10. Check list

10.1. Before first energising

What to check:	When	Check:
1. External packing appearance	A	No signs of careless handling
2. Transformer tightness	A, B, C	No visible oil leaks or greasy stains (even if the packing is intact)
3. Transformer housing	B, C	Insulator, terminals and housing of the transformer show no signs of mechanical damage.
4. Oil level	B, C	Oil level indicator is in the proper position
5. Quality and correctness of performed connections	C	Performed connections are reliable and in accordance with the design

10.2. After first energising

What to check:	When	Check:
6. Transformer tightness	D, E	No visible oil leaks or greasy stains
7. Transformer housing	D, E	Insulator, terminals and housing of the transformer show no signs of mechanical damage.
8. Oil level	D, E	Oil level indicator is in the proper position
9. Secondary winding insulation test (measurement method depends on local practices)	E	Values dependent on age, voltage level, measurement method and temperature
10. Dielectric loss factor tg δ (measurement method depends on local practices)	E	Values dependent on age, voltage level, measurement method and temperature Respective terminals are marked as: „tg δ"
11. Oil sampling: gas analysis (DGA), tg δ, water content	E	Measurements did not indicate exceeding of permissible limits

When	
A	After arrival of the transformer to the final location
B	After unpacking
C	Directly before applying voltage
D	During routine inspection in accordance with the schedule determined for the station
E	After 15–20 years or inspection of efficiency after the non-conformity state if there are suspicions as to transformer efficiency

11. End

For additional information concerning the operation and maintenance of type PA 123 and PA 145 transformers, please contact the transformer manufacturer.

ЕЛЕКТРИКСИТИ ООД София

Сд II 783

ВЯРНО С ОРИГИНАЛА

For more information, please contact:

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Phone: +48 22 22 37 777
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Accreditation Certificate of Testing Laboratory
No AB 272

AB 272

TEST REPORT

No. EWN/11/E/12-2

Tests of current instrument transformer type PA 123 (PA 145) for insulation level LI 650kV/AC 275kV, manufactured by ABB sp. z o.o.

Warsaw, March 2012

ВЯРНО С ОРИГИНАЛА

TESTS REPORTS No EWN/11/E/12-2

TEST OBJECT:	**Current instrument transformer type PA 123 (PA145)** **Serial No: 2GKP011A1084700 (84700/11)**
TEST ORDERED BY:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
ORDER NO:	**4500380553/2 – 20.01.2012**
SCOPE OF TEST:	**Selected type tests and special tests**
PROCEDURA OF TESTS:	**in accordance with standards:** **PN-EN 60044-1:2000 (EN 60044-1:1999)**
RECEIVING OBJECT DATE:	**January 2012**
DATE OF TESTS:	**January 2012 – March 2012**
TESTS RESULTS:	**are presented in following parts of report** Test results are concern to tested object only.

Tests was performed in witness of representatives of ABB sp. z o.o. :

Marcin TARNOWSKI M.Sc.E.E.
Paweł DĘBSKI M.Sc.E.E.
Jarosław DUZDOWSKI M.Sc.E.E.
Zbigniew WESOŁOWSKI M.Sc.E.E.

TEST PERFORMER:	**Jan SZOKALSKI** **M.Sc.E.E.**	SIGNATURE
TEST OVERSEERER:	**Jerzy MIKOŁAJCZYK** **M.Sc.E.E.**	SIGNATURE
HEAD OF HIGH VOLTAGE DEPARTMENT:	**January L. MIKULSKI,** **Ass. Prof., Dr. hab. E. E.**	SIGNATURE

Warsaw, March 2012

ВЯРНО С ОРИГИНАЛА

CONTENTS

The Report contain:
18 numbered pages
In Report are presented:
5 drawing
1 numbered table
6 appendixes
and non numbered diagrams and tables

ЕЛЕКТРИКСИТИ ЦЕНТЪР СОФИЯ ООД

ВЯРНО С ОРИГИНАЛА

1. COMPETENCE OF THE LABORATORY

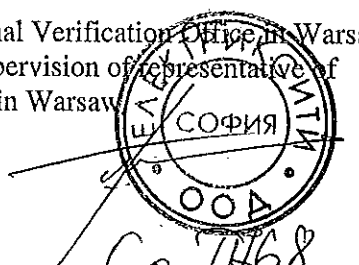
The High Voltage Laboratory of Institute of Power Engineering (IEn) in Warsaw is in possession of accreditation issued by the Polish Centre for Accreditation (Accreditation Certificate of Testing Laboratory No AB 272) concerning following tests:

Insulators and insulator strings	–	lightning and switching impulse tests
	–	power-frequency voltage 50 Hz tests
	–	radio interference measurements
Distribution substations	–	lightning and switching impulse tests
	–	power-frequency voltage 50 Hz tests
	–	radio interference measurements
Circuit breakers, disconnectors	–	lightning and switching impulse tests
	–	power-frequency voltage 50 Hz tests
	–	radio interference measurements
Insulators	–	lightning and switching impulse tests
	–	power-frequency voltage 50 Hz tests
	–	radio interference measurements
Current and voltage transformers	–	**lightning and switching impulse tests**
	–	**power-frequency voltage 50 Hz tests**
Power transformers	–	lightning and switching impulse tests
	–	power-frequency voltage 50 Hz tests
Lightning arresters and limiters	–	lightning and switching impulse tests
	–	power-frequency voltage 50 Hz tests
Cables and cable fittings	–	lightning and switching impulse tests

Note! Tests described in sub-clauses 4.8, hereby Report are not comply the scope of Laboratory accreditation.

Hereby Report concerning test results obtained in other competent laboratories - (see Appendixes 2,3) :

- Distribution Equipment Laboratory of Institute of Power Engineering in Warsaw having Accreditation Certificate PCA Nr AB 324
- High Current Laboratory of Institute of Power Engineering in Warsaw having Accreditation Certificate PCA Nr AB 323
- Factory Laboratory of ABB sp. z o.o. in Przasnysz - Regional Verification Office in Warsaw - determination of errors and test in range of type tests at supervision of representative of High Voltage Laboratory of Institute of Power Engineering in Warsaw



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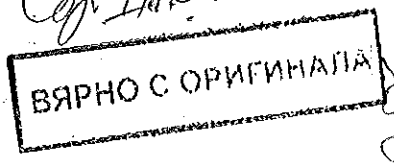

2. DESCRIPTION OF TEST OBJECT

The tested object was current instrument transformer type PA 123 (Pa 145) manufactured by ABB sp. z o.o. 04-713 Warszawa, ul. Żegańska 1, had following parameters:

Serial number 2GKP011A1084700 (84703/11)

◻ Rated primary current	50 – 100 – 200 A
◻ Rated short-time current I_{th}/1s	40 –50 – 50 kA
◻ Rated dynamic current I dyn	100 – 125 – 125 kA
◻ Rated frequency	50 Hz
◻ Rated insulation level	LI 550kV/ AC 230kV*)
◻ Minimum creepage distance	3800 mm (composite insulator)

*) **Attention ! All voltarge test was performed for insulation level LI 650kV/AC 275kV (for current transformer type PA 145).**

View of rated nameplates of tested transformers show figure 1.

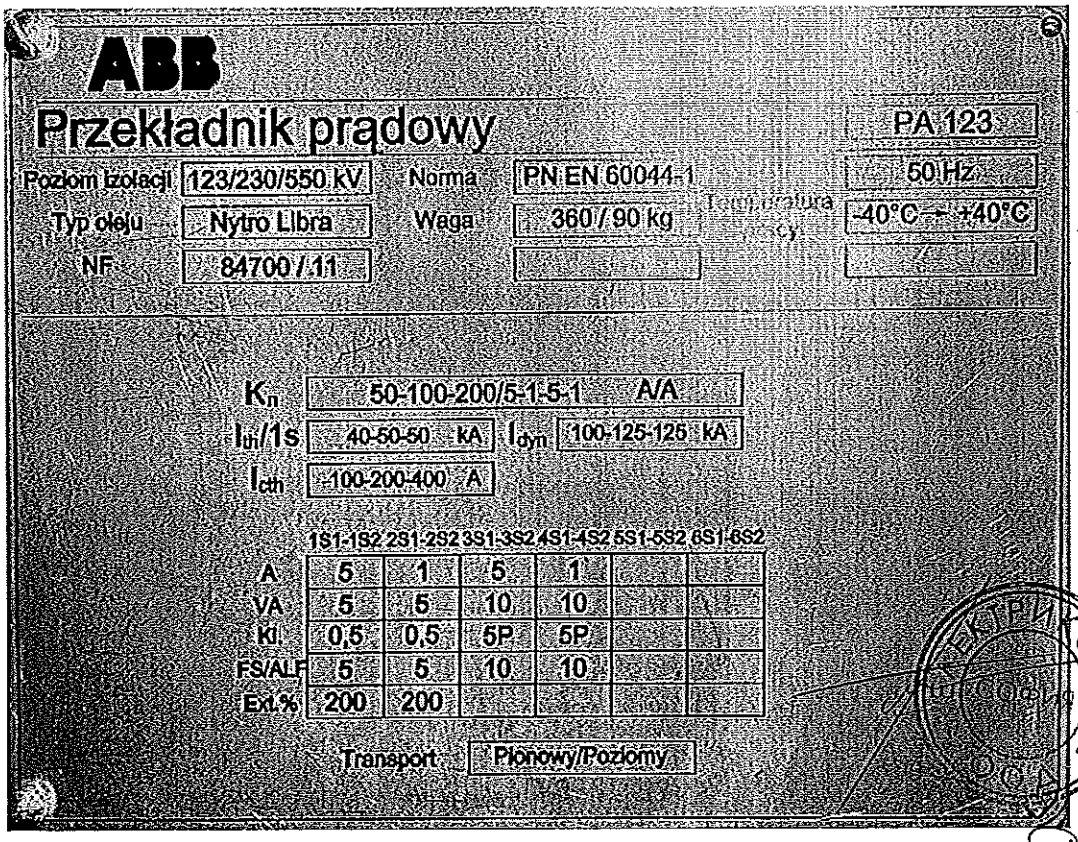

Fig. 1 Rated nameplate of tested transformer

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ВЯРНО С ОРИГИНАЛА

Identification of tested object was done at following documents attached to hereby Report (Appendix 1):

- Manufacturer Conformity Declaration,
- Dimension drawing No. 2GKA614117 (19.01.2012),
- Electric diagram of Current instrument transformer,
- Drawing of rated nameplate.

3. AGREED SCOPE OF TESTS

According to ordered selected tests were done comply following standards:

- PN-EN 60044-1:2000 + A1:2003 +A2:2004 „Przekładniki. Część 1: Przekładniki prądowe" (EN-60044-1:1999 + A1:2000 + A2:2003 „Instrument transformers. Part 1: Current transformers").

On request of ordering party the additional special test were performed. The performed test results are contained in Table 1.

ЕЛЕКТРИКСИТИ ООД София

ВЯРНО С ОРИГИНАЛА

Table 1. List of performed tests

Item	Performed tests	Requirement
TYPE TESTS		
1	Lighting impulse test	PN EN 60044-1, p.7.3
2	Wet test for outdoor transformers	PN EN 60044-1, p.7.4
3	Determination of errors	PN EN 60044-1, p. 11.4, 11.6, 12.4
4	Measurement of the radio interference voltage (RIV)	PN EN 60044-1/A1, p. 7.5
SPECIAL TESTS		
5	Chopped impulse test on the primary winding	PN EN 60044-1, p. 9.1
6	Measurement of capacitance and dielectric dissipation factor	PN EN 60044-1, p. 9.2
7	Mechanical test	PN EN 60044-1, p. 9.3
8	Transmitted overvoltage measurement	PN EN 60044-1/A2, p. 9.3

During mentioned above tests at Factory Laboratory of ABB sp. z o.o. in Przasnysz Leszno 59 Street, were performed determination of errors of transformer to prove positive results of consecutive tests. The complete tests were performed according to mentioned above standards. The tests were supervised by representatives of High Voltage Laboratory of Institute of Power Engineering in Warsaw in purpose to prove results of tests. The tests stands are under authority of Regional Verification Office in Warsaw (No. stand S08/OUM1-5/01 XVI, S08/OUM1-5/01 XVII).

ВЯРНО С ОРИГИНАЛА

ЕЛЕКТРИКСИТИ СОФИЯ ООД

4. PERFORMED TESTS

4.0 Routine test and determination of errors before tests in IEn and after tests finishing.

Before delivery the transformer to IEn Laboratory and after type test and special test completed in ABB Factory Laboratory in Przasnysz were performed determination of errors measurement under supervision of representative of IEn. During test were checked:

- verification of terminals marking,
- power-frequency withstand test on the primary winding 50 Hz, Utest = 275 kV, t = 60 s,
- partial discharge measurement for current transformers q<10pC (U_m) q < 5pC ($1{,}2 \cdot U_m / \sqrt{3}$),
- power-frequency withstand test on secondary windings 50 Hz, Utest = 3 kV, t = 60 s,
- power-frequency withstand test between sections 50 Hz, Utest = 4,5 kV, t = 60 s,
- determination of errors.

The test results are presented in reports attached to hereby Report (Appendix 2):

- Tests before type test and special test (Measurements before type test and special tests) - Report No. 2GKP011A1084700 – 19.01.2012,
- Tests after type test and special tests completed (Measurements after type test and special test completed) - 2GKP011A1084700 – 26.03.2012.

It were proved that all tests required in routine test gave positive results. It were proved that all metrological properties of transformer are comply accurate classes for all winding.

These tests results are base for later determination of errors for purpose of verification results of tests described below.

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ВЯРНО С ОРИГИНАЛА

4.1 Lightning impulse test

Test was done in test arrangement of surge generator type Haefely 5 MV, 375 kJ. Equivalent circuit diagram is shows on Figure 2. The test was performed on standardized lightning impulse 1,2/50μs. The purpose of test was checking internal insulation of transformer. The influence of atmospheric condition on test voltage value was not taken into consideration.

The Lightning impulse test was performed jointly with chopped impulse test on the primary winding (clause 3.8 of hereby Report).

Test condition:

- Full impulse test voltage U = 650 kV,
- Chocked impulse test voltage 1,15 · 650 kV = 747,5 kV,
- Sequence of impulses:
  positive polarity – 15 full impulses,
  negative polarity – 1 full impulse, 2 chocked impulses, 14 full impulses,
- During test was recorded test voltage and current flowed through along of current transformer.

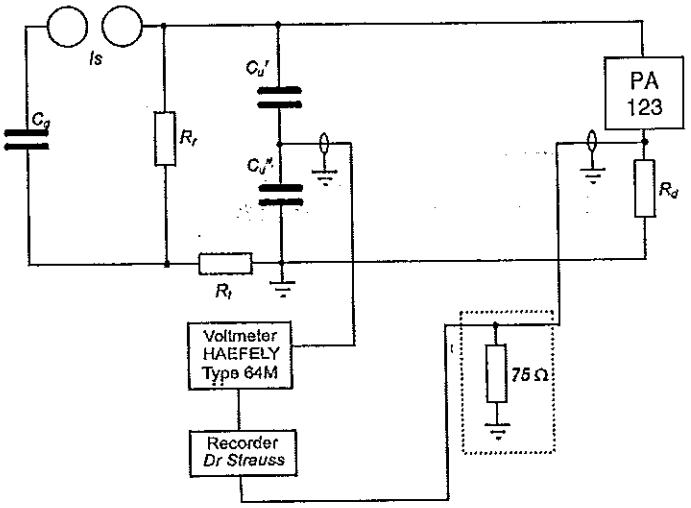

Fig. 2 Equivalent circuit diagram of test arrangement for lightning impulses:
C_g = 0,125 μF, C_u = 1,2 nF, R_t = 175 Ω, R_r = 600 Ω, R_d = 8,95 Ω.
Measurement uncertainty - 1,5 %

The oscillograms not shows failures of transformer insulation.

Result of test - positive.

Recorded oscillograms of all applied impulses are shown in Appendix No. 5 of hereby Report.

4.2 Wet test for outdoor transformers

The test was performed in arrangement of test transformer type TuR 700kV, 0,5A. according to standard PN-EN 60060-1:2011 (EN 60060-1:2010). Equivalent circuit diagram is presented on Figure 3.

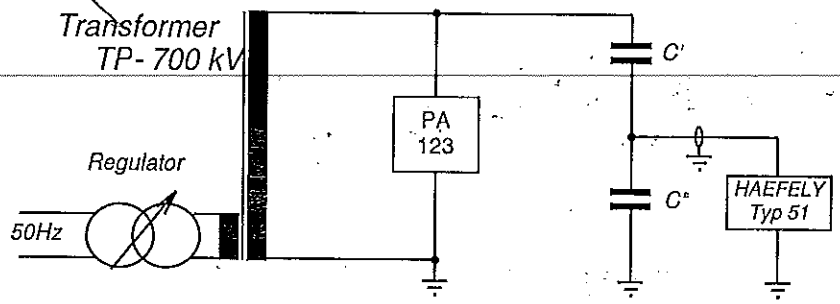

Fig. 3 Equivalent circuit diagram for power frequency voltage 50 Hz:
C = 200 pF (C' in series with C")
Measurement uncertainty - 1,5 %

During wet test for outdoor transformers the transformer was wetting by artificial rain at parameters:

- vertical component of precipitation H_v = 1,6 mm/min
- horizontal component of precipitation H_h = 1,7 mm/min
- water electrical resistivity ρ= 98 Ωm

The test voltage **U=275 kV** (corrected according to density of air) was applied during 1 minute.

During test were not observed any flashover or failure of insulation.
Test result - positive.

ЕЛЕКТРИКСИТИ София ООД
ВЯРНО С ОРИГИНАЛА

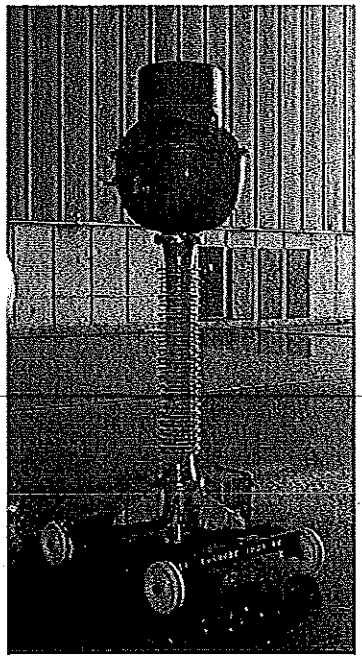

Fig. 4 Wet test of current transformers type PA 123 (PA 145) at power frequency voltage 50 Hz.

4.3 Determination of errors

4.3.1 Determination of errors

Measurements of errors for current transformers was performed in Factory Laboratory of ABB sp. z o.o. in Przasnysz 59 Leszno 59 Street, under supervision of representative of IEn.
The measurement was done two times:

- Tests before type test and special test (Measurements before type test and special tests) - Report No. 2GKP011A1084700 – 19.01.2012,
- Tests after type test and special tests completed (Measurements after type test and special test completed) - Report No. 2GKP011A1084700 – 26.03.2012.

Detailed information about tests results consists Appendix No. 2 of hereby Report.

Analyzing test results for current transformer was found that:

- **For measurement windings 1S1-1S2(5A) class 0,5S FS5 and 2S1-2S2(1A) class 0,5FS5:**
  - **for currents 0,05 I_n current error $\Delta I(\%) < 1,5\%$ and phase displacement $\delta_u(min) < 90$ min.**
  - **for currents 0,20 I_n current error $\Delta I(\%) < 0,75\%$ and phase displacement $\delta_u(min) < 45$ min.**
  - **for currents 1,0 I_n i 1,2 I_n current error $\Delta I(\%) < 0,5\%$ and phase displacement $\delta_u(min) < 30$ min.**
- **For protective windings 3S1-3S2(5A) class 5P10 and 4S1-2S2(1A) class 5P10:**
  - **for currents 1,0 I_n current error $\Delta I(\%) < 1\%$ and phase displacement $\delta_u(min) < 60$ min.**

For each of current windings values of error are contain in range compatible to appropriate class of accuracy.

4.3.2 Verification of instrument security factor FS of current part measurement windings of instrument transformer

The tested current transformer has two measurement windings:

1S1-1S2 → I_n= 5 A, S_n=5VA, class 0,5S FS5;

2S1-2S2 → I_n= 1 A, S_n=5VA, class 0,5 FS5.

The results of determination of core magnetization characteristics and veryfication of limiting e.m.f (check of instrument security factor (FS)) are present in Report No. 2GKP011A1084700 – 19.01.2012– (Appendix No. 2 of hereby Report).

It was found that instrument security factor FS is equal to 5 for measurement windings of current transformer is determined properly.

Test result - positive.

4.3.3 Verification of Limits of error ALF for protective winding of current part of instrument transformer

The tested combined transformer has two windings for protection purposes:

3S1-3S2 → I_n= 5 A, S_n=10VA, class 5P10;

4S1-4S2 → I_n= 1 A, S_n=10VA, class 5P10.

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The results of determination of core magnetization characteristics and veryfication of limiting e.m.f (check of accuracy limit factor (ALF)) are present in No. 2GKP011A1084700 – 19.01.2012 – (Appendix No. 2 of hereby Report).

It was found that limit of error ALF equal 10 for windings for protection of current transformer is determined properly.

Test result - positive.

4.4 Radio interference voltage measurement

Following to requirement of IEC/CISPR 18-2 the measurements was performed in testing arrangement as is show on Figure 5. The interference voltage was measured on resistance 300Ω at frequency 0,5 MHz. To determinate coefficient of correction +24 dB before measurement the instrument was calibrated by stabile signal generator . To measurement of interference voltage the instrument LMZ-5 was used. The level of background was checked for range of test voltages 0 - 150 kV. Interference voltages originated form testing arrangement, radio broadcasts etc., were below 5μV (14 dB).

According to PN EN 60044-1/A1 interference voltage at voltage $Up=1.1 \cdot U_m / \sqrt{3} = 92$ kV has not to exceed the value $RIV_{dop} = 2500\mu V$.

The instrument had logarithmic scale:

$RIV_{dop} = 2500\mu V \rightarrow 68$ dB (0 dB = 1 μV).

Before the test, the instrument transformer was supplied with voltage $1,5 \cdot U_m / \sqrt{3}$, held for 30 sec. Next, within about 10 sec the voltage was decreased to value $1,1 \cdot U_m / \sqrt{3}$, held for 30 sec.

The measurements were done at test voltages in range $0,3 \div 1,1 \cdot U_m / \sqrt{3}$. Test voltage was decreased step by step with value 0,1xUp since $Up=1,1 \cdot U_m / \sqrt{3}$ up to value $Up=0,3 \cdot U_m / \sqrt{3}$.. Next, voltage was increased by this same values and finally deceased again.. For each of test voltage the measurement of radio interference voltage were performed and registered level in last series of decreasing voltage was drawn in function of test voltage Utest.

ВЯРНО С ОРИГИНАЛА

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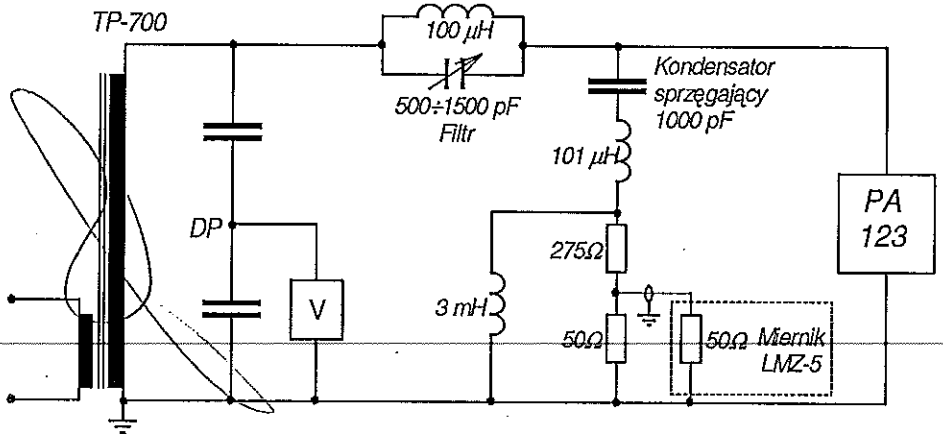
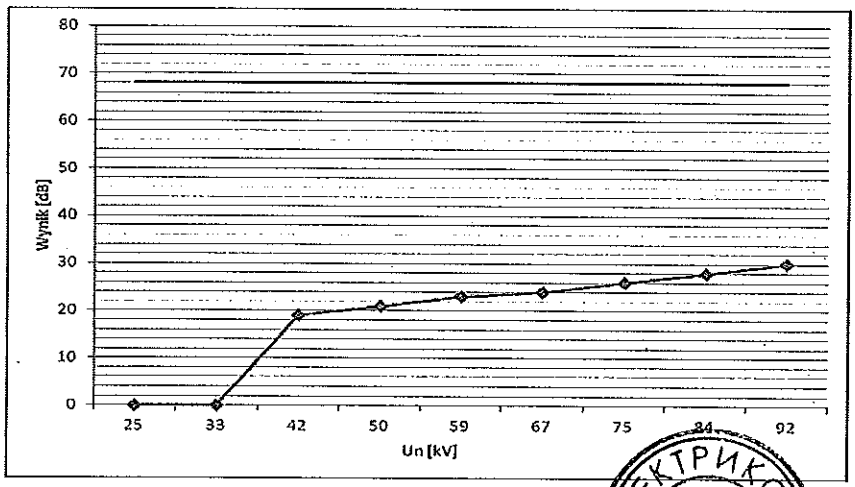


Fig. 5 Test arrangement for Radio interference voltage measurement

The results of measurements are present in Table and diagram below.

Up [kV]		92	84	75	67	59	50	42	33	25
xUn/√3		1,1	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3
[dB]	→	6	5	2	0	-1	-2	-5	-	-
	←	6	3	2	0	-1	-3	-5	-	-
	→	6	3	2	0	-1	-3	-5	-	-
Wynik	[dB]	30	28	26	24	23	21	19	-	-
	[µV]	32	25	20	16	14	11	9	-	-



Measured Radio Interference Voltage RIV = 32 µV (30dB) is much less than permissible level RIV_{perm} = 2500 µV (68dB).

Test result - positive.

4.5 Chopped impulse test on the primary winding

Chopped Impulse Test was supplemented to Lightning Impulse test 1,2/50μs and was described in clause 4.3 of hereby Report.

Recorded oscillograms not show of failure of insulation of current transformers. Test result - positive.

Oscillograms of all applied impulses are present in Appendix No. 4 of hereby Report.

4.6 Measurement of capacitance and dielectric dissipation factor

The measurement was performed st at ABB's Factory Laboratory (Raports No. 2GKP011A1084700 – 19.01.2012 and No. No. 2GKP011A1084700 – 26.03.2012 of Factory Laboratory ABB sp. z o.o. Przasnysz Division).

Condition of measurements:

Up = 10 kV; $110/\sqrt{3}$ kV = 63,5 kV; $123/\sqrt{3}$ kV = 71 kV

Ambient temperature during measurement was 22,2°C and (22,3°C).

Test results are present in table below:

Up [kV]	C_x [pF]	tgδ [%]
10	973 (973)	0,22 (0,22)
63,5	973 (973)	0,22 (0,22)
71	973 (973)	0,22 (0,22)

The standard specifications for capacitance and dissipation factor for instrument transformers not provide criterion for these parameters. The Standard PN-EN 60044-1:2000 (EN 60044-1:1999) only contain note that value of dissipation factor is usually less than 0,5%.

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4.7 Mechanical tests

The mechanical tests were performed in Distribution Equipment Laboratory of Institute of Power Engineering in Warsaw. The test consist in applying to the transformer mechanical load – static and dynamic, in three direction in turn. Static load was 20% higher than standard requirement for II class of load. The test conditions were as follow:

$F_R = 3600$ N, $t = 60$ s

It was assumed that dynamic load is 1,4 times higher than static load.

During the tests behaving of current transformer was correct. After test not stated any damages or oil leakage.

Test result - positive.

Detailed information about test arrangement, performed tests and tests results are present in Report No. EUR/12/E/12-1E – 28.03.2012 – (Appendix 3)

4.10 Transmitted overvoltage measurement

During the test to the HV terminal of transformer were applied impulse voltage.
It were recorded maximal value of overvoltages which came in each secondary windings - both current and voltage. According to requirement of Standard for impulse 0,5/50 μs and value $U_{test}=1,6 \times \sqrt{2} \times U_m/\sqrt{3} \cong 189$ kV the values of transmitted overvoltages can not exceed 1,6 kV. During all measurements to the transformer were applied lightning impulses at value ten times less, that is $U_1= 16$ kV. Concerning linear of phenomenon, registered overvoltages should have values less than 160 V (peak-to- peak value).
Registration was don by digital oscilloscope of "Dr Strauss" with input impedance 50 Ω and transmission band 200 MHz.

Results of test are present in table below.

Winding	Overvoltage value $U_{pp}/2$ x 10 [V]
1S1-1S2	346
2S1-2S2	314
3S1-3S2	420
4S1-4S2	398

It was found that for each of secondary winding of transformer transmitted overvoltages not exceed value of 1600 V.

Test result - positive.

The oscillograms of all applied and registered impulses are present in Appendix No. 6 of hereby Report.

5. SUMMARY

- The current instruments transformer type PA 123 (PA 145) manufactured by ABB sp. z o.o. 04-713 Warszawa, ul. Żegańska 1, with parameters described in clause 2 of hereby Report and identified on base provided documents (as presented in Appendix No. 1) was performed.
- The current instruments transformer type PA 123 (PA 145) for insulation level LI 650kV/ /AC 275kV **passed positively** selected type test according to requirement of standard:
  - PN-EN 60044-1:2000 + A1:2003 +A2:2004 „Przekładniki. Część 1: Przekładniki prądowe" (EN-60044-1:1999 + A1:2000 + A2:2003 „Instrument transformers. Part 1: Current transformers").

  and according program described in Table 1, clause 3 of hereby Report.

ЕЛЕКТРИКСИМ ООД София

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6. LIST OF APPENDIXES

Appendix No. 1

Documents provided by ABB Sp. z o.o. used as base of identification of test object:

- Manufacturer Conformity Declaration
- Dimension drawing No. 2GKA614117 (19.01.2012)
- Electric diagram of Current instrument transformer
- Drawing of rated nameplate

Appendix No. 2

Reports of routine test and determination of errors of current transformer type PA 123 performed in Factory Laboratory of ABB sp. z o.o.

- Tests before type test and special test (Measurements before type test and special tests) - Report No. 2GKP011A1084700 – 19.01.2012,
- Tests after type test and special tests completed (Measurements after type test and special test completed) - 2GKP011A1084700 – 26.03.2012.

Appendix No. 3

Report of performed tests in Distribution Equipment Laboratory
of Institute of Power Engineering in Warsaw.

- Test Report No. EUR/12/E/12-1E
  (Mechanical tests.)

Appendix No. 4

Lightning impulse test. Impulse 1,2/50 μs, full and chopped:

- Oscillograms of test currents and detection currents.

Appendix No. 5

Transmitted overvoltage measurement:

- Oscillograms of measured transmitted to secondary windings overvoltages.

ЕЛЕКТРИКСИТИ ООД София

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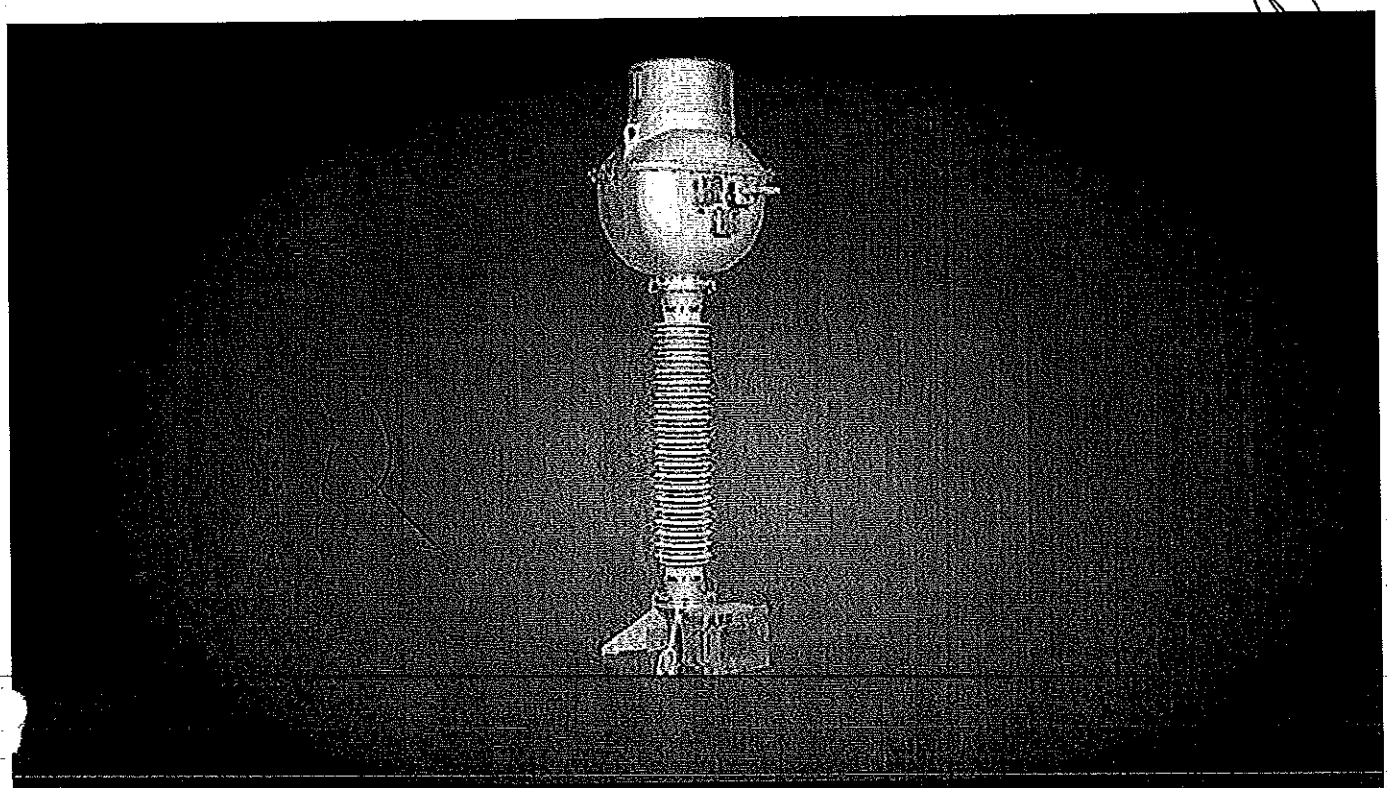
Стр. 782



High Voltage Products

Current instrument transformers PA 123 and PA 145

Power and productivity for a better world™

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General information

The PA 123 and PA 145 current instrument transformers are used for feeding measurement and protection systems in electric power grids with highest system voltage of up to 123 kV and up to 145 kV respectively and frequency of 50 Hz.
They are designed to operate in grids with effectively earthed or insulated neutral points as well as in resonant (compensated) earthed systems. The PA 123 and PA 145 current instrument transformers are suitable to operate in outdoor conditions with ambient temperature from 233 K (– 40°C) to 313 K (40°C) and at relative humidity of up to 100% at 303 K (30°C) and at the altitude not exceeding 1000 m above the sea level.

General information
The PA 123 and PA 145 current instrument transformers are top core construction; active current module is located in transformer's head and encapsulated in hermetic housing filled with PCB free transformer oil.
The transformer's stainless steel expansion bellows is fixed to the head and shielded with aluminium cover. The expansion bellows compensates for thermal changes in oil volume.

Top core construction
Top core construction makes it possible to achieve high values of thermal and dynamic short-circuit currents as well as a broad range of rated primary currents and outputs of secondary windings.

Primary and secondary windings and accuracy classes
The primary and secondary windings are made of highest quality electrical copper, enabling us to deliver to customers requiring high accuracy (classes 0.2S and 0.5S) with low values of rated primary current. We guarantee very high transformation accuracy in special classes [„S"], from 1% to 120%, 150% and even to 200% of the value of selected rated primary currents for both secondary currents of 1 A and 5 A.
ABB's factory test laboratory is one of the most modern units of this type in the world.

Main insulation
The main insulation is made of insulation paper impregnated with transformer oil. We use high quality oil conforming to IEC 60296 Standard requirements. This oil does not contain PCB's nor any other toxic substances and has low environmental impact.

Hollow insulator
The standard insulator is made of brown porcelain with creepage distance of 25 mm/kV. A grey composite insulator with creepage distance of 31 mm/kV is available upon request.

All materials used in production of our insulators conform to relevant IEC Standards.

Housing
All external parts are robust and made of corrosion resistant materials.
The PA 123 and PA 145 current instrument transformers are leak proof due to o-ring sealing system in the housing that is made of high quality aluminium alloy. The expansion bellows is equipped with large oil level indicator that enables observations of thermal changes in oil volume even from a distance.
Each completely assembled unit is subject to stringent leakage checks during routine testing.

Primary terminals
The standard primary terminals are flat, made of aluminium, 100 mm or 200 mm width. Upon request we can offer pin type primary terminals, made of copper or aluminium, with diameter of 30 mm or 40 mm.

Secondary terminal box
The secondary terminal box is IP55, constructed of aluminium. The terminal box is fixed to the transformer's bottom base. Secondary terminals are available for connection of up to 10 mm_2 conductors. Sealing of current measurement secondary terminals is also possible upon request. The secondary terminal box has two M40 cable glands (for cables from Ø 19 mm to Ø 28 mm). We offer secondary terminal boxes with higher number of cable glands upon request.

