4.11 При товарене/разтоварване на кабелни барабани е необходимо да се използват разтоварни аксесоари (кръстосани уреди) с каишки, предотвратяващи наранявани по ръбовете и обвивката на барабаните, както и валове, да се поставят втулки и кабелни скоби с куки захванати за отворите на осите на барабана (виж фиг. E2 и E3 от Приложение E).

4.12 Забранено е да се разтоварват кабелни барабани чрез хвърляне от коли и други превозни средства.

4.13 Забранено е да се разтоварват кабелни барабани чрез претъркаляне т коли идруги превозни средства, както и тяхното натоварване чрез търкаляне, с изключение на случайте в които дъното на каросерията на превозното средство (или дъното на жп платформата, и т.н.) е на едно ниво с пода на площадката, на която се разтоварват кабелните барабани или от която се товарят кабелните барабани).

4.14 При търкаляне на кабелните барабани е необходимо да се спазват указанията за търкаляне описани от стрелката на страната на барабана. Забранено е търкалянето на барабани със стърчащи краища на кабели. Кабелните краища трябва да бъдат закрепени за вътрешността на барабана, за означителните срес кабели, е разрешено да се извади края на кабела от барабана и да се закрепи за ръба на барабана.

4.15 Кабелните барабани трябва да се разтоварват на плоска твърда площадка, без вещества които могат да наранят обвивката на барабана или кабела.

4.16 При разтоварване на открито върху почви, е необходимо да се прецени потенциалната повреда на барабанната обвивка и на кабела, поради разместването на почвата под тежестта на барабана. Големи барабани могат да бъдат разтоварвани и съхранявани след това на посилени бетонни плочи, разположени върху земята, на асфалтови или метални платформи.

4.17 При всички случай на товарене/разтоварване и съхпанение е необходимо да се пземат превантивни мерки за само търкаляне на барабаните.

4.18 При товарене и ръзтоварване на барабаните посредством вилков електрокар, вилката трябва да бъде подравнена с барабана, където всички краища на барабана да бъдат поставени на вилката (виж Приложение F, което съдържа предупредителни знаци за товарене и разтоварване на кабелни барабани).

4.19 Кабелните аксесоари трябва да бъдат превозвани в покрити превозни средства.

Ако е необходимо, типа на превозното средство може да бъде указан в техническата документация на производителя.

4.20 Преди транспортирането кабелните аксесоари трябва да бъдат безопасно закрепени в превозното предство.

4.21 Забранява се разтоварването на кабелни аксесоари чрез хвъляне от превозното средство.

4.22 Кабелните аксесоари трябва да бъдат съхранявани в оригиналната опаковка на производителя.

4.23 При съхранението, пакетираните кабелни аксесоари могат да бъдат съхранявани на няколко слоя. Броят на разрешените слоеве, трябва да съответства на спецификацията маркирана върху опаковката на кабелните аксесоари, или се определя от доставчика на кабелните аксесоари.

4.24 Кабелните аксесоари трябва да бъдат съхранявани в покрити помещения извън достъп на неоторизирани лица.

4.25 При съхранението кабелните аксесоари трябва да бъдат защитени от механицни въздействия, изпарение на киселини, алкали и други агресивни вещества, които могат да повредят опаковката и кабелните аксесоари, както и от слънчеви лъчи, валежи и прах.

4.26 При съхранението е необходимо да се спазва окомплектоваността на кабелните аксесоари. Забранено е изваждането на компоненти от кабелните аксесоари без пререгистрация на кабелните аксесоари в отчетната складова документация.

5. Работна процедура при откриване на дефекти в кабелите в барабана, кабелните аксесоари, повреди по обвивкат ана барабана или опаковката на кабелните аксесоари

5.1 Всички открити дефекти по кабели, барабани, обвивки на барабани, дефекти в кабелните аксесоари или повреди в опаковката на кабелните ексесоари трябва незабавно да бъдат сведени до знанието на „Естралин ПС" ЛЛК.

5.2 Повредите трябва да бъдат проверени от комисия в присъствието на оторизирани представители на „Естралин ПС" ЛЛК.

5.3 В случай на повреда на кабелния барабан, доклада за повредата включва: номер на поръчка, наименование на кабелната линия, за която е предназначен кабела, класа на кабела, заводски номер на кабелния барабан, дата на производство, заводска дължина, кабелна дължина на барабана, място и вид на повредата, дата и място на съставяне на протокола, фамилия и длъжност на подписалите лица, с посочване на организацията или предприятието.

5.4 При откриване на дефекти в кабелни аксесоари или повреди в опаковките на кабелните аксесоари, доклада трябва да съдържа: номер на поръчка, наименование на кабелната линия или подстанцията, за която са предназначени кабелните аксесоари, класа на кабела, за който са предназначени кабелните аксесоари, производителя на кабелните аксесоари, кратко описание на откритите дефекти или повреда, дата и място на съставяне на протокола, фамилия и длъжност на подписалите лица, с посочване на организацията или предприятието.

5.5 Снимки на дефектите също трябва да бъдат прикрепени към доклада.

5.6 Едно копие от отчета трябва да бъде изпратено до „Естралин ПС" ЛЛК.

5.7 В случай на значителни кабелни повреди, е необходимо да бъдат проверени не само кабелната обвивка, но и структурните елементи под обвивката със задължителното присъствие на представител на „Естралин ПС" ЛЛК. Необходимостта и процедурата за такава проверка се определя от комисия за проверка на повредата на площадката в присъствието на представител на „Естралин ПС" ЛЛК.

5.8 В определени случаи, при съмнения относно качеството на частите и елементите на кабелните аксесоари, тези части и аксесоари могат да бъдат върнати на „Естралин ПС" ЛЛК за качествена експертиза с привличане на специалисти на производителя на кабелните аксесоари. Заключения по казуси за дефекти и годността за монтаж се се изготвят на база на резултатите от проверката.

6. Приложения

Приложение A. Размери и Тегло на дървени кабелни барабани
Приложение B. Размери и тегло на метални кабелни барабани
Приложение C. Списък на вещества възздействащи на PE кабелни обвивки
Приложение D. Закрепване на кабелни барабани за Ниско-рамкови платформи
Приложение E. Транспортиране, Товарене и Разтоварване на кабелни барабани
Приложение F. Предупредителни знаци с изисквания за товарене и разтоварване на кабелни барабани.

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Приложение А.
Размери и Тегло на дървени кабелни барабани

(чертеж, не се чете)

Таблица А1. Размери на страните илентите на дървените опаковки на барабаните

№ на барабана	Страна, mm		Дебелина и ширина на стоманената лента, mm
	Дебелина на страната S_1, mm	Ширина на страната, не повече от, mm	
5-8	16	150	0,3-0,5 x 20-35
10-14	19	200	0,3-0,5 x 20-35
16-18	25	280	0,3-0,5 x 25-35
20-22	32	250	0,3-0,5 x 35-45
25-30	40	250	0,3-0,5 x 45-55

Приложение А. (продлжение)

ВЯРНО С ОРИГИНАЛА

Таблица 2. Размери на Дървен барабан (всички размери са в mm)

№ барабан	Диаметър		Дължина на Барел L	Дебелина:		Вътрешен диаметър		Размер A	Дължина оп.	Дължина щифт L1
	Ръб D	Барел D1		S	S2	Осов d	Водещ d_1			

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5	500	200	230	38	16	35	35	60	300	350
6	600	200	250	38	19	35	35	60	326	370
8	800	450	230	38	19	50	50	150	306	530
8а	800	450	400	38	19	50	50	150	476	520
8б	800	450	500	38	19	50	50	150	576	620
10	1000	545	500	50	22	50	50	150	600	630
10а	1000	500	710	50	22	50	50	150	810	864
12	1220	650	500	50	22	70	50	250	800	850
12а	1220	650	710	50	22	70	50	250	810	864
12б	1220	600	600	50	22	90	50	250	700	746
14	1400	750	710	58	28	70	50	250	836	875
14а	1400	900	500	58	22	70	50	250	616	665
14б	1400	1000	600	58	28	90	50	250	716	770
14в	1400	750	710	70	28	90	50	250	850	900
14г	1400	750	900	58	28	70	50	250	1016	1065
16	1600	1200	600	58	30	70	50	300	816	770
16а	1600	800	800	58	30	80	50	300	916	970
17	1700	900	750	70	28	80	50	300	886	936
17а	1700	900	900	70	28	80	50	300	1036	1086
18	1800	1120	900	80	36	80	50	300	1060	1120
18а	1800	900	900	80	36	80	50	300	1060	1120
18б	1800	750	1000	80	36	80	50	300	1101	1160
18в	1800	900	750	80	30	80	50	300	886	950
20	2000	1220	1000	90	36	80	50	300	1380	1450
20а	2000	1000	1060	90	36	80	50	400	1240	1305
20б	2000	1300	1000	90	36	80	50	400	1350	1420
22	2200	1320	1000	115	46	100	50	400	1360	1433
22а	2200	1080	1050	118	36	100	50	400	1386	1448
22б	2200	1080	1200	118	46	100	50	400	1516	1578
22в	2200	1320	1300	118	46	100	50	400	1516	1578
25	2500	1500	1300	130	56	120	50	400	1610	1678
25а	2500	1500	1500	130	56	120	50	400	1810	1878
30	3000	1800	1800	180	56	150	50	400	2160	2230
36	3600	2500	700	96	56	150	50	400	1803	1862

Заб. Има и други поръчкови размери на дървени барабани (група размери 32 и по-големи).

ВЯРНО С ОРИГИНАЛА

Приложение В. Размери и тегло на метални кабелни барабани

(чертеж, не се чете)

Таблица В1. Размери и тегло на метални барабани

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Тип барабан	Обем, m3	Тегло, вкл. Тегло на оп., kg	Диаметър, вкл. Оп. mm	Диаметър на ръба, mm	Диаметър на барела,mm	Обща ширина, mm	Централен диаметър,mm
SI-28	20.6	1500	2900	2300	2000	2400	450
SI-30	24.8	1700	3130	3000	2000	2400	450
SI-33	26.8	2200	3130	3000	2000	2400	450
SI-34	28.9	2600	3530	3400	2000	2400	450
SI-35	30.9	2700	3630	3500	2000	2400	450
SI-36	33.4	3800	3730	3600	2000	2400	450
SI-37	35.5	3900	3830	3700	2000	2400	450
SI-38	36	3900	3930	3800	2000	2400	450
SI-39	38.6	4000	4030	3900	2000	2400	450
SI-41	40	3500	4130	4000	2000	2400	450
SI-43	42.1	5000	4430	4300	2000	2400	450

Заб. Съществуват и барабани с по-големи външни диаметри.

Приложение С.
Списък на вещества въздействащи на PE кабелни обвивки

Списъкът съдържа данни за устойчивостта (задоволителна, ограничена или незадоволителна) на материала на кабелната обвивка (PE с висока плътност) на въздействието на различни съставки, в отсъствието на външен механичен натиск и при температури от 20°C и 60°C.

1. Материалът на кабелната обвивка има **незадоволителна устойчивост при температури от 20°C и 60°C** на въздействието на следните съставки:

bromine (liquid or gas), iodine in alcoholic solution and potassium salt, fluorine (gas), halogen derivatives, methyl bromide, bromoform, Diesel fuel, chloronitrobenzene, dichloropropylene, methylcyclohexane, propylene dichloride, tetrachloroethylene, trichlorobenzene, trichloroethylene, nitromethane, benzene chloride, chloroform, chlorosulfuric acid, thionyl chloride, ethyl chloride, ethylene chloride, methyl chloride, methylene chloride;
aromatic hydrocarbons;
dopentene, tetradecane, tetrahydrofuran, sulfur trioxide, diethyl ether, dopentene, iso-pentane, isopropylamine, Isopropanol, amine, ethyl mercaptanne, nitrobenzene, nitrotoluene, N-pentane, oleum, pentane-2, furfurol, cyclohexane, O-Xylene, P-Xylene, ethyl benzene, nitric acid (95% and higher), nitrohydrochloric acid (HCl : HNO3 = 3:1), crude oil (boiling), kerosene, turpentine (gum).

2. Материалът на кабелната обвивка има ограничена устойчивост при температура от 20°C и незадоволителна устойчивост при температура от 60°C на въздействието на следните съставки: ethyl acrylate, decane, dibutyl, amine, carbon disulfide, carbon tetrachloride, xylene, ligroin, Lysol,

methylcyclohexane, N-heptane, ozone, styrene, titanium tetrachloride, tetrachloromethane, boron trifluoride, ioluene, brake fluid, chlorine (наситен разтвор на вода или газ), allyl chloride.

3. Материалът на кабелната обвивка има задоволителна устойчивост при температура 20° С и незадоволителна устойчивост при темпелатура 60°С на въздействието на субстанции: isopropyl, ether, nitroethane, octyl alcohol, olive oil, hydrogen dioxide (90%), sulfuric acid (from 50% to 98%), trichloric acetic (50%), ethyl acetate.
4. Материалът на кабелната обвивка има ограничена устойчивост при температура 20°С и 60°С на въздействието на следните съставки: acetone, banana oil, benzol, diacetone, diethyl, ketone, hexachlorophene, camphor oil, caleium sulfide.
5. Материабът на кабелната обвивка има задоволителна устойчивост при температура 20°С и ограничена устойчивост при температура 60°С на въздействието на следните съставки: diesel fuel, oil products, carriage grease, solid oil, aniline, hexane, benzaldehyde, benzolchloride, isooctane, sulfine acid (70%), acctic acid (над 96%), butyric acid, chromic acid, perchloric acid (50%), furfurol alcohol, ethyl acohol, hydrogen dioxide и някои други съставки.

Заб.: Материалът на кабелната обвивка има **задоволителна устойчивост при температура 20°С и 60°С** на въздействието на моторни масла (автомобилни моторни масла и др.), битум, рициново масло, сънчогледово масло, царевично и памуково масло, минерално масло, силиконови смазки.

Списъкът е изготвен на база данните, предоставени от фирма Borealis, източник – ISO TR 7472, 7474 Карловиц, конституцдобелле 3, Австия.

Приложение D. Закрепване на кабелни барабани за Ниско-рамкови платформи

(снимка, не се чете)

Фиг. D1. Закрепване на кабелен барабан за платформа с вериги преминаващи през осите

(снимка, не се чете)

Фиг. D2. Закрепване на кабел за платформа от дървена решетка и укрепления за предотвратяване на търкаляне

Приложение Е. Транспортиране, Товарене и Разтоварване на кабелни барабани

(снимка, не се чете)

Фиг. Е1. Транспортиране на кабелен барабан, закрепен за метална укрепваща конструкция осите

Фиг. Е1. Транспортиране на кабелен барабан, закрепен за метална укрепваща конструкция осите

(снимка, не се чете)

Фиг. Е2. Разтоварване на кабелен барабан, закрепен на метална укрепваща конструкция

Приложение Е (продължение)

(снимка, не се чете)

Фиг. E3 Товарене и разтоварване на кабален барабан посредством кръстосано рамо с ремъци и кабелни скоби

Приложение F. Предупредителни знаци с изисквания за товарене и разтоварване на кабелни барабани.

(снимка, не се чете)

ВЯРНО С ОРИГИНАЛА

ЕЛЕКТРИЦИТИ СОФИЯ ООД

Сд. П 322

ESTRALIN PS

APPROVED BY

General Director

Estralin PS" LLC

P.S. Velkhev

2015

ETI-15-06

Transport and Storage of
HD 500 kV XLPE cables and cable accessories

Approved on 06.10.2015

	Full name	Signature	Date
DEVELOPED BY	Leading Constructor		
	Engineer	Cardo A.V.	
	Technical Director	Moulin A.S.	
	Deputy of Technical Manager		
	Head of Project	Murcia A.V.	
AGREED BY			

ЕЛЕКТРИКА СОФИЯ 323

1 Scope

1.1 This manual is intended for transportation, loading, unloading and storage of drums with 110 - 500 kV power cables with XLPE insulation (hereinafter – cable) and cable accessories for these cables supplied by "Estralin PS" LLC.

1.2 Cable accessories include: joints, outdoor terminations, GIS compact sealing end, transformers compact sealing end, cross-bonding link boxes, earthing link boxes, and other equipment which are installed on cables and accessories and their components.

1.3 The requirements of this manual should be taken into account at work performance planning and also should be used by carriers and customers during transportation and storage of drums with cables and cable accessories.

2 References

During the loading/unloading works and cables transportation one should observe the safety regulations according to local regulatory documents:

Safety regulations in construction;

Safety regulations in work with power-driven tools and accessories;

Fire protection regulations in power plants;

Safety regulations at construction and installation works;

Regulations on labor protection during loading and unloading and positioning of loads;

Regulations on labor protection during operation of industrial vehicles

3 General

3.1 Main structural elements and the weight of drums for cables are given in Appendices A and B. The size and weight of wooden drums are given in Appendix A. The size and weight of metal drums are given in Appendix B and may also have other parameters. Packaging dimensions are determined by the supplier after obtaining data on the construction lengths from the customer.

3.2 Transportation and storage of drums with power cable should be performed according to local standards.

3.3 Conditions of transportation and storage of cable drums in terms of the climatic factors of the environmental impact should meet the following requirements: the open areas in the macroclimatic areas with temperate and cold climate in the atmosphere of [illegible]-type, at temperatures from - 50°C to + 50°C except for cables with polymer materials that do not contain halogens. Provider determines the storage conditions for such cables based on the official data from the manufacturer.

3.4 Conditions of storage of cable drums in terms of the climatic factors of the environment impact should also meet the following requirements: sheds and premises, where air temperature and humidity fluctuations differ insignificantly from outdoor fluctuations (for example, tents, metal storages without thermal insulation) located in macroclimatic areas with temperate and cold climates, at the air temperature from - 50°C to + 50°C.

- for cable drums stored in conditions which set out in [illegible] the storage period comprises 2 years;
- for cable drums stored in conditions which set out in [illegible] storage period comprises 5 years.

Upon the parties' agreement, the storage period can be extended after inspection of the cable drums by the supplier's representative and his/her conclusion on the condition of the drums and the cable on the drums.

3.5 Conditions of transportation of cable accessories in terms of the climatic factors of the environment impact should meet the requirements as per cl. 3.4.

3.6 Conditions of storage of cable accessories in terms of the climatic factors of the environment impact should meet the following requirements: heated and ventilated warehouses, storages located in any microclimatic areas.

Air temperature at storage - from +5°C to +40°C.
Relative air humidity at storage:
- average annual value of 60 % at + 20°C;
- upper value of 80% at + 25°C.

The above upper value of the relative humidity is also normative at lower temperatures; at higher temperatures the relative humidity is lower. Values of 90% at + 20°C or 50-60% at +40°C correspond to the set upper value of 80% at + 25°C.

3.7 The storage period of cable accessories, their components and materials should meet the requirements set by the manufacturer of cable accessories.

3.8 There can be other conditions of storage and transportation of cables and cable accessories set out in the manufacturers' regulatory technical documentation, on which the Customer shall be notified. The Supplier shall request for an official confirmation of conditions of storage of cable and cable accessories from the manufacturer. These conditions of storage and transportation of cables and cable accessories set by the manufacturer shall be obligatorily met, otherwise, the manufacturer's warranty obligations can be withdrawn.

3.9 At transportation and storage cable drums and accessories shall not be exposed to the impact of vapors of acids, alkalis and other aggressive media, which affect drums, cable and accessories. The list of substances affecting PE cable sheath is set out in Appendix C.

3.10 At transportation, unloading, loading and storage of drums and cable accessories on the territories of substations and functioning power plants it is necessary to comply with the regulations on labor protection (safety precautions) at operation of power plants.

3.11 Works with application of hoisting machines and mechanisms shall be performed in accordance with the requirements and regulations on labor protection at handling operations and positioning of loads and interindustry regulations on labor protection at operation of industrial enterprises.

3.12 At transportation and storage cable ends shall be sealed.

3.13 At transportation, handling operations and storage it is necessary to ensure integrity of bagging of cable drums and boxes with cable accessories, as well as integrity of labels on the drums, boxes and accompanying documentation attached to the drum or the box.

3.14 It is prohibited to load, unload, transport and store cable drums with defective bagging and cable accessories with damaged package.

3.15 Before and after transportation cable drums and boxes with cable accessories shall be inspected with the participation of the carrier's representative to determine integrity of the drum, cable sheath, as well as contents of the cable accessories package. The operating procedure at detection of damages is set out in section 5 hereof.

4 Loading, Unloading and Transportation of Cable Drums and Accessories

4.1 Cable drums and accessories can be transported by all means of transport in accordance with cargo carriage regulations and current technical and interindustry regulations applicable for each means of transport.

4.2 Loose ends of cable drums must not be left unsecured.

4.3 At transportation cable drums must be fastened. At fastening of drums it is prohibited to pierce sidings of drum flanges and lagging with nails and clamps.

An example of cable drum fastening on a low-frame platform is shown in Appendix D.

Picture D1 in Appendix D shows that for drum fastening on the platform chains fastened by hooks to clamps with apertures on the metal platform pass through the aperture in the drum axis and pull the drum to the platform. For tensioning chains are fitted with stretchers.

Picture D2 in Appendix D shows that to prevent rolling down of the drum wooden bars with knees for leaning of the drum flanges are fastened across the wooden floor of the platform.

4.4 For transportation of cable drums it is permitted to use special cages in the vehicle's cargo compartment (in the carbody, trailer, railway platform, barge, etc.).

4.5 For transportation of heavy cable drums it is permitted to use special metal supporting structures for fastening of cable drums. It is permitted to unload cable drums from the vehicle together with the supporting structures. An example of transportation and unloading of the cable drum fastened on the metal supporting structure is shown in Appendix E, pictures E1 and E2.

4.6 At fastening of drums by any of the above means the cable drum shall not touch the floor (platform) to prevent cable damage.

4.7 At transportation cable drums shall be arranged in one layer.

4.8 At placement of two or more drums on a vehicle each drum shall be fastened separately from each other to prevent damage of drums at dynamic loads occurred during transportation (for example, during speedup, braking or dusting).

4.9 The speed of transportation of cable drums shall ensure preservation of drums in case of hard braking.

4.10 Heavy and off-size cable drums shall be transported in accordance with local regulations on highway carriage of heavy and off-size cargos by motor vehicles.

At transportation of drums with large external diameters traffic limitations shall be considered. Depending on local regulations and conditions permits issued by traffic regulation authorities and special trailers with a low draft can be required.

4.11 At loading/unloading of cable drums it is necessary to apply handling accessories (cross arms) with straps excluding damage of drum flanges and lagging, as well as spindles, insert bushings and cable jaws with hooks inserted in the aperture on the drum axis (see pictures F2 and F3 in Appendix F).

4.12 It is prohibited to unload cable drums by throwing off from cars and other vehicles.

4.13 It is prohibited to unload cable drums by rolling down from cars and other vehicles, as well as to load them by rolling up, except for cases when the bottom of the carbody (or the bottom of the railway platform, etc.) is at one level with the [illegible] of the site on which cable drums are unloaded (or from which cable drums are loaded).

4.14 At rolling of cable drums it is necessary to [illegible] the direction of rotation marked by an arrow on the drum flange. Rolling of drums with protruding cable ends is prohibited. Cable ends shall be fastened to the interior of the drum; for mean sizes cables it is allowed to bring out the cable end to the drum flange.

4.15 Cable drums shall be unloaded on a flat solid site without objects, which can damage the drum lagging and the cable.

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4.16 When unloading outdoors on soil it is necessary to consider potential damage of the drum lagging and the cable due to soil settlement under the drum load. Large drums can be unloaded and further stored on reinforced concrete slabs placed on the soil, on asphalted or metal platforms.

4.17 In all cases of unloading/loading and storage it is necessary to provide for measures on prevention of self-existing rolling of drums.

4.18 At loading and unloading of drums by means of a forklift loader, the fork shall be aligned with the drum, wherein all the drum flanges shall be placed on the fork (see Appendix F, which contains warning signs on loading and unloading of cable drums).

4.19 Cable accessories shall be transported in covered vehicles.

If necessary, the vehicle type can be set in the manufacturer's regulatory technical documentation.

4.20 Before transportation cable accessories shall be safely fastened in the vehicle.

4.21 It is prohibited to unload cable accessories by throwing off from the vehicle.

4.22 Cable accessories shall be stored in the manufacturer's original package.

4.23 At storage packed cable accessories can be arranged in several layers. The number of permitted layers shall comply with the specification marked on the cable accessories package; otherwise, it is determined by the supplier of cable accessories.

4.24 Cable accessories shall be stored in covered premises beyond the reach of unauthorized persons.

4.25 During storage cable accessories shall be protected from mechanical impact, vapors of acids, alkalis and other aggressive media, which affect package and cable accessories themselves, as well as from sun rays, precipitations and dust.

4.26 During storage it is necessary to observe completeness of cable accessories. It is prohibited to seize components from cable accessories without re-registration of cable accessories in the accounting storage documentation.

5 Operating Procedure at Detection of Defects in the Cable on the Drum, Cable Accessories, Damage of Drum Lagging or Cable Accessories Package

5.1 All detected damages of cable drum, drum lagging, defects in cable accessories and damage of cable accessories package shall be immediately notified to "Estralin PS" LLC.

5.2 Damages shall be inspected by a commission in the presence of an authorized representative of "Estralin PS" LLC.

5.3 In case of a cable drum damage, the damage report shall contain: order number, name of the cable line for which the cable is meant, cable grade, factory number of the cable drum, date of manufacture, factory length, cable length on the drum, location and nature of damage, date and place of drawing up the protocol, last names and positions of signatories with specification of represented organizations or enterprises.

5.4 Upon detection of defects in cable accessories or damage of cable accessories package the specification shall contain: number, name of the cable line or substation, for which the cable accessories are meant, grade of the cable, for which the cable accessories are meant, manufacturer of the cable accessories, brief description of the detected defects or damage of package, date and place of drawing up the protocol, last names and positions of signatories with specification of represented organizations or enterprises.

5.5 [illegible] shall be sent to "Estralin PS" LLC.

5.6 One copy of the report shall be submitted to "Estralin PS" LLC.

5.7 In case of considerable cable damages it is necessary to inspect not only cable sheath but also structural elements under the sheath with obligatory participation of "Estralin PS" LLC's representative. The necessity and procedure of such inspection shall be determined by the commission on inspection of the damage site with the participation of "Estralin PS" LLC's representative.

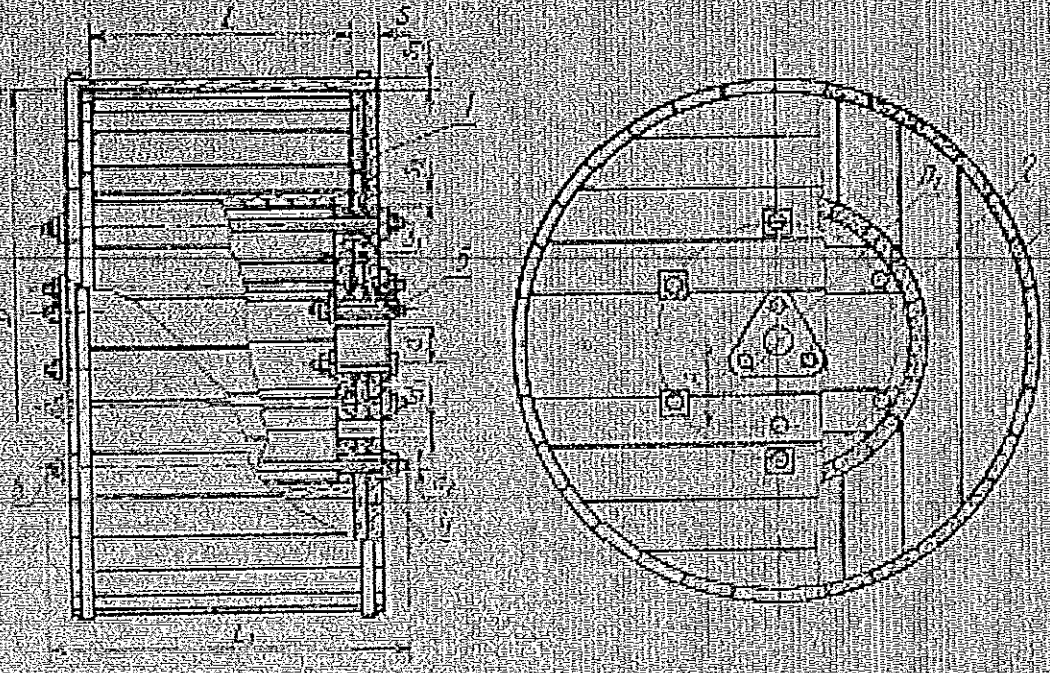
5.8 In particular cases, in case of doubts about the quality of parts and units of cable accessories, these parts and units can be returned to "Estralin PS" LLC for quality expertise with attraction of specialists from the manufacturer of cable accessories. A conclusion on causes of the defects and suitability for mounting shall be drawn up based on the examination results.

6 Appendices

Appendix A: Dimensions and Weight of Wooden Cable Drums
Appendix B: Dimensions and Weight of Metal Cable Drums
Appendix C: List of Substances Affecting PE Cable Sheath
Appendix D: Fastening of a Cable Drum on a Low-Frame Platform
Appendix E: Transportation, Loading and Unloading of Cable Drums
Appendix F: Warning Signs with Requirements to Loading and Unloading of Cable Drums

Appendix A

Dimensions and Weight of Wooden Cable Drums



Flange, 2-barrel, 3-lagging, 4- barrel ring, 5-central bore, 6-pin

Table A1. Dimensions of Sidings and Tapes for Wooden Drum Lagging

Drum number	Siding, mm		Thickness and width of the steel tape, mm
	Thickness of siding S_1, mm	Width of siding, no more than, mm	
5-8S_1	16	150	0.3-0.5 x 20-35
10-14S_1	19	200	0.3-0.5 x 20-35
16-18S_1	25	250	0.3-0.5 x 25-35
20-22S_1	32	250	0.3-0.5 x 35-45
25-30S_1	40	250	0.3-0.5 x 45-55

Appendix A (continued)

Table A2. Dimensions of Wooden Drums (all dimensions in mm)

Drum number	Diameter: flange D	Diameter: barrel D1	Barrel length L	Thickness: flange S	Thickness: barrel S2	Inside diameter: axial d	Inside diameter: driving d1	Dimension A	Lagging length	Pin length L1
5	500	200	230	38	16	35	35	60	306	350
6	600	200	250	38	19	35	35	60	326	370
8	800	450	250	38	19	50	50	150	306	350
8a	800	450	400	38	19	50	50	150	476	520
8b	800	450	500	38	19	50	50	150	576	620
10	1000	545	500	50	22	50	50	150	600	646
10a	1000	500	710	50	22	50	50	150	810	864
12	1220	650	500	50	22	70	50	250	600	650
12a	1220	650	710	50	22	70	50	250	810	864
12b	1220	600	600	50	22	70	50	250	708	746
14	1400	750	710	58	28	70	50	250	826	875
14a	1400	900	500	58	22	70	50	250	616	665
14b	1400	1000	600	58	28	70	50	260	716	770
14v	1400	750	710	70	28	70	50	250	850	904
14g	1400	750	900	58	28	70	50	250	1016	1065
16	1600	1200	600	58	30	70	50	300	716	770
16a	1600	800	800	58	30	80	50	300	916	970
17	1700	900	750	70	28	80	50	300	890	944
17a	1700	900	900	70	28	80	50	300	1040	1094
18	1800	1120	900	80	36	80	50	300	1060	1120
18a	1800	900	900	80	36	80	50	300	1060	1122
18b	1800	750	1000	80	36	80	50	300	1160	1222
18v	1800	900	710	80	30	80	50	300	822	950
20	2000	1220	1000	90	36	80	60	400	1180	1250
20a	2000	1600	1060	90	36	80	50	400	1240	1302
20b	2000	1500	1000	90	36	80	50	400	1180	1242
22	2200	1320	1000	118	46	100	50	400	1236	1298
22a	2200	1480	1050	118	46	100	50	400	1286	1348
22b	2200	1680	1100	118	50	100	50	400	1316	1398
22v	2200	1520	1100	118	46	100	50	400	[illegible]	1398
25	2500	1500	1300	150	50	120	50	400	1500	1630
26	2600	1500	1500	150	56	120	50	400	1780	1850
30	3000	1800	1800	150	50	150	50	400	2160	2250
30a	3000	2500	1700	96	46	150	50	400	1892	1962

Note: there are other customized dimensions of wooden drums [illegible] and higher)

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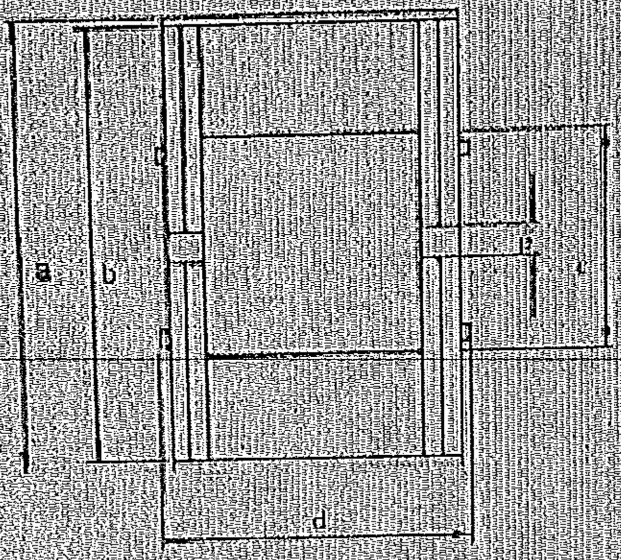
Appendix B

Dimensions and Weight of Metal Cable Drums



a) diameter, including lagging;
b) flange diameter;
c) barrel diameter;
d) total width;
e) central bore diameter.

Table B1. Dimensions and Weight of Metal Drums

Drum type	Volume, m³	Weight, including weight of lagging, kg	Diameter, including lagging, mm	Flange diameter, mm	Barrel diameter, mm	Total width, mm	Central bore diameter, mm
St 28	20.6	1500	2930	2800	2000	2400	150
St 30	23.8	1700	3130	3000	2000	2400	150
St 32	26.6	2200	3330	3200	2000	2400	150
St 34	28.[illegible]	2600	3530	3400	2000	2400	150
St 35	3[illegible]	2700	3630	3500	2000	2400	150
St 36	33.4	2800	3730	3600	2000	2400	150
St 37	35.[illegible]	3000	3830	3700	2000	2400	150
St 38	37	3100	3930	3800	2000	2400	[illegible]
St 39	3[illegible]	3300	4130	3900	2000	2400	150
St 40	40.8	3500	4130	4000	2000	2400	150
St [illegible]	47.0	[illegible]	[illegible]	[illegible]	2000	2400	150

Note: [illegible]

Appendix C

List of Substances Affecting PE Cable Sheath

The list contains data on stability (satisfactory, limited or unsatisfactory) of the material of cable sheath (high density PE) to the impact of different substances in the absence of internal pressure and external mechanic tension and at the temperatures of 20^{0}C and 60^{0}C.

1. The material of cable sheath has an **unsatisfactory stability at the temperatures of 20^{0}C and 60^{0}C** to the impact of the following substances:

- bromine (liquid or gas), iodine in alcoholic solution and potassium salt, fluorine (gas);
- halogen derivatives: methyl bromide, bromoform, Dutch liquid, dichlorobenzene, dichloropropylene, methylcyclohexane, propylene dichloride, tetrachloroethylene, trichlorobenzene, trichloroethylene, tribromomethane, benzene chloride, chloroform, chlorosulfonic acid, thionyl chloride, ethyl chloride, ethylene chloride, methyl chloride, methylene chloride;
- aromatic hydrocarbons;
- dipentene, tetradecane, tetrahydrofuran, sulfur trioxide, diethyl ether, dipentene, iso-pentane, isopropylamine, isopropanol amine, ethyl mercaptan, nitrobenzene, nitrotoluene, N-pentane, oleum, pentane-2, furfural, cyclohexane, O-Xylene, P-Xylene, ethyl benzene;
- nitric acid (95% and higher), nitrohydrochloric acid (HCl / HNO_3 = 3:1), sulfuric acid (boiling);
- kerosene, turpentine (gum).

2. The material of cable sheath has a limited stability at the temperature of 20°C and unsatisfactory stability at the temperature of 60°C to the impact of the following substances: ethyl acrylate, decane, dibutyl amine, carbon disulfide, carbon tetrachloride, xylene, ligroin, lysol, methylcyclohexane, N-heptane, ozone, styrene, titanium tetrachloride, tetrachloroethane, boron trifluoride, toluene, brake fluid, chlorine (saturated water solution or gas), allyl chloride.

3. The material of cable sheath has a satisfactory stability at the temperature of 20^{0}C and unsatisfactory stability at the temperature of 60^{0}C to the impact of the following substances: isopropyl ether, nitroethane, octyl alcohol, olive oil, hydrogen dioxide (90%), sulfuric acid (from 50% to 98%), perchloric acid (70%), ethyl acetate.

4. The material of cable sheath has a limited stability at the temperatures of 20°C and 60°C to the impact of the following substances: acetone, banana oil, benzol, benzene, diacetone alcohol, diethyl ketone, hexachlorophene, camphor oil, calcium sulfide.

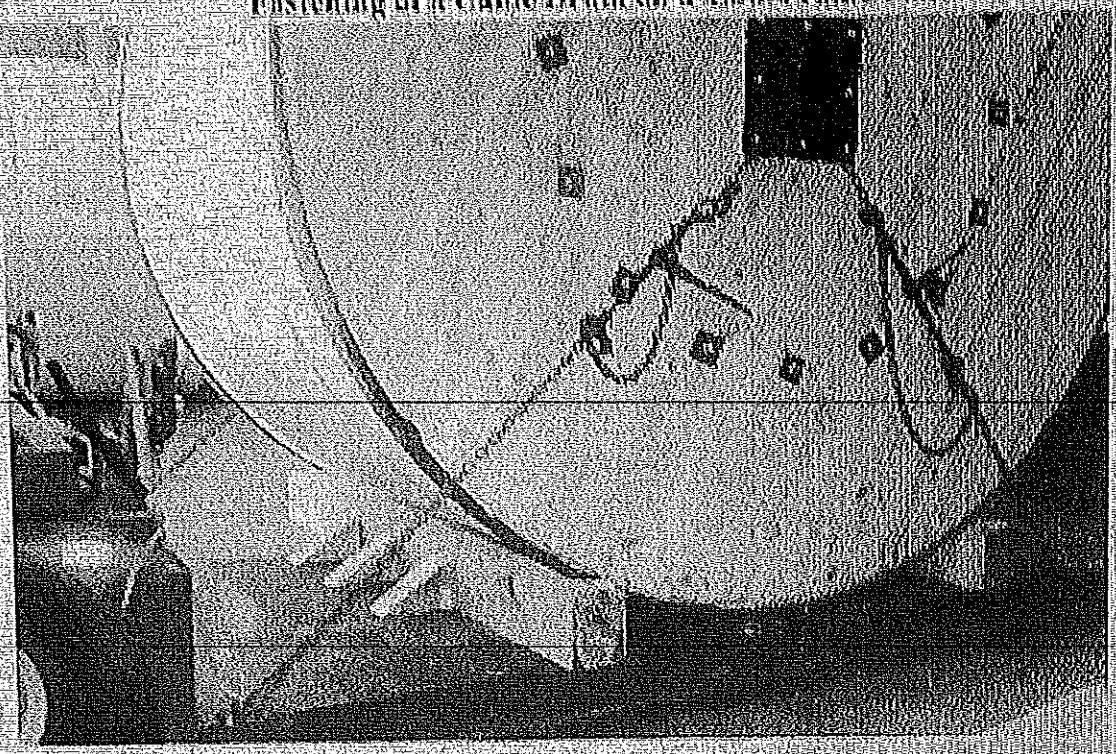
5. The material of cable sheath has a satisfactory stability at the temperature of 20^{0}C and a limited stability at the temperature of 60^{0}C to the impact of the following substances: diesel fuel, oil products, [illegible] grease, [illegible] oil, aniline, hexane, benzaldehyde, benzalchloride, isooctane, sulfuric acid ([illegible]%), acetic acid (over 70%), butyric acid, chromic acid, perchloric acid (50%), furfuryl alcohol, [illegible] alcohol, hydrogen dioxide and some other substances.

Note: The material of cable sheath has a satisfactory stability at the temperatures 20^{0}C and 60^{0}C at the [illegible] lubricating oils, [illegible] castor oil, [illegible] oil, sunflower, corn and [illegible] oils, [illegible] silicone grease.

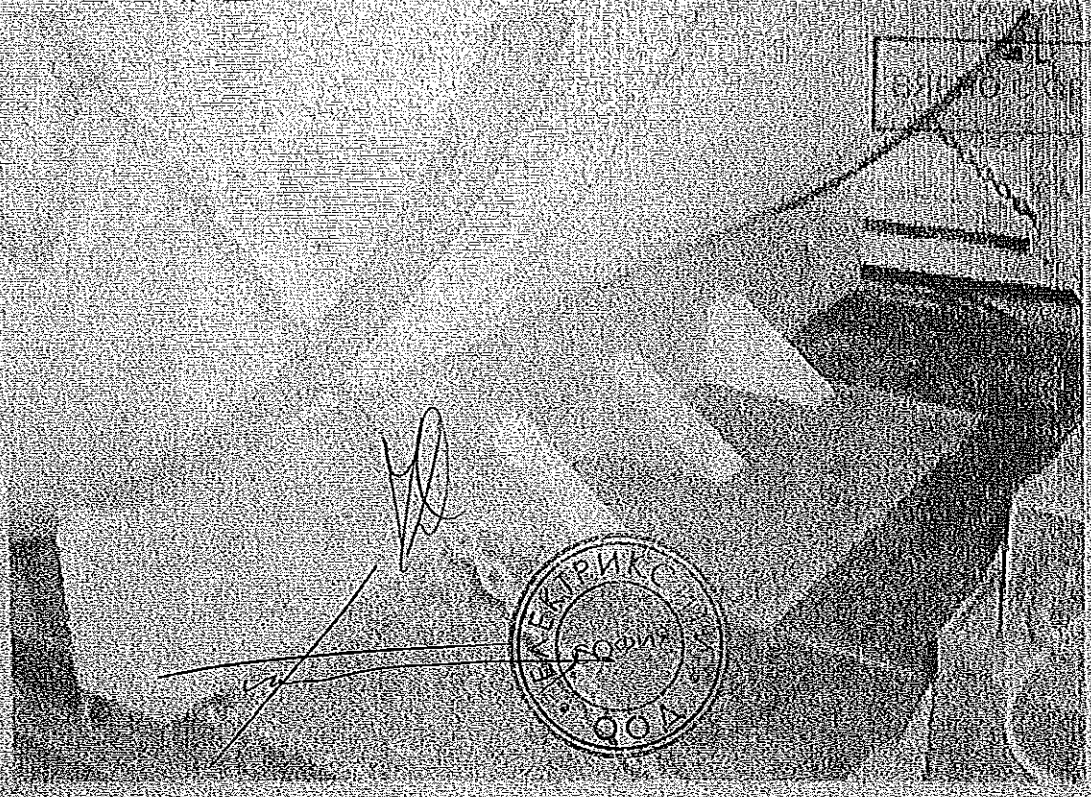
[illegible]

Appendix D

Fastening of a Cable Drum on a Low-Frame Platform



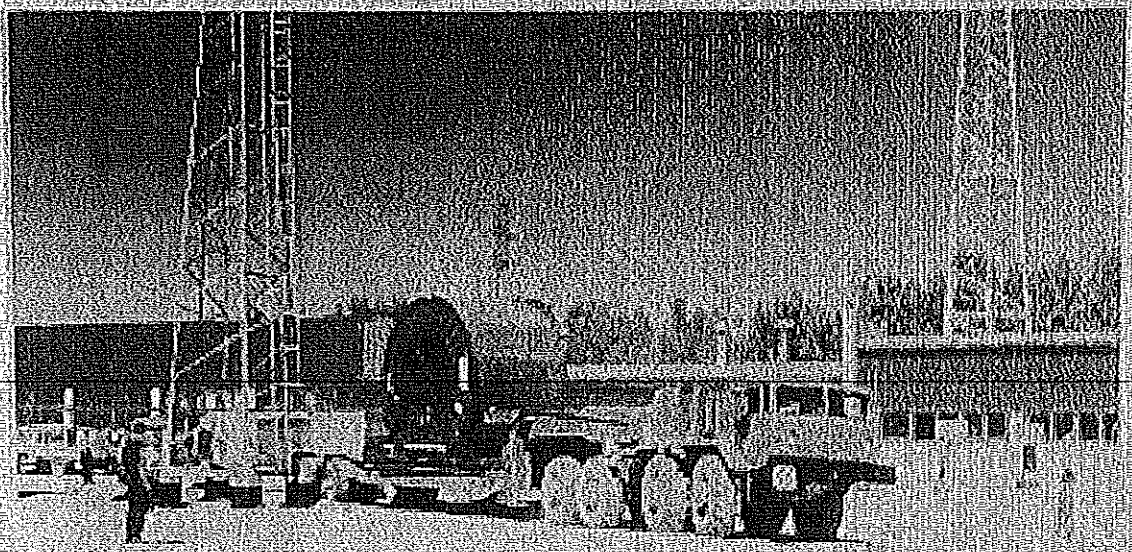
Pic. D1. Fastening of a cable drum to the platform with chains passing through the axis



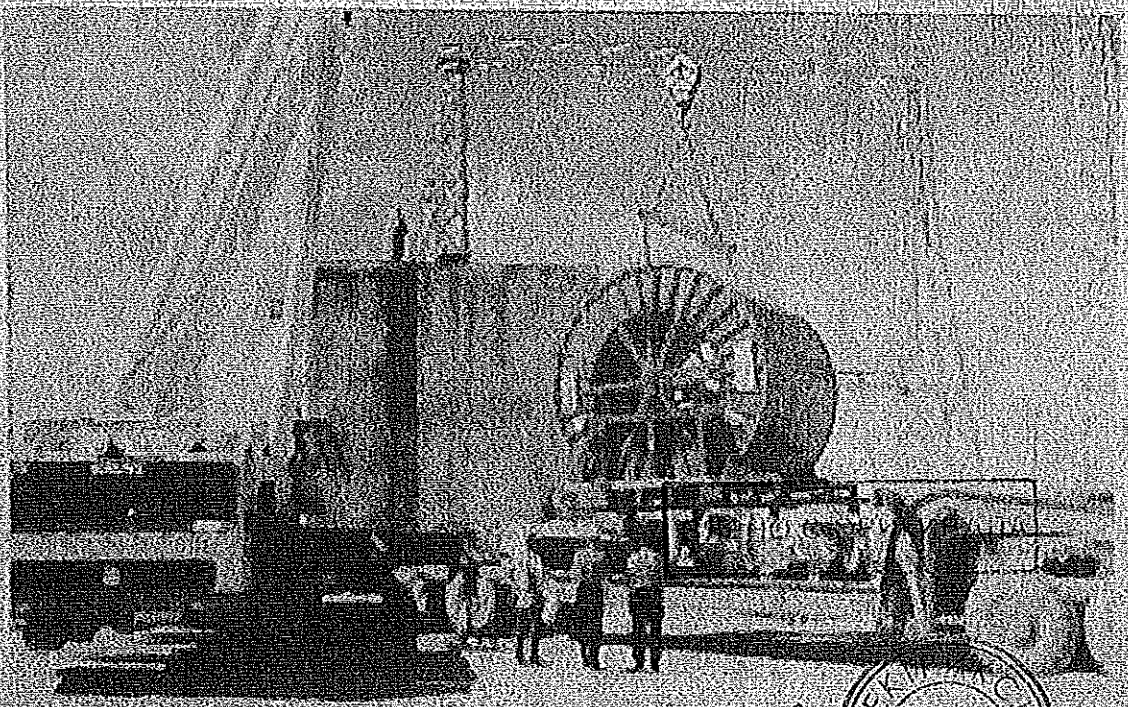
Pic. D2. Fastening of cable on the platform with wooden bars and supports to prevent rolling down

Appendix E

Transportation, Loading and Unloading of Cable Drums



Pic. E1: Transportation of a cable drum fastened on a metal support structure



Pic. E2: Unloading of a cable drum by means of a mobile crane

Appendix E (continued)

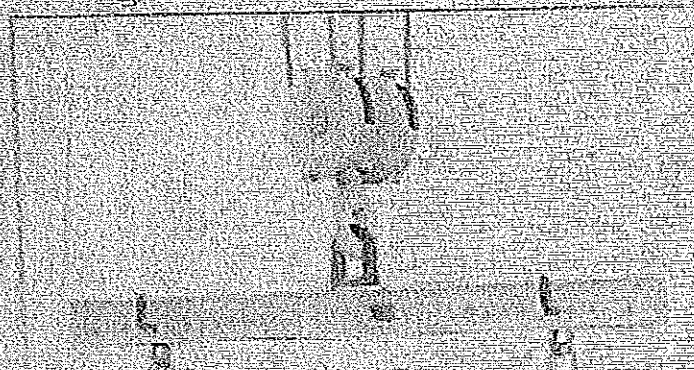


Fig. 11 Loading and unloading of a cable drum by means of a crane arm with straps and cable [illegible]

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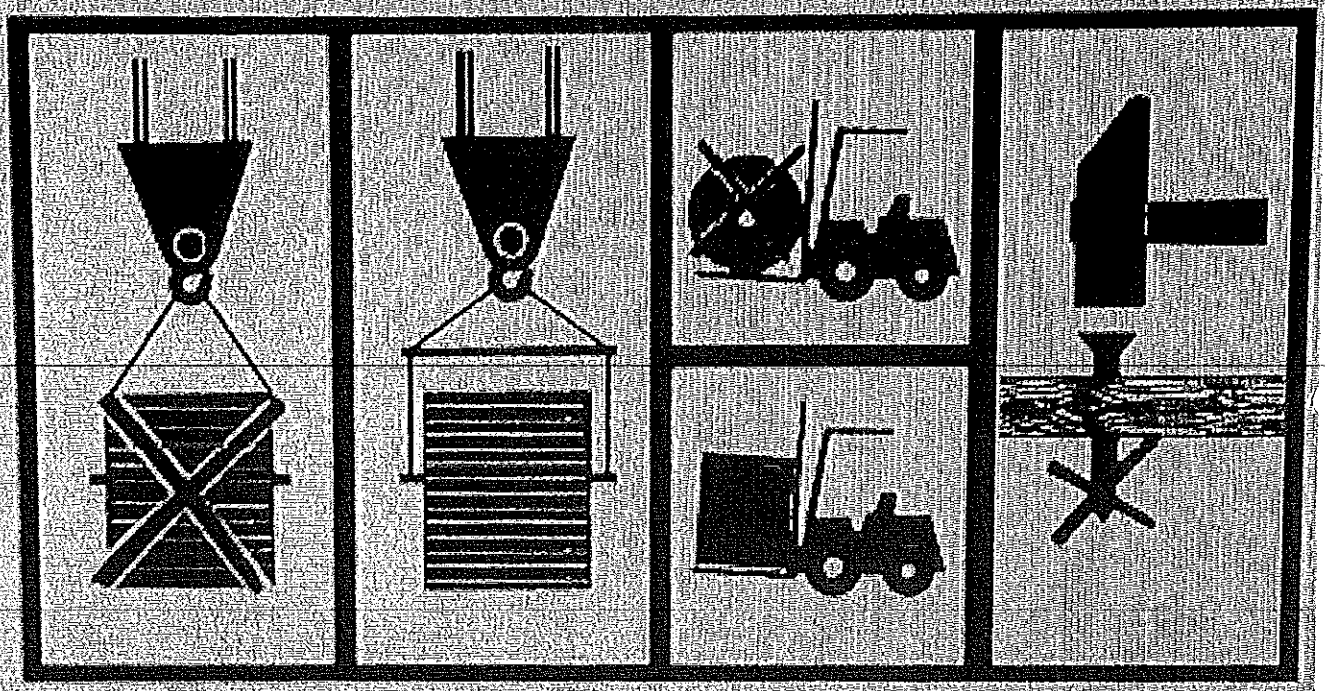
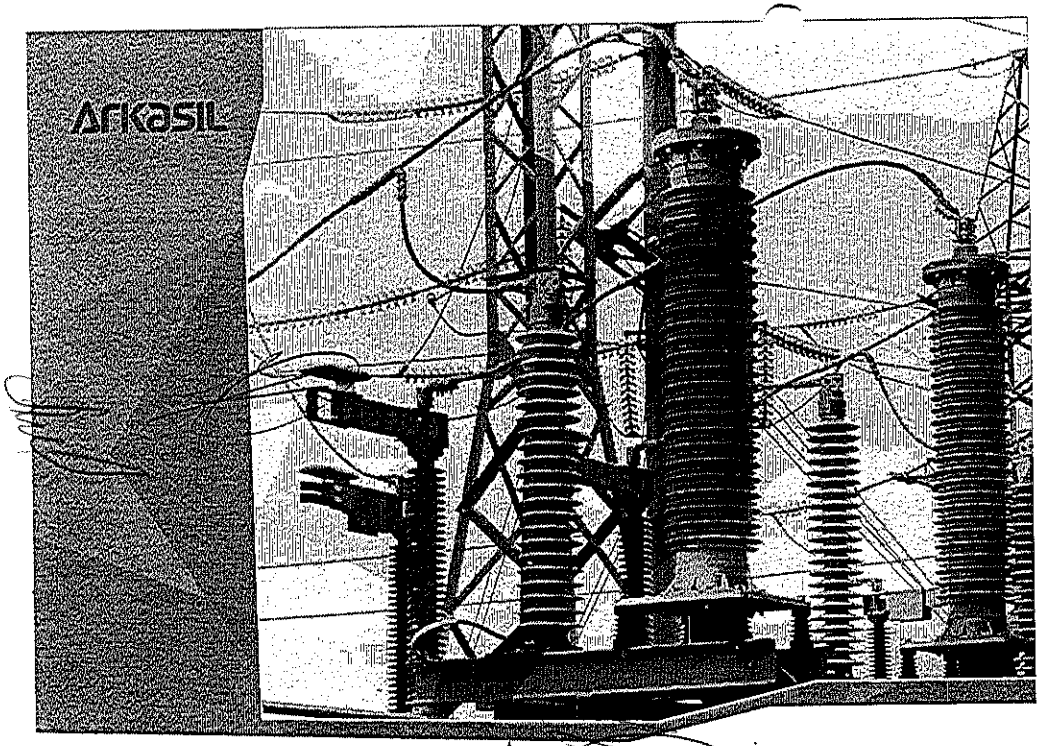
СД 3335

Appendix F

Warning Signs with Requirements to Loading and Unloading of Cable Drums



Arkasil

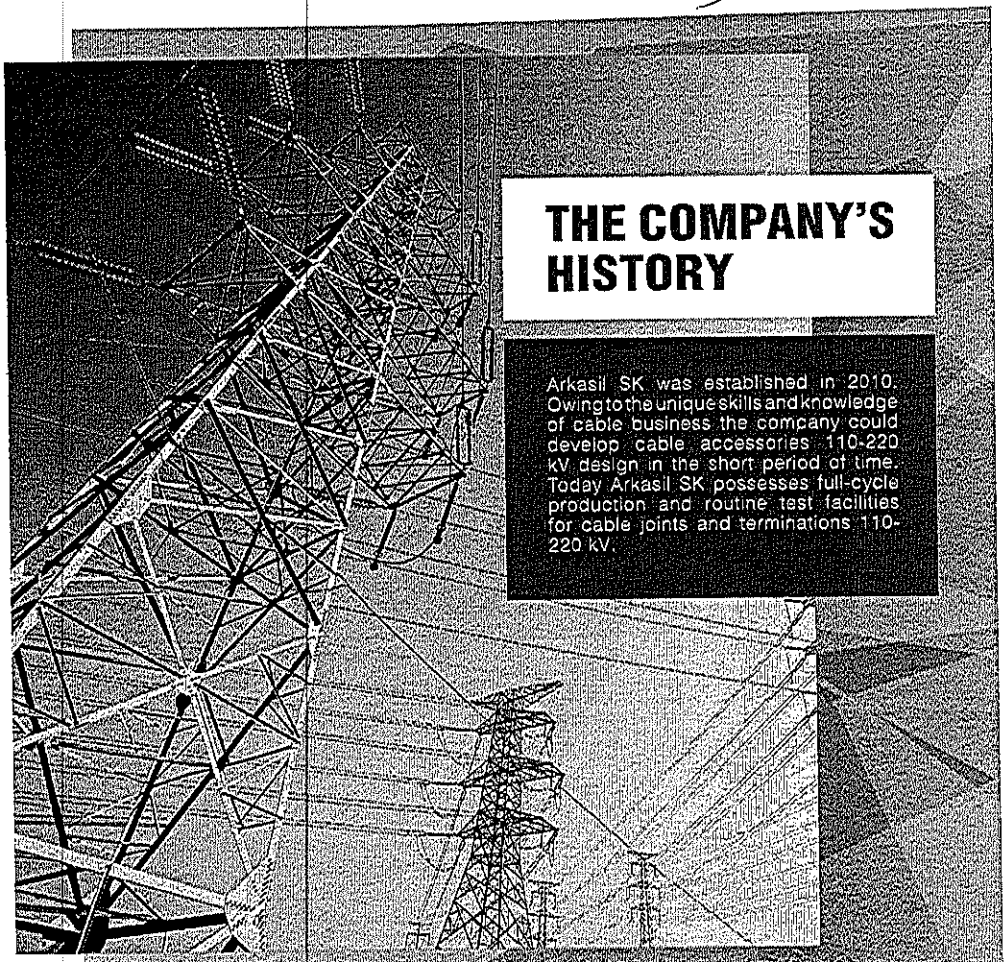


CABLE ACCESSORIES

110-220 kV

www.arkasil.com

Arkasil



THE COMPANY'S HISTORY

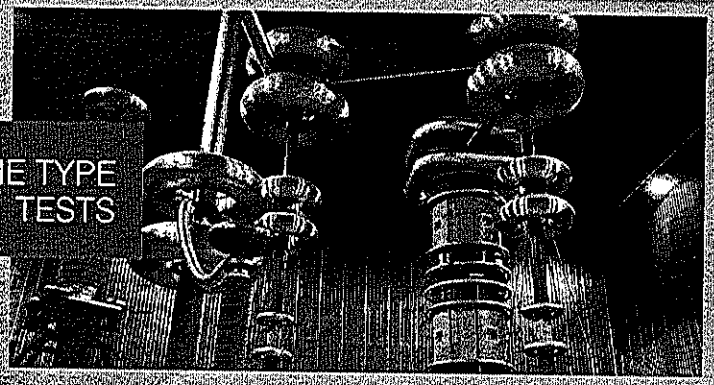
Arkasil SK was established in 2010. Owing to the unique skills and knowledge of cable business the company could develop cable accessories 110-220 kV design in the short period of time. Today Arkasil SK possesses full-cycle production and routine test facilities for cable joints and terminations 110-220 kV.

THE MAIN INFORMATION

Long terms of cable accessories delivery very often could be a big problem for cable lines establishing. That is why there is a great demand of cable accessories for HV cables in the market, with high quality and minimum terms of delivery for the reasonable price. Arkasil SK sets the goal to hold a strong position in the cable business.

The main activity of Arkasil is HV accessories 110-220 kV production and delivery and also related products such as tools, heat shrinkable components and other products for cable line construction.

ARKASIL

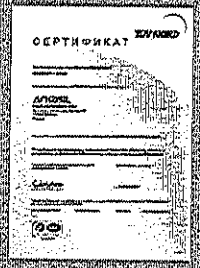


THE TYPE TESTS

At the beginning of 2011 the type tests of the cable accessories 110 (126) kV were successfully carried out together with CESI (the leader among the tests and certificates). Another type tests of cable accessories of Arkasil SK were carried out in 2011. Tests were made according to the program of the harmonized European standard HD 632 S2, part 1, analogue of IEC 60840 edition 3 (2004), in the test laboratory of KEMA (Netherlands). Also the company has KEMA type tests report for 132 (145) kV in 2013. In 2013 type tests of the cable accessories 220 (252) kV of Arkasil production were successfully passed under CESI supervision. In 2014 the company started type tests of GIS termination 220 (252) kV.

THE LONG-TERM TESTS

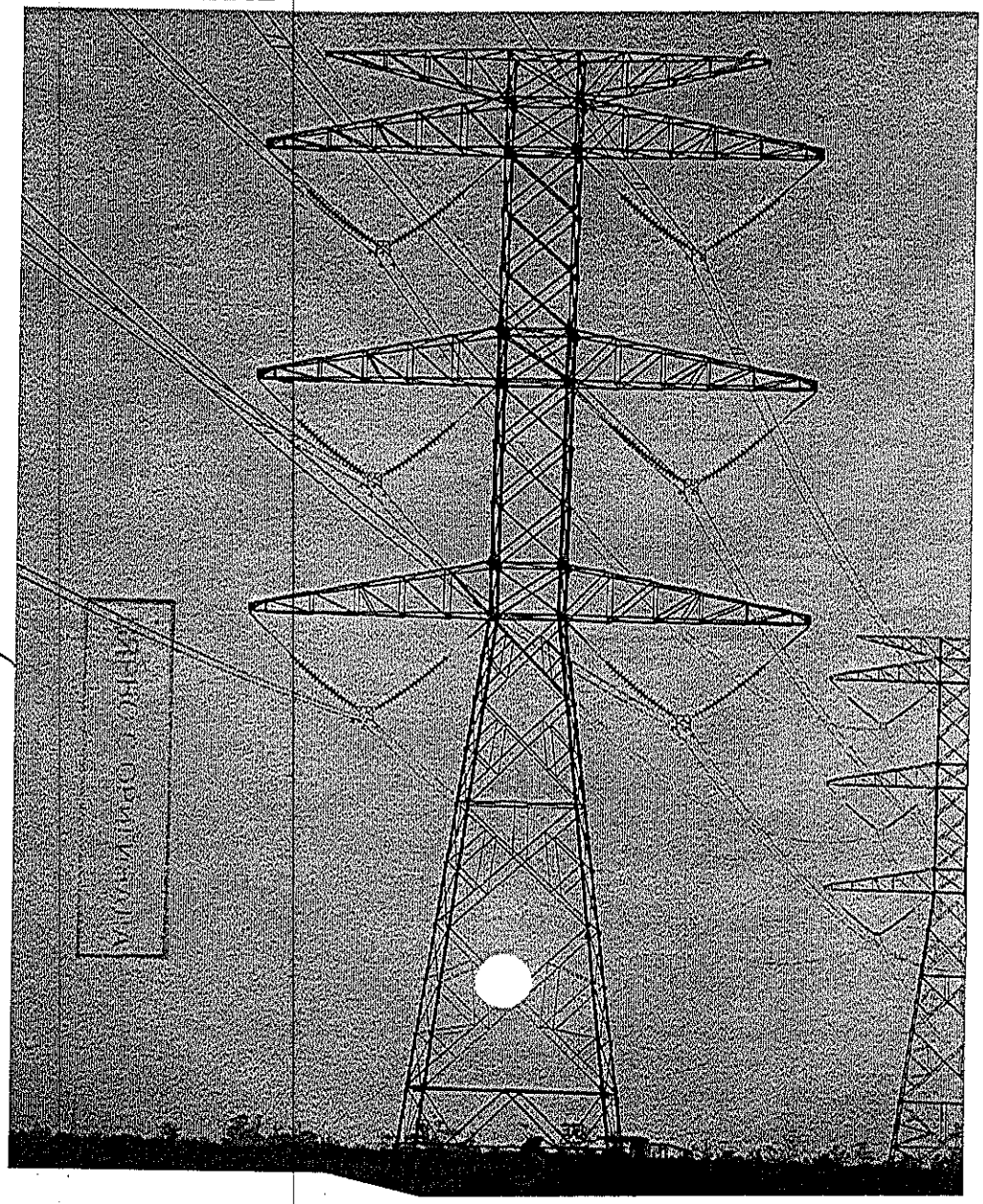
In 2013 the company started long-term tests of the cable system 220 kV, including a cable 2500 mm² and cable accessories 220 kV of Arkasil.



ISO 9001:2008

"Arkasil - SK" LLC's applies a management system in line with ISO 9001 – 2008 standard for XLPE cable accessories 110-220 kV: design, production, training, installation and supervision.

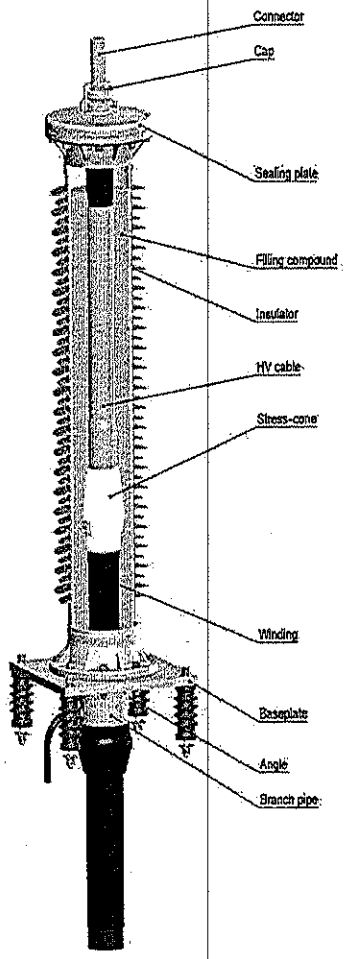
ARKASIL



Arkasil

LIST OF CONTENT

110 kV (126 kV)
Terminations MKB 126



Arkasil termination with composite type insulator is used for cable line connection to other elements of power-supply systems. Termination MKB 126 is used for outdoor and indoor installation, for XLPE cables 64/110 kV with the conductor cross-section up to 2000 mm².

Basic components

Insulator:
- composite type insulator with glass fiber reinforced epoxy resin tube and silicone rubber sheds;
- sheds color–light gray;
- top and bottom flanges glued and sealed to the composite insulator.

Cable end:
- pre-moulded and factory-tested silicone stress cone;
- cable end;
- base plate;
- branch pipe with flange;
- support insulators;
- seals and fixing materials;
- unpressurised synthetic oil as an insulating compound;
- optic fiber outlet.

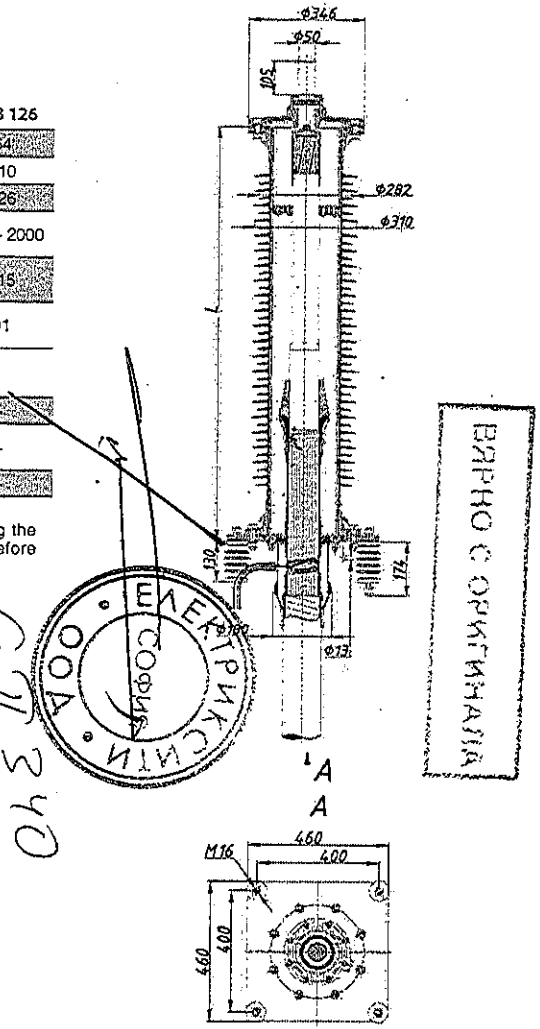
Area of application

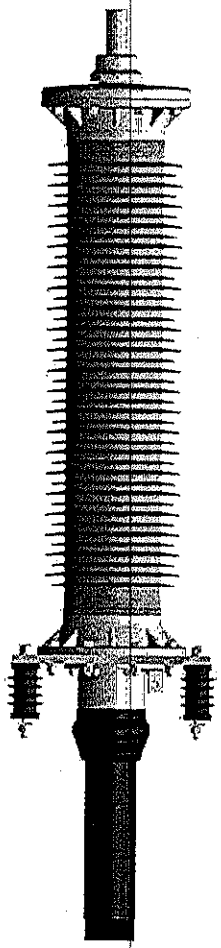
Type		MKB 126
Phase voltage	kV	64
Line voltage	kV	110
Maximum system voltage	kV	126
Cable conductor cross section range	mm²	185 ÷ 2000
Maximum cable sheath diameter	mm	115
Maximum cable insulation diameter	mm	91

Installation options:

On support	+
On high-voltage power transmission line	+
On support at an angle	+

Installation can be simplified by assembling the termination horizontally on the ground before lifting it into place.





Technical data

Electrical parameters:

AC voltage withstand test	160 kV for 30 min
Partial discharges	<5 pC at 96 kV
Impulse voltage (10+/10- impulses)	550 kV

Climatic characteristics:

Temperature	-50°C / +45°C

Nominal operating current:

limited by cable specification

Stress-cone routine tests for MKB 126:

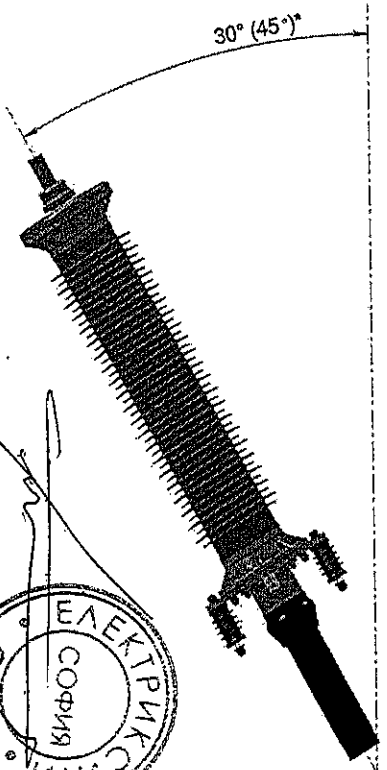
AC voltage withstand test	160 kV for 30 min
Partial discharges	<5pC at 96 kV

Support insulator withstand voltage:

AC voltage	10 kV
DC voltage	20 kV

Type		MKB 126		
Cable conductor cross section range	mm²	185-2000		
Maximum allowed inclination angle		30°(45°)*		
Termination length, L	mm	1540	1863	1875
Creepage distance length	mm	3670	4300	4820
Poilution level in accordance with IEC 60137		III	IV	IV
Volume compound	l	28	32	38
Weight	kg	104	108	78
Maximum allowed force on top connector	kN	3,5	3,5	3,5

Maximum allowed inclination angle up to 45° is only offer approval.

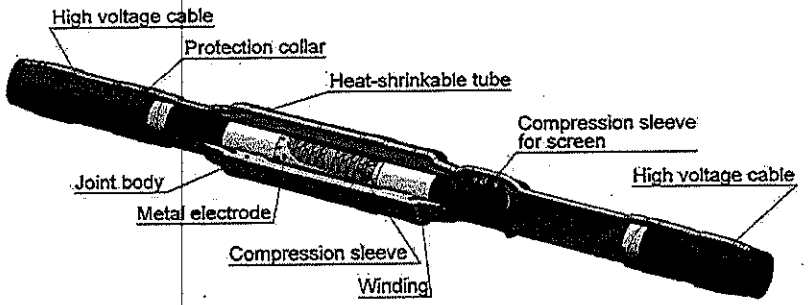


110 kV (126 kV)
Joints MCB 126

Arkasil joint is designed to connect two extruded high-voltage cables XLPE 64/110 kV. Joint MCB 126 could be produced in different designs; with screen wires direct connection, cross-bonding connection of different cable phase wires screen (screen cross-bonding), wires screen connection with optical fibers in the metal tubes.

