0.001	0.1
_19111:102	Channel 1 Range active		• no • yes	no
_19111:104	Channel 1 Conversion factor		1 to 10000	100
_19111:107	Channel 1 Upper limit		0.00 mA to 70.00 mA	20.00 mA
_19111:109	Channel 1 Upper limit factor		-50000 to 50000	100
_19111:106	Channel 1 Lower limit		-70.00 mA to 20.00 mA	4.00 mA
_19111:110	Channel 1 Lower limit factor		-10000 to 10000	100

5.6.4.4 Information List

No.	Information	Data Class (Type)	Type
General 2			
_2311:53	General Health		O
_2311:54	General Failure		O
Channel 1			
_19111:53	Channel 1 Health		O
_19111:54	Channel 1 Failure		O
_19111:301	Channel 1 (20-mA) output Scale		O
_19111:302	Channel 1 (20-mA) output Dline		O

5.6.5 Communication with 20-mA Unit

5.6.5.1 Integration of a Serial 20-mA Unit

Connection of the Communication Lines

Figure 5-39 shows how to connect the 20 mA unit to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTS-B and Pin 2 is connected to RTS-A.

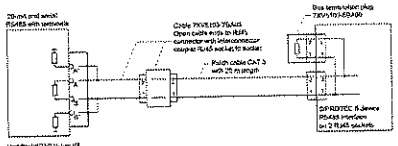


Figure 5-39 Connection of the 20-mA Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AP1EL or a USART-AC2EL USART module in DIGSI to the device. The USART module must be inserted as one of the ports to possess communication modules in the base module or in the CB202 expansion module (refer to the following figure).

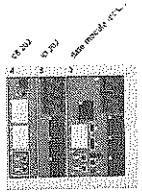


Figure 5-40 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the "Slave Unit Protocol (SUP)". This protocol is responsible for the communication between the SIPROTEC 5 device and the 20-mA unit.

Figure 5-41 Selecting the SUP Protocol

Communication Settings

Make the communications settings for the sender and send channels. For this, use the default settings specified by the 20-mA unit. Normally, you must adapt only the parameter names at the SIPROTEC 5 device to the settings of the 20 mA unit. Make sure that the setting values in both devices are the same. The settings of the "Non-Blocking Keying" (on/off) : is not relevant for the RS485 interface.

NOTE

The power for the USART module for the SUP protocol is not preinstalled as standard for the initial use of the interface (following the firmware update).

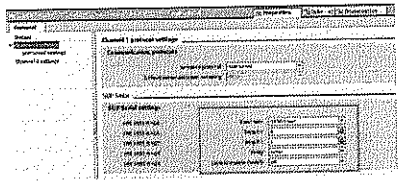


Figure 5-42 Making the Communication Settings

With the selection of the SUP protocol for the 20 mA unit DIGSI automatically adds the function group Analog units to your device configuration. You can now instantiate the function 20-mA unit serial 1 (see following figure).

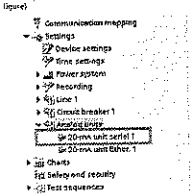


Figure 5-43 Insertion of the Function 20-mA Unit Serial 1

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the 20-mA unit. This address must be set with the same value in the 20-mA unit (refer to the following figure).
For the first use of the 20-mA unit, the following device configuration must be set on the 20-mA unit:

- Bus protocol: none
- Device address: 3
- Baud rate: 9600
- Parity: no

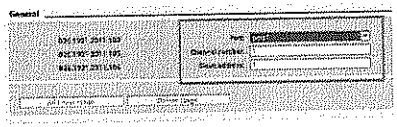


Figure 5-44 Setting the Port, Channel Number, and Device Address

Finally, load the configuration to the device.

5.6.5.2 Integration of a 20-mA Unit Ethernet

Device Configuration

In DIGSI, insert an Ethernet module into the provided slot, thus, adding the module to the device configuration. Figure 5-45 displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

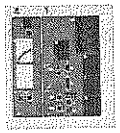


Figure 5-45 Inserting an Ethernet Module

Communication Settings

Activate the SUP Ethernet protocol for the Ethernet module.

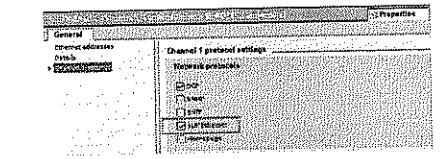


Figure 5-46 Activation of the Protocol

This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).

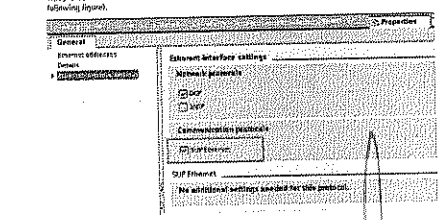


Figure 5-47 Selection of the Protocol

With the selection of the SUP protocol for the 20-mA unit, DIGSI automatically adds the Analog units function group and the 20 mA unit Ether. number to your device configuration (refer to the following figure).

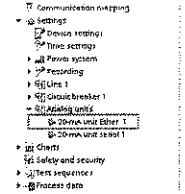


Figure 5-48 Insertion of the Function 20-mA Unit Ether 1

Now, set the port over which the SIAP protocol runs. In addition, set the IP address of the 20-mA unit (refer to the following figure). The address must be set with the same value as the 20 mA unit.

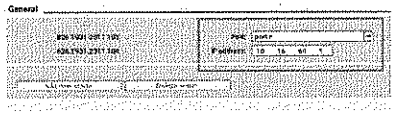


Figure 5-49 Setting the Port and IP Address

Finally, load the configuration in the device.

5.6.6 VA-Measuring-Transducer Unit with Fast Inputs

5.6.6.1 Overview

The fast analog measuring transducer inputs process voltage values (DC -10 V to +10 V) as well as current values (DC -20 mA to 20 mA).

The function **MT fast input**:

- Provides sampled values for recording in the fault record (the maximum sampling frequency is 20 kHz, and 8 kHz for all other SIPROTEC 5 devices). The recorded sampling frequency results from the setting of the fault-recorder function.
- Calculated measured values from the sampled values. These measured values have been checked from the instantaneous values. The measuring range for the measured-value calculation is adjustable in the interval from 10 ms to 100 ms.

- Converts the measured current or voltage values into process values, for example, temperature, gas pressure, etc.
- Provides the recorded process variables for further processing by the fault recorder, the CFC, and in SIPROTEC combinations for transmission via the communication protocols, and for visualization.

The fast measuring-transducer inputs are located on the ID-212 module with 8 inputs (optionally current or voltage inputs) and the ID-211 module with 4 inputs (optionally current or voltage inputs).

5.6.6.2 Structure of the Function

The function **MT fast input** works in the function group **Analog units** and contains the number of available measuring-transducer inputs, depending on the hardware configuration. You can configure these channels separately from one another either as current or as voltage inputs.

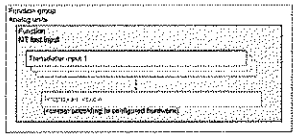


Figure 5-50 Structure/Embedding of the Function

5.6.6.3 Function Description

Once you have inserted the **MT fast input** function, it will be visible in the project tree in the function group **Analog units**. You can find the function group **Analog units** in DIGSI in the **Settings** folder. If you open the subdirectory **MT fast input**, you reach the setting sheet for the respective input (for more details, see Application and Setting Notes).

The function is designed in such a way that either a current or a voltage can be processed at each input. Use the corresponding terminals (see Hardware manual). Configure the inputs in accordance with the selected connection (Parameter **TD input-signal type**). With the parameter **Measuring window**, you set the measuring range with which the instantaneous value is determined. With the parameter **Measuring cycle**, you also determine measurement speed for the input. For example, a setting of 100 ms means that the measured value is updated every 100 ms.

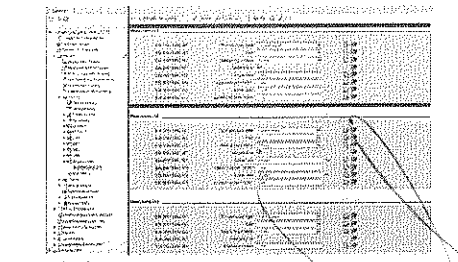


Figure 5-51 Parameters of the Measuring-Transducer Channels

The fast measuring-transducer channels can be configured either as current or as voltage inputs. Apart from this, their function corresponds to the basic functions of the 20-mA channels (see chapter 5.6.4 20-mA Channel).

5.6.6.4 Application and Setting Notes

Parameter: TD input-signal type

- Default setting (_:102) **TD input-signal type = Current input**

With the parameter **TD input-signal type**, you determine whether the measuring-transducer input channel works as a **Current input** or a **Voltage input**.

Make sure that the selected channel has also been wired correctly (see Hardware manual, Input and Output Module ID-212).

Parameter: Unit

- Default setting (_:104) **Unit = A**

With the parameter **Unit**, you set the physical unit of measurement of the measured values. The possible setting values are listed in the settings table.

Parameter: Measuring window

- Default setting (_:142) **Measuring window = 10 ms**

With the parameter **Measuring window**, you set the measuring window that is used to determine the instantaneous value from the sampled values. In case of slowly varying signals, Siemens recommends setting the new value to 100 ms. With this value, a new, current instantaneous value is provided every 100 ms for further processing.

Parameter: Range active

- Default setting (_:107) **Range active = False**

If you do not activate the **Range active** parameter, the function assumes a range of -20 mA to +20 mA or -10 V to +10 V. The setting of the range for the sensor value then assumes a usable range of -20 mA to +20 mA or -10 V to +10 V.

If you activate the **Range active** parameter, then 4 additional parameters **Upper limit - Sensor**, **Upper limit - Sensor**, **Lower limit - Sensor**, and **Lower limit - Sensor** appear.

Note that this setting is activated by either pressing, or not pressing the relevant check mark in DIGSI (see Figure 5-47).

Parameter: Conversion factor

- Default setting (_:104) **Conversion factor = 1.00**

With the parameter **Conversion factor**, you set the conversion factor for the measuring transducer.

Parameter: Upper limit, Lower limit, Upper limit - Sensor, and Lower limit - Sensor

With the following parameters, you set the scaling of the measuring variables. By that, you can scale in an application-specific way:

- Default setting **Upper limit = 20.00 mA**
- Default setting **Upper limit - Sensor = 1.00**
- Default setting **Lower limit = -20.00 mA**
- Default setting **Lower limit - Sensor = 0.00**

With these setting parameters, you set the operating range of the measuring transducer as well as the conversion of the values transmitted to the sensor values. Harmonize the operating range of the measuring transducer with the transmitter at the sensor. Using the free scalability of the system, you can meet different requirements. The following figure shows the setting parameters in general terms.

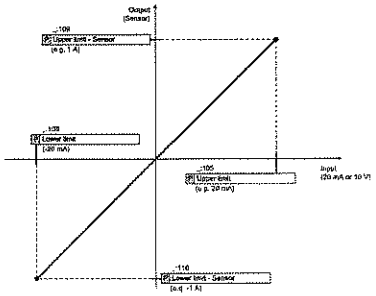


Figure 5-52 Scaling Principle

Setting Example 1:

A measuring transducer transmitting a current signal of 4 mA to 20 mA is used as a transmitter. Currents well below 4 mA indicate a transmitter failure; currents around 0 mA indicate a broken wire. A sensor detecting a temperature is attached to the transmitter. The upper value corresponds to 200 °C and the lower value to -100 °C. This results in the following parameters. In accordance with the set characteristic curve, the function calculates the sensor value from the measured current. The coefficients of the linear equation (gradient and zero point) are calculated from the set thresholds and the sensor values are determined. A supplied current of 0,333 mA corresponds to a temperature of 0 °C.