ЕЛЕКТРИКСИТИ ООД

ВЯРНО С ОРИГИНАЛА

Technical data

Parameter	Value	
Type	PA 123	PA 145
Compliance with the standards	IEC 60044-1; PN-EN 60044-1	
Highest system voltage	123 kV	145 kV
Rated power – frequency withstand voltage at 50 Hz	50 Hz 230 kV	50 Hz 275 kV
Rated lightlng – impulse withstand voltage 1.2/50 µs	1.2/50 µs 550 kV	1.2/50 µs 650 kV
Minimum creepage distence	16; 20; 25; 31 mm/kV	
Rated frequency	50 Hz	
Total weight	420; 360* kg	

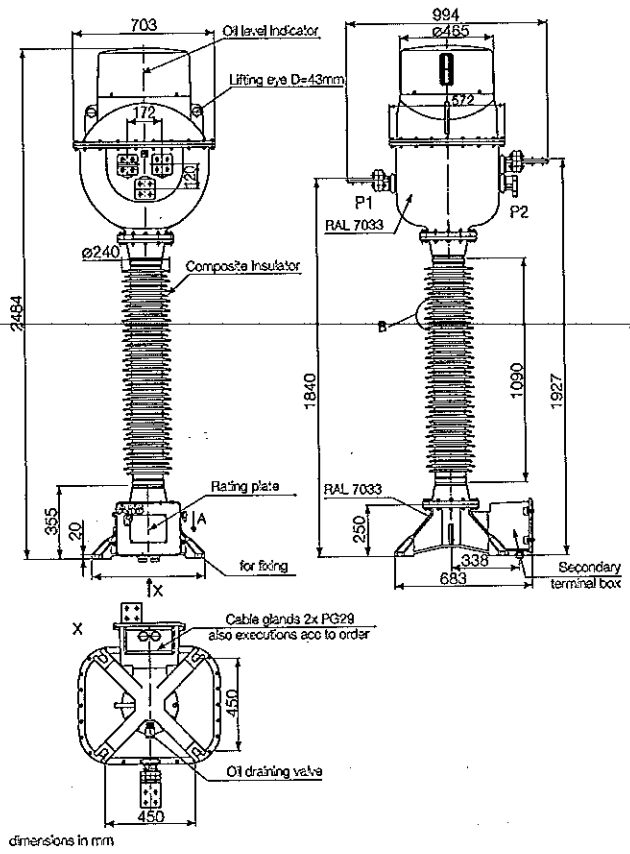
*composite insulator

Current module

Rated current [A]	Rated 1s thermal current [kA]	Rated dynamic current [kA]
50 – 3000	10 – 63	25 – 157

reconnectable 1:2 or 1:2:4

Parameter	Value
Rated secondary current	1 A; 5 A
Rated continuom thermal current	120%; 150%; 200%
Number of cores	1 – 6
Measuring cores parameters	
– total rated output	2.5 – 90 VA
– accuracy clases	from 0.2S
Protection cores parameters	
– total rated output	2.5 – 90 VA
– accuracy classes	5P, 10P, 5PR, 10PR, TPX, TPY, TPZ, PX, PXR



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www.abb.pl

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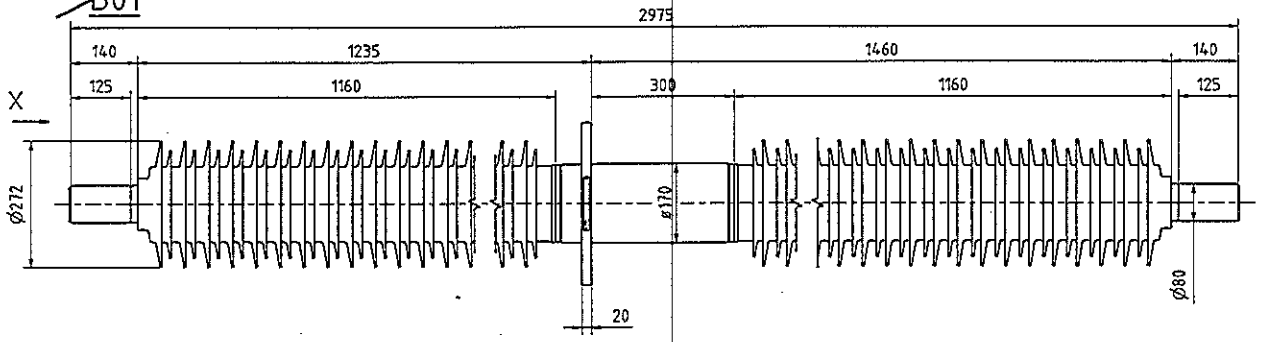
Сд. II .786

ВЯРНО С ОРИГИНАЛА

Power and productivity
for a better world™

ABB

B01



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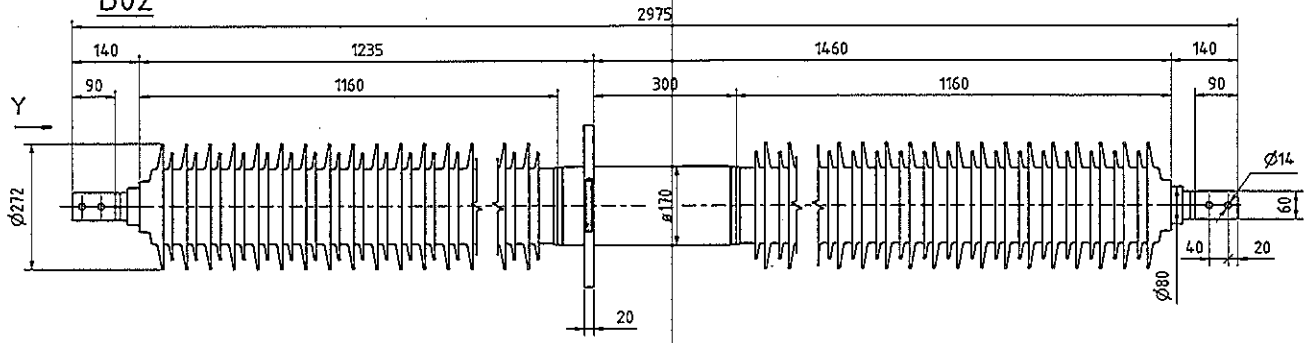
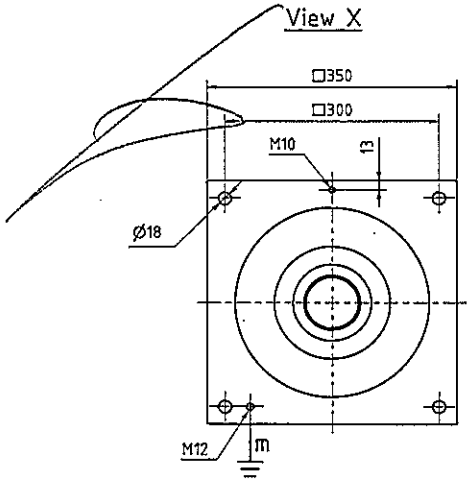
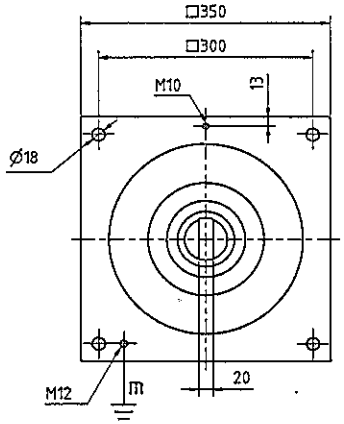


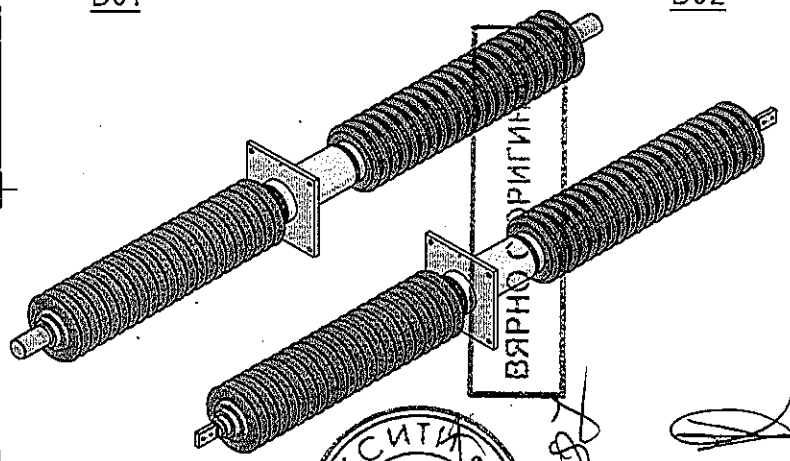
View X



View Y



B01 B02



Technical Data	
According to:	IEC 60137 (2008)
Um	123kV
Ac (1min)	230kV
BIL (1,2/50 µs)	550kV
Ir	630–1250A
fr	50 / 60Hz
Insulator	Silicone, light grey
– Pollution	IEC 60815
° Version 1986 (SCD):	31mm/kV
° Version 2008 (USCD):	53.7mm/kV
– Creepage distance	3813mm
Cantilever test load (IEC 60137, Class II)	3150N
Insulation	DURESCA (RIP)
Conductor	Al
Weight	115kg

	Tol. as per DIN ISO 2768-c	Type: DM2I1231123		PAGE: 1 / 1	FORMAT: A2		
					SCALE: 2:15		
			DATE	NAME	DM2I wall bushing		
		Creat.	08.01.2014	dom	Outdoor-outdoor		
		Check	08.07.2014	sau	123kV / 630–1250A / E=300		
		Appr.	08.07.2014	sau			
		www.mgc.ch					
A	Flanschdicke	30.04.2014	dom	MGC MOSER-GLASER	DRAWING NO.: 701.13.0242	REVISION: A	
REV	DESCRIPTION	DATE	NAME				

MGC
MOSER-GLASER

better connections

Duresca® Wanddurchführungen

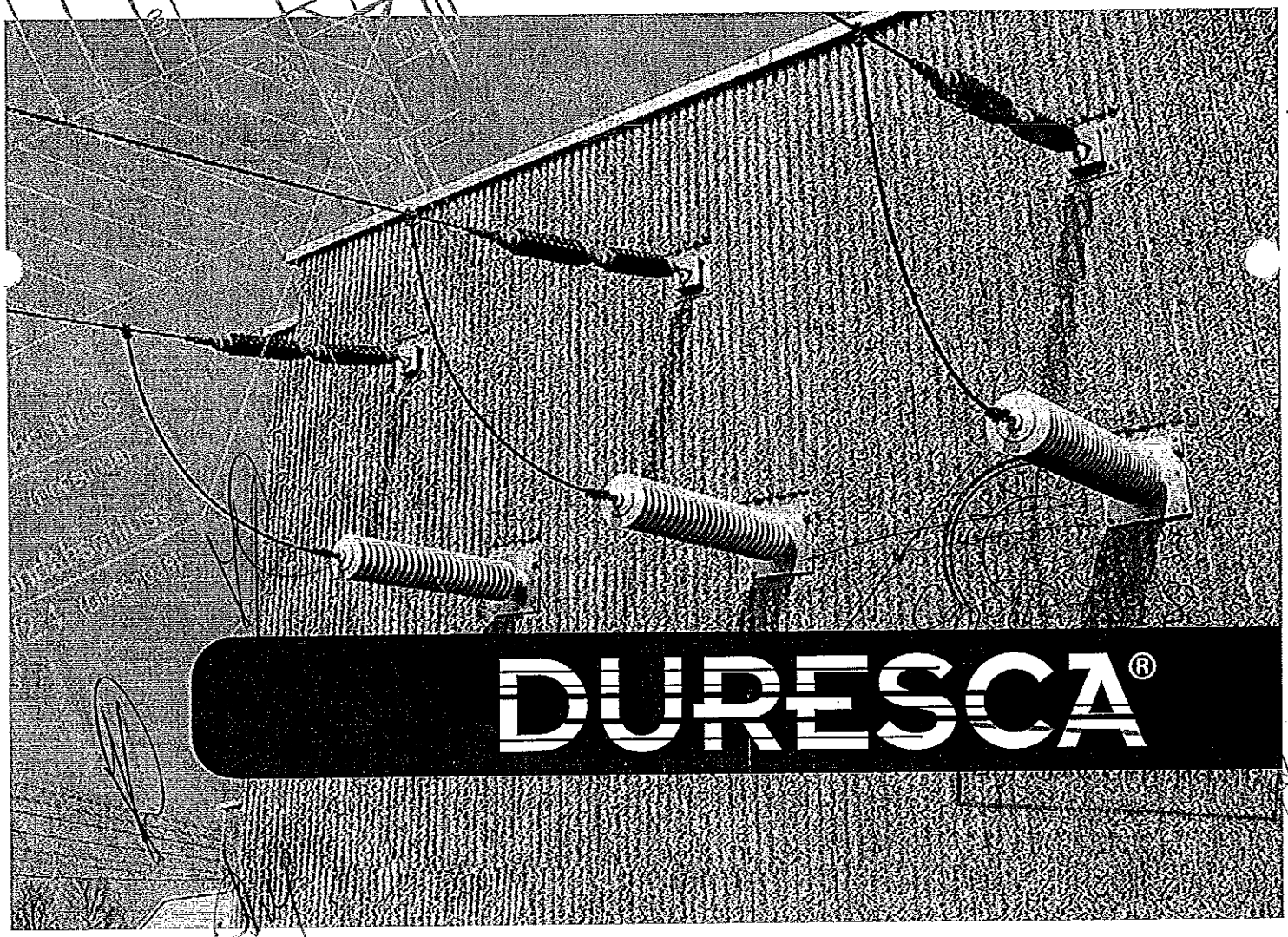
für Innenraum- und Freiluftanwendungen

Duresca® Wall bushings

for indoor and outdoor applications

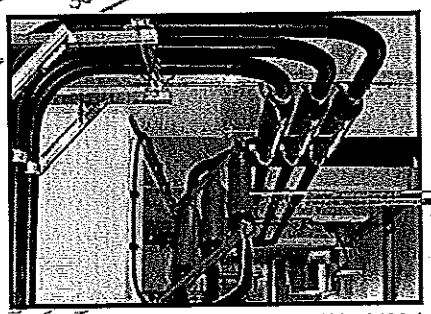
Duresca® Traversées murales

pour des applications intérieures et extérieures



MGC
MOSER-GLASER

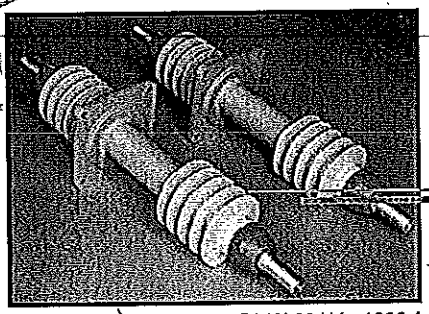
Unsere Produktpalette
Product range
Notre gamme de produits



DE 17,5 kV – 2500 A

Duresca®

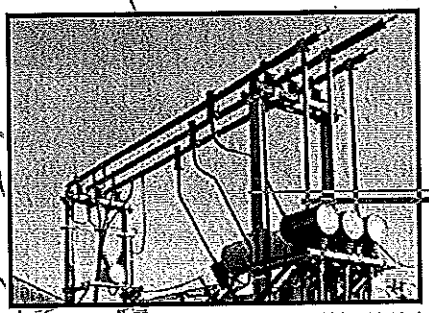
Schienensystem
Busbar system
Systèmes de barres



DM2I 36 kV – 1600 A

Duresca®

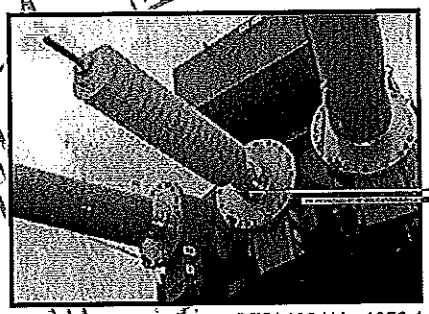
Wanddurchführungen
Wall bushings
Traversées murales



TE 24 kV – 1250 A

Tiresca®

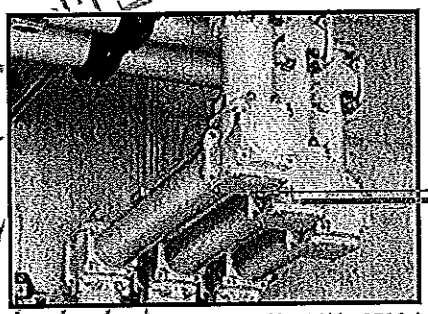
Schienensystem
Busbar system
Systèmes de barres



DTOI 123 kV – 1250 A

Travesca®

Transformator-Durchführung
Transformer bushing
Traversées pour transformateur



GL 12 kV – 2500 A

Gaslink®

SF_6 isolierter Schienensystem
SF_6 insulated busbar systems
Systèmes de barres isolé au SF_6

Titelseite / *Cover* / Couverture:
Wanddurchführungen
Wall bushings
Traversées murales
145 kV - 400 A
HS Station von La Foretaille, SIG
HV substation of La Foretaille, SIG
Poste HT de La Foretaille, SIG

MGC
MOSER-GLASER

Die Firma

Das Traditionsunternehmen wurde 1914 als Moser & Glaser Co. in Basel gegründet. 1958 entwickelte MGC Moser-Glaser AG die Technik zur Isolation von elektrischen Leitern mit harzimprägniertem Papier (RIP) für Hochspannungs- und Mittelspannungs-Durchführungen und Stromschienen.

Diese Technik wurde patentiert und eingetragen unter dem Namen DURESCA®.

Mit mehr als 45 Jahren Erfahrung und tausenden Anwendungen weltweit, ist die MGC Moser-Glaser AG der Spezialist für diese RIP-Technologie.

The Company

Moser & Glaser Company, Basel was founded in 1914. In 1958 MGC Moser-Glaser AG invented the RIP (Resin Impregnated Paper) technology: a process designed to insulate electrical conductors for bushings and busbars in middle and high voltage applications.

This technology was patented and protected under the name DURESCA®.

With more than 45 years experience and the fact that so many different applications worldwide delivered makes MGC a leader in this technology.

La Société

Cette entreprise familiale a été fondée en 1914 à Bâle en Suisse sous le nom de Moser & Glaser Co. SA. A partir de 1958, elle a développé la technique de l'isolation sèche des conducteurs électriques par imprégnation sous vide d'un papier crêpé avec de la résine époxyde (RIP), pour traversées et barres isolées haute et moyenne tension.

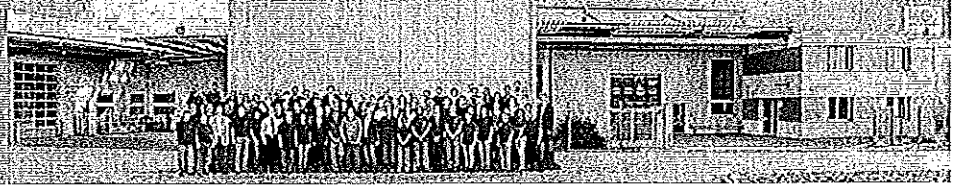
Cette technique a été patentée et commercialisée sous le nom de DURESCA®.

Après plus de 45 années d'expérience avec le RIP et des milliers d'applications dans le monde entier, MGC Moser-Glaser SA est devenu le spécialiste de cette technologie.

ЕЛЕКТРИКСИТИ София ООД

Сд. II - 790

ВЯРНО С ОРИГИНАЛА



MOSER-GLASER

Aufbau & Beschreibung
Design & Description
Construction & Description

Die DURESCA® Wanddurchführungen besitzen eine trockene Isolation aus RIP (Resin Impregnated Paper). Die Isolation liegt direkt auf dem Leiter oder Rohr und besteht aus gewickeltem Papier, das unter Vakuum mit Harz imprägniert wird. Für die bestmögliche Verteilung des elektrischen Feldes werden in die Papierisolation Steuerungsbeläge eingelegt. Dieser Aufbau ermöglicht eine längstmögliche Betriebssicherheit und eine höchstmögliche Sicherheit für Mensch und Anlage.

Die MGC Wanddurchführungen sind in 2 Ausführungen verfügbar:

Typ DEM bis zu einem Durchmesser Dfl des Flansches von 170 mm. Die Isolationsoberfläche ist mit einer hochwertigen gewellten Polyamid Schutzhülle umgeben.

Typ DM wird eingesetzt für die Durchmesser Dfl grösser als 170 mm. Die Isolationsoberfläche ist mit einem hochwertigen Lack geschützt.

The DURESCA® wall bushings have a dry insulation of RIP (Resin Impregnated Paper). The insulation lays directly on the conductor or tube and consists of wrapped paper direct under vacuum impregnated with epoxy resin. Conductive grading layers are embedded during the wrapping in the insulation for the best field control. This guarantees the highest operational and human safety.

The MGC wall bushings are available in 2 designs:

Type DEM *available with a diameter Dfl of the flange up to 170 mm. The insulated body is covered by a high quality corrugated protection tube in polyamide.*

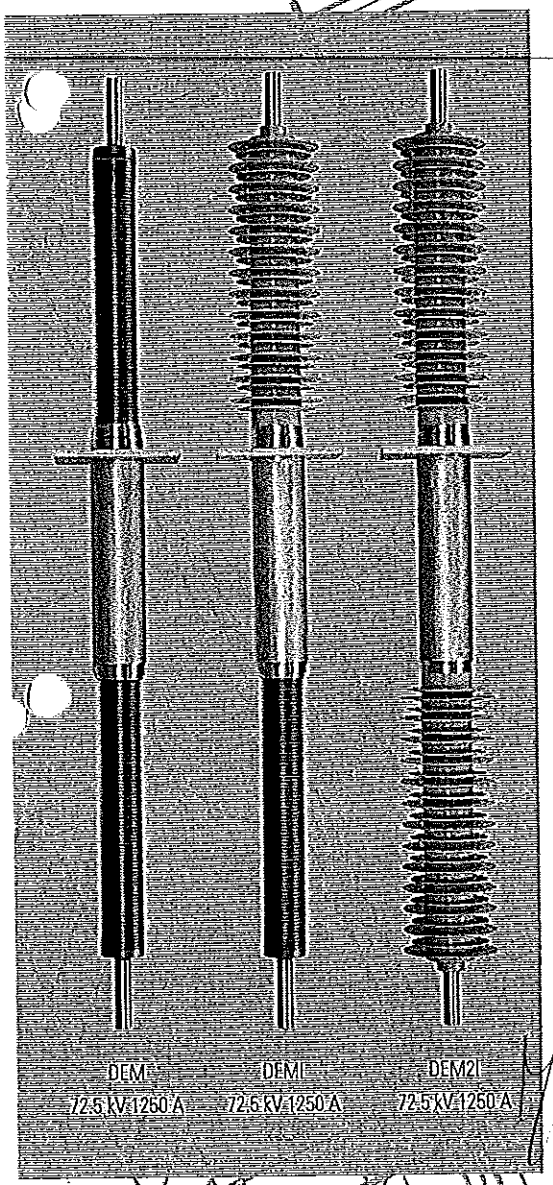
Type DM *will be used with a diameter Dfl with more than 170 mm. The insulation body is protected by a high quality varnish.*

Les traversées murales DURESCA® sont constituées d'un corps isolant sec du type RIP (Resin Impregnated Paper). Cette isolation est obtenue par enroulement autour du conducteur ou tube central, de papier séché sous vide et imprégné de résine époxy. Une bonne répartition du champ électrique est obtenue par un guidage capacitif fin. Cette conception garantie une sécurité optimale pour les biens et les personnes.

Les traversées murales MGC sont disponibles sous 2 exécutions:

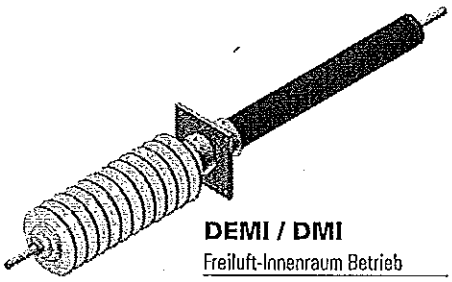
Type DEM lorsque le diamètre Dfl de la bride n'excède pas 170 mm. Le corps isolant est protégé par un tube annelé en polyamide de grande qualité.

Type DM pour tout diamètre Dfl supérieur à 170 mm. Un vernis de protection protège le corps isolant.



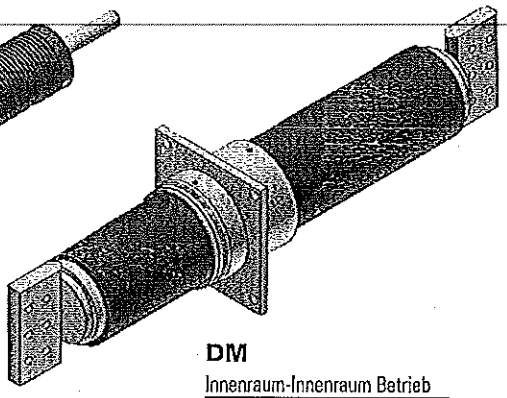
MOSER-GLASER

Übersicht
Overview
Programme



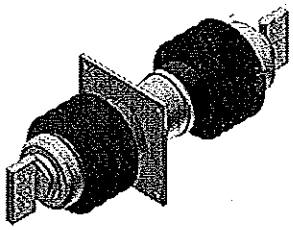
DEM2I / DM2I
Freiluft-Freiluft Betrieb
Outdoor-outdoor operation
Service extérieur-extérieur

DEMI / DMI
Freiluft-Innenraum Betrieb
Outdoor-indoor operation
Service extérieur-intérieur

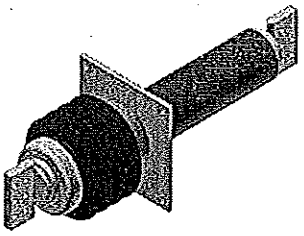


DEM
Innenraum-Innenraum Betrieb
Indoor-indoor operation
Service intérieur-intérieur

DM
Innenraum-Innenraum Betrieb
Indoor-indoor operation
Service intérieur-intérieur



DEM2P / DM2P
Freiluft-Freiluft Betrieb
Outdoor-outdoor operation
Service extérieur-extérieur



DEMP / DMP
Freiluft-Innenraum Betrieb
Outdoor-indoor operation
Service extérieur-intérieur

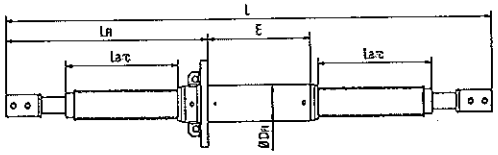
Legende / *Legend* / Légende

DEM	**I**
mit Polyamid-Schutzrohr	Silikon-Isolator
with corrugated protection tube in polyamid	*Silicone rubber insulator*
protégé par un tube annelé en polyamide	Isolateur composite
DM	**P**
mit Lack-Schutz	Porzellan-Isolator
protected with a varnish	*Porcelain insulator*
avec vernis de protection	Isolateur en porcelaine

ВЯРНО С ОРИГИНАЛА

DEM / DM

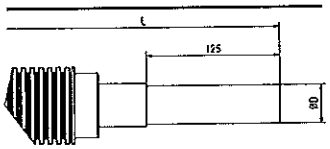
Innenraum-Innenraum
Indoor-indoor
Intérieur-intérieur



DEMI / DMI

Freiluft-Innenraum
Outdoor-indoor
Extérieur-intérieur

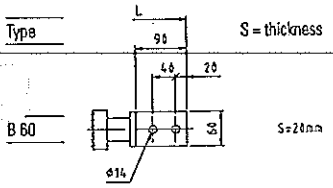
Al Connections – Al stud terminals



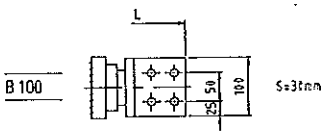
Type	Ø D mm
D 30	30
D 40	40
D 50	50
D 60	60

Al Flat pads terminals according to DIN 46206

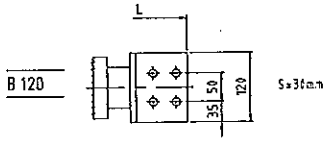
Type — S = thickness



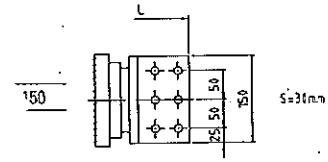
B 60 — S=20mm



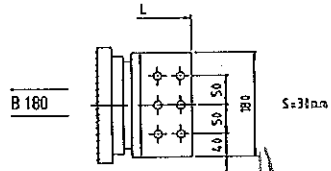
B 100 — S=30mm



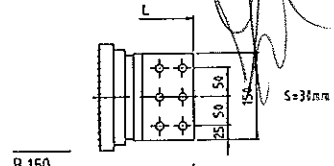
B 120 — S=30mm



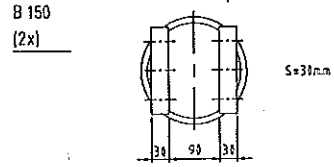
150 — S=30mm



B 180 — S=30mm



B 150 (2x) — S=30mm



Al Conductor – Technical datas & Dimensions for a wall thickness E = 300 mm

Type	Ir : A	Ø Dfl	L	Larc min.	Lfl	Ø Da	Flange	Terminal Stud	Terminal Flat pad	Weight (kg) DEM/DM	DEMI/DMI	DEM2I/DM2I
$U_m/U_p/U_{bil}$	**24/50/125 kV**		1375	320	575							
DEM/DEMI/DEM2I	630/800/1000/1250	100				200	A1	D40	B60	16	18	21
	1600/2000	130				233	B1	-	B100	26	30	33
	2500	170				272	C1	-	B100	38	42	47
DM/DMI/DM2I	3150	170				272	C1	-	B120	38	42	46
	4000/5000	226				321	E1	-	B180	51	58	64
	6300	290				385	F1	-	2xB150	73	80	88
$U_m/U_p/U_{bil}$	**36/70/170 kV**		1375	320	575							
DEM/DEMI/DEM2I	630/800/1000/1250	100				200	A1	D40	B60	16	18	21
	1600/2000	130				233	B1	-	B100	26	30	33
	2500	170				272	C1	-	B100	38	42	47
DM/DMI/DM2I	3150	170				272	C1	-	B120	38	42	47
	4000/5000	226				321	E1	-	B180	51	58	64
	6300	290				385	F1	-	2xB150	73	80	88
$U_m/U_p/U_{bil}$	**52/95/250 kV**		2075	665	925							
DEM/DEMI/DEM2I	630/800	100				200	A1	D30	B60	19	24	30
	1000/1250/1600	130				233	B1	D50	B60	36	43	50
	2000	170				272	C1	-	B100	54	63	73
DM/DMI/DM2I	2500	170				272	C1	-	B100	55	64	72
	3150	226				321	E1	-	B150	82	94	107
$U_m/U_p/U_{bil}$	**72,5/140/325 kV**		2075	665	925							
DEM/DEMI/DEM2I	630/800	100				200	A1	D30	B60	19	24	30
	1000/1250/1600	130				233	B1	D50	B60	36	43	50
	2000	170				272	C1	-	B100	54	63	73
DM/DMI/DM2I	2500	170				272	C1	-	B100	55	64	72
	3150	226				321	E1	-	B150	82	94	107
$U_m/U_p/U_{bil}$	**100/185/450 kV**		2975	1115	1375							
DEM/DEMI/DEM2I	630/800	130				233	B1	D30	B60	43	54	65
	1000/1250/1600	170				272	C1	D60	B60	81	96	111
DM/DMI/DM2I	2000	226				321	E1	-	B100	78	92	106
	2500/3150	226				321	E1	-	B120	86	139	159
$U_m/U_p/U_{bil}$	**123/230/550 kV**		2975	1115	1375							
DEM/DEMI/DEM2I	630/800	130				233	B1	D30	B60	43	54	65
	1000/1250/1600	170				272	C1	D80	B60	81	96	111
DM/DMI/DM2I	2000	226				321	E1	-	B100	78	92	106
	2500/3150	226				321	E1	-	B120	86	139	159
$U_m/U_p/U_{bil}$	**145/275/650 kV**		3375	1315	1575							
DEM/DEMI/DEM2I	630/800/1000/1250	170				272	C1	D50	B60	87	105	122
DM/DMI/DM2I	1600/2000	170				272	C1	-	B100	89	122	135
	2500	226				321	E1	-	B100	141	165	189
$U_m/U_p/U_{bil}$	**170/325/750 kV**		3775	1515	1775							
DEM/DEMI/DEM2I	630/800/1000	170				272	C1	D40	B60	93	113	133
DM/DMI/DM2I	1250/1600	170				272	C1	D60	B60	105	132	159
	2000/2500	226				321	E1	-	B100	160	187	214
$U_m/U_p/U_{bil}$	**245/460/1050 kV**		4975	2115	2375							
DM/DMI/DM2I	630/800/1000/1250/1600	226				321	E1	-	B60	249	282	299

Gemäss / *According to* / Selon IEC 60137:

Standard-Ausführung / *Standard design* / Exécution standard

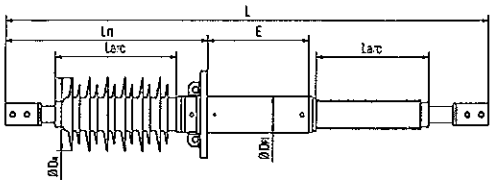
Wanddicke E / *Wall thickness E* / Epaisseur de paroi E	300 mm / 500 mm
Freiluft-Isolator aus Silikon / *Outdoor operation: silicone rubber insulator* / Service extérieur: isolateur composite	91 kV
Umgebungstemperatur / *Ambiant temperature* / Température ambiante	– 40/+40°C

Option / *Optional* / Option

Andere Abmessungen E auf Anfrage / *Other lenghts E on request* / Autres dimensions E sur demande

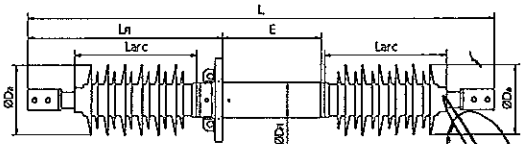
Porzellan-Isolator / *Porcelain insulator* / Isolateur en porcelaine

Stromwandler / *Current transformer* / Transformateur de courant



DEM2I / DM2I

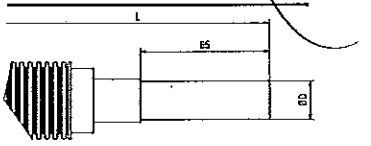
Freiluft-Freiluft
Outdoor-outdoor
Extérieur-extérieur



Cu Conductor – Technical datas & Dimensions for a wall thickness E = 300 mm

Type	Ir : A	Ø Dfl	L	Larc min. Lfl	Ø Da	Flange	Terminal Stud	Terminal Flat pad	Weight (kg) DEM/DM	DEMI/DMI	DEM2I/DM2I
$U_m/U_p/U_{bil}$	**24/50/125 kV**		1295	320 535							
DEM	630/800/1000	70				Y1	D25	BS60	12		
	1250	80				Z1	D32	B28	17		
DEMI/DEM2I	630/800/1000/1250	100			200	A1	D45	B40		30	33
DEM/DEMI/DEM2I	1600	100			200	A1	D45	B40	27	30	33
	2000/2500	130			233	B1	D70	BS100	38	41	45
	3150/4000	170			272	C1	D110	BS150	56	61	65
$U_m/U_p/U_{bil}$	**36/70/170 kV**		1295	320 535							
DEM	630/800/1000	70				Y1	D25	BS60	12		
	1250	80				Z1	D32	B28	17		
DEMI/DEM2I	630/800/1000/1250	100			200	A1	D45	B40		30	33
DEM/DEMI/DEM2I	1600	100			200	A1	D45	B40	27	30	33
	2000/2500	130			233	B1	D70	BS100	38	41	45
	3150	170			272	C1	D100	BS100	68	73	77
$U_m/U_p/U_{bil}$	**52/95/250 kV**		1995	665 885							
DEM/DEMI/DEM2I	630/800/1000/1250	100			200	A1	D32	B28	29	34	40
	1600	130			233	B1	D50	B46	59	66	74
	2000/2500	170			272	C1	D80	BS100	90	99	109
$U_m/U_p/U_{bil}$	**72.5/140/325 kV**		1995	665 885							
DEM/DEMI/DEM2I	630/800/1000/1250	100			200	A1	D32	B28	29	34	40
	1600	130			233	B1	D50	B46	59	66	74
	2000/2500	170			272	C1	D80	BS100	90	99	109
$U_m/U_p/U_{bil}$	**100/185/450 kV**		2895	1115 1335							
DEM/DEMI/DEM2I	630/800/1000	130			200	B1	D32	B28	58	69	81
	1250/1600	170			272	C1	D45	B40	102	118	133
	2000	170			272	C1	D60	B57	129	145	160
$U_m/U_p/U_{bil}$	**123/230/550 kV**		2895	1115 1335							
DEM/DEMI/DEM2I	630/800/1000	130			200	B1	D32	B28	58	69	81
	1250/1600	170			272	C1	D45	B40	102	118	133
	2000	170			272	C1	D60	B57	129	145	160
$U_m/U_p/U_{bil}$	**145/275/650 kV**		3295	1315 1535							
DEM/DEMI/DEM2I	630/800/1000	170			272	C1	D32	B28	98	114	132
	1250	170			272	C1	D40	B37	109	125	143
$U_m/U_p/U_{bil}$	**170/325/750 kV**		3695	1515 1735							
DEM/DEMI/DEM2I	630/800/1000	170			272	C1	D32	B28	108	128	148
	1250	170			272	C1	D40	B37	120	148	161

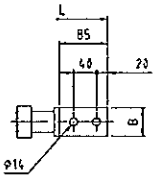
Cu Connections – Cu stud terminals

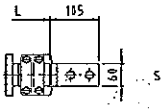


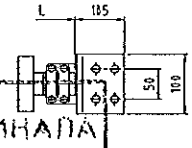
Type	Ø D mm
D 25	25
D 32	32
D 40	40
D 45	45
D 50	50
D 60	60
D 70	70
D 80	80
D 100	100
D 110	110

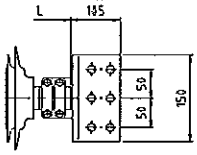
Cu Flat pads terminals according to DIN 46206

S = thickness





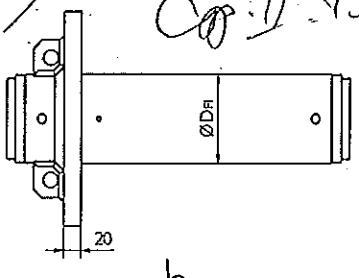


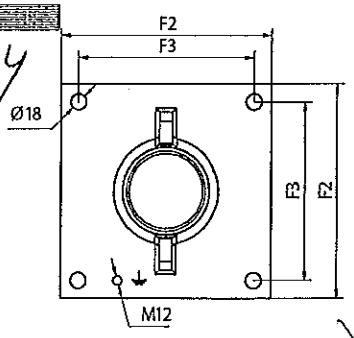


Type	B mm	S mm
B 28	28	15
B 37	37	15
B 40	40	20
B 46	46	20
B 57	57	20
BS 60	60	20
BS 100	100	30
BS 150	150	30

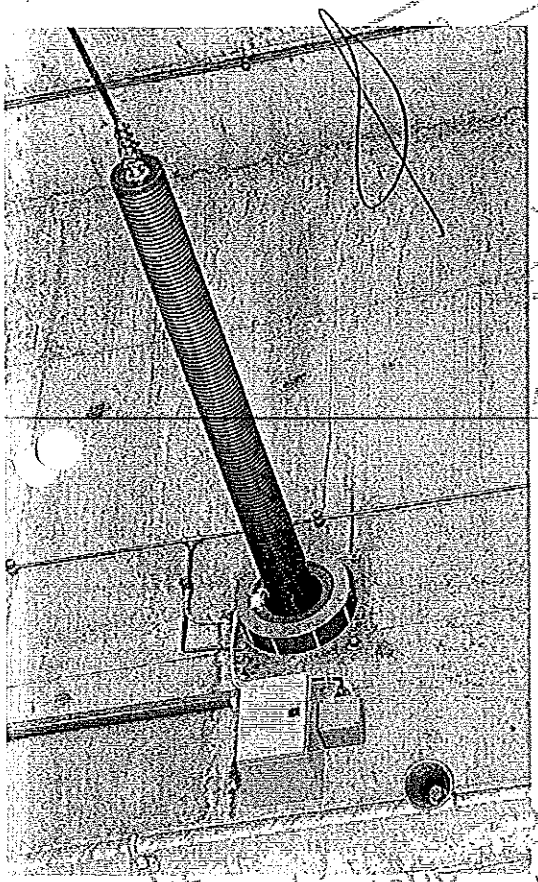
Montage-Flansch / *Mounting flange* / Bride de fixation

Type	Dfl Ø mm	F2 mm	F3 mm
A1	100	240	200
B1	130	350	300
C1	170	350	300
E1	226	400	350
F1	290	450	400
Y1	70	200	150
Z1	80	200	150





PFIFFNER



Wanddurchführung
Wall bushing
Traversée murale
145 kV - 400 A

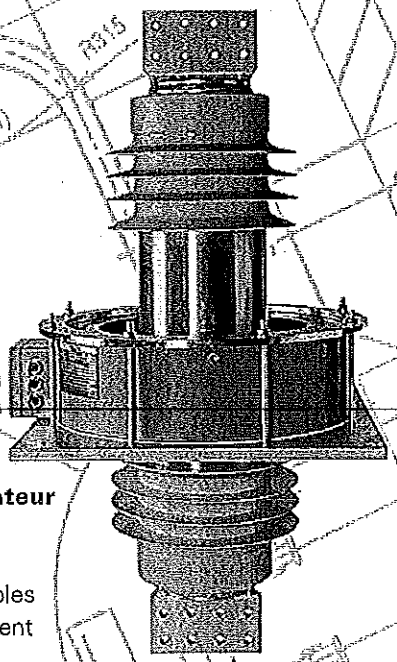
HS Station von La Foretaille, SIG
HV substation of La Foretaille, SIG
Poste HT de La Foretaille, SIG

RIP-Durchführung mit einem Stromwandler ausgerüstet

Stromwandler:
- mehrere Übersetzungen möglich
- gut zugängliche Sekundäreklemmen
- geringer Platzbedarf
- bis zu 4 Kerne
- geeignet für sehr hohe Kurzschlussströmen

RIP bushing equipped with a current transformer

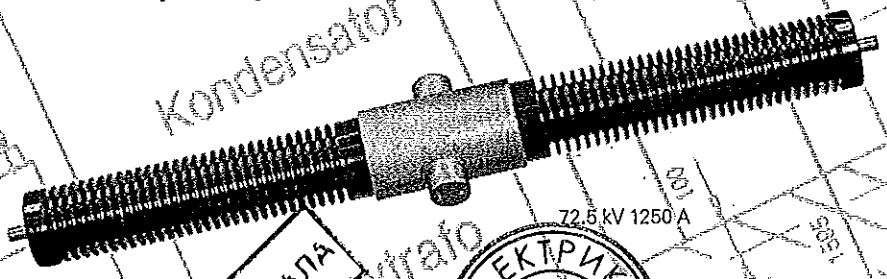
Current transformer:
- several ratios possible
- easily accessible secondary terminals
- compact size
- up to 4 cores
- suitable for very high short-time current



Traversée RIP équipée d'un transformateur de courant

Transformateur de courant:
- nombreux rapports de transformation possibles
- bornes de raccordement secondaire facilement accessible
- dimensions réduites
- apte à supporter des courants de court-circuit élevés

Sonder-Durchführung für Trenner / *Special bushing for disconnector* / Traversée spéciale pour sectionneur



72,5 kV 1250 A

MGC
MOSER-GLASER

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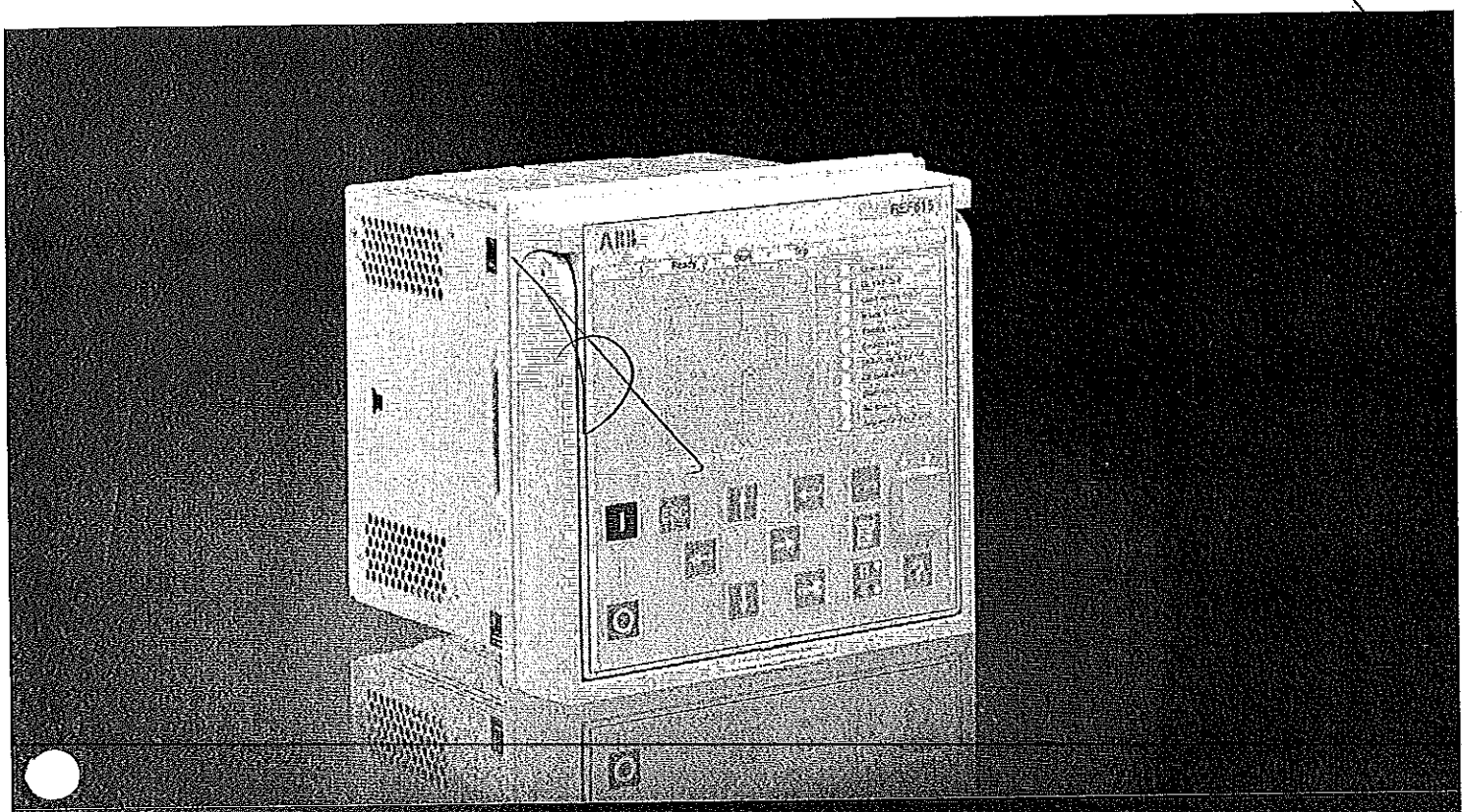
E-Mail info@mgc.ch

Vertreten durch / *Represented by* / Représenté par:

Приложение № 17 – Техническа документация (включително .каталози), даваща пълно описание, технически данни и характеристики на предлаганото оборудване към Приложение № 7 – Технически данни за резервна максималнотокова релейна защита на силов трансформатор; и Приложение №12 – Технически данни за цифрова защита за трафовход Тр-р1 10 и 20 kV в ПС орион и за трафовход 10 kV Тр-р2 в ПС "Боримечка";



Relion® 615 series

Feeder protection and control
REF615
Compact and versatile solution for utility and industrial power distribution systems

Power and productivity
for a better world™

ABB

Unique earth-fault protection for higher sensitivity and selectivity

REF615 is a dedicated feeder protection and control relay for protection, control, measurement and supervision in utility and industrial power distribution systems, including radial, looped and meshed distribution networks, with or without distributed power generation.