Main components:

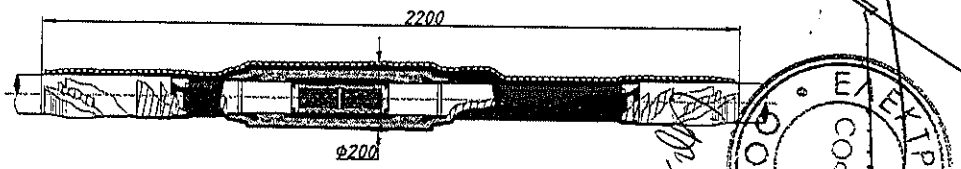
- pressed or screwed connection sleeves for cooper or aluminum conductors;
- insulator (silicone pre-molded joint body with elements for electrical field stress control);
- special tapes for different purposes;
- protective covering by shrinkable tubes and sleeves;
- cooper case protection;
- coffin box protection.



Area of application

Type		MCB 126
Phase voltage	kV	64
Line voltage	kV	110
Maximum system voltage	kV	126
Cable conductor cross section range	mm²	185 ÷ 2000
Maximum cable sheath diameter	mm	115
Maximum cable insulation diameter	mm	91
Nominal minimum insulation thickness	mm	10.5

Installation	
In the ground	+
On the air	+
Outdoor and indoor	+



Technical data

Electrical parameters:

AC voltage withstand test	160 kV for 30 min
Partial discharges	<5 pC at 96 kV
Impulse voltage (1.2+/50- impulses)	550 kV

Current load rating:

Rated operational current	limited by cable specification
Short circuit current:	limited by cable specification

Climatic characteristics:

Temperature	-50°C/+45°C

Stress-cone routine tests:

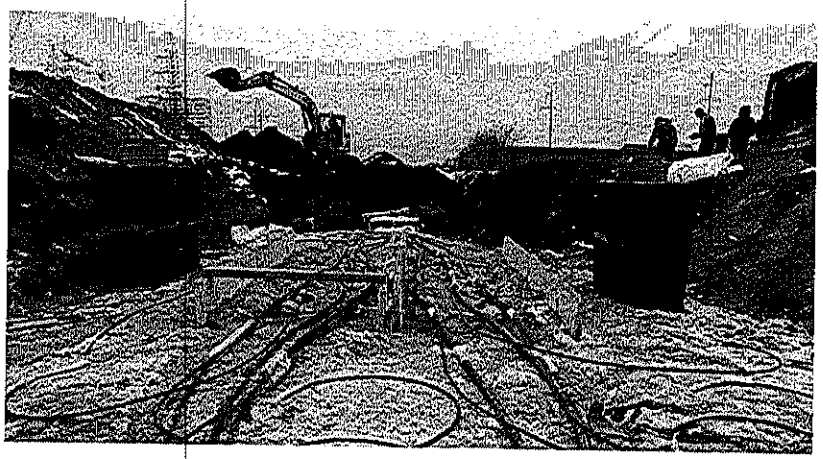
AC voltage withstand test	160 kV for 30 min
Partial discharges	<5pC at 96 kV

Cable sheath test voltage:

AC voltage	10 kV within 1 min
DC voltage	20 kV within 1 min

Mechanical characteristics:

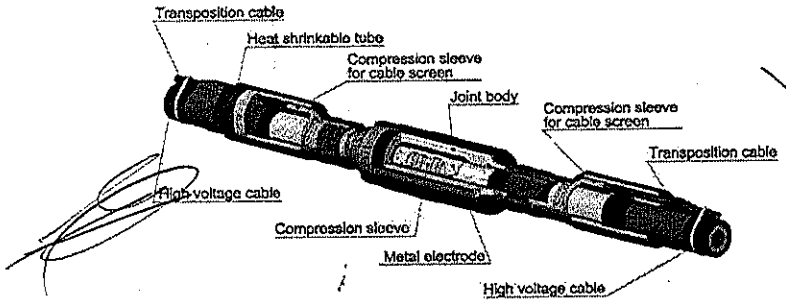
Approximate weight, kg	35

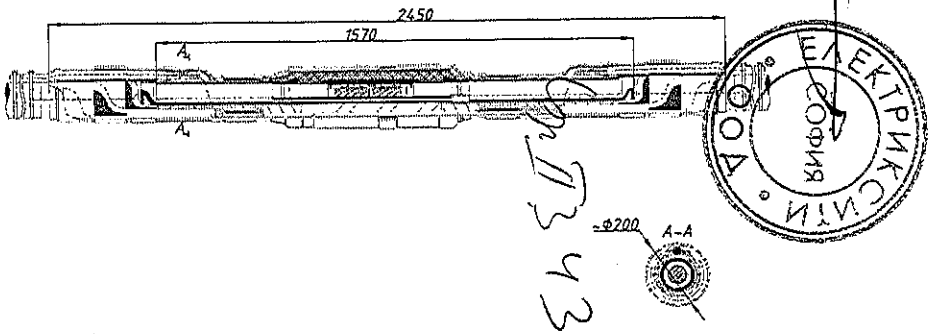


110 kV (126 kV)

Cross-bonding joints MCB 126 X

The cross-bonding joint MCB 126 X is designed to connect two extruded high-voltage cables XLPE 64/110 kV with cross connection of wire screens. Screen outlet from both sides is provided by cross-bonding cable. There is the dielectric insertion in the joint for screen interruption.



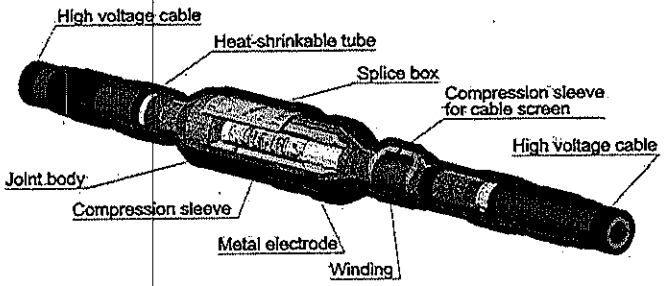


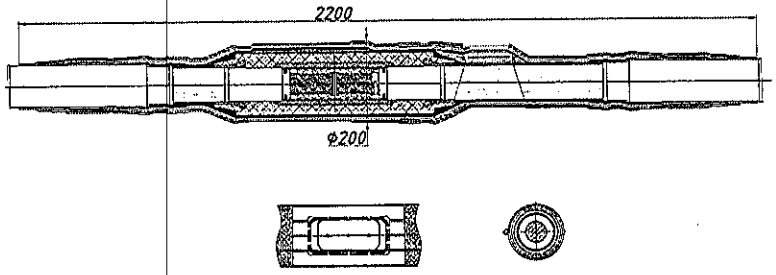
110 kV (126 kV)

Joints with optic fiber connection MCB 126 O

The joint with opric fiber connection MCB 126 O is designed to connect two extruded high-voltage cables XLPE 64/110 kV with connection of wire screens including optical module.

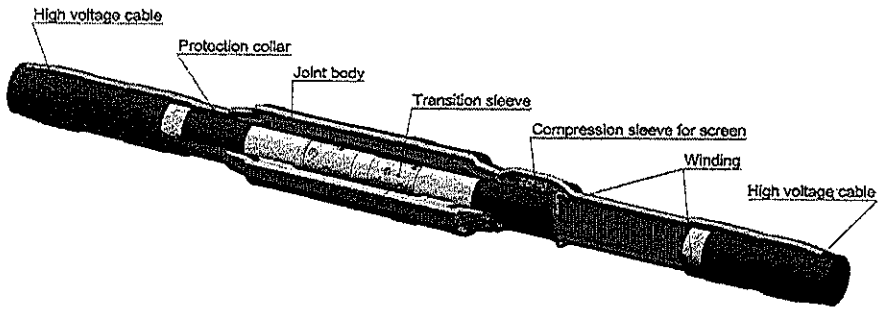
The design of joint includes splice box for connection of fiber-optical modules embended in the high-voltage cables screens.



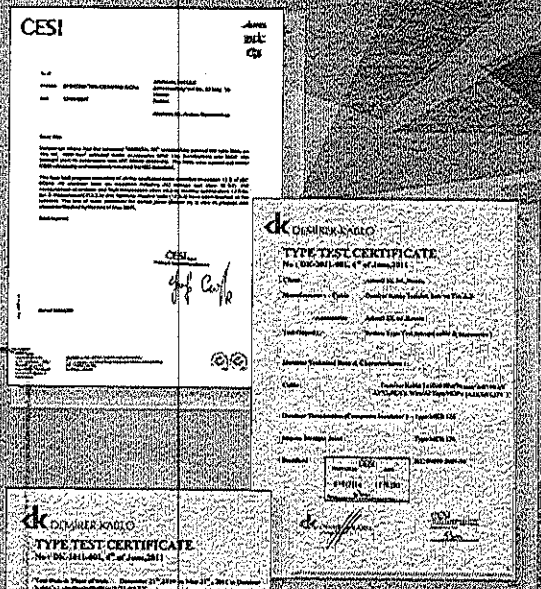


110 kV (126 kV)
Transition joints MCB 126 T

The transition joint MCB 126 T is designed to connect two extruded high-voltage cables XLPE 64/110 kV. Transition joints MCB 126 T are designed to connect cables with different conductors cross-sections including solid conductors connection and different insulation thickness.



TYPE TESTS OF CABLE SYSTEM 110 kV

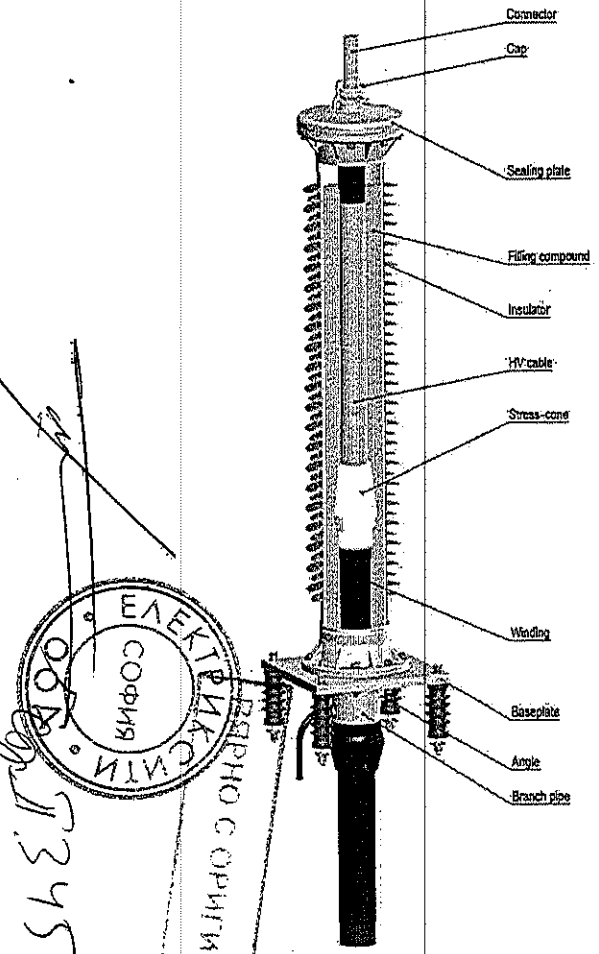


CESI, Italy

Type tests of Arkasil cable accessories 110 kV were successfully passed: 1000mm² extruded cable accessories MKB 126 (termination) and MCB 126 (straight joint) in accordance with IEC 60840 (2004-04).

132 kV (145 kV)
Terminations MKB 145

Arkasil termination with composite type insulator is used for cable line connection to other elements of power-supply systems. Termination MKB 145 is used for outdoor and indoor installation, for XLPE cables 76/132 kV with the conductor cross-section up to 2000 mm².



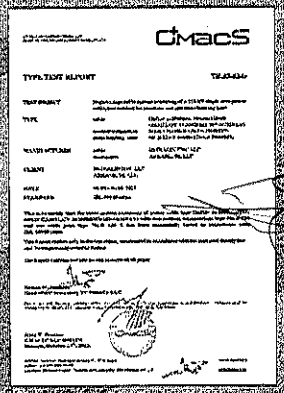
Basic components

Insulator:

- composite type insulator with glass fiber reinforced epoxy resin tube and silicone rubber sheads;
- sheds color–light gray;
- top and bottom flanges glued and sealed to the composite insulator.

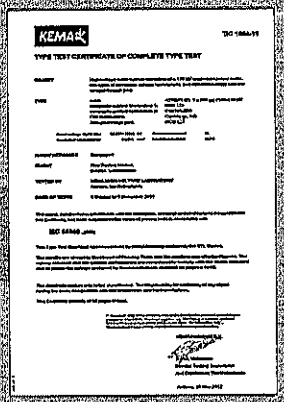
Cable end:

- pre-moulded and factory-tested silicone stress cone;
- cable end;
- base plate;
- branch pipe with flange;
- support insulators;
- seals and fixing materials;
- unpressurised synthetic oil as an insulating compound;
- optic fiber outlet.



OMACS, Russia

Type tests according to IEC 60840-2011 (OMACS, Russia)



KEMA, The Netherlands

Tests were made according to the program of the harmonized European standard HD 632 S2 "part 1 analogue of IEC 60840 edition 3 (2004)" in the test laboratory of KEMA (Netherlands)

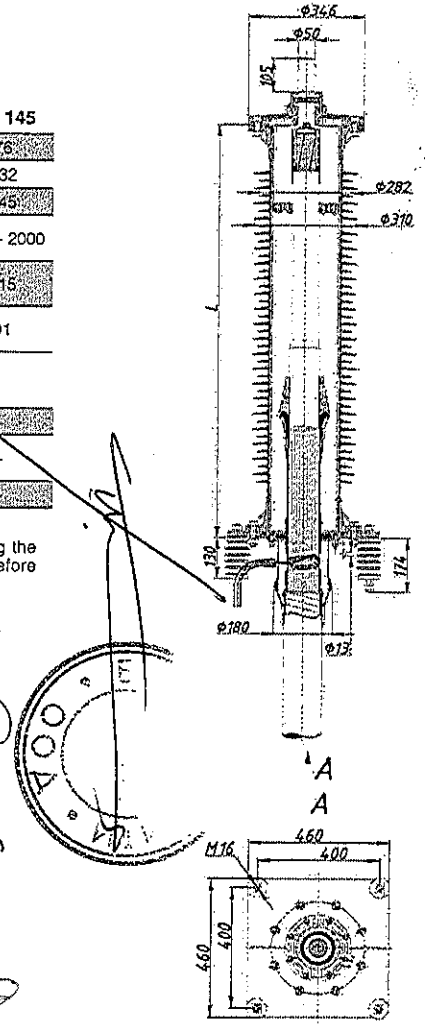
Area of application

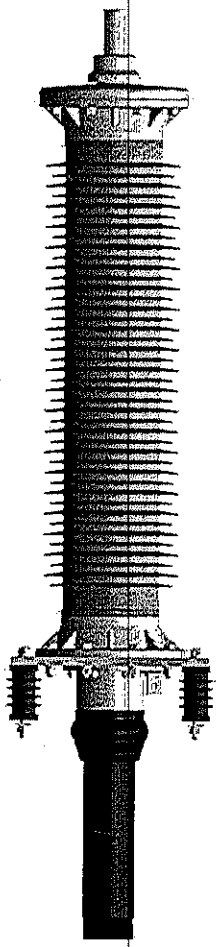
Type		MKB 145
Phase voltage	kV	76
Line voltage	kV	132
Maximum system voltage	kV	145
Cable conductor cross section range	mm²	185 ÷ 2000
Maximum cable sheath diameter	mm	115
Maximum cable insulation diameter	mm	91

Installation options:

On support	+
On high-voltage power transmission line	+
On support at an angle	+

Installation can be simplified by assembling the termination horizontally on the ground before lifting it into place.





Technical data

Electrical parameters:

AC voltage withstand test	190 kV for 30 min
Partial discharges	<5 pC at 114 kV
Impulse voltage (10+/10- impulses)	650 kV

Climatic characteristics:

Temperature	-50°C / +45°C

Nominal operating current:

limited by cable specification

Stress-cone routine tests for MKB 145:

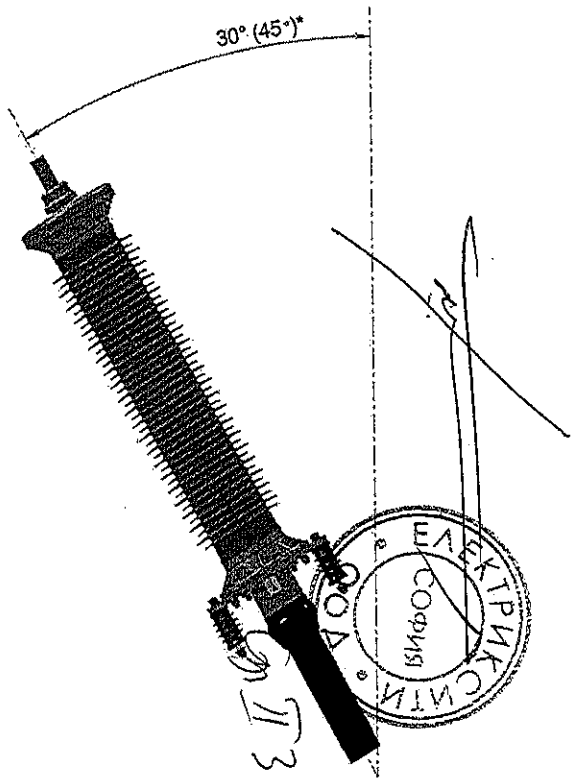
AC voltage withstand test	190 kV for 30 min
Partial discharges	<5pC at 114 kV

Cable sheath test voltage:

AC voltage	10 kV within 1 min
DC voltage	20 kV within 1 min

Type		MKB 145	
Cable conductor cross-section range	mm²	185÷1600	
Maximum allowed inclination angle		30°(45°)*	
Termination length, L	mm	1863	1875
Creepage distance length	mm	4300	4820
Pollution level in accordance with IEC 60137		III	IV
Volume compound	l	32	38
Weight	kg	105	113
Maximum allowed force on top connector	kN	3,5	3,5

Maximum allowed inclination angle up to 45° is only offer approval.



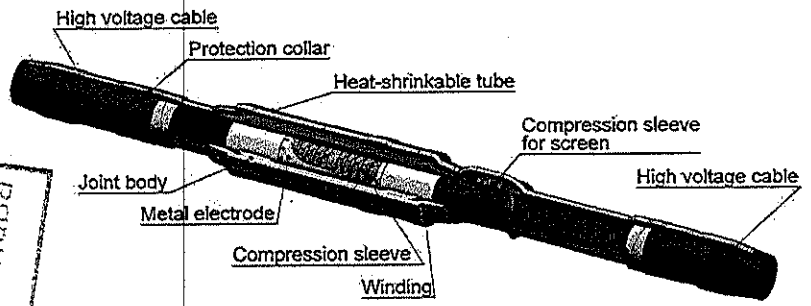
132 kV (145 kV)

Joints MCB 145

Arkasil joint is designed to connect two extruded high-voltage cables XLPE 76/132 kV. Joint MCB 145 could be produced in different designs: with screen wires direct connection, cross-bonding connection of different cable phase wires screen (screen cross-bonding), wires screen connection with optical fibers in the metal tubes.

Main components:

- pressed or screwed connection sleeves for cooper or aluminum conductor;
- Insulator (silicone pre-molded joint body with elements for electrical field stress control);
- special tapes for different purposes;
- protective covering by shrinkable tubes and sleeves;
- cooper case protection;
- coffin box protection.

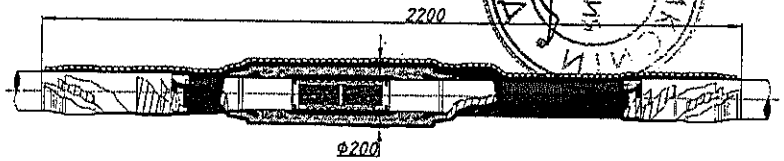


Area of application

Type		MCB 145
Phase voltage	kV	76
Line voltage	kV	132
Maximum system voltage	kV	145
Cable conductor cross section range	mm²	185÷2000
Maximum cable sheath diameter	mm	115
Maximum cable insulation diameter	mm	91
Nominal minimum insulation thickness	mm	14

Installation:

In the ground	+
On the air	+
Outdoor and indoor	+



Technical data

Electrical parameters:

AC voltage withstand test	190 kV for 30 min
Partial discharges	<5 pC at 114 kV
Impulse voltage (1.2÷50 impulses)	650 kV

Current load rating:

Rated operational current	limited by cable specification
Short circuit current	limited by cable specification

Climatic characteristics:

Temperature	-50°C / +45°C

Stress cone routine tests:

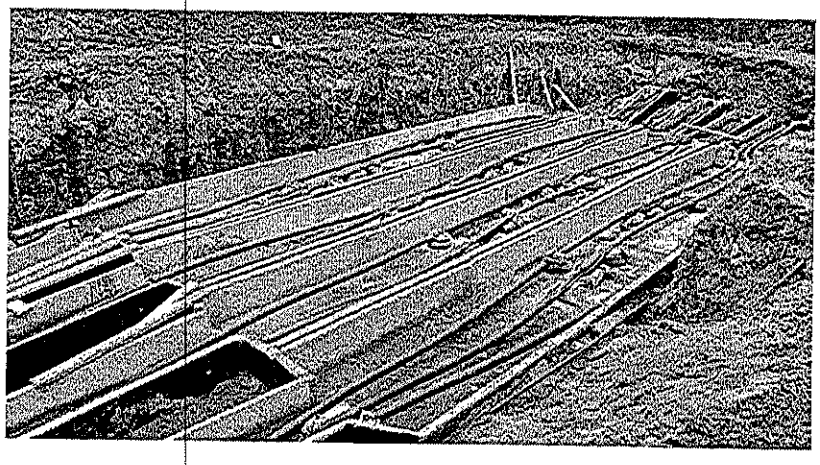
AC voltage withstand test	190 kV for 30 min
Partial discharges	<5pC at 114 kV

Cable sheath test voltage:

AC voltage	10 kV within 1 min
DC voltage	20 kV within 1 min

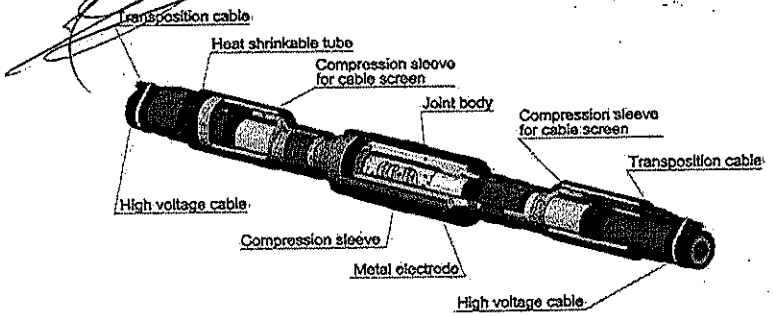
Mechanical characteristics:

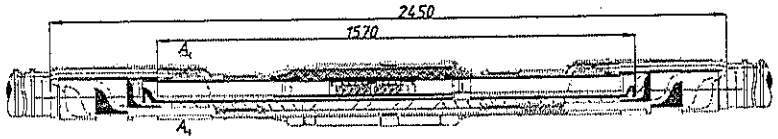
Approximate weight, kg	35

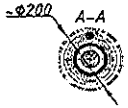


132 kV (145 kV)
Cross-bonding joints MCB 145 X

The cross-bonding joint MCB 145 X is designed to connect two extruded high-voltage cables XLPE 76/132 kV with cross-connection of wire screens. Screen outlet from both sides is provided by cross-bonding cable. There is the dielectric insertion in the joint for screen interruption.



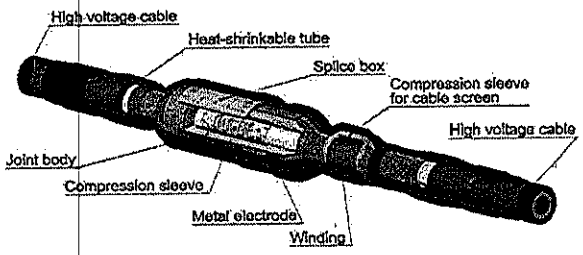


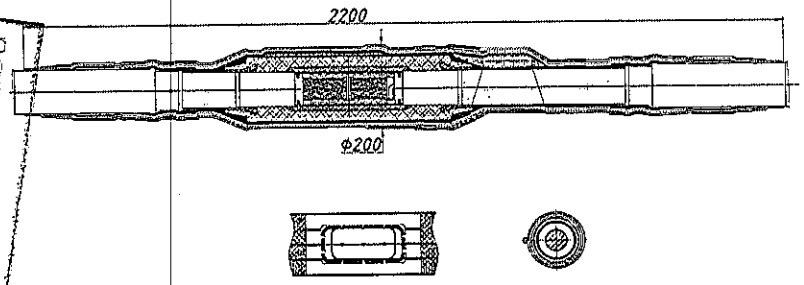


132 kV (145 kV)
Joints with optic fiber connection MCB 145 O

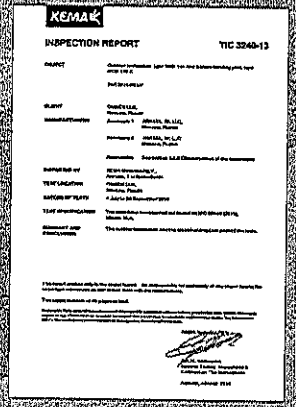
The joint with opric fiber connection MCB 145 O is designed to connect two extruded high-voltage cables XLPE 76/132 kV with connection of wire screens including optical module.

The design of joint includes splice box for connection of fiber-optical modules embended in the high-voltage cables screens.

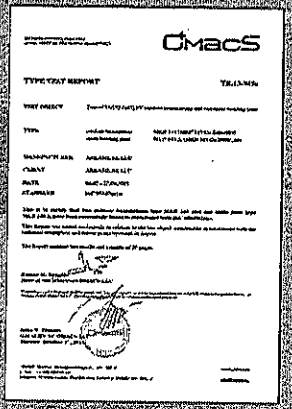




TYPE TESTS OF CABLE SYSTEM 132 kV


KEMA
INSPECTION REPORT TIC 3240-13

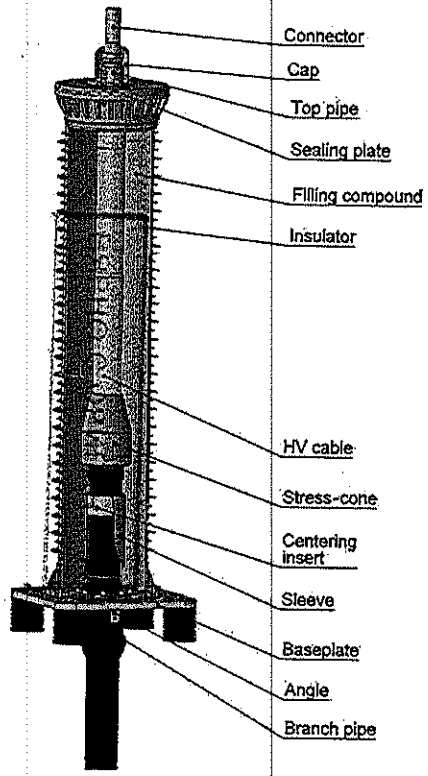
KEMA,
The Neatherlands


OMACS

OMACS,
Russia

Tests were passed under KEMA supervision

220 kV (252 kV)
Terminations MKB 252



Arkasil termination with composite type insulator is used for cable line joints with other elements of power-supply systems. Termination MKB 252 is used for outdoor and indoor installation, for XLPE cables 127/220 kV with the conductor cross section up to 2500 mm².

Basic components

Insulator:

- composite type insulator with glass fiber reinforced epoxy resin tube and silicone rubber sheds;
- sheds color–light gray;
- top and bottom flanges glued and sealed to the composite insulator.

Cable end:

- pre-moulded and factory-tested silicon stress-cone;
- cable end;
- base plate;
- branch pipe with flange;
- support insulators;
- seals and fixing materials;
- unpressurised synthetic oil as an insulating compound;
- optic fiber outlet.

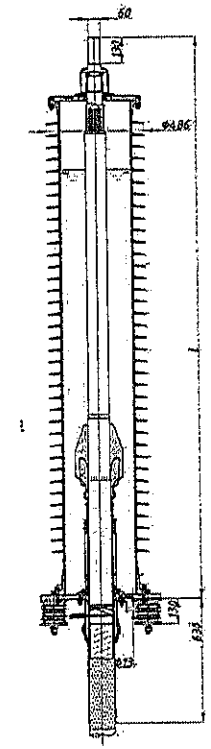
Area of application

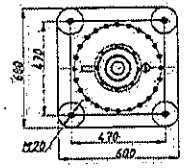
Type		MKB 252
Phase voltage	kV	127
Line voltage	kV	220
Maximum system voltage	kV	252
Cable conductor cross section range	mm²	400÷2500
Maximum cable sheath diameter	mm	150
Maximum cable insulation diameter	mm	108

Installation

On support	+
On high-voltage power transmission line	+
On support at an angle	+

Installation can be simplified by assembling the termination horizontally on the ground before lifting it into place.





Technical data

Electrical parameters:

AC voltage withstand test	318 kV for 30 min
Partial discharges	<5 pC at 190 kV
Impulse voltage (10+/10- impulses)	1050 kV

Climatic characteristics:

Temperature	-50ºC / +45ºC

Nominal operating current:

Rated operational current	limited by cable specification
Short circuit current	limited by cable specification

Type		MKB 252
Creepage distance, length	mm	6190, 7636, 8058, 8903, 9959, 10382
Pollution level in accordance with IEC 60137; GOST 9920-89		II,III, IV

Stress-cone routine tests for MKB 252:

AC voltage withstand test	318 kV for 30 min
Partial discharges	<5pC at 190 kV

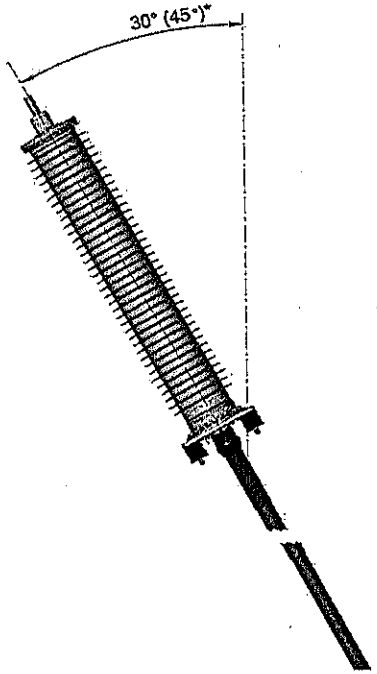
Cable sheath test voltage:

AC voltage	10 kV
DC voltage	20 kV

Mechanical characteristics:

Maximum allowed inclination angle	30° (45°)
Approximate weight, kg	350
Maximum allowed force on top connector, H	5000

Type tests according to IEC 62067.

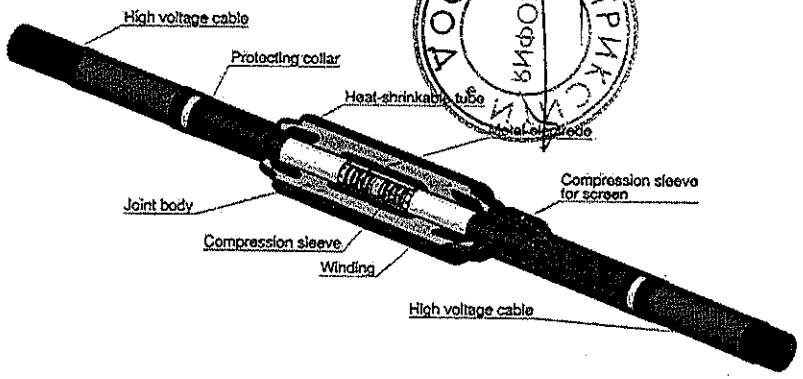


220 kV (252 kV)
Joints MCB 252

Arkasil joint is designed to connect two extruded high-voltage cables XLPE 127/220 kV. Joint MCB 252 could be produced in different designs: with screen wires direct connection, cross-bonding connection of different cable phase wires screen (screen cross-bonding), wires screen connection with optical fibers in the metal tubes.

Main components:

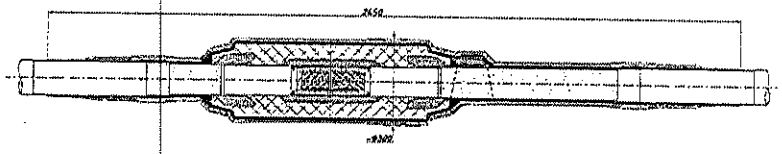
- pressed or screwed connection sleeves for cooper or aluminum conductors;
- insulator (silicone pre-molded joint body with elements for electrical field stress control);
- special tapes for different purposes;
- protective covering by shrinkable tubes and sleeves;
- cooper case protection;
- coffin box protection.



Area of application

Type		MCB 252
Phase voltage	kV	127
Line voltage	kV	220
Maximum system voltage	kV	252
Cable conductor cross section range	mm²	400+2500
Maximum cable sheath diameter	mm	150
Maximum cable insulation diameter	mm	108

Installation	
In the ground	+
On the air	+
Outdoor and indoor	+



Technical data

Electrical parameters:

AC voltage withstand test	316 kV for 30 min
Partial discharges	<5 pC at 190 kV
Impulse voltage (10+/10- impulses)	1050 kV

Climatic characteristics:

Temperature	-50°C / +45°C

Current load rating:

Rated operational current	limited by cable specification
Short circuit current	limited by cable specification

Stress-cone routine tests:

AC voltage withstand test	316 kV for 30 min
Partial discharges	<5pC at 190 kV

Cable sheath test voltage:

AC voltage	10 kV within 1 min
DC voltage	20 kV within 1 min

Mechanical characteristics:

Approximate weight, kg	80

Type tests according to IEC 62067.

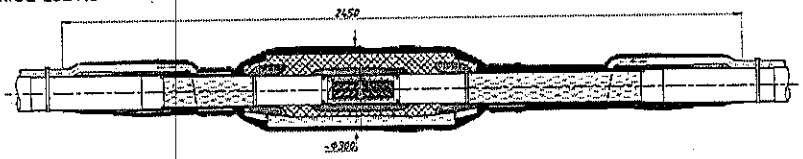
220 kV (252 kV)

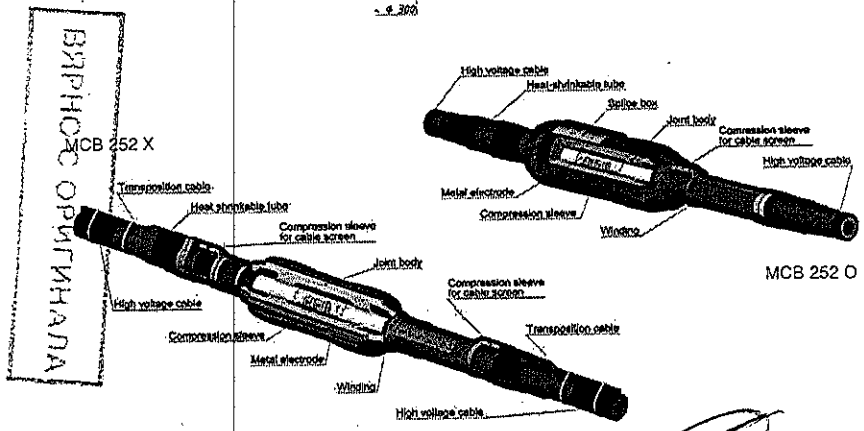
Cross-bonding joints MCB 252 X and joints with optic fiber connection MCB 252 O

The cross-bonding joint MCB 252 X is designed to connect two extruded high-voltage cables XLPE 127/220 kV with cross-connection of wire screens. Screen outlet from both sides is provided by cross-bonding cable. There is the dielectric insertion in the joint for screen interruption.

The joint with opric fiber connection MCB 252 O is designed to connect two extruded high-voltage cables XLPE 127/220 kV with connection of wire screens including optical module. The design of joint includes splice box for connection of fiber-optical modules installed in the high-voltage cables screens.

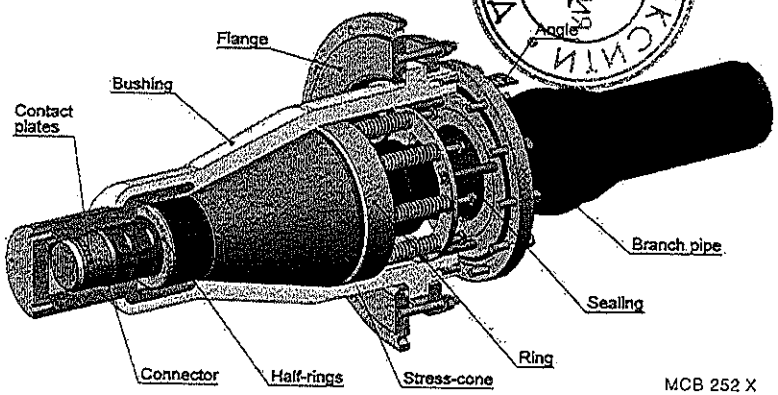
MCB 252 XO





220 kV (252 kV)
GIS terminations MBB 252

Arkasil GIS terminations are designed to connect cable lines to the gas insulated switchgear. Also, they are named GIS plug-ins, GIS adaptors. GIS terminations conform to IEC 62271-209. GIS termination consists of epoxy insulator and plug-in part. Due to such design, a cable can be disconnected from the GIS and be connected again. The epoxy insulator can be delivered with GIS or with plug-in part.



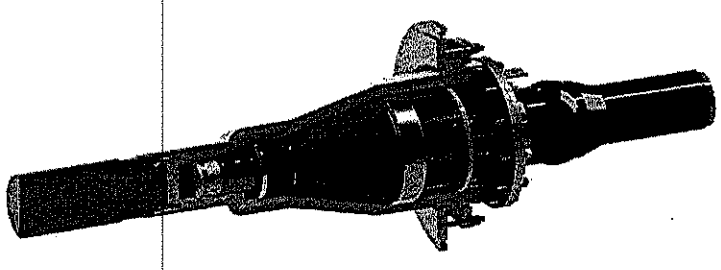
MCB 252 X

Area of application

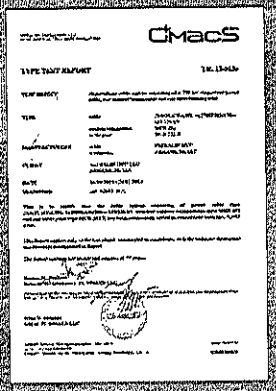
Area of application		MBB 252
Phase voltage	kV	127
Line voltage	kV	220
Maximum system voltage	kV	252
Cable conductor cross section range	mm²	400÷2500
Maximum cable sheath diameter	mm	150
Maximum cable insulation diameter	mm	112

Technical data

Electrical parameters:	
AC voltage withstand test	318 kV for 30 min
Partial discharges	<5 pC at 190 kV
Impulse voltage (10+/10- impulses)	1050 kV
Climatic characteristics:	
Temperature	-50°C / +45°C
Current load rating:	
Rated operational current	limited by cable specification
Short circuit current	limited by cable specification
Stress cone routine tests for MBB 252:	
AC voltage withstand test	318 kV for 30 min
Partial discharges	<5pC at 190 kV
Mechanical characteristics:	
Approximate weight, kg	350
Length, mm	1300



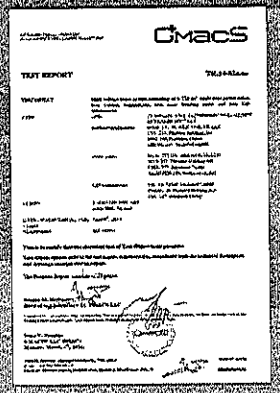
TYPE TESTS OF CABLE SYSTEM 220 kV



OMACS,
Russia

Tests were made under CESI supervision.

PREQUALIFICATION TESTS OF CABLE SYSTEM 220 kV



OMACS,
Russia

The electrical test of High-voltage cable system consisting of a 220 kV single-core power cable, four outdoor terminations, four cross-bonding joints and four GIS terminations is in progress.

HEAT-SHRINKABLE COMPONENTS

Heat shrinkable cable end caps

Heat Shrinkable cable End Caps are used to seal the ends of all types of Cables protect from ingress of water/moisture. The caps are manufactured from high quality cross linked polyolefin material.

Compatible with most commonly used Cable Jackets i.e. XLPE, PVC, PILC or Rubber Sheathed Cable.

Hot Melt adhesive lining provides seal on irregular cable sheaths.

Excellent resistance to weathering, moisture, contamination and adverse environmental conditions.

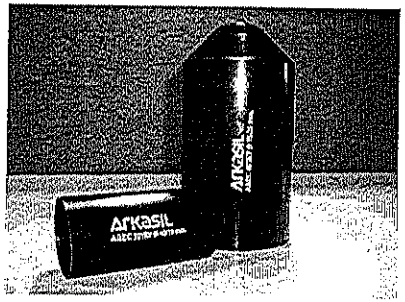
Area of application:

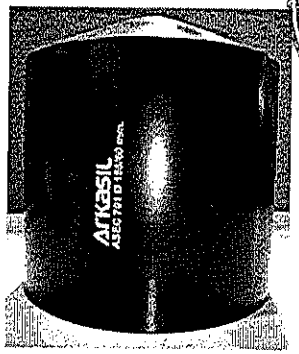
- valved end caps available for pressurized application for Telecom cables;
- special Relief valved End Caps available for degassing application in High Voltage Power cables;
- high voltage (non tracking) End Caps available for sealing live parts;
- conductive End Caps are available with conductive mastic.

Technical specification

Type		Standard
Physical properties:		
Tensile Strength	12 N/mm² (Mpa) (min.)	ASTM D638
Ultimate Elongation	350% (min)	ASTM D638
Density	1.05± 0.2	ASTM D792
Hardness	45 ±10 Shore D	ASTM D2240
Water absorption	0.2% (max.)	ASTM D570
Thermal properties:		
Accelerated ageing	(120°C for 500 hrs)	ASTM D2671
Tensile Strength	11 N/mm² (Mpa) (min.)	ASTM D638
Ultimate Elongation	300% (min.)	ASTM D638

Type		Standard
Low Temperature Flexibility:		
(-40°C for 4 hrs.)	No Cracking	ASTM D2671
Heat Shock (250°C for 30 min.)	No cracking or flowing	ESI 09-17
Shrink Temperature	125°C	IEC216
Temperature range	-40 to +100°C	IEC216
Electrical properties:		
Dielectric Strength	12 KV/mm (min)	ASTM D149
Volume Resistivity	1X 10¹⁴ Ohm. cm (min)	ASTM D257
Dielectric constant	5 (max.)	ASTM D150





Code	D min (mm)	D max (mm)	T±10 (mm)	Length (min)	Cable diameter
ASEC 001S	6	2.0	2.0	25	2-4
ASEC 001	12	4.0	2.3	38	4-8
ASEC 001L	12	4.0	2.3	58	4-8
ASEC 001A	14	4.0	2.3	58	4-11
ASEC 101	20	7.5	2.3	55	8-16
ASEC 101 L	20	7.5	2.5	75	8-16
ASEC 101 A*	25	8.0	2.3	75	8-20
ASEC 102	30	11	2.5	75	12-26
ASEC 102 A	35	11	2.5	75	12-30
ASEC 201*	40	15	3.3	90	16-35
ASEC 201 L	40	15	3.3	120	16-35
ASEC 201 AL	45	15	3.3	120	16-40
ASEC 301*	55	25	3.8	122	25-47
ASEC 301 L	55	25	3.8	170	25-47
ASEC 301 AL	63	25	3.8	170	25-55
ASEC 401*	75	35	3.8	140	35-68
ASEC 401 L	75	35	4.0	180	35-68
ASEC 501 S	85	45	4.0	160	45-80
ASEC 501*	100	45	4.0	160	45-90
ASEC 501 L	100	45	4.0	200	45-90
ASEC 501 AL	120	45	4.0	200	45-110
ASEC 601*	130	60	4.6	160	64-120
ASEC 701*	154	60	4.6	165	70-145
ASEC 801	230	120	5.5	220	140-200
ASEC 901	310	120	5.5	220	140-280
ASEC 1001	400	200	6.0	220	230-380

* Widely applied

HEAT-SHRINKABLE COMPONENTS

Heat shrinkable tubes

Heat Shrinkable Tubes ASMW and ASHW are medium wall and heavy wall black tubes. ASMW tubes are used for environmental protection of cable termination and insulating the connectors for straight through joints/splice. ASHW tubes are used for mechanical protection and outer sealing of underground straight through cable joints / splice.

Technical specification

- these tubes are manufactured from high quality cross inked polyolefin material;
- optional hot melt adhesive lining for complete environmental protection and insulation;
- excellent resistance to weathering, UV rays, chemical and solvents;
- maximum cut length available up to 1500 mm;
- custom dimensions, thickness, length & colours available on request;
- conforms to IEC standard.

Code	D min (mm)	D max (mm)	T±10 (mm)
ASHW 12/3	12	3	2.4
ASHW 19/6	19	6	2.5
ASHW 30/8	30	8	3.0
ASHW 43/12	43	12	4.0
ASHW 51/16	51	16	4.0
ASHW 72/22	72	22	4.0
ASHW 85/25	85	25	4.0
ASHW 105/30	105	30	4.0
ASHW 120/36	120	36	4.0
ASHW 140/42	140	42	4.2
ASHW 160/50	160	50	4.3
ASHW 180/55	180	55	4.3
ASHW 200/65	200	65	4.3

Code	D min (mm)	D max (mm)	T±10 (mm)
ASMW 10/3	10	3	1.0
ASMW 12/4	2	4	1.8
ASMW 19/6	19	6	2.0
ASMW 27/8	27	8	2.5
ASMW 33/10	33	10	2.5
ASMW 40/12	40	12	2.5
ASMW 50/16	50	16	2.6
ASMW 70/22	70	22	2.7
ASMW 90/28	90	28	3.0
ASMW 115/34	115	34	3.0
ASMW 130/36	130	36	3.0
ASMW 140/42	140	42	3.0
ASMW 160/50	160	50	3.0
ASMW 180/60	180	60	3.0
ASMW 200/70	200	70	3.0

Type		Standard
Physical:		
Tensile Strength	12 N/mm² (Temperature range)(min.)	ASTM D638
Ultimate Elongation	350% (Min.)	ASTM D638
Longitudinal Change	-10% (Max.)	ASTM D2671
Density	1.15 ± 0.2 g/cm³	ASTM D792
Hardness	45 ± 10 Shore D	ASTM D2240
Water Absorption	0.5% (max.)	ASTM D570
Thermal:		
Accelerated Ageing	(120°C for 500 h)	ASTM D2671
Tensile Strength	11 N/mm² (Mpa) (min.)	ASTM D 638
Ultimate Elongation	300% (Min.)	ASTM D 638
Low temperature Flexibility (-40°C for 4 h.)	No Cracking	ASTM D2671
Heat Shock (250°C for 30 min.)	No Cracking or flowing	ESI 09-11
Shrink Temperature	125°C	IEC 216
Temperature range	-40°C to +110°C	IEC 216
Electrical:		
Dielectric Strength	12 kV/mm (Min.)	ASTM D 149
Volume Resistivity	1 x 10^{14} Ohm.cm (min.)	ASTM D257
Dielectric Constant	5 (Max.)	ASTM D150

HEAT-SHRINKABLE COMPONENTS

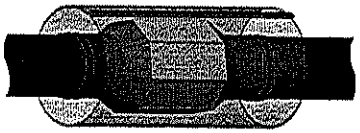
Heat shrinkable wrap around sleeve

Heat Shrinkable Wrap Around Sleeve is a cross linked polyolefin tube which is folded around the cable/pipe, zipped up with a stainless steel channel and then heat shrunk.It is also called as (Cable Repair Sleeve).

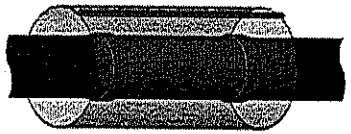
Shut down of system not required for repair

- hot melt adhesive provides complete environmental sealing and insulation;
- high resistance to UV rays, chemicals, corrosion, fungus, etc.;
- temperature sensitive paint changes colour when heat shrinking process is complete;
- maximum length available up to 1500 mm.

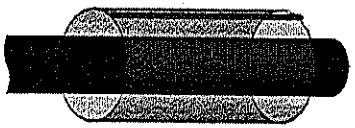
For the protection of Cable joint



For Cable Repairs



For corrosion protection of Oil, Water & Gas pipeline



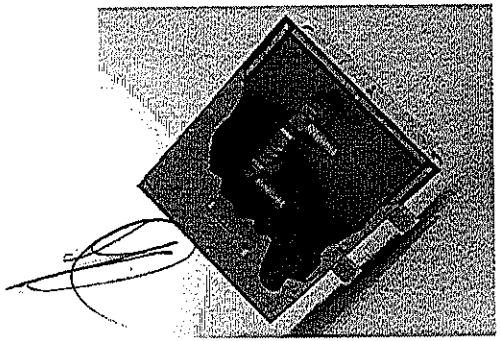
Technical specification

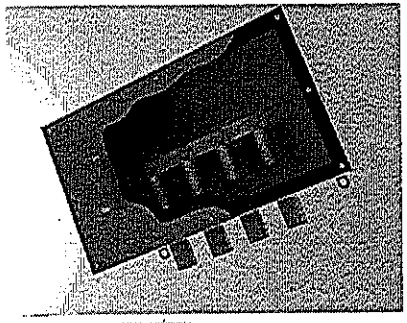
Type		Standard
Physical:		
Tensile Strength	17 N/mm² (MPa) (min)	ASTM D638
Ultimate Elongation	300% (Min.)	ASTM D638
Longitudinal Change	-10% (max.)	ASTM D2671
Water Absorption	0.2% (max.)	ASTM D570
ESCR 48 h. for 50°C	No Crack	ASTM D570
Torchability	No split	Te 201 AOL
Thermal:		
Accelerated Ageing	(120°C for 500 h)	ASTM D2671
Tensile Strength	15 N/mm² (MPa) (min.)	ASTM D 638
Ultimate Elongation	220% (Min.)	ASTM D 638
Temperature indicating Paint Conversion:		
150°C for 30 min	No Change	Visual
250°C for 5 min	Colour Cahnge	Visual
Electrical:		
Dielectric Strength	12 kV/mm (Min.)	ASTM D149

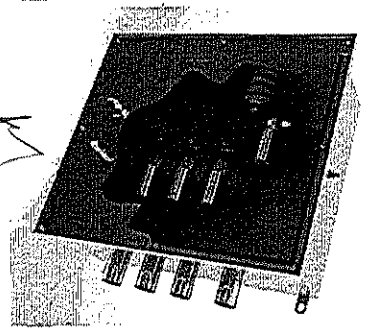
Code	Diameter (D) Supplied	Diameter (D) Recovered	Thickness (±20%) (recovered)	Application Cable Range
ASWS-55/8	55	8	2.7	42-8
ASWS-76/18	76	18	2.7	62-22
ASWS-105/28	105	28	2.7	92-30
ASWS-140/35	140	35	2.7	122-38
ASWS-190/46	190	46	2.7	160-50
ASWS-240/50	240	50	2.7	200-55

All dimensions in mm.
Length as per requirement (maximum 1500 mm).

EARTHING AND CROSS-BONDING BOXES







Earthing boxes

Earthing boxes are designed for earthing of cable screens when setting up 110 to 500 kV line.

Main components:

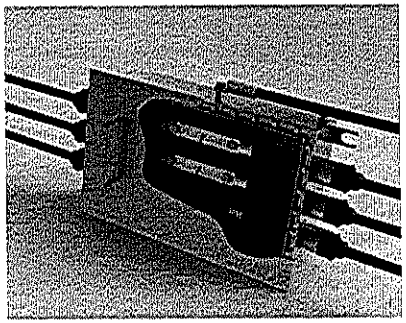
- stainless steel box with a sealed hood;
- sealed cable inputs;
- device housing earthing;
- surge arrester (standard, network, voltage 6 kV);
- insulators (standard, voltage rating 10 kV);
- copper buses for connection of insulators (for opening the circuit);
- sealed cable terminals to be crimped.

Technical specification:

- cross-bonding cable input is designed to prevent moisture from getting inside the box as well as to ensure that cable can be installed and removed from the box without taking a cable lug off;
- copper is a material of the cable conductor;
- a cable with conductor cross-section of 400 mm² is used.

Cross-bonding boxes

Cross-bonding boxes are designed for cross-connection of six single-core cables and for power transposition of HV cable screens when setting up 110 to 500 kV line.



Main components:

- stainless steel box with a sealed hood;
- sealed cable inputs;
- device housing earthing;
- surge arrester (standard, network, voltage 6 kV);
- insulators (standard, voltage rating 10 kV);
- copper buses for connection of insulators (for opening the circuit);
- sealed cable terminals to be crimped.

Calculated weight	66 kg
Protection grade	IP68

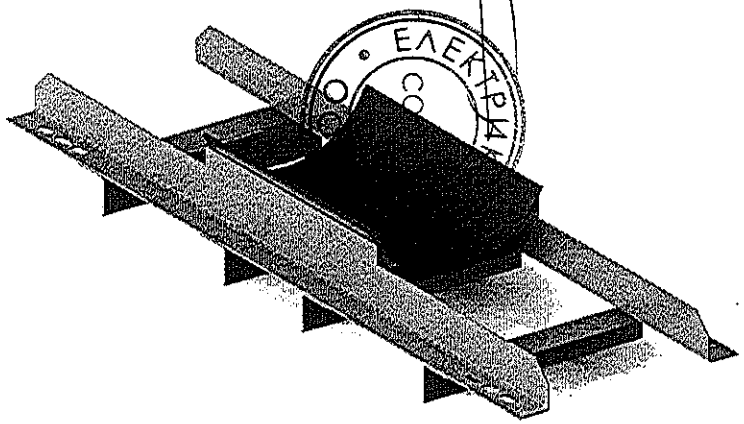
Installation:

- boxes are suitable for underground laying;
- the device design allows it to be installed both on a horizontal and vertical plane;
- the device can be fastened both directly on the floor/ wall and on a metal structure;
- the box can be fully submerged in water;
- a wire input is sealed using rubber gaskets and heat-shrinkable tubes;
- KTK construction allows to install the box in wells fitted with standard hatches per GOST 3634-89, with opening diameter D=600 mm, without dismantling the box and/or removing the hatch ring.

SUPPORT ASSEMBLY

Support assembly is designed for installation of joints.

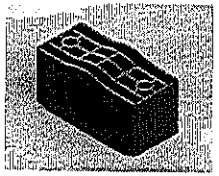
Support assembly consists of steel corners with supporting stand for installation of joints.



CABLE CLAMPS

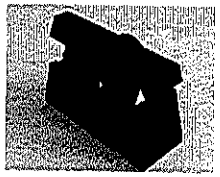
Application
Clamping of all types of medium, high and extra high voltage cables.

Cable clamps RKK series



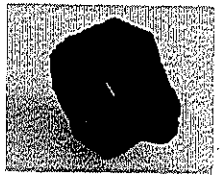
Type	Outer cable diameter
RKK-25/40	25 - 40 mm
RKK-40/60	40 - 60 mm

Cable clamps YKK3 series



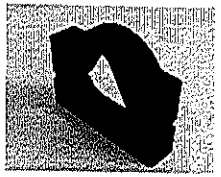
Type	Outer cable diameter
YKK-35/55	35 - 55 mm
YKK-40/70	40 - 70 mm

Cable clamps for voltage cables VKK series



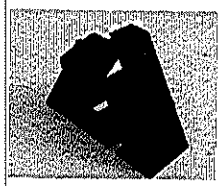
Type	Outer cable diameter
VKK-65/90	65 - 90 mm
VKK-85/105	85 - 105 mm
VKK-100/125	100 - 125 mm
VKK-125/150	125 - 150 mm
VKK-145/170	145 - 170 mm

Cable clamps for high voltage cables VKK3 series



Type	Outer cable diameter
VKK3-65/90	65 - 90 mm
VKK3-85/110	85 - 110 mm
VKK3-110/135	110 - 135 mm

YKK-60 Series

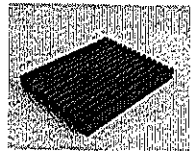


Type	Outer cable diameter
YKK-60-YKK2-60	30 - 40 mm

PST-80 (elastic inlay)

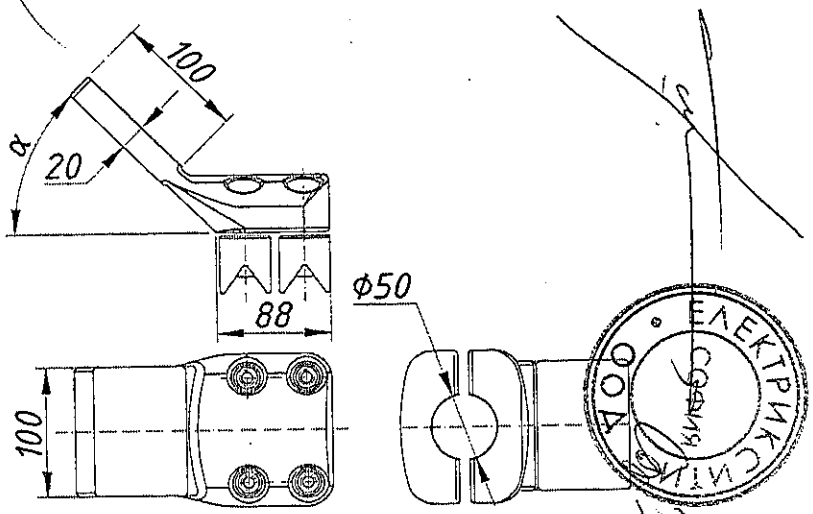
Application
Fixation of cables and support of weight in vertical installations.

Material
Silicone gasket is made of organosilicon.



CABLE CONNECTOR

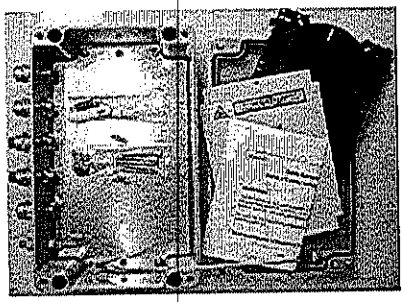
For connection of termination to cable lines it is necessary to use cable connectors. Arkasil SK delivers aluminium, bronze and bimetallic cable connectors.

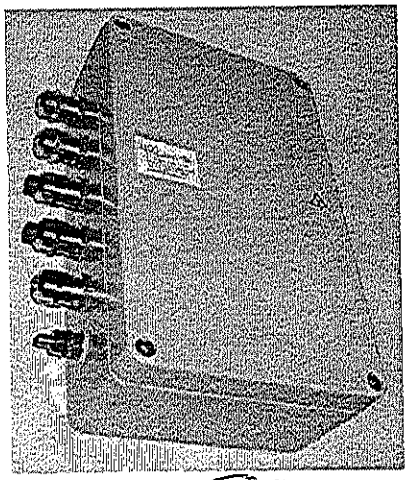


TERMINATION SPLICE BOX

It is applied for connection of fiber-optical modules installed in the high-voltage cables screens.

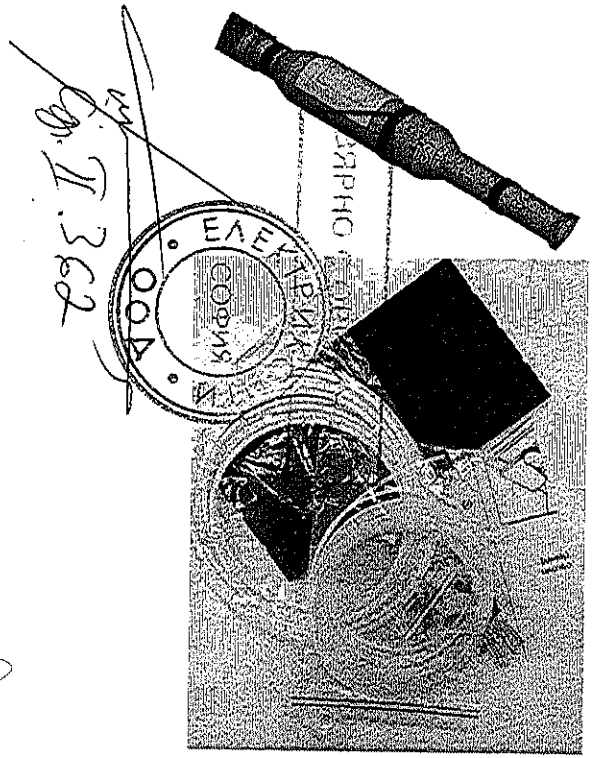
Splice box is a protective metal tray, safety class IP66, with 4 inputs for fiber-optical modules, 2,5 - 5,5 mm² in diameter. It protects the connection point and is applied to store the fiber stock necessary for repair or preventive works.



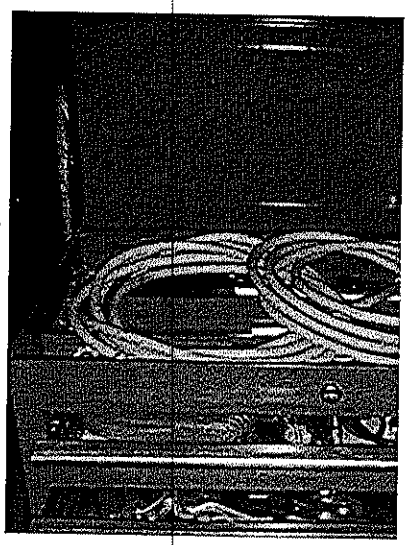


JOINT SPLICE BOX

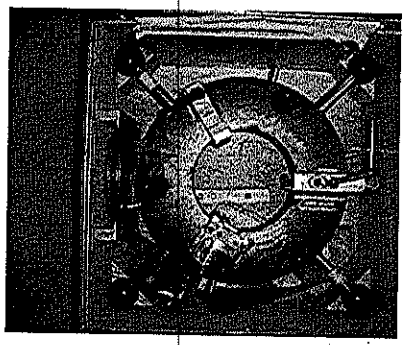
It is applied for connection of fiber-optical modules installed in the high-voltage cables screens. A joint splice box is a protective rubber base with slots and channels for the optical fibers, it provides connection of the modules, protects the connection point. It is fixed during the joint installation. The supply complete set includes all necessary accessories for the optical modules welding.



TOOLS FOR ARKASIL SK CABLE ACCESSORIES INSTALLATION



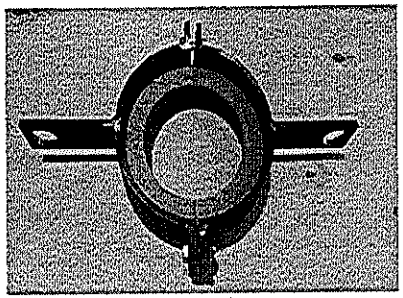
Installation Tool Kits
1010 Kit
The installation tools including all necessary items for the high-voltage cable and cable accessories preparation and installation.



Unicut 30 Universal Cable Machine
For removal of the semi-conducting screen and insulation from the high-voltage cables, the 30mm-85mm diameter over insulation.

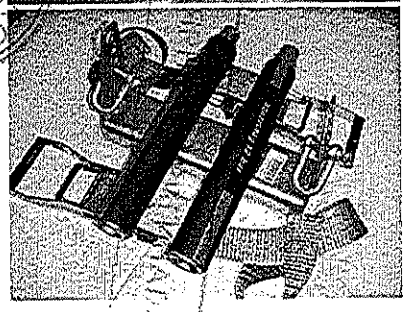
Unicut 40 Universal Cable Machine
For removal of the semi-conducting screen and insulation from the high-voltage cables, the 70mm-125mm diameter over insulation.

1000 kg Belt Winch
For pulling the silicon insulator on the cable.

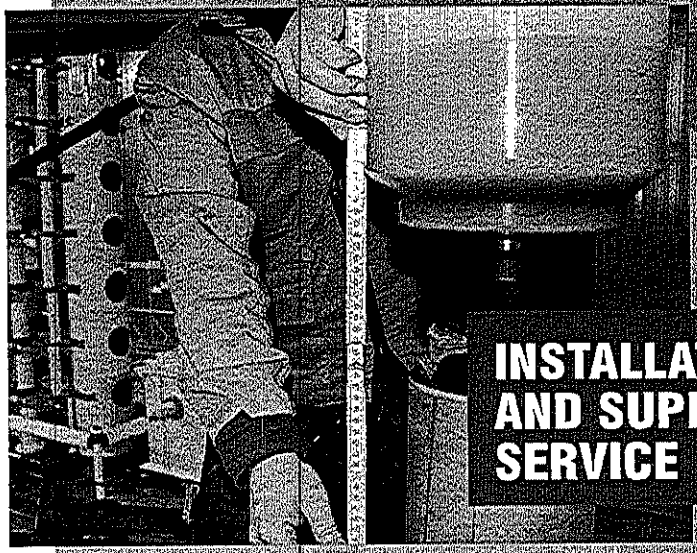


Cable Heating Kit
1080 Kit
For the high-voltage cable heating. In addition, the kit shall include the temp and controlling instruments.

Winch-to-Cable Fixing Device
The device is fixed on the cable, and has terminals for fixing the winches.



Other Auxiliary and Installation Tools



INSTALLATION AND SUPERVISION SERVICE

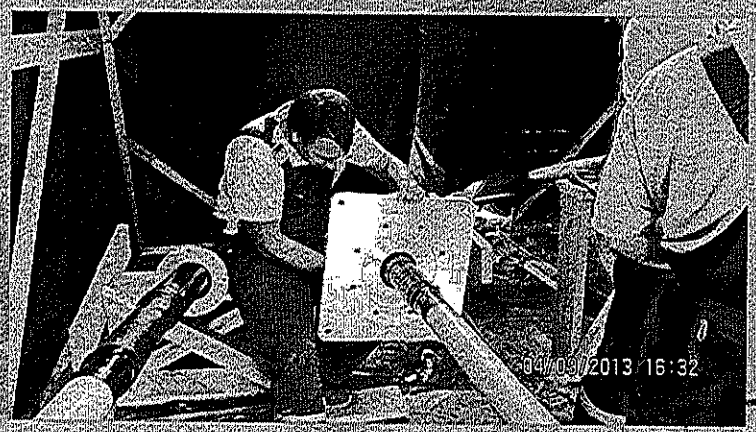
SUPERVISION SERVICE

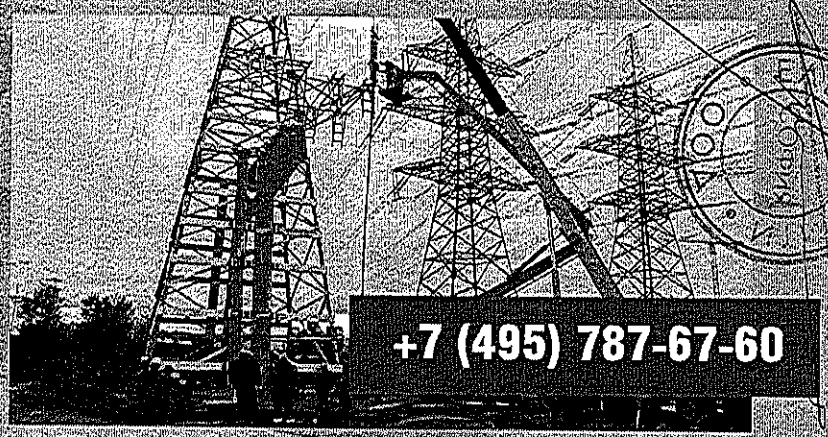
Arkasil SK renders services on installation and supervision of own high-voltage cable accessories. Our installation supervision services for the cable accessories shall mean:

- multipurpose and process supervision;
- the works quality control of the personnel trained in Arkasil SK cable accessories and who have spacial certificates;
- guarantee documentation on the installed Arkasil SK cable accessories;
- The Arkasil SK cable accessories related consultations.
- "Installation Supervision" in the construction standards is not defined yet. Therefore, when making an agreement, it is necessary to be governed by the normative documents, including "The Regulations For Installation Supervision", governing the bases for granting consulting services and the contractual relations, in general.

INSTALLATION SERVICE

- Installation of the Arkasil SK cable accessories by the specialists certified by Arkasil SK for those works
- Guarantee documentation on the installed Arkasil SK cable accessories
- The Arkasil SK cable accessories related consultations



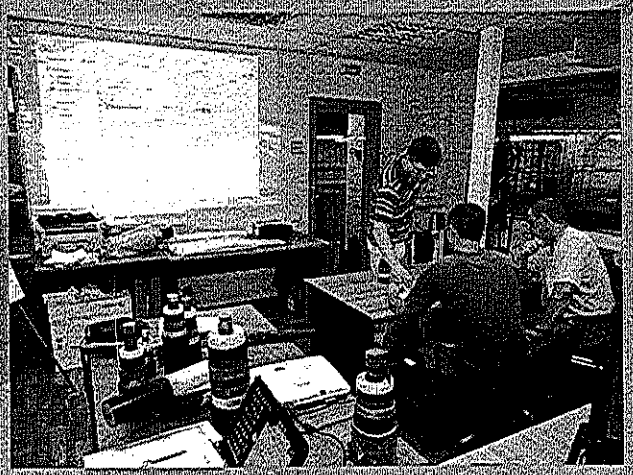


+7 (495) 787-67-60

FOR MORE INFORMATION
on the installation and supervision provided by Arkasil SK
please call: +7 (495) 787-67-60

INSTALLATION TRAINING

Arkasil SK arranges training for the installation contractor specialists. The training is arranged at the training center located at the Arkasil SK production facilities. There is organization of the educational process. Arkasil SK renders the training service at the installation contractor production facilities.