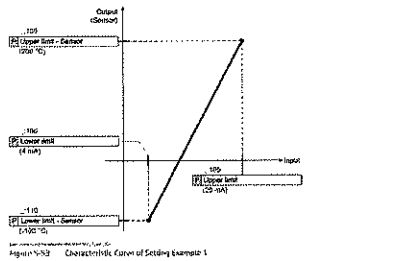


Figure 5-53 Characteristic Curve of Setting Example 1

NOTE

The hardware of the measuring transducer has been designed in such a way that measured values are transmitted and analyzed using the sensing range (**Upper limit** or **Lower limit**). Therefore, special applications are possible, if necessary. The limits for approximately -25 mA and 25 mA or +15 V and -15 V, if the measured values are supplied above or below these limits, the quality **Invalid** is assigned.

Setting Example 2:

For special applications, the transmitter sends a maximum of ±12 V. This voltage shall be output correspondingly as sensor voltage.

Set the parameters as follows:

- **Upper limit = 10.00 V**
- **Upper limit - Sensor = 10.00 V**
- **Lower limit = -10.00 V**
- **Lower limit - Sensor = -10.00 V**

With this setting, a signal of 12 V is issued as a 12 V measured value (see following figure).

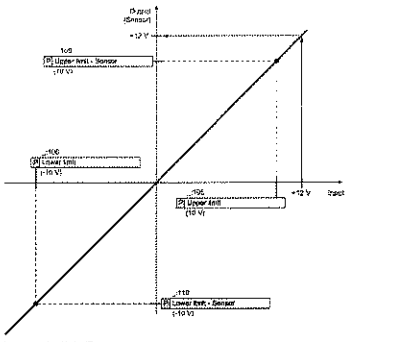


Figure 5-54 Parameter Settings and Representation of an Input Signal Greater than 10 V

5.6.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MV Event 4				
:101	MT in RTD input signal type		• Voltage input • Current input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
:102	MT in RTD unit		• ° • ' • °C • °F • '' • Ω/km • Ω/mi • Ω • kΩ • MΩ • nS • oct g • oct/m • dB • dBm • mW • h • Hz • kHz • in • J • JMol • K • lb • m • mi • min • p.u. • Pa • periods • rad • rmin • s • V • Vdip • VA • VAr • var • vsm • Vs • W • Wh • Wh	A
:142	MT in # Measuring window		• 10 ms • 20 ms • 40 ms • 60 ms • 80 ms • 100 ms	10 ms
:107	MT in # Range value		• 0 • 1	false
:104	MT in #Conversion factor		-10000.000 to 10000.000	1.000
:105	MT in #Upper limit		-20.00 mA to 20.00 mA	5.00 mA
:109	MT in #Upper limit - Sensor		-10000.00 to 10000.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
:108	MT in #Lower limit		-20.00 mA to 20.00 mA	4.00 mA
:110	MT in #Lower limit - Sensor		-10000.00 to 10000.00	1.00

5.6.6.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
910	MT in #RTD scale MV	MV	O
1906	MT in #RTD scale SPS	SPS	O

5.6.7 RTD Unit Ethernet

5.6.7.1 Overview

The RTD unit Ether. function:

- Communicates with an external RTD unit via the Slave Unit Protocol (SUP) and reads the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature monitoring function
- Monitors communication with the RTD unit

5.6.7.2 Structure of the Function

The RTD unit Ether. function can only work in the Analog units function group. A maximum of 20 function instances can work simultaneously. Each instance contains 12 preconfigured sensor function blocks.

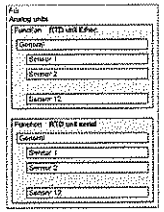


Figure 5-55 Structural Embedding of the Function

5.6.7.3 Communication with an RTD Unit

Logic

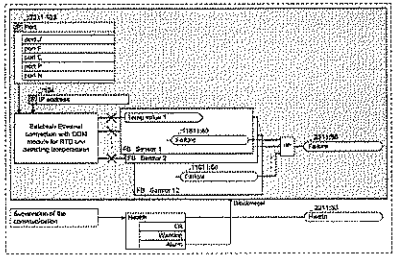


Figure 5-56 Logic of the RTD Unit Ether. Function

Communication with an RTD Unit

The function is used to communicate with an RTD unit connected via an Ethernet connection. If the connection of the function is successfully established to the external RTD box via the Ethernet interface, the RTD box transmits the temperatures of all connected sensors to the RTD box Ether. function. For the connection to be established successfully, certain communication settings must be set, see chapter *5.6.7.4 Application and Setting Notes*.

The RTD box Ziehl TR1200 IP supports only an Ethernet connection of 10 MBit/s. A direct connection to a 100-MBit communication module is therefore not possible. For this reason, you must connect the RTD box to the communication module via a 10/100 MBit/s autosensing switch which automatically recognizes the transmission rates and adapts them accordingly. Further information can be found in the *Application and Setting Notes*, see chapter *5.6.7.4 Application and Setting Notes*.

Error Responses

The following table lists the conditions under which the *Hea.Tch* status transitions to the Alarm or Warning state.

Table 5-7 Error Responses

Error Description	Status Health
The RTD unit Ether. function cannot establish a connection with a communication module.	Alarm
The connection between the communication module and the RTD unit causes a time-out	Warning

Error Description	Status Health
A communication module has not received any fresh data from the RTD unit for 5 sec.	Warning

The *Fail Type* signal is set as soon as one of the sensor function blocks reports a failure

5.6.7.4 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:104) Port = port_J

Use the *Port* parameter to define over which port the external RTD unit is connected to the SIPROTEC 5 device.

If you want to connect the external RTD unit to the integrated Ethernet interface, set the parameter *Port* = *Port_E* if you want to connect the external RTD unit to an Ethernet plug-in module, set the parameter *Port* = *Port_F*, *Port_E*, *Port_J*, or *Port_K*.

You can connect directly the RTD unit to the device via the internal 10-Mbit Ethernet port J. If you operate the RTD unit on another port via a 100-Mbit communication module, you need an interconnected 10/100-Mbit autosensing switch, which adapts transmission rates accordingly.

Parameter: IP address

- Default setting (_:2311:104) IP address = 10.36.60.3

With the *IP address* parameter, you set the IP address of the RTD unit connection to the communication module via the SUP protocol. Every RTD unit has to be assigned a unique IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. Set an appropriate IP address for all the Ziehl TR1200 IP RTD units. Then specify the *IP address* parameter for the communication module to the same address.

Settings on the RTD Unit

The Ziehl TR1200 IP RTD unit is set with the front keys or in a Web browser on a laptop computer via its Ethernet interface. Set the connection type of the sensors (3-wire connection or resistance value for 2-wire connection), the idle state of the fault-indication relay, as well as the IP interface setting.

You can look up how to do so in the manual for parameterization. This is only possible using the front keys at the RTD unit. The code lock is off (switched off) in as-delivered condition and has pin 004.

For step-by-step information on the settings, refer to the TR1200 IP manual that comes with the RTD unit. The documents are also available in the SIPROTEC download area (http://www.siprotec.de) under **Accessories** > **7KV5662-xAD**.

For an Ethernet connection or a SIPROTEC 5 device communication with the RTD unit TR1200 IP via the SUP protocol (Slave Unit Protocol), the Modbus TCP setting must be activated in the RTD unit. You can activate the Modbus TCP protocol using the function keys under the TCP - mod menu item or with the Web browser in the TCP/UDP Config tab. The RTD (RTD method) and UDP Port settings have no effect here. The Modbus TCP port is permanently set to 502 and cannot be changed.

5.6.7.5 Temperature Sensor

Logic

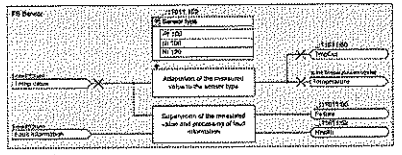


Figure 5-57 Logic Diagram of the Temperature Sensor Function Block

Measured Temperature Value

The Temperature sensor function block processes one single measured temperature value delivered from the RTD box for the assigned sensor. 12 temperature sensor function blocks are always available in each RTD box function (both via Ethernet and serial). A set of these sensors are connected to the RTD box.

Various temperature sensor types are supported: Pt100, Ni100, Ni120, and Ni/Fe sensors. The function block is available regarding the selection of connected type via the *Sensor type* parameter.

The function block delivers a measured temperature value in °C or °F as an output variable. The measured temperature value is available as an operational measured value and can be monitored by the Temperature supervision function.

Error Responses

If the measured input value is determined to be incorrect, the quality attributes of the output measured temperature value is set as *Invalid*. The statuses for Health and Error take the statuses in accordance with the following table:

Table 5-8 Error response

Error Description	Health Status	Error Status
Sensor or line short circuited	Alarm	Yes
Sensor or line interrupted	Alarm	Yes
Measured temperature value outside the valid measuring range, specified by the peripheral data. The valid measuring range depends on the sensor type.	Alarm	Yes
Sensor not connected	OK	No

5.6.7.6 Application and Setting Notes

Parameter: Sensor type

- Default setting (_:123,123:102) Sensor type = Pt 100

The *Sensor type* parameter is used to set the sensor characteristic. You can choose between Pt 100, Ni 100 and Ni 120.

Parameter: Temperature unit

To change the display and evaluation of measured temperature values (unit °C or °F), adapt the DIGSI user default settings accordingly.

Proceed as follows:

- In DIGSI select the menu item Extras → Settings.
- In the Settings view select the menu item DIGSI 5 User preferences.
- Under Standard unit system change the setting value of the unit system used from SI (°C) to US (°F).

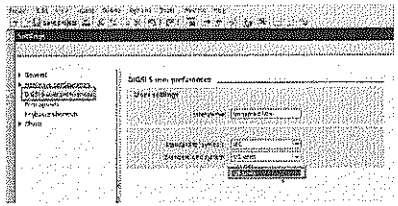


Figure 5-58 Change of the Display Between °C and °F

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.6.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_2311:103	GeneralPort		• port E • port F • port J • port N • port P	port J
Sensor 1				
_11611:102	Sensor 1SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.6.7.8 Information List

No.	Information	Data Class (Type)	Type
General			
_2311:53	GeneralHealth	ENS	O
_2311:54	GeneralFailure	SPS	O

Addr.	Parameter	C	Setting Options	Default Setting
Sensor 11				
_11611:102	Sensor 11SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 12				
_11611:103	Sensor 12SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.6.8.4 Information List

No.	Information	Data Class (Type)	Type
General			
_2311:53	GeneralHealth	CHS	O
_2311:54	GeneralFailure	SPS	O
Sensor 1			
_11611:52	Sensor 1Health	ENS	O
_11611:60	Sensor 1Failure	SPS	O
_11611:80	Sensor 1TmpOut	MV	O
Sensor 2			
_11612:52	Sensor 2Health	ENS	O
_11612:60	Sensor 2Failure	SPS	O
_11612:80	Sensor 2TmpOut	MV	O
Sensor 3			
_11613:52	Sensor 3Health	ENS	O
_11613:60	Sensor 3Failure	SPS	O
_11613:80	Sensor 3TmpOut	MV	O
Sensor 4			
_11614:52	Sensor 4Health	ENS	O
_11614:60	Sensor 4Failure	SPS	O
_11614:80	Sensor 4TmpOut	MV	O
Sensor 5			
_11615:52	Sensor 5Health	ENS	O
_11615:60	Sensor 5Failure	SPS	O
_11615:80	Sensor 5TmpOut	MV	O
Sensor 6			
_11616:52	Sensor 6Health	ENS	O
_11616:60	Sensor 6Failure	SPS	O
_11616:80	Sensor 6TmpOut	MV	O
Sensor 7			
_11617:52	Sensor 7Health	ENS	O
_11617:60	Sensor 7Failure	SPS	O
_11617:80	Sensor 7TmpOut	MV	O
Sensor 8			
_11618:52	Sensor 8Health	ENS	O
_11618:60	Sensor 8Failure	SPS	O
_11618:80	Sensor 8TmpOut	MV	O

No.	Information	Data Class (Type)	Type
Sensor 8			
_11618:52	Sensor 8Health	ENS	O
_11618:60	Sensor 8Failure	SPS	O
_11618:80	Sensor 8TmpOut	MV	O
Sensor 9			
_11619:52	Sensor 9Health	ENS	O
_11619:60	Sensor 9Failure	SPS	O
_11619:80	Sensor 9TmpOut	MV	O
Sensor 10			
_11611:52	Sensor 10Health	ENS	O
_11611:60	Sensor 10Failure	SPS	O
_11611:80	Sensor 10TmpOut	MV	O
Sensor 11			
_11611:57	Sensor 11Health	ENS	O
_11611:65	Sensor 11Failure	SPS	O
_11611:85	Sensor 11TmpOut	MV	O
Sensor 12			
_11611:57	Sensor 12Health	ENS	O
_11611:65	Sensor 12Failure	SPS	O
_11611:85	Sensor 12TmpOut	MV	O

5.6.8 RTD Unit, Serial

5.6.8.1 Overview

The RTD unit serial forwards

- Communication with an external RTD unit serial via the Siemens Protocol (SER) and returns the measured temperature from the RTD unit
- Provides the measured temperatures to the temperature supervision function
- Monitors communication with the RTD unit

The RTD unit Serial function is set up structurally in the same manner as the RTD unit Ether, function. The mode of operation is also identical (see Sec. 5.2 Communication with an RTD Unit).