Application

REF615 has been designed to be the main overcurrent and earth-fault protection for overhead lines and cable feeders, in either isolated neutral, resistance-earthed, compensated or effectively-earthed distribution networks, depending on the standard configuration.

REF615 is available in twelve standard configurations, all of which can be tailored to meet application-specific requirements using the IEC 61850-compliant Protection and Control IED Manager PCM600. In addition to standard configuration N, also L now provides maximum functionality to allow fully flexible tailoring. The major difference is that L includes support for three combi-sensor inputs for phase currents (Rogowski coil) and voltages (voltage divider), whereas N supports conventional current and voltage instrument transformers.

The extensive earth-fault protection portfolio has been expanded to include a unique multifrequency admittance-based protection for higher sensitivity and selectivity, in response to the requirements of today's growing cable networks. The new earth-fault protection is intended for all types of earth faults – continuous, transient and intermittent – and combines both reliability and sensitivity in one function.

REF615 includes a fault locator which locates short circuits in radial distribution networks and earth faults in effectively and low-resistance earthed ones. If the fault current is as high as or higher than the load current, earth faults in isolated neutral distribution networks will also be located. To minimize the effects of an arc fault, REF615 can be equipped with high-speed outputs decreasing the operate time by four to six milliseconds compared to conventional binary outputs.

Human-machine interface

As a member of the Relion® product family, REF615 shares the same human-machine interface (HMI) look and feel as the other Relion protection and control relays and IEDs. The same look and feel includes the location of a push button with a certain function and the menu structure.

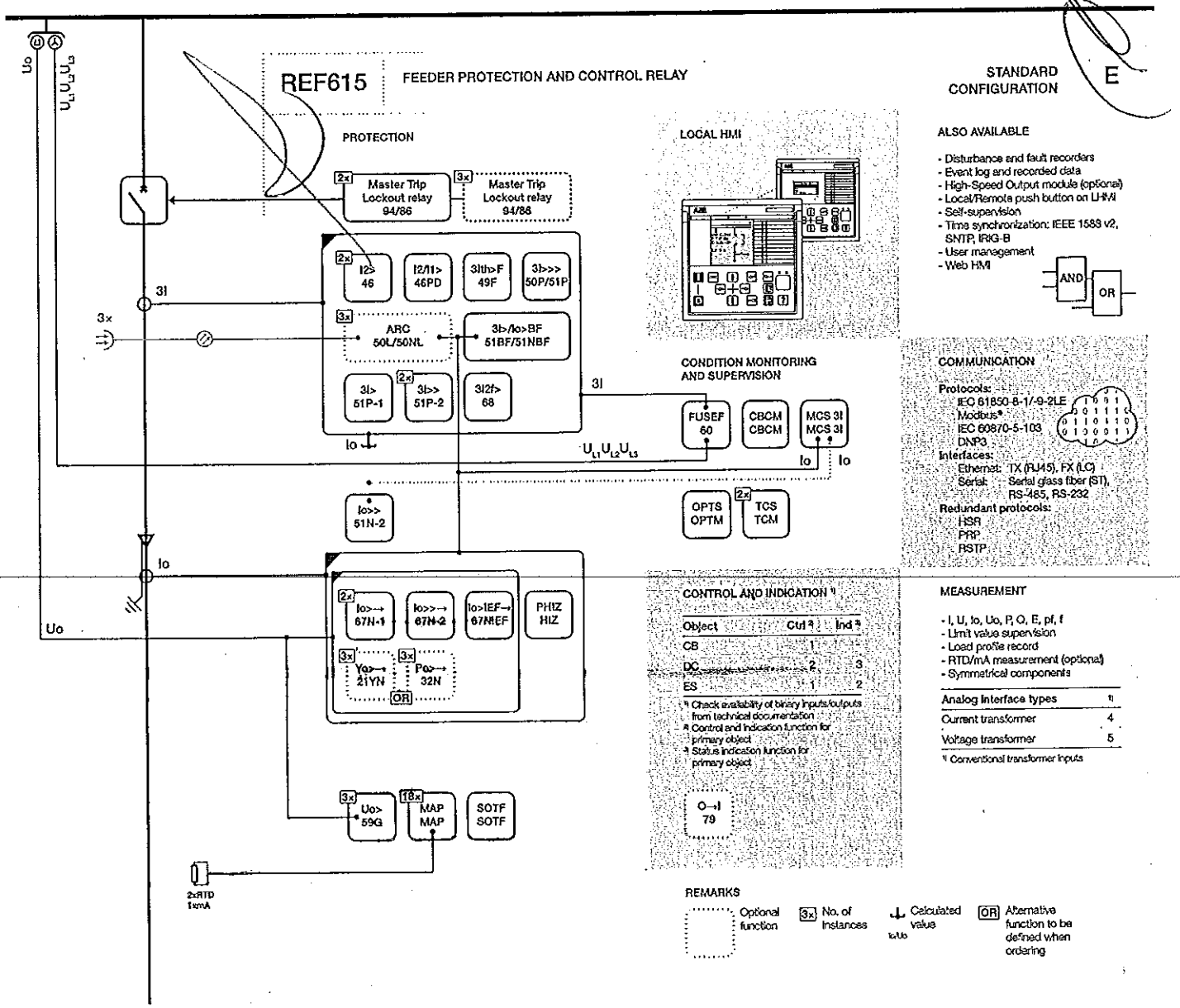
REF615 is equipped with a large graphical display which can show customizable single-line diagrams (SLD) with position indication for the circuit breaker, disconnectors and the earthing switch. Also measured values provided by the chosen standard configuration can be displayed. The SLDs are customized using PCM600 and can have multiple pages for easy access to selected information. The SLDs can be accessed not only locally but also via the web browser-based HMI that has now been enriched with a number of usability enhancing features.

Standardized communication

REF615 fully supports the IEC 61850 standard for communication and interoperability of substation automation devices, including fast GOOSE messaging and IEC 61850-9-2 LE, and can now also benefit from the extended interoperability provided by Edition 2. The feeder relay further supports both the parallel redundancy protocol (PRP) and the high-availability seamless redundancy (HSR) protocol, together with the DNP3, IEC 60870-5-103 and Modbus® protocols. With the protocol adapter SPA-ZC 302, Profibus DVP1 can also be used. REF615 is able to use two communication protocols simultaneously.

For redundant Ethernet communication, REF615 offers either two optical or two galvanic Ethernet network interfaces. A third port with a galvanic Ethernet network interface provides connectivity of any other Ethernet devices to an IEC 61850 station bus inside a switchgear bay. The redundant Ethernet solution can be built on the Ethernet-based IEC 61850, Modbus® and DNP3 protocols.

The implementation of the IEC 61850 standard in REF615 covers both vertical and horizontal communication, including GOOSE messaging with both binary and analog signals as well as parameter setting according to IEC 61850-8-1. Also IEC 61850-9-2 LE process bus with sending sampled values of not only analog voltages but now also currents, in addition to receiving sampled values of voltages, is supported. The sampled values can now be used for synchro-check as well, both in conventional instrument transformer and now also sensor-based applications, to ensure safe interconnection of two networks. For process bus applications, which require high-accuracy time synchronization, IEEE 1588 V2 is used, with a time stamp resolution of not more than four microseconds. IEEE 1588 V2 is supported in all variants with a redundant Ethernet communication module. In addition, REF615 supports synchronization over Ethernet using SNTP or over a separate bus using IRIG-B.



Function overview of the E configuration of REF615.

Main benefits

- Withdrawable plug-in unit design for swift installation and testing
- Extensive range of protection and control functionality, either with sensors or conventional instrument transformers
- Ready-made standard configurations for fast and easy setup with tailoring capabilities
- Extensive earth-fault protection portfolio with unique multifrequency admittance-based protection for higher sensitivity and selectivity
- Advanced and fast fault location of short circuits and earth faults
- IEC 61850 Edition 2 and Edition 1 support, including HSR and PRP, GOOSE messaging and IEC 61850-9-2 LE for less wiring and supervised communication
- IEEE 1588 V2 for high-accuracy time synchronization and maximum benefit of substation-level Ethernet communication
- Large graphical display for showing customizable SLDs, accessible either locally or through a web browser-based HMI

615 series

REF615 is a member of ABB's Relion product family and part of its 615 protection and control series of relays, characterized by compactness and withdrawable plug-in unit design. In addition to REF615, the 615 series includes the following relays:

- RED615 Line differential protection and control
- RET615 Transformer protection and control
- REU615 Voltage protection and control
- REM615 Motor protection and control
- REV615 Capacitor bank protection and control

Life-cycle services

ABB offers full support for all protection and control relays throughout their entire lifecycle. Our extensive life cycle services include training, customer support, maintenance and modernization.

Standard configurations

Standard configurations

Description	Standard configuration
Non-directional overcurrent and directional earth-fault protection	A
Non-directional overcurrent and directional earth-fault protection and circuit-breaker condition monitoring (RTD otion)	B
Non-directional overcurrent and earth-fault protection	C
Non-directional overcurrent and earth-fault protection and circuit-breaker condition monitoring (RTD option)	D
Non-directional overcurrent and directional earth-fault protection, voltage-based measurements and circuit-breaker condition monitoring (RTD option)	E
Directional overcurrent and earth-fault protection, voltage-based protection and measurement functions, and circuit-breaker condition monitoring (RTD option)	F
Directional overcurrent and earth-fault protection, voltage-based protection and measurement functions, and circuit-breaker condition monitoring (sensor inputs and optional synchro-check with IEC 61850-9-2LE)	G
Non-directional overcurrent and earth-fault protection, voltage and frequency based protection and measurement functions, synchro-check and circuit-breaker condition monitoring (RTD option)	H

Supported functions, codes and symbols

Functionality	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	3I>	51P-1
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	3I>>	51P-2
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	3I>>>	50P/51P
Three-phase directional overcurrent protection, low stage	DPHLPDOC	3I> →	67-1
Three-phase directional overcurrent protection, high stage	DPHHPDOC	3I>> →	67-2
Non-directional earth-fault protection, low stage	EFLPTOC	Io>	51N-1
Non-directional earth-fault protection, high stage	EFHPTOC	Io>>	51N-2
Non-directional earth-fault protection, instantaneous stage	EFIPTOC	Io>>>	50N/51N
Directional earth-fault protection, low stage	DEFLPDEF	Io> →	67N-1
Directional earth-fault protection, high stage	DEFHPDEF	Io>> →	67N-2
Admittance based earth-fault protection [3]	EFPADM	Yo> →	21YN
Wattmetric based earth-fault protection [3]	WPWDE	Po> →	32N
Transient / intermittent earth-fault protection	INTRPTEF	Io> → IEF	67NIEF
Harmonics based earth-fault protection [3]	HAEFPTOC	Io> HA	51NHA
Non-directional (cross-country) earth fault protection, using calculated Io	EFHPTOC	Io>>	51N-2
Negative-sequence overcurrent protection	NSPTOC	I2>	46
Phase discontinuity protection	PDNSPTOC	I2/I1>	46PD
Residual overvoltage protection	ROVPTOV	Uo>	59G
Three-phase undervoltage protection	PHPTUV	3U<	27
Three-phase overvoltage protection	PHPTOV	3U>	59
Positive-sequence undervoltage protection	PSPTUV	U1<	47U+
Negative-sequence overvoltage protection	NSPTOV	U2>	47O-
Frequency protection	FRPFRQ	f>/f<, df/dt	81
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR	3Ith>F	49F
High impedance based restricted earth-fault protection	HREFPDIF	dIoHi>	87NH
High-impedance differential protection for phase A	HIAPDIF	dHi> (A)	87 (2)
High-impedance differential protection for phase B	HIBPDIF	dHi> (B)	87 (2)
High-impedance differential protection for phase C	HICPDIF	dHi> (C)	87 (3)
Circuit breaker failure protection	CCBRBRF	3I>/Io>BF	51BF/51NBF
Three-phase inrush detector	INRPHAR	3I2f>	68
Switch onto fault	CBPSOF	SOTF	SOTF
Master trip	TRPPTRC	Master Trip	94/86
Arc protection	ARCSARC	ARC	50L/50NL
Multi-purpose protection	MAPGAPC	MAP	MAP
Fault locator	SCEFRFLO	FLOC	21FL
High impedance fault detection	PHIZ	HIF	HIZ

Standard configurations

Description	Standard configuration
Directional overcurrent and earth-fault protection, voltage and frequency based protection and measurement functions, synchro-check and circuit-breaker condition monitoring (optional power quality and RTD option)	J
Directional and non-directional overcurrent and earth-fault protection, high-impedance restricted earth-fault protection, voltage and frequency based protection and measurement functions, synchrocheck and circuit-breaker condition monitoring (optional power quality and fault locator)	K
Directional and non-directional overcurrent and earth-fault protection with multifrequency neutral admittance, voltage, frequency and power based protection and measurement functions, and circuit breaker condition monitoring (sensor inputs, optional power quality, fault locator, interconnetion protection and synchro-check with IEC 61850-9-2LE)	L
Directional and non-directional overcurrent and earth-fault protection with multifrequency neutral admittance, voltage, frequency and power based protection and measurement functions, highimpedance differential protection, synchro-check and circuit-breaker condition monitoring (optional power quality, fault locator and interconnection protection)	N

1, 2,... = number of included instances, I/Os) = optional

A	B	C	D	E	F	G	H	J	K	L	N
1	1	1	1	1	-	-	1	-	1	2	2
2	2	2	2	2	-	-	2	-	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
-	-	-	-	-	2	2	-	2	1	2	2
-	-	-	-	-	1	1	-	1	1	1	1
-	-	2	2	-	-	-	2	-	2	2	2
-	-	1	1	-	-	-	1	-	1	-	1
-	-	1	1	-	-	-	1	-	1	1	1
2 [1]	2 [1]	-	-	2	2	2 [2]	-	2	1	2 [2]	2
1 [1]	1 [1]	-	-	1	1	1 [2]	-	1	1	1 [2]	1
(3) [1][3]	(3) [1][3]	-	-	(3) [3]	(3) [3]	(3) [2][3]	-	(3) [3]	-	(3) [2][3]	(3) [3]
(3) [1][3]	(3) [1][3]	-	-	(3) [3]	(3) [3]	(3) [2][3]	-	(3) [3]	-	(3) [2][3]	(3) [3]
1 [4]	1 [4]	-	-	1 [4]	1 [4]	-	-	1 [4]	-	1 [2][4]	1 [4]
-	(1) [3][4]	-	(1) [3][4]	-	(1) [3][4]	-	-	(1) [3][4]	-	(1) [3][4]	(1) [3][4]
1	1	-	-	1	1	1	-	1	-	1	-
2	2	2	2	2	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	-	1	1
3 [1]	3 [1]	-	-	3	3	3 [2]	3	3	2	3 [2]	3
-	-	-	-	-	3	3	3	3	2	3	3
-	-	-	-	-	3	3	3	3	2	3	3
-	-	-	-	-	1	1	-	1	-	2	2
-	-	-	-	-	1	1	-	1	-	2	2
-	-	-	-	-	-	-	3	3	3	6	6
1	1	1	1	1	1	1	-	1	1	1	1
-	-	-	-	-	-	-	-	-	1 [5]	-	-
-	-	-	-	-	-	-	-	-	-	-	1
-	-	-	-	-	-	-	-	-	-	-	1
-	-	-	-	-	-	-	-	-	-	-	1
1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
2	2(5) [6]	2	2(5) [6]	2(5) [6]	2(5) [5]	2(5) [6]	2(5) [6]	2(5) [6]	2(5) [6]	2(5) [6]	2(5) [6]
(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
18	18	18	18	18	18	18	18	18	18	18	18
-	-	-	-	-	-	-	-	-	(1)	(1)	(1)
-	1	-	1	1	1	1	1	1	-	-	-

Standard configurations

Supported functions, codes and symbols

Functionality	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Reverse power/directional overpower protection	DOPPDPR	P> / Q>	32R/32O
Multifrequency admittance-based earth-fault protection	MFADPSDE	Io> → Y	67YN
Interconnect functions			
Directional reactive power undervoltage protection	DQPTUV	Q>→, 3U>	32Q, 27
Low-voltage ridethrough protection	LVRTPTUV	U<RT	27RT
Voltage vector shift protection	VVSPPAM	VS	78V
Power Quality			
Current total demand distortion	CMHAI	PQM3I	PQM3I
Voltage total harmonic distortion	VMHAI	PQM3U	PQM3V
Voltage variation	PHQVVR	PQMU	PQMV
Voltage unbalance	VSQVUB	PQMUBU	PQMUBV
Control			
Circuit-breaker control	CBXCBR	I ↔ O CB	I ↔ O CB
Disconnector control	DCXSWI	I ↔ O DCC	I ↔ O DCC
Earthing switch control	ESXSWI	I ↔ O ESC	I ↔ O ESC
Disconnector position indication	DCSXSWI	I ↔ O DC	I ↔ O DC
Earthing switch indication	ESSXSWI	I ↔ O ES	I ↔ O ES
Auto-reclosing	DARREC	O → I	79
Synchronism and energizing check	SECRSYN	SYNC	25
Condition Monitoring			
Circuit-breaker condition monitoring	SSCBR	CBCM	CBCM
Trip circuit supervision	TCSSCBR	TCS	TCM
Current circuit supervision	CCRDIF	MCS 3I	MCS 3I
Current transformer supervision for highimpedance protection scheme for phase A	HZCCASPVC	MCS I_A	MCS I_A
Current transformer supervision for highimpedance protection scheme for phase B	HZCCBSPVC	MCS I_B	MCS I_B
Current transformer supervision for highimpedance protection scheme for phase C	HZCCCSPVC	MCS I_C	MCS I_C
Fuse failure supervision	SEQRFUF	FUSEF	60
Runtime counter for machines and devices	MDSOPT	OPTS	OPTM
Measurement			
Disturbance recorder	RDRE	DR	DFR
Load profile record	LDPMSTA	LOADPROF	LOADPROF
Fault record	FLTRFRC	FAULTREC	FAULTREC
Three-phase current measurement	CMMXU	3I	3I
Sequence current measurement	CSMSQI	I1, I2, I0	I1, I2, I0
Residual current measurement	RESCMMXU	Io	In
Three-phase voltage measurement	VMMXU	3U	3U
Residual voltage measurement	RESVMMXU	Uo	Vn
Sequence voltage measurement	VSMSQI	U1, U2, U0	V1, V2, V0
Three-phase power and energy measurement, including power factor	PEMMXU	P, E	P, E
RTD/mA measurement	XRGGIO130	X130 (RTD)	X130 (RTD)
Frequency measurement	FMMXU	f	f
IEC 61850-9-2 LE sampled value receiving [8) 9)]	SMVSENDER	SMVSENDER	SMVSENDER
IEC 61850-9-2 LE sampled value receiving (voltage sharing) [8) 9)]	SMVRCV	SMVRCV	SMVRCV

1) "Uo measured" is always used.
2) "Uo calculated" is always used.
3) One of the following can be ordered as an option: admittance-based E/F, wattmetric-based E/F or harmonics-based E/F.
4) "Io measured" is always used.
5) "IoB measured" is always used.
6) Master trip is included and connected to the corresponding HSO in the configuration only when the BIO0007 module is used. If additionally the ARC option is selected, ARC-SARC is connected in the configuration to the corresponding master trip input.

1, 2,... = number of included instances / I/Os
( ) = optional

A	B	C	D	E	F	G	H	J	K	L	N
-	-	-	-	-	-	-	-	-	-	2	2
-	-	-	-	-	-	-	-	-	-	1	1
-	-	-	-	-	-	-	-	-	-	(1)	(1)
-	-	-	-	-	-	-	-	-	-	(3)	(3)
-	-	-	-	-	-	-	-	-	-	(1)	(1)
-	-	-	-	-	-	-	-	(1) [7]	(1) [7]	(1) [7]	(1) [7]
-	-	-	-	-	-	-	-	(1) [7]	(1) [7]	(1) [7]	(1) [7]
-	-	-	-	-	-	-	-	(1) [7]	(1) [7]	(1) [7]	(1) [7]
-	-	-	-	-	-	-	-	(1) [7]	(1) [7]	(1) [7]	(1) [7]
1	1	1	1	1	1	1	1	1	1	1	1
-	2	-	2	2	2	2	2	2	2	2	2
-	1	-	1	1	1	1	1	1	1	1	1
-	3	-	3	3	3	3	3	3	3	3	3
-	2	-	2	2	2	2	2	2	2	2	2
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
-	-	-	-	-	-	(1)[5]	1	1	1	(1)[8]	1
-	1	-	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2
-	-	-	-	1	1	1	1	1	1	1	1
-	-	-	-	-	-	-	-	-	-	-	1
-	-	-	-	-	-	-	-	-	-	-	1
-	-	-	-	-	-	-	-	-	-	-	1
-	-	-	-	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
-	1	-	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	2	1	1
-	-	-	-	1	1	1 (2)[8]	2	2	2	1 (2)[8]	2
1	1	-	-	1	1	-	1	1	1	-	1
-	-	-	-	1	1	1	1	1	1	1	1
-	-	-	-	1	1	1	1	1	1	1	1
-	(1)	-	(1)	(1)	(1)	-	(1)	(1)	-	-	(1)
-	-	-	-	1	1	1	1	1	1	1	1
-	-	-	-	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
-	-	-	-	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

7) Power quality option includes current total demand distortion, voltage total harmonic distortion, voltage variation and voltage unbalance.
8) Available only with IEC 61850-9-2
9) Available only with COM0031-0037

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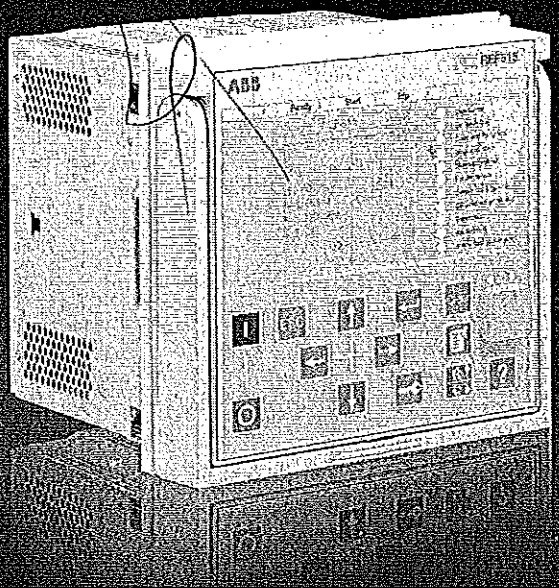

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Feeder Protection and Control
REF615
Product Guide

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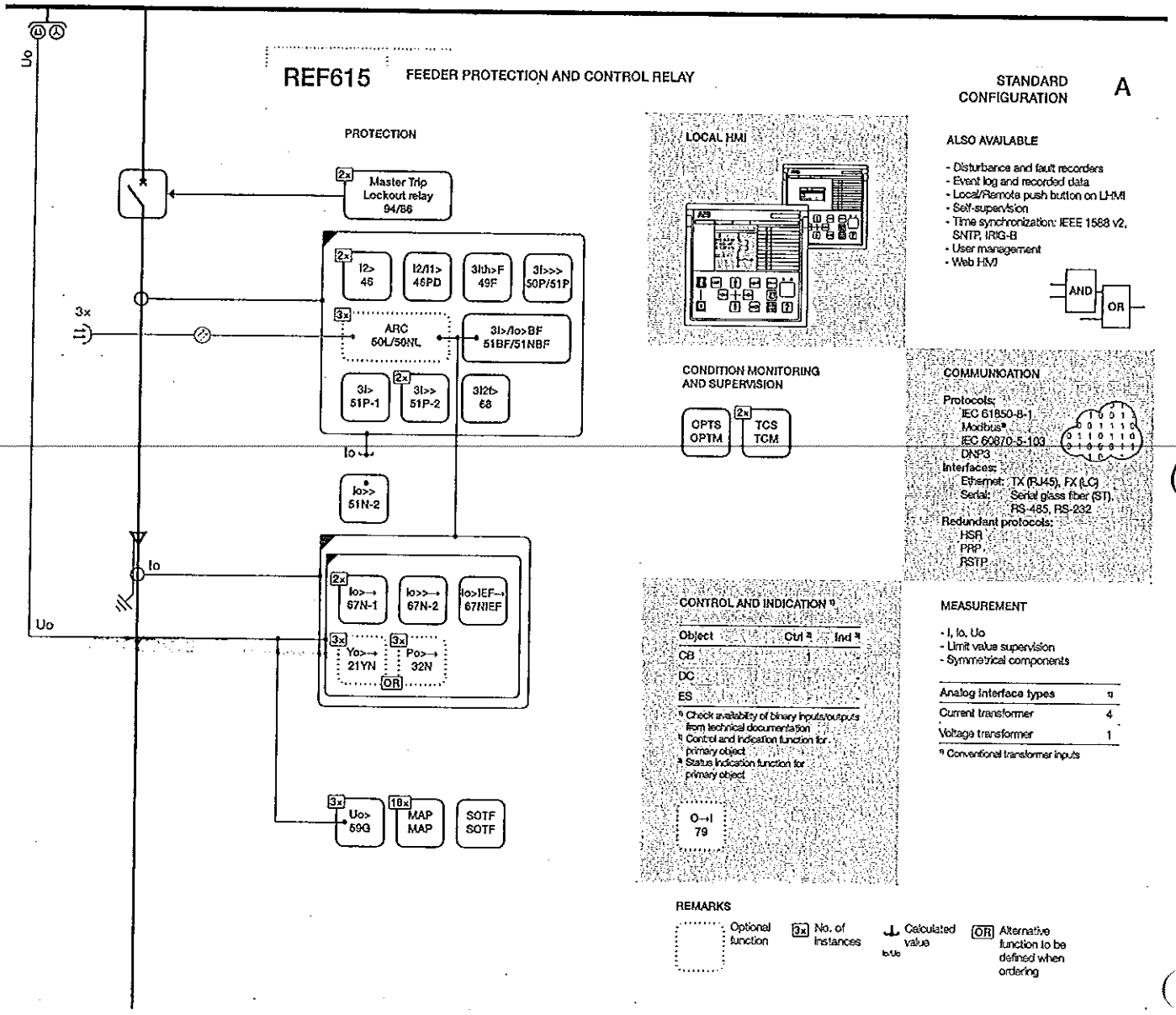