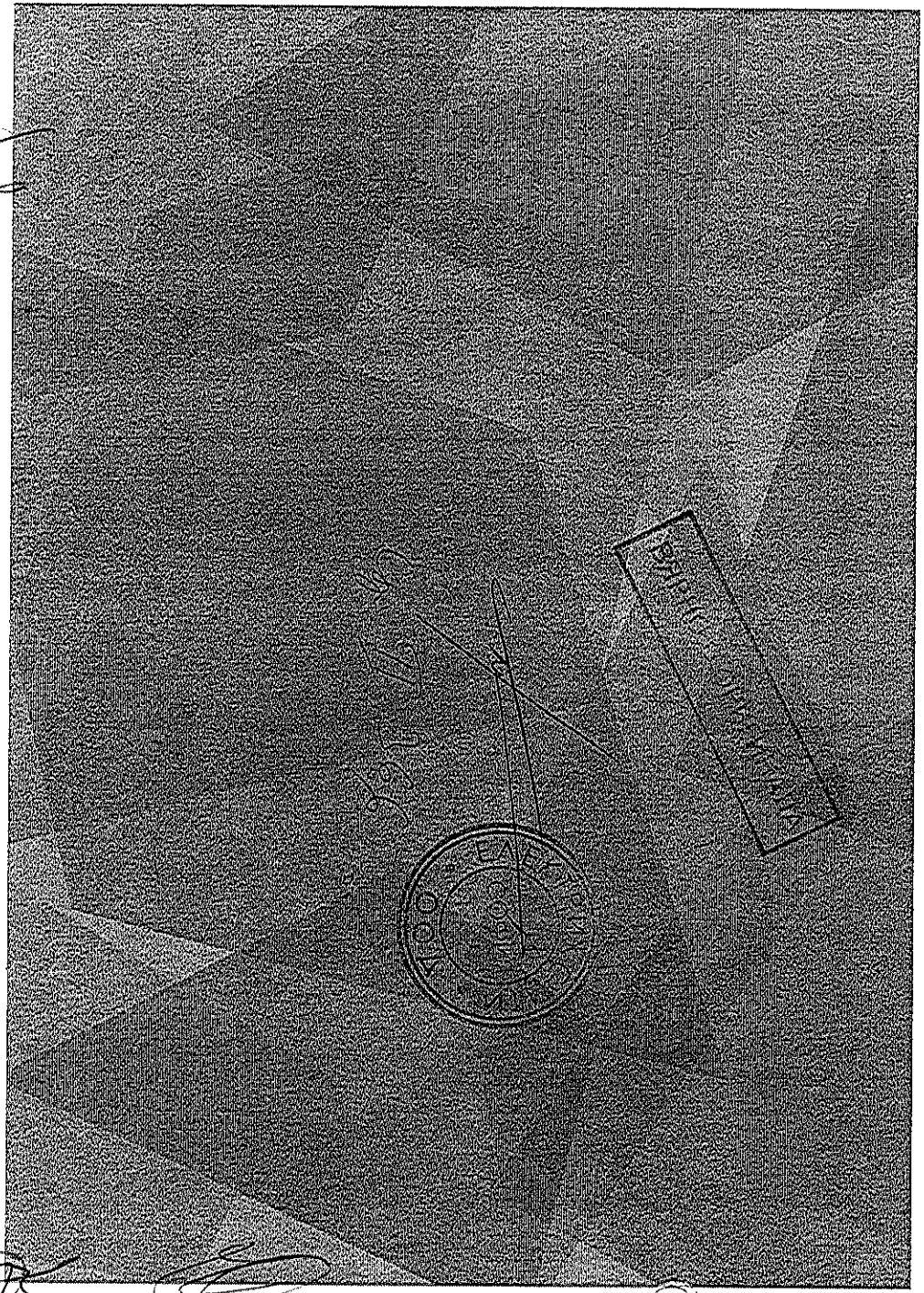


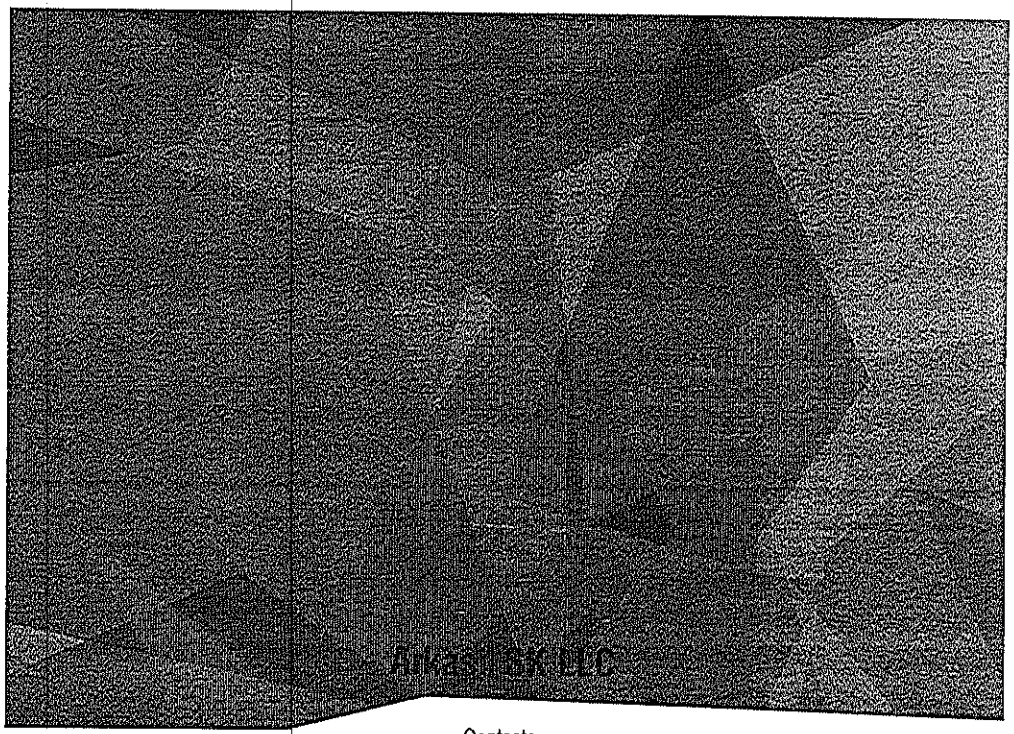
THE TRAINING SHALL INCLUDE

- Theory training
- Practical training
- Tests
- Sample preparation for certification
- Granting certificates

By the results of examinations, the installation contractor specialists shall receive the permits for performance of installation works with the Arkasil SK cable accessories.

REMARKS





Contacts:

111024, Moscow, Proezd Zavoda Serp i Molot str, 6. bld.1
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E-mail: www.arkasil.com
Web-site: info@arkasil.com

Приложение № 17 – Техническа документация (включително каталози), даваща пълно описание, технически данни и характеристики на предлаганото оборудване към Приложение № 4 – Технически данни за цифрови защити за въводно поле „Захарна фабрика“ 110 kV основна цифрова надлъжна диференциална защита (комплект от две релета); Приложение № 5 - Технически данни за цифрова резервна максимално токова защита за поле „Захарна фабрика“ 110кV; и Приложение № 6 – Технически данни за цифрови защити за трансформаторно присъединение, диференциална защита за силов тринамотъчен трансформатор

ЕЛЕКТРИКСИТИ ООД София

СД 3 67

670 series pre-configured product range
Summary - Product selections

Tender ID: 16Q2863109 Pos: 110

Country of End User	BG
End User - Utility	CEZ
Station Name	Borimechkata/Orion
Voltage Range in kV	110/20

IED code:
REDG70*2.0-A31X00-A05B10B11C24-B1X0-
AA-KB-B-A7-E1AX-XXBX-CD
Product description: Line differential protection, REDG70,A31,Single breaker,3 phase tripping

BASIC FUNCTIONS

for configuration alternative A31

Apparatus control (QCBAY),1pcs
Autorecloser (SMBRREC,79),1pcs
Breaker failure protection (CCRBRF,50BF),1pcs
Broken conductor check (BRCPTOC,46),1pcs
Configurable logic blocks,1pcs
Current circuit supervision (CCSSPVC,87),1pcs
Disturbance report (DRPRDRE),1pcs
Event function (EVENT),20pcs
Fault locator (LMBRFLO),1pcs
Four step phase overcurrent protection (OC4PTOC,51/67),1pcs
Function block for service values presentation of the analog inputs (AISVBAS),1pcs
Function for energy calculation and demand handling (ETPMMTR),6pcs
Fuse failure supervision (FUFSPVC),3pcs
Gas medium supervision (SSIMG,63),21pcs
Handling of LRswitch positions (LocalRemote),1pcs
Instantaneous phase overcurrent protection (PHPIOC,50),1pcs
LHMI control of PSTO (LocRemControl),1pcs
Line differential protection, 3 CT sets, 2-3 line ends (L3CPDIF,87L),1pcs
Liquid medium supervision (SSIML,71),3pcs
Loss of voltage check (LOVPTUV,27),1pcs
Measurements,1pcs
Pole discordance protection (CCPDSC,52PD),1pcs
Synchrocheck, energizing check and synchronizing (SESRSYN,25),1pcs
Thermal overload protection, one time constant, Celcius (LCPTTR,26),1pcs
Thermal overload protection, one time constant, Fahrenheit (LFPTTR,26),1pcs
Tripping logic (SMPPTRC,94),6pcs
Two step overvoltage protection (OV2PTOV,59),2pcs
Two step residual overvoltage protection (ROV2PTOV,59N),1pcs
Two step undervoltage protection (UV2PTUV,27),1pcs
Voltage differential protection (VDCPTOV,60),2pcs

ACT CONFIGURATION

ABB Standard configuration, X00

FUNCTION PACKAGES

The basic functionality is configured and ready for direct use. The selected optional function packages (listed below) are not included in the default configuration when delivered from the factory; and thereby require additional engineering, using PCM600 Engineering software. For further information contact your ABB representative.

Line differential protection 3 CT sets + transformer, A05
- Line differential protection 3 CT sets, with inzone transformers, 2-3 line ends (LT3CPDIF,87LT),1pcs

Line Distance protection - quadrilateral - 4:th zone, B10
- Distance protection zones, quadrilateral characteristic (ZMQPDIS,21),1pcs

Line Distance protection - quadrilateral - 3 zones, B11
- Automatic switch onto fault logic, voltage and current based (ZCVPSOF),1pcs
- Current reversal and weak-end infeed logic for distance protection (ZCRWPSCH,85),1pcs
- Directional impedance quadrilateral (ZDRDIR,21D),1pcs
- Distance protection zones, quadrilateral characteristic (ZMQPDIS,21),3pcs
- Local acceleration logic (ZCLCPSCH),1pcs
- Phase selection, quadrilateral characteristic with fixed angle (FDPSPDIS,21),1pcs
- Power swing detection (ZMRPSB,68),1pcs
- Scheme communication logic for distance or overcurrent protection (ZCPSCH,85),1pcs
- Stub protection (STBPTOC,50STB),1pcs

ЕЛЕКТРИКСИМ ООД София

Сд. II 368

ВЯРНО С ОРИГИНАЛА

Residual overcurrent protection, C24
- Current reversal and weak-end infeed logic for residual overcurrent protection (ECRWPSCH,85),1pcs
- Four step directional negative phase sequence overcurrent protection (NS4PTOC,46I2),1pcs
- Four step residual overcurrent protection (EF4PTOC,51N/67N),1pcs
- Instantaneous residual overcurrent protection (EFPIOC,50N),1pcs
- Scheme communication logic for residual overcurrent protection (ECPSCH,85),1pcs

First HMI Language	HMI language, English IEC, B1
Additional HMI Language	No second HMI language, X0

HARDWARE

Casing	Rack, 1/2 x 19 inch, max 3 I/O modules, max 1 TRM, A
Basic hardware	Comb Backplane Module, 1/2 x 19 inch, 2 cPCI, 1 TRM
Basic hardware	Numeric processing module, 600 MHz with 1MB cache
Basic hardware	Universial Backplane Module, 1 ADM, 1 TRM
Mounting details with IP40 protection from the front	19 inch rack mounting kit for case size 6U*1/2, grey, A
Connection type	Compression terminals, K
Power supply module	Power supply module, 90-250 VDC, B
Human Machine Interface	Human machine interface, medium size - graphic display, IEC symbols 1/2 x 19 inch, B
Transformer Module 1 pos P40/X401	Transformer module, 6I +6U, 5A, 110/220V, 50/60Hz, compression, A7
A/D Module for TRM 1	Analog digital conversion module 12 channels,
I/O Module pos P3/X31,X32	BIM, 16 inputs, RL220, 220-250VDC, 50mA, E1
I/O Module pos P4/X41,X42	BOM, 24 output relays, A
I/O Module pos P5/X51,X52	No board in this slot, X
Communication Module pos P31:2/X312	No remote communication board included , X
Communication Module pos P31:3/X313	No remote communication board included , X
Communication Module pos P30:2/X302	Optical medium range line data communication module Single mode 1310 nm, B
Communication Module pos P30:3/X303	No remote communication board included , X
Serial communication module pos P30:1/X301	Serial communication module Serial SPA/LON/DNP/IEC 60870-5-103 glass interface, C
Optical Ethernet Module pos P31:1/X311	Optical ethernet module 1 glass interface, D

PRODUCT INFORMATION

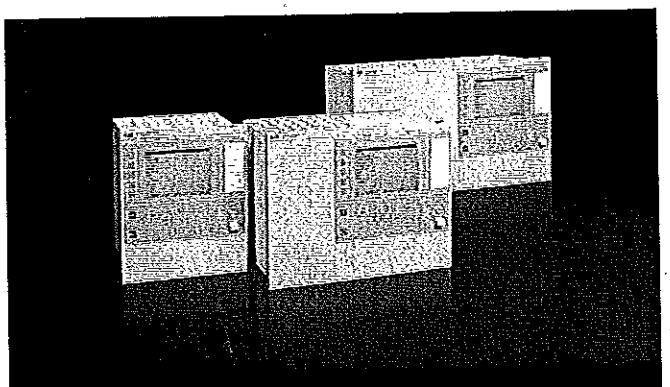
Data Sheet - Product Guide Line Differential Protection RED670 2.0
Data Sheet - Ordering form, RED670 2.0 Preconfigured
Data Sheet - Accessories, 670 series IEC

ABB AB
Substation Automation Products
http://www.abb.com/substationautomation

ЕЛЕКТРИКСИТИ СОФИЯ ООД

Сд.П 369

ВЯРНО С ОРИГИНАЛА



Relion® 670 series

Line differential protection RED670 2.0 Product Guide

Contents

Power and productivity for a better world™ ABB

1. Application

RED670 is used for the protection, control and monitoring of overhead lines and cables in all types of networks. The IED can be used from distribution up to the highest voltage levels. It is suitable for the protection of heavily loaded lines and multi-terminal lines where the requirement for tripping is one-, two-, and/or three-phase. The IED is also suitable for protection of cable feeders to generator block transformers.

The phase segregated current differential protection provides an excellent sensitivity for high resistive faults and gives a secure phase selection. The availability of six stabilized current inputs per phase allows use on multi-breaker arrangements in three terminal applications or up to five terminal applications with single breaker arrangements. The communication between the IEDs involved in the differential scheme is based on the IEEE C37.94 standard and can be duplicated for important installations when required for redundancy reasons. Charging current compensation allows high sensitivity also on long overhead lines and cables.

A full scheme distance protection is included to provide independent protection in parallel with the differential scheme in case of a communication channel failure for the differential scheme. The distance protection then provide protection for the entire line including the remote end back up capability either in case of a communications failure or via use of an independent communication channel to provide a fully redundant scheme of protection (that is a second main protection scheme). Eight channels for intertrip and other binary signals are available in the communication between the IEDs.

A high impedance differential protection can be used to protect T-feeders or line reactors.

The **auto-reclose** for single-, two- **and/or three** phase reclosing includes priority circuits for multi-breaker arrangements. It co-operates with the synchronism check function with high-speed or delayed reclosing.

High set instantaneous phase and earth overcurrent, four step directional or un-directional delayed phase and earth overcurrent, thermal overload and two step under- and overvoltage functions are examples of the available functions allowing the user to fulfill any application requirement.

The IED can also be provided with full control and interlocking functionality including co-operation with the synchronism check function to allow integration of the main or back-up control.

Disturbance recording and fault locator are available to allow independent post-fault analysis after primary disturbances. The Disturbance recorder will also show remote station currents, as received to this IED, time compensated with measure communication time.

Out of Step function is available to separate power system sections close to electrical centre at occurring out of step.

RED670 can be used in applications with IEC 61850-9-2LE process bus with up to four merging units (MU) depending on other functionality included in the IED

Each MU has eight analogue channels, normally four currents and four voltages. Conventional and Merging Unit channels can be mixed freely in the application.

The logic is prepared with a graphical tool. The advanced logic capability allows special applications such as automatic opening of disconnectors in multi-breaker arrangements, closing of breaker rings, load transfer logics etc. The graphical configuration tool ensures simple and fast testing and commissioning.

A loop testing function allows complete testing including remote end IED when local IED is set in test mode.

Communication via optical connections ensures immunity against disturbances.

Four packages have been defined for following applications:

- Single-breaker (double or single bus) with three phase tripping (A31)
- Single-breaker (double or single bus) with single phase tripping (A32)
- Multi-breaker (one-and a half or ring) with three phase tripping (B31)
- Multi-breaker (one-and a half or ring) with single phase tripping (B32)

Optional functions are not configured but a maximum configuration with all optional functions are available as templates in the graphical configuration tool. Analog inputs and binary input/output signals are pre-defined for basic use. Other signals may be required by each particular application.

Add binary I/O boards as required for the application when ordering.

"Basic IED functions"

Description of configuration A31

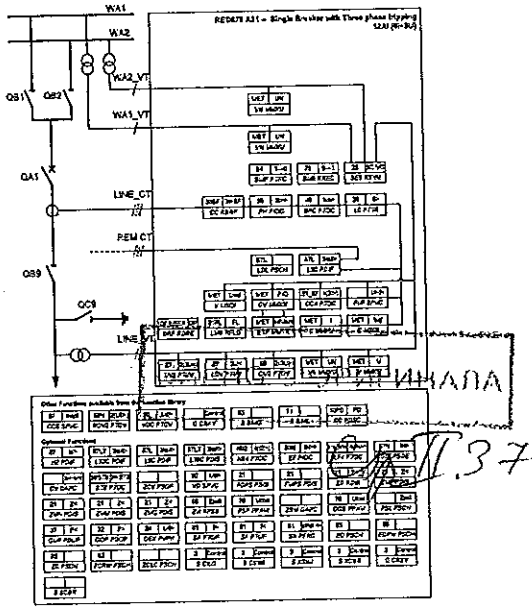


Figure 1. Configuration diagram for

Description of configuration A32

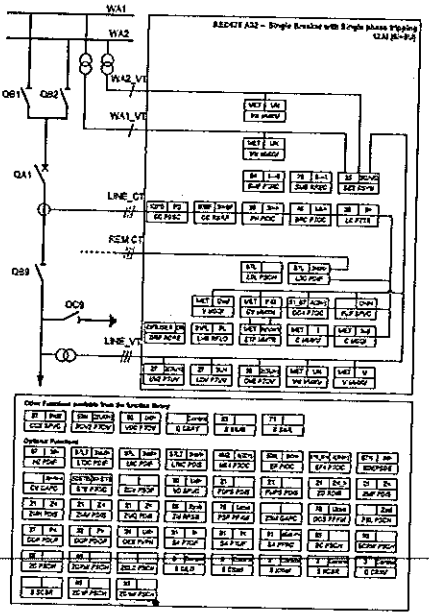


Figure 2. Configuration diagram for configuration A32

Description of configuration B31

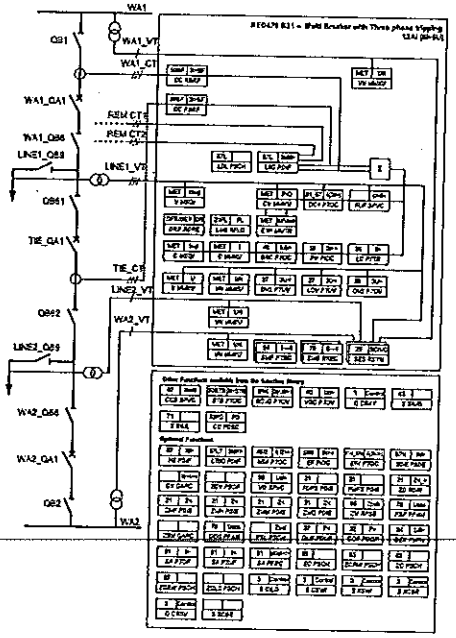


Figure 3. Configuration diagram for configuration B31

Description of configuration B32

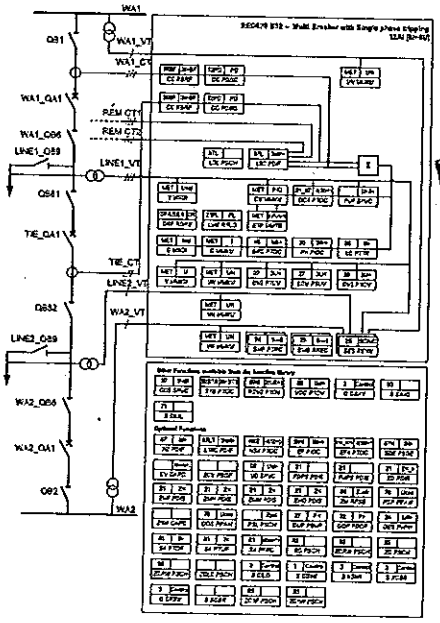


Figure 4. Configuration diagram for configuration B32

2. Available functions

Main protection functions

2 = number of basic instances
0-3 = option quantities
3-A03 = optional function included in packages A03 (refer to ordering details)

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
Differential protection							
HZPDIF	87	1Ph high impedance differential protection	0-3	3-A02	3-A02	3-A02	3-A02
REFPDIF	87N	Restricted earth fault protection, low impedance	0-2				
L3CPDIF	87L	Line differential protection, 3 CT sets, 2-3 line ends	1	1		1	
L6CPDIF	87L	Line differential protection, 6 CT sets, 3-5 line ends	1	1-A04	1	1-A04	1
LT3CPDIF	87LT	Line differential protection, 3 CT sets, with 1 power transformers, 2-3 line ends	1	1-A05		1-A05	
LT6CPDIF	87LT	Line differential protection, 6 CT sets, with 1 power transformers, 3-5 line ends	1	1-A06	1-A06	1-A06	1-A06
LDLPSCH	87L	Line differential protection logic	1	1	1	1	1
LDRGFC	11RSL	Additional security logic for differential protection	0-1				
Impedance protection							
ZMQPDIS, ZMQAPDIS	21	Distance protection zone, quadrilateral characteristic	0-5	1-B13 3-B11	1-B16 3-B11	1-B10 3-B11	1-B10 3-B11
ZDRDIR	21D	Directional impedance quadrilateral	0-2	1-B11	1-B11	1-B11	1-B11
ZMCAPDIS	21	Additional distance measuring zone, quadrilateral characteristic	0-5	3-B16	3-B16	3-B16	3-B16
ZMCPDIS, ZMCAPDIS	21	Distance measuring zone, quadrilateral characteristic for series compensated lines	0-5	1-B16	1-B16	1-B16	1-B16
ZDSRDIR	21D	Directional impedance quadrilateral, including series compensation	0-2	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16
FDPSPDIS	21	Phase selection, quadrilateral characteristic with fixed angle	0-5	4-B17	4-B17	4-B17	4-B17
ZMHPDIS	21	Fullscheme distance protection, mho characteristic	0-5	4-B17	4-B17	4-B17	4-B17
ZMMPDIS, ZMMAPDIS	21	Fullscheme distance protection, quadrilateral for earth faults	0-2	1-B17	1-B17	1-B17	1-B17
ZDMRDIR	21D	Directional impedance element for mho characteristic	0-2	1-B17	1-B17	1-B17	1-B17
ZDARDIR		Additional distance protection directional function for earth faults	0-1	1-B17	1-B17	1-B17	1-B17
ZSMGAPC		Mho impedance supervision logic	0-2	2-B17	2-B17	2-B17	2-B17
FMPSPDIS	21	Faulty phase identification with load enchroachment	0-5				
ZMRPDIS, ZMRAPDIS	21	Distance protection zone, quadrilateral characteristic, separate settings	0-2				
FRPSPDIS	21	Phase selection, quadrilateral characteristic with fixed angle	0-1				
ZMFPDIS	21	High speed distance protection	0-1	1-B19	1-B19	1-B19	1-B19
ZMFCPDIS	21	High speed distance protection for series compensated lines	0-1	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16
ZMRPSB	68	Power swing detection					

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
PSLPSCH		Power swing logic	0-1	1-B03	1-B03	1-B03	1-B03
PSPPPAM	78	Pole slip/out-of-step protection	0-1	1-B22	1-B22	1-B22	1-B22
OOSPPAM	78	Out-of-step protection	0-1	1-B22	1-B22	1-B22	1-B22
ZCVPSOF		Automatic switch onto fault logic, voltage and current based	0-1	1-B11 1-B16 1-B17	1-B11 1-B16 1-B17	1-B11 1-B16 1-B17	1-B11 1-B16 1-B17
PPLPHIZ		Phase preference logic	0-1	1-B04			

Back-up protection functions

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
Current protection							
PHPIOC	50	Instantaneous phase overcurrent protection	0-3	1	1	1	1
OC4PTOC	51_67[1]	Four step phase overcurrent protection	0-3	1	1	1	1
EFPIOC	50N	Instantaneous residual overcurrent protection	0-1	1-C24	1-C24	1-C24	1-C24
EF4PTOC	51N 67N[2]	Four step residual overcurrent protection	0-3	1-C24	1-C24	1-C24	1-C24
NS4PTOC	46I2	Four step directional negative phase sequence overcurrent protection	0-2	1-C24	1-C24	1-C24	1-C24
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	0-1	1-C16	1-C16	1-C16	1-C16
LCPTTR	26	Thermal overload protection, one time constant, Celsius	0-2	1	1	1	1
LFPTTR	26	Thermal overload protection, one time constant, Fahrenheit	0-2	1	1	1	1
CCRBRF	50BF	Breaker failure protection	0-2	1	2	1	2
STBPTOC	50STB	Stub protection	0-2	1-B11	1B 1-B11	1-B11	1B 1-B11
CCPDSC	52PD	Pole discordance protection	0-2	1	2	1	2
GUPPDUP	37	Directional underpower protection	0-2	1-C17	1-C17	1-C17	1-C17
GOPPDOP	32	Directional overpower protection	0-2	1-C17	1-C17	1-C17	1-C17
BRCPTOC	46	Broken conductor check	1	1	1	1	1
VRPVOC	51V	Voltage restrained overcurrent protection	0-3				
Voltage protection							
UV2PTUV	27	Two step undervoltage protection	0-2	1	1	1	1
OV2PTOV	59	Two step overvoltage protection	0-2	1	1	1	1
ROV2PTOV	59N	Two step residual overvoltage protection	0-2	1	1	1	1
OEXPVPH	24	Overexcitation protection	0-1	1-D03	1-D03	1-D03	1-D03
VDCPTOV	60	Voltage differential protection	0-2	2	2	2	2
LOVPTUV	27	Loss of voltage check	1	1	1	1	1
PAPGAPC	27	Radial feeder protection	0-1				
Frequency protection							
SAPTUF	81	Underfrequency protection	0-2	2-E02	2-E02	2-E02	2-E02
SAPTOF	81	Overfrequency protection	0-2	2-E02	2-E02	2-E02	2-E02
SAPFRC	81	Rate-of-change frequency protection	0-2	2-E02	2-E02	2-E02	2-E02

ВЯРНО С ОРИГИНАЛА

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
Multipurpose protection							
CVGAPC		General current and voltage protection	0-4	4-F01	4-F01	4-F01	4-F01
General calculation							
SMAIPAC		Multipurpose filter	0-6				

1) 67 requires voltage
2) 67N requires voltage

ЕЛЕКТРИК СОФИЯ ООД

Спец. 372

Control and monitoring functions

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
Control							
SESRSYN	25	Synchrocheck, energizing check and synchronizing	0-2	1	2	1	2
SMBRREC	79	Autorecloser	0-4	1 1-H04	2 2-H05	1 1-H04	2 2-H05
APC8	3	Apparatus control for single bay, max 8 apparatuses (1CB) incl. interlocking	0-1	1-H07		1-H07	
APC15	3	Apparatus control for single bay, max 15 apparatuses (2CBs) incl. interlocking	0-1		1-H06		1-H06
QCBAY		Apparatus control	1	1	1	1	1
LOCREM		Handling of LR-switch positions	1	1	1	1	1
LOCREMCTRL		LHMI control of PSTO	1	1	1	1	1
SLGAPC		Logic rotating switch for function selection and LHMI presentation	15	15	15	15	15
VSGAPC		Selector mini switch	20	20	20	20	20
DPGAPC		Generic communication function for Double Point Indication	16	16	16	16	16
SPC8GAPC		Single point generic control 8 signals	5	5	5	5	5
AUTOBITS		AutomationBits, command function for DNP3.0	3	3	3	3	3
SINGLECMD		Single command, 16 signals	4	4	4	4	4
I103CMD		Function commands for IEC 60870-5-103	1	1	1	1	1
I103GENCMD		Function commands generic for IEC 60870-5-103	50	50	50	50	50
I103POSCMD		IED commands with position and select for IEC 60870-5-103	50	50	50	50	50
I103IEDCMD		IED commands for IEC 60870-5-103	1	1	1	1	1
I103USRCMD		Function commands user defined for IEC 60870-5-103	1	1	1	1	1
Secondary system supervision							
CCSSPVC	87	Current circuit supervision					
FUFSPVC		Fuse failure supervision	0-2 0-3	1 3	2 3	1 3	2 3
VDSPVC	60	Fuse failure supervision based on voltage difference	0-3	1-G03	1-G03	1-G03	1-G03
Logic							
SMPPTRC	94	Tripping logic	1-6	6	6	6	6
TMAGAPC		Trip matrix logic	12	12	12	12	12
ALMCALH		Logic for group alarm	5	5	5	5	5
WRNCALH		Logic for group warning	5	5	5	5	5
INDCALH		Logic for group indication	5	5	5	5	5

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
AND, GR, INV, PULSETIMER, GATE, TIMERSET, XOR, LLD, SRMEMORY, RSMEMORY		Configurable logic blocks	40-280	40-280	40-280	40-280	40-280
ANDQT, ORQT, INVERTERQT, XORQT, SRMEMORYQT, RSMEMORYQT, TIMERSETQT, PULSETIMERQT, INVALIDQT, INDCOMBSPQT, INDEXTSPQT		Configurable logic blocks Q/T	0-1				
SLGAPC, VSGAPC, AND, OR, PULSETIMER, GATE, TIMERSET, XOR, LLD, SRMEMORY, INV		Extension logic package	0-1				
FXDSIGN		Fixed signal function block	1	1	1	1	1
B16I		Boolean 16 to Integer conversion	18	18	18	18	18
BTIGAPC		Boolean 16 to Integer conversion with Logic Node representation	16	16	16	16	16
IB16		Integer to Boolean 16 conversion	16	16	16	16	16
ITBGAPC		Integer to Boolean 16 conversion with Logic Node representation	16	16	16	16	16
TEIGAPC		Elapsed time integrator with limit transgression and overflow supervision	12	12	12	12	12
Monitoring							
CVMMXN, CMMXU, VMMXU, CMSQI, VMSQI, VNMMXU		Measurements	6	6	6	6	6
AISVBAS		Function block for service value presentation of secondary analog inputs	1	1	1	1	1
EVENT		Event function	20	20	20	20	20

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
DRPRDRE, A1RADR, A2RADR, A3RADR, A4RADR, B1RBDR, B2RBDR, B3RBDR, B4RBDR, B5RBDR, B6RBDR		Disturbance report	1	1	1	1	1
SPGAPC		Generic communication function for Single Point Indication	64	64	64	64	64
SP16GAPC		Generic communication function for Single Point Indication 16 inputs	16	16	16	16	16
MVGAPC		Generic communication function for Measured Value	24	24	24	24	24
BINSTATREP		Logical signal status report	3	3	3	3	3
RANGE_XP		Measured value expander block	66	66	66	66	66
SSIMG	63	Gas medium supervision	21	21	21	21	21
SSIML	71	Liquid medium supervision	3	3	3	3	3
SSCBR		Circuit breaker monitoring	0-2	1-M11	2-M12	1-M11	2-M12
LMBRFLO		Fault locator	1	1	1	1	1
I103MEAS		Measurands for IEC 60870-5-103	1	1	1	1	1
I103MEASUSR		Measurands user defined signals for IEC 60870-5-103	3	3	3	3	3
I103AR		Function status auto-recloser for IEC 60870-5-103	1	1	1	1	1
I103EF		Function status earth-fault for IEC 60870-5-103	1	1	1	1	1
I103FLTPROT		Function status fault protection for IEC 60870-5-103	1	1	1	1	1
I103IED		IED status for IED 60870-5-103	1	1	1	1	1
I103SUPERV		Supervision status for IEC 60870-5-103	1	1	1	1	1
I103USRDEF		Status for user defined signals for IEC 60870-5-103	20	20	20	20	20
L4UFCNT		Event counter with limit supervision	30	30	30	30	30
Metering							
PCFCNT		Pulse-counter logic	16	16	16	16	16
ETPMMTR		Function for energy calculation and demand handling	6	6	6	6	6

Communication

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
Station communication							
LONSPA, SPA		SPA communication protocol	1	1	1	1	1
ADE		LON communication protocol	1	1	1	1	1
HORZCOMM		Network variables via LON	1	1	1	1	1
PROTOCOL		Operation selection between SPA and IEC 60870-5-103 for SLM	1	1	1	1	1
RS485PROT		Operation selection for RS485	1	1	1	1	1
RS485GEN		RS485	1	1	1	1	1
DNPGEN		DNP3.0 communication general protocol	1	1	1	1	1
DNPGENTCP		DNP3.0 communication general TCP protocol	1	1	1	1	1
CHSERRS485		DNP3.0 for EIA-485 communication protocol	1	1	1	1	1
CH1TCP, CH2TCP, CH3TCP, CH4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1	1
CHSEROPT		DNP3.0 for TCP/IP and EIA-485 communication protocol	1	1	1	1	1
MST1TCP, MST2TCP, MST3TCP, MST4TCP		DNP3.0 for serial communication protocol	1	1	1	1	1
DNPFREC		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol	1	1	1	1	1
IEC61850-8-1		Parameter setting function for IEC 61850	1	1	1		1
GOOSENTLK RCV		Horizontal communication via GOOSE for interlocking	59	59	59	59	59
GOOSEBINR		Goose binary receive	16	16	16	16	16
GOOSEDPRC		GOOSE function block to receive a double point value	64	64	64	64	64
GOOSEINTR V		GOOSE function block to receive an integer value	32	32	32	32	32
GOOSEMVR		GOOSE function block to receive a measurand value	60	60	60	60	60
GOOSESPR V		GOOSE function block to receive a single point value	64	64	64	64	64
MULTICMDRC		Multiple command and transmit	60/10	60/10	60/10	60/10	60/10
MULTICMDSN							

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
FRONT, LANABI, LANAB, LANCDI, LANCD		Ethernet configuration of links	1	1	1	1	1
GATEWAY		Ethernet configuration of link one	1	1	1	1	1
OPTICAL103		IEC 60870-5-103 Optical serial communication	1	1	1	1	1
RS485103		IEC 60870-5-103 serial communication for RS485	1	1	1	1	1
AGSAL		Generic security application component	1	1	1	1	1
LDCLLN0		IEC 61850 LD0 LLN0	1	1	1	1	1
SYSLLN0		IEC 61850 SYS LLN0	1	1	1	1	1
LPHD		Physical device information	1	1	1	1	1
PCMACCS		IED Configuration Protocol	1	1	1	1	1
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1	1	1
FSTACCS		Field service tool access via SPA protocol over ethernet communication	1	1	1	1	1
ACTIVLOG		Activity logging parameters	1	1	1	1	1
ALTRK		Service Tracking	1	1	1	1	1
SINGLELCCH		Single ethernet port link status	1	1	1	1	1
PRPSTATUS		Dual ethernet port link status	1	1	1	1	1
		Process bus communication IEC 61850-9-2 LE					
PRP		IEC 62439-3 parallel redundancy protocol	0-1	1-P03	1-P03	1-P03	1-P03
Remote communication							
		Binary signal transfer receive/transmit	6/36	6/36	6/36	6/36	6/36
		Transmission of analog data from LDCM	1	1	1	1	1
		Receive binary status from remote LDCM	6/3/3	6/3/3	6/3/3	6/3/3	6/3/3
Scheme communication							
ZCPSCH	85	Scheme communication logic for distance or overcurrent protection	0-1	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16
ZC1PPSCH	85	Phase segregated scheme communication logic for distance protection	0-1			1-B05	1-B05
ZCRWPSCH	85	Current reversal and weak-end infeed logic for distance protection	0-1	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16
ZC1WPSCH	85	Current reversal and weak-end infeed logic for phase segregated communication	0-1			1-B05	1-B05
ZCLCPSCH		Local acceleration logic	0-1	1-B11	1-B11	1-B11	1-B11

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
ECPSCH	85	Scheme communication logic for residual overcurrent protection	0-1	1-C24	1-C24	1-C24	1-C24
ECRWPSCH	85	Current reversal and weak-end infeed logic for residual overcurrent protection	0-1	1-C24	1-C24	1-C24	1-C24
DTT		Direct transfer trip	0-1				

1) Only included for 3-PLE products

Basic IED functions

Table 1. Basic IED functions

IEC 61850 or function name	Description
INTERRSIG	Self supervision with internal event list
SELFSUPEVLST	Self supervision with internal event list
TIMESYNCHGEN	Time synchronization module
SYNCHBIN, SYNCHCAN, SYNCHCMPPS, SYNCHLON, SYNCHPPH, SYNCHPPS, SYNCHSNTP, SYNCHSPA, SYNCHCMPPS	Time synchronization
TIMEZONE	Time synchronization
DSTBEGIN, DSTENABLE, DSTEND	GPS time synchronization module
IRIG-B	Time synchronization
SETGRPS	Number of setting groups
ACTVGRP	Parameter setting groups
TESTMODE	Test mode functionality
CHNGLCK	Change lock function
SMSI	Signal matrix for binary inputs
SMBO	Signal matrix for binary outputs
SMMI	Signal matrix for mA inputs
SMAI1 - SMAI20	Signal matrix for analog inputs
3PHSUM	Summation block 3 phase
ATHSTAT	Authority status
ATHCHCK	Authority check
AUTHMAN	Authority management
FTPACCS	FTP access with password
SPACOMMMAP	SPA communication mapping
SPATD	Date and time via SPA protocol
DOSFRNT	Denial of service, frame rate control for front port
DOSLANAB	Denial of service, frame rate control for OEM port AB
DOSLANCD	Denial of service, frame rate control for OEM port CD
DOSSCKT	Denial of service, socket flow control
GBASVAL	Global base values for settings
PRIMVAL	Primary system values
ALTMS	Time master supervision
ALTIM	Time management

Table 1. Basic IED functions, continued

IEC 61850 or function name	Description
ALTRK	Service tracking
ACTIVLOG	Activity logging parameters
FSTACCS	Field service tool access via SPA protocol over ethernet communication
PCMACCS	IED Configuration Protocol
SECALARM	Component for mapping security events on protocols such as DNP3 and IEC103
DNPGEN	DNP3.0 communication general protocol
DNPGENTCP	DNP3.0 communication general TCP protocol
CHSEROPT	DNP3.0 for TCP/IP and EIA-485 communication protocol
MSTSER	DNP3.0 for serial communication protocol
OPTICAL103	IEC 60870-5-103 Optical serial communication
RS485103	IEC 60870-5-103 serial communication for RS485
IEC61850-8-1	Parameter setting function for IEC 61850
HORZCOMM	Network variables via LON
LONSPA	SPA communication protocol
LEDGEN	General LED indication part for LHMI

3. Differential protection

1Ph High Impedance differential protection HZPDIF

The 1Ph High Impedance differential protection HZPDIF functions can be used when the involved CT cores have the same turns ratio and similar magnetizing characteristics. It utilizes an external CT secondary current summation by wiring. All galvanically all CT secondary circuits which are involved in the differential scheme are connected in parallel. External series resistor, and a voltage dependant resistor which are both mounted externally to the IED, are also required.

The external resistor unit shall be ordered under IED accessories in the Product Guide.

HZPDIF can be used to protect tee-feeders or busbars, reactors, motors, auto-transformers, capacitor banks and so on. One such function block is used for a high-impedance restricted earth fault protection. Three such function blocks are used to form three-phase, phase-segregated differential protection. Several function block instances (for example, six) can be available in a single IED.

Restricted earth-fault protection, low impedance REFPDIF

Restricted earth-fault protection, low-impedance function REFPDIF can be used on all directly or low-impedance earthed windings. The REFPDIF function provides high sensitivity and high speed tripping as it protects each winding separately and thus does not need inrush stabilization.

The REFPDIF function is a percentage biased function with an additional zero sequence current directional comparison criterion. This gives excellent sensitivity and stability during through faults.

REFPDIF can also protect autotransformers. Five currents are measured at the most complicated configuration as shown in Figure 5.

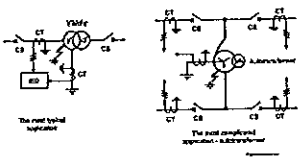


Figure 5. Examples of applications of the REFPDIF

Line differential protection, 3 or 6 CT sets, L3CPDIF, L6CPDIF

Line differential protection applies the Kirchhoff's law and compares the currents entering and leaving the protected multi-terminal circuit, consisting of overhead power lines,

power transformers and cables. Under the condition that there are no in-line or tap (shunt) power transformers within the zone of protection, it offers a phase-segregated fundamental frequency current based differential protection with high sensitivity and provides phase selection information for single-pole tripping.

The three-terminal version is used for conventional two-terminal lines with or without a 1½ circuit breaker arrangement in one end, as well as three-terminal lines with single breaker arrangements at all terminals.

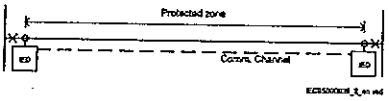


Figure 6. Example of application on a conventional two-terminal line

The six-terminal versions are used for conventional two-terminal lines with 1½ circuit breaker arrangements in both ends, as well as multi-terminal lines with up to five terminals.

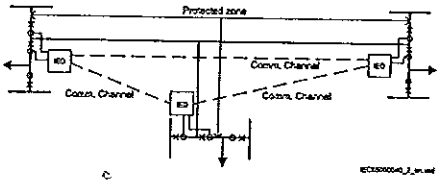


Figure 7. Example of application on a three-terminal line with 1½ breaker arrangements

The current differential algorithm provides high sensitivity for internal faults and it has excellent stability for external faults. Current samples from all CTs are exchanged between the IEDs in the line ends (master-master mode) or sent to one IED (master-slave mode) for evaluation.

A restrained dual biased slope evaluation is made where the bias current is the highest phase current in any line end, giving a secure through-fault stability even with heavily saturated CTs. In addition to the restrained evaluation, an unrestrained (instantaneous) high differential current setting can be used for fast tripping of internal faults with very high currents.

A special feature with this function is that applications with small power transformers (rated current less than 50% of the differential current setting *IdMin*) connected as line taps (that is, as shunt power transformers), without measurements of currents in the tap, can be handled. The normal load current is considered to be negligible, and special measures must be taken in the event of a short circuit on the LV side of the transformer. In this application, the tripping of the differential protection can be time-delayed for low differential currents to achieve coordination with downstream overcurrent IEDs. The local protection of the small tap power transformer is given the time needed to disconnect the faulty transformer.

A line charging current compensation provides increased sensitivity of line differential protection.

Line differential protection 3 or 6 CT sets, with in-zone transformers LT3CPDIF, LT6CPDIF
Two two-winding power transformers or one three-winding power transformer can be included in the line differential protection zone. Both two- and three-winding transformers are correctly represented with vector group compensations made in the algorithm. The function includes 2nd and 5th harmonic restraint and zero-sequence current elimination.

The phase-segregated differential protection with single-pole tripping is usually not possible in such applications.

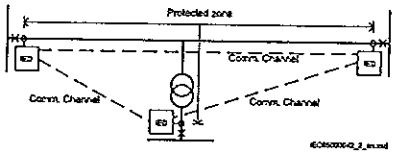


Figure 8. Example of application on a three-terminal line with an in-line power transformer in the protection zone

Analog signal transfer for line differential protection
The line differential protection function can be arranged as a master-master system or a master-slave system alternatively. In the former, current samples are exchanged between all IEDs, and an evaluation is made in each IED. This means that a 64 kbit/s communication channel is needed between every IED included in the same line differential protection zone. In the latter, current samples are sent from all slave IEDs to one master IED where the evaluation is made, and trip signals are sent to the remote ends when needed. In this system, a 64 kbit/s communication channel is only needed between the master, and each one of the slave IEDs. The Master-Slave condition for the differential function appears automatically when the setting *Operation* for the differential function is set to *On*.

It is recommended to use the same firmware version as well as hardware version for a specific RED670 scheme.

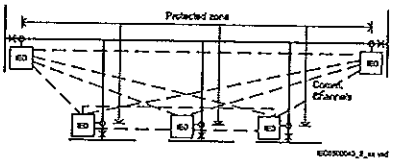


Figure 9. Five terminal lines with master-master system

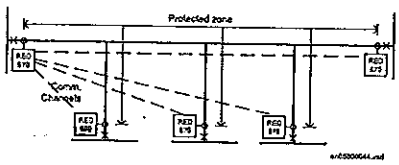


Figure 10. Five terminal line with master-slave system

Current samples from IEDs located geographically apart from each other, must be time coordinated so that the current differential algorithm can be executed correctly. In the IED, it is possible to make this coordination in two different ways. The echo method of time synchronizing is normally used whereas for applications where transmit and receive times can differ, the optional built in GPS receivers can be used.

The communication link is continuously monitored, and an automatic switchover to a standby link is possible after a preset time.

Additional security logic for differential protection LDRGFC
Additional security logic for differential protection (LDRGFC) can help the security of the protection especially when the communication system is in abnormal status or for example when there is unspecified asymmetry in the communication link. It helps to reduce the probability for mal-operation of the protection. LDRGFC is more sensitive than the main protection logic to always release operation for all faults detected by the differential function. LDRGFC consists of four *sub functions*:

- Phase-to-phase current variation
- Zero sequence current criterion
- Low voltage criterion
- Low current criterion

Phase-to-phase current variation takes the current samples as input and it calculates the variation using the sampling value based algorithm. Phase-to-phase current variation function is major one to fulfil the objectives of the startup element.

Zero sequence criterion takes the zero sequence current as input. It increases the security of protection during the high impedance fault conditions.

Low voltage criterion takes the phase voltages and phase-to-phase voltages as inputs. It increases the security of protection when the three-phase fault occurred on the weak end side.

Low current criterion takes the phase currents as inputs and it increases the dependability during the switch onto fault case of unloaded line.

The differential function can be allowed to trip as no load is fed through the line and protection is not working correctly.

Features:

- Startup element is sensitive enough to detect the abnormal status of the protected system
- Startup element does not influence the operation speed of main protection
- Startup element would detect the evolving faults, high impedance faults and three phase fault on weak side
- It is possible to block the each sub function of startup element
- Startup signal has a settable pulse time

4. Impedance protection

FunctionalityDistance measuring zone, quadrilateral characteristic ZMQPDIS, ZMQAPDIS [21]
The line distance protection is a five three zone full scheme protection with three fault loops for phase-to-phase faults and three fault loops for phase-to-earth faults for each of the independent zones. Individual settings for each zone in resistive and reactive reach gives flexibility for use as back-up protection for transformer connected to overhead lines and cables of different types and lengths.

ZMQPDIS together with Phase selection with load encroachment FDPSPDIS has functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines, as shown in figure 11.

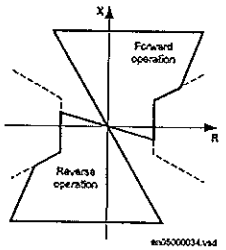


Figure 11. Typical quadrilateral distance protection zone with Phase selection with load encroachment function FDPSPDIS activated

The independent measurement of impedance for each fault loop together with a sensitive and reliable built-in phase selection makes the function suitable in applications with single-phase autoreclosing.

Built-in adaptive load compensation algorithm prevents overreaching of zone 1 at load exporting end at phase-to-earth faults on heavily loaded power lines.

The distance protection zones can operate independently of each other in directional (forward or reverse) or non-directional mode. This makes them suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines, and so on.

Distance measuring zone, quadrilateral characteristic for series compensated lines ZMCPDIS, ZMCAPDIS
The line distance protection is a five three zone full scheme protection with three fault loops for phase-to-phase faults and three fault loops for phase-to-earth fault for each of the independent zones. Individual settings for each zone resistive and reactive reach gives flexibility for use on overhead lines and cables of different types and lengths.

Mho characteristic is available.

Phase selection has functionality for load encroachment which increases the possibility to detect high resistive faults on heavily loaded lines

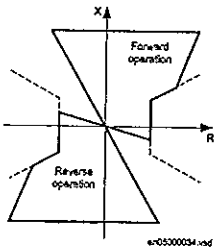


Figure 12. Typical quadrilateral distance protection zone with load encroachment function activated

The independent measurement of impedance for each fault loop together with a sensitive and reliable built in phase selection makes the function suitable in applications with single phase auto-reclosing.

Built-in adaptive load compensation algorithm for the quadrilateral function prevents overreaching of zone1 at load exporting end at phase to earth-faults on heavily loaded power lines.

The distance protection zones can operate, independent of each other, in directional (forward or reverse) or non-directional mode. This makes them suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines.

Phase selection, quadrilateral characteristic with fixed angle FDPSPDIS
The operation of transmission networks today is in many cases close to the stability limit. Due to environmental considerations, the rate of expansion and reinforcement of the power system is reduced, for example, difficulties to get permission to build new power lines. The ability to accurately and reliably classify the different types of fault, so that single pole tripping and autoreclosing can be used plays an important role in this matter. Phase selection, quadrilateral characteristic with fixed angle FDPSPDIS is designed to accurately select the proper fault loop in the distance function dependent on the fault type.

The heavy load transfer that is common in many transmission networks may make fault resistance coverage difficult to achieve. Therefore, FDPSPDIS has a built-in algorithm for load encroachment, which gives the possibility to enlarge the

resistive setting of both the phase selection and the measuring zones without interfering with the load.

The extensive output signals from the phase selection gives also important information about faulty phase(s), which can be used for fault analysis.

A current-based phase selection is also included. The measuring elements continuously measure three phase currents and the residual current and, compare them with the set values.

Full-scheme distance measuring, Mho characteristic ZMHPDIS
The numerical mho line distance protection is a four zone full scheme protection for back-up detection of short circuit and earth faults. The numerical mho line distance protection is a three zone full scheme protection for back-up detection of short circuit and earth faults.

The four zones have fully independent measuring and settings, which gives high flexibility for all types of lines.

The IED can be used up to the highest voltage levels. It is suitable for the protection of heavily loaded lines and multi-terminal lines where the requirement for tripping is one-, two- and/or three-pole.

The independent measurement of impedance for each fault loop together with a sensitive and reliable phase selection makes the function suitable in applications with single phase autoreclosing.

Built-in selectable zone timer logic is also provided in the function.

Adaptive load compensation algorithm prevents overreaching at phase-to-earth faults on heavily loaded power lines, see Figure 13.

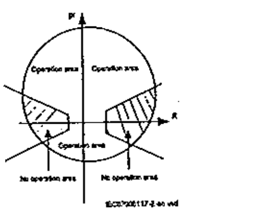


Figure 13. Load encroachment influence on the offset mho characteristic

The distance protection zones can operate, independent of each other, in directional (forward or reverse) or non-directional mode (offset). This makes them suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines and so on.

The possibility to use the phase-to-earth quadrilateral impedance characteristic together with the mho characteristic increases the possibility to overcome eventual lack of sensitivity of the mho element due to the shaping of the curve at remote end faults.

The integrated control and monitoring functions offer effective solutions for operating and monitoring all types of transmission and sub-transmission lines.

Full scheme distance protection, quadrilateral for earth faults ZMMPDIS, ZMMAPDIS
The line distance protection is a five zone protection with three fault loops for phase-to-earth- fault for each of the independent zones. Individual settings for each zone resistive and reactive reach give flexibility for use on overhead lines and cables of different types and lengths.

The Full-scheme distance protection, quadrilateral for earth fault functions ZMMOPIS and ZMMAPDIS have functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines. , see Figure 11.

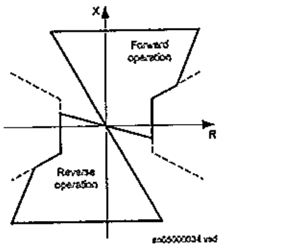


Figure 14. Typical quadrilateral distance protection zone with Phase selection, quadrilateral characteristic with settable angle function FRPSPDIS activated

The independent measurement of impedance for each fault loop together with a sensitive and reliable built in phase selection makes the function suitable in applications with single phase auto-reclosing.

The distance protection zones can operate, independent of each other, in directional (forward or reverse) or non-directional mode. This makes them suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines.

Directional impedance element for Mho characteristic ZDMRDIR
The phase-to-earth impedance elements can be optionally supervised by a phase unselective directional function (phase unselective, because it is based on symmetrical components).

Mho impedance supervision logic ZSMGAPC
The Mho impedance supervision logic (ZSMGAPC) includes features for fault inception detection and high SIR detection. It also includes the functionality for loss of potential logic as well as for the pilot channel blocking scheme.

ZSMGAPC can mainly be decomposed in two different parts:

1. A fault inception detection logic
2. High SIR detection logic

Faulty phase identification with load encroachment FMPSPDIS
The ability to accurately and reliably classify different types of fault so that single phase tripping and autoreclosing can be used plays an important roll in today's power systems.

The phase selection function is design to accurately select the proper fault loop(s) in the distance function dependent on the fault type.

The heavy load transfer that is common in many transmission networks may in some cases interfere with the distance protection zone reach and cause unwanted operation. Therefore the function has a built in algorithm for load encroachment, which gives the possibility to enlarge the resistive setting of the measuring zones without interfering with the load.

The output signals from the phase selection function produce important information about faulty phase(s), which can be used for fault analysis as well.

Distance protection zone, quadrilateral characteristic, separate settings ZMRPDIS, ZMRAPDIS
The line distance protection is up to five zone full scheme protection with three fault loops for phase-to-phase faults and three fault loops for phase-to-earth fault for each of the independent zones. Individual settings for each zone in resistive and reactive reach gives flexibility for use as back-up protection for transformer connected to overhead lines and cables of different types and lengths.

Mho alternative quadrilateral characteristic is available.

ZMRPDIS together with Phase selection, quadrilateral characteristic with settable angle FRPSPDIS has functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines, as shown in figure 11.

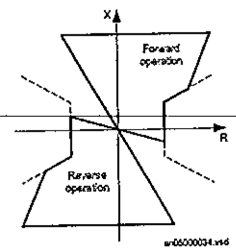


Figure 15. Typical quadrilateral distance protection zone with Phase selection, quadrilateral characteristic with settable angle function FRPSPDIS activated

The independent measurement of impedance for each fault loop together with a sensitive and reliable built-in phase selection makes the function suitable in applications with single pole tripping and autoreclosing.

Built-in adaptive load compensation algorithm prevents overreaching of zone 1 at load exporting end at phase-to-earth faults on heavily loaded power lines.

The distance protection zones can operate, independent of each other, in directional (forward or reverse) or non-directional mode. This makes them suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines and so on.

Phase selection, quadrilateral characteristic with settable angle FRPSPDIS
The operation of transmission networks today is in many cases close to the stability limit. Due to environmental considerations, the rate of expansion and reinforcement of the power system is reduced for example, difficulties to get permission to build new power lines. The ability to accurately and reliably classify the different types of fault, so that single pole tripping and autoreclosing can be used plays an important role in this matter. The phase selection function is designed to accurately select the proper fault loop in the distance function dependent on the fault type.

The heavy load transfer that is common in many transmission networks may make fault resistance coverage difficult to achieve. Therefore, the function has a built in algorithm for load encroachment, which gives the possibility to enlarge the resistive setting of both the phase selection and the measuring zones without interfering with the load.

The extensive output signals from the phase selection gives also important information about faulty phase(s) which can be used for fault analysis.

A current-based phase selection is also included. The measuring elements continuously measure three phase currents and the residual current and, compare them with the set values.

Distance zones quad with high speed distance protection ZMFPDIS
The High speed distance protection (ZMFPDIS) is providing sub-cycle, down towards half-cycle, operate time for basic faults within 60% of the line length and up to around SIR 5. At the same time, it is specifically designed for extra care during difficult conditions in high voltage transmission networks, like faults on long heavily loaded lines and faults generating heavily distorted signals. These faults are handled with outmost security and dependability, although sometimes with reduced operating speed.

The ZMFPDIS function is a six zone full scheme protection with three fault loops for phase-to-phase faults and three fault loops for phase-to-earth faults for each of the independent zones, which makes the function suitable in applications with single-phase autoreclosing.

The zones can operate independently of each other in directional (forward or reverse) or non-directional mode. However, zone1 and zone2 is designed to measure in forward direction only, while one zone (ZRV) is designed to measure in the reverse direction. This makes them suitable, together with a communication scheme, for protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines, and so on.

A new built-in adaptive load compensation algorithm prevents overreaching of the distance zones in the load exporting end during phase-to-earth faults on heavily loaded power lines. It also reduces underreach in the importing end.

The ZMFPDIS function-block itself incorporates a phase-selection element and a directional element, contrary to previous designs in the 670-series, where these elements were represented with separate function-blocks.

The operation of the phase-selection element is primarily based on current change criteria (i.e. delta quantities), with significantly increased dependability. Naturally, there is also a phase selection criterion operating in parallel which bases its operation only on voltage and current phasors.

The directional element utilizes a set of well-established quantities to provide fast and correct directional decision during various power system operating conditions, including close-in three-phase faults, simultaneous faults and faults with only zero-sequence in-feed.

Distance zones quad with high speed distance for series compensated networks ZMFCPDIS
High speed distance protection (ZMFCPDIS) provides sub-cycle, down towards half-cycle, operate time for basic faults within 60% of the line length and up to around SIR 5. At the same time, it is specifically designed for extra care during difficult conditions in high voltage transmission networks, like faults on long heavily loaded lines and faults generating heavily distorted signals. These faults are handled with outmost security and dependability, although sometimes with reduced operating speed.

High speed distance protection ZMFCPDIS is fundamentally the same function as ZMFPDIS but provides more flexibility in zone settings to suit more complex applications, such as series compensated lines. In operation for series compensated networks, the parameters of the directional function are altered to handle voltage reversal.

The ZMFCPDIS function is a six-zone full scheme protection with three fault loops for phase-to-phase faults and three fault loops for phase-to-earth faults for each of the independent zones, which makes the function suitable in applications with single-phase autoreclosing.

The zones can operate independandy of each other in directional (forward or reverse) or non-directional mode. This makes them suitable, together with a communication scheme, for protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines, and so on.

A new built-in adaptive load compensation algorithm prevents overreaching of the distance zones in the load exporting end during phase-to-earth faults on heavily loaded power lines. It also reduces underreach in the importing end.

The ZMFCPDIS function block incorporates a phase-selection element and a directional element, contrary to previous designs in the 670-series, where these elements were represented with separate function blocks.

The operation of the phase-selection element is primarily based on current change criteria, with significant increased dependability. Naturally, there is also a part operating with continuous criteria that operates in parallel

The directional element utilizes a set of well-established quantities to provide fast and correct directional evaluation during various conditions, including close-in three-phase faults, simultaneous faults and faults with only zero-sequence in-feed.

Power swing detection ZMRPSB
Power swings may occur after disconnection of heavy loads or trip of big generation plants.

Power swing detection function ZMRPSB is used to detect power swings and initiate block of all distance protection zones. Occurrence of earth-fault currents during a power swing inhibits the ZMRPSB function, to allow fault clearance.

Power swing logic PSLPSCH
Power Swing Logic (PSLPSCH) is a complementary function to Power Swing Detection (ZMRPSB) function. It provides possibility for selective tripping of faults on power lines during system oscillations (power swings or pole slips), when the distance protection function should normally be blocked. The complete logic consists of two different parts:

- Communication and tripping part: provides selective tripping on the basis of special distance protection zones and a scheme communication logic, which are not blocked during the system oscillations.
- Blocking part: blocks unwanted operation of instantaneous distance protection zone 1 for oscillations, which are initiated by faults and their clearing on the adjacent power lines and other primary elements.

Pole slip protection PSPPPAM
Sudden events in an electric power system such as large changes in load, fault occurrence or fault clearance, can cause power oscillations referred to as power swings. In a non-recoverable situation, the power swings become so severe that the synchronism is lost, a condition referred to as pole slipping. The main purpose of the pole slip protection (PSPPPAM) is to detect, evaluate, and take the required action for pole slipping occurrences in the power system

Out-of-step protection OOSPPAM
The out-of-step protection OOSPPAM function in the IED can be used for both generator protection and as well for line protection applications.

The main purpose of the OOSPPAM function is to detect, evaluate, and take the required action during pole slipping occurrences in the power system.

The OOSPPAM function detects pole slip conditions and trips the generator as fast as possible, after the first pole-slip if the center of oscillation is found to be in zone 1, which normally includes the generator and its step-up power transformer. If the center of oscillation is found to be further out in the power system, in zone 2, more than one pole-slip is usually allowed before the generator-transformer unit is disconnected. A parameter setting is available to take into account the circuit breaker opening time. If there are several out-of-step relays in the power system, then the one which finds the center of oscillation in its zone 1 should operate first.

Two current channels I3P1 and I3P2 are available in OOSPPAM function to allow the direct connection of two groups of three-phase currents; that may be needed for very powerful generators, with stator windings split into two groups per phase, when each group is equipped with current transformers. The protection function performs a simple summation of the currents of the two channels I3P1 and I3P2.

Automatic switch onto fault logic, voltage and current based ZCVPSOF
Automatic switch onto fault logic (ZCVPSOF) is a function that gives an instantaneous trip at closing of breaker onto a fault. A dead line detection check is provided to activate the function when the line is dead.

Phase preference logic PPLPHIZ
The optional phase preference logic main purpose is to provide a selective tripping for cross-country faults in isolated or high impedance-earthed networks.

5. Current protection

Instantaneous phase overcurrent protection PHPIOC
The instantaneous three phase overcurrent function has a low transient overreach and short tripping time to allow use as a high set short-circuit protection function.

Four step phase overcurrent protection OC4PTOC
The four step three-phase overcurrent protection function OC4PTOC has an inverse or definite time delay independent for step 1 to 4 separately.

All IEC and ANSI inverse time characteristics are available together with an optional user defined time characteristic

The directional function needs voltage as it is voltage polarized with memory. The function can be set to be directional or non-directional independently for each of the steps.

Second harmonic blocking level can be set for the function and can be used to block each step individually

Instantaneous residual overcurrent protection EFPIOC
The Instantaneous residual overcurrent protection EFPIOC has a low transient overreach and short tripping times to allow the use for instantaneous earth-fault protection, with the reach limited to less than the typical eighty percent of the line at minimum source impedance. EFPIOC is configured to measure the residual current from the three-phase current inputs and can be configured to measure the current from a separate current input.

Four step residual overcurrent protection, zero sequence and negative sequence direction EF4PTOC
The four step residual overcurrent protection EF4PTOC has an inverse or definite time delay independent for each step.

All IEC and ANSI time-delayed characteristics are available together with an optional user defined characteristic.

EF4PTOC can be set directional or non-directional independently for each of the steps.

IDir, UPol and IPol can be independently selected to be either zero sequence or negative sequence.

Second harmonic blocking can be set individually for each step.

EF4PTOC can be used as main protection for phase-to-earth faults.

EF4PTOC can also be used to provide a system back-up for example, in the case of the primary protection being out of service due to communication or voltage transformer circuit failure.

Directional operation can be combined together with corresponding communication logic in permissive or blocking teleprotection scheme. Current reversal and weak-end infeed functionality are available as well.

Residual current can be calculated by summing the three phase currents or taking the input from neutral CT

Four step negative sequence overcurrent protection NS4PTOC
Four step negative sequence overcurrent protection (NS4PTOC) has an inverse or definite time delay independent for each step separately.

All IEC and ANSI time delayed characteristics are available together with an optional user defined characteristic.

The directional function is voltage polarized.

NS4PTOC can be set directional or non-directional independently for each of the steps.

NS4PTOC can be used as main protection for unsymmetrical fault; phase-phase short circuits, phase-phase-earth short circuits and single phase earth faults.

NS4PTOC can also be used to provide a system backup for example, in the case of the primary protection being out of service due to communication or voltage transformer circuit failure.

Directional operation can be combined together with corresponding communication logic in permissive or blocking teleprotection scheme. The same logic as for directional zero sequence current can be used. Current reversal and weak-end infeed functionality are available.

Sensitive directional residual overcurrent and power protection SDEPSDE
In isolated networks or in networks with high impedance earthing, the earth fault current is significantly smaller than the short circuit currents. In addition to this, the magnitude of the fault current is almost independent on the fault location in the network. The protection can be selected to use either the residual current or residual power component 3U0·3I0·cos φ, for operating quantity with maintained short circuit capacity. There is also available one non-directional 3I0 step and one 3U0 overvoltage tripping step.

No specific sensitive current input is needed. SDEPSDE can be set as low 0.25% of IBase.

Thermal overload protection, one time constant LCPTTR/ LFPTTR
The increasing utilization of the power system closer to the thermal limits has generated a need of a thermal overload protection for power lines.

A thermal overload will often not be detected by other protection functions and the introduction of the thermal overload protection can allow the protected circuit to operate closer to the thermal limits.

The three-phase current measuring protection has an I^2t characteristic with settable time constant and a thermal memory. The temperature is displayed in either Celsius or Fahrenheit, depending on whether the function used is LCPTTR (Celsius) or LFPTTR (Fahrenheit).

An alarm level gives early warning to allow operators to take action well before the line is tripped.

Estimated time to trip before operation, and estimated time to reclose after operation are presented.

Breaker failure protection CCRBRF
Breaker failure protection (CCRBRF) ensures a fast backup tripping of surrounding breakers in case the own breaker fails to open. CCRBRF can be current-based, contact-based or an adaptive combination of these two conditions.

Current check with extremely short reset time is used as check criterion to achieve high security against inadvertent operation.

Contact check criteria can be used where the fault current through the breaker is small.

CCRBRF can be single- or three-phase initiated to allow use with single phase tripping applications. For the three-phase version of CCRBRF the current criteria can be set to operate only if two out of four for example, two phases or one phase plus the residual current start. This gives a higher security to the back-up trip command.

CCRBRF function can be programmed to give a single- or three-phase re-trip of the own breaker to avoid unnecessary tripping of surrounding breakers at an incorrect initiation due to mistakes during testing.

Stub protection STBPTOC
When a power line is taken out of service for maintenance and the line disconnector is opened in multi-breaker arrangements the voltage transformers will mostly be outside on the disconnected part. The primary line distance protection will thus not be able to operate and must be blocked.

The stub protection STBPTOC covers the zone between the current transformers and the open disconnector. The three-phase instantaneous overcurrent function is released from a normally open, NO (b) auxiliary contact on the line disconnector.

Pole discordance protection CCPDSC
An open phase can cause negative and zero sequence currents which cause thermal stress on rotating machines and can cause unwanted operation of zero sequence or negative sequence current functions.

Normally the own breaker is tripped to correct such a situation. If the situation persists the surrounding breakers should be tripped to clear the unsymmetrical load situation.

The Pole discordance protection function CCPDSC operates based on information from auxiliary contacts of the circuit breaker for the three phases with additional criteria from unsymmetrical phase currents when required.

Directional over/underpower protection GOPPDOP/ GUPPDUP
The directional over-/under-power protection GOPPDOP/ GUPPDUP can be used wherever a high/low active, reactive or apparent power protection or alarming is required. The functions can alternatively be used to check the direction of active or reactive power flow in the power system. There are a number of applications where such functionality is needed. Some of them are:

- detection of reversed active power flow
- detection of high reactive power flow

Each function has two steps with definite time delay.

Broken conductor check BRCPTOC
The main purpose of the function Broken conductor check (BRCPTOC) is the detection of broken conductors on protected power lines and cables (series faults). Detection can be used to give alarm only or trip the line breaker.

Voltage-restrained time overcurrent protection VRPVOC
Voltage-restrained time overcurrent protection (VRPVOC) function can be used as generator backup protection against short-circuits.

The overcurrent protection feature has a settable current level that can be used either with definite time or inverse time characteristic. Additionally, it can be voltage controlled/ restrained.

One undervoltage step with definite time characteristic is also available within the function in order to provide functionality for overcurrent protection with undervoltage seal-in.

6. Voltage protection

Two step undervoltage protection UV2PTUV
Undervoltages can occur in the power system during faults or abnormal conditions. Two step undervoltage protection (UV2PTUV) function can be used to open circuit breakers to prepare for system restoration at power outages or as long-time delayed back-up to primary protection.

UV2PTUV has two voltage steps, each with inverse or definite time delay.

UV2PTUV has a high reset ratio to allow settings close to system service voltage.

Two step overvoltage protection OV2PTOV
Overvoltages may occur in the power systems during abnormal conditions such as sudden power loss, tap changer regulating failures, and open line ends on long lines.

OV2PTOV has two voltage steps, each of them with inverse or definite time delayed.

OV2PTOV has a high reset ratio to allow settings close to system service voltage.

Two step residual overvoltage protection ROV2PTOV
Residual voltages may occur in the power system during earth faults

Two step residual overvoltage protection ROV2PTOV function calculates the residual voltage from the three-phase voltage input transformers or measures it from a single voltage input transformer fed from an open delta or neutral point voltage transformer.

ROV2PTOV has two voltage steps, each with inverse or definite time delay.

Reset delay ensures operation for intermittent earth faults.

Overexcitation protection OEXPVPH
When the laminated core of a power transformer or generator is subjected to a magnetic flux density beyond its design limits, stray flux will flow into non-laminated components that are not designed to carry flux. This will cause eddy currents to flow. These eddy currents can cause excessive heating and severe damage to insulation and adjacent parts in a relatively short time. The function has settable inverse operating curves and independent alarm stages

Voltage differential protection VDCPTOV
A voltage differential monitoring function is available. It compares the voltages from two three phase sets of voltage transformers and has one sensitive alarm step and one trip step.

Loss of voltage check LOVPTUV
Loss of voltage check LOVPTUV is suitable for use in networks with an automatic system restoration function. LOVPTUV issues a three-pole trip command to the circuit breaker, if all three phase voltages fall below the set value for a time longer than the set time and the circuit breaker remains closed.

The operation of LOVPTUV is supervised by the fuse failure supervision FUFSPVC.

Radial feeder protection PAPGAPC
The PAPGAPC function is used to provide protection of radial feeders having passive loads or weak end in-feed sources. It is possible to achieve fast tripping using communication system with remote end or delayed tripping not requiring communication or upon communication system failure. For fast tripping, scheme communication is required. Delayed tripping does not require scheme communication.

The PAPGAPC function performs phase selection using measured voltages. Each phase voltage is compared to the opposite phase-phase voltage. A phase is deemed to have a fault if its phase voltage drops below a settable percentage of the opposite phase-phase voltage. The phase - phase voltages include memory. This memory function has a settable time constant.

The voltage-based phase selection is used for both fast and delayed tripping. To achieve fast tripping, scheme communication is required. Delayed tripping does not require scheme communication. It is possible to permit delayed tripping only upon failure of the communications channel by blocking the delayed tripping logic with a communications channel healthy input signal.

On receipt of the communications signal, phase selective outputs for fast tripping are set based on the phase(s) in which the phase selection function has operated.

For delayed tripping, single pole and three pole delays are separately and independently settable. Furthermore, it is possible to enable or disable single pole and three pole delayed tripping. For single phase faults, it is possible to include a residual current check in the tripping logic. Three pole tripping is always selected for phase selection on more than one phase. Three pole tripping will also occur if the residual current exceeds the set level during fuse failure for a time longer than the three pole trip delay time.

7. Frequency protection

Underfrequency protection SAPTUF
Underfrequency occurs as a result of a lack of generation in the network.

Underfrequency protection SAPTUF measures frequency with high accuracy, and is used for load shedding systems, remedial action schemes, gas turbine start-up and so on. Separate definite time delays are provided for operate and restore.

SAPTUF is provided with undervoltage blocking.

The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected. For information about how to connect analog inputs, refer to Application manual/IED application/Analog Inputs/Setting guidelines

Overfrequency protection SAPTOF
Overfrequency protection function SAPTOF is applicable in all situations, where reliable detection of high fundamental power system frequency is needed.

Overfrequency occurs because of sudden load drops or shunt faults in the power network. Close to the generating plant, generator governor problems can also cause over frequency.

SAPTOF measures frequency with high accuracy, and is used mainly for generation shedding and remedial action schemes. It is also used as a frequency stage initiating load restoring. A definite time delay is provided for operate.

SAPTOF is provided with an undervoltage blocking.

The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected. For information about how

to connect analog inputs, refer to Application manual/IED application/Analog Inputs/Setting guidelines

Rate-of-change frequency protection SAPFRC
The rate-of-change frequency protection function SAPFRC gives an early indication of a main disturbance in the system. SAPFRC measures frequency with high accuracy, and can be used for generation shedding, load shedding and remedial action schemes. SAPFRC can discriminate between a positive or negative change of frequency. A definite time delay is provided for operate.

SAPFRC is provided with an undervoltage blocking. The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected. For information about how to connect analog inputs, refer to Application manual/IED application/Analog Inputs/Setting guidelines

8. Multipurpose protection

General current and voltage protection CVGAPC
The General current and voltage protection (CVGAPC) can be utilized as a backup overcurrent protection detecting unsymmetrical conditions such as open phase or unsymmetrical faults.