5.6.8.2 Application and Setting Notes

Parameter Port

- Default setting (_2311:103) Port = F

With the Port parameter, you set the slot for the communication module that will be used for the connection with an external RTD unit.

If you want to connect the external RTD box to an Ethernet plug-in module, set the parameter Port = Port F. Port E Port F or plug-in module position.

Parameter Channel number

- Default setting (_2311:105) Channel number = 1

A serial communication module optionally owns 2 channels. With the Channel number settings, you set the channel number (1 or 2) through which the RTD unit is connected to the device. The communication module inputs are labeled with the channel numbers.

Parameter Slave address

- Default setting (_2311:104) Slave address = 2

Use the Slave address parameter to define the device address of the RTD unit. If only one RTD unit is connected to the serial bus, the default value 2 can be used. The same device address has to be set on the RTD unit. The device address is important for distinguishing among several RTD units connected to a serial bus. Set a unique device address (for example 1, 2 and 3 when connecting 3 RTD units) for each RTD unit and the same device address for the parameter Slave address in the 3 RTD unit serial functions.

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

Addr.	Parameter	C	Setting Options	Default Setting
General				
_2311:103	GeneralPort		• port E • port F • port J • port N • port P	port J
_2311:104	General.Channel number		1 to 2	1
_2311:106	General.Slave address		1 to 254	2
Sensor 1				
_11611:102	Sensor 1SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 2				
_11612:102	Sensor 2SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 3				
_11613:102	Sensor 3SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 4				
_11614:102	Sensor 4SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 5				
_11615:102	Sensor 5SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 6				
_11616:102	Sensor 6SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 7				
_11617:102	Sensor 7SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 8				
_11618:102	Sensor 8SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 9				
_11619:102	Sensor 9SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 10				
_11611:102	Sensor 10SensorType		• Pt 100 • Ni 100 • Ni 120	Pt 100

No.	Information	Data Class (Type)	Type
Sensor 9			
_11619:52	Sensor 9Health	ENS	O
_11619:60	Sensor 9Failure	SPS	O
_11619:80	Sensor 9TmpOut	MV	O
Sensor 10			
_11611:50	Sensor 10Health	ENS	O
_11611:60	Sensor 10Failure	SPS	O
_11611:80	Sensor 10TmpOut	MV	O
Sensor 11			
_11611:57	Sensor 11Health	ENS	O
_11611:65	Sensor 11Failure	SPS	O
_11611:85	Sensor 11TmpOut	MV	O
Sensor 12			
_11611:57	Sensor 12Health	ENS	O
_11611:65	Sensor 12Failure	SPS	O
_11611:85	Sensor 12TmpOut	MV	O

5.6.9 Communication with RTD Unit

5.6.9.1 Integration of a Serial RTD Unit (Zehnder YR1200)

Connection of the Communication Lines

Figure 5-59 shows how you connect the RTD box to the SIPROTEC 5 device. Note that only 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD A.

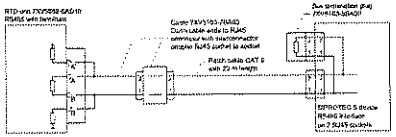


Figure 5-59 Connection of the RTD Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB 1EL or a USART-AC 2EL USART module (-.GIGE) to the device. The USART module must be inserted ahead of the plug-in positions for protection-operation modules in the base module or in the CB202 expansion module (refer to the following figure).

Figure 5-60 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Siemens Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the RTD units.

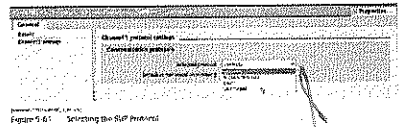


Figure 5-61 Selecting the SUP Protocol

Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the RTD box. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the RTD box. Make sure that the setting values in both devices are the same. The settings of the Baudrate and Parity parameters must be set identically in both devices.

NOTE

The driver for the USART module for the SUP protocol is not pre-installed as standard for the initial use of this interface (following the firmware update).

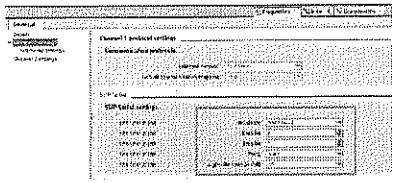


Figure 5-62 Making the Communication Settings

With the selection of the SUP protocol for the RTD box DIGSI 4 automatically adds the function group Analog units to your device configuration. You can now instantiate the function RTD box serial 1 (refer to the following figure).

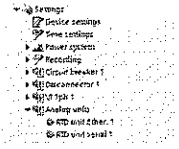


Figure 5-63 Analog Unit Instance

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the RTD box. This address must be the same value as the RTD box (refer to the following figure).
The following device configuration must be set on the TRI 200 RTD unit when the RTD unit is used for the first time:

- Bus protocol: mod
- Device address: 1
- Baud rate: 9600
- Parity: no

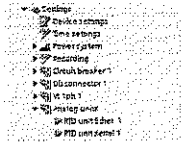


Figure 5-68 Analog Unit Instance

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the RTD box (refer to the following figure). This address must be set with the same value as the RTD box.

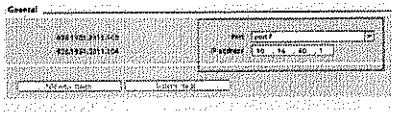


Figure 5-69 Setting the Port and IP Address

Finally, load the configuration to the device.

5.6.9.3 Temperature Simulation without Sensors

Connect a resistor on the sensor terminals of the RTD unit, using link contact. Simulate a constant temperature. The resistance value should be among 50 Ω to 250 Ω.
If you want to simulate a changeable temperature, connect an adjustable resistor of e.g. shown 470 Ω instead of a fixed resistor.

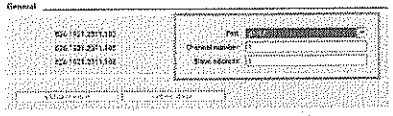


Figure 5-64 Set up the Port, Channel Number, and Slave Address

Finally, load the configuration to the device.

5.6.9.2 Integration of an RTD-Unit Ethernet (TRI 200 IP)

Device Configuration

In the DIGSI, insert an Ethernet module into the provided slot, thus adding the module to the device configuration. Picture 5-65 displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

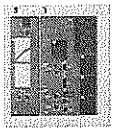


Figure 5-66 Inserting an Ethernet Module

Communication Settings

Activate the SUP Ethernet protocol for the Ethernet module.

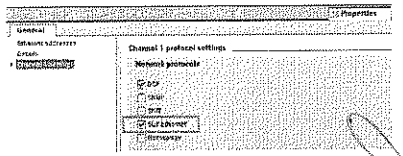


Figure 5-67 SUP Ethernet Protocol Activation (base module)

This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).

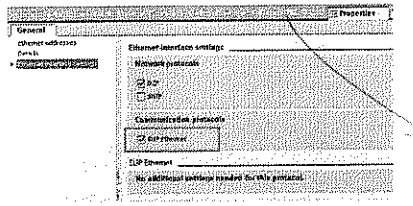


Figure 5-67 SUP Ethernet Protocol Activation (base module)

With the selection of the SUP protocol for the RTD unit, DIGSI automatically adds the Analog units function group and the RTD unit Ether. instance in your device configuration (refer to the following figure).

5.7 Process Monitor

5.7.1 Overview of Functions

All function groups that have functions with dependencies on the state of the protected object contain a process monitor. The process monitor checks the current state of the protected object.

5.7.2 Structure of the Function

The Process monitor function is used in the Standard VI 3-phase protection function group.
The Process monitor function is provided by the manufacturer with the following function blocks:

- Cold-load pickup detection (optional)
- Current-flow criterion
- Circuit breaker condition
- Closure detection

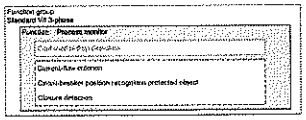


Figure 5-70 Structural Embedding of the Function

You can activate the cold-load pickup detection as needed. All other stages of the process monitor run permanently in the background and are not displayed in DIGSI.
The following figure shows the relationships of the individual function blocks.

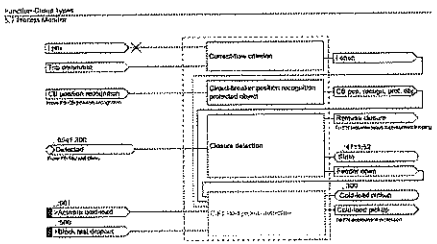


Figure 5-71 Logic Diagram of the Overall Function Process Monitor

5.7.3 Current-Flow Criterion

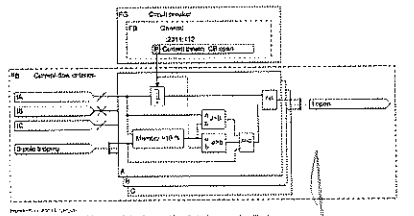


Figure 5-72 Logic Diagram of the Current-Flow Criterion function Block

The 3 ph tripping signal of the stage is generated if one of the following conditions is met:

- A single current falls below the set threshold of the Current threshold CB open parameter. The hysteresis amplifies the signal.
- The corresponding phase current, for example, I_A, falls below 10 % of the phase current with the trip command arrives. If the current does not then drop after a delay due to current flow through the load or an open pole can therefore be detected quickly even after a high-current fault in the line.

With the Current thresh. CB open parameter you define the minimum current as a criterion for a deactivated line. The parameter set in the Circuit-breaker function group. If set to both in the Circuit-breaker function group, for example circuit breaker condition recognition, and also for the current criterion in the Protection function group.

5.7.4 Application and Setting Notes (Current-Flow Criterion)

Parameter: Current thresh. CB open

- Recommended setting value (_:2311:112) Current thresh. CB open = 0.100 A

The Current thresh. CB open parameter is used to define the threshold for the leakage current as the criterion for a deactivated line.

Set the Current thresh. CB open parameter so that it is current transient when the feeder is deactivated, but below the value of the Current thresh. CB open parameter with certainty. The hysteresis is additionally active if the threshold is exceeded.

If parasitic currents, for example, due to induction, are ruled out when the feeder is deactivated, set the Current thresh. CB open parameter sensitively.