Figure 1. Functionality overview for standard configuration A

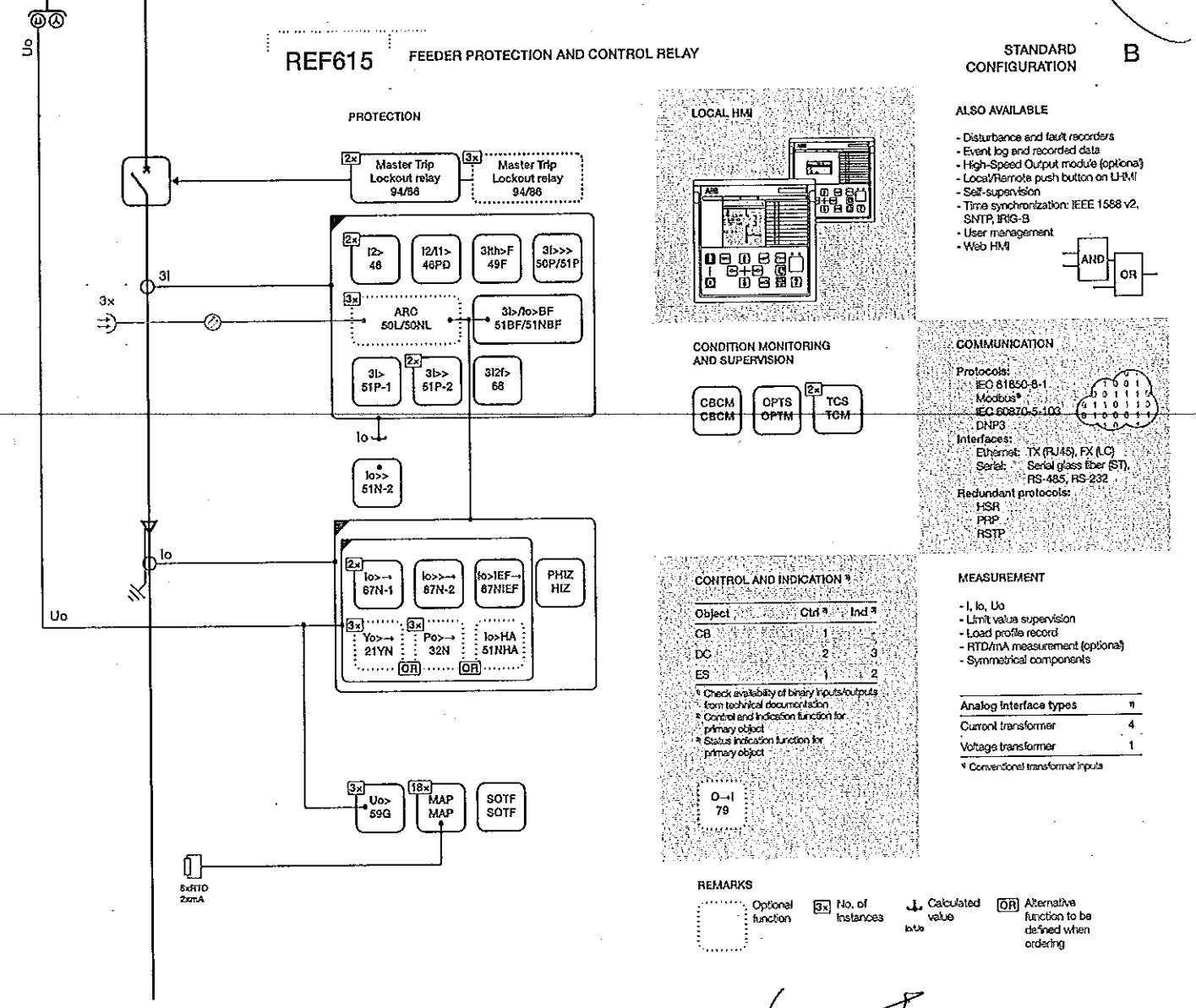


Figure 2. Functionality overview for standard configuration B

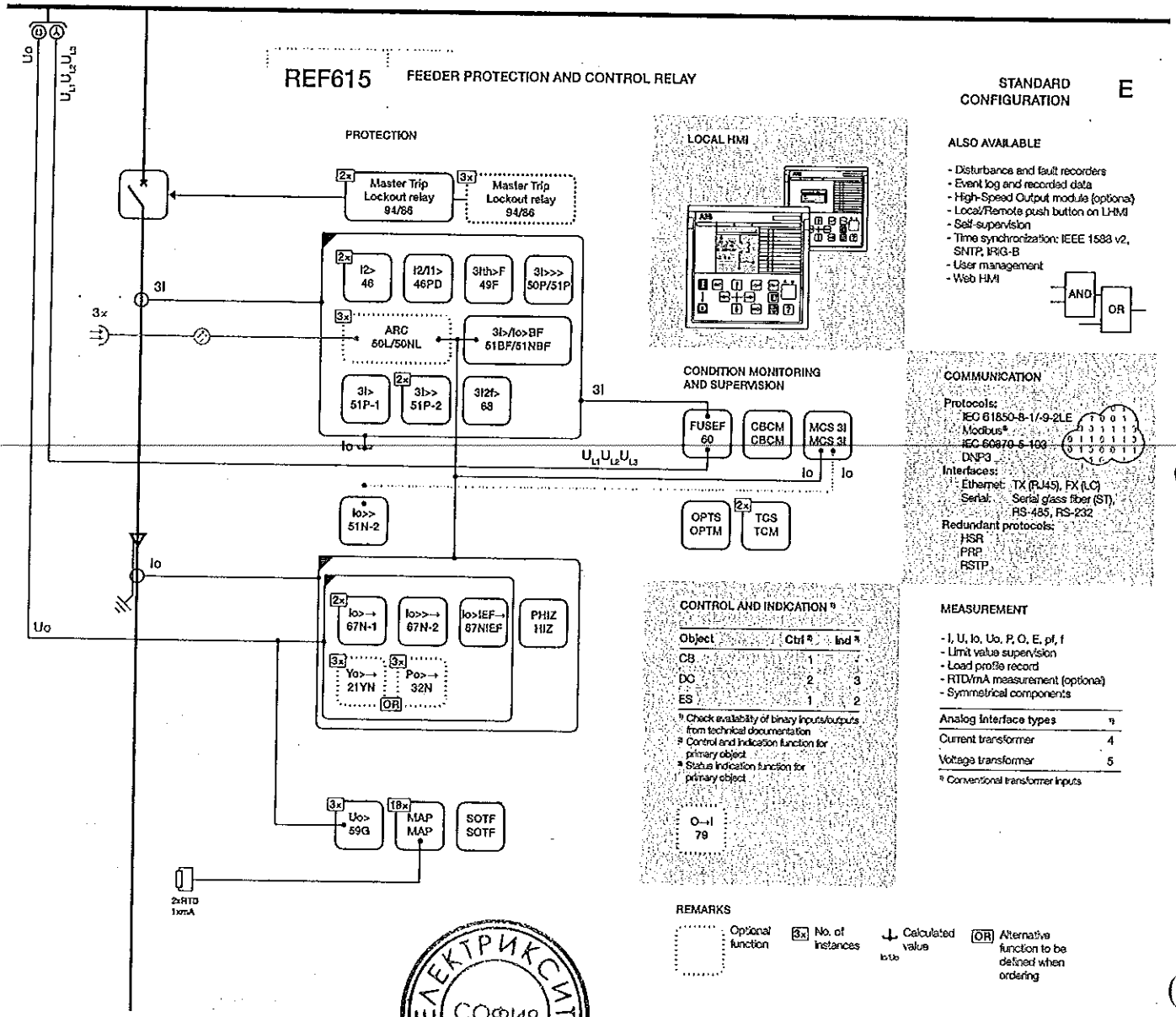


Figure 5. Functionality overview for standard configuration E

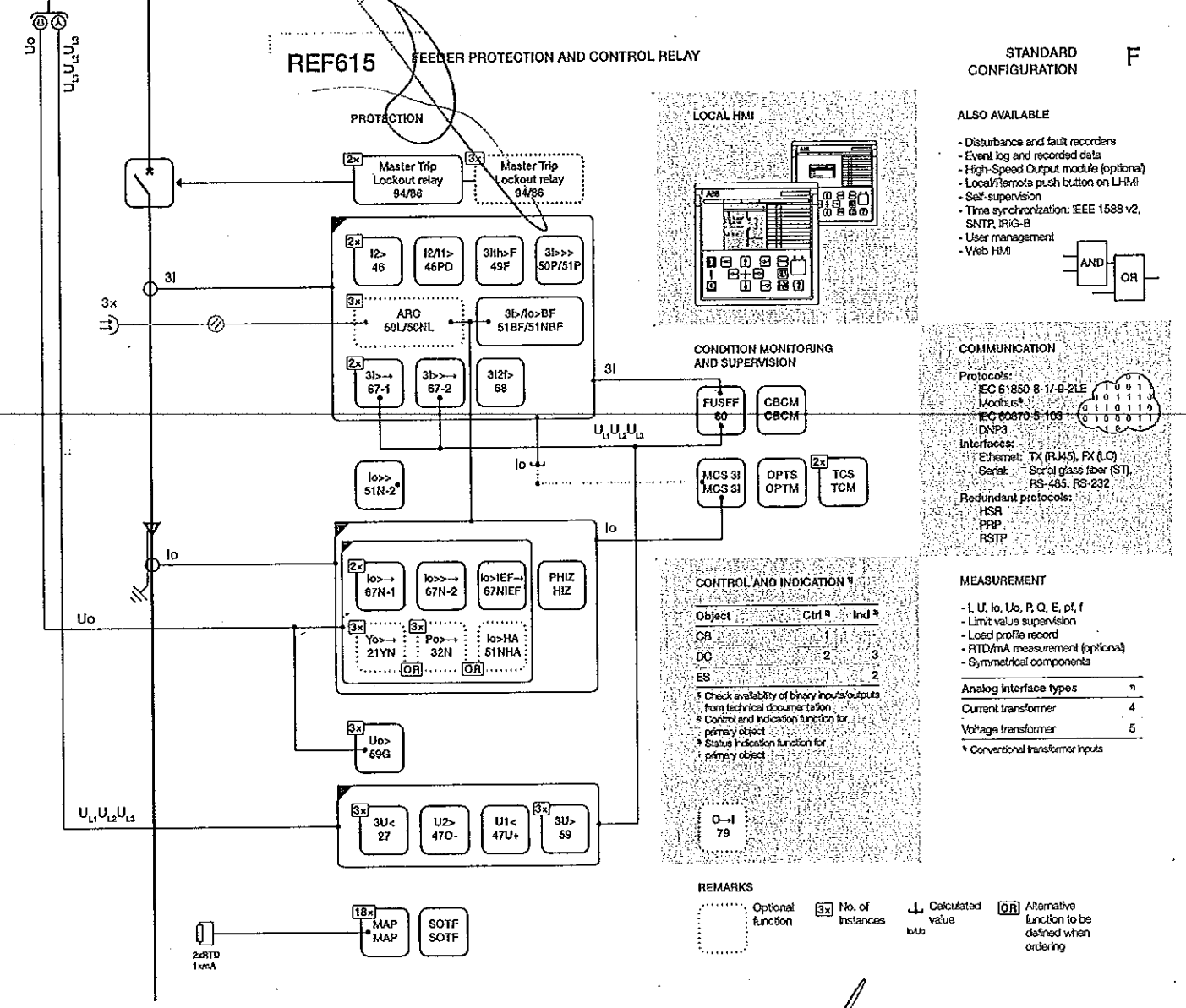


Figure 6. Functionality overview for standard configuration F

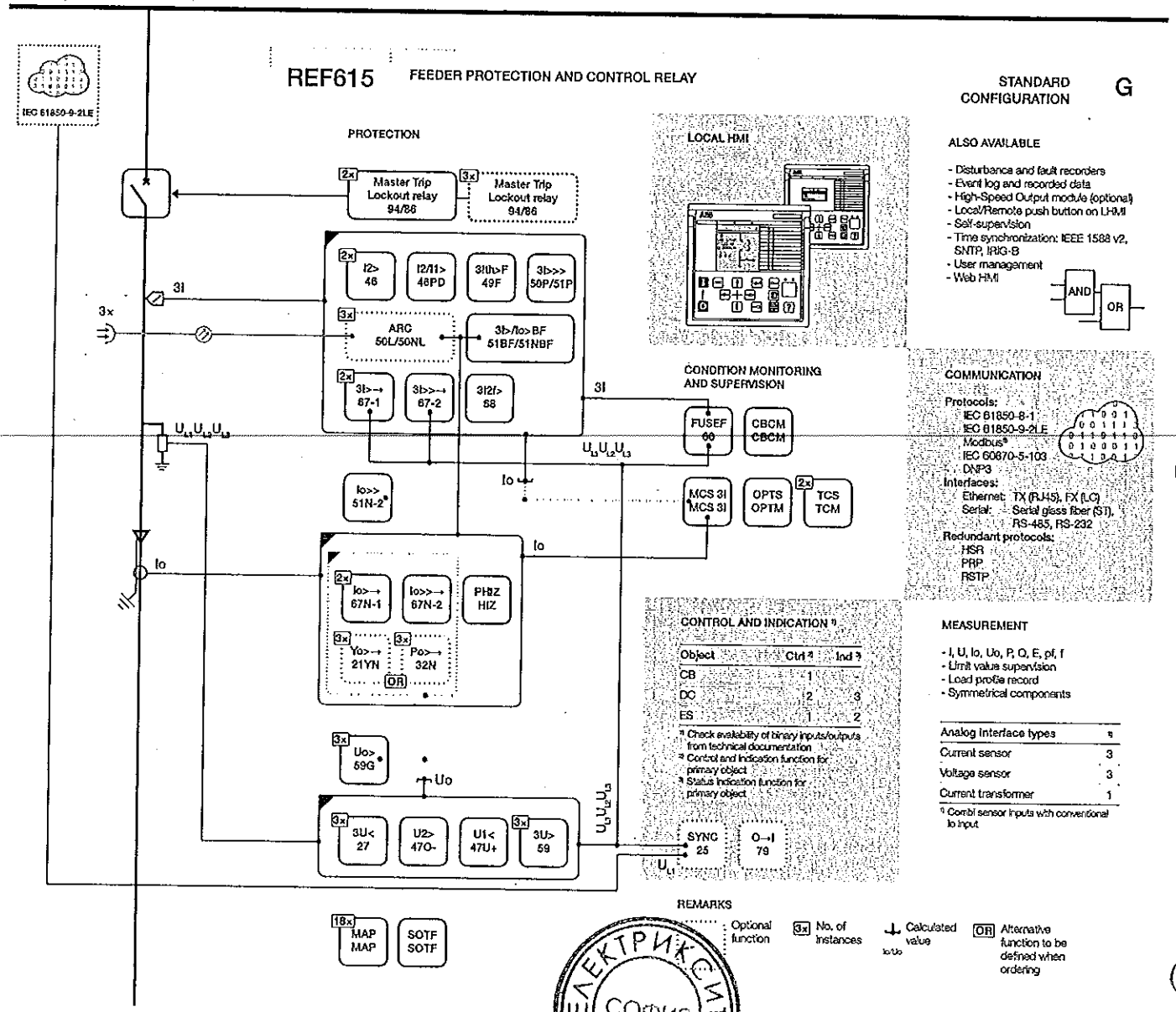


Figure 7. Functionality overview for standard configuration G

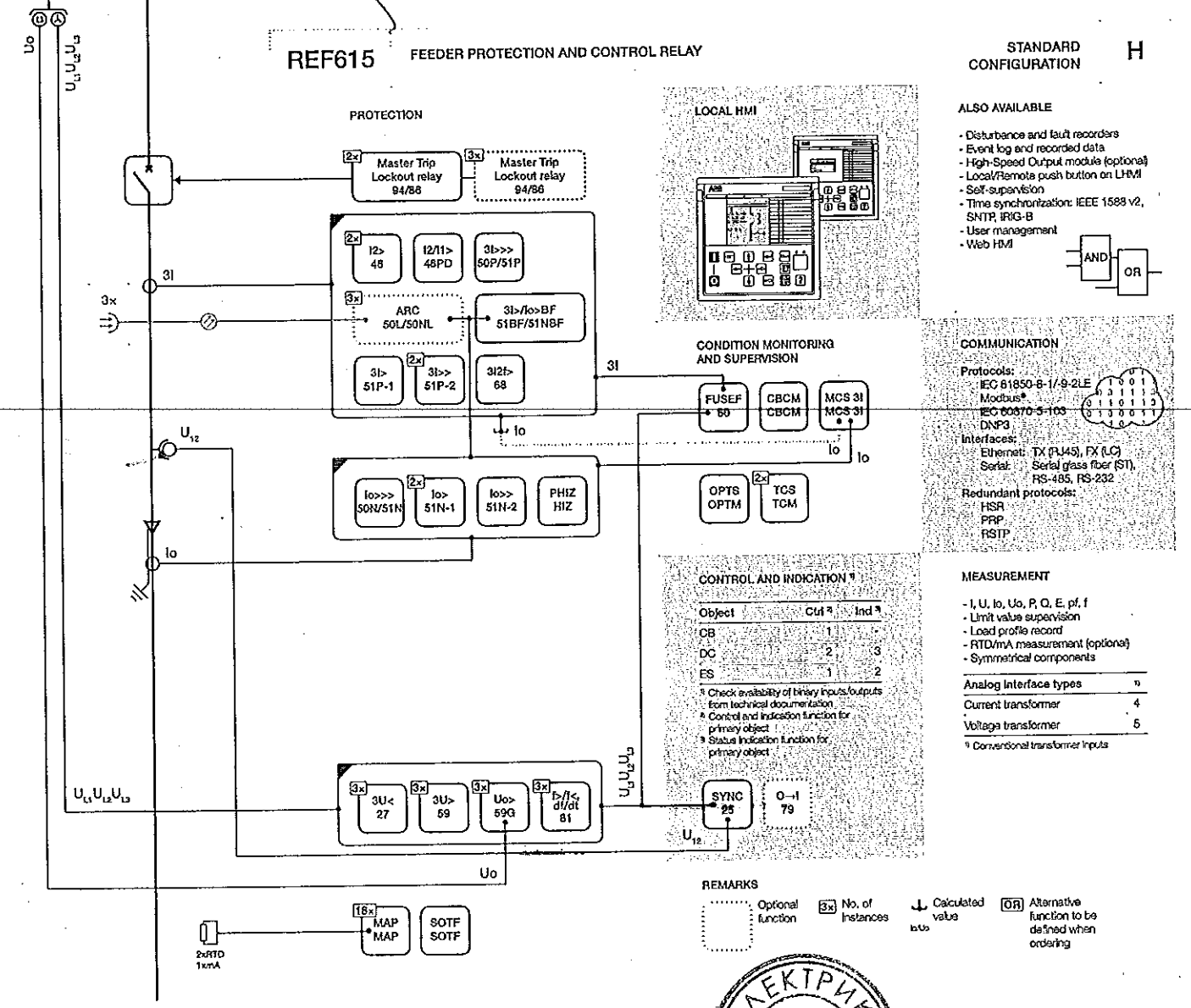


Figure 8. Functionality overview for standard configuration H

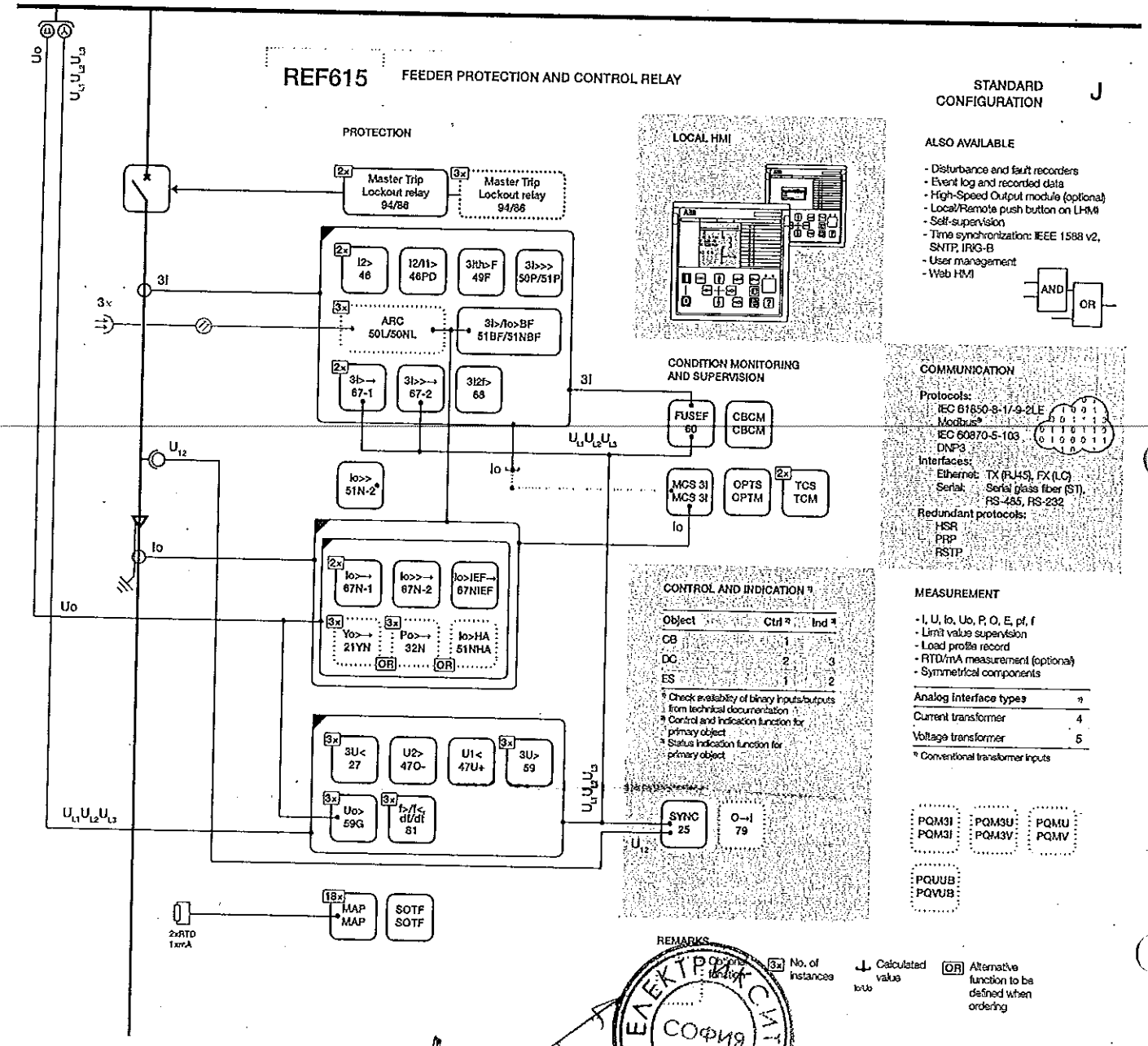


Figure 9. Functionality overview for standard configuration J

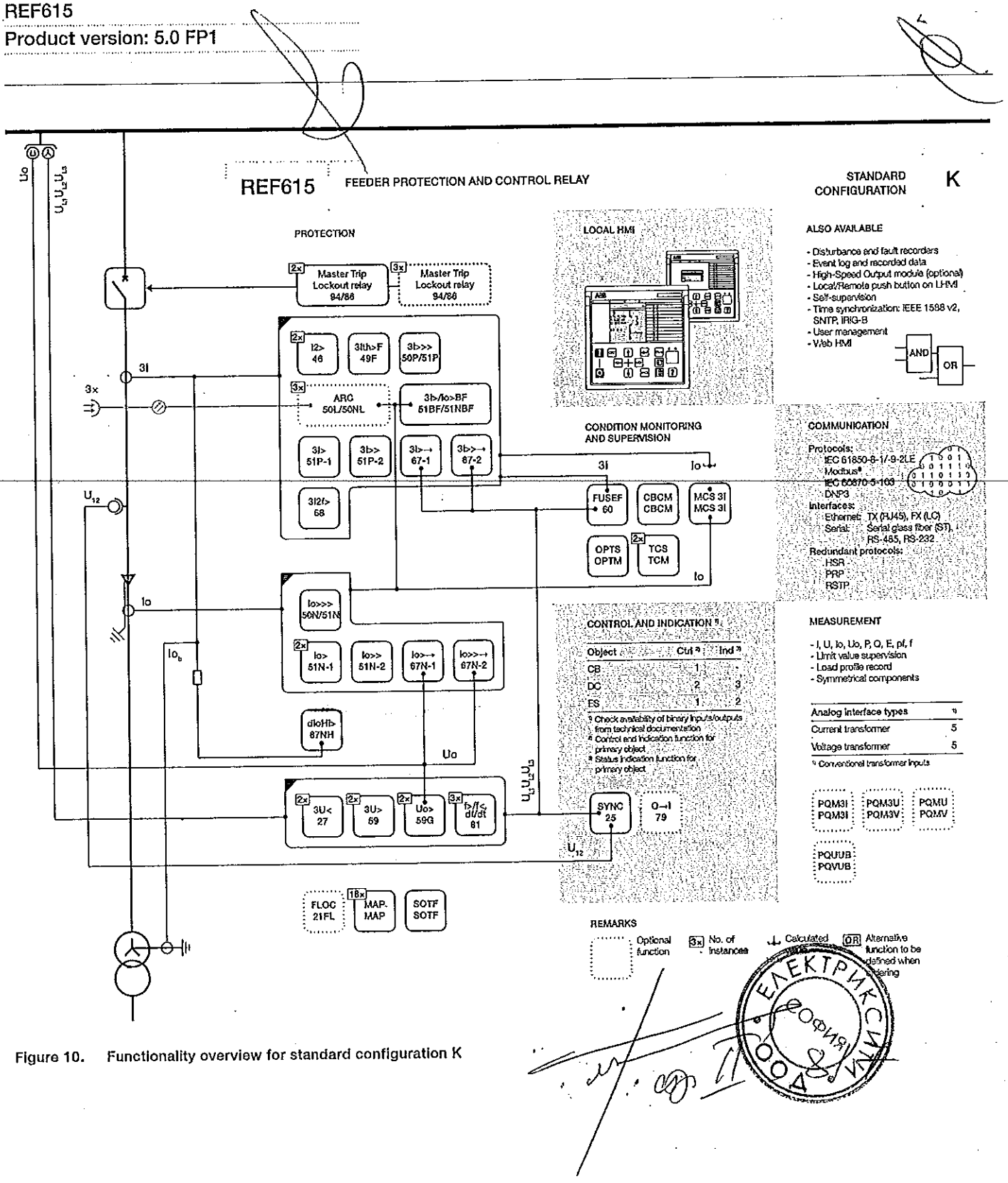


Figure 10. Functionality overview for standard configuration K

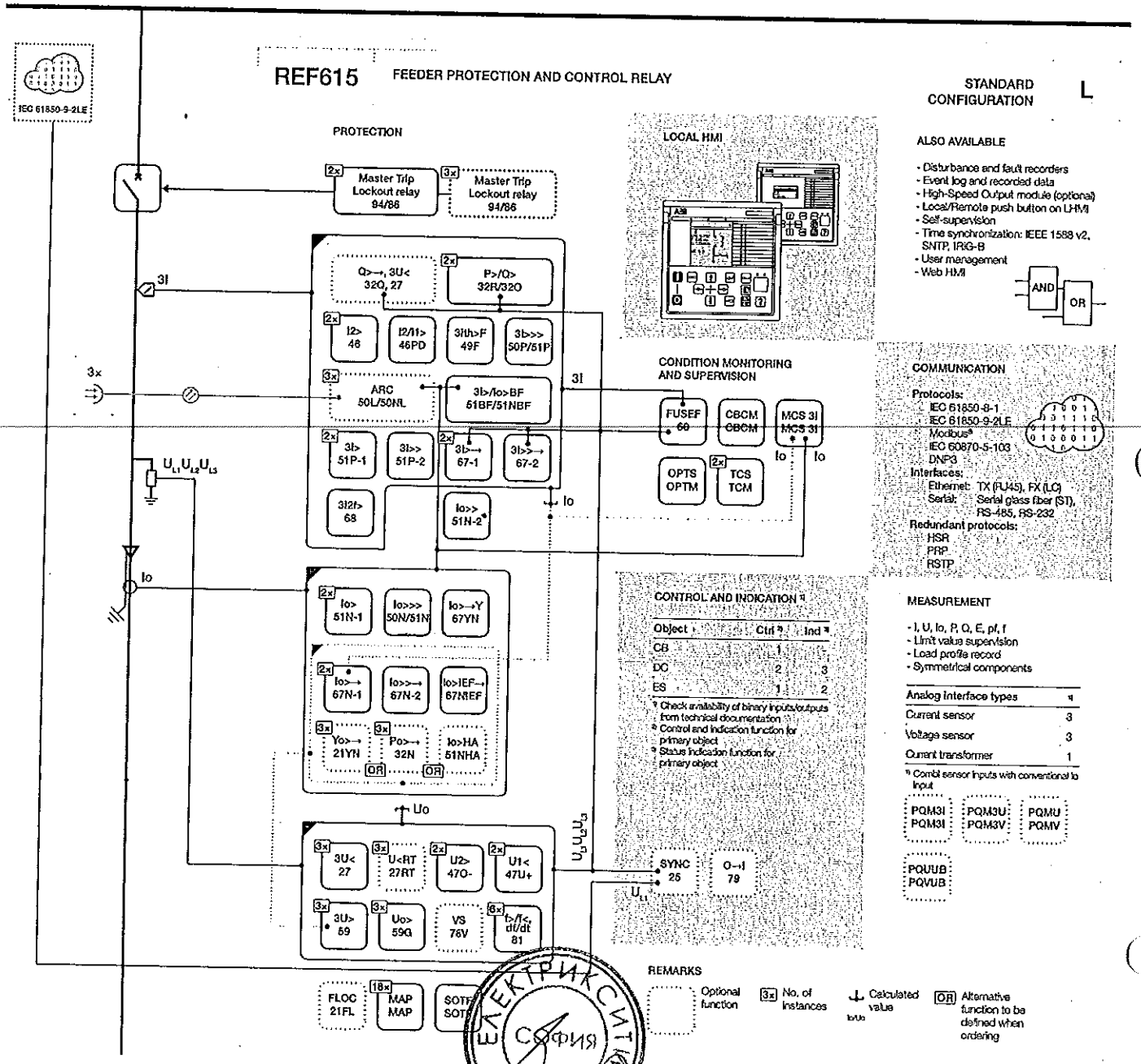


Figure 11. Functionality overview for standard configuration L

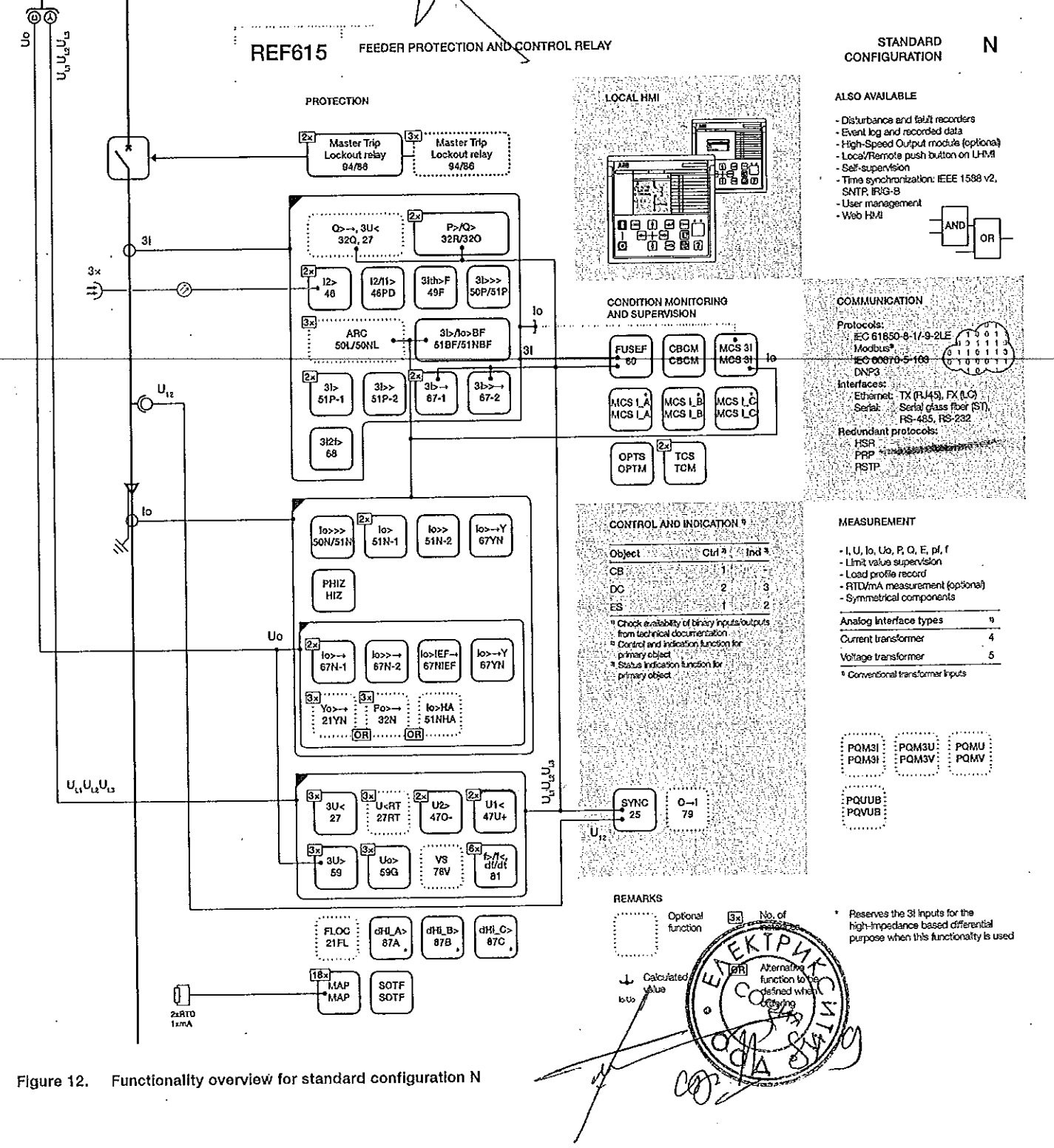


Figure 12. Functionality overview for standard configuration N

Table 2. Supported functions, continued

Function	IEC 61850	A	B	C	D	E	F	G	H	J	K	L	N
High-impedance differential protection for phase B	HIBPDIF												1
High-impedance differential protection for phase C	HICPDIF												1
Circuit breaker failure protection	CCBRBRF	1	1	1	1	1	1	1	1	1	1	1	1
Three-phase inrush detector	INRPHAR	1	1	1	1	1	1	1	1	1	1	1	1
Switch onto fault	CBPSOF	1	1	1	1	1	1	1	1	1	1	1	1
Master trip	TRPPTRC	2	2 (3)[6]	2	2 (3)[6]	2 (3)[6]	2 (3)[6]	2 (3)[6]	2 (3)[6]	2 (3)[6]	2 (3)[6]	2 (3)[6]	2 (3)[6]
Arc protection	ARCSARC	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Multipurpose protection	MAPGAPC	18	18	18	18	18	18	18	18	18	18	18	18
Fault locator	SCEFRFLO										(1)	(1)	(1)
High-impedance fault detection	PHIZ		1		1	1	1	1	1	1			1
Reverse power/ directional overpower protection	DOPPDPR											2	2
Multifrequency admittance-based earth-fault protection	MFADPSDE											1	1
Interconnection functions													
Directional reactive power undervoltage protection	DQPTUV											(1)	(1)
Low-voltage ride-through protection	LVRTPTUV											(3)	(3)
Voltage vector shift protection	VVSPPAM											(1)	(1)
Power quality													
Current total demand distortion	CMHAI									(1)[7]	(1)[7]	(1)[7]	(1)[7]
Voltage total harmonic distortion	VMHAI									(1)[7]	(1)[7]	(1)[7]	(1)[7]
Voltage variation	PHQVVR									(1)[7]	(1)[7]	(1)[7]	(1)[7]
Voltage unbalance	VSQVUB									(1)[7]	(1)[7]	(1)[7]	(1)[7]
Control													
Circuit-breaker control	CBXCBR	1	1	1	1	1	1	1	1	1	1	1	1
Disconnector control	DCXSWI		2		2	2	2	2	2	2	2	2	2
Earthing switch control	ESXSWI		1		1	1	1	1	1	1	1	1	1
Disconnector position indication	DCSXSWI		3		3	3	3	3	3	3	3	3	3
Earthing switch indication	ESSXSWI		2		2	2	2	2	2	2	2	2	2
Autoreclosing	DARREC	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Synchronism and energizing check	SECRSYN							(1)[8]	1	1	1	(1)[8]	1
Condition monitoring and supervision													
Circuit-breaker condition monitoring	SSCBR		1		1	1	1	1	1	1	1	1	1
Trip circuit supervision	TCSSCBR	2	2	2	2	2	2	2	2	2	2	2	2
Current circuit supervision	CCSPVC					1	1	1	1	1	1	1	1
Current transformer supervision for high-impedance protection scheme for phase A	HZCCASPVC												1
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPVC												1

Table 2. Supported functions, continued

Function	IEC 61850	A	B	C	D	E	F	G	H	J	K	L	N
Current transformer supervision for high-impedance protection scheme for phase C	HZCCCSPVC												1
Fuse failure supervision	SEQSPVC					1	1	1	1	1	1	1	1
Runtime counter for machines and devices	MDSOPT	1	1	1	1	1	1	1	1	1	1	1	1
Measurement													
Disturbance recorder	RDRE	1	1	1	1	1	1	1	1	1	1	1	1
Load profile record	LDPRLRC		1		1	1	1	1	1	1	1	1	1
Fault record	FLTRFRC	1	1	1	1	1	1	1	1	1	1	1	1
Three-phase current measurement	CMMXU	1	1	1	1	1	1	1	1	1	1	1	1
Sequence current measurement	CSMSQI	1	1	1	1	1	1	1	1	1	1	1	1
Residual current measurement	RESCMMXU	1	1	1	1	1	1	1	1	1	2	1	1
Three-phase voltage measurement	VMMXU					1	1	1 (1)[8]	2	2	2	1 (1)[8]	2
Residual voltage measurement	RESVMMXU	1	1			1	1		1	1	1		1
Sequence voltage measurement	VSMSQI					1	1	1	1	1	1	1	1
Three-phase power and energy measurement	PEMMXU					1	1	1	1	1	1	1	1
RTD/mA measurement	XRGGIO130		(1)		(1)	(1)	(1)		(1)	(1)			(1)
Frequency measurement	FMMXU					1	1	1	1	1	1	1	1
IEC 61850-9-2 LE sampled value sending[8][9]	SMVSENDER					(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
IEC 61850-9-2 LE sampled value receiving (voltage sharing) [8][9]	SMVRCV					(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Other													
Minimum pulse timer (2 pcs)	TPGAPC	4	4	4	4	4	4	4	4	4	4	4	4
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	1	1	1	1	1	1	1	1	1	1	1	1
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	1	1	1	1	1	1	1	1	1	1	1	1
Pulse timer (8 pcs)	PTGAPC	2	2	2	2	2	2	2	2	2	2	2	2
Time delay off (8 pcs)	TOFGAPC	4	4	4	4	4	4	4	4	4	4	4	4
Time delay on (8 pcs)	TONGAPC	4	4	4	4	4	4	4	4	4	4	4	4
Set-reset (8 pcs)	SRGAPC	4	4	4	4	4	4	4	4	4	4	4	4
Move (8 pcs)	MVGAPC	2	2	2	2	2	2	2	2	2	2	2	2
Generic control point (16 pcs)	SPCGAPC	2	2	2	2	2	2	2	2	2	2	2	2
Analog value scaling (4 pcs)	SCA4GAPC	4	4	4	4	4	4	4	4	4	4	4	4
Integer value move (4 pcs)	MVI4GAPC	1	1	1	1	1	1	1	1	1	1	1	1

1, 2, ... = Number of included instances. The instances of a protection function represent the number of identical protection function blocks available in the standard configuration.
() = optional

1) "Uo measured" is always used.
2) "Uo calculated" is always used.
3) One of the following can be ordered as an option: admittance-based E/F, wattmetric-based E/F or harmonics-based E/F.
4) "Io measured" is always used.
5) "IoB measured" is always used.
6) Master trip is included and connected to the corresponding HSO in the configuration only when the BIO0007 module is used. If additionally the ARC option is selected, ARCSARC is connected in the configuration to the corresponding master trip input.
7) Power quality option includes current total demand distortion, voltage total harmonic distortion, voltage variation and voltage unbalance.
8) Available only with IEC 61850-9-2
9) Available only with COM0031...0037

3. Protection functions

The relay offers directional and non-directional overcurrent and thermal overload protection as well as directional and non-directional earth-fault protection. Some standard configurations allow as an option admittance-based, harmonics-based or wattmetric-based earth-fault protection to be used in addition to directional earth-fault protection. Further, the relay features sensitive earth-fault protection, phase discontinuity protection, transient/intermittent earth-fault protection, overvoltage and undervoltage protection, residual overvoltage protection, positive-sequence undervoltage and negative-sequence overvoltage protection. Frequency protection, including overfrequency, underfrequency and frequency rate-of-change protection, is offered in relays with standard configurations H, J, K, L and N. The relay also incorporates optional three-pole multishot autoreclosing functions for overhead line feeders.

The standard configurations L and N additionally offer multifrequency admittance-based earth-fault protection providing selective directional earth-fault protection for high-impedance earthed networks. The operation is based on multifrequency neutral admittance measurement utilizing fundamental frequency and harmonic components in Uo and Io. A special filtering algorithm enables dependable and secure fault direction also during intermittent/restriking earth faults. It provides a very good combination of reliability and sensitivity of protection with a single function for low ohmic and higher ohmic earth faults and for transient and intermittent or restriking earth faults.

Enhanced with optional hardware and software, the relay also features three light detection channels for arc fault protection of the circuit breaker, busbar and cable compartment of metal-enclosed indoor switchgear.

The arc-fault protection sensor interface is available on the optional communication module. Fast tripping increases staff safety and security and limits material damage in an arc fault situation. A binary input and output module can be selected as an option - having three high speed binary outputs (HSO) - further decreases the total operate time with typically 4...6 ms compared to the normal power outputs.

4. Application

The feeder protection relay can be supplied either with directional or non-directional earth-fault protection. Directional earth-fault protection is mainly used in isolated neutral or compensated networks, whereas non-directional earth-fault protection is intended for directly or low impedance earthed neutral networks. The relay can also be used for protection of ring-type and meshed distribution networks as well of radial networks containing distributed power generation.

The standard configurations A and B offer directional earth-fault protection, if the outgoing feeder is equipped with phase current transformers, a core-balance current transformer and residual voltage measurement. The residual current calculated from the phase currents can be used for double (cross country) earth-fault protection. The relay further features transient/intermittent earth-fault protection. The standard configurations C and D offer non-directional earth-fault protection for outgoing feeders equipped with phase current transformers. The residual current for the earth-fault protection is derived from the phase currents. When applicable, the core-balance current transformers can be used for measuring the residual current, especially when sensitive earth-fault protection is required. The standard configurations E and F offer directional earth-fault protection with phase voltage and residual voltage measurement. Furthermore, the two standard configurations E and F include current circuit supervision and fuse failure supervision for incoming feeders provided with busbar voltage measurement. In addition to the functionality of standard configuration E, the standard configuration F offers directional overcurrent protection, overvoltage and undervoltage protection, positive-sequence undervoltage and negative-sequence overvoltage protection and residual voltage protection.

The standard configurations G and L include one conventional residual current (Io) input and three combi-sensor inputs for phase currents and phase voltages. The connection of the three combi-sensors is made with RJ-45 type connectors. Sensors offer certain benefits compared to conventional current and voltage instrument transformers. For example, current sensors do not saturate at high currents, they consume less energy and they weigh less. In voltage sensors the risk of ferro-resonance is eliminated. The sensor inputs also enable the use of the relay in compact medium voltage switchgears, such as ABB's UniGear Digital, SafeRing and SafePlus, with limited space for conventional measuring transformers, thus requiring the use of sensor technology. Further, the adapters also enable the use of sensors with Twin-BNC connectors.

The standard configuration H includes non-directional overcurrent and non-directional earth-fault protection, phase-voltage and frequency based protection and measurement functions. The provided functionality supports the use of the standard configuration in industrial power systems, where the power is generated in the plant itself and/or derived from the distribution network. Completed with the synchrocheck function, relays with standard configuration H ensure a safe interconnection of two networks.

The standard configuration J includes directional overcurrent and directional earth-fault protection, phase-voltage and frequency based protection and measurement functions. The provided functionality supports the use of the standard configuration in industrial power systems, where the power is generated in the plant itself and/or derived from the distribution network. Completed with the synchrocheck function, relays with standard configuration J ensure a safe interconnection of two networks. The standard configuration J includes also optional power quality functions which enable monitoring and

detecting current and voltage harmonics and short duration system disturbances.

The standard configuration K includes non-directional overcurrent and earth-fault protection and two stages of directional overcurrent and earth-fault protection, high impedance based restricted earth-fault protection, phase-voltage and frequency based protection and measurement functions. The provided functionality supports the use of the standard configuration in feeder applications with a closely located transformer for which the earth-fault protection is according to the high impedance restricted earth-fault principle. The configuration is completed with the synchrocheck function to ensure a safe interconnection of two networks. The standard configuration K includes an optional power quality function which enables monitoring and detecting current and voltage harmonics and short duration system disturbances. The standard configuration K also features an optional impedance-measuring fault location function suitable for locating short-circuits in radial distribution systems and earth-faults in effectively and low-resistance earthed networks.

The standard configuration L includes directional overcurrent and directional earth-fault protection, phase-voltage and frequency based protection and measurement functions. The analog measurements include one conventional residual current (Io) input and three combi-sensor inputs for phase currents and phase voltages. The provided functionality supports the use of the standard configuration in power systems, where power is generated in the plant itself and/or derived from the distribution network. The standard configuration L includes an optional power quality function which enables monitoring and detecting current and voltage harmonics and short duration system disturbances. The standard configuration L also features an optional impedance-measuring fault location function suitable for locating short-circuits in radial distribution systems and earth-faults in effectively and low-resistance earthed networks. The standard configuration L has been pre-configured especially for ABB switchgears, for example, UniGear Digital. The use of standard configuration L is however not restricted for switchgears only but provides the highest functionality level with sensor inputs for phase currents and phase voltages. Standard configuration L is not designed for using all the available functionality content in one relay at the same time. In order to ensure the performance of the relay, the user specific configuration load is verified with the Application Configuration tool in PCM600.

Completed with the optional synchrocheck function and process bus with sampled values of analog phase voltages, relays with standard configuration G and L ensure a safe interconnection of two networks.

The standard configuration N provides the highest functionality level of all standard configurations. It is delivered as pre-configured, in the same way as other 615 standard configurations. It is typically reconfigured when taken into use. This allows flexibility in standardizing one type of REF615. Depending on the specific feeder application the appropriate functionality can be selected and own configurations can be created with the Application Configuration tool in PCM600. Standard configuration N is not designed for using all the available functionality content in one relay at the same time. In order to ensure the performance of the relay the user specific configuration load is verified with Application Configuration tool of PCM600.

In addition to directional earth-fault protection, one of the these three functions can be ordered as an option: admittance-based, harmonics-based or wattmetric-based earth-fault protection. Admittance- and wattmetric-based earth-fault protection functions are available for standard configurations A, B, E, F, G, J, L and N. Harmonics-based earth-fault protection is available for standard configurations B, D, F, J, L and N. The admittance-based earth-fault protection ensures a correct operation of the protection even though the connection status information of the Petersen coil is missing. The standard configurations L and N additionally offer multifrequency admittance-based earth-fault protection.

ЕЛЕКТРИКСИМ ООД София

ВЯРНО С ОРИГИНАЛА

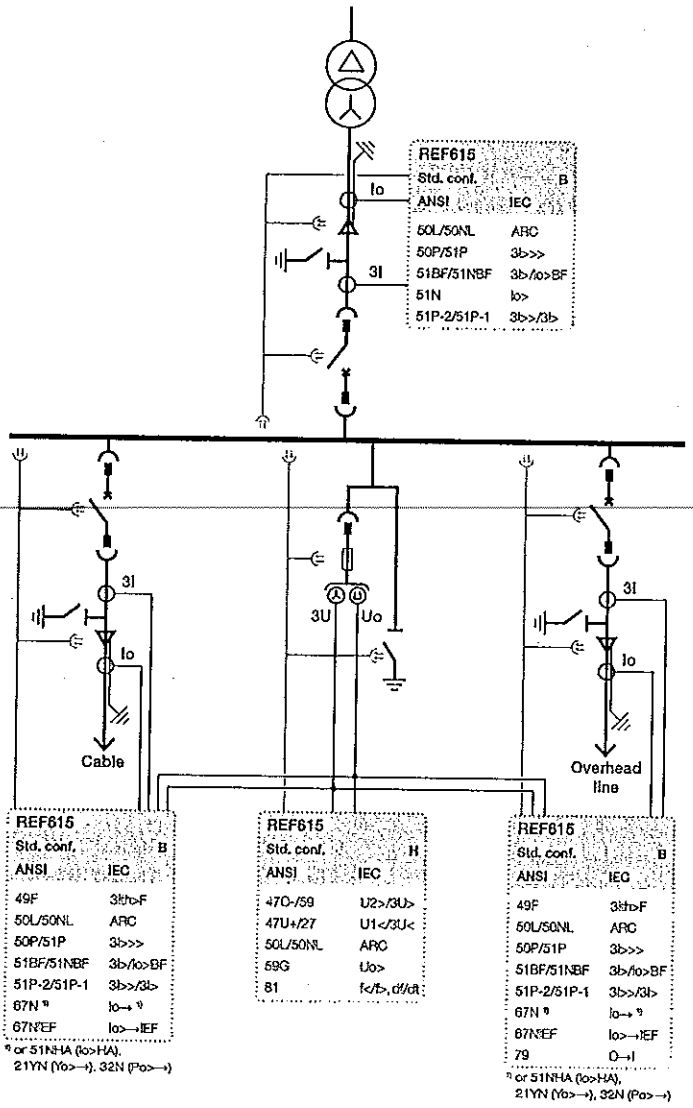


Figure 13. Substation example with overcurrent and earth-fault protection using the standard configuration B

Figure 13 shows a substation example with overcurrent and earth-fault protection using the standard configuration B. Additionally voltage and frequency based protection is used with standard configuration B. The relays are equipped with optional arc protection function enabling fast and selective arc protection throughout the switchgear. Additionally for the feeder with overhead line the optional autoreclosing function is used.

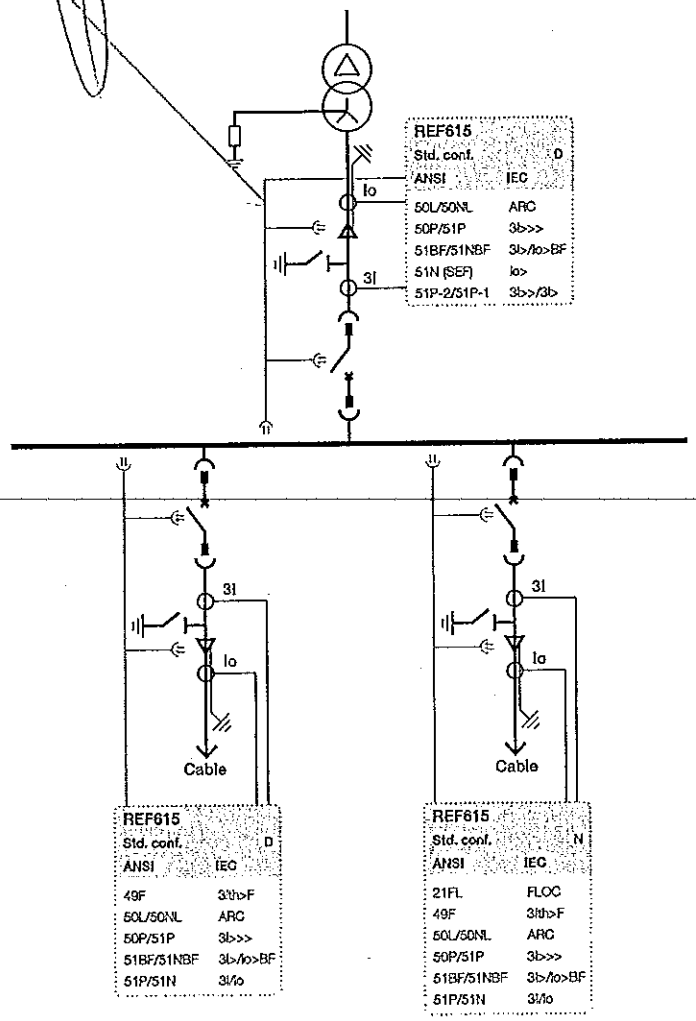


Figure 14. Substation example in low impedance earthed network using the D and N standard configurations with overcurrent, earth-fault and thermal protection for the outgoing feeder cables

Figure 14 illustrates a substation example in low impedance earthed network using the D and N standard configurations with overcurrent, earth-fault and thermal protection for the outgoing feeder cables. The relays are equipped with optional arc protection function enabling fast and selective arc protection throughout the switchgear. Additionally the optional fault locator function is used in standard configuration N for the calculation of fault distance from the substation.