CVGAPC can also be used to improve phase selection for high resistive earth faults, outside the distance protection reach, for the transmission line. Three functions are used, which measures the neutral current and each of the three phase voltages. This will give an independence from load currents and this phase selection will be used in conjunction with the detection of the earth fault from the directional earth fault protection function.

9. Secondary system supervision

Current circuit supervision CCSSPVC
Open or short circuited current transformer cores can cause unwanted operation of many protection functions such as differential, earth-fault current and negative sequence current functions.

It must be remembered that a blocking of protection functions, at an occurrence of open CT circuit will mean that the protection will remain and extremely high voltages will stress the secondary circuit.

Current circuit supervision (CCSSPVC) compares the residual current from a three-phase set of current transformer cores with the neutral point current on a separate input taken from another set of cores on the current transformer.

A detection of a difference indicates a fault in the circuit and is used as alarm or to block protection functions expected to give inadvertent tripping

Fuse failure supervision FUFSPVC
The aim of the fuse failure supervision function FUFSPVC is to block voltage measuring functions at failures in the secondary circuits between the voltage transformer and the IED in order to avoid inadvertent operations that otherwise might occur.

The fuse failure supervision function basically has three different detection methods, negative sequence and zero sequence based detection and an additional delta voltage and delta current detection.

The negative sequence detection algorithm is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence quantities.

The zero sequence detection is recommended for IEDs used in directly or low impedance earthed networks. It is based on the zero sequence measuring quantities.

The selection of different operation modes is possible by a setting parameter in order to take into account the particular earthing of the network.

A criterion based on delta current and delta voltage measurements can be added to the fuse failure supervision function in order to detect a three phase fuse failure, which in practice is more associated with voltage transformer switching during station operations.

Fuse failure supervision VDSPVC
Different protection functions within the protection IED, operates on the basis of measured voltage at the relay point. Some example of protection functions are:

- Distance protection function.
- Undervoltage function.
- Energisation function and voltage check for the weak infeed logic.

These functions can operate unintentionally, if a fault occurs in the secondary circuits between voltage instrument transformers and the IED. These unintentional operations can be prevented by VDSPVC.

VDSPVC is designed to detect fuse failures or faults in voltage measurement circuit, based on phase wise comparison of voltages of main and pilot fused circuits. VDSPVC blocking output can be configured to block functions that need to be blocked in case of faults in the voltage circuit.

Multipurpose filter SMAIHPAC
The multi-purpose filter function block, SMAIHPAC, is arranged as a three-phase filter. It has very much the same user interface (e.g. inputs and outputs) as the standard pre-processing function block SMAI. However the main difference is that it can be used to extract any frequency component from the input signal. Thus it can, for example, be used to build sub-synchronous resonance protection for synchronous generator.

10. Control

Synchrocheck, energizing check, and synchronizing SESRSYN
The Synchronizing function allows closing of asynchronous networks at the correct moment including the breaker closing time, which improves the network stability.

Synchrocheck, energizing check, and synchronizing SESRSYN function checks that the voltages on both sides of the circuit breaker are in synchronism, or with at least one side dead to ensure that closing can be done safely.

SESRSYN function includes a built-in voltage selection scheme for double bus and 1½ breaker or ring busbar arrangements.

Manual closing as well as automatic reclosing can be checked by the function and can have different settings.

For systems, which are running asynchronous, a synchronizing function is provided. The main purpose of the synchronizing function is to provide controlled closing of circuit breakers when two asynchronous systems are going to be connected. The synchronizing function evaluates voltage difference, phase angle difference, slip frequency and frequency rate of change before issuing a controlled closing of the circuit breaker. Breaker closing time is a parameter setting.

Autorecloser SMBRREC
The autorecloser SMBRREC function provides high-speed and/or delayed auto-reclosing for single or multi-breaker applications.

Up to five three-phase reclosing attempts can be included by parameter setting. The first attempt can be single-, two and/or three phase for single phase or multi-phase faults respectively.

Multiple autoreclosing functions are provided for multi-breaker arrangements. A priority circuit allows one circuit breaker to close first and the second will only close if the fault proved to be transient.

Each autoreclosing function is configured to co-operate with the synchrocheck function.

Apparatus control APC
The apparatus control functions are used for control and supervision of circuit breakers, disconnectors and earthing switches within a bay. Permission to operate is given after evaluation of conditions from other functions such as interlocking, synchrocheck, operator place selection and external or internal blockings.

Apparatus control features:
- Select-Execute principle to give high reliability
- Selection function to prevent simultaneous operation
- Selection and supervision of operator place
- Command supervision
- Block/deblock of operation
- Block/deblock of updating of position indications
- Substitution of position and quality indications
- Overriding of interlocking functions
- Overriding of synchrocheck
- Operation counter
- Suppression of mid position

Two types of command models can be used:
- Direct with normal security
- SBO (Select-Before-Operate) with enhanced security

Normal security means that only the command is evaluated and the resulting position is not supervised. Enhanced security means that the command is evaluated with an additional supervision of the status value of the control object. The command sequence with enhanced security is always terminated by a CommandTermination service primitive and an AddCause telling if the command was successful or if something went wrong.

Control operation can be performed from the local HMI with authority control if so defined.

Interlocking
The interlocking function blocks the possibility to operate primary switching devices, for instance when a disconnector is under load, in order to prevent material damage and/or accidental human injury.

Each apparatus control function has interlocking modules included for different switchyard arrangements, where each function handles interlocking of one bay. The interlocking function is distributed to each IED and is not dependent on any central function. For the station-wide interlocking, the IEDs communicate via the system-wide interbay bus (IEC 61850-8-1) or by using hard wired binary inputs/outputs. The interlocking conditions depend on the circuit configuration and apparatus position status at any given time.

For easy and safe implementation of the interlocking function, the IED is delivered with standardized and tested software interlocking modules containing logic for the interlocking conditions. The interlocking conditions can be altered, to meet the customer's specific requirements, by adding configurable logic by means of the graphical configuration tool.

Switch controller SCSWI
The Switch controller (SCSWI) initializes and supervises all functions to properly select and operate switching primary apparatuses. The Switch controller may handle and operate on one three-phase device or up to three one-phase devices.

Circuit breaker SXCBR
The purpose of Circuit breaker (SXCBR) is to provide the actual status of positions and to perform the control

operations, that is, pass all the commands to primary apparatuses in the form of circuit breakers via binary output boards and to supervise the switching operation and position.

Circuit switch SXSWI
The purpose of Circuit switch (SXSWI) function is to provide the actual status of positions and to perform the control operations, that is, pass all the commands to primary apparatuses in the form of disconnectors or earthing switches via binary output boards and to supervise the switching operation and position.

Reservation function QCRSV
The purpose of the reservation function is primarily to transfer interlocking information between IEDs in a safe way and to prevent double operation in a bay, switchyard part, or complete substation.

Reservation input RESIN
The Reservation input (RESIN) function receives the reservation information from other bays. The number of instances is the same as the number of involved bays (up to 60 instances are available).

Bay control QCBAY
The Bay control QCBAY function is used together with Local remote and local remote control functions to handle the selection of the operator place per bay. QCBAY also provides blocking functions that can be distributed to different apparatuses within the bay.

Local remote LOCREM/Local remote control LOCREMCTRL
The signals from the local HMI or from an external local/remote switch are connected via the function blocks LOCREM and LOCREMCTRL to the Bay control QCBAY function block. The parameter *ControlMode* in function block LOCREM is set to choose if the switch signals are coming from the local HMI or from an external hardware switch connected via binary inputs.

Logic rotating switch for function selection and LHMI presentation SLGAPC
The logic rotating switch for function selection and LHMI presentation SLGAPC (or the selector switch function block) is used to get an enhanced selector switch functionality compared to the one provided by a hardware selector switch. Hardware selector switches are used extensively by utilities, in order to have different functions operating on pre-set values. Hardware switches are however sources for maintenance issues, lower system reliability and an extended purchase portfolio. The selector switch function eliminates all these problems.

Selector mini switch VSGAPC
The Selector mini switch VSGAPC function block is a multipurpose function used for a variety of applications, as a general purpose switch.

VSGAPC can be controlled from the menu or from a symbol on the single line diagram (SLD) on the local HMI.

Generic communication function for Double Point Indication DPGAPC
Generic communication function for Double Point Indication DPGAPC function block is used to send double indications to other systems, equipment or functions in the substation through IEC 61850-8-1 or other communication protocols. It is especially used in the interlocking station-wide logics.

Single point generic control 8 signals SPC8GAPC
The Single point generic control 8 signals SPC8GAPC function block is a collection of 8 single point commands, designed to bring in commands from REMOTE (SCADA) to those parts of the logic configuration that do not need extensive command receiving functionality (for example, SCSWI). In this way, simple commands can be sent directly to the IED outputs, without confirmation. Confirmation (status) of the result of the commands is supposed to be achieved by other means, such as binary inputs and SPGAPC function blocks. The commands can be pulsed or steady with a settable pulse time.

AutomationBits, command function for DNP3.0 AUTOBITS
AutomationBits function for DNP3 (AUTOBITS) is used within PCM600 to get into the configuration of the commands coming through the DNP3 protocol. The AUTOBITS function plays the same role as functions GOOSEBINRCV (for IEC 61850) and MULTICMDRCV (for LON).

Single command, 16 signals
The IEDs can receive commands either from a substation automation system or from the local HMI. The command function block has outputs that can be used, for example, to control high voltage apparatuses or for other user defined functionality.

11. Scheme communication

Scheme communication logic for distance or overcurrent protection ZCPSCH
To achieve instantaneous fault clearance for all line faults, scheme communication logic is provided. All types of communication schemes for example, permissive underreaching, permissive overreaching, blocking, unblocking, intertrip are available.

The built-in communication module (LDCM) can be used for scheme communication signaling when included.

Phase segregated communication is also available for correct operation at simultaneous faults when three distance protection communication channels are available between the line ends.

Phase segregated scheme communication logic for distance protection ZC1PPSCH
Communication between line ends is used to achieve fault clearance for all faults on a power line. All possible types of communication schemes for example, permissive underreach, permissive overreach and blocking schemes are available. To manage problems with simultaneous faults on parallel power lines phase segregated communication is needed. This will then replace the standard Scheme communication logic for distance or Overcurrent protection (ZCPSCH) on important lines where three communication channels (in each subsystem) are available for the distance protection communication.

The main purpose of the Phase segregated scheme communication logic for distance protection (ZC1PPSCH) function is to supplement the distance protection function such that:

- fast clearance of faults is also achieved at the line end for which the faults are on the part of the line not covered by its underreaching zone.
- correct phase selection can be maintained to support single-pole tripping for faults occurring anywhere on the entire length of a double circuit line.

To accomplish this, three separate communication channels, that is, one per phase, each capable of transmitting a signal in each direction is required.

ZC1PPSCH can be completed with the current reversal and WEI logic for phase segregated communication, when found necessary in Blocking and Permissive overreaching schemes.

Current reversal and weak-end infeed logic for distance protection ZCRWPSCH
The ZCRWPSCH function provides the current reversal and weak end infeed logic functions that supplement the standard scheme communication logic. It is not suitable for standalone use as it requires inputs from the distance protection functions and the scheme communications function included within the terminal.

On detection of a current reversal, the current reversal logic provides an output to block the sending of the teleprotection signal to the remote end, and to block the permissive tripping at the local end. This blocking condition is maintained long enough to ensure that no unwanted operation will occur as a result of the current reversal.

On verification of a weak end infeed condition, the weak end infeed logic provides an output for sending the received teleprotection signal back to the remote sending end and other output(s) for local tripping. For terminals equipped for single-, two-, and three-pole tripping, outputs for the faulted phase(s) are provided. Undervoltage detectors are used to detect the faulted phase(s).

Current reversal and weak-end infeed logic for phase segregated communication ZC1WPSCH
Current reversal and weak-end infeed logic for phase segregated communication (ZC1WPSCH) function is used to prevent unwanted operations due to current reversal when using permissive overreach protection schemes in application with parallel lines where the overreach from the two ends overlaps on the parallel line.

The weak-end infeed logic is used in cases where the apparent power behind the protection can be too low to activate the distance protection function. When activated, received carrier signal together with local undervoltage criteria and no reverse zone operation gives an instantaneous trip. The received signal is also echoed back to accelerate the sending end.

Local acceleration logic ZCLCPSCH
To achieve fast clearing of faults on the whole line, when no communication channel is available, local acceleration logic ZCLCPSCH can be used. This logic enables fast fault clearing and re-closing during certain conditions, but naturally, it can not fully replace a communication channel.

The logic can be controlled either by the autorecloser (zone extension) or by the loss-of-load current (loss-of-load acceleration).

Scheme communication logic for residual overcurrent protection ECPSCH
To achieve fast fault clearance of earth faults on the part of the line not covered by the instantaneous step of the residual overcurrent protection, the directional residual overcurrent protection can be supported with a logic that uses communication channels.

In the directional scheme, information of the fault current direction must be transmitted to the other line end. With directional comparison, a short operate time of the protection including a channel transmission time, can be achieved. This short operate time enables rapid autoreclosing function after the fault clearance.

The communication logic module for directional residual current protection enables blocking as well as permissive under/overreaching, and unblocking schemes. The logic can also be supported by additional logic for weak-end infeed and current reversal, included in Current reversal and weak-end infeed logic for residual overcurrent protection ECRWPSCH function.

Current reversal and weak-end infeed logic for residual overcurrent protection ECRWPSCH
The Current reversal and weak-end infeed logic for residual overcurrent protection ECRWPSCH is a supplement to Scheme communication logic for residual overcurrent protection ECPSCH.

To achieve fast fault clearing for all earth faults on the line, the directional earth fault protection function can be supported with logic that uses tele protection channels.

The 670 series IEDs have for this reason available additions to scheme communication logic.

If parallel lines are connected to common busbars at both terminals, overreaching permissive communication schemes can trip unselectively due to fault current reversal. This unwanted tripping affects the healthy line when a fault is cleared on the other line. This lack of security can result in a total loss of interconnection between the two buses. To avoid this type of disturbance, a fault current reversal logic (transient blocking logic) can be used.

Permissive communication schemes for residual overcurrent protection can basically operate only when the protection in the remote IED can detect the fault. The detection requires a sufficient minimum residual fault current, out from this IED. The fault current can be too low due to an opened breaker or high-positive and/or zero-sequence source impedance behind this IED. To overcome these conditions, weak-end infeed (WEI) echo logic is used. The weak-end infeed echo is limited to 200 ms to avoid channel lockup.

Direct transfer trip DTT
Low active power and power factor protection LAPPGAPC

Low active power and power factor protection LAPPGAPC function measures power flow. It can be used for detection and monitoring of:

- phase wise low active power
- phase wise low power factor
- phase wise reactive power and apparent power as service values

Following features are available:

- Definite time stage for low active power detection
- Definite time stage for low power factor detection
- Individual enabling of Low active power and low power factor functions
- Low active power trip with 2 selection modes '1 out of 3' and '2 out of 3'
- Phase wise calculated values of apparent power, reactive power, active power and power factor are available as service values
- Insensitive to small variations in voltage and current

Compensated over and undervoltage protection COUVGAPC
Compensated over and undervoltage protection (COUVGAPC) function calculates the remote end voltage of the transmission line utilizing local measured voltage, current and with the help of transmission line parameters, that is, line resistance, reactance, capacitance and local shunt reactor. For protection of long transmission line for in zone faults, COUVGAPC can be incorporated with local criteria within direct transfer trip logic to ensure tripping of the line only under abnormal conditions.

Sudden change in current variation SCCVPTOC
Sudden change in current variation (SCCVPTOC) function is a fast way of finding any abnormality in line currents. When there is a fault in the system, the current changes faster than the voltage. SCCVPTOC finds abnormal condition based on phase-to-phase current variation. The main application is as a local criterion to increase security when transfer trips are used.

Carrier receive logic LCCRPTRC
In Direct transfer trip (DTT) scheme, the received CR signal gives the trip to the circuit breaker after checking certain local criteria functions in order to increase the security of the overall tripping functionality. Carrier receive logic (LCCRPTRC) function gives final trip output of the DTT scheme.

Features:

- Carrier redundancy to ensure security in DTT scheme
- Blocking function output on CR Channel Error
- Phase wise trip outputs

Negative sequence overvoltage protection LCNSPTOV
Negative sequence components are present in all types of fault condition. Negative sequence voltage and current get high values during unsymmetrical faults.

Zero sequence overvoltage protection LCZSPTOV
Zero sequence components are present in all abnormal conditions involving earth. They can reach considerably high values during earth faults.

Negative sequence overcurrent protection LCNSPTOC
Negative sequence components are present in all types of fault condition. They can reach considerably high values during abnormal operation.

Zero sequence overcurrent protection LCZSPTOC
Zero sequence components are present in all abnormal conditions involving earth. They have a considerably high value during earth faults.

Three phase overcurrent LCP3PTOC
Three phase overcurrent (LCP3PTOC) is designed for overcurrent conditions.

Features:

- Phase wise start and trip signals
- Overcurrent protection
- Phase wise RMS current is available as service values
- Single definite time stage trip function.

Three phase undercurrent LCP3PTUC
Three phase undercurrent function (LCP3PTUC) is designed for detecting loss of load conditions.

Features:

- Phase wise start and trip signals
- Phase wise RMS current is available as service values
- Single definite time stage trip function

12. Logic

Tripping logic SMPPTRC
A function block for protection tripping is provided for each circuit breaker involved in the tripping of the fault. It provides a settable pulse prolongation to ensure a trip pulse of sufficient length, as well as all functionality necessary for correct co-operation with autoreclosing functions.

The trip function block also includes a settable latch functionality for evolving faults and breaker lock-out.

Trip matrix logic TMAGAPC
Trip matrix logic TMAGAPC function is used to route trip signals and other logical output signals to different output contacts on the IED.

The trip matrix logic function has 3 output signals and these outputs can be connected to physical tripping outputs according to the specific application needs for settable pulse or steady output.

Group alarm logic function ALMCALH
Group alarm logic function ALMCALH is used to route several alarm signals to a common indication, LED and/or contact, in the IED.

Group alarm logic function WRNCALH
Group alarm logic function WRNCALH is used to route several warning signals to a common indication, LED and/or contact, in the IED.

Group indication logic function INDCALH
Group indication logic function INDCALH is used to route several indication signals to a common indication, LED and/or contact, in the IED

Extension logic package
The logic extension block package includes additional trip matrix logic and configurable logic blocks.

Logic rotating switch for function selection and LHMI presentation SLGAPC
The logic rotating switch for function selection and LHMI presentation SLGAPC (or the selector switch function block) is used to get an enhanced selector switch functionality compared to the one provided by a hardware selector switch. Hardware selector switches are used extensively by utilities, in order to have different functions operating on pre-set values. Hardware switches are however sources for maintenance issues, lower system reliability and an extended purchase portfolio. The selector switch function eliminates all these problems.

Selector mini switch VSGAPC
The Selector mini switch VSGAPC function block is a multipurpose function used for a variety of applications, as a general purpose switch.

VSGAPC can be controlled from the menu or from a symbol on the single line diagram (SLD) on the local HMI.

Fixed signal function block
The Fixed signals function FXDSIGN generates nine pre-set (fixed) signals that can be used in the configuration of an IED, either for forcing the unused inputs in other function blocks to a certain level/value, or for creating certain logic. Boolean, integer, floating point, string types of signals are available.

Elapsed time integrator with limit transgression and overflow supervision (TEIGAPC)
The Elapsed time integrator function TEIGAPC is a function that accumulates the elapsed time when a given binary signal has been high.

The main features of TEIGAPC

- Applicable to long time integration (≤999 999.9 seconds).
- Supervision of limit transgression conditions and overflow
- Possibility to define a warning or alarm with the resolution of 10 milliseconds.
- Retaining of the integration value.
- Possibilities for blocking and reset.
- Reporting of the integrated time.

Boolean 16 to Integer conversion with logic node representation BTIGAPC
Boolean 16 to Integer conversion with logic node representation function BTIGAPC is used to transform a set of 16 binary (logical) signals into an integer. The block input will freeze the output at the last value

BTIGAPC can receive remote values via IEC 61850 depending on the operator position input (PSTO).

Integer to Boolean 16 conversion IB16
Integer to boolean 16 conversion function IB16 is used to transform an integer into a set of 16 binary (logical) signals.

Integer to Boolean 16 conversion with logic node representation ITBGAPC
Integer to boolean conversion with logic node representation function ITBGAPC is used to transform an integer which is transmitted over IEC 61850 and received by the function to 16 binary coded (logic) output signals.

ITBGAPC function can only receive remote values over IEC 61850 when the R/L (Remote/Local) push button on the front HMI, indicates that the control mode for the operator is in

position R (Remote i.e. the LED adjacent to R is lit), and the corresponding signal is connected to the input PSTO ITBGAPC function block. The input BLOCK will freeze the output at the last received value and blocks new integer values to be received and converted to binary coded outputs.

13. Monitoring

Measurements CVMMXN, CMMXU, VMMXU, VNMMXU, CMSQI, VMSQI
The measurement functions are used to get on-line information from the IED. These service values make it possible to display on-line information on the local HMI and on the Substation automation system about:

- measured voltages, currents, frequency, active, reactive and apparent power and power factor
- measured analog values from merging units
- primary phasors
- positive, negative and zero sequence currents and voltages
- mA, input currents
- pulse counters

Supervision of mA input signals
The main purpose of the function is to measure and process signals from different measuring transducers. Many devices used in process control represent various parameters such as frequency, temperature and DC battery voltage as low current values, usually in the range 4-20 mA or 0-20 mA.

Alarm limits can be set and used as triggers, e.g. to generate trip or alarm signals.

The function requires that the IED is equipped with the mA input module.

Disturbance report DRPRDRE
Complete and reliable information about disturbances in the primary and/or in the secondary system together with continuous event-logging is accomplished by the disturbance report functionality.

Disturbance report DRPRDRE, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a, maximum of 40 analog and 96 binary signals.

The Disturbance report functionality is a common name for several functions:

- Event list
- Indications
- Event recorder
- Trip value recorder
- Disturbance recorder
- Fault locator

The Disturbance report function is characterized by great flexibility regarding configuration, starting conditions, recording times, and large storage capacity.

A disturbance is defined as an activation of an input to the A-RADR or B-RBDR function blocks, which are set to trigger the disturbance recorder. All connected signals from start of pre-fault time to the end of post-fault time will be included in the recording.

Every disturbance report recording is saved in the IED in the standard Comtrade format as a reader file HDR, a configuration file CFG, and a data file DAT. The same applies to all events, which are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings. The disturbance report files may be uploaded to PCM600 for further analysis using the disturbance handling tool.

Event list DRPRDRE
Continuous event-logging is useful for monitoring the system from an overview perspective and is a complement to specific disturbance recorder functions.

The event list logs all binary input signals connected to the Disturbance recorder function. The list may contain up to 1000 time-tagged events stored in a ring-buffer.

Indications DRPRDRE
To get fast, condensed and reliable information about disturbances in the primary and/or in the secondary system it is important to know, for example binary signals that have changed status during a disturbance. This information is used in the short perspective to get information via the local HMI in a straightforward way.

There are three LEDs on the local HMI (green, yellow and red), which will display status information about the IED and the Disturbance recorder function (triggered).

The Indication list function shows all selected binary input signals connected to the Disturbance recorder function that have changed status during a disturbance.

Event recorder DRPRDRE
Quick, complete and reliable information about disturbances in the primary and/or in the secondary system is vital, for example, time-tagged events logged during disturbances. This information is used for different purposes in the short term (for example corrective actions) and in the long term (for example functional analysis).

The event recorder logs all selected binary input signals connected to the Disturbance recorder function. Each recording can contain up to 150 time-tagged events.

The event recorder information is available for the disturbances locally in the IED.

The event recording information is an integrated part of the disturbance record (Comtrade file).

Trip value recorder DRPRDRE
Information about the pre-fault and fault values for currents and voltages are vital for the disturbance evaluation.

The Trip value recorder calculates the values of all selected analog input signals connected to the Disturbance recorder function. The result is magnitude and phase angle before and during the fault for each analog input signal.

The trip value recorder information is available for the disturbances locally in the IED.

The trip value recorder information is an integrated part of the disturbance record (Comtrade file).

Disturbance recorder DRPRDRE
The Disturbance recorder function supplies fast, complete and reliable information about disturbances in the power system. It facilitates understanding system behavior and related primary and secondary equipment during and after a disturbance. Recorded information is used for different purposes in the short perspective (for example corrective actions) and long perspective (for example functional analysis).

The Disturbance recorder acquires sampled data from selected analog- and binary signals connected to the Disturbance recorder function (maximum 40 analog and 96 binary signals). The binary signals available are the same as for the event recorder function.

The function is characterized by great flexibility and is not dependent on the operation of protection functions. It can record disturbances not detected by protection functions. Up to ten seconds of data before the trigger instant can be saved in the disturbance file.

The disturbance recorder information for up to 100 disturbances are saved in the IED and the local HMI is used to view the list of recordings.

Event function
When using a Substation Automation system with LON or SPA communication, time-tagged events can be sent at change or cyclically from the IED to the station level. These events are created from any available signal in the IED that is connected to the Event function (EVENT). The event function block is used for LON and SPA communication.

Analog and double indication values are also transferred through EVENT function.

Generic communication function for Single Point indication SPGAPC
Generic communication function for Single Point indication SPGAPC is used to send one single logical signal to other systems or equipment in the substation.

Generic communication function for Measured Value MVGAPC
Generic communication function for Measured Value MVGAPC function is used to send the instantaneous value of an analog signal to other systems or equipment in the substation. It can also be used inside the same IED, to attach a RANGE aspect to an analog value and to permit measurement supervision on that value.

Measured value expander block RANGE_XP
The current and voltage measurements functions (CVMMXN, CMMXU, VMMXU and VNMMXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGAPC) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The measure value expander block (RANGE_XP) has been introduced to enable translating the integer output signal from the measuring functions to 5 binary signals: below low-low limit, below low limit, normal, above high limit or above high-high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

Fault locator LMBRFLO
The accurate fault locator is an essential component to minimize the outages after a persistent fault and/or to pin-point a weak spot on the line.

The fault locator is an impedance measuring function giving the distance to the fault in km, miles or % of line length. The main advantage is the high accuracy achieved by compensating for load current and for the mutual zero-sequence effect on double circuit lines.

The compensation includes setting of the remote and local sources and calculation of the distribution of fault currents from each side. This distribution of fault current, together with recorded load (pre-fault) currents, is used to exactly calculate the fault position. The fault can be recalculated with new source data at the actual fault to further increase the accuracy.

Especially on heavily loaded long lines, where the source voltage angles can be up to 35-40 degrees apart, the accuracy can be still maintained with the advanced compensation included in fault locator.

Event counter with limit supervision L4UFCNT
The 12 Up limit counter L4UFCNT provides a settable counter with four independent limits where the number of positive and/or negative flanks on the input signal are counted against the setting values for limits. The output for each limit is activated when the counted value reaches that limit.

Overflow indication is included for each up-counter.

14. Metering

Pulse-counter logic PCFCNT
Pulse-counter logic (PCFCNT) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the binary input module and then read by the PCFCNT function. A scaled service value is available over the station bus. The special Binary Input module with enhanced pulse counting capabilities must be ordered to achieve this functionality.

Function for energy calculation and demand handling (ETPMMTR)
Measurements function block (CVMMXN) can be used to measure active as well as reactive power values. Function for energy calculation and demand handling (ETPMMTR) uses measured active and reactive power as input and calculates the accumulated active and reactive energy pulses, in forward and reverse direction. Energy values can be read or generated as pulses. Maximum demand power values are also calculated by the function. This function includes zero point clamping to remove noise from the input signal. As output of this function: periodic energy calculations, integration of energy values, calculation of energy pulses, alarm signals for limit violation of energy values and maximum power demand, can be found.

The values of active and reactive energies are calculated from the input power values by integrating them over a selected time tEnergy. The integration of active and reactive energy values will happen in both forward and reverse directions. These energy values are available as output signals and also as pulse outputs. Integration of energy values can be controlled by inputs (STARTACC and STOPACC) and EnaAcc setting and it can be reset to initial values with RSTACC input.

The maximum demand for active and reactive powers are calculated for the set time interval tEnergy and these values are updated every minute through output channels. The active and reactive maximum power demand values are calculated for both forward and reverse direction and these values can be reset with RSTDMD input.

15. Human machine interface

Local HMI

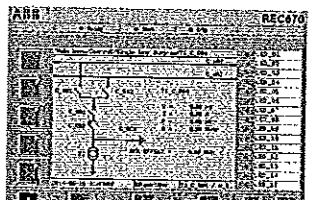


Figure 16. Local human-machine interface

The LHMI of the IED contains the following elements:

- Graphical display capable of showing a user defined single line diagram and provide an interface for controlling switchgear.
- Navigation buttons and five user defined command buttons to shortcuts in the HMI tree or simple commands.
- 15 user defined three-color LEDs.
- Communication port for PCM600.

The LHMI is used for setting, monitoring and controlling.

16. Basic IED functions

Time synchronization
The time synchronization source selector is used to select a common source of absolute time for the IED when it is a part of a protection system. This makes it possible to compare event and disturbance data between all IEDs in a station automation system. A common source shall be used for IED and merging unit when IEC 61850-9-2LE process bus communication is used.

17. Station communication

670 series protocols
Each IED is provided with a communication interface, enabling it to connect to one or many substation level systems or equipment, either on the Substation Automation (SA) bus or Substation Monitoring (SM) bus

Following communication protocols are available:

- IEC 61850-8-1 communication protocol
- IEC 61850-9-2LE communication protocol
- LON communication protocol
- SPA or IEC 60870-5-103 communication protocol
- DNP3.0 communication protocol

Theoretically, several protocols can be combined in the same IED.

IEC 61850-8-1 communication protocol
IEC 61850 Ed 1 or Ed 2 can be chosen by a setting in PCM600. The IED is equipped with single or double optical Ethernet rear ports (order dependent) for IEC 61850-8-1 station bus communication. The IEC 61850-8-1 communication is also possible from the optical Ethernet front port. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. IED-to-IED communication using GOOSE and client-server communication over MMS are supported. Disturbance recording file (COMTRADE) uploading can be done over MMS or FTP.

IEC 61850-9-2LE communication protocol
Single optical Ethernet port communication standard IEC 61850-9-2LE for process bus is provided. IEC 61850-9-2LE allows Non Conventional Instrument Transformers (NCIT) with Merging Units (MU) or stand alone Meging Units to exchange information with the IED and simplifies SA engineering.

Serial communication, LON
Existing stations with ABB station bus LON can be extended with use of the optical LON interface. This allows full SA functionality including peer-to-peer messaging and cooperation between existing ABB IED's and the new IED 670.

SPA communication protocol
A single glass or plastic port is provided for the ABB SPA protocol This allows extensions of simple substation automation systems but the main use is for Substation Monitoring Systems SMS.

IEC 60870-5-103 communication protocol
A single glass or plastic port is provided for the IEC 60870-5-103 standard. This allows design of simple substation automation systems including equipment from different vendors. Disturbance files uploading is provided.

DNP3.0 communication protocol
An electrical RS485 and an optical Ethernet port is available for the DNP3.0 communication. DNP3.0 Level 2 communication with unsolicited events, time synchronizing and disturbance reporting is provided for communication to RTUs, Gateways or HMI systems.

Multiple command and transmit
When 670 IED's are used in Substation Automation systems with LON, SPA or IEC 60870-5-103 communication protocols the Event and Multiple Command function blocks are used as the communication interface for vertical communication to station HMI and gateway and as interface for horizontal peer-to-peer communication (over LON only).

IEC 62439-3 Parallel Redundant Protocol
Redundant station bus communication according to IEC 62439-3 Edition 1 and IEC 62439-3 Edition 2 are available as options in 670 series IEDs. IEC 62439-3 parallel redundant protocol is an optional quantity and the selection is made at ordering. Redundant station bus communication according to IEC 62439-3 uses both port AB and port CD on the OEM module.

18. Remote communication

Analog and binary signal transfer to remote end
Three analog and eight binary signals can be exchanged between two IEDs. This functionality is mainly used for the line differential protection. However it can be used in other products as well. An IED can communicate with up to 4 remote IEDs.

Binary signal transfer to remote end, 192 signals
If the communication channel is used for transfer of binary signals only, up to 192 binary signals can be exchanged between two IEDs. For example, this functionality can be used to send information such as status of primary switchgear apparatus or intertripping signals to the remote IED. An IED can communicate with up to 4 remote IEDs.

Line data communication module, short, medium and long range LDCM
The line data communication module (LDCM) is used for communication between the IEDs situated at distances <110 km or from the IED to optical to electrical converter with G. 703 or G.703E1 interface located on a distances <3 km away. The LDCM module sends and receives data, to and from another LDCM module. The IEEE/ANSI C37 94 standard format is used.

Galvanic X.21 line data communication module X.21-LDCM
A module with built-in galvanic X.21 converter which e.g. can be connected to modems for pilot wires is also available.

Galvanic interface G.703 resp G.703E1
The external galvanic data communication converter G.703/G.703E1 makes an optical-to-galvanic conversion for connection to a multiplexer. These units are designed for 64 kbit/s resp 2Mbit/s operation. The converter is delivered with 19" rack mounting accessories.

19. Hardware description

Hardware modules
Power supply module PSM
The power supply module is used to provide the correct internal voltages and full isolation between the IED and the battery system. An internal fail alarm output is available.

Binary input module BIM
The binary input module has 16 optically isolated inputs and is available in two versions, one standard and one with enhanced pulse counting capabilities on the inputs to be used with the pulse counter function. The binary inputs are freely programmable and can be used for the input of logical signals to any of the functions. They can also be included in the disturbance recording and event-recording functions. This enables extensive monitoring and evaluation of operation of the IED and for all associated electrical circuits.

Binary output module BOM
The binary output module has 24 independent output relays and is used for trip output or any signaling purpose.

Static binary output module SOM
The static binary output module has six fast static outputs and six change over output relays for use in applications with high speed requirements.

Binary input/output module IOM
The binary input/output module is used when only a few input and output channels are needed. The ten standard output channels are used for trip output or any signaling purpose. The two high speed signal output channels are used for applications where short operating time is essential. Eight optically isolated binary inputs cater for required binary input information.

mA input module MIM
The milli-ampere input module is used to interface transducer signals in the –20 to +20 mA range from for example OLTC position, temperature or pressure transducers. The module has six independent, galvanically separated channels.

Optical ethernet module OEM
The optical fast-ethernet module is used to connect an IED to the communication buses (like the station bus) that use the IEC 61850-8-1 protocol (OEM rear port A, B). The process bus use the IEC 61850-9-2LE protocol (OEM rear port C, D). The module has one or two optical ports with ST connectors.

Serial and LON communication module SLM, supports SPA/IEC 60870-5-103, LON and DNP 3.0
The serial and LON communication module (SLM) is used for SPA, IEC 60870-5-103, DNP3 and LON communication. The module has two optical communication ports for plastic/plastic, plastic/glass or glass/glass. One port is used for serial communication (SPA, IEC 60870-5-103 and DNP3 port) and one port is dedicated for LON communication.

Line data communication module LDCM
Each module has one optical port, one for each remote end to which the IED communicates.

Alternative cards for Long range (1550 nm single mode), Medium range (1310 nm single mode) and Short range (850 nm multi mode) are available.

Galvanic X.21 line data communication module X.21-LDCM
The galvanic X.21 line data communication module is used for connection to telecommunication equipment, for example leased telephone lines. The module supports 64 kbit/s data communication between IEDs.

Examples of applications:

- Line differential protection
- Binary signal transfer

Galvanic RS485 serial communication module
The Galvanic RS485 communication module (RS485) is used for DNP3.0 and IEC 60870-5-103 communication. The module has one RS485 communication port. The RS485 is a balanced serial communication that can be used either in 2-wire or 4-wire connections. A 2-wire connection uses the same signal for RX and TX and is a multidrop communication with no dedicated Master or slave. This variant requires however a control of the output. The 4-wire connection has separated signals for RX and TX multidrop communication with a dedicated Master and the rest are slaves. No special control signal is needed in this case.

GPS time synchronization module GTM
This module includes a GPS receiver used for time synchronization. The GPS has one SMA contact for connection to an antenna. It also includes an optical PPS ST-connector output.

IRIG-B Time synchronizing module
The IRIG-B time synchronizing module is used for accurate time synchronizing of the IED from a station clock.

The Pulse Per Second (PPS) input shall be used for synchronizing when IEC 61850-9-2LE is used.

Electrical (BNC) and optical connection (ST) for 0XX and 12X IRIG-B support.

Transformer input module TRM
The transformer input module is used to galvanically separate and adapt the secondary currents and voltages generated by the measuring transformers. The module has twelve inputs in different combinations of currents and voltage inputs.

Alternative connectors of Ring lug or Compression type can be ordered.

High impedance resistor unit
The high impedance resistor unit, with resistors for pick-up value setting and a voltage dependent resistor, is available in

a single phase unit and a three phase unit. Both are mounted on a 1/1 19 inch apparatus plate with compression type terminals.

Layout and dimensions
Dimensions

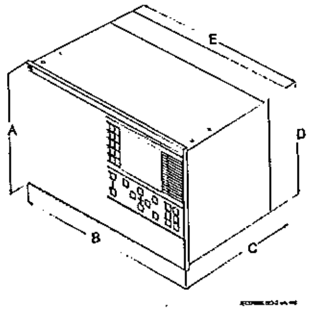


Figure 17. Case with rear cover

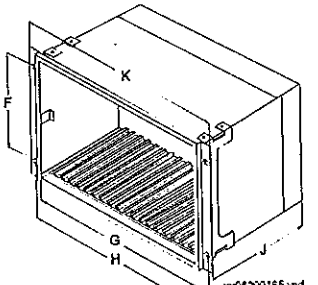


Figure 18. Case with rear cover and 19" rack mounting kit

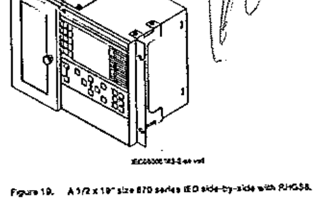


Figure 19. A 1/2 x 19" size 670 series IED side-by-side with RHGS6.

Case size (mm)	A	B	C	D	E	F	G	H	J	K
6U, 1/2 x 19"	265.9	223.7	242.1	255.8	205.7	190.5	203.7	-	228.6	-
6U, 3/4 x 19"	265.9	336.0	242.1	255.8	318.0	190.5	316.0	-	228.6	-
6U, 1/1 x 19"	265.9	448.3	242.1	255.8	430.3	190.5	428.3	465.1	228.6	482.6

The H and K dimensions are defined by the 19" rack mounting kit.

Mounting alternatives

- 19" rack mounting kit
- Flush mounting kit with cut-out dimensions:
  - 1/2 case size (h) 254.3 mm (w) 210.1 mm
  - 3/4 case size (h) 254.3 mm (w) 322.4 mm
  - 1/1 case size (h) 254.3 mm (w) 434.7 mm
- Wall mounting kit

See ordering for details about available mounting alternatives.

НО С ОРИГИНАЛА

ЕЛЕКТРИКСИТИ ООД София

20. Connection diagrams

Connection diagrams
The connection diagrams are delivered on the IED Connectivity package DVD as part of the product delivery.

The latest versions of the connection diagrams can be downloaded from http://www.abb.com/substationautomation.

Connection diagrams for Customized products

Connection diagram, 670 series 2.0 1MRK002801-AE

Connection diagrams for Configured products

Connection diagram, RED670 2.0, A31 1MRK002809-DA

Connection diagram, RED670 2.0, B31 1MRK002802-DB

Connection diagram, RED670 2.0, A32 1MRK002801-DC

Connection diagram, RED670 2.0, B32 1MRK002803-DC

21. Technical data

General

Definitions

Reference value	The specified value of an influencing factor to which are referred the characteristics of the equipment
Nominal range	The range of values of an influencing quantity (factor) within which, under specified conditions, the equipment meets the specified requirements
Operative range	The range of values of a given energizing quantity for which the equipment, under specified conditions, is able to perform its intended functions according to the specified requirements

Energizing quantities, rated values and limits
Analog inputs

Table 2. TRM - Energizing quantities, rated values and limits for protection transformer modules

Quantity	Rated value	Nominal range
Current	I_r = 1 or 5 A	(0.2-40) x I_r
Operative range	(0-100) x I_r	
Permissive overload	4 x I_r cont. 100 x I_r for 1 s [1]	
Burden	< 150 mVA at I_r = 5 A < 20 mVA at I_r = 1 A	
Ac voltage	U_r = 110 V	0.5-288 V
Operative range	(0-340) V	
Permissive overload	420 V cont. 450 V 10 s	
Burden	< 20 mVA at 110 V	
Frequency	f_r = 50/60 Hz	± 5%

[1] max. 350 A for 1 s when COMBITEST test switch is included

Table 3. TRM - Energizing quantities, rated values and limits for measuring transformer modules

Quantity	Rated value	Nominal range
Current	I_r = 1 or 5 A	(0-1.6) x I_r at I_r = 1 A (0-1.6) x I_r at I_r = 5 A
Permissive overload	1.1 x I_r cont. 1.8 x I_r for 30 min at I_r = 1 A 1.6 x I_r for 30 min at I_r = 5 A	
Burden	< 350 mVA at I_r = 5 A < 200 mVA at I_r = 1 A	
Ac voltage	U_r = 110 V	0.5-288 V
Operative range	(0-340) V	
Permissive overload	420 V cont. 450 V 10 s	
Burden	< 20 mVA at 110 V	
Frequency	f_r = 50/60 Hz	± 5%

Table 4. MIM - mA input module

Quantity	Rated value	Nominal range
Input resistance	R_{in} = 194 Ohm	-
Input range	± 5, ± 10, ± 20mA 0-5, 0-10, 0-20, 4-20mA	-
Power consumption each mA-board each mA input	< 2 W ≤ 0.1 W	-

Table 5. OEM - Optical ethernet module

Quantity	Rated value
Number of channels	1 or 2 (port A, B for IEC 61850-8-1 and port C, D for IEC 61850-9-2LE)
Standard	IEEE 802.3u 100BASE-FX
Type of fiber	62.5/125 µm multimode fibre
Wave length	1300 nm
Optical connector	Type ST
Communication speed	Fast Ethernet 100 MBit/s

Auxiliary DC voltage

Table 6. PSM - Power supply module

Quantity	Rated value	Nominal range
Auxiliary dc voltage, EL (input)	EL = (24 - 60) V EL = (90 - 250) V	EL ± 20% EL ± 20%
Power consumption	50 W typically	-
Auxiliary DC power in-rush	< 13 A during 0.1 s	-

Binary inputs and outputs

Table 7. BIM - Binary input module

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ± 20% RL ± 20% RL ± 20% RL ± 20%
Power consumption 24/30 V, 50mA 48/60 V, 50mA 110/125 V, 50mA 220/250 V, 110mA	max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input max. 0.5 W/input	-
Counter input frequency	10 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1-40 Hz Release settable 1-30 Hz	
Debounce filter	Settable 1-20ms	

Table 8. BIM - Binary input module with enhanced pulse counting capabilities

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ± 20% RL ± 20% RL ± 20% RL ± 20%
Power consumption 24/30 V 48/60 V 110/125 V 220/250 V	max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input	-
Counter input frequency	10 pulses/s max	-
Balanced counter input frequency	40 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1-40 Hz Release settable 1-30 Hz	

Table 9. IOM - Binary input/output module

Quantity	Rated value	Nominal range
Binary inputs	8	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ± 20% RL ± 20% RL ± 20% RL ± 20%
Power consumption 24/30 V, 50 mA 48/60 V, 50 mA 110/125 V, 50 mA 220/250 V, 50 mA 220/250 V, 110 mA	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input max. 0.8 W/input	-
Counter input frequency	10 pulses/s max	
Balanced counter input frequency	40 pulses/s max	
Oscillating signal discriminator	Blocking settable 1-40 Hz Release settable 1-30 Hz	
Debounce filter	Settable 1-20 ms	

Table 10. IOM - Binary input/output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and signal relays	Fast signal relays (parallel reed relay)
Binary outputs	10	2
Max system voltage	250 V AC, DC	250 V DC
Test voltage across open contact, 1 min	1000 V rms	800 V DC
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	8 A 10 A 12 A	8 A 10 A 12 A
Making capacity at inductive load with L/R>10 ms 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A	 220-250 V/0.4 A 110-125 V/0.4 A 48-60 V/0.2 A 24-30 V/0.1 A
Breaking capacity for AC, cos φ > 0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Maximum capacitive load	-	10 nF

Table 11. IOM with MOV and IOM 220/250 V, 110mA - contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and Signal relays	Fast signal relays (parallel reed relay)
Binary outputs	IOM: 10	IOM: 2
Max system voltage	250 V AC, DC	250 V DC
Test voltage across open contact, 1 min	250 V rms	250 V rms
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	8 A 10 A 12 A	8 A 10 A 12 A
Making capacity at inductive loadwith L/R>10 ms 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A	 220-250 V/0.4 A 110-125 V/0.4 A 48-60 V/0.2 A 24-30 V/0.1 A
Breaking capacity for AC, cos φ>0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A
Maximum capacitive load	-	10 nF

Table 12. SOM - Static Output Module (reference standard: IEC 61810-2): Static binary outputs

Function of quantity	Static binary output trip	
Rated voltage	48 - 60 VDC	110 - 250 VDC
Number of outputs	6	6
Impedance open state	~300 kΩ	~810 kΩ
Test voltage across open contact, 1 min	No galvanic separation	No galvanic separation
Current carrying capacity:		
Continuous	5A	5A
1.0s	10A	10A
Making capacity at capacitive load with the maximum capacitance of 0.2 µF :		
0.2s	30A	30A
1.0s	10A	10A
Breaking capacity for DC with L/R ≤ 40ms	48V / 1A 60V / 0.75A	110V / 0.4A 125V / 0.35A 220V / 0.2A 250V / 0.15A
Operating time	<1ms	<1ms

Table 13. SOM - Static Output module data (reference standard: IEC 61810-2): Electromechanical relay outputs

Function of quantity	Trip and signal relays
Max system voltage	250V AC/DC
Number of outputs	6
Test voltage across open contact, 1 min	1000V rms
Current carrying capacity: Continuous 1.0s	 8A 10A
Making capacity at capacitive load with the maximum capacitance of 0.2 µF: 0.2s 1.0s	 30A 10A
Breaking capacity for DC with L/R ≤ 40ms	48V / 1A 110V / 0.4A 125V / 0.35A 220V / 0.2A 250V / 0.15A

Table 14. SOM - Binary output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and Signal relays
Binary outputs	24
Max system voltage	250 V AC, DC
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	8 A 10 A 12 A
Making capacity at inductive load with L/R>10 ms 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for AC, cos φ>0.4	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A

Influencing factors

Table 15. Temperature and humidity influence

Parameter	Reference value	Nominal range	Influence
Ambient temperature, operate value	+20 °C	-10 °C to +55 °C	0.02% /°C
Relative humidity Operative range	10%-90% 0%-95%	10%-90%	-
Storage temperature	+40 °C to +85 °C	-	-

Table 16. Auxiliary DC supply voltage influence on functionality during operation

Dependence on	Reference value	Within nominal range	Influence
Ripple, in DC auxiliary voltage Operative range	max. 2% Full wave rectified	15% of EL	0.01% /%
Auxiliary voltage dependence, operate value		± 20% of EL	0.01% /%
Interrupted auxiliary DC voltage		24-60 V DC ± 20% 90-250 V DC ± 20%	
Interruption interval 0-50 ms			No restart
0-[illegible] s			Correct behaviour at power down
Restart time			<300 s

Table 17. Frequency influence (reference standard: IEC 60255-1)

Dependence on	Within nominal range	Influence
Frequency dependence, operate value	f_r ± 2.5 Hz for 50 Hz f_r ± 3.0 Hz for 60 Hz	± 1.0% / Hz
Frequency dependence for distance protection operate value	f_r ± 2.5 Hz for 50 Hz f_r ± 3.0 Hz for 60 Hz	±2.0% / Hz
Harmonic frequency dependence (20% content)	2nd, 3rd and 5th harmonic of f_r	± 2.0%
Harmonic frequency dependence for distance protection (10% content)	2nd, 3rd and 5th harmonic of f_r	± 12.0%
Harmonic frequency dependence for high impedance differential protection (5% content)	2nd, 3rd and 5th harmonic of f_r	±5.0%

Type tests according to standards

Table 18. Electromagnetic compatibility

Test	Type test values	Reference standards
1 MHz burst disturbance	2.5 kV	IEC 60255-26
100 kHz slow damped oscillatory wave immunity test	2.5 kV	IEC 61000-4-18, Class III
Ring wave immunity test, 100 kHz	2-4 kV	IEC 61000-4-12, Class IV
Surge withstand capability test	2.5 kV, oscillatory 4.0 kV, fast transient	IEEE/ANSI C37.90.1
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEC 60255-26 IEC 61000-4-2, Class IV
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEEE/ANSI C37.90.1
Fast transient disturbance	4 kV	IEC 60255-26, Zone A
Surge immunity test	2-4 kV, 1.2/50 μs high energy	IEC 60255-26, Zone A
Power frequency immunity test	150-300 V, 50 Hz	IEC 60255-26, Zone A
Conducted common mode immunity test	15 Hz-150 kHz	IEC 61000-4-16, Class IV
Power frequency magnetic field test	1000 A/m, 3 s 100 A/m, cont.	IEC 61000-4-8, Class V
Pulse magnetic field immunity test	1000 A/m	IEC 61000-4-9, Class V
Damped oscillatory magnetic field test	100 A/m	IEC 61000-4-10, Class V
Radiated electromagnetic field disturbance	20 V/m, 80-1000 MHz 1.4-2.7 GHz	IEC 60255-26
Radiated electromagnetic field disturbance	20 V/m 80-1000 MHz	IEEE/ANSI C37.90.2
Conducted electromagnetic field disturbance	10 V, 0.15-80 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEEE/ANSI C63.4, FCC
Conducted emission	0.15-30 MHz	IEC 60255-26

Table 19. Insulation

Test	Type test values	Reference standard
Dielectric test	2.0 kV AC, 1 min.	IEC 60255-27
Impulse voltage test	5 kV, 1.2/50 μs, 0.5 J	
Insulation resistance	>100 MΩ at 500 VDC	

Table 20. Environmental tests

Test	Type test value	Reference standard
Cold operation test	Test Ad for 16 h at -25°C	IEC 60068-2-1
Cold storage test	Test Ad for 16 h at -40°C	IEC 60068-2-1
Dry heat operation test	Test Bd for 16 h at +70°C	IEC 60068-2-2
Dry heat storage test	Test Bd for 16 h at +85°C	IEC 60068-2-2
Change of temperature test	Test Nb for 5 cycles at -25°C to +85°C	IEC 60068-2-14
Damp heat test, steady state	Test Ca for 10 days at +40 °C and humidity 93%	IEC 60068-2-78
Damp heat test, cyclic	Test Db for 6 cycles at +25 to +55 °C and humidity 93 to 95% (1 cycle = 24 hours)	IEC 60068-2-30

Table 21. CE compliance

Test	According to
Immunity	EN 60255-26
Emissivity	EN 60255-26
Low voltage directive	EN 60255-27

Table 22. Mechanical tests

Test	Type test values	Reference standards
Vibration response test	Class II	IEC 60255-21-1
Vibration endurance test	Class I	IEC 60255-21-1
Shock response test	Class I	IEC 60255-21-2
Shock withstand test	Class I	IEC 60255-21-2
Bump test	Class I	IEC 60255-21-2
Seismic test	Class II	IEC 60255-21-3

Differential protection

Table 23. Restricted earth-fault protection, low impedance REFPDIF

Function	Range or value	Accuracy
Operate characteristic	Adaptable	± 1.0% of I_r for I ≤ I_r ± 1.0% of I for I > I_r
Reset ratio	>95%	-
Minimum pickup	(4.0-100.0)% of IBase	± 1.0% of I_r
Directional characteristic	Fixed 180 degrees or ± 60 to ± 90 degrees	± 2.0 degrees
Operate time, trip at 0 to 10 x IdMin	Min = 15 ms Max = 30 ms	-
Reset time, trip at 10 to 0 x IdMin	Min = 15 ms Max = 30 ms	-
Second harmonic blocking	60.0% of fundamental (hidden setting)	± 1.0% of I_r

Table 24. 1Ph High impedance differential protection HZPDIF

Function	Range or value	Accuracy
Operate voltage	(10-900) V I=U/R	± 1.0% of I_r at I ≤ I_r ± 1.0% of I at I > I_r
Reset ratio	>95% at (30-900) V	-
Maximum continuous power	U>Trip²/SeriesResistor ≤200 W	-
Operate time at 0 to 10 x U_d	Min = 5 ms Max = 15 ms	
Reset time at 10 to 0 x U_d	Min = 75 ms Max = 95 ms	
Critical impulse time	2 ms typically at 0 to 10 x U_d	-
Operate time at 0 to 2 x U_d	Min = 25 ms Max = 35 ms	
Reset time at 2 to 0 x U_d	Min = 50 ms Max = 70 ms	
Critical impulse time	15 ms typically at 0 to 2 x U_d	-

Table 25. Line differential protection L3CPDIF, L6CPDIF, LT3CPDIF, LT6CPDIF

Function	Range or value	Accuracy
Minimum operate current	(20-200)% of *IBase*	± 1.0% of I_r at I ≤ I_r ± 1.0% of I at I > I_r
SlopeSection2	(10.0-50.0)%	-
SlopeSection3	(30.0-100.0)%	-
EndSection 1	(20-150)% of *IBase*	-
EndSection 2	(150-1000)% of *IBase*	-
Unrestrained limit function	(100-5000)% of *IBase*	± 1.0% of I_r at I ≤ I_r ± 1.0% of I at I > I_r
Second harmonic blocking	(5.0-100.0)% of fundamental	± 1.0% of I_r Note: fundamental magnitude = 100% of I_r
Fifth harmonic blocking	(5.0-100.0)% of fundamental	± 2.0% of I_r Note: fundamental magnitude = 100% of I_r
Inverse characteristics, see table 129, 130 and table 130	16 curve types	See table 129, 130 and table 130
Critical impulse time	2ms typically at 0 to 10 x I_d	-
Charging current compensation	On/Off	-
LT3CPDIF and LT6CPDIF:		
*Operate time, restrained function at 0 to 10 x I_d	Min = 25 ms Max = 35 ms	-
*Reset time, restrained function at 10 to 0 x I_d	Min = 5 ms Max = 15 ms	-
*Operate time, unrestrained function at 0 to 10 x I_d	Min = 5 ms Max = 15 ms	-
*Reset time, unrestrained function at 10 to 0 x I_d	Min = 15 ms Max = 25 ms	-
L3CPDIF and L6CPDIF:		
*Operate time, restrained function at 0 to 10 x I_d	Min = [illegible] Max = 25 ms	-
*Reset time, restrained function at 10 to 0 x I_d	Min = 15 ms Max = 25 ms	-
*Operate time, unrestrained function at 0 to 10 x I_d	Min = [illegible] ms Max = 15 ms	-
*Reset time, unrestrained function at 10 to 0 x I_d	Min = 15 ms Max = [illegible] ms	-

*Note: Data [illegible] single IED with two local current input groups

ВЯРНО С ОРИГИНАЛА

Table 26. Additional security logic for differential protection LDRGFC

Function	Range or value	Accuracy
Operate current, zero sequence current	(1-100)% of IBase	±1.0% of I_r
Operate current, low current operation	(1-100)% of IBase	±1.0% of I_r
Operate voltage, phase to neutral	(1-100)% of UBase	± 0.5% of U_r
Operate voltage, phase to phase	(1-100)% of UBase	± 0.5% of U_r
Independent time delay, zero sequence current at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater
Independent time delay, low current operation at 2 x I_{set} to 0	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater
Independent time delay, low voltage operation at 2 x U_{set} to 0	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater
Reset time delay for start-up signal at 0 to 2 x U_{set}	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater

Impedance protection

Table 27. Distance measuring zone, Quad ZMQPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10-1000)% of IBase	-
Positive sequence reactance	(0.10-3000.00) Ω/phase	± 2.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01-1000.00) Ω/phase	
Zero sequence reactance	(0.10-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, phase-to-earth	(0.10-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVTs and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min = 20 ms Max = 35 ms	-

Table 28. Distance measuring zone, quadrilateral characteristic for series compensated lines ZMCPDIS, ZMCAPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of *IBase*	-
Minimum operate current, Ph-Ph and Ph-E	(10-1000)% of *IBase*	-
Positive sequence reactance	(0.10-3000.00) Ω/phase	± 2.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.10-1000.00) Ω/phase	
Zero sequence reactance	(0.01-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, Ph-E	(0.10-9000.00) Ω/loop	
Fault resistance, Ph-Ph	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CCVTs and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min = 20 ms Max = 35 ms	-

Table 29. Phase selection, quadrilateral characteristic with fixed angle FDPSPDIS

Function	Range or value	Accuracy
Minimum operate current	(5-500)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reactive reach, positive sequence	(0.50-3000.00) Ω/phase	± 2.5% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach, positive sequence	(0.10-1000.00) Ω/phase	
Reactive reach, zero sequence	(0.50-9000.00) Ω/phase	
Resistive reach, zero sequence	(0.50-3000.00) Ω/phase	
Fault resistance, phase-to-earth faults, forward and reverse	(1.00-9000.00) Ω/loop	
Fault resistance, phase-to-phase faults, forward and reverse	(0.50-3000.00) Ω/loop	
Load encroachment criteria: Load resistance, forward and reverse Safety load impedance angle	(1.00-3000.00) Ω/phase (5-70) degrees	
Reset ratio	105% typically	-

Table 30. Full-scheme distance protection, Mho characteristic ZMHPDIS

Function	Range or value	Accuracy
Number of zones, Ph-E		-
Minimum operate current	(10-30)% of IBase	-
Positive sequence impedance, Ph-E loop	(0.005-3000.000) Ω/phase	± 2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: 85 degrees
Positive sequence impedance angle, Ph-E loop	(10-90) degrees	
Reverse reach, Ph-E loop (Magnitude)	(0.005-3000.000) Ω/phase	
Magnitude of earth return compensation factor KN	(0.00-3.00)	
Angle for earth compensation factor KN	(-180-180) degrees	
Dynamic overreach	<5% at 85 degrees measured with CVTs and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	± 0.2% or ± 50 ms whichever is greater
Operate time	22 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.5 to 1.5 x Zreach	Min = 30 ms Max = 45 ms	-

Table 31. Full-scheme distance protection, quadrilateral for earth faults ZMMPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate current	(10-30)% of *IBase*	-
Positive sequence reactance	(0.50-3000.00) Ω/phase	± 2.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.10-1000.00) Ω/phase	
Zero sequence reactance	(0.50-9000.00) Ω/phase	
Zero sequence resistance	(0.50-3000.00) Ω/phase	
Fault resistance, Ph-E	(1.00-9000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVTs and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min = 20 ms Max = 35 ms	-

Table 32. Faulty phase identification with load encroachment FMPSPDIS

Function	Range or value	Accuracy
Load encroachment criteria: Load resistance, forward and reverse	(1.00–3000.00) Ω/phase (5–70) degrees	± 2.0% static accuracy Conditions: Voltage range: (0.1–1.1) x U_n Current range: (0.5–30) x I_n Angle: at 0 degrees and 85 degrees

Table 33. Distance measuring zone, quadrilateral characteristic, separate settings ZMRPDIS, ZMRAPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5–1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10–1000)% of IBase	-
Positive sequence reactance	(0.10–3000.00) Ω/ phase	± 2.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1–1.1) x U_n Current range: (0.5–30) x I_n Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01–1000.00) Ω/ phase	
Zero sequence reactance	(0.10–9000.00) Ω/ phase	
Zero sequence resistance	(0.01–3000.00) Ω/ phase	
Fault resistance, phase-to-earth	(0.10–9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10–3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVTs and 0.5<SIR<30	-
Definite time delay phase-phase and phase-earth operation	(0.000–60.000) s	± 0.2% or ± 40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min = 20 ms Max = 35 ms	-

Table 34. Phase selection with load encroachment, quadrilateral characteristic FRPSPDIS

Function	Range or value	Accuracy
Minimum operate current	(5-500)% of IBase	± 1.0% of I_n at $I \leq I_n$ ± 1.0% of I at $I > I_n$
Reactive reach, positive sequence	(0.50–3000.00) Ω/phase	± 2.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1–1.1) x U_n Current range: (0.5–30) x I_n Angle: at 0 degrees and 85 degrees
Resistive reach, positive sequence	(0.10–1000.00) Ω/phase	
Reactive reach, zero sequence	(0.50–9000.00) Ω/phase	
Resistive reach, zero sequence	(0.50–3000.00) Ω/phase	
Fault resistance, Ph-E faults, forward and reverse	(1.00–9000.00) Ω/loop	
Fault resistance, Ph-Ph faults, forward and reverse	(0.50–3000.00) Ω/loop	
Load encroachment criteria: Load resistance, forward and reverse Safety load impedance angle	(1.00–3000.00) Ω/phase (5–70) degrees	
Reset ratio	105% typically	-

Table 35. Fast distance protection ZMFPDIS, ZMFCPDIS

Function	Range or value	Accuracy
Number of zones	3 selectable directions, 3 fixed directions	-
Minimum operate current, Ph-Ph and Ph-E	(5-5000)% of IBase	±1.0% of I_n
Positive sequence reactance reach, Ph-E and Ph-Ph loop	(0.01 - 3000.00) ohm/ phase	
Positive sequence resistance reach, Ph-E and Ph-Ph loop	(0.00 - 1000.00) ohm/ phase	
Zero sequence reactance reach	(0.01 - 9000.00) ohm/p	±2.0% of static accuracy ±2.0 deg static angular accuracy Conditions: Voltage range: (0.1–1.1) x U_n Current range: (0.5-30) x I_n Angle: At 0 deg and 85 deg
Zero sequence resistive reach	(0.00 - 3000.00) ohm/p	
Fault resistance reach, Ph-E and Ph-Ph	(0.01-9000.00) ohm/	
Dynamic overreach	< 5% at 85 deg measured with CVTs and 0.5 < SIR < 30	
Definite time delay to trip, Ph-E and Ph-Ph operation	(0.000-60.000) s	±2.0% or ±35 ms whichever is greater
Operate time	18 ms typically	IEC 60255-121
Reset time at 0.1 to 2 x Zreach	Min = 20 ms Max = 35 ms	-
Reset ratio	105% typically	-

Table 36. Power swing detection ZMRPSB

Function	Range or value	Accuracy
Reactive reach	(0.10-3000.00) Ω/phase	± 2.0% static accuracy Conditions: Voltage range: (0.1–1.1) x U_n Current range: (0.5-30) x I_n Angle: at 0 degrees and 85 degrees
Resistive reach	(0.10–1000.00) Ω/loop	
Power swing detection operate time	(0.000-60.000) s	± 0.2% or ± 10 ms whichever is greater
Second swing reclaim operate time	(0.000-60.000) s	± 0.2% or ± 20 ms whichever is greater
Minimum operate current	(5-30)% of IBase	± 1.0% of I_n

Table 37. Power swing logic PSLPSCH

Function	Range or value	Accuracy
Permitted maximum operating time difference between higher and lower zone	(0.000 — 60.0000) s	± 0.2% or ± 15 ms whichever is greater
Delay for operation of underreach zone with detected difference in operating time	(0.000 — 60.0000) s	± 0.2% or ± 15 ms whichever is greater
Conditional timer for sending the CS at power swings	(0.000 — 60.0000) s	± 0.2% or ± 15 ms whichever is greater
Conditional timer for tripping at power swings	(0.000 — 60.0000) s	± 0.2% or ± 15 ms whichever is greater
Timer for blocking the overreaching zones trip	(0.000 — 60.0000) s	± 0.2% or ± 15 ms whichever is greater

Table 38. Pole slip protection PSPPPAM

Function	Range or value	Accuracy
Impedance reach	(0.00 - 1000.00)% of Zbase	± 2.0% of U_n/I_n
Zone 1 and Zone 2 trip counters	(1 - 20)	-

Table 39. Pole slip protection OOSPPAM

Function	Range or value	Accuracy
Impedance reach	(0.00 - 1000.00)% of Zbase	± 2.0% of $U_n/(\sqrt{3} \cdot I_n)$
Rotor start angle	(90.0 - 130.0) degrees	± 5.0 degrees
Rotor trip angle	(15.0 - 90.0) degrees	± 5.0 degrees
Zone 1 and Zone 2 trip counters	(1 - 20)	-

Table 40. Phase preference logic PPLPHIZ

Function	Range or value	Accuracy
Operate value, phase-to-phase and phase-to-neutral undervoltage	(1 - 100)% of UBase	± 0.5% of U_n
Reset ratio, undervoltage	< 105%	-
Operate value, residual voltage	(5 - 300)% of UBase	± 0.5% of U_n for $U \leq U_n$ ± 0.5% of U for $U > U_n$
Reset ratio, residual voltage	> 95%	-
Operate value, residual current	(10 - 200)% of IBase	± 1.0% of I_n for $I \leq I_n$ ± 1.0% of I for $I > I_n$
Reset ratio, residual current	> 95%	-
Independent time delay for residual current at 0 to 2 x I_{set}	(0.000 - 60.000) s	± 0.2% or ± 25 ms whichever is greater
Independent time delay for residual voltage at 0.8 to 1.2 x U_{set}	(0.000 - 60.000) s	± 0.2% or ± 25 ms whichever is greater
Independent dropoff-delay for residual voltage at 1.2 to 0.8 x U_{set}	(0.000 - 60.000) s	± 0.2% or ± 25 ms whichever is greater
Operating mode	No Filter, No Pref Cyclic: 123i, 132i Acyclic: 123i, 132i, 213i, 231i, 312i, 321i	

Table 41. Automatic switch onto fault logic, voltage and current based ZCVPSOF

Parameter	Range or value	Accuracy
Operate voltage, detection of dead line	(1–100)% of *UBase*	± 0.5% of U_n
Operate current, detection of dead line	(1–100)% of *IBase*	± 1.0% of I_n
Time delay to operate for the switch onto fault function	(0.03–120.00) s	± 2.0% or ± 20 ms whichever is greater
Time delay for UI detection (s)	(0.000-60.000) s	± 2.0% or ± 20 ms whichever is greater
Delay time for activation of dead line detection	(0.000-60.000) s	± 2.0% or ± 20 ms whichever is greater
Drop-off delay time of switch onto fault function	(0.000-60.000) s	± 2.0% or ± 30 ms whichever is greater

Current protection

Table 42. Instantaneous phase overcurrent protection PHPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of IBase	-
Operate time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Reset time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time at 0 to 10 x I_{set}	Min. = 5 ms Max. = 15 ms	-
Reset time at 10 to 0 x I_{set}	Min. = 25 ms Max. = 40 ms	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 43. Four step phase overcurrent protection OC4PTOC

Function	Setting range	Accuracy
Operate current	(5-2500)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of *IBase*	-
Min. operating current	(1-10000)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Relay characteristic angle (RCA)	(40.0-65.0) degrees	± 2.0 degrees
Relay operating angle (ROA)	(40.0-89.0) degrees	± 2.0 degrees
2nd harmonic blocking	(5-100)% of fundamental	± 2.0% of I_r
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2 % or ± 35 ms whichever is greater
Minimum operate time	(0.000-60.000) s	± 2.0 % or ± 40 ms whichever is greater
Inverse characteristics, see table 129, table 130 and table 131	16 curve types	See table 129, table 130 and table 131
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	
Reset time, start non-directional at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 44. Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of IBase	-
Operate time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Reset time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time at 0 to 10 x I_{set}	Min. = 5 ms Max. = 15 ms	-
Reset time at 10 to 0 x I_{set}	Min. = 25 ms Max. = 35 ms	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 45. Four step residual overcurrent protection EF4PTOC technical data

Function	Range or value	Accuracy
Operate current	(1-2500)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95% at (10-2500)% of *IBase*	-
Relay characteristic angle	(-180 to 180) degrees	± 2.0 degrees
Operate current for directional comparison	(1–100)% of *IBase*	For RCA ± 60 degrees: ± 2.5% of I_r at $I \leq I_r$ ± 2.5% of I at $I > I_r$
Independent time delay for step 1, 2, 3, and 4 at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Inverse characteristics, see table 129, table 130 and table 131	16 curve types	See table 129, table 130 and table 131
Second harmonic restrain operation	(5–100)% of fundamental	± 2.0% of I_r
Minimum polarizing voltage	(1–100)% of *UBase*	± 0.3% of U_r
Minimum polarizing current	(2-100)% of *IBase*	± 1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start function at 0 to 2 x I_{set}	Min = 15 ms Max = 30 ms	-
Reset time, start function at 2 to 0 x I_{set}	Min = 15 ms Max = 30 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 46. Four step negative sequence overcurrent protection NS4PTOC

Function	Range or value	Accuracy
Operate value, negative sequence current, step 1-4	(1-2500)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95% at (10-2500)% of *IBase*	-
Independent time delay for step 1, 2, 3, and 4 at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Inverse characteristics, see table 129, table 130 and table 131	16 curve types	See table 129, table 130 and table 131
Minimum operate current for steps 1 - 4	(1.00 - 10000.00)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Relay characteristic angle	(-180 to 180) degrees	± 2.0 degrees
Operate value, negative current for directional release	(1–100)% of *IBase*	For RCA ± 60 degrees: ± 2.5% of I_r at $I \leq I_r$ ± 2.5% of I at $I > I_r$
Minimum polarizing voltage	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing current	(2-100)% of *IBase*	± 1.0% of I_r
Real part of negative sequence source impedance used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of negative sequence source impedance used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start function at 0 to 2 x I_{set}	Min = 15 ms Max = 30 ms	-
Reset time, start function at 2 to 0 x I_{set}	Min = 15 ms Max = 30 ms	-
Critical impulse time, start function	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time, start function	15 ms typically	-
Transient overreach	<10% at τ = 100 ms	-

Table 47. Sensitive directional residual overcurrent and power protection SDEPSDE

Function	Range or value	Accuracy
Operate level for $3I_0 \cos\varphi$ directional residual overcurrent	(0.25-200.00)% of *SBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Operate level for $-3V_0 3I_0 \cos\varphi$ directional residual power	(0.25-200.00)% of *SBase*	± 1.0% of S_r at $S \leq S_r$ ± 1.0% of S at $S > S_r$
Operate level for $3I_0$ and φ residual overcurrent	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Operate level for non-directional overcurrent	(1.00-400.00)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Operate level for non-directional residual overvoltage	(1.00-200.00)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Residual release current for all directional modes	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Residual release voltage for all directional modes	(1.00-300.00)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Operate time for non-directional residual overcurrent at 0 to 2 x Iset	Min = 40 ms Max = 85 ms	
Reset time for non-directional residual overcurrent at 2 to 0 x Iset	Min = 40 ms Max = 85 ms	
Operate time for directional residual overcurrent at 0 to 2 x Iset	Min = 115 ms Max = 165 ms	
Reset time for directional residual overcurrent at 2 to 0 x Iset	Min = 25 ms Max = 85 ms	
Independent time delay for non-directional residual overvoltage at 0.8 to 1.2 x Uset	(0.000 – 60.000) sec	±0.2% or ± 80 ms whichever is greater
Independent time delay for non-directional residual overcurrent at 0 to 2 x Iset	(0.000 – 60.000) sec	±0.2% or ± 80 ms whichever is greater
Independent time delay for directional residual overcurrent at 0 to 2 x Iset	(0.000 – 60.000) sec	±0.2% or ± 150 ms whichever is greater
Inverse characteristics	16 curve types	See table 129, table 130 and table 131
Relay characteristic angle RCA	(-179 to 180) degrees	± 2.0 degrees
Relay Open angle ROA	(0 to 90) degrees	± 2.0 degrees