Siemens recommends a setting value of 0.100 A.

5.7.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Breaker settings				
_2111:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_2111:134	General:Op. mode CB P		• uncalculating • to query	uncalculating

5.7.6 Circuit-Breaker Condition for the Protected Object

Logic

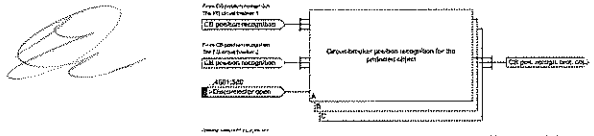


Figure 5-71 Logic Diagram of the Circuit-Breaker Condition for the Protected-Object Function Block

The circuit-breaker position recognition in the Circuit Breaker (CB) function group provides the result breaker condition by way of the internal signal CB pos. recogn. prot. obj..

If a protected object is supplied via 2 circuit breakers (1½ ... for example with the 1½ circuit-breaker layout, then the circuit breaker switch position of the protected object must be determined with the aid of both circuit breakers. In this case, the Circuit-breaker position recognition for the protected object function block compares the individual CB states. The corresponding parameter between CB pos. recogn. prot. obj. signal in the other function block via the internal marker and enables functions, for example, Trip in the event of weak infeed and Echo function for teleprotection method, within the same function group

If one of the following 2 conditions is met, the CB pos. recogn. prot. obj. signal is in the open state

- All currents of circuit breakers signal the open state really.
- The Disconnector open input is active.

If the following 2 conditions are met, the CB pos. recogn. prot. obj. signal is in the closed state

- At least one of the connected circuit breakers signals the closed state internally.
- The Disconnector open input is not active.

5.7.7 Closure Detection

The closure detection enables the immediate response of selected protection functions or protection stages when switching to a short circuit or the selection of the responsibility. The closure detection determines whether the protected object is switched on.

Logic

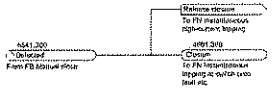


Figure 5-74 Logic Diagram of Closure Detection

For an applied binary input signal Detected from Manual close function block, the indication Closure is active.

5.7.8 Information List

No.	Information	Data Class (Type)	Type
Closure detect.			
_6641:300	Closure detect.:>CB-connection open	SPS	I
_6641:301	Closure detect. Closure	SPS	O

5.7.9 Cold-Load Pickup Detection (Optional)

Logic

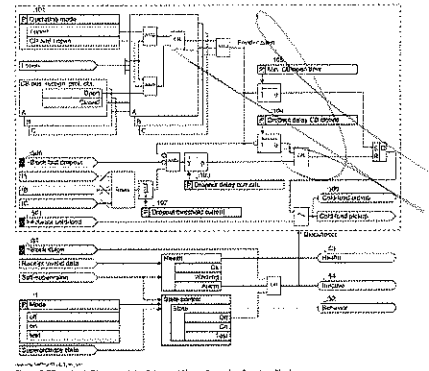


Figure 5-75 Logic Diagram of the Cold Load Pickup Detection Function Block

The Cold-load pickup detection function block prevents the, a specific time has been extended after deactivation of the line or protected object. If you want to connect the protected object again, you must note that an increased load-current requirement exists for a limited time after connection. This results from the nature of the load.

The Cold-load pickup detection function block ensures that different parameters are used for an adjustable time after connection. For example, for the time of the max. CB-open time parameter, you can increase the threshold value of a protection function or you can select a special characteristic curve.

If the Cold-load pickup detection function block detects an open feeder and the set time of the max. CB-open time parameter has expired, the indication Activate cold-load is generated.

With the Activate cold-load indication, you can activate a parameter set of the Cold-load pickup function. Via the binary input signal Activate cold-load, you can also activate the Activate cold-load indication directly.

If the Cold-load pickup detection function block detects closure and the corresponding load current, it starts the time set in the Dropout delay CB closed parameter. The Activate cold-load indication and the activated parameter set are deactivated after this time has elapsed.

If, for the time set in the Dropout delay max. calc. parameter, the maximum phase current falls below the threshold value Dropout threshold current, the parameter set for the Cold-load pickup detection function block is also deactivated. As a result, if the load current is very low, the actual time Dropout delay max. calc. of the Deactivate cold-load indicator can be shortened.

5.7.10 Application and Setting Notes (Cold-Load Pickup Detection)

NOTE

The settings and indications described in this chapter are only available when using the optional Cold-load pickup detection function block.

Parameter: Operating mode

- Default setting (_:101) Operating mode = Z open

With the Operating mode parameter, you set the criteria with which the Closure-detection function block operates.

Parameter Value	Description
Z open	When the Current-flow criterion function block detects a clearing open condition, the decision is made for pickup. For this setting, make sure that the Current thresh. CB open parameter is set lower than the possible load current, if this is not the case, open is operated continuously and each fault current that exceeds the Current thresh. CB open parameter is interpreted as closure.
CB and Z open	Closure is detected if one of the following conditions is met: • Analysis of the circuit-breaker auxiliary contact detects a clearing open condition in at least one phase. • The current-flow criterion detects a clearing open condition

Parameter: Dropout threshold current

- Default setting (_:102) Dropout threshold current = 1.00 A

With the Dropout threshold current parameter, you set the threshold at which the output signal Cold-load pickup is deactivated when the current in at least one phase falls below this threshold.

Parameter: Dropout delay current criterion

- Default setting (_:103) Dropout delay curr. crit. = 600 s

With the Dropout delay curr. crit. parameter, you set the time for which the actual value must be below the Dropout threshold current threshold so that the output signal Cold-load pickup can be deactivated prematurely.

Parameter: Dropout delay CB closed

- Default setting (_:104) Dropout delay CB closed = 3600 s

With the Dropout delay CB closed parameter, you set the action time for the dynamic parameter set switching in the event of cold load pickup detection.

Parameter: Max. CB open time

- Default setting (_:105) Max. CB-open time = 3600 s

With the Max. CB-open time parameter, you set the time with which the dynamic parameter set is activated in the event of cold-load pickup when the line is opened.

5.7.11 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Cold-load PU				
_:1	Cold-load PU:Mode		• off • on • test	off
_:101	Cold-load PU:Operating mode		• Inrush • CB and I open	I open
_:102	Cold-load PU:Dropout threshold current	1 A @ 100 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.000 A
_:103	Cold-load PU:Dropout delay curr.crit.		1s to 600s	600s
_:104	Cold-load PU:Dropout delay CB closed		1 s to 21600 s	3600 s
_:105	Cold-load PU:Max. CB-open time		1 s to 21600 s	3600 s

5.7.12 Information List

No.	Information	Data Class (Type)	Type
Cold-load PU			
_:81	Cold-load PU:Block stage	SPS	I
_:308	Cold-load PU:Block test dropout	SPS	I
_:311	Cold-load PU:Reset cold-load	SPS	I
_:54	Cold-load PU:Inactive	SPS	O
_:55	Cold-load PU:Behavior	ENC	O
_:56	Cold-load PU:Health	ENS	O
_:309	Cold-load PU:Cold-load pickup	SPS	O

5.8 Voltage Measuring-Point Selection

5.8.1 Overview of Functions

The function block Voltage measuring-point selection can:

- Provide the ability to switchover the voltage measuring points to be applied, if various voltage measuring points are connected to the voltage interface of the function group
- Select the correct voltage based on the switch position of the plant

If more than one voltage measuring points are connected to the same voltage interface of the function group, use the Voltage measuring point selection function block in the function group to select the correct voltage based on the switch position of the plant.

The Voltage measuring-point selection is a common functionality for the function groups of the protected objects.

5.8.2 Function Description

The Voltage measuring-point selection function block realizes the selection of voltage measuring points by a logic block chart. The logic block chart controls the input signal 3ph.-typ set/reset depending on the switch and state of disconnectors.

Example

Figure 5-76 shows an example of voltage measuring point selection for the filtering group Capacitor bank in a double busbar application.

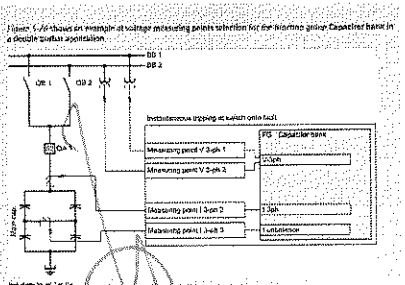


Figure 5-76 Double Busbar with Capacitor Bank

Connecting Measuring Points to Capacitor Bank Function Group

Figure 5-77 shows the connection of the function group Capacitor bank with several measurement points to assign the ID of each measuring point number in the function group.

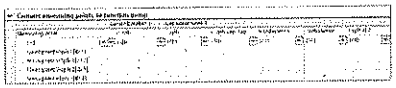


Figure 5-77 Connecting the Measuring Points with the Capacitor Bank Function Group

There are consistency checks that validate the connections of voltage measuring points to one function group:

- The connection type must be identical for all measuring points connected to the same interface of the function group.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- If more than 1 measuring point is connected to one voltage interface, a function block must be added to enable the selection of the voltage measuring points.

5.8.3 Application and Setting Notes

CFC Control

The voltage measuring point is selected by logic block chart on basis of the measuring point ID. If more than one measuring point is connected to the interface of the function group, instantiate the function block Voltage measuring point selection from the library in the corresponding function group.

In order to ensure the correct measuring point connection for the function group, a logic block chart has to define the actual valid IDs for the input *MP_ID selection* of the function block.

The following logic block chart implementation is based on the example given in Figure 5-76.

If the Disconnector 1 (QB1) is closed and no matter what the position the Disconnector 2 (QB2) is, the value 2 is the output of CFC block *Max_1* and transferred to the input *MP_ID selection*. Then, the Measurement V-Talk with ID 2 is selected as the reference voltage. Similarly, the Measurement V-Talk with ID 3 is selected as the reference voltage if the Disconnector 1 (QB1) is not closed (open or in intermediate position) while Disconnector 2 (QB2) is closed.

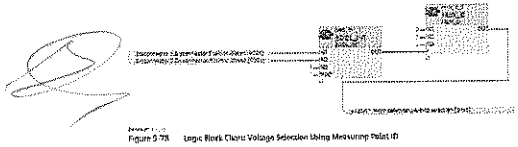


Figure 5-78 Logic Block Charts: Voltage Selection Using Measuring Point ID

However, the disconnectors might be both open or in a transient state. In this case, the input in3 of the block *Boot_Int_1* becomes true, the value 0 is used as the ID for voltage selection (input *MP_ID selection*). If ID 0 is selected, then all voltage values of the protection function group interface are set to 0 V immediately. No alarm indication *Selection Wrong Info* issued and the indication *Invalid* is issued as QC. In case you want to supply the function group with voltage values under the condition that both disconnectors are open or in transient state from one or the other busbar, you can alter the CFC chart respectively.

6.1 Introduction

6.1.1 Overview

The SIPROTEC 5 series of devices offers powerful command processing capability as well as additional functionalities that are needed when relying on bay controllers for the substation automation technology or when providing current protection. The object model for the devices is based on the IEC 61850 standard, making the SIPROTEC 5 series of devices ideally suited for use in systems employing the IEC 61850 communication protocol. In some of the function blocks necessary for the control functions, option logs are also used.

6.1.2 Concept of Controllables

The concept of so-called controllables is based on the data model described in IEC 61850. Controllables are objects that can be controlled, such as a switch with feedback. The model of a transformer tap changer , for example, contains controllables. The controllables are identifiable by their last letter CF of the data type (for example, DPC - Double Point Controllable/Double Command with feedback or BSC - Binary-Controlled Step Position Information / transformer tap command with feedback).