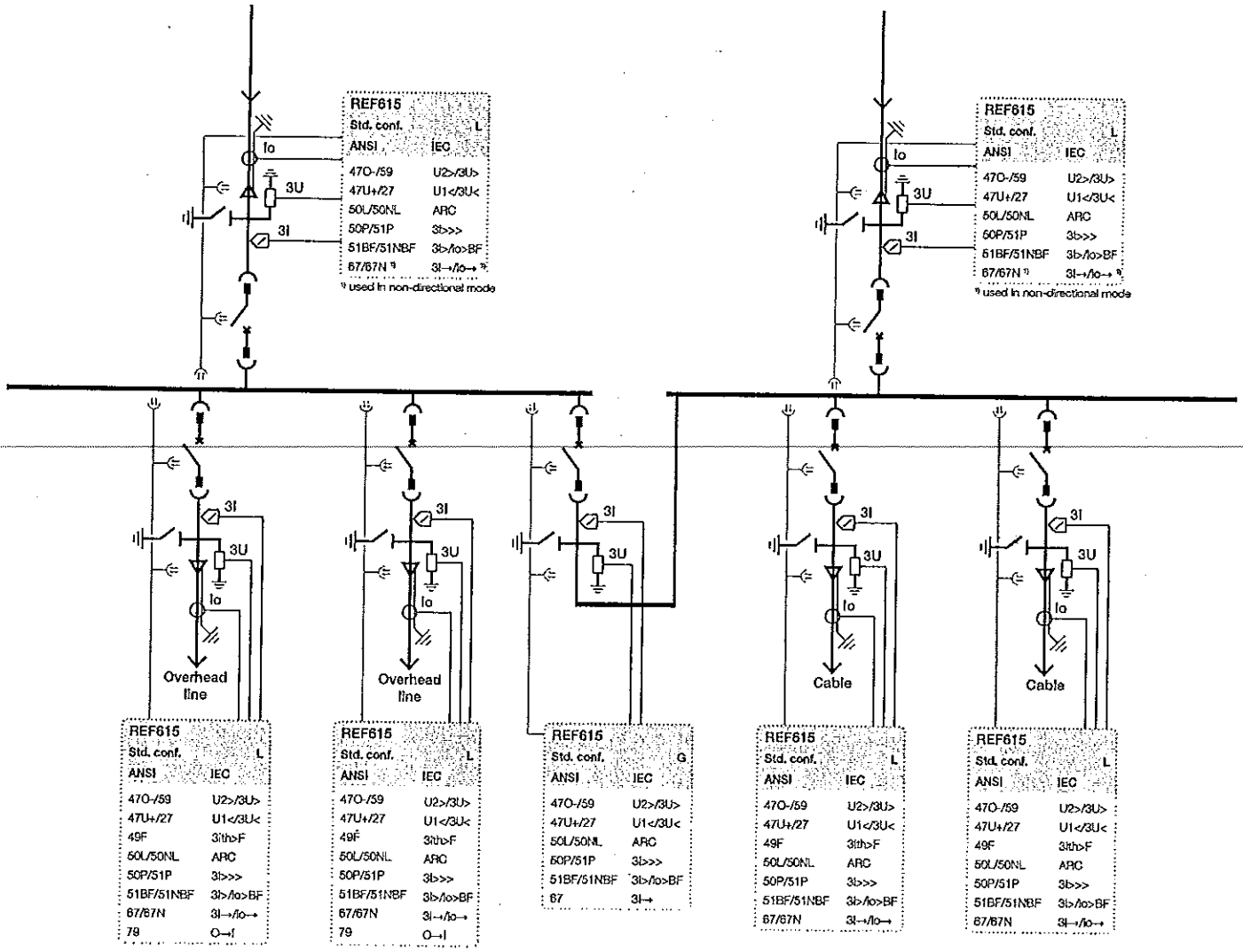


Figure 15. Application example with single busbar switchgear arrangement

Application example with single busbar switchgear arrangement is shown in Figure 15. Current sensors (Rogowski coil) and voltage sensors (voltage divider) are used for the measurements in standard configurations L and G. The used main protection functions are overcurrent, earth-fault and voltage based protection. Also thermal protection is used for the protection of the outgoing feeder cables. The optional autoreclosing function is used for the feeders with overhead line.

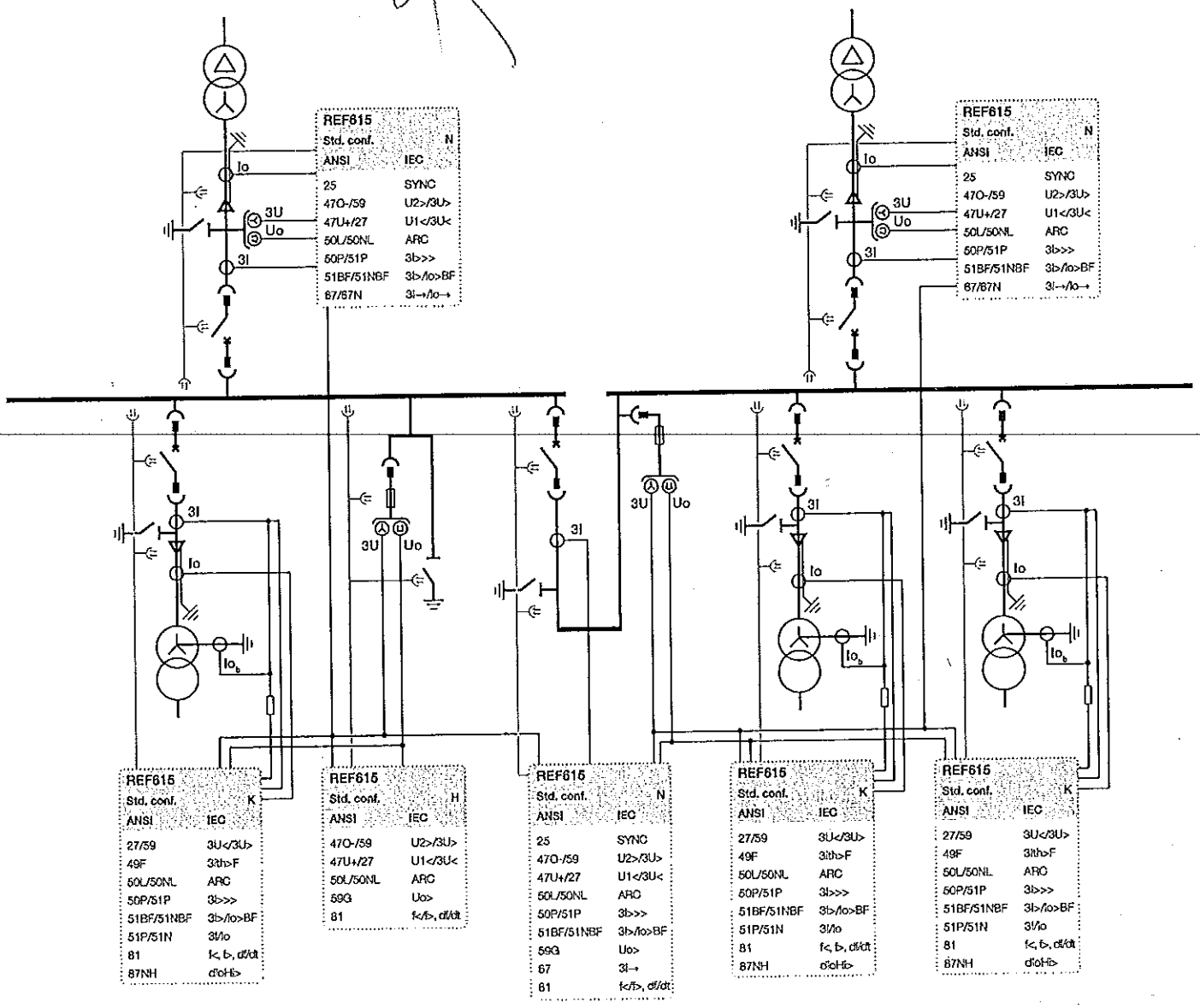


Figure 16. Application example with single busbar switchgear arranged into two bus sections separated with bus coupler

In the application example in Figure 16, a single busbar switchgear is arranged into two bus sections separated with bus coupler. Standard configuration K is used in the outgoing feeders with closely located distribution transformers offering a high impedance restricted earth-fault protection in addition to the ordinary overcurrent and earth-fault protection. The synchrocheck function is used in standard configuration in incoming feeders and bus coupler.

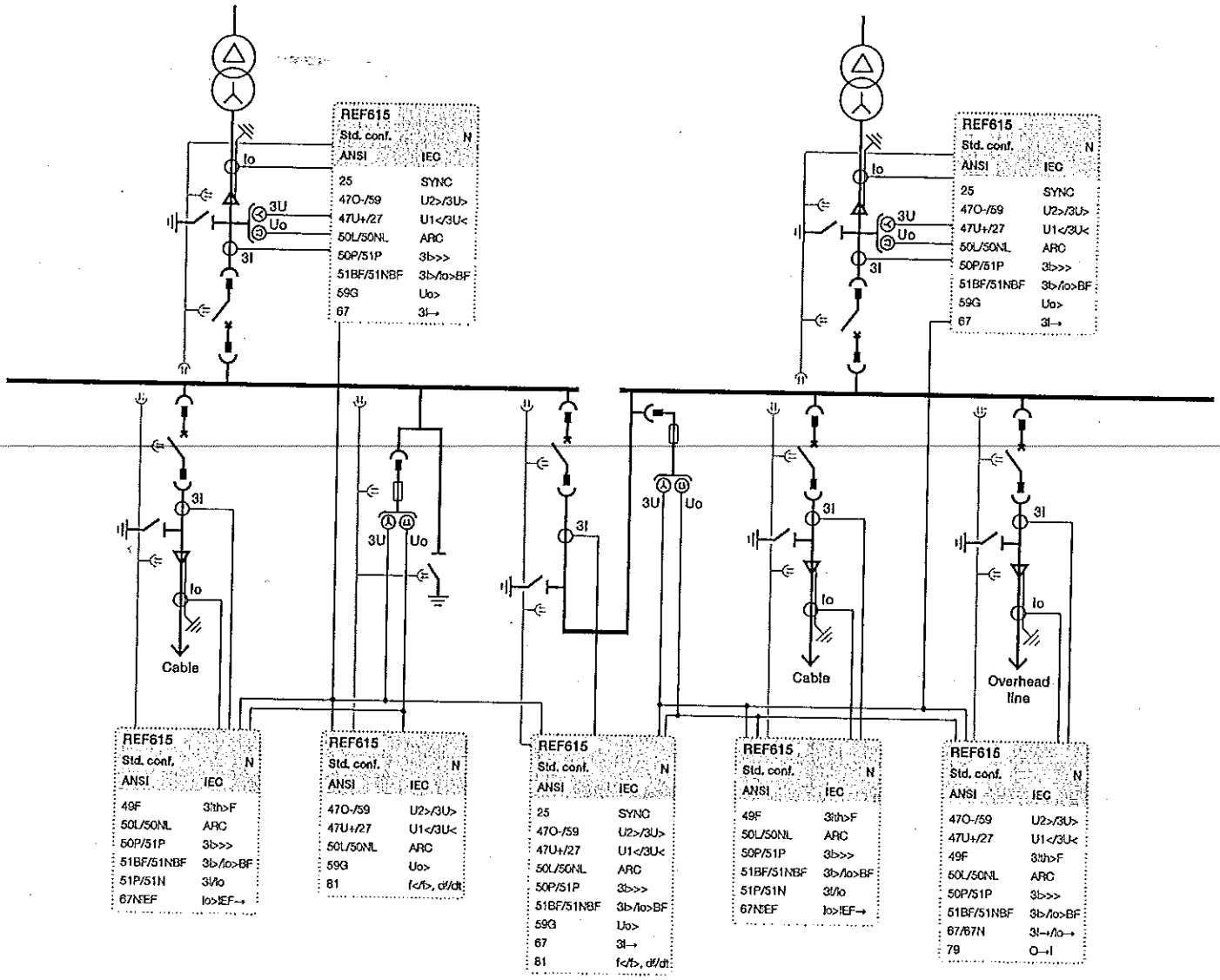


Figure 17. Application example of single busbar switchgear using the most comprehensive standard configuration N

Figure 17 illustrates an application example of single busbar switchgear using the most comprehensive standard configuration N. The used main protection functions overcurrent, earth-fault and voltage based protection. Also thermal and intermittent earth-fault protection are used for the protection of the outgoing feeder cables. Additionally, an optional autoreclosing function is used for the feeders with overhead line. The relays are equipped with optional arc protection function enabling fast and selective arc protection throughout the switchgear.

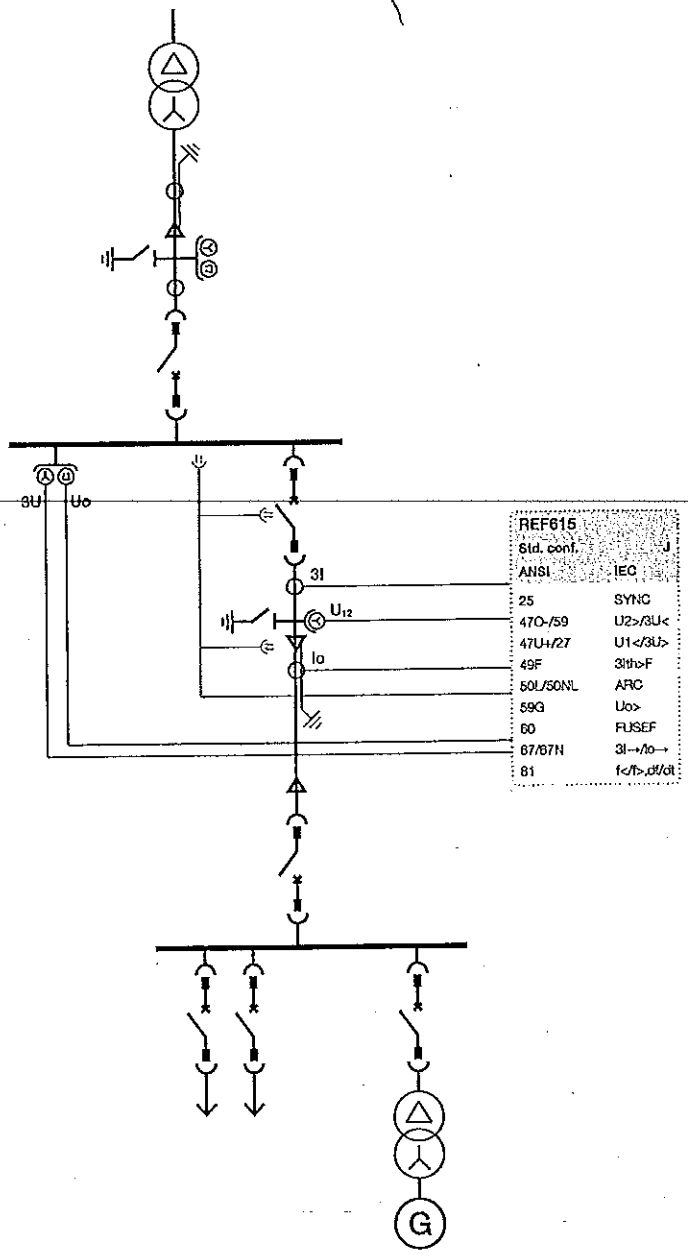


Figure 18. Protection and control of outgoing feeder with standard configuration J

Figure 18 illustrates the protection and control of outgoing feeder with standard configuration J using synchrocheck functionality for safe connection of distributed generation into the grid.

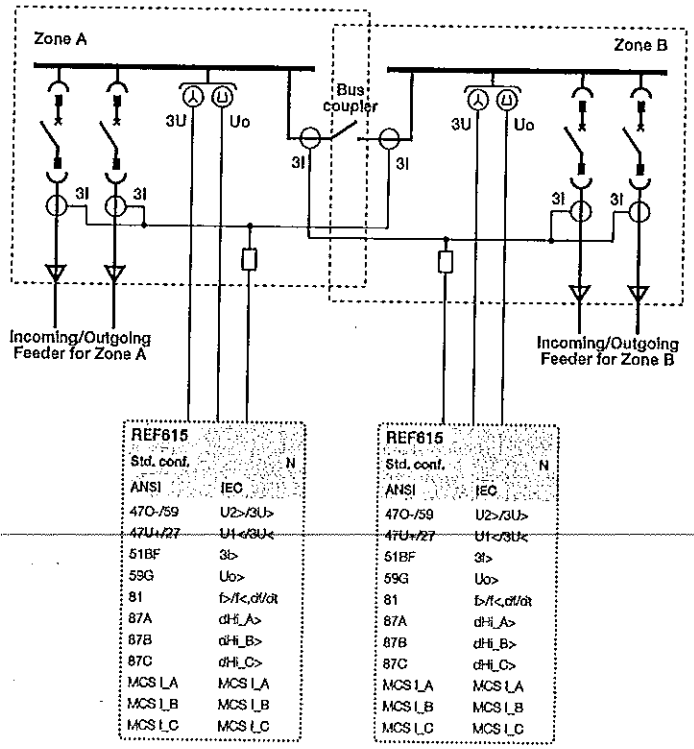


Figure 19. Application example of busbar differential protection covering two zones using standard configuration N

In the application example in Figure 19, single busbar switchgear has been arranged into two bus sections separated with bus coupler. Standard configuration N is used with high-impedance differential protection for busbar and covering two zones with two protection relays. Additionally, voltage and frequency based protection is used with standard configuration N.

5. Supported ABB solutions

ABB's 615 series protection and control relays together with the Substation Automation Unit COM600 constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. To facilitate and streamline the system engineering, ABB's relays are supplied with connectivity packages. The connectivity packages include a compilation of software and relay-specific information, including single-line diagram templates and a full relay data model. The data model also includes event and parameter lists. With the connectivity packages, the relays can be readily configured using PCM600 and integrated with the Substation Automation Unit COM600 or the network control and management system MicroSCADA Pro.

The 615 series relays offer native support for IEC 61850 Edition 2 also including binary and analog horizontal GOOSE messaging. In addition, process bus with the sending of sampled values of analog currents and voltages and the receiving of sampled values of voltages is supported. Compared to traditional hard-wired, inter-device signaling, peer-to-peer communication over a switched Ethernet LAN offers an advanced and versatile platform for power system protection. Among the distinctive features of the protection system approach, enabled by the full implementation of the IEC 61850 substation automation standard, are fast communication capability, continuous supervision of the integrity of the protection and communication system, and an inherent flexibility regarding reconfiguration and upgrades. This protection relay series is able to optimally utilize interoperability provided by the IEC 61850 Edition 2 features.

At substation level, COM600 uses the data content of the bay-level devices to enhance substation level functionality. COM600 features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. The SLD feature is especially useful when 615 series relays without the optional single-line diagram feature are used. The Web HMI of COM600 also provides an overview of the whole substation, including relay-specific single-line diagrams, which makes information easily accessible. Substation devices and processes can also be remotely accessed through the Web HMI, which improves personnel safety.

In addition, COM600 can be used as a local data warehouse for the substation's technical documentation and for the network data collected by the devices. The collected network data facilitates extensive reporting and analyzing of network fault situations, by using the data historian and event handling features of COM600. The history data can be used for accurate monitoring of process and equipment performance, using calculations based on both real-time and history values. A better understanding of the process dynamics is achieved by combining time-based process measurements with production and maintenance events.

COM600 can also function as a gateway and provide seamless connectivity between the substation devices and network-level control and management systems, such as MicroSCADA Pro and System 800xA.

GOOSE Analyzer interface in COM600 enables the following and analyzing the horizontal IEC 61850 application during commissioning and operation at station level. It logs all GOOSE events during substation operation to enable improved system supervision.

Table 3. Supported ABB solutions

Product	Version
Substation Automation Unit COM600	4.0 SP1 or later
	4.1 or later (Edition 2)
MicroSCADA Pro SYS 600	9.3 FP2 or later
	9.4 or later (Edition 2)
System 800xA	5.1 or later

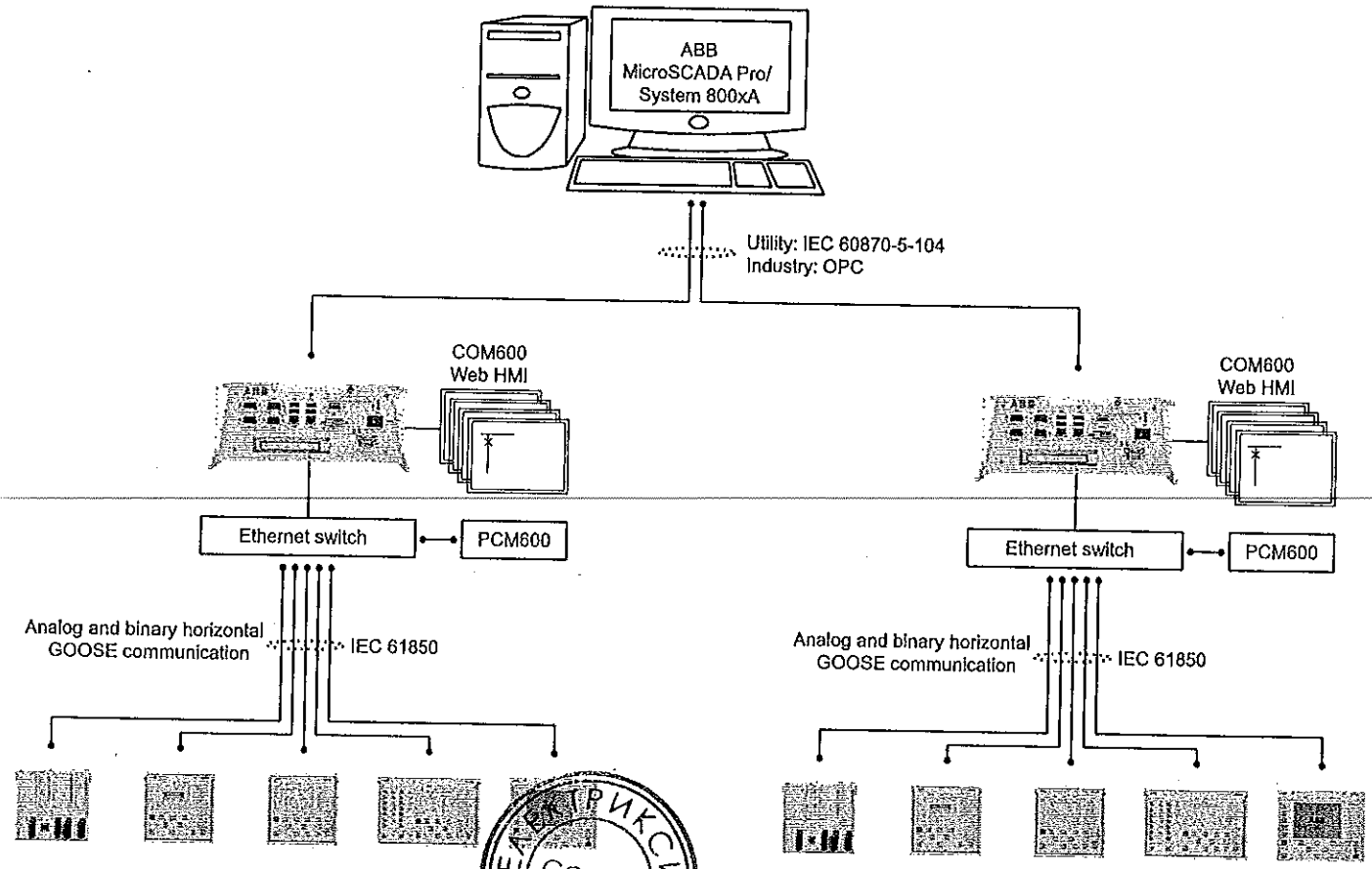


Figure 20. ABB power system example using REF615 relays, Substation Automation Unit COM600 and MicroSCADA Pro/System 800xA

6. Control

REF615 integrates functionality for the control of a circuit breaker via the front panel HMI or by means of remote controls. In addition to the circuit-breaker control the relay features two control blocks which are intended for motor-operated control of disconnectors or circuit breaker truck and for their position indications. Further, the relay offers one control block which is intended for motor-operated control of one earthing switch control and its position indication.

Two physical binary inputs and two physical binary outputs are needed in the relay for each controllable primary device taken into use. Depending on the chosen standard configuration of the relay the number of unused binary inputs and binary outputs varies. Further, some standard configurations also offer optional hardware modules that increase the number of available binary inputs and outputs.

If the amount of available binary inputs or outputs of the chosen standard configuration is not sufficient, the standard configuration can be modified to release some binary inputs or outputs which have originally been configured for other purposes, when applicable, or an external input or output module, for example, RIO600 can be integrated to the relay. The binary inputs and outputs of the external I/O module can be used for the less time critical binary signals of the application. The integration enables releasing of some initially reserved binary inputs and outputs of the relay in the standard configuration.

The suitability of the relay's binary outputs which have been selected for controlling of primary devices should be carefully verified, for example, the make and carry as well as the breaking capacity should be considered. In case the requirements for the control-circuit of the primary device are not met, the use of external auxiliary relays should be considered.

The optional large graphical LCD of the relay's local HMI includes a single-line diagram (SLD) with position indication for the relevant primary devices. Interlocking schemes required by the application are configured using the signal matrix or the application configuration functionality of PCM600. Depending on the standard configuration, the relay also incorporates a synchrocheck function to ensure that the voltage, phase angle

and frequency on either side of an open circuit breaker satisfy the conditions for safe interconnection of two networks.

7. Measurements

The relay continuously measures the phase currents, the symmetrical components of the currents and the residual current. If the relay includes voltage measurements, it also measures the residual voltage, the phase voltages and the voltage sequence components. Depending on the standard configuration the relay additionally offers frequency measurement. The relay also calculates the demand value of the current over a user-selectable, pre-set time frame, the thermal overload of the protected object, and the phase unbalance based on the ratio between the negative-sequence and positive-sequence current.

Furthermore, the relay offers three-phase power and energy measurement including power factor.

The values measured can be accessed locally via the user interface on the relay's front panel or remotely via the communication interface of the relay. The values can also be accessed locally or remotely using the Web browser-based user interface.

The relay is provided with a load profile recorder. The load profile feature stores the historical load data captured at a periodical time interval (demand interval). The records are in COMTRADE format.

8. Power quality

In the EN standards, power quality is defined through the characteristics of the supply voltage. Transients, short-duration and long-duration voltage variations and unbalance and waveform distortions are the key characteristics describing power quality. The distortion monitoring functions are used for monitoring the current total demand distortion and the voltage total harmonic distortion.

Power quality monitoring is an essential service that utilities can provide for their industrial and key customers. Not only can a monitoring system provide information about system disturbances and their possible causes, it can also detect problem conditions throughout the system before they cause customer complaints, equipment malfunctions and even equipment damage or failure. Power quality problems are not limited to the utility side of the system. In fact, the majority of power quality problems are localized within customer facilities. Thus, power quality monitoring is not only an effective customer service strategy but also a way to protect a utility's reputation for quality power and service.

The protection relay has the following power quality monitoring functions.

- Voltage variation
- Voltage unbalance
- Current harmonics
- Voltage harmonics

The voltage unbalance and voltage variation functions are used for measuring short-duration voltage variations and monitoring voltage unbalance conditions in power transmission and distribution networks.

The voltage and current harmonics functions provide a method for monitoring the power quality by means of the current waveform distortion and voltage waveform distortion. The functions provides a short-term 3-second average and a long-term demand for total demand distortion TDD and total harmonic distortion THD.

9. Fault location

The relay features an optional impedance-measuring fault location function suitable for locating short-circuits in radial distribution systems. Earth faults can be located in effectively and low-resistance earthed networks. Under circumstances where the fault current magnitude is at least of the same order of magnitude or higher than the load current, earth faults can also be located in isolated neutral distribution networks. The fault location function identifies the type of the fault and then calculates the distance to the fault point. An estimate of the fault resistance value is also calculated. The estimate provides information about the possible fault cause and the accuracy of the estimated distance to the fault point.

10. Disturbance recorder

The relay is provided with a disturbance recorder with up to 12 analog and 64 binary signal channels. The analog channels can be set to record either the waveform or the trend of the currents and voltages measured.

The analog channels can be set to trigger the recording function when the measured value falls below, or exceeds, the set values. The binary signal channels can be set to start a recording either on the rising or the falling edge of the binary signal or on both.

By default, the binary channels are set to record external or internal relay signals, for example, the start or trip signals of the relay stages, or external blocking or control signals. Binary relay signals, such as protection start and trip signals, or an external relay control signal via a binary input, can be set to trigger the recording. Recorded information is stored in a non-volatile memory and can be uploaded for subsequent fault analysis.

11. Event log

To collect sequence-of-events information, the relay has a non-volatile memory with a capacity of storing 1024 events with associated time stamps. The non-volatile memory retains its data also in case the relay temporarily loses its auxiliary supply.

The event log facilitates detailed pre- and post-fault analyses of feeder faults and disturbances. The increased capacity to process and store data and events in the relay offers prerequisites to support the growing information demand of future network configurations.

The sequence-of-events information can be accessed either locally via the user interface on the relay's front panel, or remotely via the communication interface of the relay. The information can also be accessed using the Web browser-based user interface, either locally or remotely.

12. Recorded data

The relay has the capacity to store the records of the 128 latest fault events. The records enable the user to analyze the power system events. Each record includes current, voltage and angle values, time stamp and so on. The fault recording can be triggered by the start signal or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. Fault records store relay measurement values at the moment when any protection function starts. In addition, the maximum demand current with time stamp is separately recorded. The records are stored in the non-volatile memory.

13. Condition monitoring

The condition monitoring functions of the relay constantly monitor the performance and the condition of the circuit breaker. The monitoring comprises the spring charging time, SF6 gas pressure, the travel time and the inactivity time of the circuit breaker.

The monitoring functions provide operational circuit breaker history data, which can be used for scheduling preventive circuit breaker maintenance.

In addition, the relay includes a runtime counter for monitoring of how many hours a protected device has been in operation thus enabling scheduling of time-based preventive maintenance of the device.

14. Trip-circuit supervision

The trip-circuit supervision continuously monitors the availability and operability of the trip circuit. It provides open-circuit monitoring both when the circuit breaker is in its closed and in its open position. It also detects loss of circuit-breaker control voltage.

15. Self-supervision

The relay's built-in self-supervision system continuously monitors the state of the relay hardware and the operation of the relay software. Any fault or malfunction detected is used for alerting the operator.

A permanent relay fault blocks the protection functions to prevent incorrect operation.

16. Fuse failure supervision

Depending on the chosen standard configuration, the relay includes fuse failure supervision functionality. The fuse failure supervision detects failures between the voltage measurement circuit and the relay. The failures are detected either by the negative sequence-based algorithm or by the delta voltage and delta current algorithm. Upon the detection of a failure, the fuse failure supervision function activates an alarm and blocks voltage-dependent protection functions from unintended operation.

17. Current circuit supervision

Depending on the chosen standard configuration, the relay includes current circuit supervision. Current circuit supervision is used for detecting faults in the current transformer secondary circuits. On detecting of a fault the current circuit supervision function activates an alarm LED and blocks certain protection functions to avoid unintended operation. The current circuit supervision function calculates the sum of the phase currents from the protection cores and compares the sum with the measured single reference current from a core balance current transformer or from separate cores in the phase current transformers.

18. Access control

To protect the relay from unauthorized access and to maintain information integrity, the relay is provided with a four-level, role-based authentication system with administrator-programmable individual passwords for the viewer, operator, engineer and administrator level. The access control applies to the front-panel user interface, the Web browser-based user interface and PCM600.

19. Inputs and outputs

Depending on the standard configuration selected, the relay is equipped with three phase-current inputs and one residual-current input for non-directional earth-fault protection, or three phase-current inputs, one residual-current input and one residual voltage input for directional earth-fault protection or three phase-current inputs, one residual-current input, three phase-voltage inputs and one residual voltage input for directional earth-fault protection and directional overcurrent protection. Standard configurations G and L include one conventional residual current (I_0 0.2/1 A) input and three sensor inputs for the direct connection of three combi-sensors with RJ-45 connectors. As an alternative to combi-sensors, separate current and voltage sensors can be utilized using adapters. Furthermore, the adapters also enable the use of sensors with Twin-BNC connectors.

The phase-current inputs are rated 1/5 A. Two optional residual-current inputs are available, that is, 1/5 A or 0.2/1 A. The 0.2/1 A input is normally used in applications requiring sensitive earth-fault protection and featuring core-balance current transformers. The three phase-voltage inputs and the

residual-voltage input covers the rated voltages 60...210 V. Both phase-to-phase voltages and phase-to-earth voltages can be connected.

The phase-current input 1 A or 5 A, the residual-current input 1 A or 5 A, alternatively 0.2 A or 1 A, and the rated voltage of the residual voltage input are selected in the relay software. In addition, the binary input thresholds 16...176 V DC are selected by adjusting the relay's parameter settings.

All binary inputs and outputs contacts are freely configurable with the signal matrix or application configuration functionality of PCM600.

Please refer to the Input/output overview table and the terminal diagrams for more detailed information about the inputs and outputs.

Optionally, a binary input and output module can be selected. It has three high speed binary outputs (HSO) and it decreases the total operate time with typically 4...6 ms compared to the normal power outputs.

Table 4. Input/output overview

Std. conf.	Order code digit		Analog channels			Binary channels			
	5-6	7-8	CT	VT	Combi sensor	BI	BO	RTD	mA
A	AA / AB	AA	4	1	-	3	4 PO + 2 SO	-	-
		AE	4	1	-	17	4 PO + 9 SO	-	-
B	AA / AB	FA	4	1	-	17	4 PO + 5 SO + 3 HSO	-	-
	AA / AB FA / FB	AC	4	1	-	11	4 PO + 6 SO	6	2
		FG	4	1	-	11	4 PO + 2 SO + 3 HSO		
C	AC / AD	AB	4	-	-	4	4 PO + 2 SO	-	-
		AF	4	-	-	18	4 PO + 9 SO	-	-
D	AC / AD	FB	4	-	-	18	4 PO + 5 SO + 3 HSO	-	-
	AC / AD FC / FD	AD	4	-	-	12	4 PO + 6 SO	6	2
		FE	4	-	-	12	4 PO + 2 SO + 3 HSO		
E F H J N	AE / AF	AG	4	5	-	16	4 PO + 6 SO	-	-
		FC	4	5	-	16	4 PO + 2 SO + 3 HSO	-	-
	FE / FF	AG	4	5	-	12	4 PO + 6 SO	2	1
		FC	4	5	-	12	4 PO + 2 SO + 3 HSO	2	1
G L	DA	AH	1	-	3	8	4 PO + 6 SO	-	-
		FD	1	-	3	8	4 PO + 2 SO + 3 HSO	-	-
K	BC	AD	5	5	-	12	4 PO + 6 SO	-	-
		FE	5	5	-	12	4 PO + 2 SO + 3 HSO	-	-

20. Station communication

The relay supports a range of communication protocols including IEC 61850 Edition 2, IEC 61850-9-2 LE, IEC 60870-5-103, Modbus® and DNP3. Profibus DPV1 communication protocol is supported with using the protocol converter SPA-ZC 302. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the relays, is only enabled by the IEC 61850 communication protocol.

The IEC 61850 protocol is a core part of the relay as the protection and control application is fully based on standard modelling. The relay supports Edition 2 and Edition 1 versions of the standard. With Edition 2 support, the relay has the latest functionality modelling for substation applications and the best interoperability for modern substations. It incorporates also the full support of standard device mode functionality supporting different test applications. Control applications can utilize the new safe and advanced station control authority feature.

The IEC 61850 communication implementation supports monitoring and control functions. Additionally, parameter settings, disturbance recordings and fault records can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the standard COMTRADE file format. The relay supports simultaneous event reporting to five different clients on the station bus. The relay can exchange data with other devices using the IEC 61850 protocol.

The relay can send binary and analog signals to other devices using the IEC 61850-8-1 GOOSE (Generic Object Oriented Substation Event) profile. Binary GOOSE messaging can, for example, be employed for protection and interlocking-based protection schemes. The relay meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard (<10 ms data exchange between the devices). The relay also supports the sending and receiving of analog values using GOOSE messaging. Analog GOOSE messaging enables easy transfer of analog measurement values over the station bus, thus facilitating for example the sending of measurement values between the relays when controlling parallel running transformers.

The relay also supports IEC 61850 process bus by sending sampled values of analog currents and voltages and by receiving sampled values of voltages. With this functionality the galvanic interpanel wiring can be replaced with Ethernet communication. The measured values are transferred as sampled values using IEC 61850-9-2 LE protocol. The intended application for sampled values shares the voltages to other 615 series relays, having voltage based functions and 9-2 support. 615 relays with process bus based applications use IEEE 1588 for high accuracy time synchronization.

For redundant Ethernet communication, the relay offers either two optical or two galvanic Ethernet network interfaces. A third port with galvanic Ethernet network interface is also available. The third Ethernet interface provides connectivity for any other Ethernet device to an IEC 61850 station bus inside a switchgear bay, for example connection of a Remote I/O. Ethernet network redundancy can be achieved using the high-availability seamless redundancy (HSR) protocol or the parallel redundancy protocol (PRP) or a with self-healing ring using RSTP in managed switches. Ethernet redundancy can be applied to Ethernet-based IEC 61850, Modbus and DNP3 protocols.

The IEC 61850 standard specifies network redundancy which improves the system availability for the substation communication. The network redundancy is based on two complementary protocols defined in the IEC 62439-3 standard: PRP and HSR protocols. Both the protocols are able to overcome a failure of a link or switch with a zero switch-over time. In both the protocols, each network node has two identical Ethernet ports dedicated for one network connection. The protocols rely on the duplication of all transmitted information and provide a zero switch-over time if the links or switches fail, thus fulfilling all the stringent real-time requirements of substation automation.

In PRP, each network node is attached to two independent networks operated in parallel. The networks are completely separated to ensure failure independence and can have different topologies. The networks operate in parallel, thus providing zero-time recovery and continuous checking of redundancy to avoid failures.