Table 48. Thermal overload protection, one time constant LCPTTR/LFPTTR

Function	Range or value	Accuracy
Reference current	(2-400)% of I_{Base}	± 1.0% of I_r
Reference temperature	(0-300)°C, (0 - 600)°F	± 1.0°C, ± 2.0°F
Operate time: $t = \tau \ln\left[\frac{I^2 - I_p^2}{I^2 - I_{eq}^2}\right]$ (Equation 1)	Time constant τ = (1-1000) minutes	IEC 60255-8, ±5.0% or ±200 ms whichever is greater
Alarm temperature	(0-200)°C, (0-400)°F	±2.0°C, ±4.0°F
Operate temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F
Reset level temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F

T_{Trip} = set operate temperature
T_{Amb} = ambient temperature
T_{rise} = temperature rise above ambient at I_{ref}
I_{ref} = reference load current
I = actual measured current
I_p = load current before overload occurs

Table 49. Breaker failure protection CCRBRF

Function	Range or value	Accuracy
Operate phase current	(5-200)% of I_{Base}	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of I_{Base}	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of I_{Base}	±1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time for current detection	10 ms typically	-
Reset time for current detection	15 ms maximum	-
Time delay for re-trip at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Time delay for back-up trip at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Time delay for back-up trip at multi-phase start at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 20 ms whichever is greater
Additional time delay for a second back-up trip at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 20 ms whichever is greater
Time delay for alarm for faulty circuit breaker	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater

Table 53. Stub protection STBPTOC

Function	Range or value	Accuracy
Operating current	(5-2500)% of I_{Base}	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95% at (50-2500)% of I_{Base}	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Operate time, start at 0 to 2 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Reset time, start at 2 to 0 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 51. Pole discordance protection CCPDSC

Function	Range or value	Accuracy
Operate current	(0-100)% of I_{Base}	± 1.0% of I_r
Independent time delay between trip condition and trip signal	(0.000-60.000) s	± 0.2% or ± 25 ms whichever is greater

Table 52. Directional underpower protection GUPPDUP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of S_{Base}	± 1.0% of S_r at $S \le S_r$ ± 1.0% of S at $S > S_r$ where $S_r = 1.731 \cdot U_r \cdot I_r$
Characteristic angle for Step 1 and Step 2	(-180.0–180.0) degrees	± 2.0 degrees
Independent time delay to operate for Step 1 and Step 2 at 2 to 0.5 x S_r and $k=0.000$	(0.01-6000.00) s	± 0.2% or ± 40 ms whichever is greater

Table 53. Directional overpower protection GOPPDOP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of S_{Base}	± 1.0% of S_r at $S \le S_r$ ± 1.0% of S at $S > S_r$
Characteristic angle for Step 1 and Step 2	(-180.0–180.0) degrees	± 2.0 degrees
Operate time, start at 0.5 to 2 x S_r and $k=0.000$	Min = 10 ms Max = 25 ms	
Reset time, start at 2 to 0.5 x S_r and $k=0.000$	Min = 35 ms Max = 55 ms	
Independent time delay to operate for Step 1 and Step 2 at 0.5 to 2 x S_r and $k=0.000$	(0.01-6000.00) s	± 0.2% or ± 40 ms whichever is greater

Table 54. Broken conductor check BRCPTOC

Function	Range or value	Accuracy
Minimum phase current for operation	(5–100)% of I_{Base}	± 1.0% of I_r
Unbalance current operation	(50–90)% of maximum current	± 1.0% of I_r
Independent operate time delay	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Independent reset time delay	(0.010-60.000) s	± 0.2% or ± 30 ms whichever is greater
Start time at current change from I_r to 0	Min = 25 ms Max = 35 ms	-
Reset time at current change from 0 to I_r	Min = 5 ms Max = 20 ms	-

Voltage protection

Table 55. Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1.0-100.0)% of U_{Base}	±0.5% of U_r
Absolute hysteresis	(0.0-50.0)% of U_{Base}	±0.5% of U_r
Internal blocking level, step 1 and step 2	(1-50)% of U_{Base}	±0.5% of U_r
Inverse time characteristics for step 1 and step 2, see table 133	-	See table 133
Definite time delay, step 1 at 1.2 to 0 x U_{set}	(0.00-6000.00) s	±0.2% or ±40ms whichever is greater
Definite time delay, step 2 at 1.2 to 0 x U_{set}	(0.000-60.000) s	±0.2% or ±40ms whichever is greater
Minimum operate time, inverse characteristics	(0.000-60.000) s	±0.2% or ±40ms whichever is greater
Operate time, start at 2 to 0 x U_{set}	Min= 15 ms Max= 30 ms	-
Reset time, start at 0 to 2 x U_{set}	Min= 15 ms Max= 30 ms	-
Operate time, start at 1.2 to 0 x U_{set}	Min= 5 ms Max= 25 ms	-
Reset time, start at 0 to 1.2 x U_{set}	Min= 15 ms Max= 35 ms	-
Critical impulse time	5 ms typically at 1.2 to 0 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 56. Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and 2	(1.0-200.0)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Absolute hysteresis	(0.0-50.0)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Inverse time characteristics for step 1 and 2, see table 132	-	See table 132
Definite time delay, low step (step 1) at 0 to 1.2 x U_{set}	(0.00 - 6000.00) s	± 0.2% or ± 45 ms whichever is greater
Definite time delay, high step (step 2) at 0 to 1.2 x U_{set}	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Minimum operate time, inverse characteristics	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 57. Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and step 2	(1.0-200.0)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Absolute hysteresis	(0.0-50.0)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Inverse time characteristics for low and high step, see table 134	-	See table 134
Definite time delay low step (step 1) at 0 to 1.2 x U_{set}	(0.00-6000.00) s	± 0.2% or ± 45 ms whichever is greater
Definite time delay high step (step 2) at 0 to 1.2 x U_{set}	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Minimum operate time	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 58. Overexcitation protection OEXPVPH

Function	Range or value	Accuracy
Operate value, start	(100-180)% of (U/f_{Base})$_{base}$	± 0.5% of U
Operate value, alarm	(50-120)% of start level	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Operate value, high level	(100-200)% of (U/f_{Base})$_{base}$	± 0.5% of U
Curve type	IEEE or customer defined $t = \frac{(0.18 \cdot D)}{(M - 1)^2}$ (Equation 2) where M = (E/f)/(U/f)	± 5.0 % or ± 45 ms, whichever is greater
Minimum time delay for inverse function	(0.000-60.000) s	± 1.0% or ± 45 ms, whichever is greater
Maximum time delay for inverse function	(0.00-9000.00) s	± 1.0% or ± 45 ms, whichever is greater
Alarm time delay	(0.00-9000.00)	± 1.0% or ± 45 ms, whichever is greater

Table 59. Voltage differential protection VDCPTOV

Function	Range or value	Accuracy
Voltage difference for alarm and trip	(2.0-100.0) % of *UBase*	± 0.5% of U_r
Under voltage level	(1.0-100.0) % of *UBase*	± 0.5% of U_r
Independent time delay for voltage differential alarm at 0.8 to 1.2 x UDAlarm	(0.000-60.000)s	± 0.2% or ± 40 ms whichever is greater
Independent time delay for voltage differential trip at 0.8 to 1.2 x UDTrip	(0.000-60.000)s	± 0.2% or ± 40 ms whichever is greater
Independent time delay for voltage differential reset at 1.2 to 0.8 x UDTrip	(0.000-60.000)s	± 0.2% or ± 40 ms whichever is greater

Table 60. Loss of voltage check LOVPTUV

Function	Range or value	Accuracy
Operate voltage	(1-100)% of UBase	± 0.5% of U_r
Pulse timer when disconnecting all three phases	(0.050-60.000) s	± 0.2% or ± 15 ms whichever is greater
Time delay for enabling the functions after restoration	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Operate time delay when disconnecting all three phases	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Time delay to block when all three phase voltages are not low	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater

Table 61. Radial feeder protection PAPGAPC

Function	Range or value	Accuracy
Residual current detection	(10 - 150)% of IBase	± 1.0% of Ir at I ≤ Ir ± 1.0% of Ir at I > Ir
Reset ratio	>95% at (50 - 150)% of IBase	-
Operate time, residual current detection at 0 to 2 x I_{set}	Min = 15 ms Max = 30 ms	-
Independent time delay to operate, residual current detection at 0 to 2 x I_{set}	(0.000 - 60.000) s	± 0.2% or ± 40 ms whichever is greater
Voltage based phase selection	(30 - 100)% of UBase	± 1.0% of U_r
Reset ratio	<115%	-
Operate time, voltage based phase selection at 1.2 to 0.8 x U_{set}	Min = 15 ms Max = 30 ms	-
Independent time delay to operate, voltage based phase selection at 1.2 to 0.8 x U_{set}	(0.000 – 60.000) s	± 0.2% or ± 40 ms whichever is greater

Frequency protection

Table 62. Underfrequency protection SAPTUF

Function	Range or value		Accuracy
Operate value, start function, at symmetrical three phase voltage	(35.00-75.00) Hz		± 2.0 mHz
Operate time, start at f_{set} + 0.02 Hz to f_{set} - 0.02 Hz	fn = 50 Hz	Min. = 80 ms Max. = 95 ms	-
	fn = 60 Hz	Min. = 65 ms Max. = 80 ms	
Reset time, start at f_{set} - 0.02 Hz to f_{set} + 0.02 Hz	Min. = 15 ms Max. = 30 ms		-
Operate time, definite time function at f_{set} + 0.02 Hz to f_{set} - 0.02 Hz	(0.000-60.000)s		± 0.2% or ± 100 ms whichever is greater
Reset time, definite time function at f_{set} - 0.02 Hz to f_{set} + 0.02 Hz	(0.000-60.000)s		± 0.2% or ± 120 ms whichever is greater
Voltage dependent time delay	Settings: UNom=(50-150)% of U_{base} UMin=(50-150)% of U_{base} Exponent=0.0-5.0 tMax=(0.010-60.000)s tMin=(0.010-60.000)s		± 1.0% or ± 120 ms whichever is greater

$t = \left[\frac{U - UMin}{UNom - UMin}\right]^{Exponent} \cdot (tMax - tMin) + tMin$ (Equation 3)

U=$U_{measured}$

Table 63. Overfrequency protection SAPTOF

Function	Range or value		Accuracy
Operate value, start function at symmetrical three-phase voltage	(35.00-90.00) Hz		± 2.0 mHz
Operate time, start at f_{set} - 0.02 Hz to f_{set} + 0.02 Hz	fn = 50Hz	Min. = 80 ms Max. = 95 ms	-
	fn = 60 Hz	Min. = 65 ms Max. = 80 ms	
Reset time, start at f_{set} + 0.02 Hz to f_{set} - 0.02 Hz	Min. = 15 ms Max. = 30 ms		-
Operate time, definite time function at f_{set} -0.02 Hz to f_{set} + 0.02 Hz	(0.000-60.000)s		± 0.2% ± 100 ms whichever is greater
Reset time, definite time function at f_{set} + 0.02 Hz to f_{set} - 0.02 Hz	(0.000-60.000)s		± 0.2% ± 120 ms whichever is greater

Table 84. Rate-of-change frequency protection SAPFRC

Function	Range or value	Accuracy
Operate value, start function	(-10.00-10.00) Hz/s	± 10.0 mHz/s
Operate value, restore enable frequency	(45.00-65.00) Hz	± 2.0 mHz
Definite restore time delay	(0.000-60.000) s	± 0.2% or ± 100 ms whichever is greater
Definite time delay for frequency gradient trip	(0.200-60.000) s	± 0.2% or ± 120 ms whichever is greater
Definite reset time delay	(0.000-60.000) s	± 0.2% or ± 250 ms whichever is greater

Multipurpose protection

Table 85. General current and voltage protection CVGAPC

Function	Range or value	Accuracy
Measuring current input	phase1, phase2, phase3, PosSeq, NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Base current	(1 - 99999) A	-
Measuring voltage input	phase1, phase2, phase3, PosSeq, NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Base voltage	(0.05 - 2000.00) kV	-
Start overcurrent, step 1 and 2	(2 - 5000)% of IBase	± 1.0% of I_r for $I \leq I_r$ ± 1.0% of I for $I > I_r$
Start undercurrent, step 1 and 2	(2 - 150)% of IBase	± 1.0% of I_r for $I \leq I_r$ ± 1.0% of I for $I > I_r$
Independent time delay, overcurrent at 0 to 2 x I_{set}	(0.00 - 6000.00) s	± 0.2% or ± 35 ms whichever is greater
Independent time delay, undercurrent at 2 to 0 x I_{set}	(0.00 - 6000.00) s	± 0.2% or ± 35 ms whichever is greater
Overcurrent:		
Start time at 0 to 2 x I_{set}	Min = 15 ms Max = 30 ms	-
Reset time at 2 to 0 x I_{set}	Min = 15 ms Max = 30 ms	-
Undercurrent:		
Start time at 2 to 0 x I_{set}	Min = 15 ms Max = 30 ms	-
Reset time at 0 to 2 x I_{set}	Min = 15 ms Max = 30 ms	-
See table 129 and table 133	Parameter ranges for customer defined characteristic no 17: I: 0.05 - 999.00 A: 0.0000 - 999.0000 B: 0.0000 - 99.0000 C: 0.0000 - 1.0000 P, 0.0001 - 10.0000 PR: 0.005 - 3.000 TR: 0.005 - 600.000 CR: 0.1 - 10.0	See table 129 and table 133
Voltage level where voltage memory takes over	(0.0 - 5.0)% of UBase	± 0.5% of U_r
Start overvoltage, step 1 and 2	(2.0 - 200.0)% of UBase	± 0.5% of U_r for $U \leq U_r$ ± 0.5% of U for $U > U_r$
Start undervoltage, step 1 and 2	(2.0 - 150.0)% of UBase	± 0.5% of U_r for $U \leq U_r$ ±0.5% of U for $U > U_r$

Table 85. General current and voltage protection CVGAPC , continued

Function	Range or value	Accuracy
Independent time delay, overvoltage at 0.8 to 1.2 x U_{set}	(0.00 - 6000.00) s	± 0.2% or ± 35 ms whichever is greater
Independent time delay, undervoltage at 1.2 to 0.8 x U_{set}	(0.00 - 6000.00) s	± 0.2% or ± 35 ms whichever is greater
Overvoltage:		
Start time at 0.8 to 1.2 x U_{set}	Min = 15 ms Max = 30 ms	-
Reset time at 1.2 to 0.8 x U_{set}	Min = 15 ms Max = 30 ms	-
Undervoltage:		
Start time at 1.2 to 0.8 x U_{set}	Min = 15 ms Max = 30 ms	-
Reset time at 1.2 to 0.8 x U_{set}	Min = 15 ms Max = 30 ms	-
High and low voltage limit, voltage dependent operation	(1.0 - 200.0)% of UBase	± 1.0% of U_r for $U \leq U_r$ ± 1.0% of U for $U > U_r$
Directional function	Settable: NonDir, forward and reverse	-
Relay characteristic angle	(-180 to +180) degrees	± 2.0 degrees
Relay operate angle	(1 to 90) degrees	± 2.0 degrees
Reset ratio, overcurrent	> 95%	-
Reset ratio, undercurrent	< 105%	-
Reset ratio, overvoltage	> 95%	-
Reset ratio, undervoltage	< 105%	-
Overcurrent:		
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Undercurrent:		
Critical impulse time	10 ms typically at 2 to 0 x I_{set}	-
Impulse margin time	15 ms typically	-
Overvoltage:		
Critical impulse time	10 ms typically at 0.8 to 1.2 x U_{set}	-
Impulse margin time	15 ms typically	-
Undervoltage:		
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 86. Voltage-restrained time overcurrent protection VRPVOC

Function	Range or value	Accuracy
Start overcurrent	(2.0 - 5000.0)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, overcurrent	> 95%	
Operate time, start overcurrent at 0 to 2 x I_{set}	Min = 15 ms Max = 30 ms	
Reset time, start overcurrent at 0 to 2 x I_{set}	Min = 15 ms Max = 30 ms	
Independent time delay to operate at 0 to 2 x I_{set}	(0.00 - 6000.00) s	± 0.2% or ± 35 ms whichever is greater
Inverse time characteristics	18 curve types	ANSI/IEEE C37.112 IEC 60255-151 ±5.0% or ±40 ms whichever is greater $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$ See Table, and Table
Minimum operate time for inverse time characteristics	(0.00 - 60.00) s	±0.2% or ±35 ms whichever is greater
High voltage limit, voltage dependent operation	(30.0 - 100.0)% of UBase	± 1.0% of U_r
Start undervoltage	(2.0 - 150.0)% of UBase	±0.5% of U_r
Reset ratio, undervoltage	< 105%	
Operate time start undervoltage at 2 to 0 x U_{set}	Min = 15 ms Max = 30 ms	-
Reset time start undervoltage at 0 to 2 x U_{set}	Min = 15 ms Max = 30 ms	-
Independent time delay to operate, undervoltage at 2 to 0 x U_{set}	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Internal low voltage blocking	(0.0 - 5.0)% of UBase	±0.25% of U_r
Overcurrent: Critical impulse time Impulse margin time	10 ms typically at 0 to 2 x I_{set} 15 ms typically	-
Undervoltage: Critical impulse time Impulse margin time	10 ms typically at 2 to 0 x U_{set} 15 ms typically	-

Secondary system supervision

Table 67. Current circuit supervision CCSSPVC

Function	Range or value	Accuracy
Operate current	(10-200)% of IBase	±10.0% of I_r at $I \le I_r$ ±10.0% of I at $I > I_r$
Reset ratio, Operate current	>90%	
Block current	(20-500)% of IBase	±5.0% of I_r at $I \le I_r$ ±5.0% of I at $I > I_r$
Reset ratio, Block current	>90% at (50-500)% of IBase	

Table 68. Fuse failure supervision FUFSPVC

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	±0.5% of U_r
Operate current, zero sequence	(1-100)% of IBase	±0.5% of I_r
Operate voltage, negative sequence	(1-100)% of UBase	0.5% of U_r
Operate current, negative sequence	(1-100)% of IBase	±0.5% of I_r
Operate voltage change level	(1-100)% of UBase	±10.0% of U_r
Operate current change level	(1-100)% of IBase	±10.0% of I_r
Operate phase voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase current	(1-100)% of IBase	±0.5% of I_r
Operate phase dead line voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase dead line current	(1-100)% of IBase	±0.5% of I_r
Operate time, start, 1 ph, at 1 to 0 x U_r	Min. = 10 ms Max. = 25 ms	-
Reset time, start, 1 ph, at 0 to 1 x U_r	Min. = 15 ms Max. = 30 ms	-

Table 69. Fuse failure supervision VDSPVC

Function	Range or value	Accuracy
Operate value, block of main fuse failure	(10.0-80.0)% of UBase	±0.5% of Ur
Reset ratio	<110%	
Operate time, block of main fuse failure at 1 to 0 x U_r	Min = 5 ms Max = 15 ms	-
Reset time, block of main fuse failure at 0 to 1 x U_r	Min = 15 ms Max = 30 ms	-
Operate value, alarm for pilot fuse failure	(10.0-80.0)% of UBase	±0.5% of Ur
Reset ratio	<110%	-
Operate time, alarm for pilot fuse failure at 1 to 0 x U_r	Min = 5 ms Max = 15 ms	-
Reset time, alarm for pilot fuse failure at 0 to 1 x U_r	Min = 15 ms Max = 30 ms	-

Control

Table 70. Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, $\varphi_{line} - \varphi_{bus}$	(-180 to 180) degrees	-
Voltage high limit for synchronizing and synchrocheck	(50.0-120.0)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Reset ratio, synchrocheck	> 95%	-
Frequency difference limit between bus and line for synchrocheck	(0.003-1.000) Hz	±2.5 mHz
Phase angle difference limit between bus and line for synchrocheck	(5.0-90.0) degrees	± 2.0 degrees
Voltage difference limit between bus and line for synchronizing and synchrocheck	(0.02-0.5) p.u	± 0.5% of U_r
Time delay output for synchrocheck when angle difference between bus and line jumps from "PhaseDiff" + 2 degrees to "PhaseDiff" - 2 degrees	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Frequency difference minimum limit for synchronizing	(0.003-0.250) Hz	± 2.5 mHz
Frequency difference maximum limit for synchronizing	(0.050-0.500) Hz	± 2.5 mHz
Maximum allowed frequency rate of change	(0.000-0.500) Hz/s	± 10.0 mHz/s
Breaker closing pulse duration	(0.050-60.000) s	± 0.2% or ± 15 ms whichever is greater
tMaxSynch, which resets synchronizing function if no close has been made before set time	(0.000-6000.00) s	± 0.2% or ± 35 ms whichever is greater
Minimum time to accept synchronizing conditions	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Voltage high limit for energizing check	(50.0-120.0)% of UBase	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Reset ratio, voltage high limit	≥ 95%	-
Voltage low limit for energizing check	(10.0-80.0)% of UBase	± 0.5% of U_r
Reset ratio, voltage low limit	< 105%	-
Maximum voltage for energizing	(50.0-153.0)% of UBase	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Time delay for energizing check when voltage jumps from 0 to 90% of Urated	(0.000-60.000) s	± 0.2% or ± 100 ms whichever is greater
Operate time for synchrocheck function when angle difference between bus and line jumps from "PhaseDiff" + 2 degrees to "PhaseDiff" - 2 degrees	Min = 15 ms Max = 30 ms	-
Operate time for energizing function when voltage jumps from 0 to 90% of Urated	Min = 70 ms Max = 90 ms	-

Table 71. Autoreclose SMBRREC

Function	Range or value	Accuracy
Number of autoreclosing shots	1 - 5	-
Autoreclosing open time: shot 1 - t1 1Ph shot 1 - t1 2Ph shot 1 - t1 3PHS shot 1 - t1 3Ph	(0.000-120.000) s	± 0.2% or ± 35 ms whichever is greater
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) s	± 0.2% or ± 35 ms whichever is greater
Extended autoreclose open time	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	± 0.2% or ± 35 ms whichever is greater
Maximum operate pulse duration	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Reclaim time	(0.00-6000.00) s	± 0.2% or ± 15 ms whichever is greater
Circuit breaker closing pulse length	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Wait for master release	(0.00-6000.00) s	± 0.2% or ± 15 ms whichever is greater
Inhibit reset time	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Autoreclose maximum wait time for sync	(0.00-6000.00) s	± 0.2% or ± 45 ms whichever is greater
CB check time before unsuccessful	(0.00-6000.00) s	± 0.2% or ± 45 ms whichever is greater
Wait time after close command before proceeding to next shot	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater

Scheme communication

Table 72. Scheme communication logic for distance or overcurrent protection ZCPSCH

Function	Range or value	Accuracy
Scheme type	Intertrip Permissive Underreach Permissive Overreach Blocking	-
Co-ordination time for blocking communication scheme	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Minimum duration of a send signal	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Security timer for loss of guard signal detection	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Operation mode of unblocking logic	Off NoRestart Restart	-

Table 73. Phase segregated scheme communication logic for distance protection ZC1PPSCH

Function	Range or value	Accuracy
Scheme type	Intertrip Permissive UR Permissive OR Blocking	-
Co-ordination time for blocking communication scheme	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Minimum duration of a carrier send signal	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater

Table 74. Current reversal and weak-end infeed logic for distance protection ZCRWPSCH

Function	Range or value	Accuracy
Detection level phase-to-neutral voltage	(10-90)% of UBase	± 0.5% of U_r
Detection level phase-to-phase voltage	(10-90)% of UBase	± 0.5% of U_r
Operate time for current reversal logic	(0.000-60.000) s	± 0.2% or ±15 ms whichever is greater
Delay time for current reversal	(0.000-60.000) s	± 0.2% or ±15 ms whichever is greater
Coordination time for weak-end infeed logic	(0.000-60.000) s	± 0.2% or ±15 ms whichever is greater

Table 75. Current reversal and weak-end infeed logic for phase segregated communication ZC1WPSCH

Function	Range or value	Accuracy
Detection level phase to neutral voltage	(10-90)% of UBase	± 0.5% of U_r
Detection level phase to phase voltage	(10-90)% of UBase	± 0.5% of U_r
Reset ratio	<105% at (20-90)% of UBase	-
Operate time for current reversal	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Delay time for current reversal	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater
Coordination time for weak-end infeed logic	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater

Table 76. Scheme communication logic for residual overcurrent protection ECPSCH

Function	Range or value	Accuracy
Scheme type	Permissive Underreaching Permissive Overreaching Blocking	-
Communication scheme coordination time	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater

Table 77. Current reversal and weak-end infeed logic for residual overcurrent protection ECRWPSCH

Function	Range or value	Accuracy
Operate mode of WEI logic	Off Echo Echo & Trip	-
Operate voltage 3U0 for WEI trip	(5-70) % of UBase	± 0.5% of U_r
Operate time for current reversal logic	(0.000-60.000) s	± 0.2% or ±30 ms whichever is greater
Delay time for current reversal	(0.000-60.000) s	± 0.2% or ±30 ms whichever is greater
Coordination time for weak-end infeed logic	(0.000-60.000) s	± 0.2% or ±30 ms whichever is greater

Direct transfer trip

Table 78. Low active power and power factor protection LAPPGAPC

Function	Range or value	Accuracy
Operate value, low active power	(2.0-100.0)% of SBase	± 1.0% of S_r
Reset ratio, low active power	<105%	-
Operate value, low power factor	0.00-1.00	± 0.02
Independent time delay to operate for low active power at 1.2 to 0.8 x P_{set}	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater
Independent time delay to operate for low power factor at 1.2 to 0.8 x PF_{set}	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater
Critical impulse time, low active power	10 ms typically at 1.2 to 0.8 x P_{set}	-
Impulse margin time, low active power	10 ms typically	-

Table 79. Compensated over- and undervoltage protection COUVGAPC

Function	Range or value	Accuracy
Operate value, undervoltage	(1-100)% of UBase	± 0.5% of U_r
Absolute hysteresis	(0.00- 50.0)% of UBase	± 0.5% of U_r at U ≤ U_r ± 0.5% of U at U > U_r
Critical impulse time, undervoltage	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time, undervoltage	15 ms typically	-
Operate value, overvoltage	(1-200)% of UBase	± 0.5% of U_r at U≤U_r ± 0.5% of U at U>U_r
Critical impulse time, overvoltage	10 ms typically at 0.8 to 1.2 x U_{set}	-
Impulse margin time, overvoltage	15 ms typically	-
Independent time delay for undervoltage functionality at 1.2 to 0.8 x U_{set}	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater
Independent time delay for overvoltage functionality at 0.8 to 1.2 x U_{set}	(0.000-60.000) s	± 0.2% or ± 40 ms whichever is greater

Table 80. Sudden change in current variation SCCVPTOC

Function	Range or value	Accuracy
Operate value, overcurrent	(5-100)% of IBase	± 2.0% of I_r
Hold time for operate signal at 0 to 2 x Iset	(0.000-60.000) s	± 0.2% or ± 15 ms whichever is greater

Table 81. Carrier receive logic LCCRPTRC

Function	Range or value	Accuracy
Operation mode	1 Out Of 2 2 Out Of 2	-
Independent time delay	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater

Table 82. Negative sequence overvoltage protection LCNSPTOV

Function	Range or value	Accuracy
Operate value, negative sequence overvoltage	(1-200)% of UBase	± 0.5% of U_r at U≤U_r ± 0.5% of U at U>U_r
Reset ratio, negative sequence overvoltage	>95% at (10-200)% of UBase	-
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Critical impulse time, negative sequence overvoltage	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time, negative sequence overvoltage	15 ms typically	-
Independent time delay to operate at 0 to 1.2 x U_{set}	(0.000-120.000) s	± 0.2% or ± 40 ms whichever is greater

Table 83. Zero sequence overvoltage protection LCZSPTOV

Function	Range or value	Accuracy
Operate value, zero sequence overvoltage	(1-200)% of UBase	± 0.5% of U_r at U≤U_r ± 0.5% of U at U>U_r
Reset ratio, zero sequence overvoltage	>95% at (10-200)% of UBase	-
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Critical impulse time, zero sequence overvoltage	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time, zero sequence overvoltage	15 ms typically	-
Independent time delay to operate at 0 to 1.2 x U_{set}	(0.000-120.000) s	± 0.2% or ± 40 ms whichever is greater

Table 84. Negative sequence overcurrent protection LCNSPTOC

Function	Range or value	Accuracy
Operate value, negative sequence overcurrent	(3 - 2500)% of IBase	± 1.0% of Ir at I ≤ Ir ± 1.0% of I at I > Ir
Reset ratio, negative sequence overcurrent	>95% at (50–2500)% of IBase	-
Operate time, start at 0 to 2 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Reset time, start at 2 to 0 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Operate time, start at 0 to 10 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Reset time, start at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time, negative sequence overcurrent	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time, negative sequence overcurrent	15 ms typically	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 35 ms, whichever is greater
Transient overreach, start function	<5% at τ = 100 ms	-

Table 85. Zero sequence overcurrent protection LCZSPTOC

Function	Range or value	Accuracy
Operate value, zero sequence overcurrent	(3-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, zero sequence overcurrent	>95% at (50–2500)% of IBase	-
Operate time, start at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 10 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Reset time, start at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time, zero sequence overcurrent	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time, zero sequence overcurrent	15 ms typically	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater

Table 86. Three phase overcurrent LCP3PTOC

Function	Range or value	Accuracy
Operate value, overcurrent	(5-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, overcurrent	> 95% at (50-2500)% of IBase	-
Start time at 0 to 2 x I_{set}	Min = 10 ms Max = 25 ms	-
Reset time at 2 to 0 x I_{set}	Min = 20 ms Max = 35 ms	-
Critical impulse time, overcurrent	5 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time, overcurrent	10 ms typically	-
Independent time delay to operate at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 30 ms whichever is greater

Table 87. Three phase undercurrent LCP3PTUC

Function	Range or value	Accuracy
Operate value, undercurrent	(1.00-100.00)% of IBase	± 1.0% of I_r
Reset ratio, undercurrent	< 105% at (50.00-100.00)% of IBase	-
Start time at 2 to 0 x I_{set}	Min = 15 ms Max = 30 ms	-
Reset time at 0 to 2 x I_{set}	Min = 10 ms Max = 25 ms	-
Critical impulse time, undercurrent	10 ms typically at 2 to 0 x I_{set}	-
Impulse margin time, undercurrent	10 ms typically	-
Independent time delay to operate at 2 to 0 x I_{set}	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater

Logic

Table 88. Tripping logic common 3-phase output SMPPTRC

Function	Range or value	Accuracy
Trip action	3-ph, 1/3-ph, 1/2/3-ph	-
Minimum trip pulse length	(0.000-60.000) s	± 0.2% or ± 30 ms whichever is greater
3-pole trip delay	(0.020-0.500) s	± 0.2% or ±10 ms whichever is greater
Single phase delay, two phase delay and evolving fault delay	(0.000-60.000) s	± 0.2% or ±10 ms whichever is greater

Table 89. Configurable logic blocks

Logic block	Quantity with cycle time			Range or value	Accuracy
	fast	medium	normal		
LogicAND	60	60	160	-	-
LogicOR	60	60	160	-	-
LogicXOR	10	10	20	-	-
LogicInverter	30	30	60	-	-
LogicSRMemory	10	10	20	-	-
LogicRSMemory	10	10	20	-	-
LogicGate	10	10	20	-	-
LogicTimer	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicPulseTimer	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicTimerSet	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicLoopDelay	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
Trip Matrix Logic	6	6	-	-	-
Boolean 16 to Integer	4	4	6	-	-
Boolean 16 to Integer with Logic Node	4	4	6	-	-
Integer to Boolean 16	4	4	6	-	-
Integer to Boolean 16 with Logic Node	4	4	6	-	-

Table 90. Elapsed time integrator with limit transgression and overflow supervision TEIGAPC

Function	Cycle time (ms)	Range or value	Accuracy
Elapsed time integration	3	0 – 999999.9 s	±0.2% or ±20 ms whichever is greater
	6	0 – 999999.9 s	±0.2% or ±100 ms whichever is greater
	100	0 – 999999.9 s	±0.2% or ±250 ms whichever is greater

Monitoring

Table 91. Measurements CVMMXN

Function	Range or value	Accuracy
Frequency	(0.95-1.05) × f_r	± 2.0 mHz
Voltage	(0.1-1.5) × U_r	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Connected current	(0.2-4.0) × I_r	± 0.5% of I_r at $I \leq I_r$ ± 0.5% of I at $I > I_r$
Active power, P	0.1 x U_r < U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	± 1.0% of S at S ≤ S_r ± 1.0% of S at S > S_r
Reactive power, Q	0.1 x U_r < U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	Conditions: 0.8 x U_r < U < 1.2 U_r 0.2 x I_r < I < 1.2 I_r
Apparent power, S	0.1 x U_r < U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	
Power factor, cos (φ)	0.1 x U_r < U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	± 0.02

Table 92. Phase current measurement CMMXU

Function	Range or value	Accuracy
Current at symmetrical load	(0.1-4.0) x I_r	± 0.3% of I_r at $I \leq 0.5 \times I_r$ ± 0.3% of I at $I > 0.5 \times I_r$
Phase angle at symmetrical load	(0.1-4.0) x I_r	± 10° at 0.1 x I_r < I < 0.5 x I_r ± 0.5° at 0.5 x I_r < I < 4.0 x I_r

Table 93. Phase-phase voltage measurement VMMXU

Function	Range or value	Accuracy
Voltage	(10 to 300) V	± 0.5% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Phase angle	(10 to 300) V	± 0.5° at U ≤ 50 V ± 0.2° at U > 50 V

Table 94. Phase-neutral voltage measurement VNMMXU

Function	Range or value	Accuracy
Voltage	(5 to 175) V	± 0.5% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Phase angle	(5 to 175) V	± 0.5° at U ≤ 50 V ± 0.2° at U > 50 V

Table 95. Current sequence component measurement CMSQI

Function	Range or value	Accuracy
Current positive sequence, I1 Three phase settings	(0.1–4.0) × I_r	± 0.3% of I_r at I ≤ 0.5 × I_r ± 0.3% of I at I > 0.5 × I_r
Current zero sequence, 3I0 Three phase settings	(0.1–1.0) × I_r	± 0.3% of I_r at I ≤ 0.5 × I_r ± 0.3% of I at I > 0.5 × I_r
Current negative sequence, I2 Three phase settings	(0.1–1.0) × I_r	± 0.3% of I_r at I ≤ 0.5 × I_r ± 0.3% of I at I > 0.5 × I_r
Phase angle	(0.1–4.0) × I_r	± 1.0° at 0.1 × I_r < I ≤ 0.5 × I_r ± 0.5° at 0.5 × I_r < I ≤ 4.0 × I_r

Table 96. Voltage sequence measurement VMSQI

Function	Range or value	Accuracy
Voltage positive sequence, U1	(10 to 300) V	± 0.3% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Voltage zero sequence, 3U0	(10 to 300) V	± 0.3% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Voltage negative sequence, U2	(10 to 300) V	± 0.3% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Phase angle	(10 to 300) V	± 0.3° at U ≤ 50 V ± 0.2° at U > 50 V

Table 97. Supervision of mA input signals

Function	Range or value	Accuracy
mA measuring function	± 5, ± 10, ± 20 mA 0-5, 0-10, 0-20, 4-20 mA	± 0.1 % of set value ± 0.005 mA
Max current of transducer to input	(-20.00 to +20.00) mA	
Min current of transducer to input	(-20.00 to +20.00) mA	
Alarm level for input	(-20.00 to +20.00) mA	
Warning level for input	(-20.00 to +20.00) mA	
Alarm hysteresis for input	(0.0-20.0) mA	

Table 98. Limit counter L4UFCNT

Function	Range or value	Accuracy
Counter value	0-65535	-
Max. count up speed	30 pulses/s (50% duty cycle)	-

Table 99. Disturbance report DRPRDRE

Function	Range or value	Accuracy
Pre-fault time	(0.05-9.90) s	-
Post-fault time	(0.1-10.0) s	-
Limit time	(0.5-10.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See table 123
Maximum number of analog inputs	30 + 10 (external + internally derived)	-
Maximum number of binary inputs	96	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	96	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 100. Fault locator LMBRFLO

Function	Value or range	Accuracy
Reactive and resistive reach	(0.001-1500.000) Ω/phase	± 2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r
Phase selection	According to input signals	-
Maximum number of fault locations	100	-

Table 101. Event list

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 102. Indications

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100

Table 103. Event recorder

Function		Value
Buffer capacity	Maximum number of events in disturbance report	150
	Maximum number of disturbance reports	100
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 104. Trip value recorder

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	100

Table 105. Disturbance recorder

Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of binary inputs	96
	Maximum number of disturbance reports	100
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)		340 seconds (100 recordings) at 50 Hz 280 seconds (80 recordings) at 60 Hz

Metering

Table 106. Pulse-counter logic PCFCNT

Function	Setting range	Accuracy
Input frequency	See Binary Input Module (BIM)	-
Cycle time for report of counter value	(1-3600) s	-

Table 107. Energy metering ETPMMTR

Function	Range or value	Accuracy
Energy metering	kWh Export/Import, kvarh Export/Import	Input from MMXU. No extra error at steady load

Station communication

Table 108. IEC 61850-8-1 communication protocol

Function	Value
Protocol	IEC 61850-8-1
Communication speed for the IEDs	100BASE-FX
Protocol	IEC 60870-5-103
Communication speed for the IEDs	9600 or 19200 Bd
Protocol	DNP3.0
Communication speed for the IEDs	300–19200 Bd
Protocol	TCP/IP, Ethernet
Communication speed for the IEDs	100 Mbit/s

Table 109. IEC 61850-9-2LE communication protocol

Function	Value
Protocol	IEC 61850-9-2LE
Communication speed for the IEDs	100BASE-FX

Table 110. LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 111. SPA communication protocol

Function	Value
Protocol	SPA
Communication speed	300, 1200, 2400, 4800, 9600, 19200 or 38400 Bd
Slave number	1 to 899

Table 112. IEC 60870-5-103 communication protocol

Function	Value
Protocol	IEC 60870-5-103
Communication speed	9600, 19200 Bd

Table 113. SLM – LON port

Quantity	Range or value
Optical connector	Glass fibre: type ST Plastic fibre: type HFBR snap-in
Fibre, optical budget	Glass fibre: 11 dB (1000 m typically *) Plastic fibre: 7 dB (10 m typically *)
Fibre diameter	Glass fibre: 62.5/125 µm Plastic fibre: 1 mm

*) depending on optical budget calculation

Table 114. SLM – SPA/IEC 60870-5-103/DNP3 port

Quantity	Range or value
Optical connector	Glass fibre: type ST Plastic fibre: type HFBR snap-in
Fibre, optical budget	Glass fibre: 11 dB (3000/1000 m typically *) Plastic fibre: 7 dB (80/25 m typically *)
Fibre diameter	Glass fibre: 62.5/125 µm Plastic fibre: 1 mm

*) depending on optical budget calculation

Table 115. Galvanic X.21 line data communication module (X.21-LDCM)

Quantity	Range or value
Connector, X.21	Micro D-sub, 15-pole male, 1.27 mm (0.050") pitch
Connector, ground selection	2 pole screw terminal
Standard	CCITT X21
Communication speed	64 kbit/s
Insulation	1 kV
Maximum cable length	100 m

Table 116. Galvanic RS485 communication module

Quantity	Range or value
Communication speed	2400–19200 bauds
External connectors	RS-485 9-pole connector Soft ground 2-pole connector

Table 117. IEC 62439-3 Edition 1 and Edition 2 parallel redundancy protocol

Function	Value
Protocol	IEC 61850-8-1
Communication speed	100 Base-FX

Remote communication

Table 118. Line data communication module

Characteristic	Range or value		
Type of LDCM	Short range (SR)	Medium range (MR)	Long range (LR)
Type of fibre	Graded-index multimode 62.5/125 µm	Singlemode 9/125 µm	Singlemode 9/125 µm
Peak Emission Wave length Nominal Maximum Minimum	 820 nm 865 nm 792 nm	 1310 nm 1330 nm 1290 nm	 1550 nm 1580 nm 1520 nm
Optical budget Graded-index multimode 62.5/125 µm, Graded-index multimode 50/125 µm	13 dB (typical distance about 3 km *) 9 dB (typical distance about 2 km *)	22 dB (typical distance 80 km *)	26 dB (typical distance 150 km *)
Optical connector	Type ST	Type FC/PC	Type FC/PC
Protocol	C37.94	C37.94 Implementation **)	C37.94 Implementation **)
Data transmission	Synchronous	Synchronous	Synchronous
Transmission rate / Data rate	2 Mbit/s / 64 kbit/s	2 Mbit/s / 64 kbit/s	2 Mbit/s / 64 kbit/s
Clock source	Internal or derived from received signal	Internal or derived from received signal	Internal or derived from received signal

*) depending on optical budget calculation
**) C37.94 originally defined just for multimode; using same header, configuration and data format as C37.94

Hardware
IED

Table 119. Case

Material	Sheet sheet
Front plate	Steel sheet profile with cut-out for HMI
Surface treatment	Aluzink preplated steel
Finish	Light grey (RAL 7035)

Table 120. Water and dust protection level according to IEC 60529

Front	IP40 (IP54 with sealing strip)
Sides, top and bottom	IP20
Rear side	IP20 with screw compression type IP10 with ring lug terminals

Table 121. Weight

Case size	Weight
6U, 1/2 x 19"	≤ 10 kg
6U, 3/4 x 19"	≤ 15 kg
6U, 1/1 x 19"	≤ 18 kg

Connection system

Table 122. CT and VT circuit connectors

Connector type	Rated voltage and current	Maximum conductor area
Screw compression type	250 V AC, 20 A	4 mm² (AWG12) 2 x 2.5 mm² (2 x AWG14)
Terminal blocks suitable for ring lug terminals	250 V AC, 20 A	4 mm² (AWG12)

Table 123. Binary I/O connection system

Connector type	Rated voltage	Maximum conductor area
Screw compression type	250 V AC	2.5 mm² (AWG14) 2 x 1 mm² (2 x AWG18)
Terminal blocks suitable for ring lug terminals	300 V AC	3 mm² (AWG14)

Basic IED functions

Table 124. Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	40 events, first-in-first-out

Table 125. Time synchronization, time tagging

Function	Value
Time tagging resolution, events and sampled measurement values	1 ms
Time tagging error with synchronization once/min (minute pulse synchronization), events and sampled measurement values	± 1.0 ms typically
Time tagging error with SNTP synchronization, sampled measurement values	± 1.0 ms typically

Table 126. GPS time synchronization module (GTM)

Function	Range or value	Accuracy
Receiver	-	±1 µs relative UTC
Time to reliable time reference with antenna in new position or after power loss longer than 1 month	<30 minutes	-
Time to reliable time reference after a power loss longer than 48 hours	<15 minutes	-
Time to reliable time reference after a power loss shorter than 48 hours	<5 minutes	-

Table 127. GPS - Antenna and cable

Function	Value
Max antenna cable attenuation	26 db @ 1.6 GHz
Antenna cable impedance	50 ohm
Lightning protection	Must be provided externally
Antenna cable connector	SMA in receiver and TNC in antenna end
Accuracy	+/-1 µs

Table 128. IRIG-B

Quantity	Rated value
Number of channels IRIG-B	1
Number of channels PPS	1
Electrical connector:	
Electrical connector IRIG-B	BNC
Pulse-width modulated	5 Vpp
Amplitude modulated - low level - high level	1-3 Vpp 3 x low level, max 9 Vpp
Supported formats	IRIG-B 00x, IRIG-B 12x
Accuracy	+/-10 µs for IRIG-B 00x and +/-100µs for IRIG-B 12x
Input impedance	100 k ohms
Optical connector:	
Optical connector PPS and IRIG-B	Type ST
Type of fibre	62.5/125 µm multimode fibre
Supported formats	IRIG-B 00x, PPS
Accuracy	+/- 1 µs

Inverse characteristic

Table 129. ANSI inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic $t = \left(\frac{A}{(I^P - 1)} + B\right) \cdot k + tDef$ Reset characteristic: $t = \frac{t_r}{(I^P - 1)} \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-2.00) in steps of 0.01	ANSI/IEEE C37.112, ± 2.0% or ± 40 ms whichever is greater
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0 , tr=29.1	
ANSI Very Inverse	A=19.61, B=0.491, P=2.0 , tr=21.6	
ANSI Normal Inverse	A=0.0086, B=0.0185, P=0.02, tr=0.46	
ANSI Moderately Inverse	A=0.0515, B=0.1140, P=0.02, tr=4.85	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0, tr=30	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0, tr=13.46	
ANSI Long Time Inverse	A=0.086, B=0.185, P=0.02, tr=4.6	

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Table 130. IEC inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic $t = \left(\frac{A}{(I^P - 1)}\right) \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-2.00) in steps of 0.01	IEC 60255-151, ± 2.0% or ± 40 ms whichever is greater
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very Inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely Inverse	A=80.0, P=2.0	
IEC Short time Inverse	A=0.05, P=0.04	
IEC Long time Inverse	A=120, P=1.0	
Programmable characteristic Operate characteristic: $t = \left(\frac{A}{(I^P - C)} + B\right) \cdot k$ Reset characteristic: $t = \frac{TR}{\left(I^{CR} - CR\right)} \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 A=(0.005-200.000) in steps of 0.001 B=(0.00-20.00) in steps of 0.01 C=(0.1-10.0) in steps of 0.1 P=(0.005-3.000) in steps of 0.001 TR=(0.005-100.000) in steps of 0.001 CR=(0.1-10.0) in steps of 0.1 PR=(0.005-3.000) in steps of 0.001	

Table 131. RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-2.00) in steps of 0.01	IEC 60255-151, ± 2.0% or ± 40 ms whichever is greater
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot \ln\frac{I}{k}\right)$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	

Table 132. Inverse time characteristics for overvoltage protection

Function	Range or value	Accuracy
Type A curve: $t = \frac{k}{\left(\frac{U-U>}{U>}\right)}$ $U> = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5.0% or ±45 ms whichever is greater
Type B curve: $t = \frac{k \cdot 480}{\left(32 \cdot \frac{U-U>}{U>} - 0.5\right)^{2.0}} - 0.035$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $t = \frac{k \cdot 480}{\left(32 \cdot \frac{U-U>}{U>} - 0.5\right)^{3.0}} - 0.035$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $t = \frac{k \cdot A}{\left(B \cdot \frac{U-U>}{U>} - C\right)^{P}} + D$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

Table 133. Inverse time characteristics for undervoltage protection

Function	Range or value	Accuracy
Type A curve: $t = \frac{k}{\left(\frac{U<-U}{U<}\right)}$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5.0% or ±45 ms whichever is greater
Type B curve: $t = \frac{k \cdot 480}{\left(32 \cdot \frac{U<-U}{U<} - 0.5\right)^{2.0}} + 0.055$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $t = \left[\frac{k \cdot A}{\left(B \cdot \frac{U<-U}{U<} - C\right)^{P}}\right] + D$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

Table 134. Inverse time characteristics for residual overvoltage protection

Function	Range or value	Accuracy
Type A curve: $t = \frac{k}{\left(\frac{U-U>}{U>}\right)}$ $U> = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5.0% or ±45 ms whichever is greater
Type B curve: $t = \frac{k \cdot 480}{\left(32 \cdot \frac{U-U>}{U>} - 0.5\right)^{2.0}} - 0.035$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $t = \frac{k \cdot 480}{\left(32 \cdot \frac{U-U>}{U>} - 0.5\right)^{3.0}} - 0.035$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $t = \frac{k \cdot A}{\left(B \cdot \frac{U-U>}{U>} - C\right)^{P}} + D$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

22. Ordering for customized IED

Table 135. General guidelines

Guidelines
Carefully read and follow the set of rules to ensure problem-free order management.
Please refer to the available functions table for included application functions.
PCM600 can be used to make changes and/or additions to the delivered factory configuration of the pre-configured.

Table 136. Example ordering code

To obtain the complete ordering code, please combine code from the selection tables, as given in the example below.
The selected qty of each table must be filled in, if no selection is possible the code is 0
Example of a complete code: RED670*2.0 - F00X00 - A00000000211111 - B52232552212552211111101000 - C33000321222200222100300 - D22212 011 - E2220 - F4 - S6 - G232 - H25401330000 - K11111111 - L0611 - M21 - P01 - B1X0 - AC - KB - B - A3X0 - D1D1ARGN1N000000X - AAFXXX - AX

Product definition	RED670* 2.0 - X00
Differential protection	A 0 0 0 0 0 0 0
Impedance protection	B ... 0 0 0 0
Current protection	C 00 0 00 0 0 0 0 0
Voltage protection	D 0 1
Frequency protection	E
Multipurpose protection	F
General calculation	S
Secondary system supervision	G
Control	H [illegible] 0 0 0 0 0 0
Scheme communication	K
Logic	L
Monitoring	M 1
Station communication	P 0 1
Language	B1
Casing and Mounting	
Connection and power	
HMI	
Analog input	
Binary input/output	
Remote end serial communication	
Serial communication unit for station communication	

Table 137. Product definition

RED670*	2.0		X00

Table 138. Product definition ordering codes

Product	RED670*
Software version	2.0
Configuration alternatives	
Line differential protection RED670	F00
Line differential protection RED670 61850-9-2LE	N00
Selection:	
ACT configuration	
No ACT configuration downloaded	X00

Table 139. Differential protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0	0	0	0	0	0		0						

Table 140. Differential functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
1Ph High impedance differential protection	HZPDIF	1MRK005904-HA	7	0-3		
Restricted earth fault protection, low impedance	REFPDIF	1MRK005904-LA	8	0-2		
Line differential protection, 3 CT sets, 2-3 line ends	L3CPDIF	1MRK005904-MA	10	0-1		Note: One, and only one PDIF must be ordered.
Line differential protection, 6 CT sets, 3-5 line ends	L6CPDIF	1MRK005904-NA	11	0-1		
Line differential protection 3 CT sets, with inzone transformers, 2-3 line ends	LT3CPDIF	1MRK005904-PA	12	0-1		
Line differential protection 6 CT sets, with inzone transformers, 3-5 line ends	LT6CPDIF	1MRK005904-RA	13	0-1		
Additional security logic for differential protection	LDRGFC	1MRK005904-TA	14	0-1		

Table 141. Impedance protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
B																					0		0	0	0

Table 142. Impedance functions, alternatives

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Note: One, and only one alternative can be selected. Selected qty is 0 for other functions in an unselected alternative.						
Alternative 1 Distance protection, quadrilateral						
Distance protection zone, quadrilateral characteristic	ZMQPDIS, ZMQAPDIS	1MRK005907-AA	1	0-5		
Directional impedance quadrilateral	ZDRDIR	1MRK005907-BA	2	0-2		
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS	1MRK005907-CA	3	0-2		
Alternative 2 Distance protection for series compensated lines, quadrilateral						
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS	1MRK005907-CA	3	0-2		
Distance measuring zone, quadrilateral characteristic for series compensated lines	ZMCPDIS, ZMCAPDIS	1MRK005907-DA	4	0-5		
Directional impedance quadrilateral, including series compensation	ZDSRDIR	1MRK005907-EA	5	0-2		
Alternative 3 Distance protection, mho (mho for phase - phase fault and mho in parallel with quad for earth fault)						
Fullscheme distance protection, mho characteristic	ZMHPDIS	1MRK005907-FA	6	0-3		
Fullscheme distance protection, quadrilateral for earth faults	ZMMPDIS, ZMMAPDIS	1MRK005907-GA	7	0-5		
Directional impedance element for mho characteristic	ZDMRDIR	1MRK005907-HA	8	0-2		
Additional distance protection directional function for earth faults	ZDARDIR	1MRK005907-KA	9	0-2		
Mho impedance supervision logic	ZSMGAPC	1MRK005907-LA	10	0-1		
Faulty phase identification with load encroachment	FMPSPDIS	1MRK005907-MA	11	0-2		
Alternative 4 Distance protection, quadrilateral with separate settings for PP and PE						
Directional impedance quadrilateral	ZDRDIR	1MRK005907-BA	2	0-2		
Distance protection zone, quadrilateral characteristic, separate settings	ZMRPDIS, ZMRAPDIS	1MRK005907-NA	12	0-5		
Phase selection, quadrilateral characteristic with settable angle	FRPSPDIS	1MRK005907-PA	13	0-2		
Alternative 5 High speed distance protection, quadrilateral						
Directional distance protection with phase selection	ZMFPDIS	1MRK005907-SA	14	0-1		
Alternative 6 High speed distance protection for series compensated lines, quadrilateral						
Directional distance protection with phase selection, series compensation	ZMFCPDIS	1MRK005907-RA	15	0-1		
Optional for alternative 1						
Directional impedance element for mho characteristic	ZDMRDIR	1MRK005907-HA	8	0-2		
Optional for alternative 3						
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS	1MRK005907-CA	3	0-2		
Optional for alternatives 1, 2 and 4						
Additional distance protection directional function for earth faults	ZDARDIR	1MRK005907-KA	9	0-2		
Faulty phase identification with load encroachment	FMPSPDIS	1MRK005907-MA	11	0-2		
Optional with any alternative						
Power swing detection	ZMRPSB	1MRK005907-UA	16	0-1		
Automatic switch onto fault logic, voltage and current based	ZCVPSOF	1MRK005908-AA	17	0-1		
Power swing logic	PSLPSCH	1MRK005907-VA	18	0-1		
PoleSlip/Out-of-step protection	PSPPPAM	1MRK005908-CA	19	0-1		
Out-of-step protection	OOSPPAM	1MRK005908-GA	20	0-1		
Phase preference logic	PPLPHIZ	1MRK005908-DA	22	0-1		

Table 143. Current protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
C			00							0		00					1	0	0	0		0	0

Table 144. Current functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Instantaneous phase overcurrent protection	PHPIOC	1MRK005910-AA	1	0-3		
Four step phase overcurrent protection	OC4PTOC	1MRK005910-BA	2	0-3		
Instantaneous residual overcurrent protection	EFPIOC	1MRK005910-DA	4	0-1		
Four step residual overcurrent protection	EF4PTOC	1MRK005910-EA	5	0-3		
Four step directional negative phase sequence overcurrent protection	NS4PTOC	1MRK005910-FA	6	0-2		
Sensitive Directional residual over current and power protection	SDEPSDE	1MRK005910-GA	7	0-1		
Thermal overload protection, one time constant, Celsius	LCPTTR	1MRK005911-BA	8	0-2		
Thermal overload protection, one time constant, Fahrenheit	LFPTTR	1MRK005911-AA	9	0-2		
Breaker failure protection	CCRBRF	1MRK005910-LA	11	0-2		
Stub protection	STBPTOC	1MRK005910-NA	13	0-2		
Pole discordance protection	CCPDSC	1MRK005910-PA	14	0-2		
Directional Underpower protection	GUPPDUP	1MRK005910-RA	15	0-2		
Directional Overpower protection	GOPPDOP	1MRK005910-TA	16	0-2		
Broken conductor check	BRCPTOC	1MRK005910-SA	17	1		
Voltage restrained overcurrent protection	VRPVOC	1MRK005910-XA	21	0-3		

Table 145. Voltage protection

Position	1	2	3	4	5	6	7	8
D						0	1	

Table 146. Voltage functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Two step undervoltage protection	UV2PTUV	1MRK005912-AA	1	0-2		
Two step overvoltage protection	OV2PTOV	1MRK005912-BA	2	0-2		
Two step residual overvoltage protection	ROV2PTOV	1MRK005912-CA	3	0-2		
Overexcitation protection	OEXPVPH	1MRK005912-DA	4	0-1		
Voltage differential protection	VDCPTOV	1MRK005912-EA	5	0-2		
Loss of voltage check	LOVPTUV	1MRK005912-GA	7	1		
Radial feeder protection	PAPGAPC	1MRK005912-HA	8	0-1		

Table 147. Frequency protection

Position	1	2	3	4
E				0

Table 148. Frequency functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Underfrequency protection	SAPTUF	1MRK005914-AA	1	0-2		
Overfrequency protection	SAPTOF	1MRK005914-BA	2	0-2		
Rate-of-change frequency protection	SAPFRC	1MRK005914-CA	3	0-2		

Table 149. Multipurpose protection

Position	1
F	

Table 150. Multipurpose functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
General current and voltage protection	CVGAPC	1MRK005915				

Table 151. General calculation

Position	1
S	

Table 152. General calculation functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Frequency tracking filter	SMAIHPAC	1MRK005915-KA	1	0-6		

Table 153. Secondary system supervision

Position	1	2	3
G			

Table 154. Secondary system supervision functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Current circuit supervision	CCSSPVC	1MRK005916-AA	1	0-2		
Fuse failure supervision	FUFSPVC	1MRK005916-BA	2	0-3		
Fuse failure supervision based on voltage difference	VDSPVC	1MRK005916-CA	3	0-2		

Table 155. Control

Position	1	2	3	4	5	6	7	8	9	10	11
H		0		0			0	0	0	0	0

Table 156. Control functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Synchrocheck, energizing check and synchronizing	SESRSYN	1MRK005917-AA	1	0-2		
Autorecloser	SMBRREC	1MRK005917-BA	3	0-4		
Apparatus control for single bay, max 8 app. (1CB) incl. interlocking	APC8	1MRK005917-AX	5	0-1		Note: Only one Apparatus control can be ordered.
Apparatus control for single bay, max 15 app. (2CBs) incl. interlocking	APC15	1MRK005917-BX	6	0-1		

Table 157. Scheme communication

Position	1	2	3	4	5	6	7	8
X								

Table 158. Scheme communication functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Scheme communication logic for distance or Overcurrent protection	ZCPSCH	1MRK005920-AA	1	0-1		Note: Only one of ZCPSCH/ZC1PPSCH can be selected. Note: Only one of ZCRWPSCH/ZC1WPSCH to be selected
Phase segregated Scheme communication logic for distance protection	ZC1PPSCH	1MRK005920-BA	2	0-1		
Current reversal and weak-end infeed logic for distance protection	ZCRWPSCH	1MRK005920-CA	3	0-1		
Current reversal and weak-end infeed logic for phase segregated communication	ZC1WPSCH	1MRK005920-DA	4	0-1		
Local acceleration logic	ZCLCPSCH	1MRK005920-EA	5	0-1		
Scheme communication logic for residual overcurrent protection	ECPSCH	1MRK005920-FA	6	0-1		
Current reversal and weak-end infeed logic for residual overcurrent protection	ECRWPSCH	1MRK005920-GA	7	0-1		
Direct transfer trip	DTT	1MRK005921-AX	8	0-1		

Table 153. Logic

Position	1	2	3
L			

Table 180. Logic functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Configurable logic blocks Q/T		1MRK005823-MA	1	0-1		
Extension logic package		1MRK005822-AX	2	0-1		

Table 181. Monitoring

Position	1	0
M		1

Table 182. Monitoring functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Circuit breaker condition monitoring	SSCBR	1MRK005824-HA	1	0-6		
Fault locator	LMBRFLO	1MRK005825-XA	2	1		

Table 183. Station communication

Position	1	2
P		

Table 184. Station communication functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Process Bus communication IEC 61850-9-2		1MRK005930-TA	1	0-8		Note: RED670 customized qty = 0, RED670 61850-9-2 qty = 8
IEC 62439-3 parallel redundancy protocol	PRP	1MRK002924-YB	2	1		Note: Not valid in RED670 61850-9-2 LE product. Note: Requires 2 ethernet OEM

Table 185. Language selection

First local HMI user dialogue language	Selection	Notes and Rules
HMI language, English IEC	B1	
Additional HMI language		
No additional HMI language	X0	
HMI language, English US	A12	
Selected		

Table 186. Casing selection

Casing	Selection	Notes and Rules
1/2 x 19" case	A	
3/4 19" case 1 TRM slot	B	
3/4 x 19" case 2 TRM slots	C	
1/1 x 19" case 1 TRM slot	D	
1/1 x 19" case 2 TRM slots	E	
Selected		

Table 187. Mounting selection

Mounting details with IP40 of protection from the front	Selection	Notes and Rules
No mounting kit included	X	
19" rack mounting kit for 1/2 x 19" case or 2xRHGS6 or RHGS12	A	
19" rack mounting kit for 3/4 x 19" case or 3xRHGS6	B	
19" rack mounting kit for 1/1 x 19" case	C	
Wall mounting kit	D	Note: Wall mounting not recommended with communication modules with fibre connection (SLM, OEM, LDCM)
Flush mounting kit	E	
Flush mounting kit + IP54 mounting seal	F	
Selected		

Table 188. Connection type and power supply

Connection type for Power supply modules, and Input/Output modules	Selection	Notes and Rules
Compression terminals	K	
Ringlug terminals	L	
Auxiliary power supply		
Power supply module 24-60 VDC	A	
Power supply module 90-250 VDC	B	
Selected		

Table 189. Human machine interface selection

Human machine hardware interface	Selection	Notes and Rules
Medium size - graphic display, IEC keypad symbols	B	
Medium size - graphic display, ANSI keypad symbols	C	
Selected		

Table 170. Analog system selection

Analog system	Selection				Notes and Rules
No first TRM included	X0				Note: Only valid in RED670-N00
Compression terminals	A				Note: Only the same type of TRM (compression or ringlug) in the same terminal.
Ringlug terminals	B				
First TRM 12I 1A, 50/60Hz		1			
First TRM 12I 5A, 50/60Hz		2			
First TRM 9I+3U 1A, 100/220V, 50/60Hz		3			
First TRM 9I+3U 5A, 100/220V, 50/60Hz		4			
First TRM 3I, 1A+4I, 5A+3U, 100/220V, 50/60Hz		5			
First TRM 6I+6U 1A, 100/220V, 50/60Hz		6			
First TRM 6I+6U 5A, 100/220V, 50/60Hz		7			
First TRM 9I 1A, 50/60Hz		8			Maximum qty = 1
First TRM 9I 5A, 50/60Hz		9			Maximum qty = 1
First TRM 7I+5U 1A, 100/220V, 50/60Hz		12			
First TRM 7I+5U 5A, 100/220V, 50/60Hz		13			
First TRM 5I, 5A + 1I, 1A + 5U, 110/220V, 50/60Hz		14			
First TRM 3I, 5A + 4I, 1A + 5U, 110/220V, 50/60Hz		15			
First TRM 3I, 5A + 3I, 1A + 3U, 110/220V, 50/60Hz		16			
First TRM 3I4I, 1A + 4IP, 1A + 5U, 110/220V, 50/60Hz		17			
First TRM 3I4I, 5A + 4IP, 5A + 5U, 110/220V, 50/60Hz		18			
No second TRM included			X0		
Compressive terminals			A		
Ringlug terminals			B		
Second TRM 12I 1A, 50/60Hz				1	
Second TRM 12I 5A, 50/60Hz				2	
Second TRM 9I+3U 1A, 100/220V, 50/60Hz				3	
Second TRM 9I+3U 5A, 100/220V, 50/60Hz				4	
Second TRM 3I, 1A+4I, 5A+3U, 100/220V, 50/60Hz				5	
Second TRM 6I+6U 1A, 100/220V, 50/60Hz				6	
Second TRM 6I+6U 5A, 100/220V, 50/60Hz				7	
Second TRM 9I 1A, 50/60Hz				8	Maximum qty = 1
Second TRM 9I 5A, 50/60Hz				9	Maximum qty = 1
Second TRM 7I+5U 1A, 100/220V, 50/60Hz				12	
Second TRM 7I+5U 5A, 100/220V, 50/60Hz				13	
Second TRM 5I, 5A + 1I, 1A + 5U, 110/220V, 50/60Hz				14	
Second TRM 3I, 5A + 4I, 1A + 5U, 110/220V, 50/60Hz				15	
Second TRM 3I, 5A + 3I, 1A + 5U, 110/220V, 50/60Hz				16	
Second TRM 3I4I, 1A + 4IP, 1A + 5U, 110/220V, 50/60Hz				17	
Second TRM 3I4I, 5A + 4IP, 5A + 5U, 110/220V, 50/60Hz				18	
Selected					

Table 171. Maximum quantity of I/O modules

Note: When ordering I/O modules, observe the maximum quantities according to the table below

Case size	BIM	IOM	BOM/SOM	MIM	Max. no. in case
1/1 x 19", one (1) TRM	14	6	4	4	14 (max 4 BOM+SOM+MIM)
1/1 x 19", two (2) TRM	11	6	4	4	11 (max 4 BOM+SOM+MIM)
3/4 x 19", one (1) TRM	8	6	4	4	8 (max 4 BOM+SOM+1 MIM)
3/4 x 19", two (2) TRM	5	5	4	4	5 (max 4 BOM+SOM+1 MIM)
1/2 x 19", one (1) TRM	3	3	3	1	3

Table 172. Binary input/output module selection

Binary input/output modules	Selection															Notes and Rules
Slot position (rear view)	X31	X41	X51	X61	X71	X81	X91	X101	X111	X121	X131	X141	X151	X161		Note! Max 3 positions in 1/2 rack, 6 in 3/4 rack with 1TRM, 5 in 3/4 rack with 2 TRM, 11 in 1/1 rack with 2 TRM and 14 in 1/1 rack with 1 TRM
1/2 Case with 1 TRM	■	■	■													
3/4 Case with 1 TRM	■	■	■	■	■	■	■									
3/4 Case with 2 TRM	■	■	■	■	■											
1/1 Case with 1 TRM	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
1/1 Case with 2 TRM	■	■	■	■	■	■	■	■	■	■	■					
No board in slot	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Binary output module 24 output relays (BOM)	A	A	A	A	A	A	A	A	A	A	A	A	A	A		
BIM 16 inputs, RL24-30 VDC, 50 mA	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1		
BIM 16 inputs, RL48-60 VDC, 50 mA	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1		
BIM 16 inputs, RL110-125 VDC, 50 mA	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1		
BIM 16 inputs, RL220-250 VDC, 50 mA	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1		
BIM 16 inputs, 220-250 VDC, 120mA	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2		
BIMp 16 inputs, RL24-30 VDC, 30 mA, for pulse counting	F	F	F	F	F	F	F	F	F	F	F	F	F	F		
BIMp 16 inputs, RL48-60 VDC, 30 mA, for pulse counting	G	G	G	G	G	G	G	G	G	G	G	G	G	G		
BIMp 16 inputs, RL110-125 VDC, 30 mA, for pulse counting	H	H	H	H	H	H	H	H	H	H	H	H	H	H		
BIM 16 inputs, RL220-250 VDC, 30 mA, for pulse counting	K	K	K	K	K	K	K	K	K	K	K	K	K	K		
IOM 8 inputs, 10-2 output, RL24-30 VDC, 50 mA	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1		
IOM 8 inputs, 10-2 output, RL48-60 VDC, 50 mA	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1		
IOM 8 inputs, 10-2 output, RL110-125 VDC, 50 mA	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1		
IOM 8 inputs, 10-2 output, RL220-250 VDC, 50 mA	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1		
IOM 8 inputs, 10-2 output, 220-250 VDC, 120mA	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2		
IOM with MOV 8 inputs, 10-2 output, 24-30 VDC, 50 mA	U	U	U	U	U	U	U	U	U	U	U	U	U	U		
IOM with MOV 8 inputs, 10-2 output, 48-60 VDC, 50 mA	V	V	V	V	V	V	V	V	V	V	V	V	V	V		
IOM with MOV 8 inputs, 10-2 output, 110-125 VDC, 50 mA	W	W	W	W	W	W	W	W	W	W	W	W	W	W		
IOM with MOV 8 inputs, 10-2 output, 220-250 VDC, 50 mA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
mA input module MIM 6 channels	R	R	R	R	R	R	R	R	R	R	R	R	R	R		

Table 172. Binary input/output module selection, continued

Binary input/output modules	Selection														Notes and Rules
SOM Static output module, 12 outputs, 48-60 VDC	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	Note: SOM must not to be placed in position nearest to NUM; 1/2 case slot P5, 3/4 case 1 TRM slot P10, 3/4 case 2 TRM slot P7, 1/1 case 1 TRM slot P16, 1/1 case 2 TRM slot P13
SOM static outputs module, 12 outputs, 110-250 VDC	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	
Selected.															

Table 173. Remote and serial communication selection

Remote end communication, DNP serial comm. and time synchronization modules Slot position (rear view)	X312	X313	X302	X303	X322	X323	Notes and Rules
Available slots in 1/2, 3/4 or 1/1 case with 1TRM	■	■	■	■			Note: Max 1 LDCM in 1/2 case
Available slots in 3/4 and 1/1 case with 2 TRM	■	■	■	■	■	■	Note: Max 2 LDCM in 3/4 and 1/1 case
No remote communication board included	X	X	X	X	X	X	
Optical short range LDCM	A	A	A	A	A	A	Max 4 LDCM (same or different type) can be selected.
Optical medium range, LDCM 1310 nm	B	B	B	B	B	B	Note: Max 2 Medium/Long range
Optical long range, LDCM 1550 nm	C	C	C	C	C	C	LDCM in 3/4 case
Galvanic X21 line data communication module	E	E	E	E	E	E	Always place LDCM modules on the same board to support redundant communication: in P30:2 and P30:3, P31:2 and P31:3 or P32:2 and P32:3
IRIG-B Time synchronization module	F	F	F	F	F	F	
Galvanic RS485 communication module	G	G	G	G	G	G	
GPS time synchronization module	S	S			S	S	
Selected							

Table 174. Serial communication unit for station communication selection

Serial communication unit for station communication Slot position (rear view)	X301	X311	Notes and Rules
No communication board included	X	X	
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	A		
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface	B		
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	C		
Optical ethernet module, 1 channel glass		D	
Optical ethernet module, 2 channel glass		E	
Selected			

23. Ordering for pre-configured IED

Guidelines
Carefully read and follow the set of rules to ensure problem-free order management.
Please refer to the available functions table for included application functions.
PCM600 can be used to make changes and/or additions to the delivered factory configuration of the pre-configured.

To obtain the complete ordering code, please combine code from the tables, as given in the example below.
Example code: RED670 *2.0-A31X00- A02H02-B1A3-AC-KB-B-A3X0-DAB1RGN1N1XXXXXXX-AXFXXX-AX. Using the code of each position #1-12 specified as RED670*1-2 2-3 3 3 3 3 3 3 3 3 3 3 3 3 3-4 4-5-6-7 7-8-9 9 9-10 10 10 10 10 10 10 10 10 10 10-11 11 11 11 11 11 11-12 12

#	1	-	2	-	3	-	4	-	5	6	-	7	-	8	-
RED670*		-		-		-		-			-		-		-

9	-	10	-	11	-	12
	-		-		-	

SOFTWARE	#1	Notes and Rules
Version number		
Version no	2.0	
Selection for position #1.		

Configuration alternatives		#2	Notes and Rules
Single breaker, 3 phase tripping	A31		
Multi breaker, 3 phase tripping	B31		
Single breaker, 1 phase tripping	A32		
Multi breaker, 1 phase tripping	B32		
ACT configuration			
ABB standard configuration		X00	
Selection for position #2.			

Software options	#3	Notes and Rules
No option	X 00	All fields in the ordering form do not need to be filled in
High impedance differential protection	A 02	
Line differential protection 6 CT sets, 3-5 line ends	A 04	Note: Only one Line differential protection have to be selected Note: A04/A05 only in A31/A32
Line differential protection 3 CT sets, with in-zone transformers, 2-3 line ends	A 05	
Line differential protection 6 CT sets, with in-zone transformers, 3-5 line ends	A 06	
Power swing logic	B 03	
Phase preference logic	B 04	Note: Only for A31
Phase segregated scheme communication	B 05	Note: Only for A32 and B32
Distance zones quadrilateral, 4th zone	B 10	Note: Only one of B10/B11/B15/B17/B18/B19 to be selected. B11 is required with B10. 1 block of STBPTOC already included on B31/B32
Distance zones quadrilateral, 3 zones	B 11	
Distance zones quadrilateral series compensation, 3 zones	B 15	
Line Distance protection - mho - 4 zones	B 17	
Directional distance protection with phase selection	B 18	
Directional distance protection with phase selection, series compensation	B 19	
Out-of-step protection	B 22	
Sensitive directional residual overcurrent and power protection	C 16	
Directional power protection	C 17	
Residual overcurrent protection	C 21	
Overexcitation protection	D 03	
Frequency protections - line	E 02	
General current and voltage protection	F0 1	
Fuse failure supervision based on voltage difference	G 03	
Autorecloser, 1 circuit breaker	H 04	Note: H04 only for A31/A32, 1 block already included
Autorecloser, 2 circuit breaker	H 05	Note: H05 only for B31/B32, 2 blocks already included
Apparatus control 8 objects	H 07	Note: Only one Apparatus control can be ordered Note: H07 only for A31/A32, H08 only for B31/B32
Apparatus control 15 objects	H 08	
Circuit breaker condition monitoring - 3 CB	M 13	Note: M13 only for A31/32, M15 only for B31/B32
Circuit breaker condition monitoring - 6 CB	M 15	
IEC 62439-3 parallel redundancy protocol	P 03	
Selection for position #3		

First local HMI user dialogue language		#4	Notes and Rules
HMI language, English IEC	B1		
Additional local HMI user dialogue language			
No additional HMI language		X0	
HMI language, English US		A12	
Selection for position #4.			