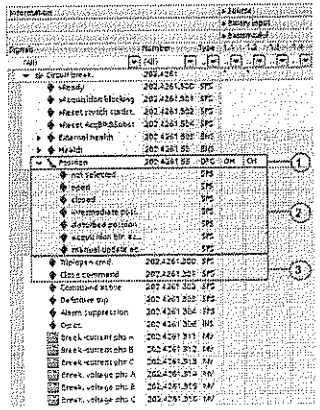
NOTE

An invalid measuring point selection (ID = 0 or an ID of a non-detected measuring point) for input *MP_ID selection* causes in the following:

- The voltage measured values are displayed as follows:
- The validity of the voltage measured values is set to invalid.
- The indication *Wrong Info* is set in Alarm.
- The indication *Selection Invalid* becomes true.

5.8.4 Information List

No	Information	Data Class (Type)	Type
V-MP_Select.on			
191	>MP selection (MP-ID selection	SPC	IS
193	V MP selected/health	ENS	DP
200	MP selection/selection invalid	SPS	DP



(1) Position (connects with binary inputs)
(2) Visualization of the current condition
(3) Command output (connect with relay)

The Ena, opening and the close commands are connected to the relays. For the trip command, a choice between valid and transient output is possible. The position is connected with 2 binary inputs (double point indication). In addition, signals are available that display the current state of the switch (not selected, off, on, intermediate position, disturbed position). These signals can be queried in CFC (for example, in order to build interlocking conditions).

Control Models

You can set the control mode of the controllables by selecting the control model.

6 Control Functions

4 different control models are available:

- Direct without feedback monitoring (direct w. normal secur.)
- Sbo (enhanced security) without feedback monitoring (SBO w. normal secur.)
- Direct with feedback monitoring (direct w. enh. security)
- With SBO with feedback monitoring (SBO w. enh. security)

The next figure shows the command sources, command types and control models.

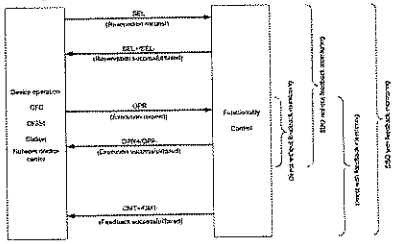


Figure 6-1 Command Sources, Command Types and Control Models

The figure shows the control models together with the respective control mechanisms (cycles). The standard control model for a switching component in an IEC 61850 compliant system is SBO with feedback monitoring (SBO w. enh. security). This control provides a high degree of safety for locally created switching devices.

6.2 Switching Devices

6.2.1 General Overview

The following switching devices can be found in the DIGSI 5 library in the Circuit-breaker and Switching-devices function groups (see the following images).

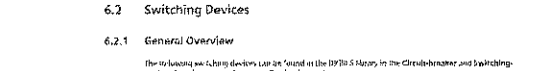


Figure 6-2 Selecting the Circuit-Breaker Switching Device Using the DIGSI Circuit-Breaker Function Group Library

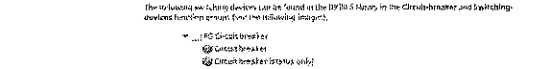


Figure 6-3 Selecting the Remaining Switching Devices Using the DIGSI Switching-Devices Menu

6.2.2 Switching Device Circuit Breaker

6.2.2.1 Structure of the Circuit Breaker Switching Device

This chapter describes the control properties of the circuit breaker switching device.
The circuit breaker switching device contains the following function blocks that are needed for control:

- Function block Circuit breaker
- Function block Control
- Function block Interlocking

This corresponds to the logical nodes XCBR, CSWI, and CILO in IEC 61850.
In the case of protection devices or combined protection and control devices, additional functions can be contained in the circuit breaker switching device, for example, synchrocheck, the automatic reclosing (ANSI), the trip logic or manual On function. However, these are not relevant for the control function. The description of these functions is in the chapter Protection and Automatic Functions.

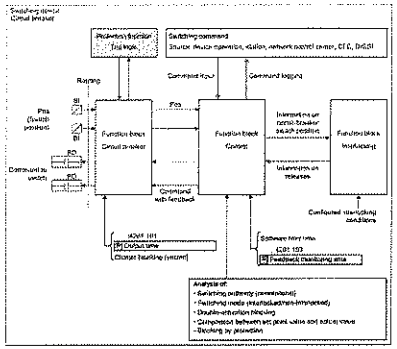


Figure 6-4 Control Function Blocks of the Circuit-Breaker Switching Device

The circuit breaker in DIGSI 5 is linked with the binary inputs that acquire the switch position via information routing. The circuit breaker in DIGSI is also linked with the binary outputs that issue the switching commands.
The circuit breaker switching device is available in 4 different types:

- 3-pole circuit breaker (control only)
  This switching device contains the Control, Interlocking, and Circuit-breaker function blocks needed for control. The standard situation for the control function is that the SIPROTEC 5 device switches all 3 poles of the circuit breaker On or Off together. The Synchronization function can also be added.
- 1-pole circuit breaker
  This switching device contains additional base function blocks for protection functions (for example, trip logic, Manual close, circuit-breaker test).
- 1-pole circuit breaker
  This switching device is intended for 1-pole tripping via the protection functions and contains the same base function blocks for protection as the 3-pole circuit breaker switching device.
- Circuit breaker (status only)
  This switching device contains only the Circuit-breaker function block. It is used to acquire the position of a switch, for example, from a switchgear bay. The object type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.

NOTE

Note: When the parameter of a device, you will find 3-circuit-breaker types in the DIGSI library:
- 3-pole circuit breaker (1 pole circuit breaker, depending on the device type selected it could or it have jumpers)
- Circuit breaker (status only)

Function Blocks of the Circuit Breaker

Table 6-1 Function Blocks of the Circuit-Breaker Function Group

Function Block	Description	Parameters	Function
Circuit breaker	The Circuit breaker function block, in the SIPROTEC 5 device represents the physical switch.	Output time	The circuit breaker forms the switch position from the information of the binary inputs and also outputs the commands via the binary outputs.
Control	Command processing	Control model SBO time-out Feedback monitoring time Check switching authority by Check if pos. is reached Check double activat. With Check blk. by protection	Command check, coordination with the command source and with the function block Circuit breaker
Interlocking	Switchgear interlocking protection	Interlocking position (direction) in CFC	The interlocking functionality recognizes the releases for switchgear interlocking protection.

The setting values of the parameter can be found in the chapter 6.2.2.2 Application and Setting Notes.

Additional Setting Options of the Circuit Breaker Switching Element

The setting options of the circuit breaker can optionally to the function blocks on the basis of their relevancy. Additional setting options of the circuit breakers that cannot be directly assigned to one of the 3 function blocks are nevertheless available:

Table 6-2 Setting Options of the Controllable Command with Feedback in the Control Function Block of the Circuit Breaker

Properties	Function	To Be Found in
Software filtering time	Software filtering time for position detection	Panel on of the Control[1] function block
Retrigger filter (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the Control[1] function block
Discharge time before filtering (yes/no)	Consideration of the hardware filtering time for position detection (live stamp)	Position of the Control[1] function block
Suppress intermediate position (yes/no)	When activated, only the intermediate position is suppressed by the duration of the software filtering time.	Position of the Control[1] function block

Properties	Function	To Be Found in
Treatment of spontaneous operation changes (from, software filt.Spont. software filt.)	If the General software filt.(ms) setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. By selecting Spontaneous software filter, a separate filtering is activated for spontaneous position changes.	Position of the Control[1] function block
Spontaneous software filtering time	Software filtering time for spontaneous position changes	Position of the Control[1] function block
Spontaneous switchgear filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the Control[1] function block
Spontaneous indication discharge before filtering (yes/no)	Consideration of the hardware filtering time for position detection (live stamp in case of a spontaneous change	Position of the Control[1] function block
Inhibit intermediate position for a spontaneous (yes/no)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the Control[1] function block

(1) First click Position and then click the Details button in the Properties window (below).

Table 6-3 Setting Options of the Controllable Function in the Circuit Breaker Function Block (Chatter Blocking)

Properties	Function	To Be Found in
Chatter blocking (yes/no)	Switching chatter blocking on/off	Position of the Circuit breaker[1] function block

(1) First click Position and then click the Details button in the Properties window (below).

Table 6-4 Additional Settings in the On-Line Settings Tuning Effort on the Circuit Breaker

Properties	Function	To Be Found in
Number of permissible motor changes	Chatter-blocking setting value: Once for the entire device	Device settings (can be found under Settings)
Chatter test time		
Number of chatter tests		
Chatter idle time		
Chatter check time		

The inputs and outputs as well as the setting options of the Circuit breaker and General function blocks are described in the next section (see 6.2.2.2 Connection Variants of the Circuit Breaker).

Interlocking

The Interlocking function block generates the releases for switchgear interlocking protection. The actual interlocking conditions are described in CFC. For more information on this, see chapter 6.2.1 Overview) Circuit and Feedback Interlocking Protection.

6.2.2.2 Application and Setting Notes

Circuit Breaker

The Circuit breaker function block in the SIPROTEC 5 device represents the physical switch device. The task of the circuit breaker is to replicate the switch position from the status of the binary inputs.
The following figure shows the logical inputs and outputs of the Circuit-breaker function block.

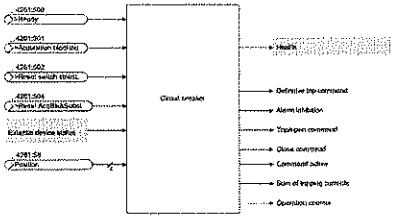


Figure 6-5 Logical Inputs and Outputs of the Circuit-Breaker Function Blocks

Table 6-5 and Table 6-6 list the inputs and outputs with a description of their function and type. For inputs, the effect of Quality = Invalid on the value of the signal is described.

EXAMPLE

If the signal >Ready has the Quality = Invalid, then the value is set to disabled, in problematic operating states, the circuit breaker should signal that it is not ready for an Off-On-Off cycle

Table 6-5 Inputs of the Circuit-Breaker Function Block

Signal Name	Description	Type	Default Value if Signal Quality = Invalid
>Ready	The signal >Ready indicates that the OFF-ON-OFF cycle is possible with the circuit breaker. This signal is used for the ANSI standby status	SPS	Ideim
>Acquisition blocking	The binary input activates acquisition blocking. The user can set this binary input with an external toggle switch.	SPS	Unchanged
>Manual Close/Close	Acquisition blocking and the subfunctions of the circuit breaker are reset with this input. If the input is activated, neither the actions on blocking and the subfunctions is blocked.	SPS	Unchanged
>Manual switch status	Actuing either (high), the binary input sets the position counter for the switch to the value 0.	SPS	Unchanged

Signal Name	Description	Type	Default Value if Signal Quality = Invalid
>External health	The binary input External health reflects the circuit-breaker status (Unhealthy) This input will be set by the CFC using the BUILD_SAFE block, in turn, BUILD_INC can query binary inputs that represent the conditions OK, Warning, Alarm (and reset of the function Trip-circuit supervision)	EKS	Unchanged
Position	The signal Position can be used to read the circuit breaker position with double-point indication.	DPC	Unchanged

If the quality of the input signal assumes the status Quality = Invalid, then the standby status (Health) of the Circuit-breaker function block is set to Warning.