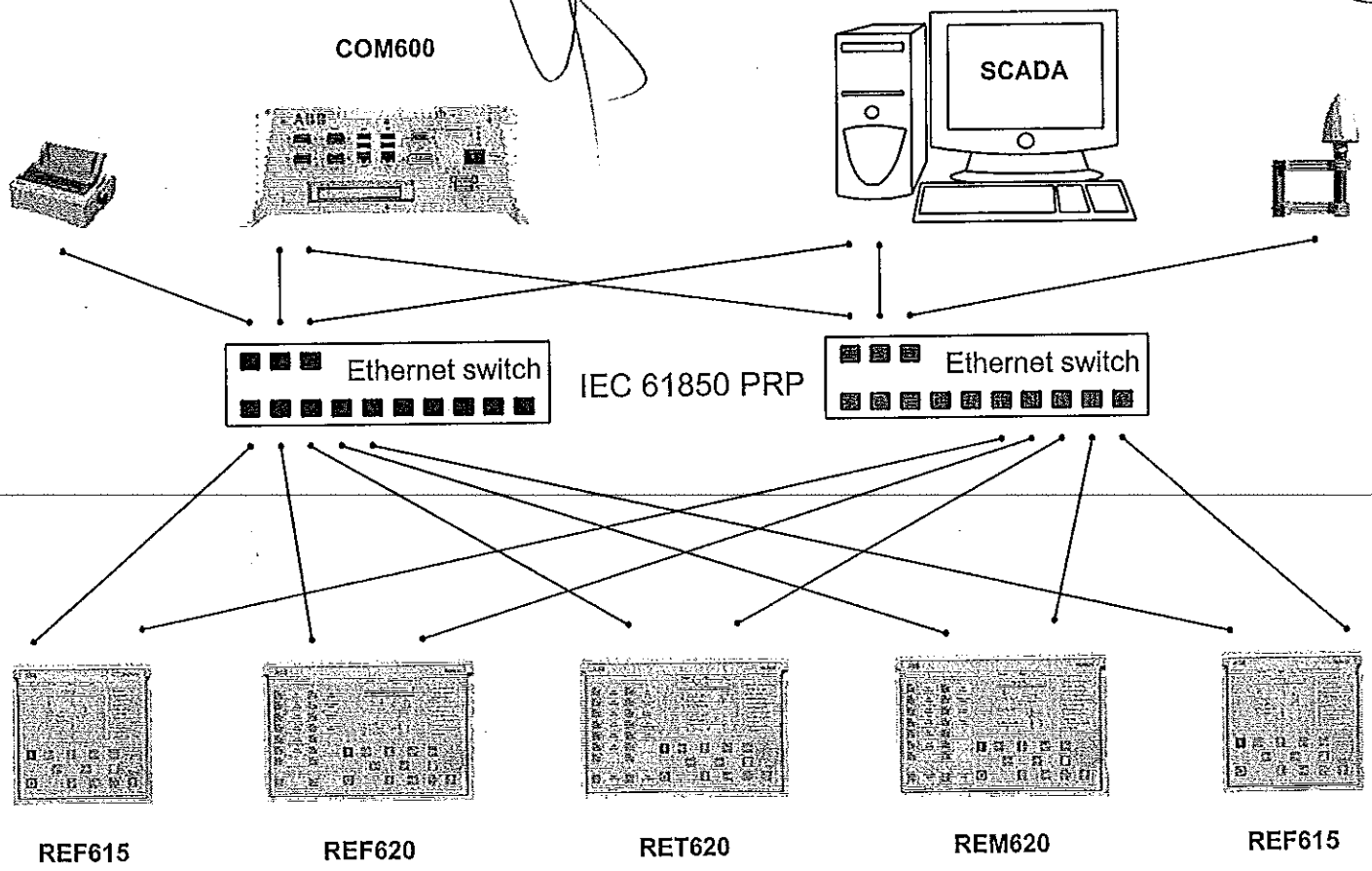


Figure 21. Parallel redundancy protocol (PRP) solution

HSR applies the PRP principle of parallel operation to a single ring. For each message sent, the node sends two frames, one through each port. Both the frames circulate in opposite directions over the ring. Every node forwards the frames it receives from one port to another to reach the next node. When the originating sender node receives the frame it sent, the sender node discards the frame to avoid loops. The HSR ring with 615 series relays supports the connection of up to 30 relays. If more than 30 relays are to be connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

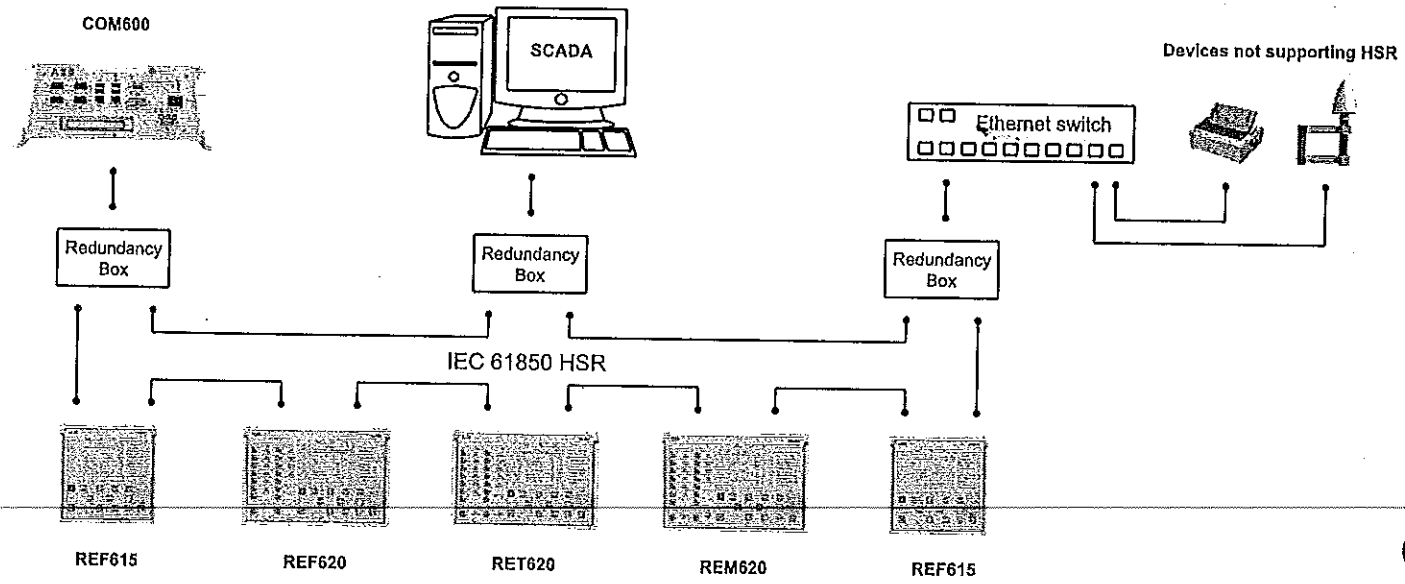
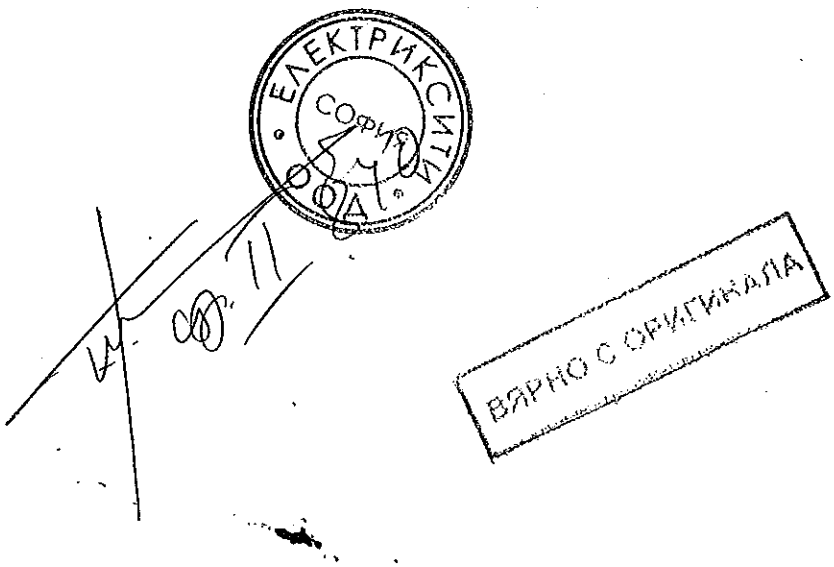


Figure 22. High availability seamless redundancy (HSR) solution

The choice between the HSR and PRP redundancy protocols depends on the required functionality, cost and complexity.

The self-healing Ethernet ring solution enables a cost-efficient communication ring controlled by a managed switch with standard Rapid Spanning Tree Protocol (RSTP) support. The managed switch controls the consistency of the loop, routes the data and corrects the data flow in case of a communication switch-over. The relays in the ring topology act as unmanaged switches forwarding unrelated data traffic. The Ethernet ring solution supports the connection of up to 30 615 series relays. If more than 30 relays are to be connected, it is recommended to split the network into several rings. The self-healing Ethernet ring solution avoids single point of failure concerns and improves the reliability of the communication.



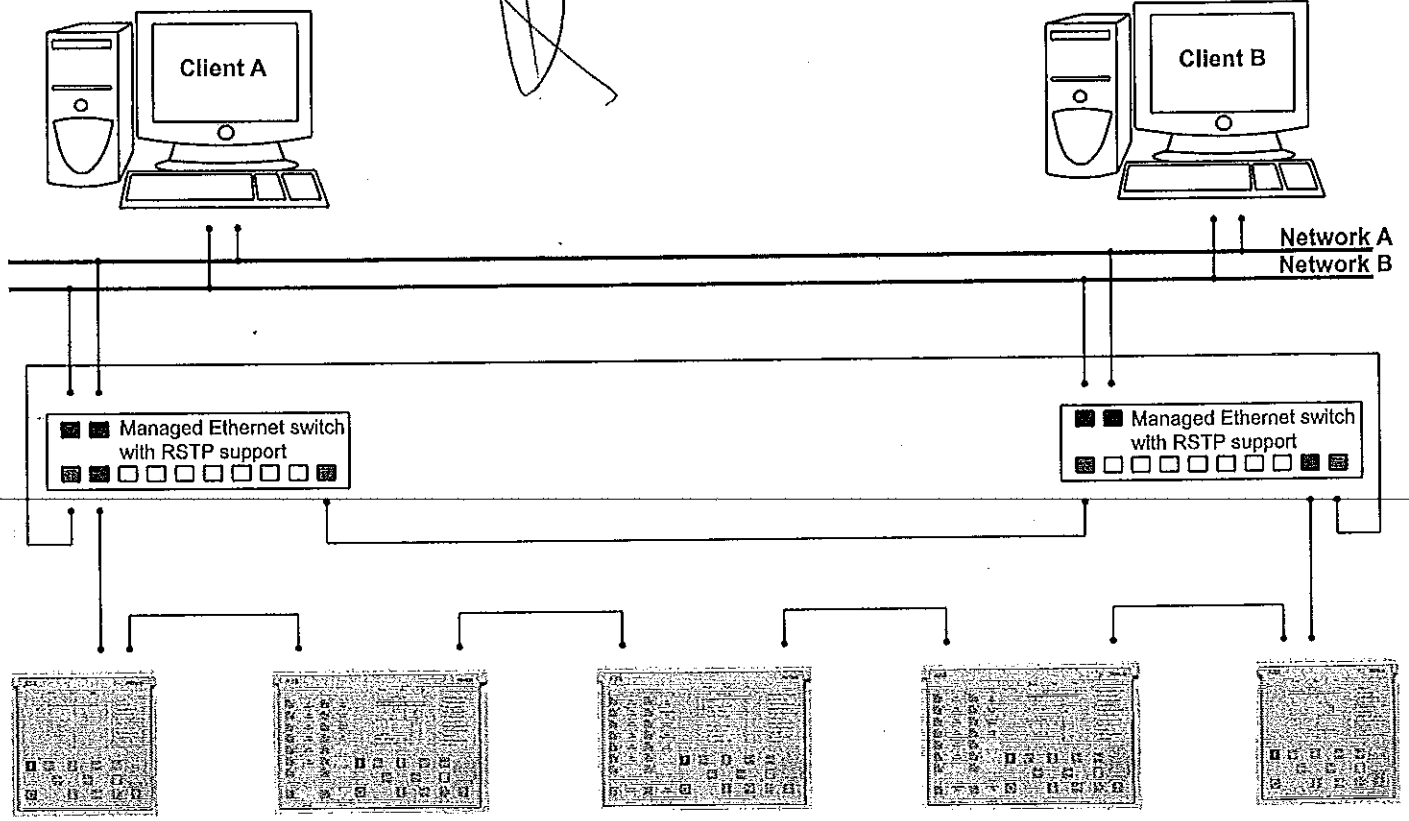


Figure 23. Self-healing Ethernet ring solution

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The relay can be connected to Ethernet-based communication systems via the RJ-45 connector (100Base-TX) or the fiber optic LC connector (100Base-FX). If connection to serial bus is required, the 9-pin RS-485 screw-terminal can be used. An optional serial interface is available for RS-232 communication.

Modbus implementation supports RTU, ASCII and TCP modes. Besides standard Modbus functionality, the relay supports retrieval of time-stamped events, changing the active setting group and uploading of the latest fault records. If a Modbus TCP connection is used, five clients can be connected to the relay simultaneously. Further, Modbus serial and Modbus TCP can be used in parallel, and if required both IEC 61850 and Modbus protocols can be run simultaneously.

The IEC 60870-5-103 implementation supports two parallel serial bus connections to two different masters. Besides basic standard functionality, the relay supports changing of the active setting group and uploading of disturbance recordings in IEC 60870-5-103 format. Further, IEC 60870-5-103 can be used at the same time with the IEC 61850 protocol.

DNP3 supports both serial and TCP modes for connection up to five masters. Changing of the active setting and reading fault records are supported. DNP serial and DNP TCP can be used in parallel. If required, both IEC 61850 and DNP protocols can be run simultaneously.

615 series supports Profibus DPV1 with support of SPA-ZC 302 Profibus adapter. If Profibus is required the relay must be ordered with **Modbus serial options.** Modbus implementation includes SPA-protocol emulation functionality. This functionality enables connection to SPA-ZC 302.

When the relay uses the RS-485 bus for the serial communication, both two- and four-wire connections are supported. Termination and pull-up/down resistors can be configured with jumpers on the communication card so external resistors are not needed.

The relay supports the following time synchronization methods with a time-stamping resolution of 1 ms.

Ethernet-based
- SNTP (Simple Network Time Protocol)

With special time synchronization wiring
- IRIG-B (Inter-Range Instrumentation Group - Time Code Format B)

The relay supports the following high accuracy time synchronization method with a time-stamping resolution of 4 µs required especially in process bus applications.

- PTP (IEEE 1588) v2 with Power Profile

The IEEE 1588 support is included in all variants having a redundant Ethernet communication module.

IEEE 1588 v2 features

- Ordinary Clock with Best Master Clock algorithm
- One-step Transparent Clock for Ethernet ring topology
- 1588 v2 Power Profile
- Receive (slave): 1-step/2-step
- Transmit (master): 1-step
- Layer 2 mapping
- Peer to peer delay calculation
- Multicast operation

Required accuracy of grandmaster clock is +/-1 µs. The relay can work as a master clock per BMC algorithm if the external grandmaster clock is not available for short term.

The IEEE 1588 support is included in all variants having a redundant Ethernet communication module.

In addition, the relay supports time synchronization via Modbus, DNP3 and IEC 60870-5-103 serial communication protocols.

Table 5. Supported station communication interfaces and protocols

Interfaces/Protocols	Ethernet		Serial	
	100BASE-TX RJ-45	100BASE-FX LC	RS-232/RS-485	Fiber optic ST
IEC 61850-8-1	•	•	-	-
IEC 61850-9-2 LE	•	•	-	-
MODBUS RTU/ASCII	-	-	•	•
MODBUS TCP/IP	•	•	-	-
DNP3 (serial)	-	-	•	•
DNP3 TCP/IP	•	•	-	-
IEC 60870-5-103	-	-	•	•

• = Supported

21. Technical data

Table 6. Dimensions

Description	Value	
Width	Frame	177 mm
	Case	164 mm
Height	Frame	177 mm (4U)
	Case	160 mm
Depth		201 mm (153 + 48 mm)
Weight	Complete protection relay	4.1 kg
	Plug-in unit only	2.1 kg

Table 7. Power supply

Description	Type 1	Type 2
Nominal auxiliary voltage U_n	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	48, 60, 110, 125, 220, 250 V DC	
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U_n	
Auxiliary voltage variation	38...110% of U_n (38...264 V AC)	50...120% of U_n (12...72 V DC)
	80...120% of U_n (38.4...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC × 80%)
Burden of auxiliary voltage supply under quiescent (P_q)/operating condition	DC <12.0 W (nominal)/<18.0 W (max) AC <16.0 W (nominal)/<21.0 W (max)	DC <12.0 W (nominal)/<18.0 W (max)
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Fuse type	T4A/250 V	

Table 8. Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Current inputs	Rated current, I_n	0.2/1 A[1]	1/5 A[2]
	Thermal withstand capability:		
	• Continuously	4 A	20 A
	• For 1 s	100 A	500 A
	Dynamic current withstand:		
	• Half-wave value	250 A	1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage	60...210 V AC	
	Voltage withstand:		
	• Continuous	240 V AC	
	• For 10 s	360 V AC	
	Burden at rated voltage	<0.05 VA	

1) Ordering option for residual current input
2) Residual current and/or phase current

Table 9. Energizing inputs (sensors)

Description		Value
Current sensor input	Rated current voltage (in secondary side)	75 mV...9000 mV[1]
	Continuous voltage withstand	125 V
	Input impedance at 50/60 Hz	2...3 MΩ[2]
Voltage sensor input	Rated voltage	6 kV...30 kV[3]
	Continuous voltage withstand	50 V
	Input impedance at 50/60 Hz	3 MΩ

1) Equals the current range of 40...4000 A with a 80 A, 3 mV/Hz Rogowski
2) Depending on the used nominal current (hardware gain)
3) This range is covered (up to 2*rated) with sensor division ratio of 10 000:1

Table 10. Binary inputs

Description	Value
Operating range	±20% of the rated voltage
Rated voltage	24...250 V DC
Current drain	1.6...1.9 mA
Power consumption	31.0...570.0 mW
Threshold voltage	16...176 V DC
Reaction time	<3 ms

Table 11. Signal output X100: SO1

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

Table 12. Signal outputs and IRF output

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	15 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	10 mA at 5 V AC/DC

Table 13. Double-pole power output relays with TCS function

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Trip-circuit supervision (TCS):	
• Control voltage range	20...250 V AC/DC
• Current drain through the supervision circuit	~1.5 mA
• Minimum voltage over the TCS contact	20 V AC/DC (15...20 V)

Table 14. Single-pole power output relays

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC

Table 15. High-speed output HSO with BIO0007

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	6 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R <40 ms, at 48/110/220 V DC	5 A/3 A/1 A
Operate time	<1 ms
Reset	<20 ms, resistive load

Table 16. Front port Ethernet interfaces

Ethernet Interface	Protocol	Cable	Data transfer rate
Front	TCP/IP protocol	Standard Ethernet CAT 5 cable with RJ-45 connector	10 MBits/s

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Table 17. Station communication link, fiber optic

Connector	Fiber type[1]	Wave length	Typical max. length[2]	Permitted path attenuation[3]
LC	MM 62.5/125 or 50/125 µm glass fiber core	1300 nm	2 km	<8 dB
ST	MM 62.5/125 or 50/125 µm glass fiber core	820...900 nm	1 km	<11 dB

1) (MM) multi-mode fiber, (SM) single-mode fiber
2) Maximum length depends on the cable attenuation and quality, the amount of splices and connectors in the path.
3) Maximum allowed attenuation caused by connectors and cable together

Table 18. IRIG-B

Description	Value
IRIG time code format	B004, B005[1]
Isolation	500V 1 min
Modulation	Unmodulated
Logic level	5 V TTL
Current consumption	<4 mA
Power consumption	<20 mW

1) According to the 200-04 IRIG standard

Table 19. Lens sensor and optical fiber for arc protection

Description	Value
Fiber optic cable including lens	1.5 m, 3.0 m or 5.0 m
Normal service temperature range of the lens	-40...+100°C
Maximum service temperature range of the lens, max 1 h	+140°C
Minimum permissible bending radius of the connection fiber	100 mm

Table 20. Degree of protection of flush-mounted protection relay

Description	Value
Front side	IP 54
Rear side, connection terminals	IP 20

Table 21. Environmental conditions

Description	Value
Operating temperature range	-25...+55°C (continuous)
Short-time service temperature range	-40...+85°C (<16h)[1)2)]
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	Up to 2000 m
Transport and storage temperature range	-40...+85°C

1) Degradation in MTBF and HMI performance outside the temperature range of -25...+55 °C
2) For relays with an LC communication interface the maximum operating temperature is +70 °C

Table 22. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz/100 kHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III IEEE C37.90.1-2002
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III
• Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-26 IEEE C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference test		
	10 V (rms) f = 150 kHz...80 MHz	IEC 61000-4-6 IEC 60255-26, class III
	10 V/m (rms) f = 80...2700 MHz	IEC 61000-4-3 IEC 60255-26, class III
	10 V/m f = 900 MHz	ENV 50204 IEC 60255-26, class III
	20 V/m (rms) f = 80...1000 MHz	IEEE C37.90.2-2004
Fast transient disturbance test		IEC 61000-4-4 IEC 60255-26 IEEE C37.90.1-2002
• All ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-26
• Communication	1 kV, line-to-earth	
• Other ports	4 kV, line-to-earth 2 kV, line-to-line	
Power frequency (50 Hz) magnetic field immunity test		IEC 61000-4-8
• Continuous	300 A/m	
• 1...3 s	1000 A/m	
Pulse magnetic field immunity test	1000 A/m 6.4/16 µs	IEC 61000-4-9
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s	100 A/m	
• 1 MHz	400 transients/s	
Voltage dips and short interruptions	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11

Protection functions

Table 29. Three-phase non-directional overcurrent protection (PHxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	PHLPTOC	±1.5% of the set value or ±0.002 × I_n		
	PHHPTOC and PHIPTOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n)		
Start time [1)2)]		Minimum	Typical	Maximum
	PHIPTOC: I_{Fault} = 2 × set *Start value*	16 ms	19 ms	23 ms
	I_{Fault} = 10 × set *Start value*	11 ms	12 ms	14 ms
	PHHPTOC and PHLPTOC: I_{Fault} = 2 x set *Start value*	23 ms	26 ms	29 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression P-to-P+backup: No suppression		

1) Set *Operate delay time* = 0,02 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 × In, fn = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Includes the delay of the heavy-duty output contact

Table 30. Three-phase non-directional overcurrent protection (PHxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start Value	PHLPTOC	0.05...5.00 × I_n	0.01
	PHHPTOC	0.10...40.00 × I_n	0.01
	PHIPTOC	1.00...40.00 × I_n	0.01
Time multiplier	PHLPTOC	0.05...15.00	0.01
	PHHPTOC	0.05...15.00	0.01
Operate delay time	PHLPTOC	40...200000 ms	10
	PHHPTOC	40...200000 ms	10
	PHIPTOC	20...200000 ms	10
Operating curve type[1)]	PHLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	PHHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHIPTOC	Definite time	

1) For further reference, see Operation characteristics table

Table 31. Three-phase directional overcurrent protection (DPHxPDOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current/voltage measured: f_n ±2 Hz		
	DPHLPDOC	Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DPHHPDOC	Current: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Start value*	39 ms	43 ms	47 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) *Measurement mode* and *Pol quantity* = default, current before fault = 0.0 × I_n, voltage before fault = 1.0 × U_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 1.5 to 20

Table 32. Three-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 × In	0.01
	DPHHPDOC	0.10...40.00 × In	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.01
Operate delay time	DPHxPDOC	40...200000 ms	10
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPHxPDOC	-179...180°	1
Operating curve type[1)]	DPHLPDOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHHPDOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	

1) For further reference, refer to the Operating characteristics table

Table 33. Non-directional earth-fault protection (EFxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	EFLPTOC	±1.5% of the set value or ±0.002 × I_n		
	EFHPTOC and EFIPTOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n)		
Start time [1)2)]		Minimum	Typical	Maximum
	EFIPTOC:			
	I_{Fault} = 2 × set *Start value*	16 ms	19 ms	23 ms
	I_{Fault} = 10 × set *Start value*	11 ms	12 ms	14 ms
	EFHPTOC and EFLPTOC:			
	I_{Fault} = 2 × set *Start value*	23 ms	26 ms	29 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		≤30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression		

1) *Measurement mode* = default (depends on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 1.5...20

Table 34. Non-directional earth-fault protection (EFxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	EFLPTOC	0.010...5.000 × I_n	0.005
	EFHPTOC	0.10...40.00 × I_n	0.01
	EFIPTOC	1.00...40.00 × I_n	0.01
Time multiplier	EFLPTOC	0.05...15.00	0.01
	EFHPTOC	0.05...15.00	0.01
Operate delay time	EFLPTOC	40...200000 ms	10
	EFHPTOC	40...200000 ms	10
	EFIPTOC	20...200000 ms	10
Operating curve type[1)]	EFLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	EFIPTOC	Definite time	

1) For further reference, see Operation characteristics table

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Table 35. Directional earth-fault protection (DEFxPDEF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	DEFLPDEF	Current: ±1.5% of the set value or ±0.002 × I_n Voltage ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DEFHPDEF	Current: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time [1)2)]		Minimum	Typical	Maximum
	DEFHPDEF I_{Fault} = 2 × set *Start value*	42 ms	46 ms	49 ms
	DEFLPDEF I_{Fault} = 2 × set *Start value*	58 ms	62 ms	66 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression		

1) Set *Operate delay time* = 0.06 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 1.5...20

Table 36. Directional earth-fault protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start Value	DEFLPDEF	0.010...5.000 × I_n	0.005
	DEFHPDEF	0.10...40.00 × I_n	0.01
Directional mode	DEFLPDEF and DEFHPDEF	1 = Non-directional 2 = Forward 3 = Reverse	
Time multiplier	DEFLPDEF	0.05...15.00	0.01
	DEFHPDEF	0.05...15.00	0.01
Operate delay time	DEFLPDEF	60...200000 ms	10
	DEFHPDEF	40...200000 ms	10
Operating curve type[1)]	DEFLPDEF	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFHPDEF	Definite or inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFLPDEF and DEFHPDEF	1 = Phase angle 2 = IoSin 3 = IoCos 4 = Phase angle 80 5 = Phase angle 88	

1) For further reference, refer to the Operating characteristics table

Table 37. Admittance-based earth-fault protection (EFPADM)

Characteristic	Value		
Operation accuracy[1)]	At the frequency f = f_n ±1.0% or ±0.01 mS (In range of 0.5...100 mS)		
Start time[2)]	Minimum	Typical	Maximum
	56 ms	60 ms	64 ms
Reset time	40 ms		
Operate time accuracy	±1.0% of the set value of ±20 ms		
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) U_o = 1.0 × Un
2) Includes the delay of the signal output contact. Results based on statistical distribution of 1000 measurements.

Table 38. Admittance-based earth-fault protection (EFPADM) main settings

Parameter	Function	Value (Range)	Step
Voltage start value	EFPADM	0.01...2.00 × U_n	0.01
Directional mode	EFPADM	1 = Non-directional 2 = Forward 3 = Reverse	
Operation mode	EFPADM	1 = Yo 2 = Go 3 = Bo 4 = Yo, Go 5 = Yo, Bo 6 = Go, Bo 7 = Yo, Go, Bo	
Operate delay time	EFPADM	60...200000 ms	10
Circle radius	EFPADM	0.05...500.00 mS	0.01
Circle conductance	EFPADM	-500.00...500.00 mS	0.01
Circle susceptance	EFPADM	-500.00...500.00 mS	0.01
Conductance forward	EFPADM	-500.00...500.00 mS	0.01
Conductance reverse	EFPADM	-500.00...500.00 mS	0.01
Conductance tilt Ang	EFPADM	-30...30°	1
Susceptance forward	EFPADM	-500.00...500.00 mS	0.01
Susceptance reverse	EFPADM	-500.00...500.00 mS	0.01
Susceptance tilt Ang	EFPADM	-30...30°	1

Table 39. Wattmetric-based earth-fault protection (WPWDE)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz Current and voltage: ±1.5% of the set value or ±0.002 × I_n Power: ±3% of the set value or ±0.002 × P_n
Start time [1)2)]	Typically 63 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in IDMT mode	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at $f = n \times f_n$, where $n = 2,3,4,5,...$

1) Io varied during the test. Uo = 1.0 × U_n = phase to earth voltage during earth fault in compensated or un-earthed network. The residual power value before fault = 0.0 pu, f_n = 50 Hz, results based on statistical distribution of 1000 measurement
2) Includes the delay of the signal output contact.

Table 40. Wattmetric-based earth-fault protection (WPWDE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	WPWDE	2 = Forward 3 = Reverse	
Current start value	WPWDE	0.010...5.000 × I_n	0.001
Voltage start value	WPWDE	0.010...1.000 × U_n	0.001
Power start value	WPWDE	0.003...1.000 × P_n	0.001
Reference power	WPWDE	0.050...1.000 × P_n	0.001
Characteristic angle	WPWDE	-179...180°	1
Time multiplier	WPWDE	0.05...2.00	0.01
Operating curve type	WPWDE	Definite or inverse time Curve type: 5, 15, 20	
Operate delay time	WPWDE	60...200000 ms	10
Min operate current	WPWDE	0.010...1.000 × I_n	0.001
Min operate voltage	WPWDE	0.01...1.00 × U_n	0.01

Table 41. Transient/intermittent earth-fault protection (INTRPTEF)

Characteristic	Value
Operation accuracy (Uo criteria with transient protection)	Depending on the frequency of the measured current: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × Uo
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5

Table 42. Transient/intermittent earth-fault protection (INTRPTEF) main settings

Parameter	Function	Value (Range)	Step
Directional mode	INTRPTEF	1=Non-directional 2=Forward 3=Reverse	-
Operate delay time	INTRPTEF	40...1200000 ms	10
Voltage start value (voltage start value for transient EF)	INTRPTEF	0.01...0.50 × Un	0.01
Operation mode	INTRPTEF	1=Intermittent EF 2=Transient EF	-
Peak counter limit (Min requirement for peak counter before start in IEF mode)	INTRPTEF	2...20	-
Min operate current	INTRPTEF	0.01...1.00 × In	0.01

Table 43. Harmonics-based earth-fault protection (HAEFPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz ±5% of the set value or ±0.004 × I_n
Start time [1)2)]	Typically 77 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in IDMT mode [3)]	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = f_n -3 dB at f = 13 × f_n

1) Fundamental frequency current = 1.0 × I_n. Harmonics current before fault = 0.0 × I_n, harmonics fault current 2.0 × *Start value*. Results based on statistical distribution of 1000 measurement.
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n. *Start value* multiples in range of 2...20

Table 44. Harmonics-based earth-fault protection (HAEFPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	HAEFPTOC	0.05...5.00 × I_n	0.01
Time multiplier	HAEFPTOC	0.05...15.00	0.01
Operate delay time	HAEFPTOC	100...200000 ms	10
Minimum operate time	HAEFPTOC	100...200000 ms	10
Operating curve type	HAEFPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	

Table 45. Negative-sequence overcurrent protection (NSPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n		
Start time [1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2 × set *Start value*	25 ms	26 ms	28 ms
	I_{Fault} = 10 × set *Start value*	15 ms	18 ms	20ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) Negative sequence current before fault = 0.0, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 1.5...20

Table 46. Negative-sequence overcurrent protection (NSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	NSPTOC	0.01...5.00 × I_n	0.01
Time multiplier	NSPTOC	0.05...15.00	0.01
Operate delay time	NSPTOC	40...200000 ms	10
Operating curve type[1)]	NSPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	

1) For further reference, see Operation characteristics table

Table 47. Phase discontinuity protection (PDNSPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±2% of the set value
Start time	<70 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

Table 48. Phase discontinuity protection (PDNSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value (Current ratio setting I_2/I_1)	PDNSPTOC	10...100%	1
Operate delay time	PDNSPTOC	100...30000 ms	1
Min phase current	PDNSPTOC	0.05...0.30 × I_n	0.01

Table 49. Residual overvoltage protection (ROVPTOV)

Characteristic	Value		
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz		
	±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)]	Minimum	Typical	Maximum
U_{Fault} = 2 × set *Start value*	48 ms	51 ms	54 ms
Reset time	Typically 40 ms		
Reset ratio	Typically 0.96		
Retardation time	<35 ms		
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms		
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) Residual voltage before fault = 0.0 × U_n, f_n = 50 Hz, residual voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 50. Residual overvoltage protection (ROVPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	ROVPTOV	0.010...1.000 × U_n	0.001
Operate delay time	ROVPTOV	40...300000 ms	1

Table 51. Three-phase undervoltage protection (PHPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 0.9 × set *Start value*	62 ms	66 ms	70 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) *Start value* = 1.0 × U_n, Voltage before fault = 1.1 × U_n, f_n = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90...0.20

Table 52. Three-phase undervoltage protection (PHPTUV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPTUV	0.05...1.20 × U_n	0.01
Time multiplier	PHPTUV	0.05...15.00	0.01
Operate delay time	PHPTUV	60...300000 ms	10
Operating curve type[1)]	PHPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

1) For further reference, see Operation characteristics table

Table 53. Three-phase overvoltage protection (PHPTOV)

Characteristic	Value		
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)] U_{Fault} = 1.1 × set *Start value*	Minimum 23 ms	Typical 27 ms	Maximum 31 ms
Reset time	Typically 40 ms		
Reset ratio	Depends of the set *Relative hysteresis*		
Retardation time	<35 ms		
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode	±5.0% of the theoretical value or ±20 ms[3)]		
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) *Start value* = 1.0 × U_n, Voltage before fault = 0.9 × U_n, f_n = 50 Hz, overvoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 1.20 × U_n, *Start value* multiples in range of 1.10... 2.00

Table 54. Three-phase overvoltage protection (PHPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPTOV	0.05...1.60 × U_n	0.01
Time multiplier	PHPTOV	0.05...15.00	0.01
Operate delay time	PHPTOV	40...300000 ms	10
Operating curve type[1)]	PHPTOV	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	

1) For further reference, see Operation characteristics table

Table 55. Positive-sequence undervoltage protection (PSPTUV)

Characteristic	Value		
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)] U_{Fault} = 0.99 × set *Start value* U_{Fault} = 0.9 × set *Start value*	Minimum 52 ms 44 ms	Typical 55 ms 47 ms	Maximum 58 ms 50 ms
Reset time	Typically 40 ms		
Reset ratio	Depends of the set *Relative hysteresis*		
Retardation time	<35 ms		
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms		
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

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1) *Start value* = 1.0 × U_n, Positive sequence voltage before fault = 1.1 × U_n, f_n = 50 Hz, positive sequence undervoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 56. Positive-sequence undervoltage protection (PSPTUV) main settings

Parameter	Function	Value (Range)	Step
Start value	PSPTUV	0.010...1.200 × U_n	0.001
Operate delay time	PSPTUV	40...120000 ms	10
Voltage block value	PSPTUV	0.01...1.0 × U_n	0.01

Table 57. Negative-sequence overvoltage protection (NSPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 × set *Start value*	33 ms	35 ms	37 ms
	U_{Fault} = 2.0 × set *Start value*	24 ms	26 ms	28 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) Negative-sequence voltage before fault = 0.0 × U_n, f_n = 50 Hz, negative-sequence overvoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 58. Negative-sequence overvoltage protection (NSPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	NSPTOV	0.010...1.000 × U_n	0.001
Operate delay time	NSPTOV	40...120000 ms	1

Table 59. Frequency protection (FRPFRQ)

Characteristic		Value
Operation accuracy	f>/f<	±5 mHz
	df/dt	±50 mHz/s (in range |df/dt| <5 Hz/s) ±2.0% of the set value (in range 5 Hz/s < |df/dt| < 15 Hz/s)
Start time	f>/f<	<80 ms
	df/dt	<120 ms
Reset time		<150 ms
Operate time accuracy		±1.0% of the set value or ±30 ms

Table 60. Frequency protection (FRPFRQ) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRQ	1 = Freq< 2 = Freq> 3 = df/dt 4 = Freq< + df/dt 5 = Freq> + df/dt 6 = Freq< OR df/dt 7 = Freq> OR df/dt	
Start value Freq>	FRPFRQ	0.9000...1.2000 × f_n	0.0001
Start value Freq<	FRPFRQ	0.8000...1.1000 × f_n	0.0001
Start value df/dt	FRPFRQ	-0.200...0.200 × f_n/s	0.005
Operate Tm Freq	FRPFRQ	80...200000 ms	10
Operate Tm df/dt	FRPFRQ	120...200000 ms	10

Table 61. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz Current measurement: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.01...4.00 × I_n)
Operate time accuracy[1)]	±2.0% of the theoretical value or ±0.50 s

1) Overload current > 1.2 × Operate level temperature

Table 62. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR) main settings

Parameter	Function	Value (Range)	Step
Env temperature Set (Ambient temperature used when the AmbSens is set to Off)	T1PTTR	-50...100°C	1
Current multiplier (Current multiplier when function is used for parallel lines)	T1PTTR	1...5	1
Current reference	T1PTTR	0.05...4.00 × I_n	0.01
Temperature rise (End temperature rise above ambient)	T1PTTR	0.0...200.0°C	0.1
Time constant (Time constant of the line in seconds)	T1PTTR	60...60000 s	1
Maximum temperature (temperature level for operate)	T1PTTR	20.0...200.0°C	0.1
Alarm value (Temperature level for start (alarm)	T1PTTR	20.0...150.0°C	0.1
Reclose temperature (Temperature for reset of block reclose after operate)	T1PTTR	20.0...150.0°C	0.1
Initial temperature (Temperature raise above ambient temperature at startup)	T1PTTR	-50.0...100.0°C	0.1

Table 63. High-impedance based restricted earth-fault protection (HREFPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Operate value*	16 ms	21 ms	23 ms
	I_{Fault} = 10.0 × set *Operate value*	11 ms	13 ms	14 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		

1) Current before fault = 0.0, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 64. High-impedance based restricted earth-fault protection (HREFPDIF) main settings

Parameter	Function	Value (Range)	Step
Operate value	HREFPDIF	1.0...50.0%	0.1
Minimum operate time	HREFPDIF	40...300000 ms	1
Operation	HREFPDIF	Off On	-

Table 65. High-impedance differential protection (HIxPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × In		
Start time[1)2)]		Minimum	Typical	Maximum
	IFault = 2.0 x set Start value	12 ms	16 ms	24 ms
	IFault= 10 x set Start value	10 ms	12 ms	14 ms
Reset time		<40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		

1) Measurement mode = default (depends on stage), current before fault = 0.0 × In, f_n = 50 Hz, fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 66. High-impedance differential protection (HIxPDIF) main settings

Parameter	Function	Value (Range)	Step
Operate value	HIAPDIF HIBPDIF HICPDIF	1.0...200.0 %In	1
Minimum operate time	HIAPDIF HIBPDIF HICPDIF	20...300000 ms	10

Table 67. Circuit breaker failure protection (CCBRBRF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Reset time[1)]	Typically 40 ms
Retardation time	<20 ms

1) Trip pulse time defines the minimum pulse length

Table 68. Circuit breaker failure protection (CCBRBRF) main settings

Parameter	Function	Value (Range)	Step
Current value (Operating phase current)	CCBRBRF	0.05...1.00 × I_n	0.05
Current value Res (Operating residual current)	CCBRBRF	0.05...1.00 × I_n	0.05
CB failure mode (Operating mode of function)	CCBRBRF	1 = Current 2 = Breaker status 3 = Both	-
CB fail trip mode	CCBRBRF	1 = Off 2 = Without check 3 = Current check	-
Retrip time	CCBRBRF	0...60000 ms	10
CB failure delay	CCBRBRF	0...60000 ms	10
CB fault delay	CCBRBRF	0...60000 ms	10

Table 69. Three-phase inrush detector (INRPHAR)

Characteristic	Value
Operation accuracy	At the frequency f = f_n Current measurement: ±1.5% of the set value or ±0.002 × I_n Ratio I2f/I1f measurement: ±5.0% of the set value
Reset time	+35 ms / -0 ms
Reset ratio	Typically 0.96
Operate time accuracy	+35 ms / -0 ms

Table 70. Three-phase inrush detector (INRPHAR) main settings

Parameter	Function	Value (Range)	Step
Start value (Ratio of the 2nd to the 1st harmonic leading to restraint)	INRPHAR	5...100%	1
Operate delay time	INRPHAR	20...60000 ms	1

Table 81. Reverse power/directional overpower protection (DOPPDPR) main settings

Parameter	Function	Value (Range)	Step
Directional mode	DOPPDPR	1=Non-directional 2=Forward 3=Reverse	-
Start value	DOPPDPR	0.01...2.00 × Sn	0.01
Power angle	DOPPDPR	-90...90°	1
Operate delay time	DOPPDPR	40...300000	10

Table 82. Multifrequency admittance-based earth-fault protection (MFADPSDE)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n
Start time[1)]	Typically 35 ms
Reset time	Typically 40 ms
Operate time accuracy	±1.0% of the set value or ±20 ms

1) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

Table 83. Multifrequency admittance-based earth-fault protection (MFADPSDE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	MFADPSDE	2=Forward 3=Reverse	-
Voltage start value	MFADPSDE	0.01...1.00 × Un	0.01
Operate delay time	MFADPSDE	60...1200000	10
Operating quantity	MFADPSDE	1=Adaptive 2=Amplitude	-
Operation mode	MFADPSDE	1=Intermittent EF 3=General EF 4=Alarming EF	-
Min operate current	MFADPSDE	0.005...5.000 × In	0.001
Peak counter limit	MFADPSDE	2...20	1

Table 84. Operation characteristics

Parameter	Value (Range)
Operating curve type	1 = ANSI Ext. inv. 2 = ANSI Very. inv. 3 = ANSI Norm. inv. 4 = ANSI Mod inv. 5 = ANSI Def. Time 6 = L.T.E. inv. 7 = L.T.V. inv. 8 = L.T. inv. 9 = IEC Norm. inv. 10 = IEC Very Inv. 11 = IEC inv. 12 = IEC Ext. inv. 13 = IEC S.T. inv. 14 = IEC L.T. inv 15 = IEC Def. Time 17 = Programmable 18 = RI type 19 = RD type
Operating curve type (voltage protection)	5 = ANSI Def. Time 15 = IEC Def. Time 17 = Inv. Curve A 18 = Inv. Curve B 19 = Inv. Curve C 20 = Programmable 21 = Inv. Curve A 22 = Inv. Curve B 23 = Programmable

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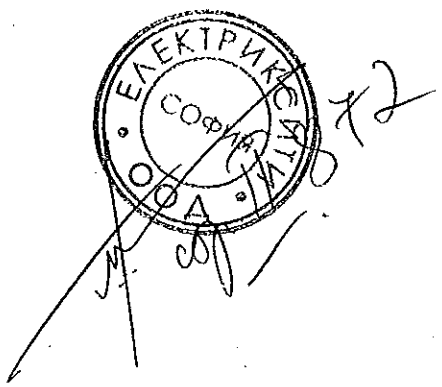
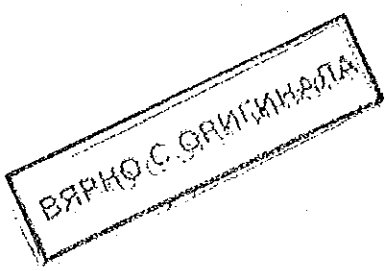
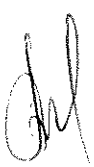
Table 90. Voltage vector shift protection (VVSPPAM) main settings

Parameter	Function	Value (Range)	Step
Start value	VVSPPAM	2.0...30.0°	0.1
Phase supervision	VVSPPAM	7=Ph A + B + C 8=Pos sequence	-
Over Volt Blk value	VVSPPAM	0.40...1.50 × Un	0.01
Under Volt Blk value	VVSPPAM	0.15...1.00 × Un	0.01







Power quality functions

Table 91. Voltage variation (PHQVVR)

Characteristic	Value
Operation accuracy	±1.5% of the set value or ±0.2% of reference voltage
Reset ratio	Typically 0.96 (Swell), 1.04 (Dip, Interruption)

Table 92. Voltage unbalance (VSQVUB)

Characteristic	Value
Operation accuracy	±1.5% of the set value or ±0.002 × U_n
Reset ratio	Typically 0.96

Control functions

Table 93. Autoreclosing (DARREC)

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

Table 94. Synchronism and energizing check (SECRSYN)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±1 Hz Voltage: ±3.0% of the set value or ±0.01 × U_n Frequency: ±10 mHz Phase angle: ±3°
Reset time	<50 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms

Table 95. Synchronism and energizing check (SECRSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	SECRSYN	-1 = Off 1 = Both Dead 2 = Live L, Dead B 3 = Dead L, Live B 4 = Dead Bus, L Any 5 = Dead L, Bus Any 6 = One Live, Dead 7 = Not Both Live	
Difference voltage	SECRSYN	0.01...0.50 × U_n	0.01
Difference frequency	SECRSYN	0.001...0.100 × f_n	0.001
Difference angle	SECRSYN	5...90°	1
Synchrocheck mode	SECRSYN	1 = Off 2 = Synchronous 3 = Asynchronous	
Control mode	SECRSYN	1 = Continuous 2 = Command	
Dead line value	SECRSYN	0.1...0.8 × U_n	0.1
Live line value	SECRSYN	0.2...1.0 × U_n	0.1
Close pulse	SECRSYN	200...60000 ms	10
Max energizing V	SECRSYN	0.50...1.15 × U_n	0.01
Phase shift	SECRSYN	-180...180°	1
Minimum Syn time	SECRSYN	0...60000 ms	10
Maximum Syn time	SECRSYN	100...6000000 ms	10
Energizing time	SECRSYN	100...60000 ms	10
Closing time of CB	SECRSYN	40...250 ms	10

Condition monitoring and supervision functions

Table 96. Circuit-breaker condition monitoring (SSCBR)

Characteristic	Value
Current measuring accuracy	±1.5% or ±0.002 x I_n (at currents in the range of 0.1...10 x I_n) ±5.0% (at currents in the range of 10...40 x I_n)
Operate time accuracy	±1.0% of the set value or ±20 ms
Travelling time measurement	+10 ms / -0 ms

Table 97. Current circuit supervision (CCSPVC)

Characteristic	Value
Operate time [1]	<30 ms

1) Including the delay of the output contact

Table 98. Current circuit supervision (CCSPVC) main settings

Parameter	Function	Value (Range)	Step
Start value	CCSPVC	0.05...0.20 × I_n	0.01
Maximum operate current	CCSPVC	1.00...5.00 × I_n	0.01

Table 99. Current transformer supervision for high-impedance protection scheme (HZCCxSPVC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × In
Reset time	<40 ms
Reset ratio	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms

Table 100. CT supervision for high-impedance protection scheme (HZCxSPVC) main settings

Parameter	Function	Value (Range)	Step
Start value	HZCASPVC HZCBSPVC HZCCSPVC	1.0...100.0%In	0.1
Alarm delay time	HZCASPVC HZCBSPVC HZCCSPVC	100...300000 ms	10
Alarm output mode	HZCASPVC HZCBSPVC HZCCSPVC	1=Non-latched 3=Lockout	

Table 101. Fuse failure supervision (SEQSPVC)

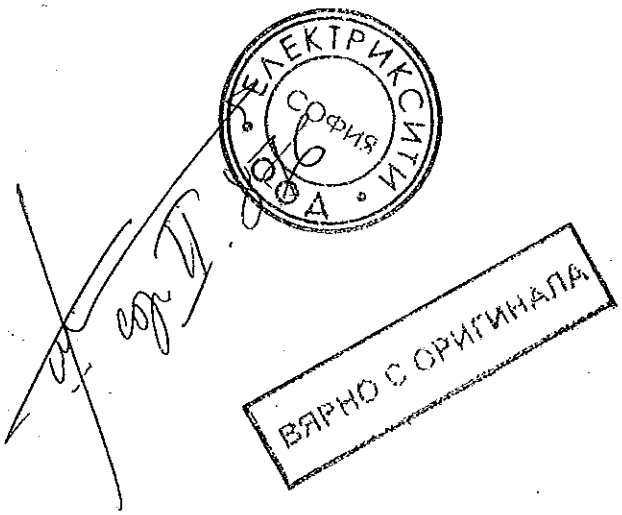
Characteristic		Value	
Operate time[1)]	NPS function	U_{Fault} = 1.1 × set *Neg Seq voltage Lev*	<33 ms
		U_{Fault} = 5.0 × set *Neg Seq voltage Lev*	<18 ms
	Delta function	ΔU = 1.1 × set *Voltage change rate*	<30 ms
		ΔU = 2.0 × set *Voltage change rate*	<24 ms

1) Includes the delay of the signal output contact, f_n = 50 Hz, fault voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

Table 102. Runtime counter for machines and devices (MDSOPT)

Description	Value
Motor runtime measurement accuracy[1)]	±0.5%

1) Of the reading, for a stand-alone relay, without time synchronization.