Casing	#5	Notes and Rules
1/2 x 19" case	A	
3/4 x 19" case 1 TRM slot	B	
3/4 x 19" case 2 TRM slots	C	
1/1 x 19" case 1TRM slots	D	
1/1 x 19" case 2 TRM slots	E	
Selection for position #5.		

Mounting details with IP40 of protection from the front	#6	Notes and Rules
No mounting kit included	X	
19" rack mounting kit for 1/2 x 19" case of 2xRHGS6 or RHGS12	A	
19" rack mounting kit for 3/4 x 19" case or 3xRGHS6	B	
19" rack mounting kit for 1/1 x 19" case	C	
Wall mounting kit	D	Note: Wall mounting not recommended with communication modules with fibre connection (SLM, OEM, LDCM)
Flush mounting kit	E	
Flush mounting kit + IP54 mounting seal	F	
Selection for position #6.		

Connection type for Power supply, Input/output and Communication modules		#7	Notes and Rules
Compression terminals	K		
Auxiliary power supply			
24-60 VDC		A	
90-250 VDC		B	
Selection for position #7.			

Human machine hardware interface	#8	Notes and Rules
Medium size - graphic display, IEC keypad symbols	B	
Medium size - graphic display, ANSI keypad symbols	C	
Selection for position #8.		

ВЯРНО С ОРИГИНАЛА

СОФИЯ ООД

Analog input system	9	Notes and Rules
Compression terminals	A	
Ringlug terminals	B	
First TRM, 6I+6U 1A, 110/220V	6	
First TRM, 6I+6U 5A, 110/220V	7	
First TRM, 3I, 5A + 3I, 1A + 6U, 110/220V	10	Note: Only for A31 and A32
No second TRM included	X0	
Compression terminals	A	
Ringlug terminals	B	
Second TRM, 6I+3U 1A, 110/220V	5	
Second TRM, 6I+3U 5A, 110/220V	4	
Second TRM, 3I, 5A+4I, 1A+3U, 110/220V	5	
Second TRM, 6I+6U, 1A, 110/220V	6	
Second TRM, 6I+6U, 5A, 110/220V	7	
Second TRM, 6I, 1A, 110/220V	8	
Second TRM, 6I, 5A, 5A, 110/220V	9	
Second TRM, 7I+5U 1A, 110/220V	12	
Second TRM, 7I+5U 5A, 110/220V	13	
Second TRM, 3I, 5A + 3I, 1A + 6U, 110/220V	16	Note: Only for A31 and A32
Selection for position #9.		

Binary input/output module, mA and time synchronizing boards	410	Notes and Rules

Make BIM with 50 mA inrush current the primary choice. BIM with 50 mA inrush current fulfill additional standards. As a consequence the EMC withstand capability is further increased.
BIM with 30 mA inrush current is still available.
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used.
Note: IRIG-B and 1 BOM included.

Slot position (rear view)	X31	X41	X51	X61	X71	X81	X91	X101	X111	X121	X131	X141	X151	Note: Max 3 positions in 1/2 rack, 6 in 3/4 rack with 1 TRM, 9 in 3/4 rack with 2 TRM, 14 in 1/1 rack with 1 TRM and 11 in 1/1 rack with 2 TRM
1/2 Case with 1 TRM														
3/4 Case with 1 TRM														
3/4 Case with 2 TRM														
1/1 Case with 1 TRM														
1/1 Case with 2 TRM														
No board in slot	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Binary output module 24 output relays (BOM)		A	A	A	A	A	A	A	A	A	A	A	A	Note: Maximum 4 (BOM+SOM +MIM) boards.
BIM 16 inputs, RL24-30 VDC, 50 mA			B 1	B 1	B 1	B 1	B 1	B 1	B 1	B 1	B 1	B 1	B 1	
BIM 16 inputs, RL48-60 VDC, 50 mA			C 1	C 1	C 1	C 1	C 1	C 1	C 1	C 1	C 1	C 1	C 1	
BIM 16 inputs, RL110-125 VDC, 50 mA			D 1	D 1	D 1	D 1	D 1	D 1	D 1	D 1	D 1	D 1	D 1	
BIM 16 inputs, RL220-250 VDC, 50 mA			E 1	E 1	E 1	E 1	E 1	E 1	E 1	E 1	E 1	E 1	E 1	
BIM 16 inputs, 220-250 VDC, 120mA			E 2	E 2	E 2	E 2	E 2	E 2	E 2	E 2	E 2	E 2	E 2	
BIMp 16 inputs, RL24-30 VDC, 30 mA, for pulse counting				F 1	F 1	F 1	F 1	F 1	F 1	F 1	F 1	F 1	F 1	
BIMp 16 inputs, RL48-60 VDC, 30 mA, for pulse counting				G 1	G 1	G 1	G 1	G 1	G 1	G 1	G 1	G 1	G 1	
BIMp 16 inputs, RL110-125 VDC, 30 mA, for pulse counting				H 1	H 1	H 1	H 1	H 1	H 1	H 1	H 1	H 1	H 1	
BIM 16 inputs, RL220-250 VDC, 30 mA, for pulse counting				K 1	K 1	K 1	K 1	K 1	K 1	K 1	K 1	K 1	K 1	
IOM 8 inputs, 10+2 output, RL24-30 VDC, 50 mA				L 1	L 1	L 1	L 1	L 1	L 1	L 1	L 1	L 1	L 1	
IOM 8 inputs, 10+2 output, RL48-60 VDC, 50 mA				M 1	M 1	M 1	M 1	M 1	M 1	M 1	M 1	M 1	M 1	
IOM 8 inputs, 10+2 output, RL110-125 VDC, 50 mA				N 1	N 1	N 1	N 1	N 1	N 1	N 1	N 1	N 1	N 1	
IOM 8 inputs, 10+2 output, RL220-250 VDC, 50 mA				P 1	P 1	P 1	P 1	P 1	P 1	P 1	P 1	P 1	P 1	
IOM 8 inputs, 10+2 output relays, 220-250 VDC, 110mA				P 2	P 2	P 2	P 2	P 2	P 2	P 2	P 2	P 2	P 2	
IOM with MOV 8 inputs, 10+2 output, 24-30 VDC, 30 mA				U 1	U 1	U 1	U 1	U 1	U 1	U 1	U 1	U 1	U 1	
IOM with MOV 8 inputs, 10+2 output, 48-60 VDC, 30 mA				V 1	V 1	V 1	V 1	V 1	V 1	V 1	V 1	V 1	V 1	
IOM with MOV 8 inputs, 10+2 output, 110-125 VDC, 30 mA				W 1	W 1	W 1	W 1	W 1	W 1	W 1	W 1	W 1	W 1	
IOM with MOV 8 inputs, 10+2 output, 220-250 VDC, 30 mA				Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	
mA input module MIM 6 channels				R 1	R 1	R 1	R 1	R 1	R 1	R 1	R 1	R 1	R 1	Note: maximum 1 MIM board in 1/2 case
SOM Static output module, 12 outputs, 48-60 VDC				T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 1	Note: SOM must not to be placed in position nearest to NUM. 1/2 case slot P4, 3/4 case 1 TRM slot P10, 3/4 case 2 TRM slot P7, 1/1 case 1 TRM slot P16, 1/1 case 2 TRM slot P13
SOM Static outputs module, 12 outputs, 110-250 VDC				T 2	T 2	T 2	T 2	T 2	T 2	T 2	T 2	T 2	T 2	
Selection for position #10.														

Remote end communication, DNP serial comm. and time synchronization modules	311						Notes and Rules
Slot position (rear view)	X312	X313	X302	X303	X322	X323	
Available slots in 1/2 and 3/4 case with 1TRM							Note: Only for A31/A32. One LDCM must be ordered. Max 1 LDCM in 1/2 case.
Available slots in 3/4 and 1/1 case with 2 TRM							Note: 2 LDCM in B31 and B32 must be ordered. Max 4 LDCM
No remote communication board included	X	X		X	X	X	A31 and A32 - 1 LDCM always in position P30.2(X302)
No remote communication board included	X	X			X	X	B31 and B32 - 1 LDCM always in position P30.2(X302) and P30.3(X303)
Optical short range LDCM	A	A	A	A	A	A	Max 4 LDCM (same or different type) can be selected. Note: Max 2 Medium/Long range LDCM in 3/4 case
Optical medium range, LDCM 1310 nm	B	B	B	B	B	B	
Optical long range, LDCM 1550 nm	C	C	C	C	C	C	Always place LDCM module on the same board to support redundant communication in P30.2 and P30.3, P31.2 and P31.3 or P32.2 and P32.3
Galvanic X.21 line data communication module	E	E	E	E	E	E	
EIA-8 Time synchronization module, with PPS	F	F	F	F	F	F	
Galvanic RS485 communication module	G	G		G	G	G	Note: No RS485 in position X303 in B31/B32
GPS time module GTM	S	S			S	S	
Selection for position #11.							

Serial communication unit for station communication	#12		Notes and Rules
Slot position (rear view)	X301	X311	
No first communication board included	X		
No second communication board included		X	
Serial and LON communication module (plastic)	A		
Serial (plastic) and LON (glass) communication module	B		
Serial and LON communication module (glass)	C		
Optical ethernet module, 1 channel glass		D	
Optical ethernet module, 2 channel glass		E	
Selection for position #12.			

24. Ordering for Accessories

Accessories
GPS antenna and mounting details

GPS antenna, including mounting kits	Quantity:	☐	1MRK 001 640-AA
Cable for antenna, 20 m	Quantity:	☐	1MRK 001 665-AA
Cable for antenna, 40 m	Quantity:	☐	1MRK 001 665-BA

Interface converter (for remote end data communication)

External interface converter from G.37.54 to G.703	Quantity:	1 2 3 4 ☐☐☐☐	1MRK 002 245-AA
External interface converter from G.37.54 to G.703 E1	Quantity:	1 2 3 4 ☐☐☐☐	1MRK 002 245-BA

Test switch
The test system COMBITEST intended for use with the IED 670 products is described in 1MRK 512 001-BEN and 1MRK 001024-CA. Please refer to the website: www.abb.com/substationautomation for detailed information.

Due to the high flexibility of our product and the wide variety of applications possible the test switches needs to be selected for each specific application.

Select your suitable test switch base on the available contacts arrangements shown in the reference documentation.

However our proposals for suitable variants are:

Single breaker/Single or Three Phase trip with internal neutral on current circuits (ordering number RK926 315-AG).

Single breaker/Single or Three Phase trip with external neutral on current circuits (ordering number RK926 315-AC).

Multi-breaker/Single or Three Phase trip with internal neutral on current circuits (ordering number RK926 315-BE).

Multi-breaker/Single or Three Phase trip with external neutral on current circuit (ordering number RK926 315-BV).

The normally open "in test mode" contact 29-30 on the RTXP test switches should be connected to the input of the test function block to allow activation of functions individually during testing.

Test switches type RTXP 24 is ordered separately. Please refer to Section Related documents for references to corresponding documents.

RHGS 6 Cases or RHGS 12 Case with mounted RTXP 24 and the on/off switch for dc-supply are ordered separately. Please refer to Section Related documents, for references to corresponding documents.

Protection cover

Protective cover for rear side of RHGS6, 6U, 1/4 x 19"	Quantity:	☐	1MRK 002 420-AE
Protective cover for rear side of terminal, 6U, 1/2 x 19"	Quantity:	☐	1MRK 002 420-AC
Protective cover for rear side of terminal, 6U, 3/4 x 19"	Quantity:	☐	1MRK 002 420-AB
Protective cover for rear side of terminal, 6U, 1/1 x 19"	Quantity:	☐	1MRK 002 420-AA

External resistor unit

High impedance resistor unit 1-ph with resistor and voltage dependent resistor for 20-100V operating voltage	Quantity:	1 2 3 ☐☐☐	RK 795 101-MA
High impedance resistor unit 3-ph with resistor and voltage dependent resistor for 20-100V operating voltage	Quantity:	☐	RK 795 101-MB
High impedance resistor unit 1-ph with resistor and voltage dependent resistor for 100-400V operating voltage	Quantity:	1 2 3 ☐☐☐	RK 795 101-CB
High impedance resistor unit 3-ph with resistor and voltage dependent resistor for 100-400V operating voltage	Quantity:	☐	RK 795 101-DC

Combiflex

Key switch for settings

Key switch for lock-out of settings via LCD-HMI	Quantity:	☐	1MRK 000 611-A

Note: To connect the key switch, leads with 16 A Combiflex socket on one end must be used.

Side-by-side mounting kit	Quantity:	☐	1MRK 002 420-Z

Configuration and monitoring tools

Front connection cable between LCD-HMI and PC	Quantity:	☐	1MRK 001 665-CA
LED Label special paper A4, 1 pc	Quantity:	☐	1MRK 002 038-CA
LED Label special paper Letter, 1 pc	Quantity:	☐	1MRK 002 038-DA

Manuals

Note: One (1) IED Connect CD containing user documentation (Operation manual, Technical manual, Installation manual, Commissioning manual, Application manual and Getting started guide), Connectivity packages and LEO label template is always included for each IED.

Rule: Specify additional quantity of IED Connect CD requested	Quantity:	☐	1MRK 002 290-AD

User documentation

Rule: Specify the number of printed manuals requested

Application manual	IEC Quantity:	☐	1MRK 505 307-UEN
	ANSI Quantity:	☐	1MRK 505 307-UUS
Technical manual	IEC Quantity:	☐	1MRK 505 308-UEN
	ANSI Quantity:	☐	1MRK 505 308-UUS
Commissioning manual	IEC Quantity:	☐	1MRK 505 309-UEN
	ANSI Quantity:	☐	1MRK 505 309-UUS
Communication protocol manual, IEC 61850 Edition 1, 670 series	IEC Quantity:	☐	1MRK 511 302-UEN
Communication protocol manual, IEC 61850 Edition 2, 670 series	IEC Quantity:	☐	1MRK 511 303-UEN
Communication protocol manual, IEC 60870-5-103, 670 series	IEC Quantity:	☐	1MRK 511 304-UEN
Communication protocol manual, LON, 670 series	IEC Quantity:	☐	1MRK 511 305-UEN
Communication protocol manual, SPA, 670 series	IEC Quantity:	☐	1MRK 511 306-UEN
Communication protocol manual, DNP, 670 series	ANSI Quantity:	☐	1MRK 511 301-UUS
Point list manual, DNP 670 series	ANSI Quantity	☐	1MRK 511 307-UUS
Operation manual, 670 series	IEC Quantity:	☐	1MRK 500 118-UEN
	ANSI Quantity:	☐	1MRK 500 118-UUS
Installation manual, 670 series	IEC Quantity:	☐	1MRK 514 019-UEN
	ANSI Quantity:	☐	1MRK 514 019-UUS

Engineering manual, 670 series	IEC Quantity:	☐	1MRK 511 308-UEN
	ANSI Quantity:	☐	1MRK 511 308-UUS
Cyber security guideline	IEC Quantity:	☐	1MRK 511 309-UEN

Reference information

For our reference and statistics we would be pleased to be provided with the following application data:

Country: End user:

Station name: Voltage level: kV

Related documents

Documents related to RED670	Identity number
Application manual	1MRK 505 307-UEN
Commissioning manual	1MRK 505 309-UEN
Product guide	1MRK 505 310-BEN
Technical manual	1MRK 505 308-UEN
Type test certificate	1MRK 505 310-TEN
Ordering form, RED670 Customized	1MRK 505 314-BEN
Ordering form, RED670 Preconfigured	1MRK 505 315-BEN

670 series manuals	Identity number
Operation manual	1MRK 500 118-UEN
Engineering manual	1MRK 511 308-UEN
Installation manual	1MRK 514 019-UEN
Communication protocol manual, DNP3	1MRK 511 301-UUS
Communication protocol manual, IEC 60870-5-103	1MRK 511 304-UEN
Communication protocol manual, IEC 61850 Edition 1	1MRK 511 302-UEN
Communication protocol manual, IEC 61850 Edition 2	1MRK 511 303-UEN
Communication protocol manual, LON	1MRK 511 305-UEN
Communication protocol manual, SPA	1MRK 511 306-UEN
Point list manual, DNP3	1MRK 511 307-UUS
Accessories guide	1MRK 514 012-BEN
Cyber security deployment guideline	1MRK 511 309-UEN
Connection and Installation components	1MRK 513 003-BEN
Test system, COMBITEST	1MRK 512 001-BEN

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Power and productivity for a better world™

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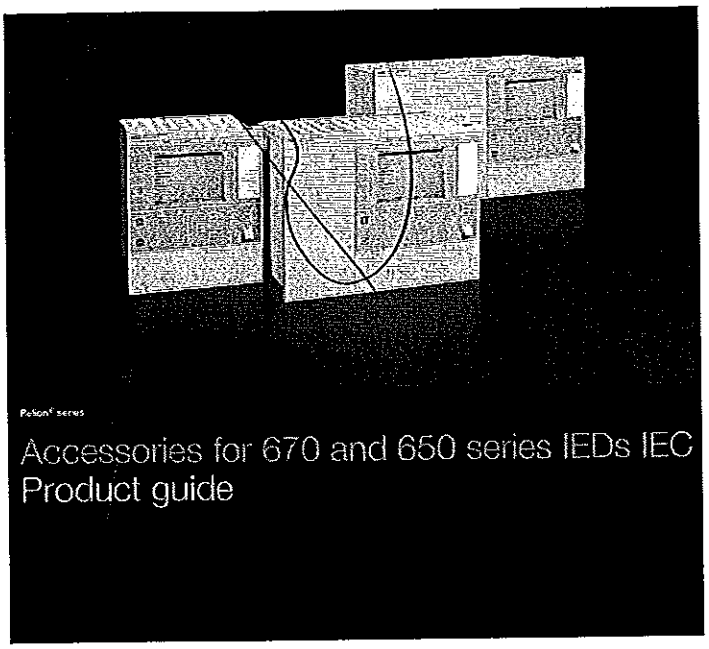
ЕЛЕКТРИКСИТИ ООД София

СрТ. 402

ВЯРНО С ОРИГИНАЛА



Relion® series

Accessories for 670 and 650 series IEDs IEC
Product guide

Contents

Power and productivity for a better world™ ABB

Issued: January 2016
Revision: C

1. Available accessories

Mounting kits
- Mounting kits for space-saving mounting in racks and cubicles and on walls
- IP54 protected mounting capability in cubicles

RHGS cases
- RHGS 6, RHGS 12 and RHGS 30 cases enable mounting of for example Combiflex modules

Test switch module
- Fail-safe testing of IEDs, using test switch RTXP 24
- Time saving while
  - all connections for test are made from the front
  - easy to move between IEDs of the same type

Combiflex modules
- Provide functionality such as lock-out, lock-out reset and external contact re-enforcement
- Supervision

Key switch for settings
- Possibility to lock settings with key switch

Connectors
- Flexible connection of analog and binary signals
  - Screw compression type
  - Terminal blocks suitable for ring-lugs

External resistor unit
- Used with the High impedance differential protection

External current transformer unit
- Used for cost effective summation type differential principle

Interface converter
- External interface converter from C37.94 to G703
- External interface converter from C37.94 to G703.E1

GPS antenna
- Used with the GPS time synchronization module GTM (or GSM)

Injection equipment hardware REX060, REX061, REX062
- Is used to inject voltage and current signals to the generator or motor.

COMBIFLEX Injection equipment
RXTTE4 and optional protective resistor are used to inject fundamental frequency AC voltage into the rotor circuit.

ESD Field Kit
- Used to make work ESD safe

Power Supply
- Used to supply power to the IED

Configuration and monitoring tools
- Protection and control manager, PCM600, used to
  - configure the IED
  - set parameters
  - monitor the IED and the system
  - visualize and evaluate disturbance recordings
- Supervision and control of the power system via IEDs (HMI Control package)
- Provides on request information from IEDs
- Collection of disturbances from IEDs
- Consists of standard library functions for easy application engineering of a station HMI

Cable and dust cover
- The cable is used to connect a PC to the RJ45 port on the local human machine interface
- The dust cover protects the RJ45 port

Labels
- Used to label the LEDs

2. Mounting kits

19" rack mounting
Use the 19" rack mounting kit for 6U housing to mount the IED in a standard rack. Combine the rack mounting kit with the side-by-side mounting kit to mount IEDs or an IED and a test switch module in the same rack position.

The 19" rack mounting kit is available in four designs, suitable for 1/4, 1/2, 3/4 or full width cases and consists of two rack flanges (1a) and (1b) with appropriate mounting screws for IED fastening to the case.

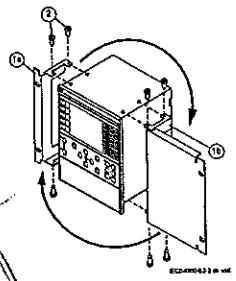


Figure 1. The rack mounting kit

Flush mounting
Use the flush mount kit for installation in a panel cut out.

The flush mounting kit consists of four fasteners (2) with appropriate mounting details (4) and a sealing strip (5) for fastening to the IED (3).

To receive IP54 class protection, an additional sealing (1) must be ordered with the IED. This sealing is factory mounted.

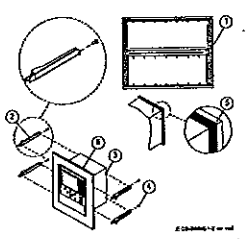


Figure 2. The flush mounting kit

Wall mounting
Use the wall mounting kit to projection mount the IED on a wall.

The wall mounting kit consists of a mounting bar pair (4) and a IED bracket pair (6). Screws (2) and (5) and washers (1) for fastening of the terminal are included, but not wall fasteners (3).

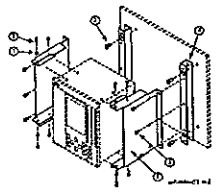


Figure 3. The wall mounting kit

Side-by-side mounting
Use the side-by-side mounting kit to mount two IEDs or a IED and its corresponding test switch module next to each other.

The side-by-side mounting kit consists of two mounting plates (1) and eight screws (2). The side-by-side mounted units are mounted in a rack or cubicle using the appropriate kit, in this example the rack mounting kit (3 and 4).

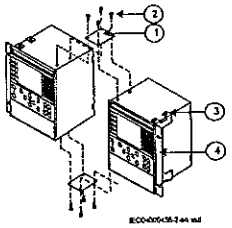


Figure 4. The side-by-side mounting kit

Protection cover for rear area
The protection cover for the rear area is a steel cover with a slot for cable entrance at the bottom part.

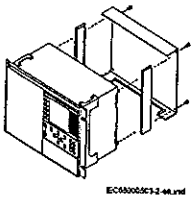


Figure 5. Protection cover for rear area

3. RHGS cases

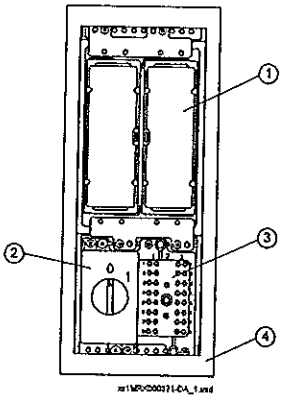
RHGS Cases
Color matched (RAL7035) RHGS cases can be used to mount for example Combiflex modules together with 670 series. See section "Related documents" for reference to more detailed information about dimensions. Please observe that cases in referenced document has a different color.

4. Test switch module

General
The test switch module consists of a RHGS 6 case with a test switch, RTXP 24, and a two-seat Combiflex terminal base mounted. An optional DC-switch occupies one seat if selected. A side-by-side mounting kit is included. The side-by-side mounted units are mounted in a rack or cubicle using the appropriate kit, for example the rack mounting kit.

All connections to the test switch module are made with Combiflex socket leads. Test contacts 1-24 of the test switch have 20 A Combiflex terminals. The signal contact of the test switch and the Combiflex terminal base have 10 A terminals.

For more details about the Combitest system and Combiflex system see section "Related documents".



1 Test switch
2 DC switch
3 Spare seat, can be used for Key switch
4 RHGS 6 case

Figure 6. Example of a test switch module

Test switch
The test switch, RTXP 24, is used to make it possible to test a IED in a failsafe way. Inserting a test-plug handle into the test switch automatically makes all preparations for test in the proper sequence. Blocked trip circuits, shortcircuited CT's, opened voltage circuits makes the IED terminals available for secondary injection test.

DC-switch
The DC-switch is optional in the test switch module and are used to switch the DC-supply of the IED ON/OFF.

The DC-switch is of one seat Combiflex type and needs a Combiflex terminal base to be mounted.

5. Key switch for settings

The key switch for lock-out of settings via the local human machine interface is used to prevent unwanted changes of settings. The switch locks the settings via a binary input.

The key switch is of one seat Combiflex type. To install it, a case including a Combiflex terminal base is needed. One possibility is to install the key switch in the same case as the test switch.

6. Combiflex modules

Auxiliary relays
Auxiliary relays can be used together with the IED to provide functionality such as lock-out, lock-out reset or external contact re-enforcement.

When the contact rating of the IED is insufficient, it is recommended to use RXME 1 as a contact re-enforcement. The RXME 1 is then activated from an IED contact which is set up to be activated together with the IED contacts tripping the breaker. The contact of the RXME 1 is connected in parallel, to take over the breaker trip coil current. This gives an efficient solution and means no time delay at tripping. See figure 7.

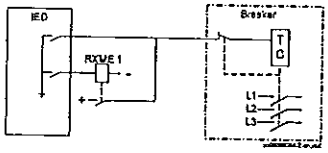


Figure 7. RXME 1 used as a trip contact re-enforcement

When single pole tripping is used one RXME 1 is required per phase and of course per subsystem in redundant systems.

Lock-out can be arranged with RXMD 1 remanance relay activated from binary outputs on IED and possible other protection relays required to activate lock-out, see figure 8. The contact of RXMD 1 is connected to open the closing circuit to the breaker closing coil. Another contact can be used to light-up a lamp push button to have indication of the lock-out and then reset with the push-button. It is recommended to avoid trip contact latching as this will mean problem for example with trip circuit supervision and further at failing breaker, mean that the trip coil is burnt and the trip coil DC supply is tripped. The most important is to prevent that the breaker is closed at persistent faults.

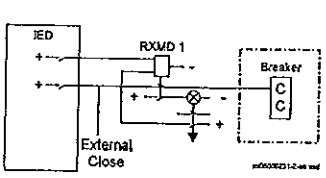


Figure 8. Lock-out using a RXMD 1 relay

For ordering codes see section "Related documents" for reference to more detailed information.

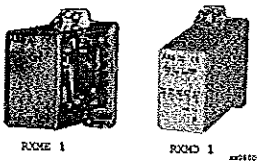


Figure 9. RXME 1 and RXMD 1 relays

Push button and selector switch
The push button is available with or without pilot lamp and with one or two buttons, it is used to reset the lock-out relays when an external independent lock-out and lock-out indications is required. The push button unit can also be used as a local selector of Auto-Reclose operation when this is required to be done locally as well as through communication.

The selector switch is available with two or three fixed positions and with different contact combinations. Selector switch can e.g. be used as Local/Remote selector or as a local selector of Auto-Reclose operation. See section "Related documents" for reference to more detailed information.

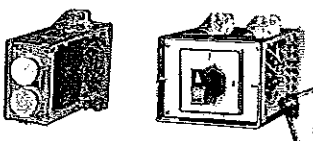


Figure 10. Push button and selector switch

Supervision relay
The relay RXEM1 can be used to detect for example loss of DC voltage supply or to detect open circuits. A typical application is continuous supervision of a circuit breaker trip circuit, including the breaker coil. See section "Related documents" for reference to more detailed information.

Figure 11. Supervision relay RXEM1

7. Connectors

The connectors are used for analogue signals and binary in- and output signals.

Use the ferrules to connect two wires to the same terminal point of a connector of screw compression type. Note that 1.5 mm² is the maximum dimension allowed on these wires. An appropriate crimping tool is needed to apply the ferrule to the wires. Use the bridge connector to jumper terminal points in a connector.

Use ring-lugs to connect the wires to terminal points of a connector of ring-lug type. Select ring-lugs suitable to wiring dimension and size of fitting screw.

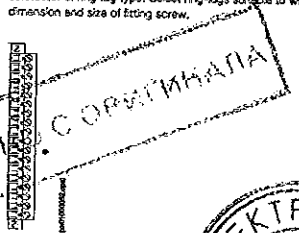


Figure 12. Voltage connector, screw compression type

Figure 13. Voltage connector, ring-lug type

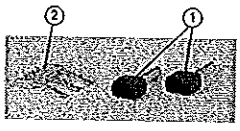


Figure 14. Ferrules and bridge connector

1 Ferrules
2 Bridge connector

8. External resistor unit

External resistor unit
The high impedance resistor unit is used with the high impedance differential protection. It is available as one phase or three phase unit.

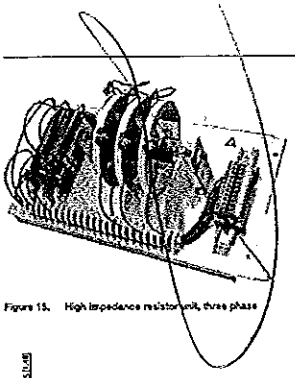


Figure 15. High impedance resistor unit, three phase

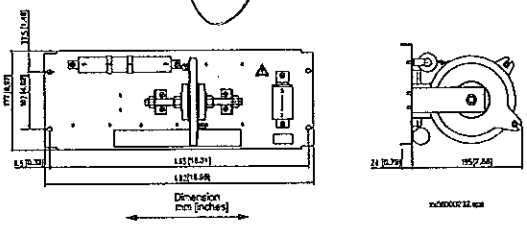


Figure 16. Dimension drawing of a one phase high impedance resistor unit

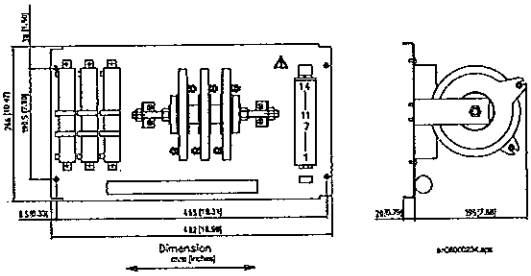


Figure 17. Dimension drawing of a three phase high impedance resistor unit

WARNING! USE EXTREME CAUTION!

Dangerously high voltages might be present on this equipment, especially on the plate with resistors. Do any maintenance ONLY if the primary object protected with this equipment is de-energized. If required by national law or standard, enclose the plate with resistors with a protective cover or install in a separate box.

9. External current transformer unit

Summation CT

The external auxiliary summation current transformers are used for the cost effective summation type differential principle.

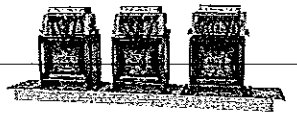


Figure 18. Summation CT

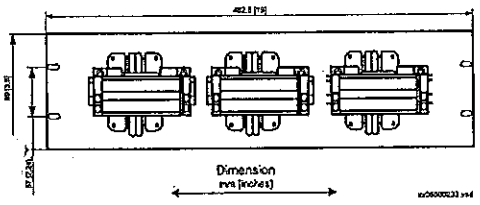


Figure 19. Dimension drawing of summation current transformers

Distance between the center of the fixing holes is 455 mm [18.33].

WARNING! USE EXTREME CAUTION!

Dangerously high voltages might be present on this equipment, especially on the plate with resistors. Do any maintenance ONLY if the primary object protected with this equipment is de-energized. If required by national law or standard, enclose the plate with transformers with a protective cover or install in a separate box.

10. Interface converter

Galvanic interface G.703 resp G.703E1

The external galvanic data communication converter G.703/G.703E1 makes an optical-to-galvanic conversion for connection to a multiplexer. These units are designed for 64 kbit/s resp 2Mbit/s operation. The converter is delivered with 19" rack mounting accessories.

Figure 20. Galvanic Converter

11. GPS antenna

Introduction

In order to receive GPS signals from the satellites orbiting the earth a GPS antenna with applicable cable must be used.

The antenna with a console for mounting on a horizontal or vertical flat surface or on an antenna mast. See figure 21

A suitable cable is available for ordering.

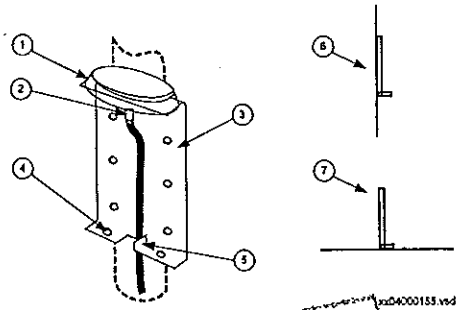


Figure 21. Antenna with console

where:		5	Tab for securing of antenna cable
1	GPS antenna	6	Vertical mounting position
2	TNC connector	7	Horizontal mounting position
3	Console, 78x150 mm		
4	Mounting holes 5.5 mm		

Table 1. GPS – Antenna and cable

Function	Value
Max. antenna cable attenuation	28 db @ 1.6 GHz
Antenna cable impedance	50 ohm
Lightning protection	Must be provided externally
Antenna cable connector	SMA in receiver end TNC in antenna end
Accuracy	+/-1µs

12. Injection unit REX060

Injection unit REX060

The injection unit REX060 is used to inject voltage and current signals to the generator or motor stator and rotor circuits. REX060 generates two square wave signals with different frequencies for injection into the stator and rotor circuits respectively. The response from the injected voltage and currents are then measured by the REX060 unit and amplified to a level suitable for the analog voltage inputs of IED.

For local operation, the REX060 unit is provided with a control panel on the front.

Local operation shall only be performed according to the operation regulations set up by the relevant operation authority of the plant.

Mounting the injection unit REX060

The injection unit REX060 case size is 6U, 1/2 x 19". REX060 can be rack, wall or flush mounted in the same way as the IED. For guidance, see instructions for rack mounting, wall mounting or flush mounting the IED in this manual.

REX060 shall be mounted close to the IED. It is recommended that they are mounted in the same cubicle.

REX060 Front panel

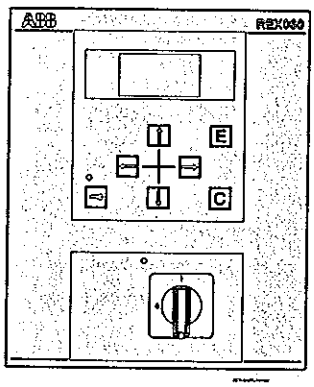


Figure 22. REX060 front panel

Rotor injection module RIM

The RIM module is installed into the REX060 enclosure. The RIM module generates a square wave voltage signal for injection into the rotor circuit via a capacitor unit REX061 for isolation. The RIM module measures the voltage and current from the injected signal and the IED consecutively calculates the rotor to earth impedance. If the calculated impedance is lower than the preset value an ALARM and/or TRIP output is set.

Stator injection module SIM

The SIM module is installed into the REX060 enclosure. The SIM module generates a square wave voltage signal for injection into the stator circuit via the neutral point VT/NGT. The SIM module measures the voltage and current from the injected signal and the IED consecutively calculates the stator to earth impedance. If the calculated impedance is lower than the preset value an ALARM and/or TRIP output is set.

13. Coupling capacitor unit REX061

Coupling capacitor unit REX061

REX061 isolates the injection circuit from the rotor exciter voltage.

The REX061 coupling capacitor unit grounding point and grounding brush of the rotor shaft should be properly interconnected.

Coupling capacitor unit REX061

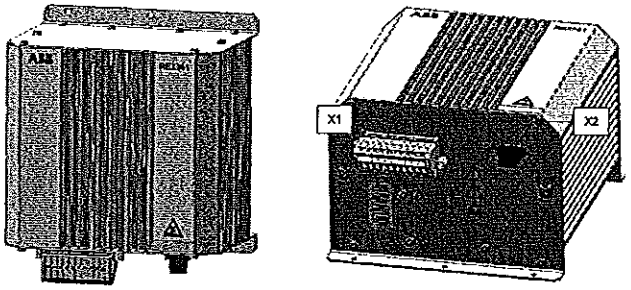


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Figure 23. Coupling capacitor unit REX061

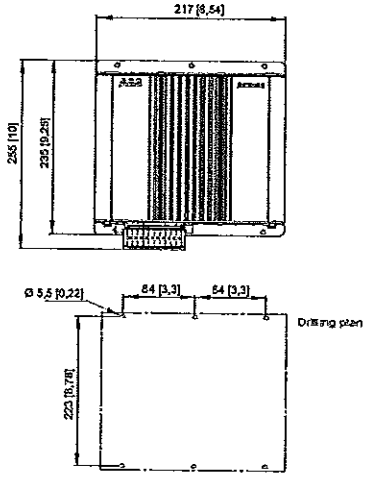

Figure 24. Measure and drilling plan

REX061 shall be mounted close to the generator in order to limit the exposure of the field circuit. Alternatively it can be located in the excitation cubicle.

The surface of REX061 unit may be temporarily very hot due to heat dissipation, up to about 50° C above the ambient temperature. It must be installed to get a open air convection and prevent contact with combustible material to the surface.

14. Shunt resistor unit REX062

Shunt resistor unit REX062

REX062 is typically used when injection is done via a grounding transformer.

Shunt resistor unit REX062

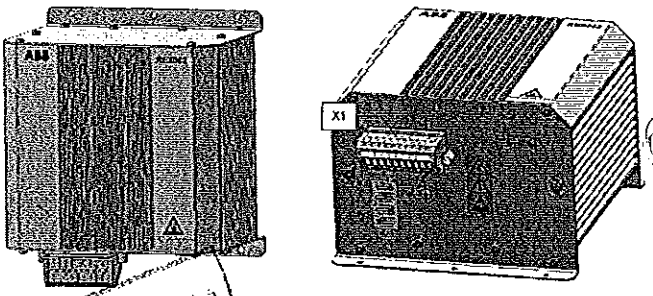

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Figure 25. Shunt resistor unit REX062

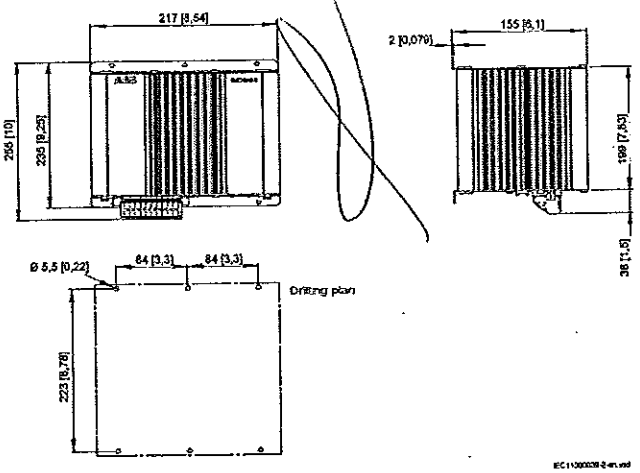


Figure 26. REX062 measures and drilling plan

REX062 shall be mounted close to the IED. It is recommended that REX060 and REX062 are mounted in the same cubicle as the IED.

The surface of REX061 unit may be temporarily very hot due to heat dissipation, up to about 65° C above the ambient temperature. It must be installed to get a open air convection and prevent contact with combustible material to the surface.

15. Voltage injection unit RXTTE4

Voltage injection unit RXTTE4
The COMBIFLEX voltage injection unit RXTTE4 is used for rotor earth fault protection applications. The RXTTE 4 contains a voltage transformer with a primary winding for connection to 120 or 230 V, 50 or 60 Hz supply voltage. From the secondary winding of the internal voltage transformer approximately 40 V AC is injected via series capacitors and resistors into the rotor circuit. The injected voltage and current are fed to one voltage input and one current input on the IED.

In order to mount injection unit RXTTE4 some COMBIFLEX accessories are required; RX4 terminal base, 10A and 20A contact sockets and Crimping tool. See section "Related documents" for more detailed information.

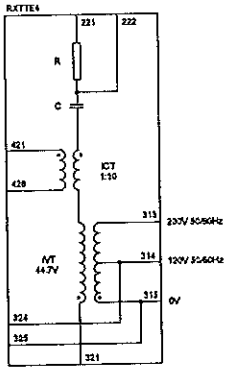


Figure 27. Voltage injection unit RXTTE4 with its main internal components

Rotor earth fault protection can be integrated in the IED among other protection functions typically required for generator protection. How this is achieved by using COMBIFLEX injection unit RXTTE4 is described in Instruction 1MRG001910.

Table 2. Rotor earth fault protection based on General current and voltage protection (CVGAPC) and RXTTE4

Function	Range or value
For machines with	
• rated field voltage up to	350 V DC
• static exciter with rated supply voltage up to	700 V 50/60 Hz
Supply voltage 120 or 230 V	50/60 Hz
Operate earth fault resistance value	Approx. 1-20 kΩ
Influence of harmonics in the DC field voltage	Negligible influence of 50 V, 150 Hz or 50 V, 300 Hz
Permitted leakage capacitance	(1–5) µF
Permitted shaft earthing resistance	Maximum 200 Ω
Protective resistor	220 Ω, 130 W, plate (the height is 160 mm (6,2 inches) and width 135 mm (5,31 inches)

External resistor for RXTTE4
The external resistor is used when either there is a need to minimize physical exposure of the field circuit or when high harmonic content of the total injection current can cause overheating of the built-in RXTTE4 resistor. The external resistor is delivered mounted on an insulated plate with overall dimensions; (the height is 160 mm (6,2 inches) and width 135

mm (5,31 inches), suitable for wall mounting, see Figure 28. It actually consists of two resistors (R1 and R2) which are on delivery connected in series. It is possible to order two different types of the external resistor. The first type (ordering number RK795102-AD) has exactly the same ohmic value of 220Ω as the internal RXTTE4 resistor. It shall be used in cases where only physical exposure of the field circuit shall be limited. The second type (ordering number RK795102-AB) has different ohmic value than internal RXTTE4 resistor. It shall be used in ...allations where current with high harmonic content is ...ed back onto the RXTTE4 injection unit by the rotor circuit

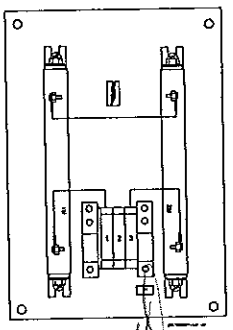
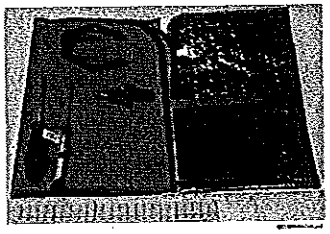


Figure 28. External ... mounted on a plate

16. ESD Field Kit

ESD Field Kit
The ESD Field Kit provides a complete portable ESD safe workstation when working in the field.



17. Power Supply

Portable Power Supply
The portable Power Supply provides the IED with power. This can be used at education or demonstration of the IED.

Power Cable
For use with the portable Power Supply.

18. Configuration and monitoring tools

PCM600
Use PCM600 through all stages of a project, from engineering, configuring and parameter setting to testing, commissioning, documentation and maintenance. Use PCM600 to adjust the default configuration, or to make a new configuration. For more information about PCM600 visit www.abb.com/substationautomation.

19. Cable and dust cover

Front communication
The front connection cable is used to connect a PC to the RJ45 port on the local human machine interface. The cable is a standard crossed-over ethernet cable (RJ45 connectors).

Dust cover
The dust cover is used to protect the RJ45 connector on the local human machine interface.

20. MicroScada tools

The LIB 520 package provides the following main functions:

- User interface for the interaction with the control system and the controlled process
- Automatic supervision and control
- Alarm and event handling
- Data acquisition, calculating and reporting

The high voltage software modules are a complement to the standard MicroSCADA software and provides an easy-to-build and easy-to-use HMI for supervision and control in MicroSCADA.

The software is made for IED's, and are providing a similar user interface as the LIB 500/510 standard library functions.

See http://www.abb.com/substationautomation for more details about the PO requirements etc.

21. Ordering

Mounting accessories

Name	For case size	Quantity	Article number
Protection cover for rear area; consisting of a steel cover with a slot for cable entrance at the bottom part, fixing screws and assembly instruction.	6U x 1/1	☐	1MRK 002 420-AA
	6U x 3/4	☐	1MRK 002 420-AB
	6U x 1/2	☐	1MRK 002 420-AC
	6U x 1/4	☐	1MRK 002 420-AE
19" rack mounting kit; consisting of two mounting angles, fixing screws and assembly instruction.	6U x 1/1	☐	1MRK 002 420-CA
	6U x 3/4	☐	1MRK 002 420-BA
	6U x 1/2	☐	1MRK 002 420-BB
	6U x 1/4	☐	1MRK 002 420-BE
Wall mounting kit; consisting of 2 mounting angles, 2 mounting bars, fixing screws and assembly instruction.	All sizes 6U	☐	1MRK 002 420-DA
Flush mounting kit; consisting of 4 fastener, sealing strip, fixing screws and assembly instruction.	All sizes	☐	1MRK 000 020-Y
Side-by-side mounting kit; consisting of 2 fixing plates, fixing screws and assembly instructions.	All sizes	☐	1MRK 002 420-Z

Note: All kits are complete including screws.

RHGS Cases

RHGS 6 with door, size 6Ux1/4, color RAL 7035	Quantity: ☐	1MRK 000 315- AG
RHGS 12 with door, size 6Ux1/2, color RAL 7035	Quantity: ☐	1MRK 000 315- BH
RHGS 30 with door, size 6Ux1/1, color RAL 7035	Quantity: ☐	1MRK 000 315- BB

Test switch module
Selection guide
Selection of a RTXP24 test switch for each ordered test switch module is required. See Selection guide for recommanded solutions or applicable IED Product guide for recommandations. Please refer to section "Related documents".

		Article number
Test switch module RTXP24	Quantity: ☐	1MRK 000 371-FA

Product	Remark	Type of earthing	Criteria		Article number
RET / REG 670	2-wind / 1CB	Internal neutral	-	☐	RK 926 315-BD
		External neutral	-	☐	RK 926 315-BH
	2-wind / 2CB	Internal neutral	3 phase current groups, 2 single phase	☐	RK 926 315-BX
		Internal neutral	2 three phase current groups, 2 single phase	☐	RK 926 315-BD
		External neutral	-	☐	RK 926 315-BH
	3-wind / 1CB	Internal neutral	3 phase current groups, 2 single phase	☐	RK 926 315-BX
		Internal neutral	2 phase current groups, 2 single phase	☐	RK 926 315-BD
		External neutral	-	☐	RK 926 315-BH
	3-wind / 2CB	Internal neutral	-	☐	RK 926 315-BD
		External neutral	-	☐	RK 926 315-BH
REQ / REL 670	1CB / 3PhTrip	Internal neutral	-	☐	RK 926 315-AK
		External neutral	-	☐	RK 926 315-AC
	1CB / 1PhTrip	Internal neutral	-	☐	RK 926 315-AK
		External neutral	-	☐	RK 926 315-AC
	2CB / 3PhTrip	Internal neutral	-	☐	RK 926 315-BE
		External neutral	-	☐	RK 926 315-BV
	2CB / 1PhTrip	Internal neutral	-	☐	RK 926 315-BE
		External neutral	-	☐	RK 926 315-BV
	1CB	Internal neutral	1 three phase current group	☐	RK 926 315-AF
	2CB		2 three phase current groups	☐	RK 926 315-AH
	2CB	Internal neutral	2 three phase current groups	☐	RK 926 315-AM

Product	Remark	Type of earthing	Criteria		Article number
	1CB	Internal neutral	1 three phase current group	☐	RK 926 315-BN
REC 670	1CB	Internal neutral	1 three phase current group	☐	RK 926 315-AK
	2CB	Internal neutral	2 three phase current groups	☐	RK 926 315-BE
	3CB	Internal neutral	3 three phase current groups	☐	RK 926 315-BL
	2CB	External neutral	-	☐	RK 926 315-BV
	1CB	Internal neutral	1 three phase current group	☐	RK 926 315-AF
	2CB	External neutral	2 three phase current groups	☐	RK 926 315-AH
	2CB	Internal neutral	2 three phase current groups	☐	RK 926 315-AM
	1CB	Internal neutral	1 three phase current group	☐	RK 926 315-BN
REB 670		Internal neutral	4 three phase current groups / 4 bays	☐	RK 926 315-CA
		External neutral	1 three phase current group / 1 bay	☐	RK 926 315-AV
RES 670	1 TRM (9I-3U) Single busbar with 3 bays	Internal neutral	3 three phase current groups	☐	RK 926 315-AN
		External neutral	1 three phase voltage group	☐	RK 926 315-DB
	2 TRMs (15I-6U) Double busbar with 6 bays.	Internal neutral	6 three phase current groups	☐	RK 923 315-AN
		External neutral	2 three phase voltage groups	☐	RK 926 315-DB

Note: 2 TRMs (15I-6U) requires two test switches for this application, so two test switch modules 1MRK000371-FA must be used.

1 TRM (6I-6U)	Internal neutral	2 three phase current groups	☐	RK 926 315-AM
	External neutral	2 three phase voltage groups	☐	RK 926 315-DC
2 TRM (12I-12U)	Internal neutral	4 three phase current groups	☐	RK 926 315-AM
	External neutral	4 three phase voltage groups	☐	RK 926 315-DC

Note: 2 TRMs (12I-12U) requires two test switches for this application, so two test switch modules 1MRK000371-FA must be used.

On/off switch for the DC-supply — Quantity: ☐ RK 795 017-AA

Labels with symbols for RTXP 24 — Quantity: ☐ 1MRK 000 132-53

Note: Leads with 20 A Combiflex socket on one end and insulation stripped on the other end must be used to connect the test switch to the terminal. To connect the signal contact of the test switch and the DC switch, leads with 10 A Combiflex socket on one end must be used.

Key switch for settings

Key switch for lock-out of settings via LCD-HMI — Quantity: ☐ 1MRK 000 611-A

Note: To connect the key switch, leads with 10 A Combiflex socket on one end must be used.

Combiflex modules

Auxiliary relays	See related documents
Push button and selector switch	See related documents
Supervision relay	See related documents
Key switch for settings	See related documents

Connectors

Female connector	18 terminals of screw compression type, conductor area max 1 x 2.5 mm² or 2 x 1.0 mm², 1 pc	Quantity: ☐	1MXC 850 004-2
Female connector	18 terminals of spring compression type, conductor area max 1 x 1.5 mm² or 2 x 0.5 mm², 1 pc	Quantity: ☐	1MXC 850 005-2
Ferrule	For 2 x 1.5 mm² conductors in screw compression terminal, 1 pc	Quantity: ☐	1MXC 840 003-4
Bridge connector	For 2 terminals in the current circuit, 1 pc	Quantity: ☐	1MXC 840 002-1
Bridge connector	For 3 terminals, 1 pc	Quantity: ☐	1MXC 840 002-2
Bridge connector	For 4 terminals, 1 pc	Quantity: ☐	1MXC 840 002-3
Female connector	18 terminals of ring-lug type, 1 pc	Quantity: ☐	1KHL380118P0001
Female connector	6 terminals of ring-lug type, 1 pc	Quantity: ☐	1KHL380106P0001

External resistor unit

High impedance resistor unit 1-ph with resistor and voltage dependent resistor for 20-100V operating voltage	Quantity: ☐	RK 795 101-MA
High impedance resistor unit 3-ph with resistor and voltage dependent resistor for 20-100V operating voltage	Quantity: ☐	RK 795 101-MB
High impedance resistor unit 1-ph with resistor and voltage dependent resistor for 100-400V operating voltage	Quantity: ☐	RK 795 101-CB
High impedance resistor unit 3-ph with resistor and voltage dependent resistor for 100-400V operating voltage	Quantity: ☐	RK 795 101-DC

External current transformer unit

3 pcs SLCE 8–1 summation transformers on apparatus plate (2U high), 1/1 A	Quantity:	☐	1MRK 000 643-EA
3 pcs SLCE 8–1 summation transformers on apparatus plate (2U high), 5/1 A	Quantity:	☐	1MRK 000 643-FA
3 pcs SLCE 8–1 summation transformers on apparatus plate (2U high), 2/1 A	Quantity:	☐	1MRK 000 643-GA

...erface converter (for remote end data communication)

External interface converter from C37.94 to G703 including 1U 19" rack mounting accessories	Quantity:	☐	1MRK 002 245-AA
External interface converter from C37.94 to G703.E1 including 1U 19" rack mounting accessories	Quantity:	☐	1MRK 002 245-BA

GPS antenna and mounting details

GPS antenna, including mounting kits	Quantity:	☐	1MRK 001 643-AA
Cable for antenna, 20 m	Quantity:	☐	1MRK 001 855-AA
Cable for antenna, 40 m		☐	1MRK 001 855-BA

Injection equipment

Rule: If injection equipment is ordered, ROTIPHIZ or STTIPHIZ is required in the IED.

Injection unit, REX060 — Quantity: ☐ 1MRK 002 500-AA

The REX060 injection unit requires a connection to a VT across the generator neutral point earthing resistor. The VT must have a rating of at least 100 VA and a rated secondary winding voltage of up to 120 V. It must adhere to IEC 61869-3:2011 section 5.5.301 Rated Output Values and the standard values specified according to burden range II.

Casing

1/2 x 19" rack casing	Basic
Backplane module (SPM)	Basic
Human machine interface	
HMI and logic module (HLM)	Basic

Injection modules
Note: One of RIM and SIM have to be selected if REX060 is specified

Rule: Stator injection module (SIM) is required if 100% stator earth fault protection, injection based (STTIPHIZ) is selected/active in REG670

Stator injection module (SIM) ☐ 1MRK 002 544-AA

If the generator is earthed via a primary resistor connected between the generator neutral point and earth, a VT is placed across the primary resistor. SIM is then connected to the secondary side of the VT. The VT must have a rating of at least 100 VA and a rated secondary winding voltage of up to 120 V. It must adhere to IEC 61869-3:2011 section 5.5.301 Rated Output Values and the standard values specified according to burden range II.

Rule: Rotor injection module (RIM) is required if Sensitive rotor earth fault protection, injection based (ROTIPHIZ) is selected/active in REG670

Rotor injection module (RIM) ☐ 1MRK 002 544-BA

Power supply module

Rule: One Power supply module must be specified

Power supply module (PSM) 24-60 VDC ☐ 1MRK 002 239-AB
90-250 VDC ☐ 1MRK 002 239-BB

Mounting details with IP40 of protection from the front
19" rack mounting kit ☐ 1MRK 002 420-BB
Wall mounting kit for terminal ☐ 1MRK 002 420-DA
IP54 ☐
Flush mounting kit for terminal ☐ 1MRK 000 020-Y
Extra IP54 mounting seal + Flush mounting kit for terminal ☐ 1MRK 002 420-EA

Rule: REX061 requires REX060 and that Rotor injection module (RIM) is selected in REX060 and that Sensitive rotor earth fault protection, injection based (ROTIPHIZ) is selected/active in REG670.

Coupling capacitor unit, REX061 — Quantity: ☐ 1MRK 002 550-AA

Rule: REX062 requires REX060 and that Stator injection module (SIM) is selected in REX060 and that 100% stator earth fault protection, injection based (STTIPHIZ) is selected/active in REG670.

Shunt resistor unit, REX062 — Quantity: ☐ 1MRK 002 555-AA

External interface units for Rotor earth fault protection

Injection unit for Rotor earth fault protection (RXTTE 4)	Quantity: ☐	1MRK 002 108-BA
Protective resistor on plate, R1 = 100 Ω, R2 = 120 Ω	Quantity: ☐	RK 795 102-AD
Protective resistor on plate, R1 = 560 Ω, R2 = 560 Ω	Quantity: ☐	RK 795 102-AB

ESD Field kit

ESD Field kit	Quantity: ☐	1MRK 001 938-A

Portable Power Supply

Power Supply Unit Input voltage: 90-264 V~, 47-63 Hz Output voltage: 48 V DC Max. output current: 2.5 A Output power: 135 W max Switch frequency: 65 kHz	Quantity: ☐	1MRK 001 665-FA
Power Cable 2m	Quantity: ☐	1MRK 001 665-EA

Configuration and monitoring tools

PCM600	See related documents

Labels

LED Label special paper A4, 1 pc	Quantity: ☐	1MRK 002 038-CA
LED Label special paper Letter, 1 pc	Quantity: ☐	1MRK 002 038-DA

Cable and dust cover

Front connection cable	Quantity: ☐	1MRK 001 665-CA
Dust cover LHMI (RJ45)	Quantity: ☐	1MKC 890 000-1

MicroSCADA tools

LIB 520	See related documents

22. Related documents

Combiflex, connection and installation components	1MRK 513 003-BEN
Combitest	1MRK 512 001-BEN
Auxiliary, signalling and tripping relays	1MRK 508 015-BEN
Auxiliary relays	1MRK 508 006-BEN
Bistable relays	1MRK 508 017-BEN
Push button and selector switch	1MRK 513 016-BEN
Supervision relay	1MRK 508 024-BEN
LIB 520	1MRK 511 182-BEN
PCM600	1MRS756448 G

Contact us

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1MRK 514 012-BEN

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650 series configured product range
Summary – Product selections

Tender ID: 16Q2863109 Pos: 120

Country of End User	BG
End User – Utility	CEZ
Station Name	Borimechkata/Orion
Voltage Range in kV	110/20

IED code: REQ650*1.3-A01X00-X00-B1X0-DH-SA-E-SA3-AXXX-F
Product description: Breaker protection, REQ650 A01, Single breaker, 3-phase, 1 busbar

BASIC FUNCTIONS

for configuration alternative A01

Autorecloser for 3-phase operation (SMBRREC,79),1pcs
Bay control (QCBAY),1pcs
Breaker close/trip circuit monitoring (TCSSCBR),3pcs
Breaker failure protection, 3-phase activation and output (CCRBRF,50BF),1pcs
Broken conductor check (BRCPTOC,46),1pcs
Circuit breaker condition monitoring (SSCBR),1pcs
Circuit breaker for 1CB,1pcs
Configurable logic blocks ( ),1pcs
Current circuit supervison (CCSRDIF,87),1pcs
Directional Over-power protection (GOPPDOP,32),1pcs
Directional Under-power protection (GUPPDUP,37),1pcs
Disturbance report (DRPRDRE),1pcs
Four step phase overcurrent protection, 3-phase output (OC4PTOC,51_67),1pcs
Four step residual overcurrent protection, zero/negative sequence direction (EF4PTOC,51N_67N),1pcs
Function block for service values presentation of the analog inputs (AISVBAS),1pcs
Function for energy calculation and demand handling (ETPMMTR),3pcs
Fuse failure supervision (SDDRFUF),1pcs
Handling of LR-switch positions (LOCREM),1pcs
Instantaneous phase overcurrent protection, 3-phase output (PHPIOC,50),1pcs
Instantaneous residual overcurrent protection (EFPIOC,50N),1pcs
Insulation gas monitoring function (SSIMG,63),1pcs
Insulation Liquid monitoring function (SSIML,71),1pcs
LHMI control of PSTO (LOCREMCTRL),1pcs
Loss of voltage check (LOVPTUV,27),1pcs
Measurements,1pcs
Negative sequence based overcurrent function (DNSPTOC,46),1pcs
Overfrequency protection (SAPTOF,81),2pcs
Pole discordance protection (CCRPLD,52PD),1pcs
Rate-of-change frequency protection (SAPFRC,81),2pcs
Sensitive Directional residual over current and power protetcion (SDEPSDE,67N),1pcs
Station battery supervision (SPVNZBAT),1pcs
Stub protection (STBPTOC,50STB),1pcs
Synchrocheck, energizing check, and synchronizing (SESRSYN,25),1pcs
Thermal overload protection, one time constant, Celsius (LCPTTR,26),1pcs
Thermal overload protection, one time constant, Fahrenheit (LFPTTR,26),1pcs
Tripping logic, common 3-phase output (SMPPTRC,94),1pcs
Two step overvoltage protection (OV2PTOV,59),1pcs
Two step residual overvoltage protection (ROV2PTOV,59N),1pcs
Two step undervoltage protection (UV2PTUV,27),1pcs
Underfrequency protection (SAPTUF,81),2pcs

ВЯРНО С ОРИГИНАЛА

ACT CONFIGURATION

ABB Standard configuration, X00

FUNCTION PACKAGES

Software options	No software options, X00
First HMI Language	HMI language, English IEC, B1
Additional HMI language	No second HMI language, X0

HARDWARE

Casing	Rack, 3U 1/1x19 inch, max 4 I/O+1 TRM or max 2 I/O+1 TRM and 1 AIM, D
Back plane module, pBPM – basic	BPM, 3U 1/1 x 19"
Mounting details	Rack mounting kit, 3U 1/1x19 inch case, H
Connection type for power supply, Input/Output and communication modules, pCONIO	Compression terminals, S

Power supply, pPSM	PSM03, 100-240V AC, 110-250V DC, 9BO, A
Human machine interface, pHMI	LHMI01, OL8000, IEC 3U 1/1 19", Basic, E
Connection type for analog modules, pCONAI	Compression terminals, S
Analog system slot P2/X101,X102	TRM01, 4I, 1/5A + 1I, 0.1/0.5A + 5U, 100/220V, A3
Binary input/output module slot P3/X321,X324	BIO01, 9BI, 9BO, A
Binary input/output module slot P4/X326,X329	No board in this slot, X
Binary input/output module slot P5/X331,X334	No board in this slot, X
Binary input/output module slot P6/X336,X339	No board in this slot, X
Communication and processing module, pCOM	CPM COM05, 12BI, IRIG-B, RS485, Ethernet, LC optical, ST serial, F
User Documentation	IED Connect, containing user documentation

PRODUCT INFORMATION

Product Guide - Product guide, REQ650 Ver.1.3

Data Sheet - Accessories, 650 series

ABB AB

Substation Automation Products

http://www.abb.com/substationautomation

ВЯРНО С ОРИГИНАЛА

ЕЛЕКТРИКСИТИ ООД СОФИЯ

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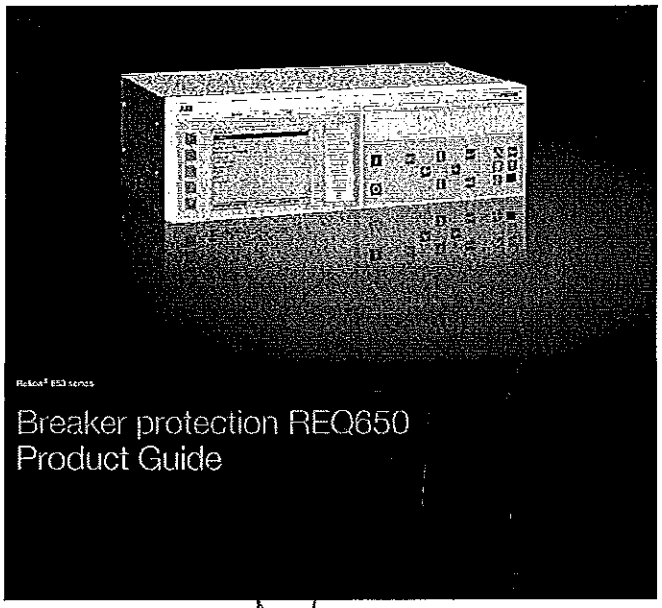

Relion® 650 series

Breaker protection REQ650
Product Guide

Contents

Power and productivity for a better world™ ABB

1. 650 series overview

Protection for a wide range of applications, control of switching devices with interlocking, and monitoring can be provided in one IED.

The 650 series IEDs provide both customized and configured solutions. With the customized IEDs you have the freedom to completely adapt the functionality according to your needs.

The 650 series IEDs provide optimum "off-the-shelf", ready-to-use solutions. It is configured with complete protection functionality and default parameters to meet the needs of a wide range of applications for generation, transmission and sub-transmission grids.

The 650 series IEDs include:

- Customized versions providing the possibility to adapt the functionality to the application needs for protection and control in one IED.
- Configured versions solutions are completely ready to use and optimized for a wide range of applications for generation, transmission and sub-transmission grids.
- Support for user-defined names in the local language for signal and function engineering.
- Minimized rule based parameter settings based on default values and ABB's global base value concept. You only need to set those parameters specific to your own installed and activated application.
- GOOSE messaging for horizontal communication on bumpless redundant station bus following IEC62439-3 ed2 PRP.
- Extended HMI functionality with 15 dynamic three-color-indication LEDs per page, on up to three pages, and configurable push-button shortcuts for different actions.
- Programmable LED text-based labels.
- Settable 1A/5A -rated current inputs.
- Role based access control with independent passwords and FTPS encrypted communication. Managed authentication and accounting of all user activities.

2. Application

Breaker protection REQ650 IED provides a standalone solution for applications, where the functions related to the breaker is not preferred or suitable to be integrated into the main protection function that is, the line distance protection for a line. The advanced automatic reclosing, synchronizing, synchrocheck and energizing check functions of REQ650 provides an optimized stand alone product. This IED also enables well-structured and reliable protection and control systems especially in systems where complete bay control functionality including interlocking is not required. Apparatus control for up to 8 apparatuses with interlocking can be included in one IED by function block engineering.

REQ650 provides backup to the main protection with redundant protection and control functions.

Three configured packages have been defined for the following applications:

- A01: Backup protection functions in a single busbar single breaker bay with three-phase trip.
- A11: Backup protection functions in a single busbar single breaker bay with single-phase trip.
- B11: Backup protection functions in a double busbar single breaker bay with single-phase trip.

The backup protection is mainly based on current and voltage functions. In line protection applications, autoreclosing with or without synchrocheck is available.

The REQ650 IED is delivered configured and ready for use in the power system. Analogue inputs and binary inputs/outputs circuits are pre-defined.

The configured IED can be modified and adapted to suit specific applications with PCM600 and the graphical configuration tool ACT, for example, using the glue logic and adjusting the parameter settings.