Table 6-6 Outputs of the Circuit-Breaker Function Block

Signal Name	Description	Type
Definitive trip	Protection has finally been tripped.	SPS
Alarm suppression	The signaling contact for external alarm suppression is suppressed during the runtime of automatic reclosing (optional) as well as during the command output or switching commands.	SPS
Op.cnt.	The information counts the number of switching cycles of the circuit breaker.	CNT
Trip/open cmd.	This logic output is responsible for the command output Off.	SPS
Close command	This logic output is responsible for the command output On.	SPS
Command active	The binary output Command active is responsible for signaling a running command (relay action or valid/set switching device (SbI))	SPS
CB open hours	The statistic value counts the hours the circuit breaker is open	MV
Operating hours	The statistic value counts the hours where at least one phase current is greater than the current thresh. CB open parameter.	MV

Control

It is the task of the controls to execute command checks and establish communication between the command source and the circuit breaker. Using the control settings, you specify how the commands are to be processed through the function SBO (Select before Operate, one option[1]) reserves the switching device prior to the actual switching operation, thus it remains locked for additional commands. Feedback monitoring provides information about the outcome of the command while the command is in process. The reason, information, indication or that the command was implemented successfully. These two options enable external individuals or the selection of the control model, so that 4 combinations in total are available (see the following table).
The control models the following settings available (see also table).

Parameters	Default Setting	Possible Parameter Values
C_\2201:101 Control model	SBO w. enh. security	Interlocked, normal secur. SBO w. normal secur. Direct w. enh. security Direct w. norm. security
C_\2201:102 SBO time-out	30.00 s	0.01 s to 1800 s Increment 0.01 s
C_\2201:103 Feedback monitoring time	1.00 s	0.01 s to 1800 s Increment 0.01 s

[1] In the SBO (Select before Operate) interlocking method, the switching device is reserved before the command is issued.

Parameter	Default Setting	Possible Parameter Values
(_:4201:104) Check switching authority	yes	no yes w/o current
(_:4201:105) Check bf pos. at reaching	yes	no yes
(_:4201:106) Check double actuat. blk.	yes	no yes
(_:4201:107) Check blk. by protection	yes	no yes

The following figure shows the logical inputs and outputs of the Control function block.

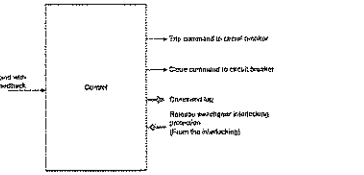


Figure 6-6 Logical Inputs and Outputs of the Control Function Block

Table 6-7 Control Function Block: Input and Output

Signal Name	Description	Type	Value (if Signal) Quality-Bmuable
Cmd. with Feedback:	With the Cmd. with Feedback signal, the circuit breaker position is accepted via the double-point indication of the circuit breaker function block and the command is submitted.	Controllable (DPC) Unchanged	Unchanged

In the information routing of DIGSI 5, you may assign a function key as a possible command source. In addition, it is displayed here if the command is act valued by CFC. The logging is routed here.

6.2.2.3 Connection Variants of the Circuit Breaker

For each switching device, you can establish the number of poles (for example, 1-pole, 1.5-pole or 3-pole) that are switched with or without feedback. The results in the necessary amount of information to be processed, thus establishing the command type.

Whether the circuit breaker is triggered 1-, 1.5-, or 3-phase, depends on the design of the auxiliary and control-voltage system. In most cases, the actuation of the opening coil of the circuit breaker is 3-pole.

Table 6-8 Meaning of the Abbreviations of the Connection Variants

Abbreviation	Meaning of the Abbreviations of the Connection Variants
PD	Binary output

Abbreviation	Meaning of the Abbreviations of the Connection Variants
1	Single-pole
3	Trip command
1pol	Close command

Table 6-9 Meaning of the Abbreviations in DIGSI

Abbreviation	Description of the Input in DIGSI
U	Blocked trip command Click the right mouse button and enter U.
Y	Close command Click the right mouse button and enter Y for the respective binary output.
OH	The switching device feedback is in the position OFF, if there is voltage at the routed binary input (H). Click the right mouse button and enter OH.
OL	The switching device feedback is in the position OFF. If there is no voltage at the routed binary input (L). Click the right mouse button and enter OL.
EH	The switching device feedback is in the position ON, if there is voltage at the routed binary input (H) Click the right mouse button and enter EH.
EL	The switching device feedback is in the position ON, if there is no voltage at the routed binary input (L). Click the right mouse button and enter EL.
TL	Trip command closed Click the right mouse button and enter TL.

Connection Variant: 3-Pole Circuit Breaker

Only the standard type for the control function. All 3 individual poles of the circuit breaker are triggered together by a double command.

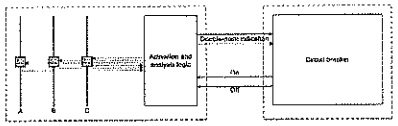


Figure 6-7 3-Pole Circuit Breaker

1-Pole Triggering

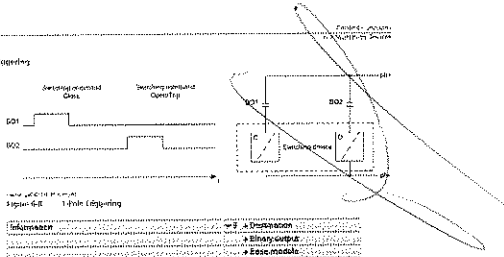


Figure 6-8 1-Pole Triggering

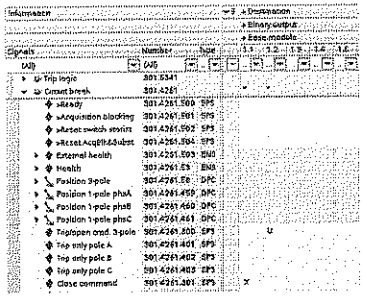


Figure 6-9 1-Pole Triggering, Routing in DIGSI

You can select the contacts for 1p and 3PP as desired. They need not necessarily be next to one another. The letter U represents an unlatched command. Alternatively, TL (latched tripping) may be selected.

1.5 Pole Triggering

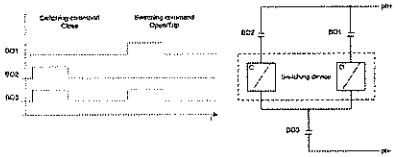


Figure 6-10 1.5-Pole Triggering

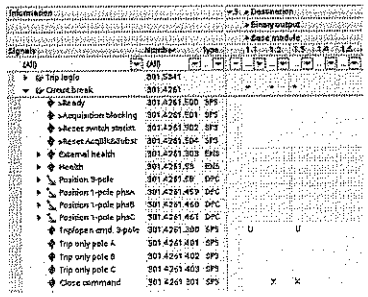


Figure 6-11 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering

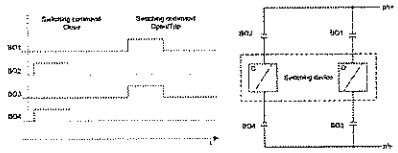


Figure 6-12 2-Pole Triggering

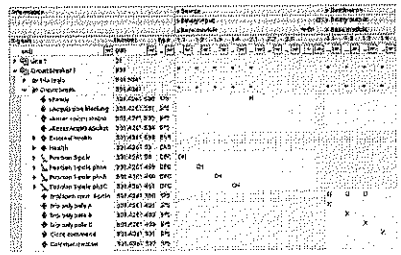


Figure 6-13 2-Pole Triggering, Routing in DIGSI

Connection Variant: 1-Pole Circuit Breaker

The 1-pole circuit breaker is used for separate actuation and acquisition of the individual poles of a circuit breaker. It is intended for common use by 1-pole switching interlocking and control functions.

NOTE

The number of the circuit-breaker function group with binary inputs and binary outputs occurs once per device.

The control function in this type switches all 3 poles on or off simultaneously.

The protection functions can switch off 1-pole. The close command is always 3-pole. Optionally, only the open poles close.

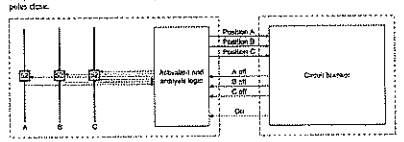


Figure 6-14 Circuit Breaker with 1-Pole Triggering

For the circuit breaker with 1-pole triggering, triggering takes place via one relay per phase for the trip command and via a 4th relay for the close command (see next figure).

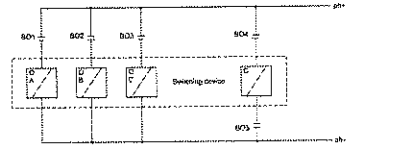


Figure 6-15 1-Pole Connection of a Circuit Breaker

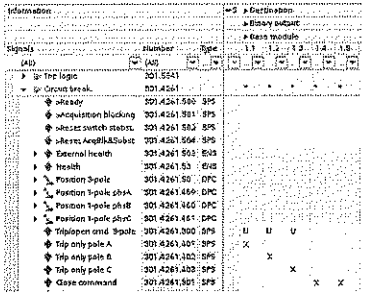
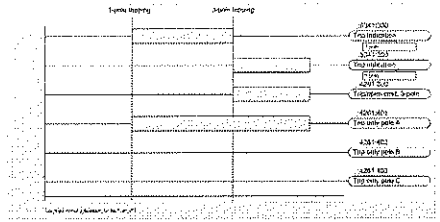


Figure 6-16 Routing in DIGSI

In the previous figure, the switch is connected 1-pole. The protection trip command is routed individually for the 3 phases (Trip only pole A to Trip only pole C). The protection trip command is routed for the 3 phases (Trip/open cmd. 3-pole). The control will always switch all the 3 poles of the switch. In addition, the 3 SI (unlocked) allocations of the activation and trip command are set to 3 pole. This routing is also used by protection functions that trip 3 poles. The close command is issued simultaneously for all 3 phases.

Example: Trip Command during Transition from 1-Pole to 3-Pole

During a transition from 1-pole to 3-pole tripping, Trip only pole A remains active. To inform, for example, an external ARC whether it is a 1 pole or 3 pole trip, you can use the indication Trip logic command. Configure the binary 2-pole and Trip logic command 3-pole.



Acquisition of the Circuit Breaker Position

The routing of the binary signals for feedback of the switch position is done as shown in the example figure below (see Chapter 6.2.3.1 Arrangement of Circuit Breaker Auxiliary Contacts and Further Information) 6.2.5.3 Acquisition of Circuit-Breaker Feedback Contacts and Further Information).

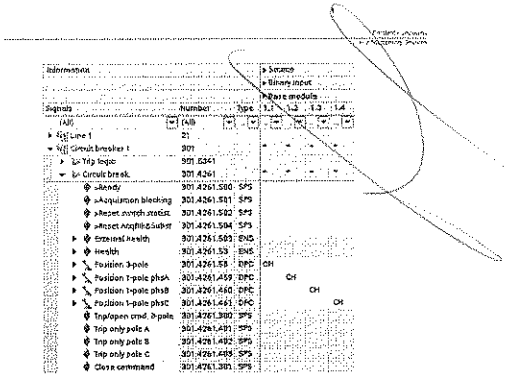


Figure 6-17 Routing of the 1-Pole in DIGSI

The meaning of abbreviations can be found in Table 6-8 Table 6-9.
The indication Command overview contains the routed in a binary output. This binary output is always active if either an On or trip command is pending, or the switching device was selected by the command control.