Measurement functions

Table 103. Three-phase current measurement (CMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz ±0.5% or ±0.002 × I_n (at currents in the range of 0.01...4.00 × I_n)
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... RMS: No suppression

Table 104. Sequence current measurement (CSMSQI)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f/f_n = ±2 Hz ±1.0% or ±0.002 × I_n at currents in the range of 0.01...4.00 × I_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

Table 105. Residual current measurement (RESCMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f/f_n = ±2 Hz ±0.5% or ±0.002 × I_n at currents in the range of 0.01...4.00 × I_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... RMS: No suppression

Table 106. Three-phase voltage measurement (VMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz At voltages in range 0.01...1.15 × U_n ±0.5% or ±0.002 × U_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... RMS: No suppression

Table 107. Residual voltage measurement (RESVMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f/f_n = ±2 Hz ±0.5% or ±0.002 × U_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... RMS: No suppression

22. Local HMI

The relay is available with two optional displays, a large one and a small one. The large display is suited for relay installations where the front panel user interface is frequently used and a single line diagram is required. The small display is suited for remotely controlled substations where the relay is only occasionally accessed locally via the front panel user interface.

Both LCD displays offer front-panel user interface functionality with menu navigation and menu views. However, the large display offers increased front-panel usability with less menu scrolling and improved information overview. In addition, the large display includes a user-configurable single line diagram (SLD) with position indication for the associated primary equipment. Depending on the chosen standard configuration, the relay displays the related measuring values, apart from the default single line diagram. The SLD view can also be accessed using the Web browser-based user interface. The default SLD can be modified according to user requirements by using the Graphical Display Editor in PCM600. The user can create up to 10 SLD pages.

The local HMI includes a push button (L/R) for local/remote operation of the relay. When the relay is in the local mode, it can be operated only by using the local front panel user interface. When the relay is in the remote mode, it can execute commands sent from a remote location. The relay supports the remote selection of local/remote mode via a binary input. This feature facilitates, for example, the use of an external switch at the substation to ensure that all relays are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control center.

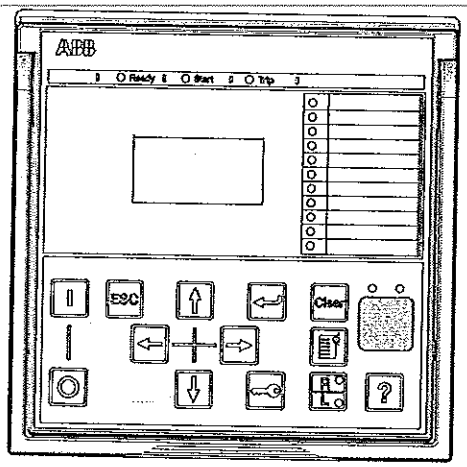


Figure 24. Small display

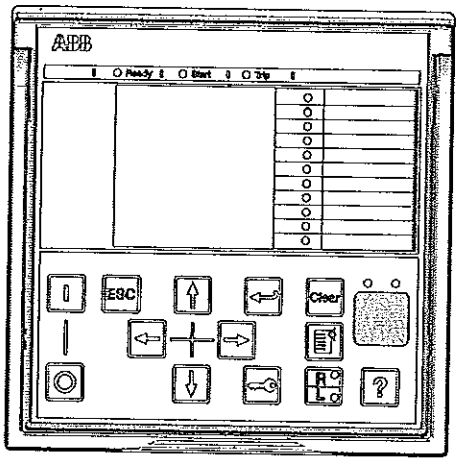


Figure 25. Large display

Table 114. Small display

Character size[1]	Rows in the view	Characters per row
Small, mono-spaced (6x12 pixels)	5	20
Large, variable width (13x14 pixels)	3	8 or more

1) Depending on the selected language

Table 115. Large display

Character size[1]	Rows in the view	Characters per row
Small, mono-spaced (6x12 pixels)		20
Large, variable width (13x14 pixels)		8 or more

1) Depending on the selected language

23. Mounting methods

By means of appropriate mounting accessories the standard relay case for the 615 series relay can be flush mounted, semi-flush mounted or wall mounted. The flush mounted and wall mounted relay cases can also be mounted in a tilted position (25°) using special accessories.

Further, the relays can be mounted in any standard 19" instrument cabinet by means of 19" mounting panels available with cut-outs for one or two relays. Alternatively, the relay can be mounted in 19" instrument cabinets by means of 4U Combiflex equipment frames.

For the routine testing purposes, the relay cases can be equipped with test switches, type RTXP 18, which can be mounted side by side with the relay cases.

Mounting methods:

- Flush mounting
- Semi-flush mounting
- Semi-flush mounting in a 25° tilt
- Rack mounting
- Wall mounting
- Mounting to a 19" equipment frame
- Mounting with a RTXP 18 test switch to a 19" rack

Panel cut-out for flush mounting:

- Height: 161.5 ±1 mm
- Width: 165.5 ±1 mm

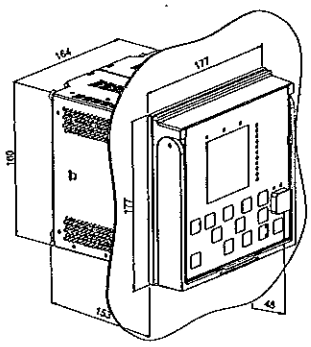


Figure 26. Flush mounting

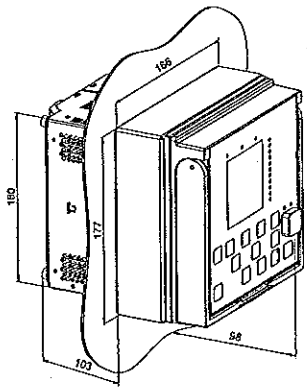


Figure 27. Semi-flush mounting

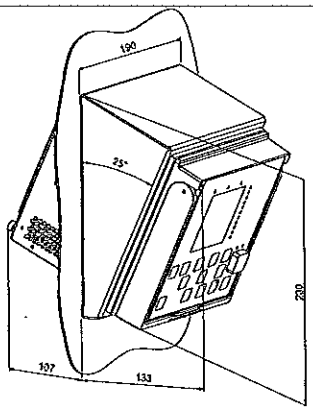


Figure 28. Semi-flush with a 25° tilt

24. Relay case and plug-in unit

For safety reasons, the relay cases for current measuring relays are provided with automatically operating contacts for short-circuiting the CT secondary circuits when a relay unit is withdrawn from its case. The relay case is further provided with a mechanical coding system preventing current measuring relay units from being inserted into a relay case for a voltage measuring relay unit and vice versa, that is, the relay cases are assigned to a certain type of plug-in unit.

25. Selection and ordering data

Use the ABB Library to access the selection and ordering information and to generate the order number.

26. Accessories and ordering data

Table 116. Cables

Item	Order number
Cable for optical sensors for arc protection 1.5 m	1MRS120534-1.5
Cable for optical sensors for arc protection 3.0 m	1MRS120534-3.0
Cable for optical sensors for arc protection 5.0 m	1MRS120534-5.0

Table 117. Mounting accessories

Item	Order number
Semi-flush mounting kit	1MRS050696
Wall mounting kit	1MRS050697
Inclined semi-flush mounting kit	1MRS050831
19" rack mounting kit with cut-out for one relay	1MRS050694
19" rack mounting kit with cut-out for two relays	1MRS050695
Mounting bracket for one relay with test switch RTXP in 4U Combiflex (RHGT 19" variant C)	2RCA022642P0001
Mounting bracket for one relay in 4U Combiflex (RHGT 19" variant C)	2RCA022643P0001
19" rack mounting kit for one relay and one RTXP18 test switch (the test switch is not included in the delivery)	2RCA021952A0003
19" rack mounting kit for one relay and one RTXP24 test switch (the test switch is not included in the delivery)	2RCA022561A0003
Replacement kit for a Strömberg SP_J40 series relay (cut-out in the center of the installation plate)	2RCA027871A0001
Replacement kit for a Strömberg SP_J40 series relay (cut-out on the left or the right of the installation plate)	2RCA027874A0001
Replacement kit for two Strömberg SP_J3 series relays	2RCA027880A0001
19" rack replacement kit for Strömberg SP_J3/J6 series relays (one cut-out)	2RCA027894A0001
19" rack replacement kit for Strömberg SP_J3/J6 series relays (two cut-outs)	2RCA027897A0001
Replacement kit for a Strömberg SP_J6 series relay	2RCA027881A0001
Replacement kit for three BBC S_ series relays	2RCA027882A0001
Replacement kit for a SPA 300 series relay	2RCA027885A0001

27. Tools

The protection relay is delivered as a pre-configured unit. The default parameter setting values can be changed from the front-panel user interface, the Web browser-based user interface (Web HMI) or the PCM600 tool in combination with the relay-specific connectivity package.

The Protection and Control IED Manager PCM600 offers extensive relay configuration functions such as relay signal configuration, application configuration, graphical display configuration including single line diagram configuration, and IEC 61850 communication configuration including horizontal GOOSE communication.

When the Web browser-based user interface is used, the protection relay can be accessed either locally or remotely using a Web browser (Internet Explorer). For security reasons, the Web browser-based user interface is disabled by default but it can be enabled via the front-panel user interface. The Web HMI functionality can be limited to read-only access.

The relay connectivity package is a collection of software and specific relay information, which enable system products and tools to connect and interact with the protection relay. The connectivity packages reduce the risk of errors in system integration, minimizing device configuration and setup times. Further, the connectivity packages for protection relays of this product series include a flexible update tool for adding one additional local HMI language to the protection relay. The update tool is activated using PCM600, and it enables multiple updates of the additional HMI language, thus offering flexible means for possible future language updates.

Table 118. Tools

Configuration and setting tools	Version
PCM600	2.6 (Rollup 20150626) or later
Web browser-based user interface	IE 8.0, IE 9.0, IE 10.0 or IE 11.0
REF615 Connectivity Package	5.1 or later

Table 119. Supported functions

Function	Web HMI	PCM600
Relay parameter setting	•	•
Saving of relay parameter settings in the relay	•	•
Signal monitoring	•	•
Disturbance recorder handling	•	•
Alarm LED viewing	•	•
Access control management	•	•
Relay signal configuration (Signal Matrix)	-	•
Modbus® communication configuration (communication management)	-	•
DNP3 communication configuration (communication management)	-	•
IEC 60870-5-103 communication configuration (communication management)	-	•
Saving of relay parameter settings in the tool	-	•
Disturbance record analysis	-	•
XRIO parameter export/import	-	•
Graphical display configuration	-	•
Application configuration	-	•
IEC 61850 communication configuration, GOOSE (communication configuration)	-	•
Phasor diagram viewing	•	-
Event viewing	•	•
Saving of event data on the user's PC	•	•
Online monitoring	-	•

• = Supported

28. Cyber security

The relay supports role based user authentication and authorization. It can store 2048 audit trail events to a non-volatile memory. The non-volatile memory is based on a memory type which does not need battery backup or regular component exchange to maintain the memory storage. FTP and Web HMI use TLS encryption with a minimum of 128 bit key length protecting the data in transit. In this case the used communication protocols are FTPS and HTTPS. All rear communication ports and optional protocol services can be deactivated according to the desired system setup.

29. Terminal diagrams

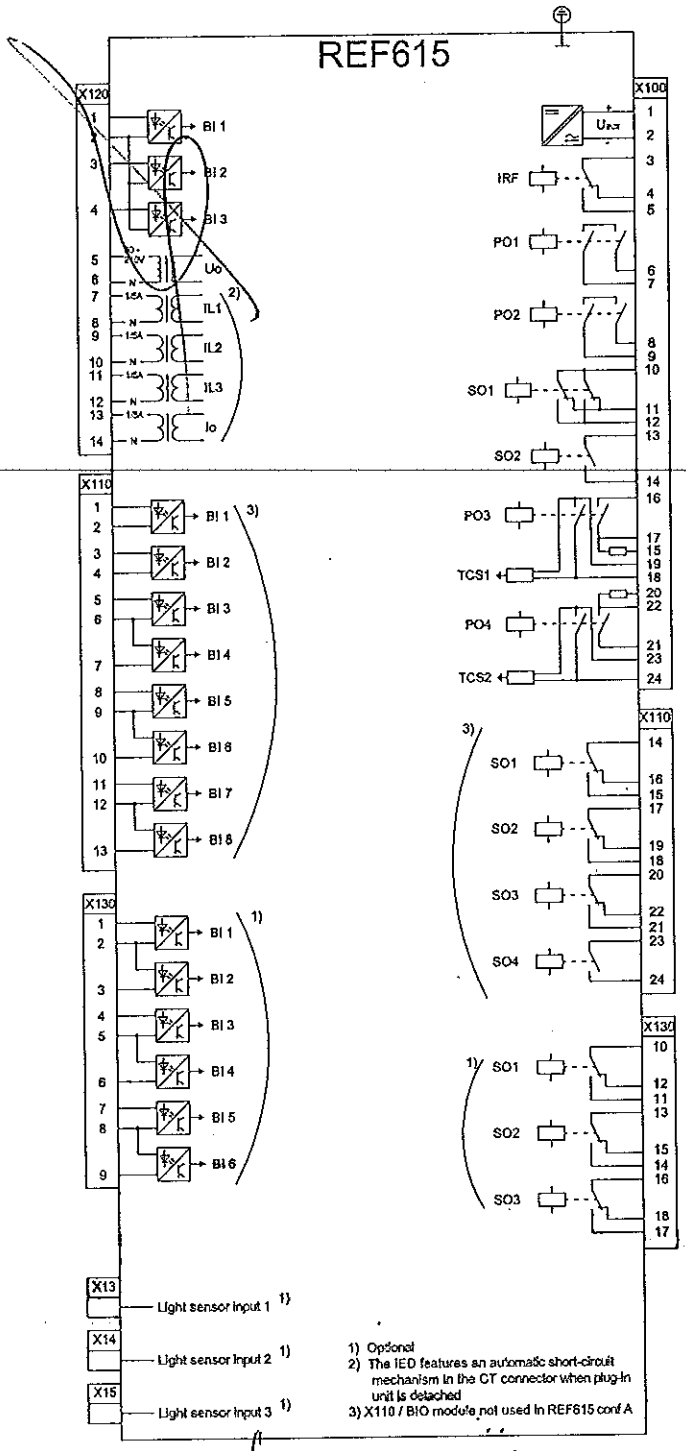


Figure 29. Terminal diagram of standard configurations A and B

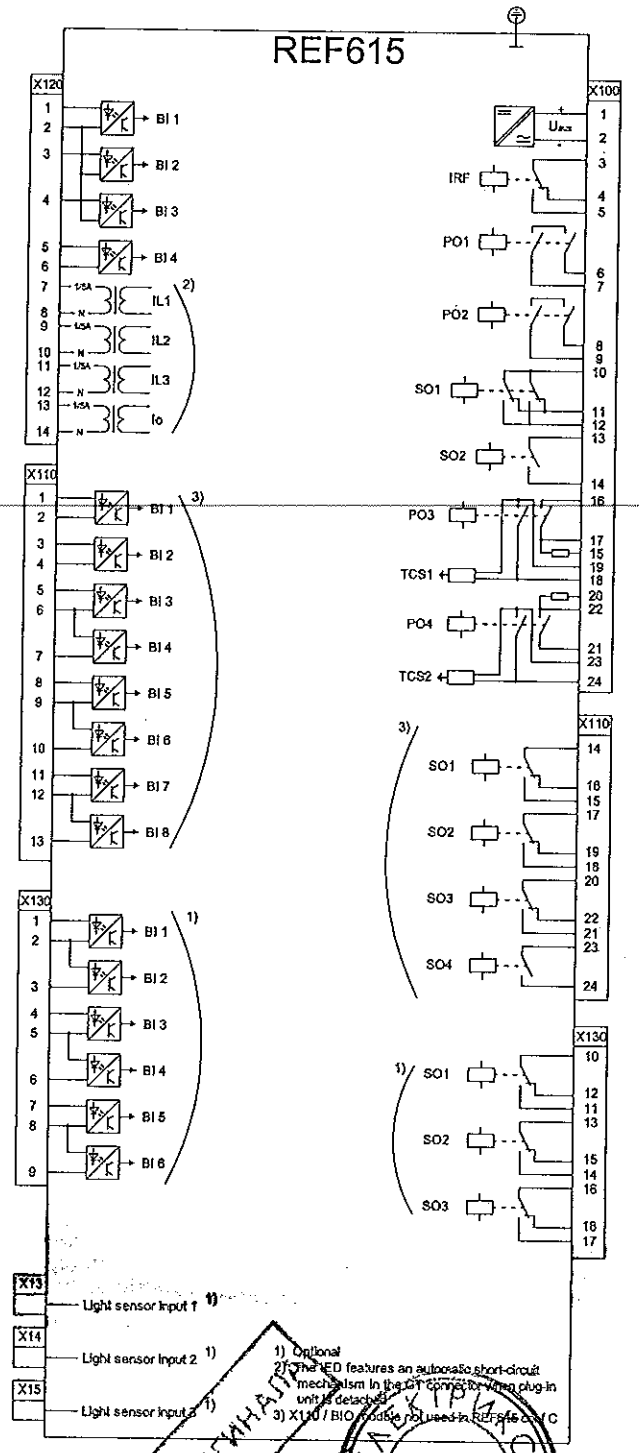


Figure 30. Terminal diagram of standard configurations C and D

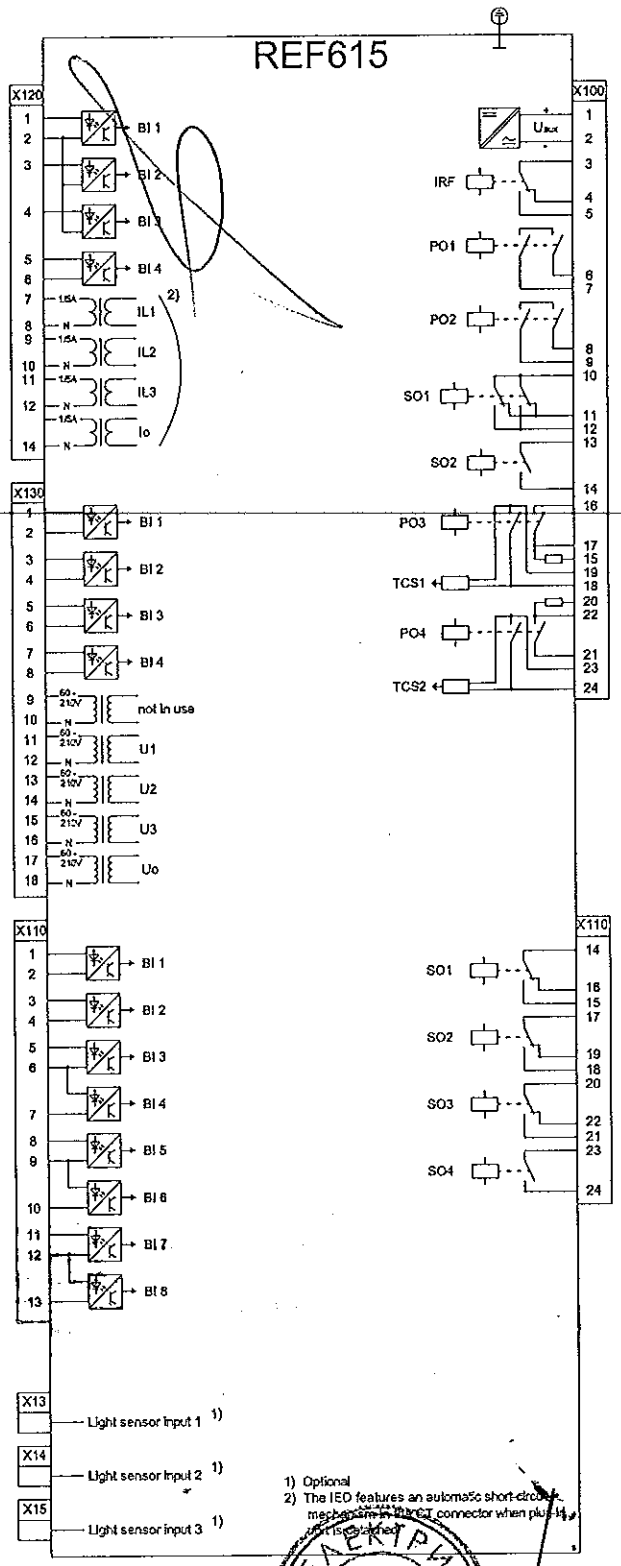


Figure 31. Terminal diagram of standard configurations E and F

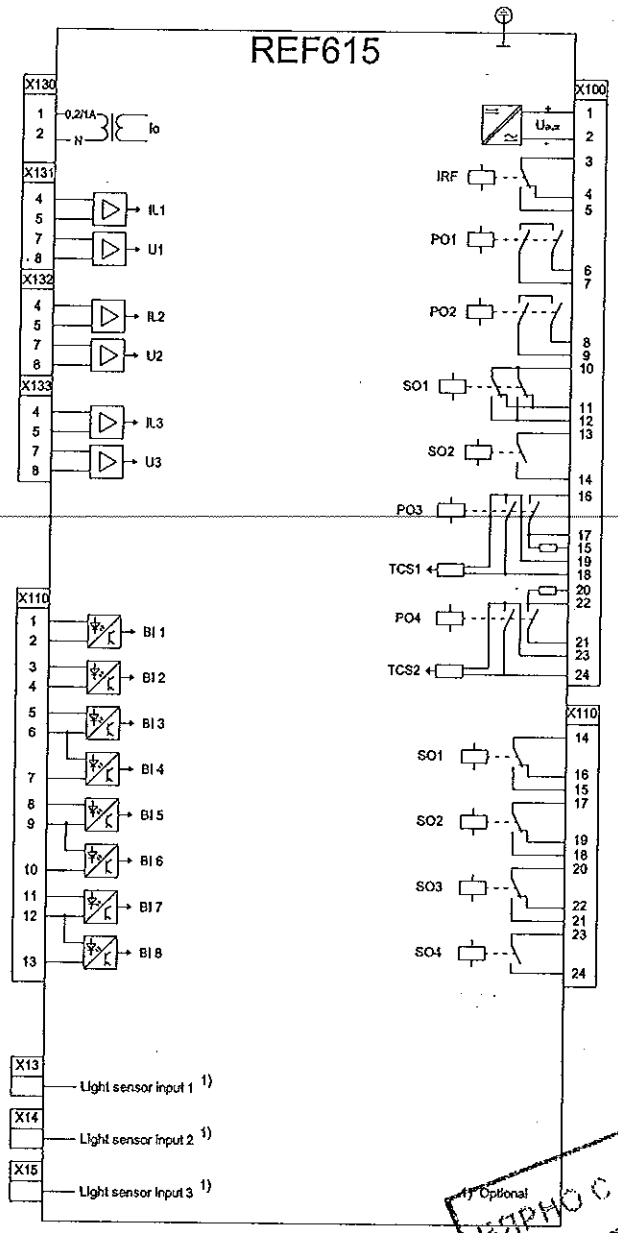


Figure 32. Terminal diagram of standard configurations G and L

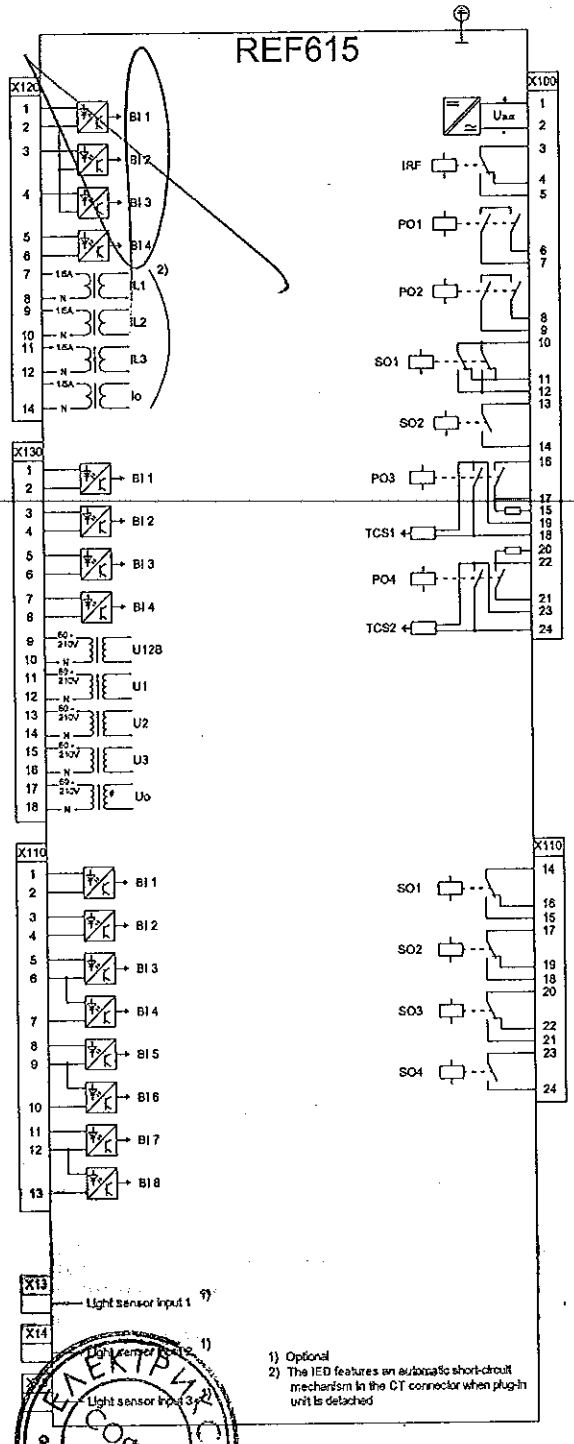


Figure 33. Terminal diagram of standard configurations H, J and N

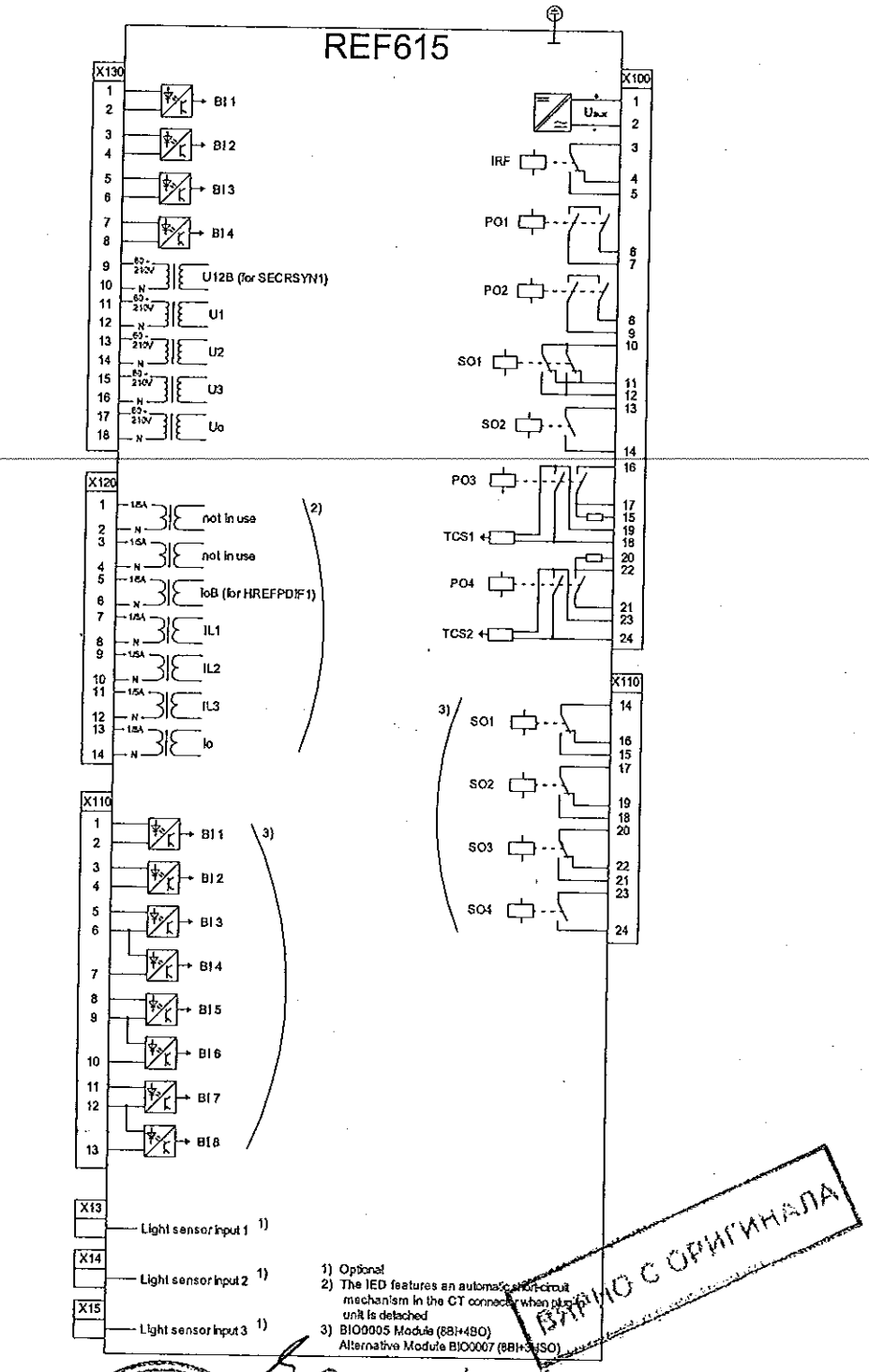


Figure 34. Terminal diagram of standard configuration K

30. Certificates

DNV GL has issued an IEC 61850 Edition 2 Certificate Level A1 for Relion® 615 series. Certificate number: 7410570I-OPE/INC 15-1136.

DNV GL has issued an IEC 61850 Edition 1 Certificate Level A1 for Relion® 615 series. Certificate number: 74105701-OPE/INC 15-1145.

Additional certificates can be found on the product page.

31. Inspection reports

KEMA has issued an Inspection report for REF615, "Comparison between hardwired and GOOSE performance of UniGear switchgear panels with REF615 and REF630 Feeder Protection and Control IEDs based on IEC 62271-3". Report number: 70972064-TDT 09-1398.

The Inspection report concludes in its summary, apart from the performance comparisons, that "both the REF630 and REF615 comply to the performance class P1 message type 1A "Trip" for distribution bays (transfer time <10 msec) as defined in IEC 61850-5".

32. References

The www.abb.com/substationautomation portal provides information on the entire range of distribution automation products and services.

You will find the latest relevant information on the REF615 protection and control relay on the product page. Scroll down the page to find and download the related documentation.