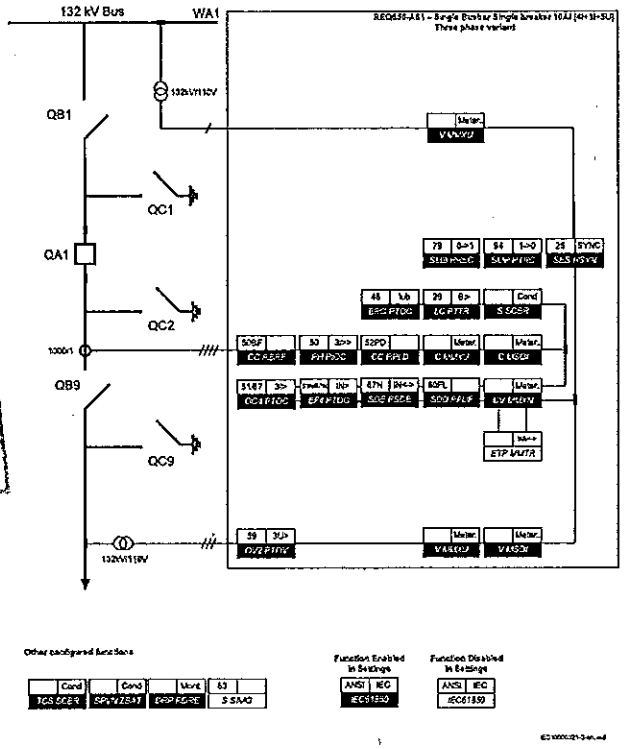

Figure 1. Typical application example of the REQ650 A01 used as backup protection in a single busbar single breaker arrangement when three-phase trip is required

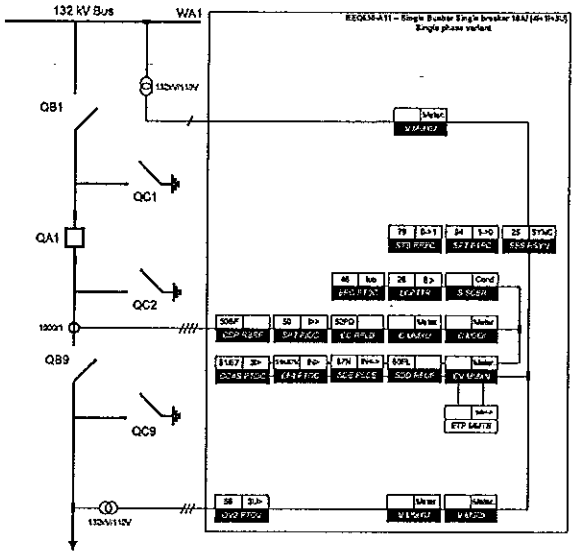

Figure 2. Typical application example of the REQ650 A11 used as backup protection in a single busbar single breaker arrangement when single-phase trip is required

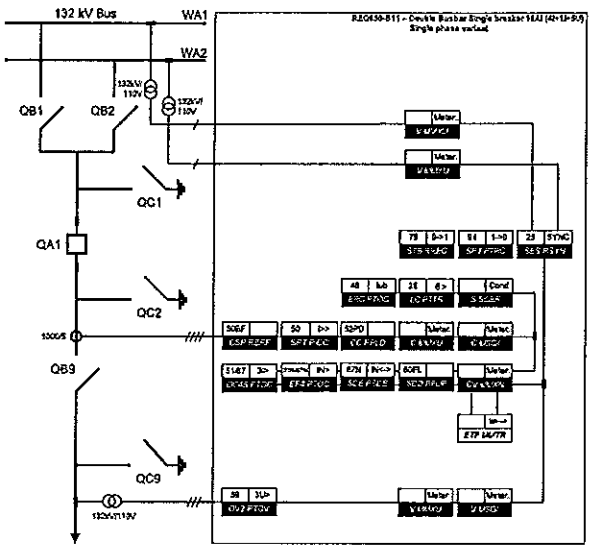

Figure 3. Typical application example of the REQ650 B11 used as backup protection in double busbar single breaker arrangement when single-phase trip is required

3. Available functions

Back-up protection functions

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3PhA/1CB/3TCS	REQ650 (A11) 1PhA/1CB/1TCS	REQ650 (B11) 1PhA/1CB/2TCS
Current protection						
PHPIOC	50	Instantaneous phase overcurrent protection, 3-phase output	0-1	1		
SPTPIOC	50	Instantaneous phase overcurrent protection, phase segregated output	0-1		1	1
OC4PTOC	51/67	Four step phase overcurrent protection, 3-phase output	0-1	1		
OC4SPTOC	51/67	Four step phase overcurrent protection, phase segregated output	0-1		1	1
EFPIOC	50N	Instantaneous residual overcurrent protection	0-1	1	1	1
EF4PTOC	51N/67N	Four step residual overcurrent protection, zero/negative sequence direction	0-1	1	1	1
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	0-1	1	1	1
LCPTTR	26	Thermal overload protection, one time constant, Celsius	0-1	1	1	1
LFPTTR	26	Thermal overload protection, one time constant, Fahrenheit	0-1	1	1	1
CCRBRF	50BF	Breaker failure protection, 3-phase activation and output	0-1	1		
CSPRBRF	50BF	Breaker failure protection, phase segregated activation and output	0-1		1	1
STBPTOC	50STB	Stub protection	0-1	1	1	1
CCRPLD	52PD	Pole discordance protection	0-1	1	1	1
BRCPTOC	46	Broken conductor check	0-1	1	1	1
GUPPDUP	37	Directional underpower protection	0-1	1	1	1
GOPPDOP	32	Directional overpower protection	0-1	1	1	1
DNSPTOC	46	Negative sequence based overcurrent function	0-1	1	1	1
Voltage protection						
UV2PTUV	27	Two step undervoltage protection	0-1	1	1	1
OV2PTOV	59	Two step overvoltage protection	0-1	1	1	1
ROV2PTOV	59N	Two step residual overvoltage protection	0-1	1	1	1
LOVPTUV	27	Loss of voltage check	0-1	1	1	1
Frequency protection						
SAPTUF	81	Underfrequency function	0-2	2	2	2
SAPTOF	81	Overfrequency function	0-2	2	2	2
SAPFRC	81	Rate-of-change frequency protection	0-2	2	2	2

Control and monitoring functions

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3PhA/1CB/3TCS	REQ650 (A11) 1PhA/1CB/1TCS	REQ650 (B11) 1PhA/1CB/2TCS
Control						
SESRSYN	25	Synchrocheck, energizing check, and synchronizing	0-1	1	1	1
SMBRREC	79	Autorecloser for 3-phase operation	0-1	1		
STBRREC	79	Autorecloser for 1/3-phase operation	0-1		1	1
SLGGIO		Logic Rotating Switch for function selection and LHMI presentation	15	15	15	15
VSGGIO		Selector mini switch	20	20	20	20
DPGGIO		IEC 61850 generic communication I/O functions double point	16	16	16	16
SPC8GGIO		Single point generic control 8 signals	5	5	5	5
AUTOBITS		AutomationBits, command function for DNP3.0	3	3	3	3
I103CMD		Function commands for IEC60870-5-103	1	1	1	1
I103IEDCMD		IED commands for IEC60870-5-103	1	1	1	1
I103USRCMD		Function commands user defined for IEC60870-5-103	4	4	4	4
I103GENCMD		Function commands generic for IEC60870-5-103	50	50	50	50
I103IEDSIMD		IED commands with position and select for IEC60870-5-103	50	50	50	50
CCBAY		Bay control	1	1	1	1
LOCREM		Handling of LR-switch positions	1	1	1	1
LOCREMCTRL		LHMI control of Permitted Source To Operate (PSTO)	1	1	1	1
CBC1		Circuit breaker control for 1CB	1	1	1	1
Secondary system supervision						
CCSRDIF	87	Current circuit supervision	0-1	1	1	1
SDCRFUF		Fuse failure supervision	0-1	1	1	1
TCSSCBR		Breaker close/trip circuit monitoring	3	3	3	3
Logic						
SMPPTRC	94	Tripping logic, common 3-phase output	1	1		
SPTPTRC	94	Tripping logic, phase segregated output	1		1	1
TRIPGGIO		Trip matrix logic	12	12	12	12
ALMCALH		Configurable logic blocks	283	283	283	283
INVERTER		Configurable logic blocks	140	140	140	140
PULSETIMER		Configurable logic blocks	40	40	40	40
XOR		Configurable logic blocks	40	40	40	40
LOOPDELAY		Configurable logic blocks	40	40	40	40

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3PH/1CB/1BB	REQ650 (A11) 1PH/1CB/1BB	REQ650 (B11) 1PH/1CB/2BB
TMERSET		Configurable logic blocks	40	40	40	40
AND		Configurable logic blocks	280	280	280	280
SRMEMORY		Configurable logic blocks	40	40	40	40
RSMEMORY		Configurable logic blocks	40	40	40	40
GT		Configurable logic blocks Q/T	0–1			
ANDQT		Configurable logic blocks Q/T	0–120			
ORQT		Configurable logic blocks Q/T	0–120			
INVERTERQT		Configurable logic blocks Q/T	0–120			
XORQT		Configurable logic blocks Q/T	0–40			
SRMEMORYQT		Configurable logic blocks Q/T	0–40			
RSMEMORYQT		Configurable logic blocks Q/T	0–40			
TMERSETQT		Configurable logic blocks Q/T	0–40			
PULSETIMERQT		Configurable logic blocks Q/T	0–40			
INVALIDQT		Configurable logic blocks Q/T	0–12			
INDCOUBSPQT		Configurable logic blocks Q/T	0–20			
INDEXTSPQT		Configurable logic blocks Q/T	0–20			
FIXDSIGN		Fixed signal function block	1	1	1	1
B16I		Boolean 16 to Integer conversion	16	16	16	16
B16IFCVI		Boolean 16 to Integer conversion with logic node representation	16	16	16	16
IB16A		Integer to Boolean 16 conversion	16	16	16	16
IB16FCVB		Integer to Boolean 16 conversion with logic node representation	16	16	16	16
TEIGGIO		Elapsed time integrator with limit transgression and overflow supervision	12	12	12	12
Monitoring						
CVMMXN		Measurements	6	6	6	6
CMMXU		Phase current measurement	10	10	10	10
VMMXU		Phase-phase voltage measurement	6	6	6	6
CMSQI		Current sequence component measurement	6	6	6	6
VMSQI		Voltage sequence measurement	6	6	6	6
VNMMXU		Phase-neutral voltage measurement	6	6	6	6
ASYBAS		Function block for service values presentation of the analog inputs	1	1	1	1
TM_P_P2		Function block for service values presentation of primary analog inputs 600TRM	1	1	1	1
AM_P_P4		Function block for service values presentation of primary analog inputs 600AM	1	1	1	1

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3PH/1CB/1BB	REQ650 (A11) 1PH/1CB/1BB	REQ650 (B11) 1PH/1CB/2BB
TM_S_P2		Function block for service values presentation of secondary analog inputs 600TRM	1	1	1	1
AM_S_P4		Function block for service values presentation of secondary analog inputs 600AM	1	1	1	1
CNTGGIO		Event counter	5	5	5	5
L4UFCNT		Event counter with limit supervision	12	12	12	12
DRPRDRE		Disturbance report	1	1	1	1
A4RADR		Analog input signals	4	4	4	4
B4RSBDR		Binary input signals	6	6	6	6
SPGGIO		IEC 61850 generic communication I/O functions	64	64	64	64
SP16GGIO		IEC 61850 generic communication I/O functions 16 inputs	16	16	16	16
MVGGIO		IEC 61850 generic communication I/O functions	16	16	16	16
MVEXP		Measured value expander block	66	66	66	66
SPVNZBAT		Station battery supervision	0–1	1	1	1
SSIMG	63	Insulation gas monitoring function	0–1	1	1	1
SSIML	71	Insulation liquid monitoring function	0–1	1	1	1
SSCBR		Circuit breaker condition monitoring	0–1	1	1	1
I103MEAS		Measurands for IEC60870-5-103	1	1	1	1
I103MEASUSR		Measurands user defined signals for IEC60870-5-103	3	3	3	3
I103AR		Function status auto-recloser for IEC60870-5-103	1	1	1	1
I103EF		Function status earth-fault for IEC60870-5-103	1	1	1	1
I103FLTFROT		Function status fault protection for IEC60870-5-103	1	1	1	1
I103IED		IED status for IEC60870-5-103	1	1	1	1
I103SUPERV		Supervision status for IEC60870-5-103	1	1	1	1
I103USRDEF		Status for user defined signals for IEC60870-5-103	20	20	20	20
Metering						
PCGGIO		Pulse counter	16	16	16	16
ETPMMTR		Function for energy calculation and demand handling	3	3	3	3

Station communication

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3PH/1CB/1BB	REQ650 (A11) 1PH/1CB/1BB	REQ650 (B11) 1PH/1CB/2BB
Station communication						
IEC61850-8-1		IEC 61850 communication protocol	1	1	1	1
DNPGEN		DNP3.0 communication general protocol	1	1	1	1
RS485DNP		DNP3.0 for RS-485 communication protocol	1	1	1	1
CH1TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
CH2TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
CH3TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
CH4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
OPTICALDNP		DNP3.0 for optical RS-232 communication protocol	1	1	1	1
MST1SERIAL		DNP3.0 for serial communication protocol	1	1	1	1
MST1TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
MST2TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
MST3TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
MST4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
RS485GEN		RS485	1	1	1	1
OPTICALPROT		Operation selection for optical serial	1	1	1	1
RS485PROT		Operation selection for RS485	1	1	1	1
DNPFREC		DNP3.0 fault records for TCP/IP communication protocol	1	1	1	1
OPTICAL103		IEC60870-5-103 Optical serial communication	1	1	1	1
RS485103		IEC60870-5-103 serial communication for RS485	1	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59	59
GOOSEBINRCV		GOOSE binary receive	4	4	4	4
ETHFRNT ETHLAN1 GATEWAY		Ethernet configuration of front port, LAN1 port and gateway	1	1	1	1
ETHLAN1_AB		Ethernet configuration of LAN1 port	1			
PRPSTATUS		System component for parallel redundancy protocol	1			
CONFPROT		IED Configuration Protocol	1	1	1	1
ACTVLOG		Activity logging parameters	1	1	1	1
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1	1
AGSAL		Generic security application component	1	1	1	1
GOOSEDPRCV		GOOSE function block to receive a double point value	32	32	32	32

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3PH/1CB/1BB	REQ650 (A11) 1PH/1CB/1BB	REQ650 (B11) 1PH/1CB/2BB
GOOSEINTRCV		GOOSE function block to receive an integer value	32	32	32	32
GOOSEMVRCV		GOOSE function block to receive a measurand value	16	16	16	16
GOOSESPRCV		GOOSE function block to receive a single point value	64	64	64	64

Basic IED functions

IEC 61850 function block name	Function description	
Basic functions included in all products		
INTERRSIG	Self supervision with internal event list	1
SELFSUPEVLST	Self supervision with internal event list	1
TIMESYNCHGEN	Time synchronization	1
SNTP	Time synchronization	1
DTSBEGIN, DTSEND, TIMEZONE	Time synchronization, daylight saving	1
IRIG-B	Time synchronization	1
SETGRPS	Setting group handling	1
ACTVGRP	Parameter setting groups	1
TESTMODE	Test mode functionality	1
CHNGLCK	Change lock function	1
PRIMVAL	Primary system values	1
SMAI_20_1 - SMAI_20_12	Signal matrix for analog inputs	2
3PHSUM	Summation block 3 phase	12
GBASVAL	Global values for settings	6
ATHSTAT	Authority status	1
ATHCHCK	Authority check	1
AUTHMAN	Authority management	1
FTPACCS	FTPS access with password	1
GSTFRNT	Ethernet service [illegible] control for front port	1
DOSLAN1	Denial of service, frame rate control for LAN1A and LAN1B ports	1
DOSSCKT	Denial of service, socket flow control	1

4. Current protection

Instantaneous phase overcurrent protection, 3-phase output PHPIOC
The instantaneous three phase overcurrent function has a low transient overreach and short tripping time to allow use as a high set short-circuit protection function.

Instantaneous phase overcurrent protection, phase segregated output SPTPIOC
The instantaneous three phase overcurrent function has a low transient overreach and short tripping time to allow use as a high set short-circuit protection function and where the requirement for tripping is one- and/or three-phase.

Four step phase overcurrent protection, 3-phase output OC4PTOC
The four step phase overcurrent protection function OC4PTOC has an inverse or definite time delay independent for step 1 and 4 separately. Step 2 and 3 are always definite time delayed

All IEC and ANSI inverse time characteristics are available.

The directional function is voltage polarized with memory. The function can be set to be directional or non-directional independently for each of the steps.

Second harmonic blocking level can be set for the function and can be used to block each step individually

Four step phase overcurrent protection, phase segregated output OC4SPTOC
The four step phase overcurrent function, phase segregated output OC4SPTOC has an inverse or definite time delay independent for each step separately.

All IEC and ANSI time delayed characteristics are available.

The directional function is voltage polarized with memory. The function can be set to be directional or non-directional independently for each of the steps.

Second harmonic blocking level can be set for the function and can be used to block each step individually.

The tripping can be configured for one- and/or three-phase.

Instantaneous residual overcurrent protection EFPIOC
The instantaneous residual overcurrent protection EFPIOC has a low transient overreach and short tripping times to allow the use for instantaneous earth-fault protection, with the reach limited to less than the typical eighty percent of the line at minimum source impedance. EFPIOC is configured to measure the residual current from the three-phase current inputs and can be configured to measure the current from a separate current input. EFPIOC can be blocked by activating the input BLOCK.

Four step residual overcurrent protection, zero sequence and negative sequence direction EF4PTOC
The four step residual overcurrent protection, zero or negative sequence direction (EF4PTOC) has a settable inverse or definite time delay independent for step 1 and 4 separately. Step 2 and 3 are always definite time delayed.

All IEC and ANSI inverse time characteristics are available.

EF4PTOC can be set directional or non-directional independently for each of the steps.

The directional part of the function can be set to operate on following combinations:

- Directional current (3PDir) versus Polarizing voltage (U3PPol)
- Directional current (3PDir) versus Polarizing current (I3PPol)
- Directional current (I3PDir) versus Dual polarizing (UPol +ZPol x IPol) where ZPol = RPol + jXPol

IDir, UPol and IPol can be independently selected to be either zero sequence or negative sequence.

Second harmonic blocking level can be set for the function and can be used to block each step individually.

Sensitive directional residual overcurrent and power protection SDEPSDE
In isolated networks or in networks with high impedance earthing, the earth fault current is significantly smaller than the short circuit currents. In addition to this, the magnitude of the fault current is almost independent on the fault location in the network. The protection can be selected to use either the residual current, $3I_0 \cdot \cos\varphi$ or $3I_0 \cdot \sin\varphi$, or residual power component $3U_0 \cdot 3I_0 \cdot \cos\varphi$, for operating quantity. There is also available one non-directional $3I_0$ step and one non-directional $3U_0$ overvoltage tripping step.

Thermal overload protection, one time constant
The increasing utilizing of the power system closer to the thermal limits has generated a need of a thermal overload protection also for power lines.

A thermal overload will often not be detected by other protection functions and the introduction of the thermal overload protection can allow the protected circuit to operate closer to the thermal limits.

The three-phase current measuring protection has an I²t characteristic with settable time constant and a thermal memory. The temperature is displayed in either in Celsius or in Fahrenheit depending on whether the function used is Thermal overload protection one time constant, Celsius LCPTTR or Fahrenheit LFPTTR.

An alarm level gives early warning to allow operators to take action well before the line is tripped.

Estimated time to trip before operation, and estimated time to reclose after operation are presented.

Breaker failure protection CCRBRF, 3-phase activation and output
CCRBRF can be current based, contact based, or an adaptive combination of these two conditions.

Breaker failure protection, 3-phase activation and output (CCRBRF) ensures fast back-up tripping of surrounding breakers in case the own breaker fails to open. CCRBRF can be current based, contact based, or an adaptive combination of these two conditions.

Current check with extremely short reset time is used as check criterion to achieve high security against inadvertent operation.

Contact check criteria can be used where the fault current through the breaker is small.

Breaker failure protection, 3-phase activation and output (CCRBRF) current criteria can be fulfilled by one or two phase currents the residual current, or one phase current plus residual current. When those currents exceed the user defined settings, the function is triggered. These conditions increase the security of the back-up trip command.

CCRBRF function can be programmed to give a three-phase re-trip of the own breaker to avoid inadvertent tripping of surrounding breakers.

Breaker failure protection, phase segregated activation and output
Breaker failure protection, phase segregated activation and output CSPRBRF ensures fast back-up tripping of surrounding breakers in case of own breaker failure to open. CSPRBRF can be current based, contact based, or adaptive combination between these two principles.

A current check with extremely short reset time is used as a check criterion to achieve a high security against inadvertent operation.

A contact check criteria can be used where the fault current through the breaker is small.

CSPRBRF function current criteria can be fulfilled by one or two phase currents, or one phase current plus residual current. When those currents exceed the user defined settings, the function is activated. These conditions increase the security of the back-up trip command.

CSPRBRF can be programmed to give an one- or three-phase re-trip of the own breaker to avoid inadvertent tripping of surrounding breakers at an incorrect initiation due to mistakes during testing.

Stub protection STBPTOC
When a power line is taken out of service for maintenance and the line disconnector is opened the voltage transformers will mostly be outside on the disconnected part. The primary line distance protection will thus not be able to operate and must be blocked.

The stub protection STBPTOC covers the zone between the current transformers and the open disconnector. The three-phase instantaneous overcurrent function is released from a normally open, NO (a) auxiliary contact on the line disconnector.

Pole discordance protection CCRPLD
Circuit breakers and disconnectors can end up with the phases in different positions (close-open), due to electrical or mechanical failures. An open phase can cause negative and zero sequence currents which cause thermal stress on rotating machines and can cause unwanted operation of zero sequence or negative sequence current functions.

Normally the own breaker is tripped to correct such a situation. If the situation persists the surrounding breakers should be tripped to clear the unsymmetrical load situation.

The pole discordance function operates based on information from the circuit breaker logic with additional criteria from phase selective current unsymmetry.

Broken conductor check BRCPTOC
Conventional protection functions can not detect the broken conductor condition. Broken conductor check BRCPTOC function, consisting of continuous phase selective current unsymmetrical check on the line where the IED is connected will give alarm or trip at detecting broken conductors.

Directional over/underpower protection GOPPDOP/GUPPDUP
The directional over-/under-power protection GOPPDOP/GUPPDUP can be used wherever a high/low active, reactive or apparent power protection or alarming is required. The functions can alternatively be used to check the direction of active or reactive power flow in the power system. There are a number of applications where such functionality is needed. Some of them are:

- detection of reversed active power flow
- detection of high reactive power flow

Each function has two steps with definite time delay.

Negative sequence based overcurrent function DNSPTOC
Negative sequence based overcurrent function DNSPTOC is typically used as sensitive earth-fault protection of power lines, where incorrect zero sequence polarization may result from mutual induction between two or more parallel lines.

Additionally, it is applied in applications on cables, where zero sequence impedance depends on the fault current return

paths, but the cable negative sequence impedance is practically constant.

The directional function is current and voltage polarized. The function can be set to forward, reverse or non-directional independently for each step. Both steps are provided with a settable definite time delay.

DNSPTOC protects against all unbalanced faults including phase-to-phase faults. The minimum start current of the function must be set to above the normal system unbalance level in order to avoid unwanted operation.

5. Voltage protection

Two step undervoltage protection UV2PTUV
Undervoltages can occur in the power system during faults or abnormal conditions. Two step undervoltage protection (UV2PTUV) function can be used to open circuit breakers to prepare for system restoration at power outages or as long-time delayed back-up to primary protection.

UV2PTUV has two voltage steps, where step 1 is settable as inverse or definite time delayed. Step 2 is always definite time delayed.

UV2PTUV has a high reset ratio to allow settings close to system service voltage.

Two step overvoltage protection OV2PTOV
Overvoltages may occur in the power system during abnormal conditions such as sudden power loss, tap changer regulating failures, and open line ends on long lines.

Two step overvoltage protection (OV2PTOV) function can be used to detect open line ends, normally then combined with a directional reactive over-power function to supervise the system voltage. When triggered, the function will cause an alarm, switch in reactors, or switch out capacitor banks.

OV2PTOV has two voltage steps, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

OV2PTOV has a high reset ratio to allow settings close to system service voltage.

Two step residual overvoltage protection ROV2PTOV
Residual voltages may occur in the power system during earth faults.

Two step residual overvoltage protection ROV2PTOV function calculates the residual voltage from the three-phase voltage input transformers or measures it from a single voltage input transformer fed from an open delta or neutral point voltage transformer.

ROV2PTOV has two voltage steps, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

Loss of voltage check LOVPTUV
Loss of voltage check LOVPTUV is suitable for use in networks with an automatic system restoration function. LOVPTUV issues a three-pole trip command to the circuit breaker, if all three phase voltages fall below the set value for a time longer than the set time and the circuit breaker remains closed.

The operation of LOVPTUV is supervised by the fuse failure supervision SDDRFUF.

6. Frequency protection

Underfrequency protection SAPTUF
Underfrequency occurs as a result of a lack of sufficient generation in the network.

Underfrequency protection SAPTUF measures frequency with high accuracy, and is used for load shedding systems, remedial action schemes, gas turbine start-up and so on. Separate definite time delays are provided for operate and restore.

SAPTUF is provided with undervoltage blocking.

Overfrequency protection SAPTOF
Overfrequency protection function SAPTOF is applicable in all situations, where reliable detection of high fundamental power system frequency is needed.

Overfrequency occurs because of sudden load drops or shunt faults in the power network. Close to the generating plant, generator governor problems can also cause over frequency.

SAPTOF measures frequency with high accuracy, and is used mainly for generation shedding and remedial action schemes. It is also used as a frequency stage initiating load restoring. A definite time delay is provided for operate.

SAPTOF is provided with an undervoltage blocking.

Rate-of-change frequency protection SAPFRC
The rate-of-change frequency protection function SAPFRC gives an early indication of a main disturbance in the system. SAPFRC measures frequency with high accuracy, and is used for generation shedding, load shedding and remedial action schemes. SAPFRC can discriminate between a positive or negative change of frequency. A definite time delay is provided for operate.

SAPFRC is provided with an undervoltage blocking.

7. Secondary system supervision

Current circuit supervision CCSRDIF
Open or short circuited current transformer cores can cause unwanted operation of many protection functions such as differential, earth-fault current and negative-sequence current functions.

It must be remembered that a blocking of protection functions at an occurrence of open CT circuit will mean that the situation will remain and extremely high voltages will stress the secondary circuit

Current circuit supervision (CCSRDIF) compares the residual current from a three phase set of current transformer cores with the neutral point current on a separate input taken from another set of cores on the current transformer.

A detection of a difference indicates a fault in the circuit and is used as alarm or to block protection functions expected to give inadvertent tripping.

Fuse failure supervision SDDRFUF
The aim of the fuse failure supervision function SDDRFUF is to block voltage measuring functions at failures in the secondary circuits between the voltage transformer and the IED in order to avoid inadvertent operations that otherwise might occur.

The fuse failure supervision function basically has three different detection methods, negative sequence and zero sequence based detection and an additional delta voltage and delta current detection.

The negative sequence detection is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence measuring quantities, a high value of negative sequence voltage $3U_2$ without the presence of the negative-sequence current $3I_2$.

The zero sequence detection is recommended for IEDs used in directly or low impedance earthed networks. It is based on the zero sequence measuring quantities, a high value of zero sequence voltage $3U_0$ without the presence of the zero sequence current $3I_0$.

For better adaptation to system requirements, an operation mode setting has been introduced which makes it possible to select the operating conditions for negative sequence and zero sequence based function. The selection of different operation modes makes it possible to choose different interaction possibilities between the negative sequence and zero sequence based detection.

A criterion based on delta current and delta voltage measurements can be added to the fuse failure supervision function in order to detect a three phase fuse failure, which in practice is more associated with voltage transformer switching during station operations.

Breaker close/trip circuit monitoring TCSSCBR
The trip circuit supervision function TCSSCBR is designed to supervise the control circuit of the circuit breaker. The trip circuit supervision generates a current of approximately 1 mA through the supervised control circuit. The validity supervision of a control circuit is provided for power output contacts T1, T2 and T3.

The trip circuit supervision operates after a settable definite operating time and resets after a settable definite time when the fault disappears.

8. Control

Synchrocheck, energizing check, and synchronizing SESRSYN
The Synchronizing function allows closing of asynchronous networks at the correct moment including the breaker closing time, which improves the network stability.

Synchrocheck, energizing check, and synchronizing SESRSYN function checks that the voltages on both sides of the circuit breaker are in synchronism, or with at least one side dead to ensure that closing can be done safely.

SESRSYN function includes a built-in voltage selection scheme for double bus and 1½ breaker or ring busbar arrangements.

Manual closing as well as automatic reclosing can be checked by the function and can have different settings.

For systems, which are running asynchronous, a synchronizing function is provided. The main purpose of the synchronizing function is to provide controlled closing of circuit breakers when two asynchronous systems are going to be connected. The synchronizing function evaluates voltage difference, phase angle difference, slip frequency and frequency rate of change before issuing a controlled closing of the circuit breaker. Breaker closing time is a parameter setting.

Autorecloser for 3-phase operation SMBRREC
The autorecloser SMBRREC function provides high-speed and/or delayed auto-reclosing for single breaker applications.

Up to five three-phase reclosing attempts can be included by parameter setting.

The autoreclosing function is configured to co-operate with the synchrocheck function.

Autorecloser for 1/3-phase operation STBRREC
The autoreclosing function provides high-speed and/or delayed auto-reclosing for single breaker applications

Up to five reclosing attempts can be included by parameter setting. The first attempt can be single- and/or three phase for single-phase or multi-phase faults respectively.

Multiple autoreclosing functions are provided for multi-breaker arrangements. A priority circuit allows one circuit breaker to close first and the second will only close if the fault proved to be transient.

The autoreclosing function is configured to co-operate with the synchrocheck function.

Interlocking
The interlocking functionality blocks the possibility to operate high-voltage switching devices, for instance when a disconnector is under load, in order to prevent material damage and/or accidental human injury.

Each control IED has interlocking functions for different switchyard arrangements, each handling the interlocking of one bay. The interlocking functionality in each IED is not dependent on any central function. For the station-wide interlocking, the IEDs communicate via the station bus or by using hard wired binary inputs/outputs.

The interlocking conditions depend on the primary bus configuration and status of any breaker or switch at any given time.

Bay control QCBAY
The Bay control QCBAY function is used together with Local remote and local remote control functions to handle the selection of the operator place per bay. QCBAY also provides blocking functions that can be distributed to different apparatuses within the bay.

Local remote LOCREM /Local remote control LOCREMCTRL
The signals from the local HMI or from an external local/remote switch are applied via the function blocks LOCREM and LOCREMCTRL to the Bay control QCBAY function block. A parameter in function block LOCREM is set to choose if the switch signals are coming from the local HMI or from an external hardware switch connected via binary inputs.

Circuit breaker control for circuit breaker, CBC1
The CBC1 consists of 3 functions:

- SCILO - The Logical node for interlocking. SCILO function contains the logic to enable a switching operation, and provides the information to SCSWI wether it is permitted to operate due to actual switchyard topology. The interlocking conditions are generated in separate function blocks containing the interlocking logic.
- SCSWI - The Switch controller initializes and supervises all functions to properly select and operate switching primary apparatuses. The Switch controller may handle and operate on one three-phase device.
- SXCBR - The circuit breaker controller SXCBR provides the actual position status and pass the commands to the primary circuit breaker and supervises the switching operation and positions.

Logic rotating switch for function selection and LHMI presentation SLGGIO
The logic rotating switch for function selection and LHMI presentation SLGGIO (or the selector switch function block) is used to get an enhanced selector switch functionality compared to the one provided by a hardware selector switch. Hardware selector switches are used extensively by utilities, in order to have different functions operating on pre-set values. Hardware switches are however sources for maintenance issues, lower system reliability and an extended purchase portfolio. The logic selector switches eliminate all these problems.

Selector mini switch VSGGIO
The Selector mini switch VSGGIO function block is a multipurpose function used for a variety of applications, as a general purpose switch.

VSGGIO can be controlled from the menu or from a symbol on the single line diagram (SLD) on the local HMI.

IEC 61850 generic communication I/O functions DPGGIO
The IEC 61850 generic communication I/O functions DPGGIO function block is used to send double indications to other systems or equipment in the substation using IEC61850. It is especially used in the interlocking and reservation station-wide logics

Single point generic control 8 signals SPC8GGIO
The Single point generic control 8 signals SPC8GGIO function block is a collection of 8 single point commands, designed to bring in commands from REMOTE (SCADA) to those parts of the logic configuration that do not need extensive command receiving functionality (for example, SCSWI). In this way, simple commands can be sent directly to the IED outputs, without confirmation. The commands can be pulsed or steady with a settable pulse time.

AutomationBits AUTOBITS
The Automation bits function AUTOBITS is used to configure the DNP3 protocol command handling. Each of the 3 AUTOBITS available has 32 individual outputs available, each can be mapped as a binary output point in DNP3.

Function commands for IEC60870-5-103, I103CMD, I103IEDCMD, I103USRCMD, I103GENCMD, I103POSCMD
IEC60870-5-103 function and command logic blocks are available for configuration of the IED. The output signals are predefined or user defined depending on selected function block.

9. Logic

Tripping logic common 3-phase output SMPPTRC
A function block for protection tripping is provided for each circuit breaker involved in the tripping of the fault. It provides a settable pulse prolongation to ensure a three-phase trip

pulse of sufficient length, as well as all functionality necessary for correct co-operation with autoreclosing functions.

The trip function block also includes a settable latch functionality for breaker lock-out.

Tripping logic phase segregated output SPTPTRC
A function block for protection tripping is provided for each circuit breaker involved in the tripping of the fault. It provides the settable pulse prolongation to ensure an one- or three-phase trip pulse of sufficient length, as well as all functionality necessary for correct cooperation with autoreclosing and communication logic functions.

The trip function block includes functionality for evolving faults and a settable latch for breaker lock-out.

Trip matrix logic TMAGGIO
The 12 Trip matrix logic TMAGGIO function each with 32 inputs are used to route trip signals and other logical output signals to the tripping logics SMPPTRC and SPTPTRC or to different output contacts on the IED.

TMAGGIO 3 output signals and the physical outputs allows the user to adapt the signals to the physical tripping outputs according to the specific application needs for settable pulse or steady output.

Configurable logic blocks
A number of logic blocks and timers are available for the user to adapt the configuration to the specific application needs.

- OR function block. Each block has 6 inputs and two outputs where one is inverted.
- INVERTER function blocks that inverts the input signal
- PULSETIMER function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.
- GATE function block is used for whether or not a signal should be able to pass from the input to the output.
- XOR function block. Each block has two outputs where one is inverted.
- LOOPDELAY function block used to delay the output signal one execution cycle.
- TIMERSET function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay and must be On for the input signal to activate the output with the appropriate time delay.
- AND function block. Each block has four inputs and two outputs where one is inverted
- SRMEMORY function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. The SET input has priority if both SET and RESET inputs are operated simultaneously.
- RSMEMORY function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. The RESET input has priority if both SET and RESET are operated simultaneously.

Configurable logic Q/T
A number of logic blocks and timers, with the capability to propagate timestamp and quality of the input signals, are available. The function blocks assist the user to adapt the IEDs configuration to the specific application needs.

- ORQT OR function block that also propagates timestamp and quality of input signals. Each block has six inputs and two outputs where one is inverted.
- INVERTERQT function block that inverts the input signal and propagates timestamp and quality of input signal.
- PULSETIMERQT Pulse timer function block can be used, for example, for pulse extensions or limiting of operation of outputs. The function also propagates timestamp and quality of input signal.
- XORQT XOR function block. The function also propagates timestamp and quality of input signals. Each block has two outputs where one is inverted.
- TIMERSETQT function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay. The function also propagates timestamp and quality of input signal.
- ANDQT AND function block. The function also propagates timestamp and quality of input signals. Each block has four inputs and two outputs where one is inverted.
- SRMEMORYQT function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. The function also propagates timestamp and quality of input signal.
- RSMEMORYQT function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. The

function also propagates timestamp and quality of input signal.

- INVALIDQT function which sets quality invalid of outputs according to a "valid" input. Inputs are copied to outputs. If input VALID is 0, or if its quality invalid bit is set, all outputs invalid quality bit will be set to invalid. The timestamp of an output will be set to the latest timestamp of INPUT and VALID inputs.
- INDCOMBSPQT combines single input signals to group signal. Single position input is copied to value part of SP_OUT output. TIME input is copied to time part of SP_OUT output. Quality input bits are copied to the corresponding quality part of SP_OUT output.
- INDEXTSPQT extracts individual signals from a group signal input. Value part of single position input is copied to SI_OUT output. Time part of single position input is copied to TIME output. Quality bits in common part and indication part of inputs signal is copied to the corresponding quality output.

Fixed signal function block
The Fixed signals function FXDSIGN generates nine pre-set (fixed) signals that can be used in the configuration of an IED, either for forcing the unused inputs in other function blocks to a certain level/value, or for creating certain logic. Boolean, integer, floating point, string types of signals are available

Boolean 16 to integer conversion B16I
Boolean 16 to integer conversion function B16I is used to transform a set of 16 binary (logical) signals into an integer.

Boolean 16 to integer conversion with logic node representation B16IFCVI
Boolean 16 to integer conversion with logic node representation function B16IFCVI is used to transform a set of 16 binary (logical) signals into an integer. The block input will freeze the output at the last value.

Integer to Boolean 16 conversion IB16A
Integer to boolean 16 conversion function IB16A is used to transform an integer into a set of 16 binary (logical) signals.

Integer to Boolean 16 conversion with logic node representation IB16FCVB
Integer to boolean conversion with logic node representation function IB16FCVB is used to transform an integer to 16 binary (logic) signals.

IB16FCVB function can receive remote values over IEC61850 when the operator position input PSTO is in position remote. The block input will freeze the output at the last value.

Elapsed time integrator with limit transgression and overflow supervision TEIGGIO
The function TEIGGIO is used for user defined logics and it can also be used for different purposes internally in the IED. An application example is the integration of elapsed time during the measurement of neutral point voltage or neutral current at earth fault conditions.

Settable time limits for warning and alarm are provided. The time limit for overflow indication is fixed.

10. Monitoring

IEC61850 generic communication I/O function SPGGIO
IEC61850 generic communication I/O functions SPGGIO is used to send one single logical signal to other systems or equipment in the substation.

IEC61850 generic communication I/O function 16 inputs SP16GGIO
IEC 61850 generic communication I/O functions 16 inputs SP16GGIO function is used to send up to 16 logical signals to other systems or equipment in the substation.

Measurements CVMMXN, CMMXU, VNMMXU, VMMXU, CMSQI, VMSQI
The measurement functions are used to get on-line information from the IED. These service values make it possible to display on-line information on the local HMI and on the Substation automation system about:

- measured voltages, currents, frequency, active, reactive and apparent power and power factor
- primary and secondary phasors
- current sequence components
- voltage sequence components

Event counter CNTGGIO
Event counter CNTGGIO has six counters which are used for storing the number of times each counter input has been activated.

Event counter with limit supervision L4UFCNT
The 12 Up limit counter L4UFCNT provides a settable counter with four independent limits where the number of positive and/or negative flanks on the input signal are counted against the setting values for limits. The output for each limit is activated when the counted value reaches that limit.

Overflow indication is included for each up-counter.

Disturbance report DRPRDRE
Complete and reliable information about disturbances in the primary and/or in the secondary system together with continuous event-logging is accomplished by the disturbance report functionality.

Disturbance report DRPRDRE, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a, maximum of 40 analog and 96 binary signals.

The Disturbance report functionality is a common name for several functions:

- Event list
- Indications
- Event recorder
- Trip value recorder
- Disturbance recorder

The Disturbance report function is characterized by great flexibility regarding configuration, starting conditions, recording times, and large storage capacity.

A disturbance is defined as an activation of an input to the AnRADR or BnRBDR function blocks, which are set to trigger the disturbance recorder. All connected signals from start of pre-fault time to the end of post-fault time will be included in the recording.

Every disturbance report recording is saved in the IED in the standard Comtrade format as a reader file HDR, a configuration file CFG, and a data file DAT. The same applies to all events, which are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings. The disturbance report files may be uploaded to PCM600 for further analysis using the disturbance handling tool

Event list DRPRDRE
Continuous event-logging is useful for monitoring the system from an overview perspective and is a complement to specific disturbance recorder functions.

The event list logs all binary input signals connected to the Disturbance recorder function. The list may contain up to 1000 time-tagged events stored in a ring-buffer.

Indications DRPRDRE
To get fast, condensed and reliable information about disturbances in the primary and/or in the secondary system it is important to know, for example binary signals that have changed status during a disturbance. This information is used in the short perspective to get information via the local HMI in a straightforward way.

There are three LEDs on the local HMI (green, yellow and red), which will display status information about the IED and the Disturbance recorder function (triggered).

The Indication list function shows all selected binary input signals connected to the Disturbance recorder function that have changed status during a disturbance.

Event recorder DRPRDRE
Quick, complete and reliable information about disturbances in the primary and/or in the secondary system is vital, for example, time-tagged events logged during disturbances. This information is used for different purposes in the short term (for example corrective actions) and in the long term (for example functional analysis).

The event recorder logs all selected binary input signals connected to the Disturbance recorder function. Each recording can contain up to 150 time-tagged events.

The event recorder information is available for the disturbances locally in the IED.

The event recording information is an integrated part of the disturbance record (Comtrade file).

Trip value recorder DRPRDRE
Information about the pre-fault and fault values for currents and voltages are vital for the disturbance evaluation.

The Trip value recorder calculates the values of all selected analog input signals connected to the Disturbance recorder function. The result is magnitude and phase angle before and during the fault for each analog input signal.

The trip value recorder information is available for the disturbances locally in the IED.

The trip value recorder information is an integrated part of the disturbance record (Comtrade file)

Disturbance recorder DRPRDRE
The Disturbance recorder function supplies fast, complete and reliable information about disturbances in the power system. It facilitates understanding system behavior and related primary and secondary equipment during and after a disturbance. Recorded information is used for different purposes in the short perspective (for example corrective actions) and long perspective (for example functional analysis)

The Disturbance recorder acquires sampled data from selected analog- and binary signals connected to the Disturbance recorder function (maximum 40 analog and 96 binary signals). The binary signals available are the same as for the event recorder function.

The function is characterized by great flexibility and is not dependant on the operation of protection functions. It can record disturbances not detected by protection functions. Up to 9,9 seconds of data before the trigger instant can be saved in the disturbance file.

The disturbance recorder information for up to 100 disturbances are saved in the IED and the local HMI is used to view the list of recordings

Measured value expander block MVEXP
The current and voltage measurements functions (CVMMXN, CMMXU, VMMXU and VNMMXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGGIO) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The measure value expander block MVEXP has been introduced to enable translating the integer output signal from the measuring functions to 5 binary signals: below low-low limit, below low limit, normal, above high limit or above high-high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

Station battery supervision SPVNZBAT
The station battery supervision function SPVNZBAT is used for monitoring battery terminal voltage.

SPVNZBAT activates the start and alarm outputs when the battery terminal voltage exceeds the set upper limit or drops below the set lower limit. A time delay for the overvoltage and undervoltage alarms can be set according to definite time characteristics.

SPVNZBAT operates after a settable operate time and resets when the battery undervoltage or overvoltage condition disappears after settable reset time.

Insulation gas monitoring function SSIMG
Insulation gas monitoring function SSIMG is used for monitoring the circuit breaker condition. Binary information based on the gas pressure in the circuit breaker is used as input signals to the function. In addition, the function generates alarms based on received information.

Insulation liquid monitoring function SSIML
Insulation liquid monitoring function SSIML is used for monitoring the circuit breaker condition. Binary information based on the oil level in the circuit breaker is used as input signals to the function. In addition, the function generates alarms based on received information.

Circuit breaker monitoring SSCBR
The circuit breaker condition monitoring function SSCBR is used to monitor different parameters of the circuit breaker. The breaker requires maintenance when the number of operations has reached a predefined value. The energy is calculated from the measured input currents as a sum of I^2t values. Alarms are generated when the calculated values exceed the threshold settings.

The function contains a block alarm functionality.

The supervised and presented breaker functions include

- breaker open and close travel time
- spring charging time
- number of breaker operations
- accumulated I^2t per phase with alarm and lockout
- remaining breaker life per phase
- breaker inactivity

11. Metering

Pulse counter logic PCGGIO
Pulse counter (PCGGIO) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the BIO (binary input/output) module and then read by the PCGGIO function. A scaled service value is available over the station bus.

Function for energy calculation and demand handling ETPMMTR
Outputs from the Measurements (CVMMXN) function can be used to calculate energy consumption. Active as well as reactive values are calculated in import and export direction. Values can be read or generated as pulses. Maximum demand power values are also calculated by the function.

12. Human Machine Interface

Local HMI

Figure 4. Local human-machine interface

The LHMI of the IED contains the following elements:

- Display (LCD)
- Buttons
- LED indicators
- Communication port for PCM600

The LHMI is used for setting, monitoring and controlling.

The Local human machine interface, LHMI includes a graphical monochrome LCD with a resolution of 320x240 pixels. The character size may vary depending on selected language. The amount of characters and rows fitting the view depends on the character size and the view that is shown.

The LHMI is simple and easy to understand. The whole front plate is divided into zones, each with a well-defined functionality:

- Status indication LEDs
- Alarm indication LEDs which can indicate three states with the colors green, yellow and red, with user defined and also printable label. All LEDs are configurable from the PCM600 tool
- Liquid crystal display (LCD)
- Keypad with push buttons for control and navigation purposes, switch for selection between local and remote control and reset
- Five user programmable function buttons
- An isolated RJ45 communication port for PCM600

13. Basic IED functions

Self supervision with internal event list
The Self supervision with Internal event list INTERRSIG and SELFSUPEVLST function reacts to internal system events generated by the different built-in self-supervision elements. The internal events are saved in an internal event list presented on the LHMI and in PCM600 event viewer tool.

Time synchronization
Use a common global source for example GPS time synchronization inside each substation as well as inside the area of the utility responsibility to achieve a common time base for the IEDs in a protection and control system. This makes comparison and analysis of events and disturbance data between all IEDs in the power system possible.

Time-tagging of internal events and disturbances are an excellent help when evaluating faults. Without time synchronization, only the events within the IED can be compared to one another. With time synchronization, events and disturbances within the entire station, and even between line ends, can be compared during evaluation.

In the IED, the internal time can be synchronized from a number of sources:

- SNTP
- IRIG-B
- DNP
- IEC60870-5-103

Parameter setting groups ACTVGRP
Use the four different groups of settings to optimize the IED operation for different power system conditions. Creating and switching between fine-tuned setting sets, either from the local HMI or configurable binary inputs, results in a highly adaptable IED that can be applied to a variety of power system scenarios.

Test mode functionality TESTMODE
The protection and control IEDs may have many included functions. To make the testing procedure easier, the IEDs include the feature that allows individual blocking of all functions except the function(s) the shall be tested.

There are two ways of entering the test mode:

- By configuration, activating an input signal of the function block TESTMODE
- By setting the IED in test mode in the local HMI

While the IED is in test mode, all protection functions are blocked.

Any function can be unblocked individually regarding functionality and event signaling. This enables the user to follow the operation of one or several related functions to check functionality and to check parts of the configuration, and so on.

Forcing of binary outputs, wether from the LHMI or from the PCM600 is only possible when the IED is in test mode.

Change lock function CHNGLCK
Change lock function CHNGLCK is used to block further changes to the IED configuration and settings once the commissioning is complete. The purpose is to block inadvertent IED configuration changes beyond a certain point in time.

The change lock function activation is normally connected to a binary input.

Authorization
The user categories and roles with user rights as defined by IEC 62359-8 for role based access control are pre-defined in the IED.

The IED users can be created, deleted and edited only with PCM600.

Password policies are set in the PCM600 IED user management tool.

At delivery, the IED user has full access as SuperUser until users are created with PCM600.

Authority status ATHSTAT
Authority status ATHSTAT function is an indication function block for user log-on activity.

User denied attempt to log-on and user successful log-on are reported.

Authority check ATHCHCK
To safeguard the interests of our customers, both the IED and the tools that are accessing the IED are protected, by means of authorization handling. The authorization handling

of the IED and the PCM600 is implemented at both access points to the IED:

- local, through the local HMI
- remote, through the communication ports

The IED users can be created, deleted and edited only with PCM600 IED user management tool.

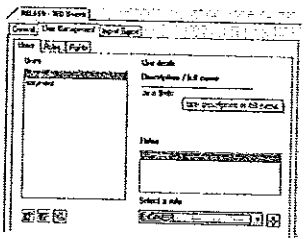

Figure 5. PCM600 user management tool

AUTHMAN
This function enables/disables the maintenance menu. It also controls the maintenance menu log on time out.

FTP access with SSL FTPACCS
The FTP Client defaults to the best possible security mode when trying to negotiate with SSL.

The automatic negotiation mode acts on port number and server features. It tries to immediately activate Implicit SSL if the specified port is 990. If the specified port is any other, it tries to negotiate with explicit SSL via AUTH SSL/TLS.

Using FTP without SSL encryption gives the FTP client reduced capabilities. This mode is only for accessing disturbance recorder data from the IED.

> If normal FTP is required to read out disturbance recordings, create a specific account for this purpose with rights only to do File transfer. The password of this user will be exposed in clear text on the wire.

Generic security application AGSAL
As a logical node AGSAL is used for monitoring security violation regarding authorization, access control and inactive association including authorization failure. Therefore, all the information in AGSAL can be configured to report to 61850 client.

Activity logging ACTIVLOG
ACTIVLOG contains all settings for activity logging.

There can be 6 external log servers to send syslog events to. Each server can be configured with IP address; IP port number and protocol format. The format can be either syslog (RFC 5424) or Common Event Format (CEF) from ArcSight.

Security alarm SECALARM
The function creates and distributes security events for mapping the security events on protocols such as DNP3.

It is possible to map respective protocol to the signals of interest and configure them for monitoring with the Communication Management tool (CMT) in PCM600. No events are mapped by default.

Parameter names:
- EVENTID: Event ID of the generated security event
- SEQNUMBER: Sequence number of the generated security event

Security events
All user operations are logged as events. These events can be sent to external security log servers using SYSLOG data formats. The log servers can be configured using PCM600.

14. Station communication

IEC 61850-8-1 communication protocol
The IED supports the communication protocols IEC 61850-8-1 and DNP3 over TCP/IP. All operational information and controls are available through these protocols. However, some communication functions, for example, horizontal communication (GOOSE) between the IEDs, is only enabled by the IEC 61850-8-1 communication protocol.

The IED is equipped with optical Ethernet rear port(s) for the substation communication standard IEC 61850-8-1. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. Peer-to-peer communication according to GOOSE is part of the standard. Disturbance files uploading is provided.

Disturbance files are accessed using the IEC 61850-8-1 protocol. Disturbance files are also available to any Ethernet based application via FTP in the standard Comtrade format. Further, the IED can send and receive binary values, double point values and measured values (for example from MVXU functions), together with their quality bit, using the IEC 61850-8-1 GOOSE profile. The IED meets the GOOSE performance requirements for tripping applications in substations, as defined by the IEC 61850 standard. The IED

interoperates with other IEC 61850-compliant IEDs, and systems and simultaneously reports events to five different clients on the IEC 61850 station bus.

The Denial of Service functions DOSLAN1 and DOSFRNT are included to limit the inbound network traffic. The communication can thus never compromise the primary functionality of the IED

The event system has a rate limiter to reduce CPU load. The event channel has a quota of 10 events/second after the initial 30 events/second. If the quota is exceeded the event channel transmission is blocked until the event changes is below the quota, no event is lost.

Table 1. Supported station communication interfaces and protocols

Protocol	Ethernet	Serial	
	100BASE-FX LC	Glass fibre (ST connector)	EIA-485
IEC 61850-8-1	•	-	-
DNP3	•	•	•
IEC 60870-5-103	-	•	•

• = Supported

Horizontal communication via GOOSE for interlocking GOOSE communication can be used for exchanging information between IEDs via the IEC 61850-8-1 station communication bus. This is typically used for sending apparatus position indications for interlocking or reservation signals for 1-of-n control. GOOSE can also be used to exchange any boolean, integer, double point and analog measured values between IEDs.

DNP3 protocol
DNP3 (Distributed Network Protocol) is a set of communications protocols used to communicate data between components in process automation systems. For a detailed description of the DNP3 protocol, see the DNP3 Communication protocol manual.

IEC 60870-5-103 communication protocol
IEC 60870-5-103 is an unbalanced (master-slave) protocol for coded-bit serial communication exchanging information with a control system, and with a data transfer rate up to 19200 bit/s. In IEC terminology, a primary station is a master and a secondary station is a slave. The communication is based on a point-to-point principle. The master must have software that can interpret IEC 60870-5-103 communication messages.

IEC 60870-5-103 can be configured to use either the optical serial or the electrical communication interface on

All communication connectors, except for the front port connector, are placed on integrated communication modules. The IED is connected to Ethernet-based communication systems via the fibre-optic multimode LC connector(s) (100BASE-FX).

The IED supports SNTP and IRIG-B time synchronization methods with a time-stamping accuracy of ±1 ms.

- Ethernet based: SNTP and DNP3
- With time synchronization wiring: IRIG-B

The IED supports IEC 60870-5-103 time synchronization methods with a time stamping accuracy of ±5 ms.

the COM03 or the COM05 communication module. The functions Operation selection for optical serial OPTICALPROT and Operation selection for RS485 RS485PROT are used to select the communication interface.

The function IEC60870-5-103 Optical serial communication, OPTICAL103, is used to configure the communication parameters for the optical serial communication interface. The function IEC60870-5-103 serial communication for RS485, RS485103, is used to configure the communication parameters for the RS485 serial communication interface.

IEC 62439-3 Parallel Redundancy Protocol
Redundant station bus communication according to IEC 62439-3 Edition 2 is available as option in the Customized 650 Ver 1.3 series IEDs, and the selection is made at ordering. Redundant station bus communication according to IEC 62439-3 Edition 2 uses both ports LAN1A and LAN1B on the COM03 module.

> Select COM03 for redundant station bus according to IEC 62439-3 Edition 2 protocol, at the time of ordering. IEC 62439-3 Edition 2 is NOT compatible with IEC 62439-3 Edition 1

15. Hardware description

See ordering for details about available mounting alternatives.

Layout and dimensions
Mounting alternatives
- 19" rack mounting kit

Rack mounting a single 3U IED

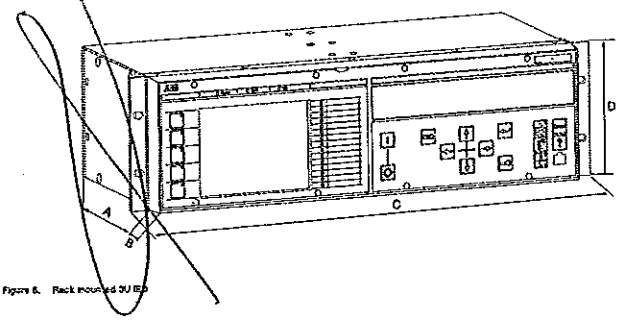

Figure 6. Rack mounted 3U IED

A 224 mm + 12 mm with ring-lug connectors
B 22.5 mm
C 432 mm
D 132 mm, 3U

16. Connection diagrams

Connection diagrams
The connection diagrams are delivered on the IED Connectivity package DVD as part of the product delivery.

The latest versions of the connection diagrams can be downloaded from http://www.abb.com/substationautomation.

Connection diagrams for Customized products

Connection diagram, 650 series 1.3 1MRK006501-AD

Connection diagrams for Configured products

Connection diagram, REQ650 1.3, (3Ph/1CB/1BB) A01 1MRK006501-LD

Connection diagram, REQ650 1.3, (1Ph/1CB/1BB) A11 1MRK006501-RD

Connection diagram, REQ650 1.3, (1Ph/1CB/2BB) B11 1MRK006501-SD

17. Technical data

General

Definitions	
Reference value	The specified value of an influencing factor to which are related the characteristics of the equipment
Nominal range	The range of values of an influencing quantity (factor) within which, under specified conditions, the equipment meets the specified requirements
Operative range	The range of values of a given energizing quantity for which the equipment, under specified conditions, is able to perform its intended functions according to the specified requirements

Energizing quantities, rated values and limits
Analog inputs

Table 2. Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Operating range		Rated frequency ± 5 Hz	
Current inputs	Rated current, I_r	0.1/0.5 A[1]	1/5 A[2]
	Thermal withstand capability:		
	• Continuously	4 A	20 A
	• For 1 s	100 A	500 A *)
	• For 10 s	20 A	100 A
	Dynamic current withstand:		
	• Half-wave value	250 A	1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage, U_r	100 V AC/ 110 V AC/ 115 V AC/ 120 V AC	
	Voltage withstand:		
	• Continuous	420 V rms	
	• For 10 s	450 V rms	
	Burden at rated voltage	<0.05 VA	

*) max. 350 A for 1 s when COMBITEST test switch is included.

1) Residual current
2) Phase current or residual current

Auxiliary AC and DC voltage

Table 3. Power supply

Description	PSM01	PSM02	PSM03
U_{aux} nominal	24, 30 V DC	48, 60, 110, 125 V DC	100, 110, 120, 220, 240 V AC, 50 and 60 Hz
			110, 125, 220, 250 V DC
U_{aux} variation	80...120% of U_r (19.2...38 V DC)	80...120% of U_r (38.4...150 V DC)	85...110% of U_r (85...264 V AC)
			80...120% of U_r (88...300 V DC)
Maximum load of auxiliary voltage supply	35 W for DC 40 VA for AC		
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 and 120 Hz)		
Maximum interruption time in the auxiliary DC voltage without resetting the IED	50 ms at U_{aux}		
Resolution of the voltage measurement in PSM module	1 bit represents 0.5 V (+/- 1 VDC)	1 bit represents 1 V (+/- 1 VDC)	1 bit represents 2 V (+/- 1 VDC)

Binary inputs and outputs

Table 4. Binary inputs

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	24...250 V DC
Current drain	1.6...1.8 mA
Power consumption/input	<0.36 W
Threshold voltage	16...221 V DC (parameterizable in the range in steps of 1% of the rated voltage)

Table 5. Signal output and IRF output

IRF relay change over - type signal output relay

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	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≥0.5 A/≥0.1 A/≥0.04 A

Table 6. Power output relays without 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 U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A

Table 7. Power output relays with TCS function

Description	Value
Rated voltage	250 V 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 U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A
Control voltage range	20...250 V DC
Current drain through the supervision circuit	~1.0 mA
Minimum voltage over the TCS contact	20 V DC

Table 8. Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
100BASE-TX	-	CAT 6 S/FTP or better	100 MB bit/s
100BASE-FX	TCP/IP protocol	Fibre-optic cable with LC connector	100 MB bit/s

Table 9. Fibre-optic communication link

Wave length	Fibre type	Connector	Permitted path attenuation1)	Distance
1300 nm	MM 62.5/125 µm glass fibre core	LC	<8 dB	2 km

1) Maximum allowed attenuation caused by connectors and cable together

Table 10. X4/IRIG-B and EIA-485 interface

Type	Protocol	Cable
Tension clamp connection	IRIG-B	Shielded twisted pair cable Recommended: CAT 6, Belden RS-485 (9841- 9844) or Alpha Wire (Alpha 6222-6230)
Tension clamp connection	IEC 60870-5-103 DNP3.0	Shielded twisted pair cable Recommended: DESCAFLEX RD-H(ST)H-2x2x0.22mm², Belden 9729, Belden 9829

Table 11. IRIG-B

Type	Value	Accuracy
Input impedance	430 Ohm	-
Minimum input voltage HIGH	4.3 V	-
Maximum input voltage LOW	8.8 V	-

Table 12. EIA-485 interface

Type	Value	Conditions
Minimum differential driver output voltage	1.5 V	-
Maximum output current	60 mA	-
Minimum differential receiver input voltage	0.2 V	-
Supported bit rates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	-
Maximum number of 650 IEDs supported on the same bus	32	-
Max. cable length	925 m (3000 ft)	Cable: AWG24 or better, stub lines shall be avoided

Table 13. Serial rear interface

Type	Counter connector
Serial port (X9)	Optical serial port, type ST for IEC 60870-5-103 and DNP serial

Table 14. Optical serial port (X9)

Wave length	Fibre type	Connector	Permitted path attenuation1)
820 nm	MM 62.5/125 µm glass fibre core	ST	6.8 dB (approx. 1700m length with 4 db / km fibre attenuation)
820 nm	MM 50/125 µm glass fibre core	ST	2.4 dB (approx. 600m length with 4 db / km fibre attenuation)

1) Maximum allowed attenuation caused by fibre

Influencing factors

Ingress protection

Table 15. Ingress protection

Description	Value
IED front	IP 54
IED rear	IP 21
IED sides	IP 42
IED top	IP 42
IED bottom	IP 21

Table 16. Environmental conditions

Description	Value
Operating temperature range	-25...+55°C (continuous)
Short-time service temperature range	-40...+70°C (<16h) Note: Degradation in MTBF and HMI performance outside the temperature range of -25...+55°C
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85°C

Table 17. Environmental tests

Description		Type test value	Reference
Cold tests	operation	96 h at -25°C 16 h at -42°C	IEC 60068-2-1/ANSI C37.90-2005 (chapter 4)
	storage	96 h at -40°C	
Dry heat tests	operation	16 h at +70°C	IEC 60068-2-2/ANSI C37.90-2005 (chapter 4)
	storage	96 h at +85°C	
Damp heat tests	steady state	240 h at +40°C humidity 93%	IEC 60068-2-78
	cyclic	6 cycles at +25 to +55°C humidity 93...55%	IEC 60068-2-30

Type tests according to standards

Table 18. Electromagnetic compatibility tests

Description	Type test value	Reference
100 kHz and 1 MHz burst disturbance test		IEC 61000-4-18, level 3 IEC 60255-22-1 ANSI C37.90.1-2012
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2, level 4 IEC 60255-22-2 ANSI C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference tests		
• Conducted, common mode	10 V (emf), f=150 kHz...80 MHz	IEC 61000-4-6 , level 3 IEC 60255-22-6
• Radiated, amplitude-modulated	20 V/m (rms), f=80...1000 MHz and f=1.4...2.7 GHz	IEC 61000-4-3, level 3 IEC 60255-22-3 ANSI C37.90.2-2004
Fast transient disturbance tests		IEC 61000-4-4 IEC 60255-22-4, class A ANSI C37.90.1-2012
• Communication ports	4 kV	
• Other ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-22-5
• Communication	1 kV line-to-earth	
• Other ports	2 kV line-to-earth, 1 kV line-to-line	
• Power supply	4 kV line-to-earth, 2 kV line-to-line	
Power frequency (50 Hz) magnetic field		IEC 61000-4-8, level 5
• 3 s	1000 A/m	
• Continuous	100 A/m	
Pulse magnetic field immunity test	1000 A/m	IEC 61000-4-9, level 5
Damped oscillatory magnetic field	100A/m, 100 kHz and 1MHz	IEC 61000-4-10, level 5
Power frequency immunity test		IEC 60255-22-7, class A IEC 61000-4-16
• Common mode	300 V rms	
• Differential mode	150 V rms	
Voltage dips and short interruptions on DC power supply	Dips: 40%/200 ms 70%/500 ms Interruptions: 0-50 ms: No restart 0-∞ s: Correct behaviour at power down	IEC 60255-11 IEC 61000-4-11

Table 18. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
Voltage dips and interruptions on AC power supply	Dips: 40% 10/12 cycles at 50/60 Hz 70% 25/30 cycles at 50/60 Hz Interruptions: 0–50 ms: No restart 0 ... s: Correct behaviour at power down	IEC 60255-11 IEC 61000-4-11
Electromagnetic emission tests		EN 55011, class A IEC 60255-25 ANSI C63.4, FCC
• Conducted, RF-emission (mains terminal)		
0.15...0.50 MHz	< 79 dB(µV) quasi peak < 66 dB(µV) average	
0.5...30 MHz	< 73 dB(µV) quasi peak < 60 dB(µV) average	
• Radiated RF-emission, IEC		
30...230 MHz	< 40 dB(µV/m) quasi peak, measured at 10 m distance	
230...1000 MHz	< 47 dB(µV/m) quasi peak, measured at 10 m distance	

Table 19. Insulation tests

Description	Type test value	Reference
Dielectric tests:		IEC 60255-5 ANSI C37.90-2005
• Test voltage	2 kV, 50 Hz, 1 min 1 kV, 50 Hz, 1 min, communication	
Impulse voltage test:		IEC 60255-5 ANSI C37.90-2005
• Test voltage	5 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J 1 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J, communication	
Insulation resistance measurements		IEC 60255-5 ANSI C37.90-2005
• Isolation resistance	>100 MΩ, 500 V DC	
Protective bonding resistance		IEC 60255-27
• Resistance	<0.1 Ω (60 s)	

Table 20. Mechanical tests

Description	Reference	Requirement
Vibration response tests (sinusoidal)	IEC 60255-21-1	Class 1
Vibration endurance test	IEC60255-21-1	Class 1
Shock response test	IEC 60255-21-2	Class 1
Shock withstand test	IEC 60255-21-2	Class 1
Bump test	IEC 60255-21-2	Class 1
Seismic test	IEC 60255-21-3	Class 2

Product safety

Table 21. Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005)

EMC compliance

Table 22. EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Current protection

Table 23. Instantaneous phase overcurrent protection, 3-phase output PHPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 5 x I_{set}	-
Reset time	40 ms typically at 5 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 24. Instantaneous phase overcurrent protection, phase segregated output SPTPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 5 x I_{set}	-
Reset time	40 ms typically at 5 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 25. Four step phase overcurrent protection, 3-phase output OC4PTOC

Function	Setting range	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Min. operating current	(5-10000)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
2nd harmonic blocking	(5-100)% of fundamental	± 2.0% of I_r
Independent time delay	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Inverse characteristics, see table 73, table 74 and table 75	15 curve types	1) ANSI/IEEE C37.112 IEC 60255-151 ±5% or ±40 ms 0.10 ≤ k ≤ 3.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}
Operate time, nondirectional start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, nondirectional start function	35 ms typically at 2 to 0 x I_{set}	-
Operate time, directional start function	50 ms typically at 0 to 2 x I_{set}	-
Reset time, directional start function	35 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

1) Note: Timing accuracy only valid when 2nd harmonic blocking is turned off

Table 26. Four step phase overcurrent protection, phase segregated output OC4SPTOC

Function	Setting range	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Min. operating current	(5-10000)% of IBase	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Independent time delay	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Inverse characteristics, see table 73, table 74 and table 75	15 curve types	1) ANSI/IEEE C37.112 IEC 60255-151 ±5% or ±40 ms 0.10 ≤ k ≤ 3.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}
Operate time, nondirectional start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, nondirectional start function	35 ms typically at 2 to 0 x I_{set}	-
Operate time, directional start function	50 ms typically at 0 to 2 x I_{set}	-
Reset time, directional start function	35 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

1) Note: Timing accuracy only valid when 2nd harmonic blocking is turned off.

Table 27. Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 5 x I_{set}	-
Reset time	40 ms typically at 5 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 28. Four step residual overcurrent protection EF4PTOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate current for directional comparison, Zero sequence	(1–100)% of *IBase*	± 2.0% of I_r
Operate current for directional comparison, Negative sequence	(1–100)% of *IBase*	± 2.0% of I_r
Min. operating current	(1–10000)% of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Timers	(0.000-60.000) s	± 0.5% ±25 ms
Inverse characteristics, see table 73, table 74 and table 75	15 curve types	1) ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \le k \le 3.00$ $1.5 \times I_{inv} \le I \le 20 \times I_{inv}$
Minimum polarizing voltage, Zero sequence	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing voltage, Negative sequence	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing current, Zero sequence	(2–100)% of *IBase*	±1.0% of I_r
Minimum polarizing current, Negative sequence	(2–100)% of *IBase*	±1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50-3000.00) Ω/phase	-
Operate time, non-directional start function	30 ms typically at 0.5 to 2 x I_{set}	-
Reset time, non-directional start function	30 ms typically at 2 to 0.5 x I_{set}	-
Operate time, directional start function	30 ms typically at 0.5 to 2 x I_{fr}	-
Reset time, directional start function	30 ms typically at 2 to 0.5 x I_{fr}	-

1) Note: Timing accuracy only valid when 2nd harmonic blocking is turned off.