6.2.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Gen. Fac. Equipment				
_2311:101	Gen/mot/station nominal current		0.20 A to 10000.00 A	1000.00 A
_2311:102	General Rated Voltage		0.20 kV to 1200.00 kV	400.00 kV
Breaker Settings				
_2311:112	Nominal Current Quasi. CB open	1 A 2000 listed	0.030 A to 10.000 A	0.100 A
		5 A 2000 listed	0.150 A to 50.000 A	0.500 A
		1 A 2000 Index	0.030 A to 10.000 A	0.100 A
		5 A 2000 listed	0.150 A to 50.000 A	0.500 A
		1 A 2000 listed	0.005 A to 1.600 A	0.100 A
		5 A 2000 Index	0.005 A to 8.000 A	0.500 A
_2311:136	General Op. mode BFP		unbalancing I-quot	unbalancing

Addr.	Parameter	C	Setting Options	Default Setting
Trip Logic				
_6341:105	Trip logic mode of trip command		with 1P with 1P & 3P cmd. contact with 3P cmd	with 1P
Circuit break.				
_4761:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
Manual close				
_6541:101	Manual close Active time		0.01 s to 60.00 s	0.30 s
Control				
_4201:101	Control:Control mode		static only dir.w. manual recur. SBO w. normal recur. dir.w. enh. security SBO w. enh. security	SBO w. enh security
_4201:102	Control:SBO time out		0.01 s to 1800.00 s	30.00 s
_4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.50 s
_4201:104	Control:Check switching authority		off yes adapted	yes
_4201:105	Control:Check 1 pos. is reached		no yes	yes
_4201:106	Control:Check double activat. blk		no yes	yes
_4201:107	Control:Check blk. by protection		no yes	yes
Switching authority				
_4201:151	Control:Sw. dev. relays sw.auth		0 1	false
_4201:152	Control:Specific sw. authorities		0 1	true
_4201:115	Control:Specific sw.auth. refer for		Voltage Station+Voltage remote	station+remote
_4201:153	Control:Num. of specific sw.auth		2 to 3	2
_4201:154	Control:Multiple specific sw.auth.		no yes	false
CB Tests				
_6157:101	CB test:Dead time		0.00 s to 60.00 s	0.10 s

6.2.2.5 Information List

No.	Information	Data Class (Type)	Type
Trip Logic			
_6341:300	Trip logic:Trip initiation	ACT	O
Circuit break.			
_4761:300	Circuit break.:Ready	SPS	I

No.	Information	Data Class (Type)	Type
_4761:301	Circuit break.:Acquisition blocking	SPS	I
_4761:302	Circuit break.:Reset switch status	SPS	I
_4761:304	Circuit break.:Reset Ana&Subst	SPS	I
_4761:303	Circuit break.:External health	ENS	I
_4761:313	Circuit break.:Health	ENS	O
_4761:58	Circuit break.:Position	DPC	C
_4761:300	Circuit break.:Trip/open cmd.	SPS	O
_4761:301	Circuit break.:Close command	SPS	O
_4761:302	Circuit break.:Command block.	SPS	O
_4761:316	Circuit break.:Definitive trip	SPS	O
_4761:304	Circuit break.:Alarm suppression	SPS	O
_4761:306	Circuit break.:Op. cy.	ENS	O
_4761:307	Circuit break.:CB ris.	BCR	O
_4761:308	Circuit break.:CB fis.	BCR	O
_4761:309	Circuit break.:CB Blk.	BCR	O
_4761:310	Circuit break.:IC Blk.	BCR	O
_4761:311	Circuit break.:Break.current phs A	MV	O
_4761:312	Circuit break.:Break.current phs B	MV	O
_4761:313	Circuit break.:Break.current phs C	MV	O
_4761:314	Circuit break.:Break.voltage phs A	MV	O
_4761:315	Circuit break.:Break.voltage phs B	MV	O
_4761:316	Circuit break.:Break.voltage phs C	MV	O
_4761:317	Circuit break.:CB open hours	BIN	O
_4761:318	Circuit break.:Operating hours	BIN	O
Manual close			
_6541:301	Manual close:Block manual close	SPS	I
_6541:300	Manual close:Input	SPS	I
_6541:302	Manual close:Detected	SPS	O
Reset LED Group			
_5 (.041:309	Reset LED Group:LED reset	SPS	I
_(5381:309	Resets LED Group:LED have been reset	SPS	O
Control			
_4201:300	Control:Sw. authority local	SPS	I
_4201:301	Control:Sw. authority remote	SPS	I
_4201:305	Control:Sw. mode interlocked	SPS	I
_4201:306	Control:Sw. mode non-interl.	SPS	I
_4201:311	Control:Health	ENS	O
_4201:58	Control:Cmd. with feedback	DPC	C
_4201:307	Control:Switching auth. station	SPC	I
_4201:308	Control:Enable sw. auth. 1	SPC	C
_4201:309	Control:Enable sw. auth. 2	SPC	C
_4201:310	Control:Enable sw. auth. 3	SPC	C
_4201:311	Control:Enable sw. auth. 4	SPC	I
_4201:312	Control:Enable sw. auth. 5	SPC	I
_4201:313	Control:Switching authority	ENS	O
_4201:314	Control:Switching mode	SPC	O

No.	Information	Data Class (Type)	Type
Interlocking			
_1231:330	Interlocking:Enable operating	SPS	I
_4231:301	Interlocking:Enable closing	SPS	I
_4231:302	Interlocking:Enable opening(fixed)	SPS	I
_4231:303	Interlocking:Enable closing (fixed)	SPS	I
_4231:314	Interlocking:Health	ENS	O
CB Tests			
_6157:53	CB test:Is etb	SPS	O
_6157:301	CB test:Cmd permission	ENS	O
_6157:302	CB test:Cmd command issued	SPS	O
_6157:303	CB test:Close command issued	ENS	O
_6157:304	CB test:Test canceled	ENS	O
_6157:313	CB test:Cycle open-close	SPC	C

6.2.3 Disconnector Switching Device

6.2.3.1 Structure of the Disconnector Switching Device

Like the circuit breaker, the disconnector switching device contains the following 3 function blocks:

- Function block Disconnector
- Function block Control
- Function block Interlocking

This corresponds to the logical nodes XSWI, CSWI and CILO in IEC 61850.

NOTE

In contrast to the Circuit breaker switching device, the Disconnector switching device cannot contain any additional functions because protection functions or synchronization can have no effect on the disconnector.

The following figure shows the structure of the Disconnector switching elements:

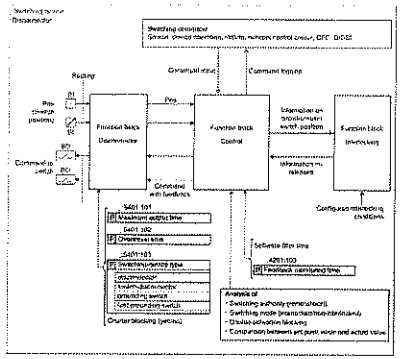


Figure 6-18 Control-Integrated Function Blocks of the Disconnector Switching Device

The Disconnector switching device behaves like the Circuit-Breaker switching device. The only difference is the designation of the function block that the physical switch provides (Disconnector instead of circuit breaker). Blocking by protection is not provided in the analysis of the Control function block.

The Disconnector switching device is available in the DIGSI 5 library in 2 different variants:

- **Disconnector with 3-pole connection**
  The device switches all 3 poles of the disconnection on or off simultaneously.
- **Disconnector without triggering (only status detection, no control)**
  This variant is rarely encountered. It is encountered with grounding switches that frequently cannot be controlled, but only monitor their current position. In addition, the position of a disconnector in a neighboring bay can be acquired.

Function Functions
6.2 Switching Devices

Function Blocks of the Disconnector

Table 6-10 Function Blocks of the Disconnector Function Group

Function Block	Description	Settings	Function
Disconnector	The function block represents the physical switch in the SIPROTEC 5 device.	Switching device type Switchgear device type	The disconnector indicates the switch position from the status of the binary inputs and also transmits the command via the binary outputs.
Control	Function processing	Control model SBO time-out Feedback monitoring time Switching authority Check if pos. is reached Check double activat. blk.	Command check, communication with the command source and with the function block disconnector
Interlocking	Switching and interlocking prevention	Interlocking condition (separated in CFC)	The Interlocking function may generate the releases for switchgear interlocking protection.

The setting values of the parameter can be found in the chapter 6.2.3.2 Application and Setting Notes.

Additional Settings of Disconnector Switching Element

The settings of the 6 components are assigned to the function blocks on the basis of their relevance. Additional disconnector settings that cannot be directly assigned to one of the 3 function blocks are are identical to the circuit-breaker settings are available.

Table 6-11 Setting positions of the Controllable **Command with feedback** in the Control function block of the Circuit Breaker

Properties	Function	To Be Found in
Software filtering time	Software filtering time for position detection	Position of the Control[1] function block
Retrigger filter (pulse)	Switching retriggering of the filtering time onset by changing the position	Position of the Control[1] function block
Message time before filtering (pulse)	Consideration of the hardware filtering time for position detection time stamp	Position of the Control[1] function block
Suppress intermediate position (pulse)	When activated, only the intermediate position is suppressed by the duration of the software filtering time.	Position of the Control[1] function block

Control Functions
6.2 Switching Devices

Properties	Function	To Be Found in
Spontaneous position changes filter-2 by hardware filtering	If the dynamic software filter should be activated, the general settings for optional filtering of spontaneous position changes and for position changes caused by a switching command apply. By selecting Spontaneous software filter, a software filtering is activated for spontaneous position changes.	
Spontaneous software filter name	Software filtering time for spontaneous position changes	Position of the Control[1] function block
Spontaneous retrigger (pulse)	Switching onset retriggering of the filtering time by spontaneous position change	Position of the Control[1] function block
Spontaneous indication timestamp before filtering (pulse)	Consideration of the hardware filtering time for position detection time stamp in case of a spontaneous change	Position of the Control[1] function block
Spontaneous suppress intermediate position (pulse)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the Control[1] function block

(1) First click Position and then the Details key in the Properties window (below).

Table 6-12 Setting positions of the Controllable Device in the Disconnector Function Block (Feeder Blocking)

Properties	Function	To Be Found in
Feeder blocking (pulse)	Switching feeder blocking input	Position of the Disconnector[1] function block

(1) First click Position and then the Details key in the Properties window (below).

Table 6-13 Additional Settings in the Circuit Settings with effect on the Disconnector

Properties	Function	To Be Found in
Number of permissible state changes	Chatter-blocking setting which does for the entire device	Device settings (can be found under Settings)
Chatter test time		
Number of chatter bursts		
Chatter dead time		
Chatter test time		

The inputs and outputs as well as the setting options of the Disconnector switch function block are described in the next chapter (see 6.2.3.3 Trigger Variants of the Disconnector). The Control function block is described identically as the Circuit-Breaker function block, with the exception that the command check, blocking a switchable through protection units, with the circuit breaker.

More information on this, it can be found in chapter 6.2.2.2 Application and Setting Notes.

Interlocking

The Interlocking function block generates the releases for switchgear interlocking protection. The actual interlocking conditions are determined in CFC. For more information on this, see section 6.2.1 Commons/ *Create and Interlocking Interlocking Function*.

Control Functions
6.2 Switching Devices

6.2.2.2 Application and Setting Notes

Disconnector

The disconnector represents the physical switch in the SIPROTEC 5 device. The task of the disconnector is to replicate the switch position from the status of the binary inputs.

The Disconnector function block is linked automatically via the information matrix with the binary inputs that register the switch position and with the binary outputs that issue the switching commands.

The Disconnector function block creates the following settings available (see next table):

Settings	Default Setting	Possible Parameter Values
(_:5401:101) Maximum output time	30.00 s	0.01 s to 1800 s (increments: 0.01 s)
(_:5401:102) Operating time	0.00 s	0 s to 60 s
(_:5401:103) Switching device type	disconnector	switch-disconnector disconnector switch-disconnector with grounding switch fast grounding switch

NOTE

The parameter **Switching device type** is effective only on the IEC 61850 interface. This parameter is used to set the disconnector type for communication via an IEC 61850 interface. It is a mandatory data object in the IEC 61850 standard.

The following figure shows the logical inputs and outputs of the Disconnector function block.

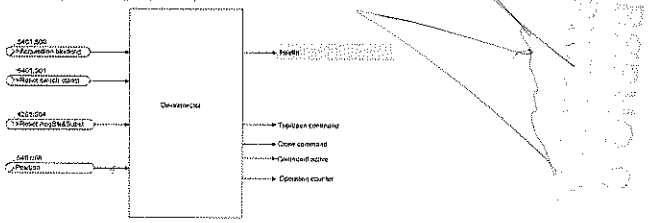


Figure 6-19 Logical Inputs and Outputs of the Disconnector Function Block

Table 6-14 and Table 6-15 list the inputs and outputs with a description of their function and type. For inputs, the effect on **Quality = invalid** on the value of the signal is described.