ЕЛЕКТРИКСИМ ООД София

ВЯРНО С ОРИГИНАЛА

33. Functions, codes and symbols

Table 120. Functions included in the relay

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I> (1)	51P-1 (1)
	PHLPTOC2	3I> (2)	51P-1 (2)
Three-phase non-directional overcurrent protection, high stage	PHHPTOC1	3I>> (1)	51P-2 (1)
	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	3I> -> (1)	67-1 (1)
	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Non-directional earth-fault protection, low stage	EFLPTOC1	Io> (1)	51N-1 (1)
	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage	DEFLPDEF1	Io> -> (1)	67N-1 (1)
	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Admittance-based earth-fault protection	EFPADM1	Yo> -> (1)	21YN (1)
	EFPADM2	Yo> -> (2)	21YN (2)
	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric-based earth-fault protection	WPWDE1	Po> -> (1)	32N (1)
	WPWDE2	Po> -> (2)	32N (2)
	WPWDE3	Po> -> (3)	32N (3)
Transient/intermittent earth-fault protection	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Harmonics-based earth-fault protection	HAEFPTOC1	Io>HA (1)	51NHA (1)
Non-directional (cross-country) earth-fault protection, using calculated Io	EFHPTOC1	Io>> (1)	51N-2 (1)
Negative-sequence overcurrent protection	NSPTOC1	I2> (1)	46 (1)
	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1> (1)	46PD (1)
Residual overvoltage protection	ROVPTOV1	Uo> (1)	59G (1)
	ROVPTOV2	Uo> (2)	59G (2)
	ROVPTOV3	Uo> (3)	59G (3)

Table 120. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
	PHPTUV2	3U< (2)	27 (2)
	PHPTUV3	3U< (3)	27 (3)
Three-phase overvoltage protection	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection	PSPTUV1	U1< (1)	47U+ (1)
	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection	NSPTOV1	U2> (1)	47O- (1)
	NSPTOV2	U2> (2)	47O- (2)
Frequency protection	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>F (1)	49F (1)
High-impedance based restricted earth-fault protection	HREFPDIF1	dIoHi> (1)	87NH (1)
High-impedance differential protection for phase A	HIAPDIF1	dHI_A>(1)	87A(1)
High-impedance differential protection for phase B	HIBPDIF1	dHI_B>(1)	87B(1)
High-impedance differential protection for phase C	HICPDIF1	dHi_C>(1)	87C(1)
Circuit breaker failure protection	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Three-phase inrush detector	INRPHAR1	3I2f> (1)	68 (1)
Switch onto fault	CBPSOF1	SOTF (1)	SOTF (1)
Master trip	TRPPTRC1	Master Trip (1)	94/86 (1)
	TRPPTRC2	Master Trip (2)	94/86 (2)
	TRPPTRC3	Master Trip (3)	94/86 (3)
	TRPPTRC4	Master Trip (4)	94/86 (4)
	TRPPTRC5	Master Trip (5)	94/86 (5)
Arc protection	ARCSARC1	ARC (1)	50L/50NL (1)
	ARCSARC2	ARC (2)	50L/50NL (2)
	ARCSARC3	ARC (3)	50L/50NL (3)

Table 120. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Multipurpose protection	MAPGAPC1	MAP (1)	MAP (1)
	MAPGAPC2	MAP (2)	MAP (2)
	MAPGAPC3	MAP (3)	MAP (3)
	MAPGAPC4	MAP (4)	MAP (4)
	MAPGAPC5	MAP (5)	MAP (5)
	MAPGAPC6	MAP (6)	MAP (6)
	MAPGAPC7	MAP (7)	MAP (7)
	MAPGAPC8	MAP (8)	MAP (8)
	MAPGAPC9	MAP (9)	MAP (9)
	MAPGAPC10	MAP (10)	MAP (10)
	MAPGAPC11	MAP (11)	MAP (11)
	MAPGAPC12	MAP (12)	MAP (12)
	MAPGAPC13	MAP (13)	MAP (13)
	MAPGAPC14	MAP (14)	MAP (14)
	MAPGAPC15	MAP (15)	MAP (15)
	MAPGAPC16	MAP (16)	MAP (16)
	MAPGAPC17	MAP (17)	MAP (17)
	MAPGAPC18	MAP (18)	MAP (18)
Fault locator	SCEFRFLO1	FLOC (1)	21FL (1)
High-impedance fault detection	PHIZ1	HIF (1)	HIZ (1)
Reverse power/directional overpower protection	DOPPDPR1	P>/Q> (1)	32R/32O (1)
	DOPPDPR2	P>/Q> (2)	32R/32O (2)
Multifrequency admittance-based earth-fault protection	MFADPSDE1	Io> ->Y (1)	67YN (1)
Interconnection functions			
Directional reactive power undervoltage protection	DQPTUV1	Q> ->,3U< (1)	32Q,27 (1)
Low-voltage ride-through protection	LVRTPTUV1	U<RT (1)	27RT (1)
	LVRTPTUV2	U<RT (2)	27RT (2)
	LVRTPTUV3	U<RT (3)	27RT (3)
Voltage vector shift protection	VVSPPAM1	VS (1)	78V (1)
Power quality			
Current total demand distortion	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation	PHQVVR1	PQMU (1)	PQMV (1)
Voltage unbalance	VSQVUB1	PQUUB (1)	PQVUB (1)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)

Table 120. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Disconnector control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector position indication	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Autoreclosing	DARREC1	O -> I (1)	79 (1)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
Current transformer supervision for high-impedance protection scheme for phase A	HZCCASPVC1	MCS I_A(1)	MCS I_A(1)
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPVC1	MCS I_B(1)	MCS I_B(1)
Current transformer supervision for high-impedance protection scheme for phase C	HZCCCSPVC1	MCS I_C(1)	MCS I_C(1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Runtime counter for machines and devices	MDSOPT1	OPTS (1)	OPTM (1)
Measurement			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Load profile record	LDPRLRC1	LOADPROF (1)	LOADPROF (1)
Fault record	FLTRFRC1	FAULTREC (1)	FAULTREC (1)
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement	RESCMMXU1	Io (1)	In (1)
	RESCMMXU2	Io (2)	In (2)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
	VMMXU2	3U (2)	3V (2)
Residual voltage measurement	RESVMMXU1	Uo (1)	Vn (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
RTD/mA measurement	XRGGIO130	X130 (RTD) (1)	X130 (RTD) (1)
Frequency measurement	FMMXU1	f (1)	f (1)
IEC 61850-9-2 LE sampled value sending	SMVSENDER	SMVSENDER	SMVSENDER

Table 120. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
IEC 61850-9-2 LE sampled value receiving (voltage sharing)	SMVRCV	SMVRCV	SMVRCV
Other			
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
Pulse timer (8 pcs)	PTGAPC1	PT (1)	PT (1)
	PTGAPC2	PT (2)	PT (2)
Time delay off (8 pcs)	TOFGAPC1	TOF (1)	TOF (1)
	TOFGAPC2	TOF (2)	TOF (2)
	TOFGAPC3	TOF (3)	TOF (3)
	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs)	TONGAPC1	TON (1)	TON (1)
	TONGAPC2	TON (2)	TON (2)
	TONGAPC3	TON (3)	TON (3)
	TONGAPC4	TON (4)	TON (4)
Set-reset (8 pcs)	SRGAPC1	SR (1)	SR (1)
	SRGAPC2	SR (2)	SR (2)
	SRGAPC3	SR (3)	SR (3)
	SRGAPC4	SR (4)	SR (4)
Move (8 pcs)	MVGAPC1	MV (1)	MV (1)
	MVGAPC2	MV (2)	MV (2)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
Analog value scaling	SCA4GAPC1	SCA4 (1)	SCA4 (1)
	SCA4GAPC2	SCA4 (2)	SCA4 (2)
	SCA4GAPC3	SCA4 (3)	SCA4 (3)
	SCA4GAPC4	SCA4 (4)	SCA4 (4)
Integer value move	MVI4GAPC1	MVI4 (1)	MVI4 (1)

34. Document revision history

Document revision/date	Product version	History
A/2007-12-20	1.0	First release
B/2008-02-22	1.0	Content updated
C/2008-06-20	1.1	Content updated to correspond to the product version
D/2009-03-03	2.0	Content updated to correspond to the product version. New layout on front and back page
E/2009-07-03	2.0	Content updated
F/2009-10-01	2.0	Content updated
G/2010-06-11	3.0	Content updated to correspond to the product version
H/2010-06-29	3.0	Terminology updated
K/2010-09-07	3.0	Content updated
L/2012-05-11	4.0	Content updated to correspond to the product version
M/2013-02-21	4.0 FP1	Content updated to correspond to the product version
N/2014-01-24	5.0	Content updated to correspond to the product version
P/2014-04-10	5.0	Content updated
R/2015-10-30	5.0 FP1	Content updated to correspond to the product version

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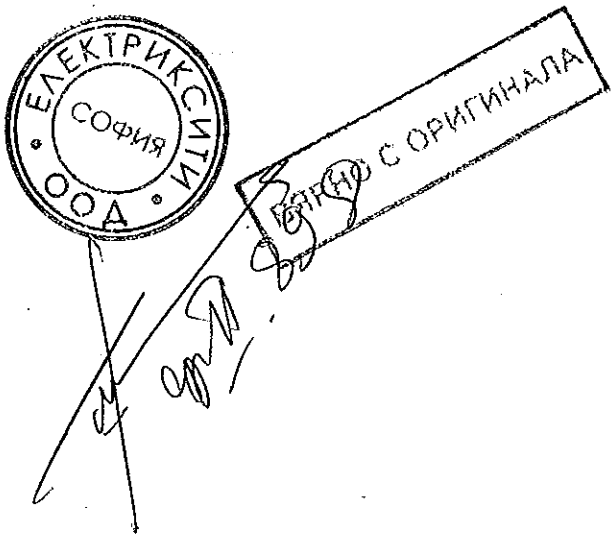
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Раздел 5 IED Физически връзки

5.1 Входове

5.1.1 Захранващи входове

5.1.1.1 Фазни токове

IED може да се използва за еднофазни или двуфазни приложения, като се оставят свободни един или два входа. Въпреки това, най-малко терминали X120/7-8 трябва да бъдат свързани.

Таблица 65: Фазни токови входове, включени в конфигурации A, B, C, D, E, F, H и J

Изводи	Описание
X120-7, 8	IL1
X120-9, 10	IL2
X120-11, 12	IL3

5.1.1.2 Ток с нулева последователност

Таблица 66: Вход за Io е включен в конфигурации A, B, C, D, E, F, H и J

Изводи	Описание
X120-13, 14	Io

Таблица 67: Вход за Io включен в конфигурация G

Изводи	Описание
X130–1, 2	Io

5.1.1.3 Фазни напрежения

Таблица 68: Входове за фазните напрежения са предвидени в конфигурации E, F, H и J

Изводи	Описание
X130-11, 12	U1
X130-13, 14	U2
X130-15, 16	U3

ВЯРНО С ОРИГИНАЛА

Таблица 69: Напреженов вход за SECRSYN1 включен в конфигурация H и J

Извод	Описание
X130-9, 10	U12B

5.1.1.4 Напрежение с нулева последователност

Таблица70: Допълнителни входове за напрежение с нулева последователност са включени в конфигурации A и B

Изводи	Описание
X120-5, 6	Uo

Таблица 71: Допълнителни входове за напрежение с нулева последователност са включени в конфигурации E, F, H и J

Изводи	Описание
X130-17, 18	Uo

5.1.1.5 Сензорни входове

Таблица 72: Входове за Combi сензор включени в конфигурация G

Изводи	Описание
X131	IL1 U1
X132	IL2 U2
X133	IL3 U3

5.1.2 Входове оперативно напрежение:

Оперативното напрежение IED се подава на терминали X100/1-2. При захранване с постоянен ток, положителния проводник е свързан към терминала X100-1. Разрешения диапазон оперативно напрежение (AC / DC или DC) е посочен върху горната част на LHMI на IED.

Таблица 73: Оперативно напрежение

Изводи:	Описание
X100-1	+ Input
X100-2	- Input

ВЯРНО С ОРИГИНА

5.1.3 Цифрови входове:

Цифровите входове могат да бъдат използвани, например, за генериране на блокиращ сигнал, за да отключите изходни контакти, за да предизвика регистъра на грешките или за дистанционно управление на IED настройки.

Цифрови входове на слот X110 са налични при конфигурации B, D, E, F, G, H и J.

Таблица74: Терминали X110-1...13

Изводи:	Описание
X110-1	BI1, +
X110-2	BI1, -
X110-3	BI2, +
X110-4	BI2, -
X110-5	BI3, +
X110-6	BI3, -
X110-6	BI4, -
X110-7	BI4, +
X110-8	BI5, +
X110-9	BI5, -
X110-9	BI6, -
X110-10	BI6, +
X110-11	BI7, +
X110-12	BI7, -
X110-12	BI8, -
X110-13	BI8, +

Цифрови входове на слот X120 са налични при конфигурации C, D, E, F, H и J.

Таблица 75: Терминали X120-1...6

Изводи:	Описание
X120-1	BI1, +
X120-2	BI1, -
X120-3	BI2, +
X120-2	BI2, -
X120-4	BI3, +
X120-2	BI3, -
X120-5	BI4, +
X120-6	BI4, -

Цифрови входове на слот X120 са налични за конфигурации A и B.

Таблица 76: Терминали X120-1...4

Изводи:	Описание
X120-1	BI1, +
X120-2	BI1, -
X120-3	BI2, +

Таблицата продължава на следващата страница

Изводи:	Описание
X120-2	BI2, -
X120-4	BI3, +
X120-2	BI3, -

Цифровите входове на слот X130 са опция при конфигурации B и D.

Таблица 77: Терминали X130-1...9

Изводи:	Описание
X130-1	BI1, +
X130-2	BI1, -
X130-2	BI2, -
X130-3	BI2, +
X130-4	BI3, +
X130-5	BI3, -
X130-5	BI4, -
X130-6	BI4, +
X130-7	BI5, +
X130-8	BI5, -
X130-8	BI6, -
X130-9	BI6, +

Цифровите входове на слот X130 са налични при конфигурации E, F, H и J.

Таблица 78: Терминали X130-1...8

Изводи:	Описание
X130-1	BI1, +
X130-2	BI1, -
X130-3	BI2, +
X130-4	BI2, -
X130-5	BI3, +
X130-6	BI3, -
X130-7	BI4, +
X130-8	BI4, -

5.1.4 Входове от светлинни датчици

Ако IED е снабден с опция модул за комуникация с входове за светлинни датчици , подготвените оптични влакна на сензорите са свързани към входовете X13, X14 и X15, вижте диаграмата на терминалите.За допълнителна информация вижте - дъгова защита.

IED е снабден с клеми за свързване X13, X14 и X15 само ако опционалният модул за комуникация с входове за светлинни датчици е инсталиран. Ако опцията дъгова защита е избрана при поръчката на IED, входовете светлинни датчици са включени в модула за комуникация.

Таблица 79: Входове светлинни датчици

Изводи	Описание
X13	Вход светлинен датчик 1
X14	Входове светлинен датчик 2
X15	Вход светлинен датчик 3

5.2 Изходи

5.2.1 Изходи за изключване и контрол

Изходни контакти PO1, PO2, PO3 и PO4 са с повишена изключвателна мощност и могат да контролират повечето прекъсвачи. При доставка от фабриката, сигналите за изключване от всички стъпала се насочват към PO3 и PO4.

Таблица 80: Изходни контакти

Изводи:	Описание
X100-6	PO1, NO
X100-7	PO1, NO
X100-8	PO2, NO
X100-9	PO2, NO
X100-15	PO3, NO (TCS резистор)
X100-16	PO3, NO
X100-17	PO3, NO
X100-18	PO3 (TCS1 вход), NO
X100-19	PO3 (TCS1 вход), NO
X100-20	PO4, NO (TCS резистор)
X100-21	PO4, NO
X100-22	PO4, NO
X100-23	PO4 (TCS2 вход), NO
X100-24	PO4 (TCS2 вход), NO

5.2.2 Изходи за сигнализация

Изходни контакти SO1 и SO2 в слота X100 или SO1, SO2, SO3 и SO4 в слота X110 или SO1, SO2 и SO3 в слота X130 (по избор) може да се използват за сигнализиране на

включване и изключван от IED. При доставка от фабриката, сигнали включване и аларма, от всички стъпала се насочват към сигналните изходи.

Таблица 81: Изходни контакти X100-10...14

Изводи:	Описание
X100-10	SO1, общ
X100-11	SO1, NC
X100-12	SO1, NO
X100-13	SO2, NO
X100-14	SO2, NO

Изходни контакти на слот X110 са налични при конфигурации B, D, E, F, G, H и J.

Таблица82: Изходни контактиX110-14...24

Изводи:	Описание
X110-14	SO1,общ
X110-15	SO1, NO
X110-16	SO1, NC
X110-17	SO2, общ
X110-18	SO2, NO
X110-19	SO2, NC
X110-20	SO3, общ
X110-21	SO3, NO
X110-22	SO3, NC
X110-23	SO4, общ
X110-24	SO4, NO

Изходните контакти на слот X130 са налични в модула по избор BIO (BIOB02A). Изходните контакти на слот X130 са опции при конфигурации B и D.

Таблица 83: Изходни контакти X130-10...18

Изводи:	Описание
X130-10	SO1, общ
X130-11	SO1, NO
X130-12	SO1, NC
X130-13	SO2, общ
X130-14	SO2, NO
X130-15	SO2, NC
X130-16	SO3, общ
X130-17	SO3, NO
X130-18	SO3, NC

5.2.3 Вътрешна повреда в защитата IRF

IRF функциите се използват, като изходен контакт на системата за самоконтрол на защитата IED. При нормални условия на работа, IED е захранена и контакта (X100/3-5) е затворен . Когато е открита неизправност от системата за самоконтрол или оперативното напрежение е изключено, напрежението на изходния контакт отпада и се затваря (X100/3-4).

Таблица 84: IR контакт

Изводи:	Описание
X100-3	IRF, общ
X100-4	Затворен; IRF, или U_{aux} прекъснато
X100-5	Затворен; по IRF, и U_{aux} подадено

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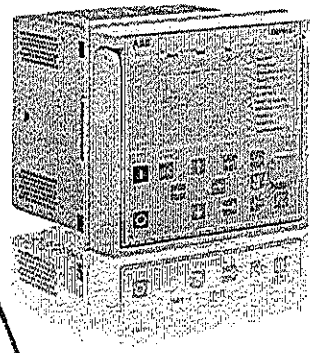

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Този продукт е създаден да бъде свързан и да обменя данни и информация чрез мрежов интерфейс, който трябва да бъде свързан към защитена мрежа. Това е отговорност единствено на лицето или организацията, която отговаря за управлението на мрежата, за да се гарантира сигурна връзка с мрежата и да се вземат необходимите мерки (например, но не само, инсталация на защитни системи, прилагане на мерки за удостоверяване, криптиране на данни, инсталиране на анти вирусни програми и т.н.), за да се защити продукта и мрежата, неговата система и интерфейс срещу всякакъв вид нарушения на защитата, неоторизиран достъп, намеса, проникване, изтичане и/или кражба на данни или информация. ABB не носи отговорност за каквито и да било такива вреди и/или загуби.

Този документ е внимателно проверен от ABB, но отклоненията не могат да бъдат напълно изключени. В случай на откриване на грешки читателят се умолява да уведоми производителя. Освен при изрични договорни задължения, ABB в никакъв случай няма да носи отговорност за загуба или повреда, произтичащи от използването на това ръководство или прилагането на оборудването.

Съответствие

Този продукт е в съответствие с директивата на Съвета на Европейската общност относно сближаването на законите на държавите-членки по отношение на електромагнитна съвместимост (EMC Директива 2004/108/EC) и относно електрическо оборудване за използване в рамките на определени граници на напрежението (Директива за ниско напрежение 2006/95/EC). Това съответствие е резултат от изпитвания, проведени от ABB, в съответствие със стандартите на продукта EN 50263 и EN 60255-26 за директивата за електромагнитна съвместимост (EMC) и съгласно стандартите на продукта EN 60255-1 и EN 60255-27 за директивата за ниско напрежение. Този продукт е проектиран в съответствие с международните стандарти на IEC 60255.

Информация за безопасност

Могат да се появят опасни напрежения на конекторите, въпреки че спомагателното напрежение е изключено.

Неспазването може да доведе до смърт, телесна повреда или значителни имуществени щети.

Само на компетентен електротехник е разрешено да работи по електрическата инсталация.

Трябва да се спазват националните и местните наредби за електрическа безопасност.

Фреймът на интелигентното електронно устройство (IED) трябва да бъде внимателно заземен.

Когато плъгинът на устройството е бил откачен от корпуса, не докосвайте вътрешността на корпуса. Вътрешността на корпуса на IED може да съдържа потенциално високо напрежение и докосването може да предизвика наранявания.

IED съдържа елементи, които са чувствителни към електростатичен разряд. Трябва да се избягва ненужно докосване на електронните компоненти.

Всеки път, когато се правят промени в IED, трябва да се вземат мерки, за да се избегне невярно изключване.

Съдържание

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София

Сер II - 91

ВЯРНО С ОРИГИНАЛ

Раздел 1 Въведение

1.1 Това ръководство

Ръководството за експлоатация съдържа инструкции за това, как да работите с IED, след като то е било въведено в експлоатация. Ръководството дава указания за наблюдение, управление и настройка на IED. Ръководството също така описва как да се идентифицират нарушения и как да разглеждате изчислените и измерените данни на електрическата мрежа, за да определите причината за неизправност.

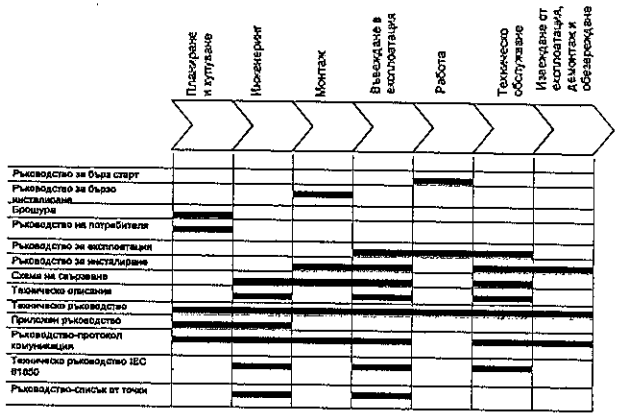
1.2 Предназначение

Това ръководство е предназначено за оператора, който ежедневно управлява IED.

Операторът трябва да бъде обучен и да има основни познания за това, как да управлява защитно оборудване. Ръководството съдържа термини и изрази, които обикновено се използват за описване на този вид оборудване.

1.3 Документация на продукта

1.3.1 Комплект документи на продукта



Фигура 1: Предполагаемо използване на документите по време на експлоатационния живот на изделието

Продуктови серии и определени наръчници за изделието могат да бъдат свалени от уебсайта на ABB http://www.abb.com/relion.

1.3.2 История на ревизията на документите

Документ ревизия / дата	Версия на продуктова серия	История
A/2009-03-04	2.0	Първа версия
B/2009-07-03	2.0	Съдържанието е обновено
C/2010-06-11	3.0	Съдържанието е актуализирано, за да съответства на продуктовата серия
D/2010-08-29	3.0	Терминологията е актуализирана
E/2010-09-24	3.0	Съдържанието е обновено
F/2012-05-11	4.0	Съдържанието е актуализирано, за да съответства на версията на продуктовата серия
G/2013-02-21	4.0 FP1	Съдържанието е актуализирано, за да съответства на версията на продуктовата серия
H/2013-12-20	5.0	Съдържанието е актуализирано, за да съответства на версията на продуктовата серия
K/2014-01-24	5.0	Съдържанието е обновено

Свалете последните документи от уебсайта на ABB http://www.abb.com/substationautomation.

1.3.3 Свързана документация

Серия продукти и специфични за продукта ръководства могат да бъдат изтеглени от уебсайта на ABB http://www.abb.com/substationautomation.

1.4 Символи и установени практики

1.4.1 Символи

Иконата на електрическото предупреждение показва наличието на опасност, която може да доведе до токов удар.

Иконата за предупреждение показва наличието на опасност, която може да доведе до нараняване.

Иконата за внимание показва важна информация или предупреждение, свързано с концепцията обсъдена в текста. Тя може да показва наличието на опасност, която може да доведе до повреда на софтуер или повреда на оборудване или имущество.

Иконата за информация алармира читателя за важни факти и условия.

Иконата дава съвети, например за това, как да проектирате свой проект или как да се използва определена функция.

Въпреки че предупредителните опасности са свързани с телесни наранявания, необходимо е да разберете, че при определени условия работата с повредено оборудване може да доведе до влошена производителност на процеса, което води до телесно нараняване или смърт. Ето защо трябва да спазвате всички бележки за предупреждение и внимание.

1.4.2 Документи за споразумения

Вътова ръководство не може да се използва специално споразумение.

- Преместването на „пуш бутона" в структурата на менюто LHMI е представено с помощта на иконите на „пуш бутона".
- Съкращения и акроними са изложени в речника. Речникът съдържа определения на важни понятия.
  За преместване между опциите, използвайте и .
- Menu paths/Пътеки меню са представени с удебелен шрифт.
  Изберете **Main menu/Settings** (Главно меню/Настройки).
- Имената на меню WHMI са представени с удебелен шрифт.
  Кликнете **Information**/Информация в структурата на меню WHMI.
- LHMI съобщения са показани с шрифт Courier.
  За да запазите промените в енерго-независима памет, изберете **Yes** и натиснете .
- Имената на параметрите са показани в курсивен шрифт.
  Функцията може да бъде разрешена и забранена с настройка ***Operation / Работа***.
- Стойностите на параметрите са посочени в кавички.
  Съответните стойности на параметрите са On и Off.
- Входни/изходни съобщения на IED и контролирани имена на данни са показани с шрифт Courier.
  Когато функцията стартира, изходът Start е зададен на **TRUE**/ВЯРНО.
- Този документ приема, че параметърът настройващ видимостта е Advanced /Подобрена.

1.4.3 Функции, кодове и символи

В таблицата са изброени всички налични функции. Не всички от тях могат да се прилагат за всички продукти.

Таблица 1: Функции, включени в IED

Функция	IEC 61850	IEC 60617	IEC-ANSI
Protection/ Защита			
Three-phase non-directional overcurrent protection, low stage/ Трифазна недиректна защита срещу свръхток, ниска степен	PHLPTOC1	3I> (1)	51P-1 (1)
	PHLPTOC2	3I> (2)	51P-1 (2)
Three-phase non-directional overcurrent protection, high stage/ Трифазна недиректна защита срещу свръхток, висока степен	PHHPTOC1	3I>> (1)	51P-2 (1)
	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantane stage/ Трифазна недиректна защита срещу свръхток, мигновена степен	PHIPTOC1	3I>>> (1)	50P/51P (1)
	PHIPTOC2	3I>>> (2)	50P/51P (2)
Three-phase directional overcurrent protection, low stage/ Трифазна недиректна защита срещу свръхток, ниска степен	DPHLPDOC1	3I> -> (1)	67-1 (1)
	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection,high stage/ Трифазна директна защита срещу свръхток, висока степен	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Non-directional earth-fault protection, low stage/ Недиректна защита срещу късо съединение земя, ниска степен	EFLPTOC1	Io> (1)	51N-1 (1)
	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage/ Недиректна защита срещу грешки при заземяване, висока степен	EFHPTOC1	Io>> (1)	51N-2 (1)
	EFHPTOC2	Io>> (2)	51N-2 (2)
Non-directional earth-fault protection, instantaneous stage/ Недиректна защита срещу грешки при заземяване, мигнов степен	EFIPTOC1	Io>>> (1)	50N/51N (1)

Таблицата продължава на следващата страница

Function/ Функция	IEC 61850	IEC 60617	IEC-ANSI
Directional earth-fault protection, low stage/ Директна защита срещу грешки при заземяване, ниска степен	DEFLPDEF1	Io> -> (1)	67N-1 (1)
	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, high stage/ Директна защита срещу грешки при заземяване, висока степен	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Admittance based earth-fault protection1)/ Достъп-базирана защита срещу грешки при заземяване1)	EFPADM1	Yo> -> (1)	21YN (1)
	EFPADM2	Yo> -> (2)	21YN (2)
	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric based earth-fault protection1)/ Защита по мощност срещу грешки при заземяване1)	WPWDE1	Po> -> (1)	32N (1)
	WPWDE2	Po> -> (2)	32N (2)
Transient / intermittent earth-fault protection/ Преходна / периодична земна защита	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Harmonic based earth-fault protection1)/ Базирана на хармони земна защита1)	HAEFPTOC1	Io>HA (1)	51NHA (1)
Non-directional (cross-country) earth-fault protection, using calculated Io/ Недиректна защита (повишено пропускане) ср грешки при заземяване, чрез използване на изчислено Io	EFHPTOC1	Io>> (1)	51N-2 (1)
Negative-sequence overcurrent protection/ Защита срещу свръхток, обратна последователност	NSPTOC1	I2> (1)	46 (1)
Phase discontinuity protection/ Защита от прекъсване на фаза	PDNSPTOC1	I2/I1> (1)	46PD (1)
Residual overvoltage protection/ Защита от остатъчно пренапрежение	ROVPTOV1	Uo> (1)	59G (1)
	ROVPTOV2	Uo> (2)	59G (2)
	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection/ Защита от трифазно подпрежение	PHPTUV1	3U< (1)	27 (1)
	PHPTUV2	3U< (2)	27 (2)
	PHPTUV3	3U< (3)	27 (3)
Three-phase overvoltage protection/ Защита от трифазно пренапрежение	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection/ Защита от подпрежение, положителна последователност	PSPTUV1	U1< (1)	47U+ (1)
	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection/ Защита от пренапрежение, обратна последователност	NSPTOV1	U2> (1)	47O- (1)
	NSPTOV2	U2> (2)	47O- (2)
Frequency protection/ Честотна защита	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers/ Трифазна топлинна защита за федери, кабели и разпределителни трансформатори	T1PTTR1	3Ith>F (1)	49F (1)
Three-phase thermal overload protection for power transformers, two time constants/ Трифазна топлинна защита за свръхтовар силови трансформатори, две времеконстанти	T2PTTR1	3Ith>T (1)	49T (1)
Negative-sequence overcurrent protection for Motors/ Защита срещу свръхток за мотори, отрицателна последователност	MNSPTOC1	I2>M (1)	46M (1)
	MNSPTOC2	I2>M (2)	46M (2)

Таблицата продължава на следващата страница

Функция	IEC 61850	IEC 60617	IEC-ANSI
Loss of load supervision/ Загуба на контрол на товара	LOFLPTUC1	3I< (1)	37 (1)
Motor load jam protection/ Защита на мотора от спиране поради натоварване	JAMPTOC1	Ist> (1)	51LR (1)
Motor start-up supervision/ Контрол на стартиране на двигател	STTPMSU1	Is2t n< (1)	49,66,48,51LR (1)
Phase reversal protection/ Защита срещу обръщане на фаза	PREVPTOC1	I2>> (1)	46R (1)
Thermal overload protection for motors/ Защита на мотор от топлинен свръхтовар	MPTTR1	3Ith>M (1)	49M (1)
Binary signal transfer/ Предаване на двоичен сигнал	BSTGGIO1	BST (1)	BST (1)
Stabilized and instantaneous differential protection for 2W transformers/ Стабилизирана и моментна диференциална	TR2PTDF1	3dI>T (1)	87T (1)
Numerical stabilized low impedance restricted earth-fault protection/ Числено стабилизиран нисък импеданс, ограничен от защитата на заземяването	LREFPNDF1	dIoLo> (1)	87NL (1)
High impedance based restricted earth-fault Protection/ Високо съпротивление базиращо се на	HREFPDIF1	dIoHi> (1)	87NH (1)
Circuit breaker failure protection/ Защита срещу неизправност на автоматичен изключвател	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Three-phase inrush detector/ Трифазен пусков детектор	INRPHAR1	3I2f> (1)	68 (1)
Master trip/ Главен изключвател	TRPPTRC1	Главен изключвател (1)	94/86 (1)
	TRPPTRC2	Главен изключвател (2)	94/86 (2)
	TRPPTRC3	Главен изключвател (3)	94/86 (3)
	TRPPTRC4	Главен изключвател (4)	94/86 (4)
	TRPPTRC5	Главен изключвател (5)	94/86 (5)
Arc protection/ Защита от дъга	ARCSARC1	ARC (1)	50L/50NL
	ARCSARC2	ARC (2)	50L/50NL
	ARCSARC3	ARC (3)	50L/50NL

Таблицата продължава на следващата страница

Функция	IEC 61850	IEC 60617	IEC-ANSI
Multi-purpose protection2)/ Многофункционална защита2)	MAPGAPC1	MAP (1)	MAP (1)
	MAPGAPC2	MAP (2)	MAP (2)
	MAPGAPC3	MAP (3)	MAP (3)
	MAPGAPC4	MAP (4)	MAP (4)
	MAPGAPC5	MAP (5)	MAP (5)
	MAPGAPC6	MAP (6)	MAP (6)
	MAPGAPC7	MAP (7)	MAP (7)
	MAPGAPC8	MAP (8)	MAP (8)
	MAPGAPC9	MAP (9)	MAP (9)
	MAPGAPC10	MAP (10)	MAP (10)
	MAPGAPC11	MAP (11)	MAP (11)
	MAPGAPC12	MAP (12)	MAP (12)
	MAPGAPC13	MAP (13)	MAP (13)
	MAPGAPC14	MAP (14)	MAP (14)
	MAPGAPC15	MAP (15)	MAP (15)
	MAPGAPC16	MAP (16)	MAP (16)
	MAPGAPC17	MAP (17)	MAP (17)
	MAPGAPC18	MAP (18)	MAP (18)
Load shedding and restoration/ Загуба на товар и възстановяване	LSHDPFRQ1	UFLS/R (1)	81LSH (1)
	LSHDPFRQ2	UFLS/R (2)	81LSH (2)
	LSHDPFRQ3	UFLS/R (3)	81LSH (3)
	LSHDPFRQ4	UFLS/R (4)	81LSH (4)
	LSHDPFRQ5	UFLS/R (5)	81LSH (5)
Fault Locator /Средство за локализация на неизправност/	SCEFRFLO1	FLOC (1)	21FL (1)
Three phase overload protection for shunt capacitor banks/ Трифазна защита от претоварване на шунтирани кондензаторни блокове	COLPTOC1	3I> 3I< (1)	51C/37 (1)
Current unbalance protection for SCB/ Токова защита при отсъствие на равновесие за SCB	CUBPTOC1	dI>C (1)	51NC-1 (1)
Three-phase current unbalance protection for Hbridge SCB/ Токова защита при отсъствие на равновесие за H-мост SCB	HCUBPTOC1	3dI>C (1)	51NC-2 (1)
Capacitor bank switching resonance protection, current based/ Кондензаторен блок превключваща защита резонанс на база	SRCPTOC1	TD> (1)	55TD (1)
Line differential protection with in zone power Transformer/ Диференциална защита на линията и зонален силов трансформатор	LNPLDF1	3Id/I> (1)	87L (1)
High impedance fault detection/ Откриване на неизправност висок импеданс	PHIZ1	HIF (1)	HIZ (1)
Power quality/ Качество на електрическата енергия			
Current total demand distortion/ Общо хармонично изкривяване на тока	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion/ Общо хармонично изкривяване на напрежението	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation/ Пад на напрежението	PHQVVR1	PQMU (1)	PQMV (1)
Control/ Управление			
Circuit-breaker control/ Управление на автоматичен изключвател	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)

Таблицата продължава на следващата страница

Функция	IEC 61850	IEC 60617	IEC-ANSI
Disconnector control/ Управление на прекъсвач	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control/Управление на заземяващ превключвател	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector position indication/ Показание на положението разединител	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
Earthing switch indication/ Показание на заземяващ нож	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Emergergency startup/ Аварийн пуск	ESMGAPC1	ESTART (1)	ESTART (1)
Auto-reclosing/ Автоматично повторно включване	DARREC1	O -> I (1)	79 (1)
Tap changer position indication/Положение на превключватели степените на трансформатора	TPOSSLTC1	TPOSM (1)	84M (1)
Tap changer control with voltage regulator/ Управление на превключвателя на степените на трансформатора с регулат на напрежение regulator	OLATCC1	COLTC (1)	90V (1)
Synchronism and energizing check/ Проверка на синфазност възбуждане	SECRSYN1	SYNC (1)	25 (1)
Condition monitoring/ Контрол на състоянието			
Circuit-breaker condition monitoring/ Контрол на състояниет на автоматичен изключвател	SSCBR1	CBCM (1)	CBCM (1)
Trip circuit supervision/ Контрол на верига за аварийно изключване	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision/ Контрол на токова верига	CCRDIF1	MCS 3I (1)	MCS 3I (1)
Fuse failure supervision/Контрол на неизправност предпазител	SEQRFUF1	FUSEF (1)	60 (1)
Protection communication supervision/ Комуникационен контрол на защита	PCSRTPC1	PCS (1)	PCS (1)
Runtime counter for machines and devices/Брояч на машинно време за машини и устройства	MDSOPT1	OPTS (1)	OPTM (1)
Measurement/ Измерване			
Disturbance recorder/ Устройство за регистрация на неизправности	RDRE1	DR (1)	DFR (1)
Load profile record/ Запис на предполагаем почасов профил	LDPMSTA1	LOADPRO	LOADPROF
Three-phase current measurement/Измерване на трифазен ток	CMMXU1	3I (1)	3I (1)
	CMMXU2	3I (2)	3I (2)
Sequence current measurement/ Последователно измерване на тока	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement/ Измерване на остатъчен ток	RESCMMXU1	Io (1)	In (1)
	RESCMMXU2	Io (2)	In (2)
Three-phase voltage measurement/ Измерване на трифазно напрежение	VMMXU1	3U (1)	3V (1)
	VMMXU2	3U (2)	3V (2)
Residual voltage measurement/ Измерване на остатъчното напрежение	RESVMMXU1	Uo (1)	Vn (1)
	RESVMMXU2	Uo (2)	Vn (2)
Sequence voltage measurement/ Последователно измерване на напрежението	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement/ Трифазно захранване и измерване на енергията	PEMMXU1	P, E (1)	P, E (1)

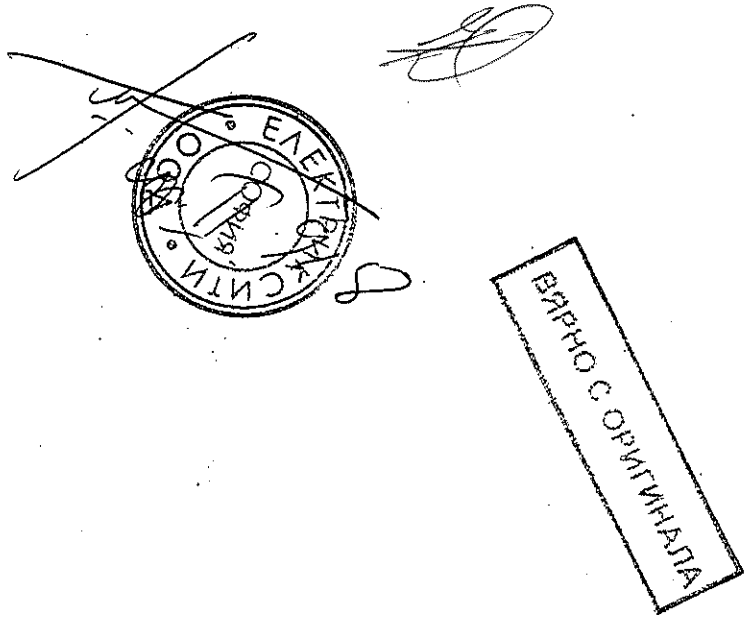
Таблицата продължава на следващата страница

Функция	IEC 61850	IEC 60617	IEC ANSI
RTD/mA measurement/ RTD/mA измерване	XRGGIO130	X130 (RTD) (1)	X130 (RTD) (1)
Frequency measurement/ Измерване на честота	FMMXU1	f (1)	f (1)
IEC 61850-9-2 LE (Voltage sharing)[3]/ IEC 61850-9-2 LE (споделяне/разделяне на напрежение)[3]	SMVSENDER	SMVSENDER	SMVSENDER

1) Едно от следните може да се поръча като опция: достъп базирана E/F, мощност базирана E/F или базирана на хармоници E/F. Опцията с допълнение към съществуващата E/F от оригиналната конфигурация. Допълнителният E/F има и предварително определена конфигурация в IED. Допълнителният E/F може да се настрои на включване или изключване.

2) Например използване за RTD/mA базирана защита или аналогови GOOSE/общи обектно ориентирани събития на подстанция/

3) Само с резервни Ethernet комуникационни модули



Раздел 2 Екологични аспекти

2.1 Устойчиво развитие

Устойчивостта е била взета предвид от началото на проектирането на продукта, включително производствения процес, про-екологичния процес на производство, дългия експлоатационен живот, надеждността на работа и изхвърлянето на IED.

Изборът на материали и доставчици е направен в съответствие с директивата за EC RoHS (2002/95/EC). Тази директива ограничава използването на опасни вещества, които са следните:

Таблица 2: Максимални стойности на концентрация за теглото на хомогенен материал

Вещество	Предложена максимална концентрация
Олово – Pb	0,1%
Живак – Hg	0,1%
Кадмий – Cd	0,01%
Шествалентен хром Cr (VI)	0,1%
Полибромирани бифенили – PBB	0,1%
Полибромирани дифенилни етери – PBDE	0,1%

Оперативната надеждност и дългият живот са сигурни при обширно изпитване по време на процеса на проектиране и производство. Освен това, дългият експлоатационен живот се поддържа от техническо обслужване и ремонт, както и от наличието на резервни части.

Проектиране и изработването са извършени в рамките на сертифицирана система за околната среда. Ефективността на системата за околната среда непрекъснато се оценява от външен орган за одит. Ние систематично следваме екологични правила и норми за оценка на въздействието им върху нашите продукти и процеси.

2.2 Обезвреждане на IED

Определенията и разпоредбите за опасни материали са специфични за всяка държава и се променят с увеличаване на познанието за материалите. Материалите, използвани в този продукт са типични за електрическите и електронни устройства.

Всички части използвани в този продукт могат да се рециклират. Когато изхвърляте IED или нейни части, се свържете с местни манипулатори на отпадъци , които са упълномощени и специализирани в обезвреждането на

електронни отпадъци. Те могат да сортират материала с помощта на специални процеси за сортиране и обезвреждане на продукта в съответствие с изискванията на местното законодателство.

Таблица 3: Материали на IED частите

IED	Части	Материал
Корпус	Метални пластини, части и винтове	Стомана
	Пластмасови части	PC[1], LCP[2]
	Електроника куплунг в модул	различен
Плъгин устройство	Електроника куплунг в модули	различен
	Електроника LHMI модул	различен
	Пластмасови части	PC, PBT[3], LCP, PA[4]
	Метални части	Алуминий
Опаковка	Кутия	Картон
Приложени материали	Ръководства	Хартия

1) Поликарбонат
2) Течен кристален полимер
3) Полибутилен терефталат
4) Полиамид

Раздел 3 Преглед на серия 615

3.1 Преглед

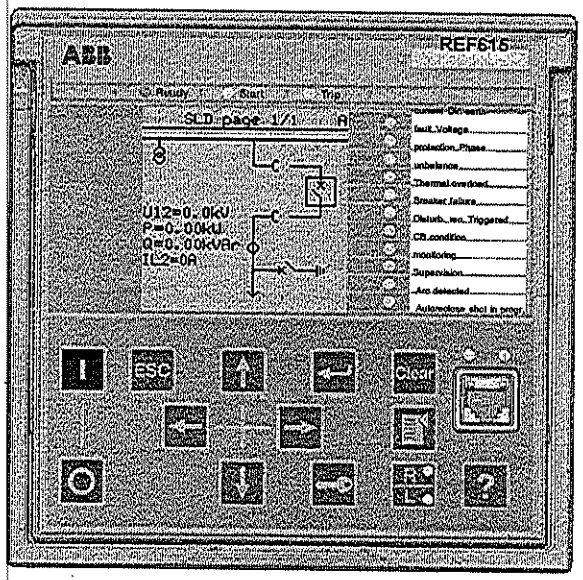
Серия 615 е продукт от семейство IED, предназначен за защита, контрол, измерване и наблюдение на подстанции и промишлени разпределителни уредби и съоръжения. Моделът на IED е в съответствие с IEC 61850 стандарта за комуникация и оперативна съвместимост на средства за автоматизация на подстанция

IED разполагат с разнообразие от методи за монтаж, компактни размери и лекота на използване. В зависимост от продукта възможността за функционалност е достъпна в момента на поръчката за софтуер и хардуер, например автоматично повторно включване и допълнителни I/O.

Серията 615 IED поддържат набор от комуникационни протоколи, включително IEC 61850 с предаване на съобщения на 'Общи обектно-ориентирани събития за подстанция' (GOOSE), IEC 61850-9-2 LE (освен в RED615), IEC 60870-5-103, Modbus® и DNP3. Profibus DPV1 протокол за комуникация се поддържа чрез използване на конвертора на протокола SPA-ZC 302.

3.2 Локален HMI

LHMI се използва за настройка, мониторинг и управление на IED. LHMI включва дисплей, бутони, LED индикатори и комуникационен порт.



Фигура 2: Пример на LHMI

3.2.1 Дисплей

LHMI включва графичен дисплей, който поддържа размерите на символите. Размерът на символите зависи от избрания език. Количеството на символите и редовете зависят от размера на символите.

Таблица 4: Малък дисплей

Размер на символа[1]	Редове в изгледа	Символи на ред
Малки, моно-разпределени (6x12 пиксела)	5	20
Големи, с променлива ширина (13x14 пиксела)	4	8 или повече

1) Зависят от избрания език

Таблица 5: Голям дисплей

Размер на символа[1]	Редове в изгледа	Символи на ред
Малки, моно-разпределени (6x12 пиксела)	1	20
Големи, с променлива ширина (13x14 пиксела)	8	8 или повече

1) Зависят от избрания език