Control Functions
6.2 Switching Devices

Table 6-14 Inputs of the Disconnector Function Block

Signal Name	Description	Type	Value if Signal Quality=Invalid
>Acquisition blocking	The binary input activates acquisition blocking. You can also set this binary input with an external toggle switch.	SPS	Unchanged
>Reset equipment status	Acquisition blocking and the substitution of the circuit breaker are reset with this input. If the input is still present, setting of the acquisition blocking and of the substitution is blocked.	SPS	Unchanged
>Reset switch statistics	The binary input resets the operation counter for the switch to the value 0.	SPS	Unchanged
Position	The binary input Position can be used to read the disconnector position with double point indication.	DPC	Unchanged

If the quality of the input signal assumes the status **Quality = invalid**, then the standby status (setting) of the **Disconnector** function block is set to *warning*.

Table 6-15 Outputs of the Disconnector Function Block

Signal Name	Description	Type
Open command	This binary output is responsible for the command output Off	SPS
Close command	This binary output is responsible for the command output On	SPS
Command active	The binary output Command active is a running command for the application (command active or selected switching device). During Command active either an On or Off command is active.	SPS
Op. etc.	The information counts the number of disconnector switching cycles.	IOS

Control

It is the task of the control to execute command inputs and establish communication between the command source and the disconnector. Using the control settings, you specify how the commands are to be processed, (through the function SBO [Select Before Operate, enumeration*]) select, the switching device type or the output switching function, that is needed, to send additional commands. Feedback monitoring provides information about the initiator of the command with the command is processed, that means, information whether or not the command was interfered-free successfully. Three feedback options can be selected individually in the selection of the control model. In the 4 configurations in total are available (see the following table).

The control model has the following settings available (see next table):

Settings	Default Setting	Possible Parameter Values
(_:4201:1003) Control model	SBO w. enh. security[1]	direct w. normal secur. SBO w. normal secur. direct w. enh. security SBO w. enh. security
(_:4201:100) SBO time-out	30.00 s	
(_:4201:103) Feedback monitoring time	10.00 s	

* As standard IEC 61850, terminology is used here as Select before Operate (SBO)
** The default setting is the standard control model for a switching combination in IEC 61850-compliant systems.

Control Functions
6.2 Switching Devices

Settings	Default Setting	Possible Parameter Values
(_:4201:104) Check switching authority	yes	no yes command
(_:4201:105) Check if pos. is reached	yes	no yes
(_:4201:106) Check double activat. blk.	yes	no yes

6.2.3.3 Trigger Variants of the Disconnector

The activation types are identical to those for the circuit breaker. The meaning of abbreviations can be found in 6.2.2.3 Connection Variants of the Circuit Breaker and 6.2.2.3 Connection Variants of the Circuit Breaker. Whether the disconnector is triggered for 1 , 1.5 , or 2 pulses depends on the design of the auxiliary and control voltage system.

1-Pole Triggering

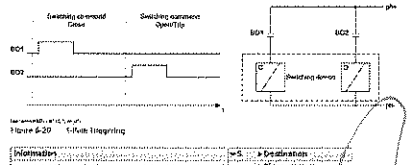


Figure 6-20 1-Pole Triggering

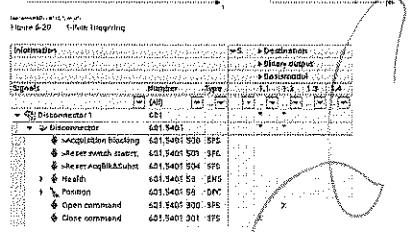


Figure 6-21 1-Pole Triggering, Routing in DIGSI

You can select the elements for on and OFF as desired. They need not necessarily be next to one another.

1-Pole Triggering

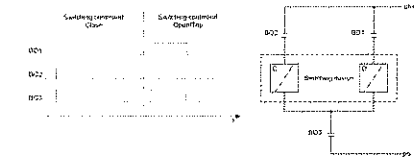


Figure 6-22 1-Pole Triggering

Information								Destination Binary output Bestmodel			
Signals		Number	Type								
		(All)									
Disconnector 1		401									
Disconnector		401.5401									
>Acquisition blocking		401.5401.500	SPS								
>Reset switch status		401.5401.501	SPS								
>Reset Acq.blk.&Subst.		401.5401.504	SPS								
Health		401.5401.55	ENS								
Position		401.5401.56	DPC								
Open command		401.5401.300	SPS			X		X			
Close command		401.5401.301	SPS				X		X		

Figure 6-23 1-Pole Triggering, Routing in DIGSI

2-Pole Triggering

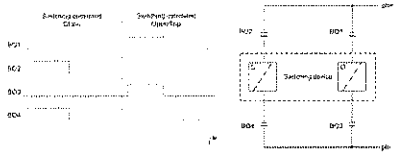


Figure 6-24 2-Pole Triggering

Information								Destination Binary output Bestmodel			
Signals		Number	Type								
		(All)									
Disconnector 1		401									
Disconnector		401.5401									
>Acquisition blocking		401.5401.500	SPS								
>Reset switch status		401.5401.501	SPS								
>Reset Acq.blk.&Subst.		401.5401.504	SPS								
Health		401.5401.55	ENS								
Position		401.5401.56	DPC								
Open command		401.5401.300	SPS			X		X			
Close command		401.5401.301	SPS				X		X		

Figure 6-25 2-Pole Triggering, Routing in DIGSI

The feedback is routed via the position with the disconnector.

6.3.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Disconnector				
5401:105	Disconnector:Maximum output time		0.01 s to 1800.00 s	10.00 s
5401:107	Disconnector:Overtravel time		0.00 s to 60.00 s	0.00 s
5401:103	Disconnector:Switching device type		• switch-disconnector • disconnector • grounding switch • fast grounding switch	disconnector

6.3.3.5 Information List

No.	Information	Data Class (Type)	Type
Disconnector			
5401:500	Disconnector:>Acquisition blocking	SPC	C
5401:501	Disconnector:>Reset switch status	SPS	I
5401:504	Disconnector:>Reset Acq.blk.&Subst.	SPS	I
5401:55	Disconnector:Health	ENS	O
5401:58	Disconnector:Behavior	BAC	O
5401:300	Disconnector:Close command	SPC	C
5401:301	Disconnector:Open command	SPC	C
5401:302	Disconnector:Cam wand active	SPS	O
5401:305	Disconnector:Blocked	SPS	O

6.3 Control Functionality

6.3.1 Command Checks and Switchgear Interlocking Protection

Before switching commands can be issued by the SIPROTEC 5 device, several steps are used to check the commands:

- Switching mode (interlocked/non-interlocked)
- Switching authority (local/DIGSI/station/remote)
- Switching direction (set-actual)
- Bay interlocking and substation interlocking
- 1-out-of-n check (double-activation blocking)
- Blocking by protection function

Confirmation IDs

SIPROTEC 5 devices offer the ability to safeguard various operations with confirmation IDs. The following confirmation IDs from the Safety menu apply to the control functions:

Figure 6-26 Confirmation IDs in DIGSI 5: Settings Menu

The following table identifies the meanings of the confirmation IDs:

Table 6-16 Relevant Confirmation IDs for Controls

Confirmation ID	Meaning	Description
SetSubstate	Changing settings	The confirmation ID is requested before device parameters can be changed.
Control (process)	Control release for control of switching devices	The confirmation ID is usually not known for key (unlocked), in the case of protection devices, this confirmation ID can be used to safeguard control of switching devices.
Control (non-interlocked)	Switching non-interlocked	Switching mode: Release for switching without querying the interlocking conditions (01 operation). The device interlocking conditions (for example, reusable operating (closed) and reusable allowing (closed)) are still queried if this is set in the params ters. The confirmation ID is needed only, for devices without a key switch; otherwise it is required with the key switch position.

Confirmation ID	Meaning	Description
Switching Authority	Release for switching authority Local	The confirmation ID is queried only for devices without a key switch; otherwise it is released with the key switch position.

The confirmation IDs are preset with the following values:

- SetSubstate: 222222
- Control (process, interlocked): 333333
- Control (non-interlocked): 444444
- Switching authority local: Manish

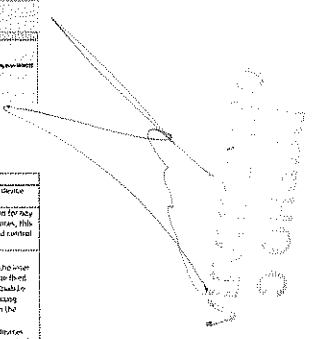
If you have configured a device with key switches, the confirmation IDs for non-interlocked switching and switching authority are not displayed or editable in DIGSI; the function is handled by the position of the key switch.

To increase security, change these codes (with DIGSI).

Switching Mode (interlocked/non-interlocked)

The switching mode determines whether or not the switchgear interlocking that has been configured in the CFC is checked before the command is output.

You can change the switching mode with the key switch S1 (interlocking withcommand). For devices without a key switch, you can change the switching mode with a corresponding menu item on the display (after entering a confirmation ID). You can also set the switching mode for switching commands from the sources DIGSI, station or remote.



DANGER

If the switching mode – non-interlocked, the switchgear interlocking protection is shut off

Erroneous switching operations can lead to severe or fatal injuries.

- Ensure manually that all checks have been implemented.

In addition, you can set the switching mode directly with a binary input or CFC, via the General function block (see next figure).

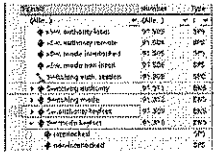


Figure 6-27 Switching Mode in Function Block General

The following table shows the effects of changing the switching mode to non-interlocked check.

Table 6-17 Relationship between Switching Mode and Command Checks

Command Check	Switching Mode	
	Interlocked	Non-interlocked
Switching Authority	Checked	Checked
Switching direction (set-actual)	Checked	Checked
Feedback interlocking conditions	Checked	Checked
Interlocking conditions	Checked	Not checked
1 out-of-n check (double activation blocking)	Checked	Not checked
Blocking by protection function	Checked	Not checked

Switching Authority

The switching authority determines which command sources are allowed. The following command sources are available:

- **Local:**
  A switching command from the local control (choice of error source Location) is possible only if the switching authority is set to Local and the device is capable of local operation. Setting the switching authority to Local is typically accomplished with key switch S5 (if established). In this case, commands from all other sources are rejected. If the switching authority is set to Local, the setting cannot be changed remotely.
- **DIGSI:**
  A switching command from DIGSI (connected via USB or Ethernet, choice of error source Maintenance) is executed only if the switching authority in the device is set to Remote. Once DIGSI has signed on the device for command output, no commands from other command sources or a different DIGSI PC will be executed.
- **Station:**
  The switching authority level can be activated via a parameter in the General function block. A switching command from the station level (choice of error source Station or Automatic station) is executed if the switching authority is set to Remote and the controllable Station switching authority is set. This is accomplished by a command from the substation automation technology. Switching commands from the device or from inside the device (choice of error source Local, Remote or Automatic remote) are rejected.
  Full support of the this overriding authority level is ensured only when using the IEC 61850 protocol.
- **Remote:**
  The switching authority level checks from remote control directly from the network control center or of the switching authority level Station, if not activated previously for Remote control. The choice of error source is Automatic remote. Commands from this level are accepted if the switching authority is set to Remote and the controllable Station switching authority is not set. Switching commands from the device or from the station (choice of error source Local, Station or Automatic station) are rejected.