Table 29. Sensitive directional residual overcurrent and power protection SDEPSDE

Function	Range or value	Accuracy
Operate level for $3I_0 \cdot 3U_0 \cdot \cos\phi$ directional residual overcurrent	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$ At low setting: (0.25-1.00)% of I_r: ±0.05% of I_r (1.00-5.00)% of I_r: ±0.1% of I_r
Operate level for $3I_0 \cdot 3U_0 \cdot \cos\phi$ directional residual power	(0.25-200.00)% of *SBase*	± 2.0% of S_r at $S \le S_r$ ± 2.0% of S at $S > S_r$ At low setting: (0.25-5.00)% of *SBase* ± 10% of set value
Operate level for $3I_0$ and φ residual overcurrent	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$ At low setting: (0.25-1.00)% of I_r: ±0.05% of I_r (1.00-5.00)% of I_r: ±0.1% of I_r
Operate level for non-directional overcurrent	(1.00-400.00)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$ At low setting <5% of I_r: ±0.1% of I_r
Operate level for non-directional residual overvoltage	(1.00-200.00)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Residual release current for all directional modes	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$ At low setting: (0.25-1.00)% of I_r: ±0.05% of I_r (1.00-5.00)% of I_r: ±0.1% of I_r
Residual release voltage for all directional modes	(1.00 - 300.00)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±25 ms
Inverse characteristics, see table 73, table 74 and table 75	15 curve types	ANSI/IEEE C37.112 IEC 60255–151 ±3.0% or±30 ms $0.10 \le k \le 3.00$ $1.5 \times I_{inv} \le I \le 20 \times I_{inv}$
Relay characteristic angle RCA	(-179 to 180) degrees	± 2.0 degrees
Relay open angle ROA	(0-90) degrees	± 2.0 degrees
Operate time, non-directional residual over current	60 ms typically at 0 to 2 x I_{set}	60 ms typically at 0 to 2 x I_{set}

Table 29. Sensitive directional residual overcurrent and power protection SDEPSDE, continued

Function	Range or value	Accuracy
Reset time, non-directional residual over current	65 ms typically at 2 to 0 x I_{set}	65 ms typically at 2 to 0 x I_{set}
Operate time, non-directional residual overvoltage	45 ms typically at 0.8 to 1.5 x U_{set}	45 ms typically at 0.8 to 1.5 x U_{set}
Reset time, non-directional residual overvoltage	65 ms typically at 1.2 to 0.8 x U_{set}	65 ms typically at 1.2 to 0.8 x U_{set}
Operate time, directional residual over current	140 ms typically at 0.5 to 2 x I_{set}	-
Reset time, directional residual over current	65 ms typically at 2 to 0.5 x I_{set}	-
Critical impulse time non-directional residual over current	35 ms typically at 0 to 2 x I_{set}	-
Impulse margin time non-directional residual over current	25 ms typically	-

Table 30. Thermal overload protection, one time constant LCPTTR/LPTTR

Function	Range or value	Accuracy
Reference current	(0-400)% of *IBase*	± 1.0% of I_r
Reference temperature	(0-300)°C, (0 - 600)°F	± 2.0°C, ±3.0°F
Operate time: $t = \tau \cdot \ln\left(\frac{I^2 - I_p^2}{I^2 - I_{ref}^2}\right)$ (Equation 1) I = actual measured current I_p = load current before overload occurs I_{ref} = reference load current	Time constant τ = (0–1000) minutes	IEC 60255-8, ±5% + 200 ms
Alarm temperature	(0-200)°C, (0-400)°F	± 2.0°C ± 2.0°F
Trip temperature	(0-300)°C, (0-600)°F	± 2.0°C ± 2.0°F
Reset level temperature	(0-300)°C, (0-600)°F	± 2.0°C ± 2.0°F

Table 31. Breaker failure protection, 3-phase activation and output CCRBRF

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±10 ms
Operate time for current detection	20 ms typically	-
Reset time for current detection	10 ms maximum	-

Table 32. Breaker failure protection, phase segregated activation and output CSPRBRF

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±10 ms
Operate time for current detection	20 ms typically	-
Reset time for current detection	10 ms maximum	-

Table 33. Stub protection STBPTOC

Function	Range or value	Accuracy
Operating current	(1-2500)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 34. Pole discordance protection CCRPLD

Function	Range or value	Accuracy
Operate value, current asymmetry level	(0-100) %	± 1.0% of I_2
Reset ratio	>95%	-
Time delay	(0.000-60.000) s	± 0.5% ± 25 ms

Table 35. Broken conductor check BRCPTOC

Function	Range or value	Accuracy
Minimum phase current for operation	(5-100)% of *IBase*	± 1.0% of I_r
Unbalance current operation	(50-90)% of maximum current	± 2.0% of I_r
Timer	(0.00-60.000) s	± 0.5% ± 25 ms
Operate time for start function	35 ms typically	-
Reset time for start function	30 ms typically	-
Critical impulse time	15 ms typically	-
Impulse margin time	10 ms typically	-

Table 36. Directional overunderpower protection GOPPDOP, GUPPDUP

Function	Range or value	Accuracy
Power level	(0.0-500.0)% of *SBase*	± 1.0% of S_r at $S < S_r$ ± 1.0% of S at $S > S_r$
	(1.0-2.0)% of *SBase*	< ± 50% of set value
	(2.0-10)% of *SBase*	< ± 20% of set value
Characteristic angle	(-180.0-180.0) degrees	2 degrees
Timers	(0.010 - 6000.000) s	± 0.5% ± 25 ms

Table 37. Negative sequence based overcurrent function DNSPTOC

Function	Range or value	Accuracy
Operate current	(2.0 - 200.0) % of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95 %	-
Low polarizing voltage level	(3.0 - 5.0) % of *UBase*	< ± 0.5% of U_r
Relay characteristic angle	(-180 - 180) degrees	± 2.0 degrees
Relay operate angle	(1 - 90) degrees	± 2.0 degrees
Timers	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Operate time, non-directional	30 ms typically at 0 to 2 x I_{set} 20 ms typically at 0 to 10 x I_{set}	-
Reset time, non-directional	40 ms typically at 2 to 0 x I_{set}	-
Operate time, directional	30 ms typically at 0 to 2 x I_{set} 20 ms typically at 0 to 10 x I_{set}	-
Reset time, directional	40 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time	15 ms typically	-
Dynamic overreach	< 10% at t = 300 ms	-

Voltage protection

Table 38. Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1-100)% of *UBase*	± 0.5% of U_r
Reset ratio	<102%	-
Inverse time characteristics for low and high step, see table 77	-	See table 77
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Definite time delays, step 2	(0.000-60.000) s	± 0.5% ±25 ms
Minimum operate time, inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 1.2 to 0.8 U_{set}	-
Reset time, start function	40 ms typically at 0.5 to 1.2 xU_{set}	-
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 39. Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and 2	(1-200)% of *UBase*	± 0.5% of U_r at $U < U_r$ ± 0.5% of U at $U > U_r$
Reset ratio	>98%	-
Inverse time characteristics for steps 1 and 2, see table 78	-	See table 78
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Definite time delays, step 2	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time, inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	40 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 40. Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1	(1-200)% of *UBase*	± 0.5% of U_r at $U < U_r$ ± 0.5% of U at $U > U_r$
Operate voltage, step 2	(1-100)% of *UBase*	± 0.5% of U_r at $U < U_r$ ± 0.5% of U at $U > U_r$
Reset ratio	> 95%	-
Inverse time characteristics for low and high step, see table 78	-	See table 78
Definite time setting, step 1	(0.00-6000.00) s	± 0.5% ± 25 ms
Definite time setting, step 2	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time for step 1 inverse characteristic	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	40 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 1.2 xU_{set}	-
Impulse margin time	15 ms typically	-

Table 41. Loss of voltage check LOVPTUV

Function	Range or value	Accuracy
Operate voltage	(5-100)% of UBase	± 0.5% of U_r
Reset ratio	<105%	-
Pulse timer	(0.050-60.000) s	± 0.5% ± 25 ms
Timers	(0.000-60.000) s	± 0.5% ± 25 ms

Frequency protection

Table 42. Under frequency protection SAPTUF

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz
Operate value, restore frequency	(45 - 65) Hz	± 2.0 mHz
Reset ratio	<1.001	-
Operate time, start function	At 50 Hz: 200 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz At 60 Hz: 170 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz	-
Reset time, start function	At 50 Hz: 60 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 50 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Operate time delay	(0.000-60.000)s	<250 ms
Restore time delay	(0.000-60.000)s	<150 ms

Table 43. Overfrequency protection SAPTOF

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz at symmetrical three-phase voltage
Reset ratio	>0.999	-
Operate time, start function	At 50 Hz: 200 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 170 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Reset time, start function	At 50 and 60 Hz: 55 ms typically at f_{set} +0.5 Hz to f_{set}-0.5 Hz	-
Timer	(0.000-60.000)s	<250 ms

Table 44. Rate-of-change frequency protection SAPFRC

Function	Range or value	Accuracy
Operate value, start function	(-10.00-10.00) Hz/s	± 10.0 mHz/s
Operate value, restore enable frequency	(45.00 - 65.00) Hz	± 2.0 mHz
Timers	(0.000 - 60.000) s	<130 ms
Operate time, start function	At 50 Hz: 100 ms typically At 60 Hz: 80 ms typically	-

Secondary system supervision

Table 45. Current circuit supervision CCSRDIF

Function	Range or value	Accuracy
Operate current	(5-200)% of I_r	± 10.0% of I_r at $I \leq I_r$ ± 10.0% of I at $I > I_r$
Block current	(5-500)% of I_r	± 5.0% of I_r at $I \leq I_r$ ± 5.0% of I at $I > I_r$

Table 46. Fuse failure supervision SDDRFUF

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	± 1.0% of U_r
Operate current, zero sequence	(1-100)% of IBase	± 1.0% of I_r
Operate voltage, negative sequence	(1-100)% of UBase	± 0.5% of U_r
Operate current, negative sequence	(1-100)% of IBase	± 1.0% of I_r
Operate voltage change level	(1-100)% of UBase	± 5.0% of U_r
Operate current change level	(1-100)% of IBase	± 5.0% of I_r
Operate phase voltage	(1-100)% of UBase	± 0.5% of U_r
Operate phase current	(1-100)% of IBase	± 1.0% of I_r
Operate phase dead line voltage	(1-100)% of UBase	± 0.5% of U_r
Operate phase dead line current	(1-100)% of IBase	± 1.0% of I_r

Table 47. Breaker close/trip circuit monitoring TCSSCBR

Function	Range or value	Accuracy
Operate time delay	(0.020 - 300.000) s	± 0.5% ± 110 ms

Control

Table 48. Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, $\phi_{line} - \phi_{bus}$	(-180 to 180) degrees	-
Voltage ratio, U_{bus}/U_{line}	0.500 - 2.000	-
Reset ratio, synchrocheck	> 95%	-
Frequency difference limit between bus and line for synchrocheck	(0.003-1.000) Hz	± 2.0 mHz
Phase angle difference limit between bus and line for synchrocheck	(5.0-90.0) degrees	± 2.0 degrees
Voltage difference limit between bus and line for synchronizing and synchrocheck	0.03-0.50 p.u	± 0.5% of U_r
Time delay output for synchrocheck	(0.000-60.000) s	± 0.5% ± 25 ms
Frequency difference minimum limit for synchronizing	(0.003-0.250) Hz	± 2.0 mHz
Frequency difference maximum limit for synchronizing	(0.050-0.500) Hz	± 2.0 mHz
Maximum allowed frequency rate of change	(0.000-0.500) Hz/s	± 10.0 mHz/s
Closing time of the breaker	(0.000-60.000) s	± 0.5% ± 25 ms
Breaker closing pulse duration	(0.050-60.000) s	± 0.5% ± 25 ms
MaxSynch, which resets synchronizing function if no close has been made before set time	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum time to accept synchronizing conditions	(0.000-60.000) s	± 0.5% ± 25 ms
Time delay output for energizing check	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time for synchrocheck function	40 ms typically	-
Operate time for energizing function	100 ms typically	-

Table 49. Autorecloser for 3-phase operation SMBRREC

Function	Range or value	Accuracy
Number of autoreclosing shots	1 - 5	-
Autoreclosing open time: shot 1 - t1 3Ph	(0.000-60.000) s	± 0.5% ± 25 ms
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) s	
Autorecloser maximum wait time for sync	(0.00-6000.00) s	
Maximum trip pulse duration	(0.000-60.000) s	
Inhibit reset time	(0.000-60.000) s	
Reclaim time	(0.00-6000.00) s	
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	
CB check time before unsuccessful	(0.00-6000.00) s	
Wait for master release	(0.00-6000.00) s	
Wait time after close command before proceeding to next shot	(0.000-60.000) s	

Table 50. Autorecloser for 1/3-phase operation STBRREC

Function	Range or value	Accuracy
Number of autoreclosing shots	1-5	-
Autoreclosing open time: Shot 1 - t1 3Ph Shot 1 - t1 1Ph	(0.000-60.000) s	± 0.5% ± 25 ms
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) s	
Autorecloser maximum wait time for sync	(0.00-6000.00) s	
Open time extension for long trip time	(0.000-60.000) s	
Maximum trip pulse duration	(0.000-60.000) s	
Inhibit reset time	(0.000-60.000) s	
Reclaim time	(0.00-6000.00) s	
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	
CB check time before unsuccessful	(0.00-6000.00) s	
Wait for master release	(0.00-6000.00) s	
Wait time after close command before proceeding to next shot	(0.000-60.000) s	

Logic

Table 51. Tripping logic common 3-phase output SMPPTRC

Function	Range or value	Accuracy
Trip action	3-ph	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 52. Tripping logic phase segregated output SFTPTRC

Function	Range or value	Accuracy
Trip action	3-Ph, 1/3-Ph	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 53. Configurable logic blocks

Logic block	Quantity with cycle time			Range or value	Accuracy
	5 ms	20 ms	100 ms		
AND	60	60	160	-	-
OR	60	60	160	-	-
XOR	10	10	20	-	-
INVERTER	30	30	60	-	-
SRMEMORY	10	10	20	-	-
RSMEMORY	10	10	20	-	-
GATE	10	10	20	-	-
PULSETIMER	10	10	20	(0.000-60000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
TIMERSET	10	10	20	(0.000-90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
LOOPDELAY	10	10	20		

Table 54. Configurable logic Q/T

Logic block	Quantity with cycle time		Range or value	Accuracy
	20 ms	100 ms		
ANDQT	20	100	-	-
ORQT	20	100	-	-
XORQT	10	30	-	-
INVERTERQT	20	100	-	-
RSMEMORYQT	10	30	-	-
SRMEMORYQT	15	10	-	-
PULSETIMERQT	10	30	(0.000-90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
TIMERSETQT	10	30	(0.000-90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
INVALIDQT	5	6	-	-
FXDSIGSPQT	15	10	-	-
INDEXTSPQT	15	10	-	-

Table 55. Elapsed time integrator with limit transgression and overflow supervision TEIGGIO

Function	Cycle time (ms)	Range or value	Accuracy
Elapsed time integrator	5	0 – 999999.9 s	±0.05% or ±0.01 s
	20	0 – 999999.9 s	±0.05% or ±0.04 s
	100	0 – 999999.9 s	±0.05% or ±0.2 s

Monitoring

Table 58. Technical data covering measurement functions: CVMMXN, CMMXU, VMMXU, CMSQI, VMSQI, VNMMXU

Function	Range or value	Accuracy
Voltage	(0.1–1.5) x U_n	± 0.5% of U_n at $U \leq U_n$ ± 0.5% of U at $U > U_n$
Connected current	(0.2–4.0) x I_n	± 0.5% of I_n at $I \leq I_n$ ± 0.5% of I at $I > I_n$
Active power, P	0.1 x U_n < U < 1.5 x U_n 0.2 x I_n < I < 4.0 x I_n	± 1.0% of S_n at $S \leq S_n$ ± 1.0% of S at $S > S_n$
Reactive power, Q	0.1 x U_n < U < 1.5 x U_n 0.2 x I_n < I < 4.0 x I_n	± 1.0% of S_n at $S \leq S_n$ ± 1.0% of S at $S > S_n$
Apparent power, S	0.1 x U_n < U < 1.5 x U_n 0.2 x I_n < I < 4.0 x I_n	± 1.0% of S_n at $S \leq S_n$ ± 1.0% of S at $S > S_n$
Apparent power, S Three phase settings	cos phi = 1	± 0.5% of S at $S > S_n$ ± 0.5% of S_n at $S \leq S_n$
Power factor, cos (φ)	0.1 x U_n < U < 1.5 x U_n 0.2 x I_n < I < 4.0 x I_n	< 0.02

Table 57. Event counter CNTGGIO

Function	Range or value	Accuracy
Counter value	0-100000	-
Max. count up speed	10 pulses/s (50% duty cycle)	-

Table 58. Limit counter L4UFCNT

Function	Range or value	Accuracy
Counter value	0-65535	-
Max. count up speed	5-150 pulses/s	-

Table 59. Disturbance report DRPRDRE

Function	Range or value	Accuracy
Current recording	-	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Voltage recording	-	± 1.0% of U_r at $U \leq U_r$ ± 1.0% of U at $U > U_r$
Pre-fault time	(0.05–3.00) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–8.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See time synchronization technical data
Maximum number of analog inputs	30 + 10 (external + internally derived)	-
Maximum number of binary inputs	96	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	96	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 60. Event list DRPRDRE

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 61. Indications DRPRDRE

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100

Table 62. Event recorder DRPRDRE

Function		Value
Buffer capacity	Maximum number of events in disturbance report	150
	Maximum number of disturbance reports	100
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 63. Trip value recorder DRPRDRE

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	100

Table 64. Disturbance recorder DRPRDRE

Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of binary inputs	96
	Maximum number of disturbance reports	100
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)		340 seconds (100 recordings) at 50 Hz 280 seconds (80 recordings) at 60 Hz

Table 65. Station battery supervision SPVNZBAT

Function	Range or value	Accuracy
Lower limit for the battery terminal voltage	(60-140) % of UBat	± 1.0% of set battery voltage
Reset ratio, lower limit	<105 %	-
Upper limit for the battery terminal voltage	(60-140) % of UBat	± 1.0% of set battery voltage
Reset ratio, upper limit	>95 %	-
Timers	(0.000-60.000) s	± 0.5% ± 110 ms
Battery rated voltage	20-250 V	-

Table 66. Insulation gas monitoring function SSIMG

Function	Range or value	Accuracy
Timers	(0.000-60.000) s	± 0.5% ± 110 ms

Table 67. Insulation liquid monitoring function SSIML

Function	Range or value	Accuracy
Timers	(0.000-60.000) s	± 0.5% ± 110 ms

Table 68. Circuit breaker condition monitoring SSCBR

Function	Range or value	Accuracy
Alarm levels for open and close travel time	(0-200) ms	± 0.5% ± 25 ms
Alarm levels for number of operations	(0 - 9999)	-
Setting of alarm for spring charging time	(0.00-60.00) s	± 0.5% ± 25 ms
Time delay for gas pressure alarm	(0.00-60.00) s	± 0.5% ± 25 ms
Time delay for gas pressure lockout	(0.00-60.00) s	± 0.5% ± 25 ms

Metering

Table 69. Pulse counter PCGGIO

Function	Setting range	Accuracy
Cycle time for report of counter value	(1–3600) s	-

Table 70. Function for energy calculation and demand handling ETPMMTR

Function	Range or value	Accuracy
Energy metering	MWh Export/Import, MVArh Export/Import	Input from MMXU. No extra error at steady load

19. Ordering for Configured IED

Guidelines
Carefully read and follow the set of rules to ensure order management.
Please refer to the available functions table for included application functions.

To obtain the complete ordering code, please combine code from the tables, as given in the example below.

Example code: REQ650*1.3-AS1X00-X00-B1X0-D-H-SA-E-SA3-AXXX-F. Using the code of each position #1-11 specified as REQ650*1-2 2-3-4 4-5-6-7 7-8-9 9-10 10-11 10-11

#	1	2	3	4	5	6	7	8	9	10	11
REQ650*											

	Position	
SOFTWARE	#1	Notes and Rules
Version number		
Version no	1.3	
Selection for position #1.	1.3	

Configuration alternatives	#2		Notes and Rules
Single breaker, 3-phase, 1 busbar	A01		
Single breaker, single phase, 1 busbar	A11		
Single breaker, single phase, 2 busbars	B11		
ACT configuration			
ABB standard configuration		X00	
Selection for position #2.		X00	

Software options	#3	Notes and Rules
No option	X00	
Selection for position #3	X00	

First HMI language	#4		Notes and Rules
English IEC	B1		
Selection for position #4.			
Additional HMI language		#4	
No second HMI language		X0	
Selection for position #4.	B1	X0	

Casing	#5	Notes and Rules
Rack casing, 3U 1/1 x 19"	D	
Selection for position #3.	D	

Mounting details	#6	Notes and Rules
No mounting kit included	X	
Rack mounting kit for 3U 1/1 x 19"	H	
Selection for position #6.		

ASB

Connection type for Power supply, Input/output and Communication modules	#7		Notes and Rules
Compression terminals	S		
Ringlug terminals	R		
Power supply			
Slot position:		PSM	
100-240V AC, 110-250V DC, 9BO, PSM03		A	
48-125V DC, 9BO, PSM02		B	
24-30V DC, 9BO, PSM01		C	
Selection for position #7.			

Human machine interface	#8	Notes and Rules
Local human machine interface LHMI01, OL6000, IEC 3U 1/1 x 19", Basic	E	
Selection for position #8.	E	

Connection type for Analog modules	#9		Notes and Rules
Compression terminals	S		
Ringlug terminals	R		
Analog system			
Slot position:		P1	
Transformer module TRM01, 4I, 1/5A+1I, 0.1/0.5A+5U, 100/220V		A3	
Selection for position #9.		A3	

Binary Input/output module	#10				Notes and Rules
Slot position (rear view)	P3	P4	P5	P6	
No board in slot		X	X	X	
Binary Input/output module BIO01, 9 BI, 3 NO Trip, 5 NO Signal, 1 CO Signal	A	A	A	A	p4, p5, p6 optional for A01 p4 basic, p5, p6 optional for A11,B11
Selection for position #10.	A				

Communication and processing module	#11	Notes and Rules
Slot position (rear view)	PCM	
12BI, IRIG-B, RS485, Ethernet, LC optical, ST serial	F	
Selection for position #11.	F	

ASB

20. Ordering for Accessories

Configuration and monitoring tools

Front connection cable between LCD-HMI and PC — Quantity: ☐ — 1MRK 001 665-CA

LED Label special paper A4, 1 pc — Quantity: ☐ — 1MRK 002 038-CA

LED Label special paper Letter, 1 pc — Quantity: ☐ — 1MRK 002 038-DA

Manuals

Note: One (1) IED Connect DVD containing User documentation
Operation manual
Technical manual
Installation manual
Commissioning manual
Application manual
Communication protocol manual, DNP3
Communication protocol manual, IEC 61850-8-1
Communication protocol manual, IEC 60870-5-103
Cyber security deployment guidelines
Type test certificate
Engineering manual
Point list manual, DNP3
Connectivity packages and LED label template is always included for each IED

Rule: Specify additional quantity of IED Connect DVD if needed

User documentation — Quantity: ☐ — 1MRK 003 500-AA

ASB

Rule: Specify the number of printed manuals requested

Operation manual	IEC	Quantity: ☐	1MRK 500 096-UEN
Technical manual	IEC	Quantity: ☐	1MRK 505 292-UEN
Commissioning manual	IEC	Quantity: ☐	1MRK 505 293-UEN
Application manual	IEC	Quantity: ☐	1MRK 505 291-UEN
Communication protocol manual, DNP3	IEC	Quantity: ☐	1MRK 511 280-UEN
Communication protocol manual, IEC 61850-8-1	IEC	Quantity: ☐	1MRK 511 281-UEN
Communication protocol manual, IEC 60870-5-103	IEC	Quantity: ☐	1MRK 511 282-UEN
Engineering manual	IEC	Quantity: ☐	1MRK 511 284-UEN
Installation manual	IEC	Quantity: ☐	1MRK 514 016-UEN
Point list manual, DNP3	IEC	Quantity: ☐	1MRK 511 283-UEN
Cyber Security deployment guidelines	IEC	Quantity: ☐	1MRK 511 285-UEN

Reference information

For our reference and statistics we would be pleased to be provided with the following application data:

Country: — End user:

Station name: — Voltage level: kV

ASB

Breaker protection REC650	1MRK 505 294-BEN A
Product version: 1.3	

Related documents

Documents related to REC650	Identity number
Application manual	1MRK 505 291-UEN
Technical manual	1MRK 505 292-UEN
Commissioning manual	1MRK 505 293-UEN
Product Guide	1MRK 505 294-BEN
Type test certificate	1MRK 505 294-TEN
Application notes for Circuit Breaker Control	1MRG006806
650 series manuals	**Identity number**
Communication protocol manual, DNP 3.0	1MRK 511 280-UEN
Communication protocol manual, IEC 61850-8-1	1MRK 511 281-UEN
Communication protocol manual, IEC 60870-5-103	1MRK 511 282-UEN
Cyber Security deployment guidelines	1MRK 511 285-UEN
Point list manual, DNP 3.0	1MRK 511 283-UEN
Engineering manual	1MRK 511 284-UEN
Operation manual	1MRK 500 095-UEN
Installation manual	1MRK 514 016-UEN
Accessories, 650 series	1MRK 513 023-BEN
IMCS	1MRG 010 656
PICS	1MRG 010 660
POTT	1MRG 010 638

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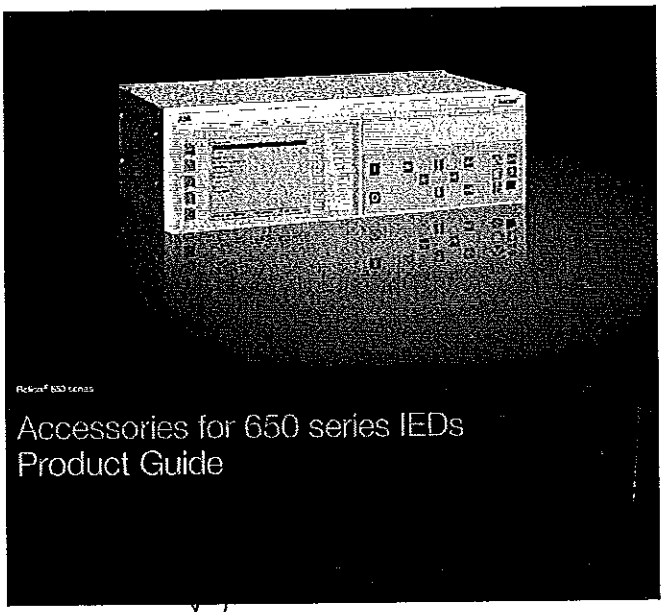
ВЯРНО С ОРИГИНАЛА

ЕЛЕКТРИКСИТИ ООД София

Power and productivity for a better world™ ABB



Relion® 650 series

Accessories for 650 series IEDs
Product Guide

Contents

Power and productivity for a better world™ ABB

1. Available accessories

Mounting kits
- Mounting kits for space-saving mounting in racks and cubicles and on walls

RHGS cases
- RHGS 6, RHGS 12 and RHGS 30 cases enable mounting of for example Combiflex modules

Test switch module
- Fail-safe testing of IEDs, using test switch RTXP 24
- Time saving while
  - all connections for test are made from the front
  - easy to move between IEDs of the same type

Combiflex modules
- Provide functionality such as lock-out, lock-out reset and external contact re-enforcement
- Supervision

Key switch for settings
- Possibility to lock settings with key switch

Connectors
- Flexible connection of analog and binary signals
  - Screw compression type
  - Terminal blocks suitable for ring-lugs

External resistor unit
- Used with the High impedance differential protection

Injection equipment hardware RXTTE4
- Used with the rotor earth fault protection to inject voltage and current signals to the generator or motor

ESD Field Kit
- Used to make work ESD safe

Power Supply
- Used to supply power to the IED

Configuration and monitoring tools
- Protection and control manager, PCM600, used to
  - configure the IED
  - set parameters
  - monitor the IED and the system
  - visualize and evaluate disturbance recordings

Cable and dust cover
- The cable is used to connect a PC to the RJ45 port on the local human machine interface
- The dust cover protects the RJ45 port

Labels
- Used to label the LEDs

2. Mounting kit for 3U

19" rack mounting for a single IED
Use the 19" rack mounting kit to mount the IED in a standard rack.

The 19" rack mounting kit for 3U housing consists of two mounting brackets with appropriate mounting details for fastening to the case.

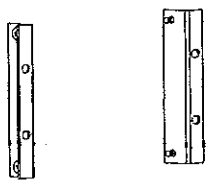


Figure 1. 19" rack mounting panels for 3U housing

3. Mounting kits for 6U

19" rack mounting for a single IED
Use the 19" rack mounting kit for 6U housing to mount the IED in a standard rack.

The 19" rack mounting kit consists of two mounting brackets with appropriate mounting details for fastening to the case.

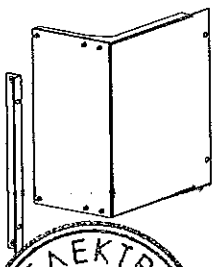


Figure 2. 19" rack mounting panels for 6U housing

Flush mounting
Use the flush mount kit for installation in a panel cut out.

The flush mounting kit for one 6U half 19" housing IED consists of a mounting frame and appropriate mounting details.

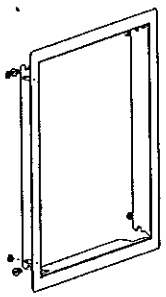


Figure 3. Flush mounting frame

Wall mounting
Use the wall mounting kit for one 6U half 19" housing IED to projection mount the IED on a wall.

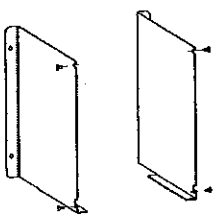


Figure 4. 6U wall mounting brackets

The wall mounting kit consists of an IED bracket pair. Screws and washers for fastening of the brackets to the IED are included, but not wall fasteners.

Wall mounting of IED with detached LHMI display
Use the wall mounting kit for one 6U half 19" housing IED to wall mount the main unit with detached display. An optional cable for connecting to the detached display is not included in the kit.

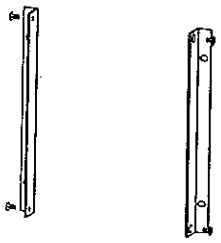


Figure 6. 6U main unit mounting brackets for IED with detached LHMI display

The wall mounting kit consists of an IED bracket pair. Screws and washers for fastening of the brackets to the IED are included, but not wall fasteners.

Rack mounting kit for two IEDs
Use the rack mounting kit to mount two IEDs next to each other.

The rack mounting kit for two 6U half 19" housing IEDs consists of upper mounting bracket, right mounting bracket, lower mounting bracket, left mounting bracket, middle mounting brackets and appropriate screws. The side-by-side mounted units are mounted in a rack or cubicle.

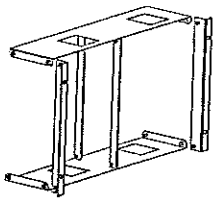


Figure 5. 19" rack mounting kit for two IEDs

Mounting kit for a RHGS 6 case next to an IED
Use the mounting kit to mount a RHGS 6 case next to one 6U half 19" housing IED.

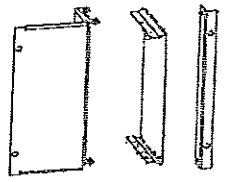


Figure 7. 6U 1/2 19" housing + RHGS 6 mounting brackets

The mounting kit for mounting a RHGS 6 case next to a 19" housing IED consists of right mounting bracket, middle mounting bracket and left mounting bracket. The side-by-side mounted units are mounted in a rack or cubicle. Screws and washers for fastening of the brackets to the IED are included, but not wall fasteners.

4. RHGS cases

RHGS Cases
Color matched (RAL7035) RHGS cases can be used to mount for example Combiflex modules together with 650 series.See section "Related documents" for reference to more detailed information about dimensions and mounting details for RHGS cases. Please observe that cases in referenced document has a different color.

5. Test switch module

General
The test switch module consists of a RHGS 6 case with a test switch, RTXP 24, and a two-seat Combiflex terminal base mounted. An optional DC-switch occupies one seat if selected.

All connections to the test switch module are made with Combiflex socket leads. Test contacts 1-24 of the test switch have 20 A Combiflex terminals. The signal contact of the test switch and the Combiflex terminal base have 10 A terminals.

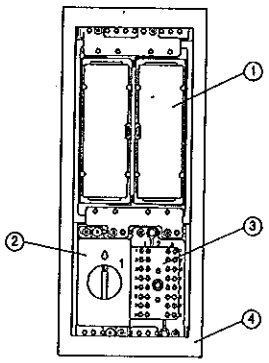
Two versions of the test switch module are available for use with:

- 3U IEDs
- 6U IEDs

The 3U version includes a test switch module and mounting details for 19" rack mounting over or under the IED.

The 6U version includes a test switch module and mounting details for 19" rack mounting of the test switch module side by side with a 6U 1/2 x 19" housing IED.

For more details about the Combitest system and Combiflex system see section "Related documents".



1 Test switch
2 DC switch
3 Spare seat, can be used for Key switch
4 RHGS 6 case

Figure 8. Example of a test switch module

Test switch
The test switch, RTXP 24, is used to make it possible to test an IED in a failsafe way. Inserting a test-plug handle into the test switch automatically makes all preparations for test in the proper sequence. Blocked trip circuits, shortcircuited CT:s, opened voltage circuits makes the IED terminals available for secondary injection test.

DC-switch
The DC-switch is optional in the test switch module and are used to switch the DC-supply of the IED ON/OFF.

The DC-switch is of one seat Combiflex type and needs a Combiflex terminal base to be mounted.

6. Key switch for settings
The key switch for lock-out of settings via the local human machine interface is used to prevent unwanted changes of settings. The switch locks the settings via a binary input.

The key switch is of one seat Combiflex type. To install it, a case including a Combiflex terminal base is needed. One possibility is to install the key switch in the same case as the test switch.

7. Combiflex modules

Auxiliary relays
Auxiliary relays can be used together with the IED to provide functionality such as lock-out, lock-out reset or external contact re-enforcement.

When the contact rating of the IED is insufficient, it is recommended to use RXME 1 as a contact re-enforcement. The RXME 1 is then activated from an IED contact which is set up to be activated together with the IED contacts tripping the breaker. The contact of the RXME 1 is connected in parallel, to take over the breaker trip coil current. This gives an efficient solution and means no time delay at tripping. See figure 9.

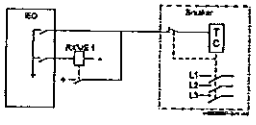


Figure 9. RXME 1 used as a trip contact re-enforcement

When single pole tripping is used one RXME 1 is required per phase and of course per subsystem in redundant systems.

Lock-out can be arranged with RXMD 1 remanence relay activated from binary outputs on IED and possible other protection relays required to activate lock-out, see figure 10. The contact of RXMD 1 is connected to open the closing circuit to the breaker closing coil. Another contact can be used to light-up a lamp push button to have indication of the lock-out and then reset with the push-button. It is recommended to avoid trip contact latching as this will mean problem for example with trip circuit supervision and further at failing breaker, mean that the trip coil is burnt and the trip coil DC supply is tripped. The most important is to prevent that the breaker is closed at persistent faults.

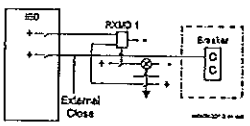


Figure 10. Lock-out using a RXMD 1 relay

For ordering codes see section "Related documents" for reference to more detailed information.

Figure 11. RXME 1 and RXMD 1 relays

Push button and selector switch
The push button is available with or without pilot lamp and with one or two buttons. It is used to reset the lock-out relays when an external independent lock-out and lock-out indications is required. The push button unit can also be used as a local selector of Auto-Reclose operation when this is required to be done locally as well as through communication.

The selector switch is available with two or three fixed positions and with different contact combinations. The selector switch can e.g. be used as Local/Remote selector or as a local selector of Auto-Reclose operation. See section "Related documents" for reference to more detailed information.

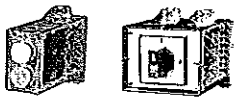


Figure 12. Push button and selector switch

Supervision relay
The relay RXEM1 can be used to detect for example loss of DC voltage supply or to detect open circuits. A typical application is continuous supervision of a circuit breaker trip circuit, including the breaker coil. See section "Related documents" for reference to more detailed information.

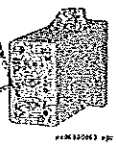


Figure 13. Supervision relay RXEM1

8. Connectors
The connectors are used for analog signals and binary in- and output signals.

Connectors for analog signals
The connectors have an automatic short-circuit mechanism for the current terminals. Therefore, detaching the connector from the unit will not open the secondary circuit of the CT which otherwise could cause dangerously high voltages.

Screw compression type
Each terminal for CTs/VTs is dimensioned for one 0.5... 6.0 mm² wire or for two wires of maximum 2.5 mm².

To help connecting the current and voltage inputs, the connector pair is marked with symbols. For a current input, the connector pair forms a circle. In the case of a voltage input, the connector pair forms two half-circles.

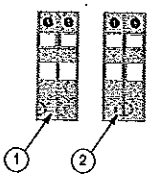


Figure 14. CT/VT connector symbols

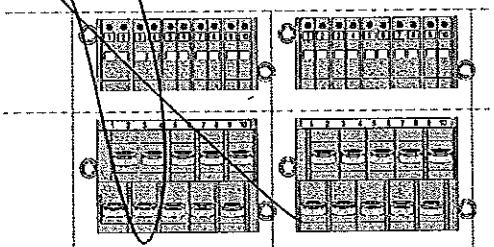
1 VT symbol
2 CT symbol

Ring-lug type
The maximum outside diameter for the M4 ring-lug type analog input terminals is 9 mm.

See the connection diagrams for information on the analog input module variant included in a particular configured IED.

Overview Analog input connectors

Table 1. Overview Analog input connectors – Transformer – AIM/TRM-variant



Terminal	1–2	3–4	5–6	7–8	9–10	1–2	3–4	5–6	7–8	9–10
Transformer	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10

TRM/AIM Variant										
4I+1I / 5I	CT	CT	CT	CT	CTs	VT	VT	VT	VT	VT
Screw compression	1KHL380065R0001					1KHL380066R0001				
Ring-lug	1KHL380065R0002					1KHL380066R0002				

6I / 4U	CT	CT	CT	CT	CT	CT	VT	VT	VT	VT
Screw compression	1KHL380065R0001					1KHL380062R0001				
Ring-lug	1KHL380065R0002					1KHL380062R0002				

6I / 2U 1)	CT	CT	CT	CT	CT	CT	CT	CT	VT	VT
Screw compression	1KHL380065R0001					1KHL380063R0001				
Ring-lug	1KHL380065R0002					1KHL380063R0002				

4I / 6U 1)	CT	CT	CT	CT	VT	VT	VT	VT	VT	VT
Screw compression	1KHL380064R0001					1KHL380068R0001				
Ring-lug	1KHL380064R0002					1KHL380068R0002				

CTs : Current Transducer (Sensitive) for 0,1 A / 0,5 A
1) TRM only

Connectors for binary signals
Screw compression type

Each signal connector terminal is connected with one 0.5...2.5 mm² wire or with two 0.5...1.0 mm² wires.

18 terminals 16 terminals 3 terminals

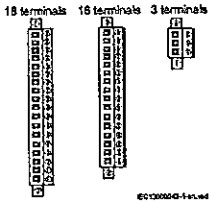


Figure 15. Signal connectors, screw compression type

Use the ferrules to connect two wires to the same terminal point of a connector of screw compression type. Note that 1.5 mm² is the maximum dimension allowed on these wires. A special crimping tool from Phoenix is needed to apply the Phoenix ferrule to the wires. Use the bridge connector to jumper terminal points in a connector.

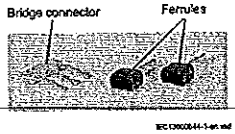


Figure 16.

9. External resistor unit

External resistor unit
The high impedance resistor unit is used with the high impedance differential protection. It is available as one phase unit or three phase unit.

Ring-lug type
Use ring-lugs to connect the wire to terminal points of a connector of ring-lug type. Select ring-lugs suitable to wiring dimension and size of terminal point.

The maximum outside diameter for the M3 ring-lug type signal terminals is 8 mm.

18 terminals 16 terminals 3 terminals

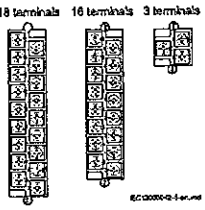


Figure 17. Signal connectors, ring-lug type

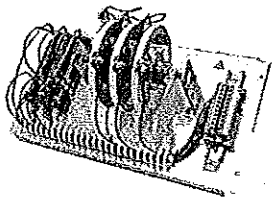


Figure 18. High impedance resistor unit, three phase

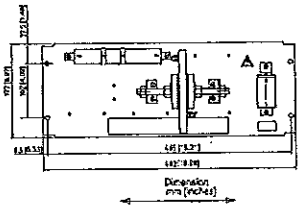


Figure 19. Dimension drawing of a one phase high impedance resistor unit

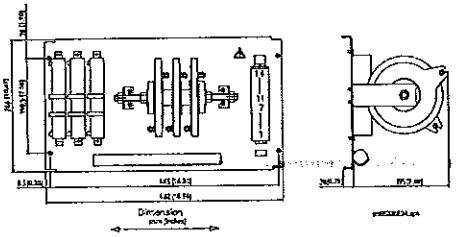


Figure 20. Dimension drawing of a three phase high impedance resistor unit

WARNING! USE EXTREME CAUTION!
Dangerously high voltages might be present on this equipment, especially on the plate with resistors. Do any maintenance ONLY if the primary object protected with this equipment is de-energized. If required by national law or standard, enclose the plate with resistors with a protective cover or install in a separate box.

10. Voltage injection unit RXTTE4

Voltage injection unit RXTTE4
The COMBIFLEX voltage injection unit RXTTE4 is used for rotor earth fault protection applications. The RXTTE 4 contains a voltage transformer with a primary winding for connection to 120 or 230 V, 50 or 60 Hz supply voltage. From the secondary winding of this internal voltage transformer approximately 40 V AC is injected via series capacitors and resistors into the rotor circuit. The injected voltage and current are fed to one voltage input and one current input on the IED.

In order to mount injection unit RXTTE4 some COMBIFLEX accessories are required; RX4 terminal base, 10A and 20A contact sockets and Crimping tool. See section "Related documents" for more detailed information.

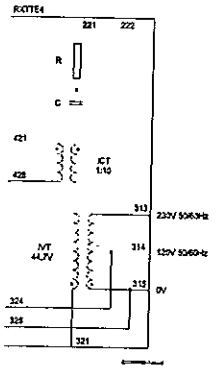


Figure 21. Voltage injection unit RXTTE4 with its main internal components

Rotor earth fault protection can be integrated in the IED among all other protection functions typically required for generator protection. How this is achieved by using COMBIFLEX injection unit RXTTE4 is described in Instruction 1MRS001910.

Table 2. Rotor earth fault protection based on Earth fault functions (SDEPSDE, EFSPTOC) and RXTTE4

Function	Range or value
For machines with:	
• rated field voltage up to	350 V DC
• static exciter with rated supply voltage up to	700 V 50/60 Hz
Supply voltage 120 or 230 V	50/60 Hz
Operate earth fault resistance value	Approx. 1–20 kΩ
Influence of harmonics in the DC field voltage	Negligible influence at 50 V, 150 Hz or 50 V, 300 Hz
Permitted leakage capacitance	(1–5) µF
Permitted shaft earthing resistance	Maximum 200 Ω
Protective resistor	220 Ω, 100 W, plate 135 x 160 mm

External resistor for RXTTE4
The external resistor is used when either there is a need to minimize physical exposure of the field circuit or when high harmonic content of the total injection current can cause overheating of the built-in RXTTE4 resistor. The external resistor is delivered mounted on an insulated plate with overall dimensions; Height = 160 mm, Width = 135 mm, suitable for wall mounting, see figure 22. It actually consists of two resistors (R1 and R2) which are on delivery connected in series. It is possible to order two different types of the external resistor. The first type (ordering number RK795102-AD) has exactly the same ohmic value of 220Ω as the internal RXTTE4 resistor. It shall be used in cases where only physical exposure of the field circuit shall be limited. The second type (ordering number RK795102-AB) has different ohmic value than internal RXTTE4 resistor. It shall be used in installations where current with high harmonic content is pushed back onto the RXTTE4 injection unit by the rotor circuit

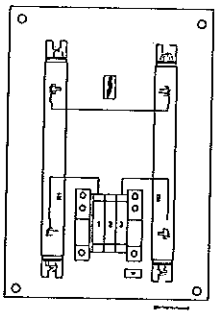
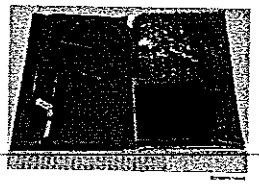


Figure 22. External resistor mounted on a plate

11. ESD Field Kit

Introduction
The ESD Field Kit provides a complete portable ESD safe workstation when working in the field.



12. Power Supply

Portable Power Supply
The portable Power Supply provides the IED with power. This can be used at education or demonstration of the IED.

Power Cable
For use with the portable Power Supply.

13. Configuration and monitoring tools

PCM600
Use PCM600 through all stages of a project, from engineering, configuring and parameter setting to testing, commissioning, documentation and maintenance. Use PCM600 to adjust the default configuration, or to make a new configuration. For more information about PCM600 visit www.abb.com/substationautomation.

14. Cable and dust cover

Front communication
The front connection cable is used to connect a PC to the RJ45 port on the local human machine interface. The cable is a standard crossed-over ethernet cable (RJ45 connectors).

Dust cover
The dust cover is used to protect the RJ45 connector on the local human machine interface.

15. Ordering

Mounting accessories

Name	For case size	Quantity	Article number
19" rack mounting kit for a single IED	3U		1KHL400332R0001
	6U		1KHL400235R0001
Wall mounting kit for one 6U half 19" housing IED	6U		1KHL400227R0001
Wall mounting kit for one 6U half 19" housing IED main unit with detached display	6U		1KHL400317R0001
Flush mounting kit for one 6U half 19" housing IED	6U		1KHL400228R0001
Rack mounting kit for two 6U half 19" housing IEDs	6U		1KHL400240R0001
Mounting kit for a RHGS 6 rack to one 6U half 19" housing IED	6U		1MRK002420-GA

Note: All kits are complete including screws for attaching the mounting details to the IED

Optional cables for detached display module (only for 6U versions)

	Quantity	Article number
LHMI cable (1m)		1KHL380031R0100
LHMI cable (2m)		1KHL380031R0200
LHMI cable (3m)		1KHL380031R0300
LHMI cable (4m)		1KHL380031R0400
LHMI cable (5m)		1KHL380031R0500

RHGS Cases

	Quantity	Article number
RHGS 6 with door, size 6U x 1/4, color RAL 7035		1MRK 000 315- AG
RHGS 12 with door, size 6U x 1/2, color RAL 7035		1MRK 000 315- BH
RHGS 19 with door, size 6U x 1/1, color RAL 7035		1MRK 000 315- BB

Test switch module
Selection of a RTXP test switch for each ordered test switch module is required. See Selection guide for recommendations. Please refer to section "Related documents".

	Quantity	Article number
Test switch module RTXP 24 for 3U		1MRK 000 371-HA
Test switch module RTXP 24 for 6U		1MRK 000 371-GA

Selection guide

Product	Product version	Variant	Analog configuration TRM	AIM	Type of earthing		Article number
REB 650	ALL	A03	6I + 4U	6I + 4U	Internal neutral	☐	RK 926 315-CA
REC 650	ALL	A01	5I + 5U	-	Internal neutral	☐	RK 926 315-AF
					External neutral	☐	RK 926 315-AY
	ALL	A02	5I + 5U	-	Internal neutral	☐	RK 926 315-AF
					External neutral	☐	RK 926 315-AY
	1.0 and 1.1	A07	6I + 4U		Internal neutral	☐	RK 926 315-CP
					External neutral	☐	RK 926 315-CD
	1.2 and 1.3	A07	6I + 5U	-	Internal neutral	☐	RK 926 315-BB
					External neutral	☐	RK 926 315-AW
REQ 650	ALL	B01	5I + 5U	6I + 4U	Internal neutral	☐	RK 926 315-BX
	ALL	B05	5I + 5U	6I + 4U	External neutral	☐	RK 926 315-BX
REL 650	ALL	A01	5I + 5U	-	Internal neutral	☐	RK 926 315-AF
					External neutral	☐	RK 926 315-AY
	1.0 and 1.1	A05	5I + 5U	-	Internal neutral	☐	RK 926 315-AF
					External neutral	☐	RK 926 315-AY
	ALL	A11	5I + 5U	-	Internal neutral	☐	RK 926 315-AF
					External neutral	☐	RK 926 315-AY
	1.2 and 1.3	B01	5I + 5U	5I + 5U	Internal neutral	☐	RK 926 315-AM
					External neutral 1)	☐	RK 926 315-DB

Product	Product version	Variant	Analog configuration TRM	AIM	Type of earthing		Article number
REQ 650	ALL	A01	5I + 5U	-	Internal neutral	☐	RK 926 315-AF
					External neutral	☐	RK 926 315-AY
	ALL	A11	5I + 5U	-	Internal neutral	☐	RK 926 315-AF
					External neutral	☐	RK 926 315-AY
	ALL	B11	5I + 5U	-	Internal neutral	☐	RK 926 315-AF
					External neutral	☐	RK 926 315-AY
RET 650	ALL	A01	5I + 2U	-	Internal neutral	☐	RK 926 315-BD
	ALL	A05	6I + 4U	6I + 4U	Internal neutral	☐	RK 926 315-CZ
	ALL	A07	6I + 4U	-	Internal neutral	☐	RK 926 315-CP

1) Note: With this solution there are no test points on the test switch for trip commands. Separate test switch for just binary signals of type RK 926 315-AS can be added if required.

On/off switch for the DC-supply — Quantity: ☐ RK 795 017-AA

Labels with symbols for RTXP 24 — Quantity: ☐ 1MRK 000 132-53

Note: Leads with 20 A Combiflex socket on one end and insulation stripped on the other end must be used to connect the test switch to the terminal. To connect the signal contact of the test switch and the DC switch, leads with 10 A Combiflex socket on one end must be used.

Key switch for settings

Key switch for lock-out of settings via LCD-HMI — Quantity: ☐ 1MRK 000 611-A

Note: To connect the key switch, leads with 10 A Combiflex socket on one end must be used.

Combiflex modules

Auxiliary relays	See related documents
Push button and selector switch	See related documents
Supervision relay	See related documents

Connectors

Screw compression type

Analog input connector	1I+4U, 1 pc	Quantity: ☐	1KHL380062R0001
Analog input connector	3I+2U, 1 pc	Quantity: ☐	1KHL380063R0001
Analog input connector	4I+1U, 1 pc	Quantity: ☐	1KHL380064R0001
Analog input connector	5U, 1 pc	Quantity: ☐	1KHL380066R0001
Analog input connector	5I, 1 pc	Quantity: ☐	1KHL380065R0001
Signal connector	18 terminals, 1 pc	Quantity: ☐	1KHL380052R0001
Signal connector	18 terminals, 1 pc	Quantity: ☐	1KHL380053R0001
Signal connector	3 terminals, 1 pc	Quantity: ☐	1KHL380033R0001
Bridge connector	For 2 terminals, 1 pc	Quantity: ☐	1MKC 840 002-1
Bridge connector	For 3 terminals, 1 pc	Quantity: ☐	1MKC 840 002-2
Bridge connector	For 4 terminals, 1 pc	Quantity: ☐	1MKC 840 002-3
Ferrule	For 2 x 1.5 mm² conductors in screw compression terminal, 1 pc	Quantity: ☐	1MKC 840 003-4

Ring-lug type

Analog input connector	1I+4U, 1 pc	Quantity: ☐	1KHL380062R0002
Analog input connector	3I+2U, 1 pc	Quantity: ☐	1KHL380063R0002
Analog input connector	4I+1U, 1 pc	Quantity: ☐	1KHL380064R0002
Analog input connector	5U, 1 pc	Quantity: ☐	1KHL380066R0002
Analog input connector	5I, 1 pc	Quantity: ☐	1KHL380065R0002
Signal connector	18 terminals, 1 pc	Quantity: ☐	1KHL380051R0001
Signal connector	18 terminals, 1 pc	Quantity: ☐	1KHL380057R0001
Signal connector	3 terminals, 1 pc	Quantity: ☐	1KHL380055R0001

External resistor unit

High impedance resistor unit 1-ph with resistor and voltage dependent resistor for 20-100V operating voltage	Quantity: ☐	RK 795 101-MA
High impedance resistor unit 3-ph with resistor and voltage dependent resistor for 20-100V operating voltage	Quantity: ☐	RK 795 101-MB
High impedance resistor unit 1-ph with resistor and voltage dependent resistor for 100-400V operating voltage	Quantity: ☐	RK 795 101-CB
High impedance resistor unit 3-ph with resistor and voltage dependent resistor for 100-400V operating voltage	Quantity: ☐	RK 795 101-DC

External interface units for Rotor earth fault protection

Injection unit for Rotor earth fault protection (RXTTE 4)	Quantity: ☐	1MRK 002 108-BA
Protective resistor on plate, R1 = 100 Ω, R2 = 120 Ω	Quantity: ☐	RK 795 102-AD
Protective resistor on plate, R1 = 560 Ω, R2 = 560 Ω	Quantity: ☐	RK 795 102-AB

ESD Field kit

ESD Field kit	Quantity: ☐	1MRK 001 938-A

Power Supply

Power Supply Unit Input voltage: 90-264 V~, 47-63 Hz Output voltage: 48 Vs Max. output current: 2,5 A Output power: 135 W max Switch frequency: 65 kHz	Quantity: ☐	1MRK 001 665-FA
Power Cable 2m	Quantity: ☐	1MRK 001 665-EA

Configuration and monitoring tools

PCM600	See related documents	

Labels

LED Label special paper A4, 1 pc	Quantity: ☐	1MRK 002 038-CA
LED Label special paper Letter, 1 pc	Quantity: ☐	1MRK 002 038-DA

Cable and dust cover

Front connection cable	Quantity: ☐	1MRK 001 665-CA
Dust cover LHMI (RJ45)	Quantity: ☐	1MKC 950 000-1

18. Related documents

Combiflex, connection and installation components	1MRK 513 003-BEN
Combitest	1MRK 512 001-BEN
Auxiliary, signalling and tripping relays	1MRK 508 018-BEN
Auxiliary relays	1MRK 508 006-BEN
Bistable relays	1MRK 508 017-BEN
Push button and selector switch	1MRK 513 018-BEN
Supervision relay	1MRK 508 024-BEN
PCM600	1MRS756448
REB650 Product guide	1MRK 505 290-BEN
REC650 Product guide	1MRK 511 239-BEN
REG650 Product guide	1MRK 502 050-BEN
REL650 Product guide	1MRK 506 337-BEN
RET650 Product guide	1MRK 504 137-BEN
REQ650 Product guide	1MRK 505 294-BEN
Rotor earth fault protection with injection unit RTXE4	1MRG001910

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Fax +46 (0) 21 14 69 18
www.abb.com/substationautomation

Power and productivity for a better world™ ABB

650 series configured product range
Summary – Product selections

Tender ID: 16Q2863109 Pos: 130

Country of End User	BG
End User – Utility	CEZ
Station Name	Borimechkata/Orion
Voltage Level – kV	110/20

IED code : RET650*1.3-A05X00-X00-B1X0-DH-SA-E-SA1B1-AA-F-
Product description : Transformer protection, RET650,A05,Single breaker, 3 winding

BASIC FUNCTIONS

for configuration alternative A05

1Ph High impedance differential protection (HZPDIF,87),2pcs
Automatic voltage control for tapchanger, parallel control (TR8ATCC,90),1pcs
Bay control (QCBAY),1pcs
Breaker close/trip circuit monitoring (TCSSCBR),3pcs
Breaker failure protection, 3-phase activation and output (CCRBRF,50BF),3pcs
Circuit breaker condition monitoring (SSCBR),3pcs
Circuit breaker for 3CB,1pcs
Configurable logic blocks ( ),1pcs
Directional Over-power protection (GOPPDOP,32),1pcs
Directional Under-power protection (GUPPDUP,37),1pcs
Disturbance report (DRPRDRE),1pcs
Four step phase overcurrent protection, 3-phase output (OC4PTOC,51_67),3pcs
Four step residual overcurrent protection, zero/negative sequence direction (EF4PTOC,51N_67N),3pcs
Function block for service values presentation of the analog inputs (AISVBAS),1pcs
Function for energy calculation and demand handling (ETPMMTR),3pcs
Handling of LR-switch positions (LOCREM),1pcs
Instantaneous phase overcurrent protection, 3-phase output (PHPIOC,50),3pcs
Instantaneous residual overcurrent protection (EFPIOC,50N),3pcs
Insulation gas monitoring function (SSIMG,63),2pcs
Insulation Liquid monitoring function (SSIML,71),2pcs
LHMI control of PSTO (LOCREMCTRL),1pcs
Measurements,1pcs
Negative sequence based overcurrent function (DNSPTOC,46),2pcs
Overexcitation protection (OEXPVPH,24),1pcs
Overfrequency protection (SAPTOF,81),4pcs
Pole discordance protection (CCRPLD,52PD),3pcs
Rate-of-change frequency protection (SAPFRC,81),2pcs
Restricted earth fault protection, low impedance (REFPDIF,87N),3pcs
Station battery supervision (SPVNZBAT),1pcs
Tap changer control and supervision, 6 binary inputs (TCMYLTC,84),1pcs
Thermal overload protection, two time constants (TRPTTR,49),3pcs
Transformer differential protection, three winding (T3WPDIF,87T),1pcs
Tripping logic, common 3-phase output (SMPPTRC,94),3pcs
Two step overvoltage protection (OV2PTOV,59),1pcs
Two step residual overvoltage protection (ROV2PTOV,59N),1pcs
Two step undervoltage protection (UV2PTUV,27),1pcs
Underfrequency protection (SAPTUF,81),4pcs

ВЯРНО С ОРИГИНАЛА

ACT CONFIGURATION

ABB Standard configuration, X00

FUNCTION PACKAGES

Software options	No software options, X00
First HMI Language	HMI language, English IEC, B1
Additional HMI language	No second HMI language, X0

HARDWARE

Casing	Rack, 3U 1/1x19 inch, max 4 I/O+1 TRM or max 2 I/O+1 TRM and 1 AIM, D
Back plane module, pBPM – basic	BPM, 3U 1/1 x 19"
Mounting details	Rack mounting kit, 3U 1/1x19 inch case, H
Connection type for power supply, Input/Output and communication modules, pCONIO	Compression terminals, S
Power supply, pPSM	PSM03, 100-240V AC, 110-250V DC, 9BO, A
Human machine interface, pHMI	LHMI01, OL8000, IEC 3U 1/1 19", Basic, E
Connection type for analog modules, pCONAI	Compression terminals, S

Analog system slot P2/X101,X102	TRM01, 6I + 4U, 1/5A, 100/220V, A1
Analog system slot P4/X103,X104	AIM01, 6I + 4U, 1/5A, 100/220V, B1
Binary input/output module slot P5/X331,X334	BIO01, 9BI, 9BO, A
Binary input/output module slot P6/X336,X339	BIO01, 9BI, 9BO, A
Communication and processing module, pCOM	CPM COM05, 12BI, IRIG-B, RS485, Ethernet, LC optical, ST serial, F
User Documentation	IED Connect, containing user documentation

PRODUCT INFORMATION

Product Guide - Product guide, RET650 Ver.1.3

Data Sheet - Accessories, 650 series

ABB AB
Substation Automation Products
http://www.abb.com/substationautomation

ВЯРНО С ОРИГИНАЛА

ЕЛЕКТРИКСИТИ ЕООД СОФИЯ

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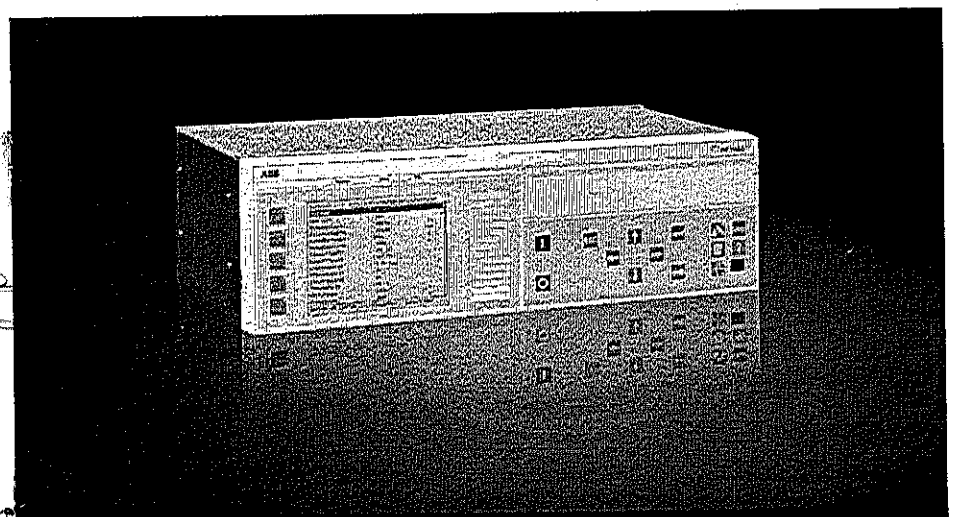


Relion® 650 series

Transformer protection RET650
Product Guide

Power and productivity for a better world™

ABB

Contents

1. 650 series overview

Protection for a wide range of applications, control of switching devices with interlocking, and monitoring can be provided in one IED.

The 650 series IEDs provide both customized and configured solutions. With the customized IEDs you have the freedom to completely adapt the functionality according to your needs.

The 650 series IEDs provide optimum 'off-the-shelf', ready-to-use solutions. It is configured with complete protection functionality and default parameters to meet the needs of a wide range of applications for generation, transmission and sub-transmission grids.

The 650 series IEDs include:

- Customized versions providing the possibility to adapt the functionality to the application needs for protection and control in one IED.
- Configured versions solutions are completely ready to use and optimized for a wide range of applications for generation, transmission and sub-transmission grids.
- Support for user-defined names in the local language for signal and function engineering.
- Minimized rule based parameter settings based on default values and ABB's global base value concept. You only need to set those parameters specific to your own installed and activated application.
- GOOSE messaging for horizontal communication on pumping, redundant stations, as following IEC62439-3 ed2 PRP
- Extended HMI functionality with 15 dynamic three-color-indication LEDs per page, of up to three pages, and configurable push-button shortcuts for different actions.
- Programmable LED text-based labels.
- Settable 1A/5A -rated current inputs.
- Role based access control with independent passwords and FTPS encrypted communication. Managed authentication and accounting of all user activities.

2. Application

RET650 provides fast and selective protection, monitoring and control for two- and three-winding transformers, autotransformers, generator-transformer units and shunt reactors. The IED is designed to operate correctly over a wide frequency range in order to accommodate power system frequency variations during disturbances and generator start-up and shut-down. Apparatus control for up to 8 apparatuses with interlocking can be included in one IED by function block engineering.

A very fast differential protection function with built-in transformer ratio matching and vector group compensation makes this IED the ideal solution even for the most demanding applications. Since RET650 has very low requirements on the main CTs, no interposing CTs are required. The differential protection function is provided with 2nd harmonic and wave-block restraint features to avoid tripping for magnetizing inrush current, and 5th harmonic restraint to avoid tripping for overexcitation.

The differential function offers a high sensitivity for low-level internal faults. The unique and innovative sensitive differential protection feature of the RET650 provides the best possible coverage for winding internal turn-to-turn faults, based on the theory of symmetrical components .

A low impedance restricted earth-fault protection function is available as a complimentary sensitive and fast main protection against winding earth faults. This function includes a directional zero-sequence current criterion for additional security.

Tripping from pressure relief/Buchholz and temperature devices can be implemented through the IED's binary inputs, where trip signal conditioning can be performed (pulsing, lockout, additional logics, etc). The binary inputs are thoroughly stabilized against disturbances in order to prevent incorrect operations due to for example DC system capacitive discharges or DC earth faults.

Versatile phase, earth, negative and zero sequence overcurrent functions with directional capability provide further alternative backup protections. Thermal overload with two time-constants, overexcitation (volts per hertz) and over/under voltage protection functions are also available.

A built-in disturbance and event recorder provides valuable data to the user about status and operation for post-fault disturbance analysis.

Breaker failure protection allows high speed back-up tripping of surrounding breakers.

Three packages have been defined for the following applications:

- Two-winding transformer in single breaker arrangements (A01)
- Three-winding transformer in single breaker arrangements (A05)
- One or two transformer tap changer control (A07)

The packages are preconfigured and ready for direct use. Analog and tripping IO has been pre-defined for basic use. Other signals need to be applied as required for each application.

The graphical configuration tool ensures simple and fast testing and commissioning.

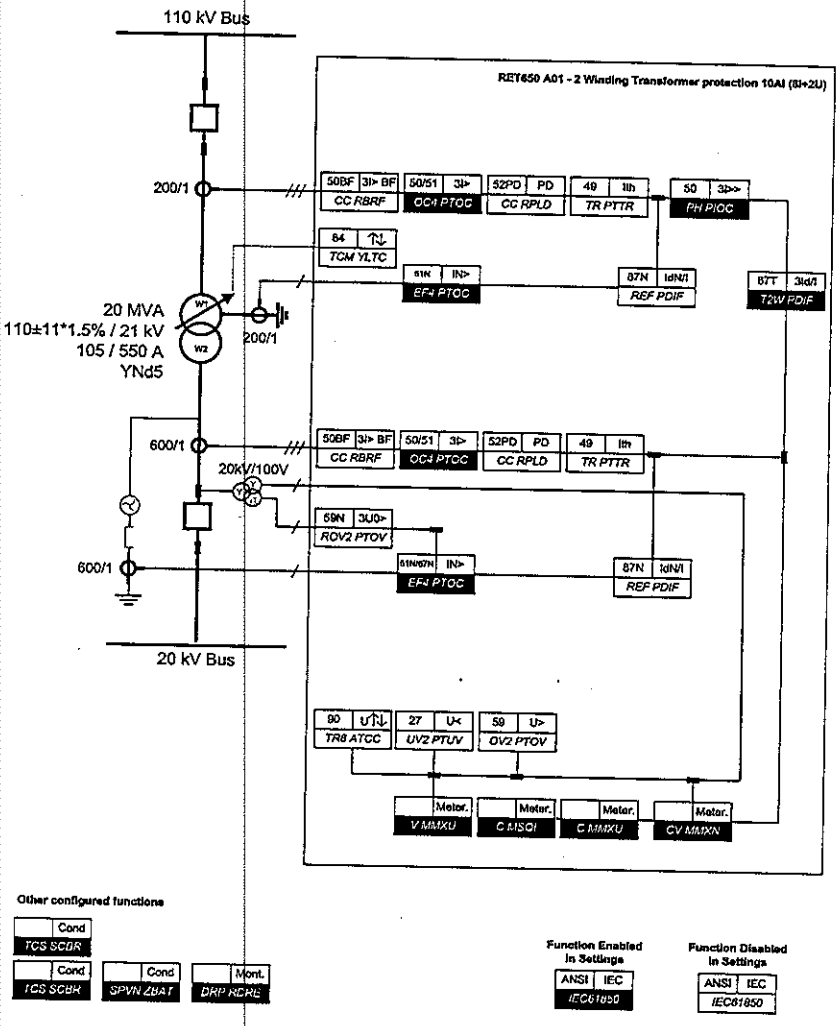
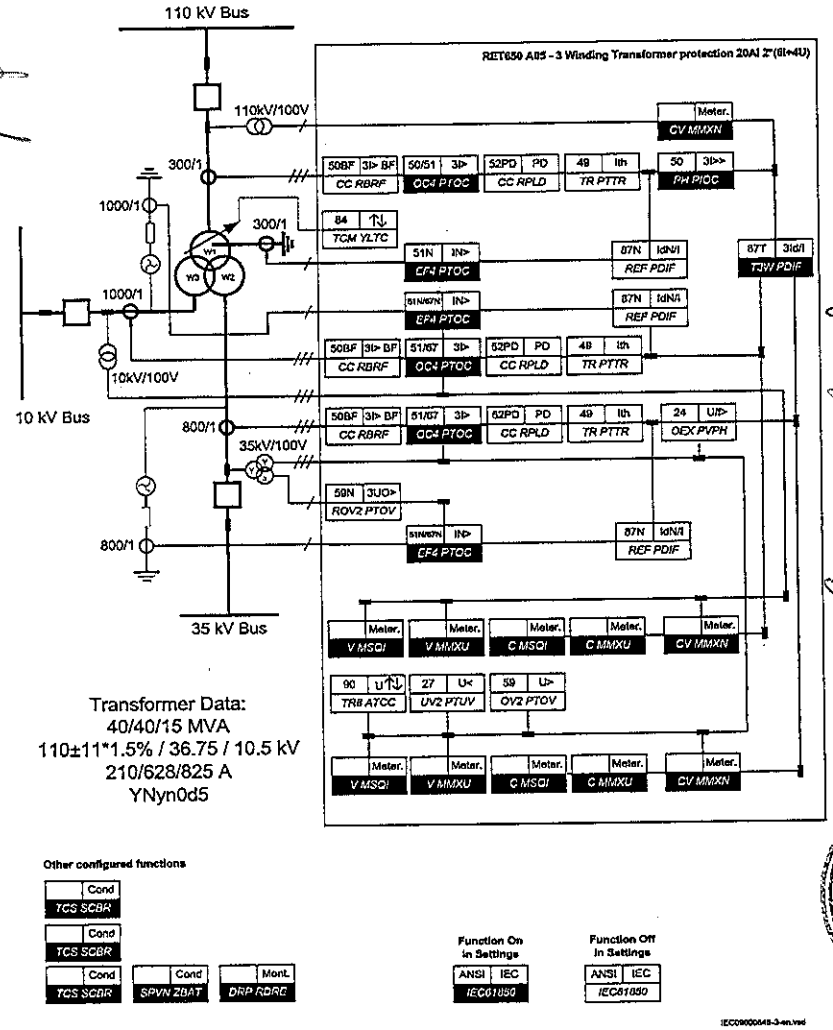


Figure 1. A typical protection application for a two-winding transformer in single breaker arrangement



Transformer Data:
40/40/15 MVA
110±11*1.5% / 36.75 / 10.5 kV
210/628/825 A
YNyn0d5

Other configured functions

Cond TCS SCBR
Cond TCS SCBR
Cond TCS SCBR | Cond SPVN ZBAT | Mont. DRP RDRE

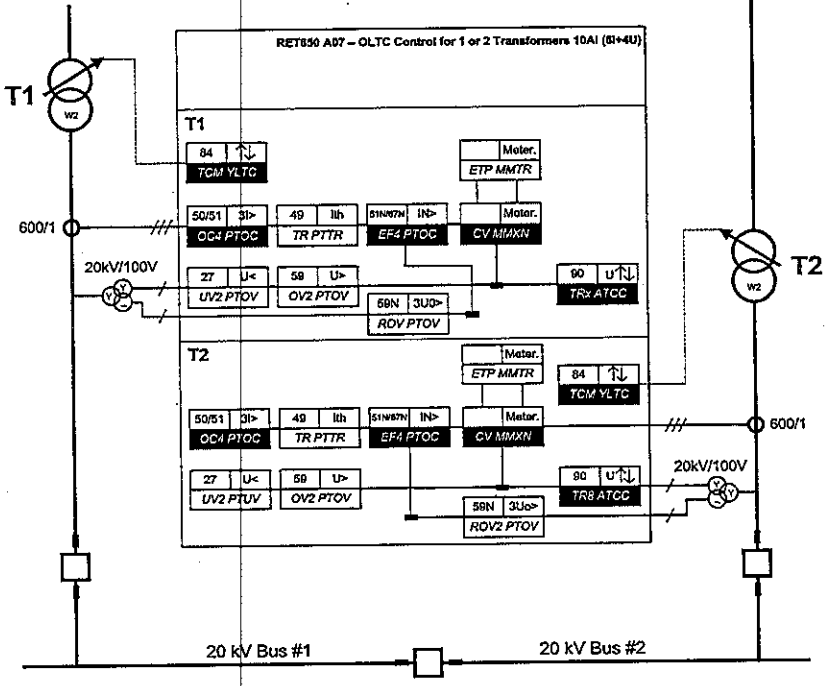
Function On in Settings	Function Off in Settings
ANSI IEC	ANSI IEC
IEC61850	IEC61850

IEC09000648-3-en.vsd

Figure 2. A typical protection application for a three-winding transformer in single breaker arrangement

T1 Data:
20 MVA
110±11*1.5% / 21 kV
105 / 550 A
YNd5
X_T=11 %

T2 Data:
~~20 MVA~~
110±11*1.5% / 21 kV
105 / 550 A
YNd5
X_T=11 %



Other configured functions

Cond TCS SCBR
Cond TCS SCBR
Cond TCS SCBR | Cond SPVN ZBAT | Mont. DRP RDRE

Function Enabled in Settings	Function Disabled in Settings
ANSI IEC	ANSI IEC
IEC61850	IEC61850

IEC09000647-4-en.vsd

Figure 3. A typical tap changer control application for one or two transformers

3. Available functions

Main protection functions

IEC 61850 or Function name	ANSI	Function description	Transformer			
			RET650	RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
Differential protection						
T2WPDIF	87T	Transformer differential protection, two winding	0–1	1		
T3WPDIF	87T	Transformer differential protection, three winding	0–1		1	
REFPDIF	87N	Restricted earth fault protection, low impedance	0–3	2	3	
HZPDIF	87	1Ph High impedance differential protection	0–2	2	2	
Impedance protection						
ZMRPSB	68	Power swing detection	0–1			
ZGCPDIS	21G	Underimpedance protection for generators and transformers	0–1			
LEPDIS		Load encroachment	0–1			

Back-up protection functions

IEC 61850 or Function name	ANSI	Function description	Transformer			
			RET650	RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
Current protection						
PHPIOC	50	Instantaneous phase overcurrent protection, 3–phase output	0–3	2	3	
OC4PTOC	51/67	Four step phase overcurrent protection, 3-phase output	0–3	2	3	2
EFPIOC	50N	Instantaneous residual overcurrent protection	0–3	2	3	
EF4PTOC	51N/67N	Four step residual overcurrent protection, zero/negative sequence direction	0–3	2	3	2
TRPTTR	49	Thermal overload protection, two time constants	0–3	2	3	2
CCRBRF	50BF	Breaker failure protection, 3–phase activation and output	0–3	2	3	
CCRPLD	52PD	Pole discordance protection	0–3	2	3	
GUPPDUP	37	Directional underpower protection	0–2	1	1	2
GOPPDOP	32	Directional overpower protection	0–2	1	1	2
DNSPTOC	46	Negative sequence based overcurrent function	0–2	1	2	
Voltage protection						
UV2PTUV	27	Two step undervoltage protection	0–2	1	1	2
OV2PTOV	59	Two step overvoltage protection	0–2	1	1	2
ROV2PTOV	59N	Two step residual overvoltage protection	0–2	1	1	2
OEXPVPH	24	Overexcitation protection	0–1	1	1	
Frequency protection						
SAPTUF	81	Underfrequency function	0–4	4	4	4
SAPTOF	81	Overfrequency function	0–4	4	4	4
SAPFRC	81	Rate-of-change frequency protection	0–4	2	2	4

Control and monitoring functions

IEC 61850 or Function name	ANSI	Function description	Transformer			
			RET650	RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
Control						
TR8ATCC	90	Automatic voltage control for tap changer, parallel control	0–2	1	1	2
TCMYLTC	84	Tap changer control and supervision, 6 binary inputs	0–2	1	1	2
SLGGIO		Logic Rotating Switch for function selection and LHMI presentation	15	15	15	15
VSGGIO		Selector mini switch	20	20	20	20
DPGGIO		IEC 61850 generic communication I/O functions double point	16	16	16	16
SPC8GGIO		Single point generic control 8 signals	5	5	5	5
AUTOBITS		AutomationBits, command function for DNP3.0	3	3	3	3
I103CMD		Function commands for IEC60870-5-103	1	1	1	1
I103IEDCMD		IED commands for IEC60870-5-103	1	1	1	1
I103USRCMD		Function commands user defined for IEC60870-5-103	4	4	4	4
I103GENCMD		Function commands generic for IEC60870-5-103	50	50	50	50
I103POSCMD		IED commands with position and select for IEC60870-5-103	50	50	50	50
Apparatus control and interlocking						
APC8		Apparatus control for single bay, max 8 app. (1CB) incl. interlocking	0–1			
QCBAY		Bay control	1	1	1	1
LOCREM		Handling of LR-switch positions	1	1	1	1
LOCREMCTRL		LHMI control of Permitted Source To Operate (PSTO)	1	1	1	1
CBC2		Circuit breaker control for 2CB	0–1	1		
CBC3		Circuit breaker control for 3CB	0–1		1	
CBC4		Circuit breaker control for 4CB	0–1			1
Secondary system supervision						
SDDRFUF		Fuse failure supervision	0–1			
TCSSCBR		Breaker close/trip circuit monitoring	3	3	3	3
Logic						
SMPPTRC	94	Tripping logic, common 3-phase output	1–3	2	3	2
TMAGGIO		Trip matrix logic	12	12	12	12
OR		Configurable logic blocks	283	283	283	283
INVERTER		Configurable logic blocks	140	140	140	140
PULSETIMER		Configurable logic blocks	40	40	40	40
GATE		Configurable logic blocks	40	40	40	40
XOR		Configurable logic blocks	40	40	40	40

Transformer protection RET650 1MRK 504 137-BEN A

Product version: 1.3

IEC 61850 or Function name	ANSI	Function description	Transformer			
			RET650	RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
LOOPDELAY		Configurable logic blocks	40	40	40	40
TIMERSET		Configurable logic blocks	40	40	40	40
AND		Configurable logic blocks	280	280	280	280
SRMEMORY		Configurable logic blocks	40	40	40	40
RSMEMORY		Configurable logic blocks	40	40	40	40
Q/T		Configurable logic blocks Q/T	0–1			
ANDQT		Configurable logic blocks Q/T	0–120			
ORQT		Configurable logic blocks Q/T	0–120			
INVERTERQT		Configurable logic blocks Q/T	0–120			
XORQT		Configurable logic blocks Q/T	0–40			
SRMEMORYQT		Configurable logic blocks Q/T	0–40			
RSMEMORYQT		Configurable logic blocks Q/T	0–40			
TIMERSETQT		Configurable logic blocks Q/T	0–40			
PULSETIMERQT		Configurable logic blocks Q/T	0–40			
INVALIDQT		Configurable logic blocks Q/T	0–12			
INDCOMBSPQT		Configurable logic blocks Q/T	0–20			
INDEXTSPQT		Configurable logic blocks Q/T	0–20			
FXDSIGN		Fixed signal function block	1	1	1	1
B16I		Boolean 16 to integer conversion	16	16	16	16
B16IFCVI		Boolean 16 to integer conversion with logic node representation	16	16	16	16
IB16A		Integer to Boolean 16 conversion	16	16	16	16
IB16FCVB		Integer to Boolean 16 conversion with logic node representation	16	16	16	16
TEIGGIO		Elapsed time integrator with limit transgression and overflow supervision	12	12	12	12
Monitoring						
CVMMXN		Measurements	6	6	6	6
CMMXU		Phase current measurement	10	10	10	10
VMMXU		Phase-phase voltage measurement	6	6	6	6
CMSQI		Current sequence component measurement	6	6	6	6
VMSQI		Voltage sequence measurement	6	6	6	6
VNMMXU		Phase-neutral voltage measurement	6	6	6	6
AISVBAS		Function block for service values presentation of the analog inputs	1	1	1	1

IEC 61850 or Function name	ANSI	Function description	Transformer			
			RET650	RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
TM_P_P2		Function block for service values presentation of primary analog inputs 600TRM	1	1	1	1
AM_P_P4		Function block for service values presentation of primary analog inputs 600AIM	1	1	1	1
TM_S_P2		Function block for service values presentation of secondary analog inputs 600TRM	1	1	1	1
AM_S_P4		Function block for service values presentation of secondary analog inputs 600AIM	1	1	1	1
CNTGGIO		Event counter	5	5	5	5
L4UFCNT		Event counter with limit supervision	12	12	12	12
DRPRDRE		Disturbance report	1	1	1	1
ANRADR		Analog input signals	4	4	4	4
BNRBDR		Binary input signals	6	6	6	6
SPGGIO		IEC 61850 generic communication I/O functions	64	64	64	64
SP16GGIO		IEC 61850 generic communication I/O functions 16 inputs	16	16	16	16
MVGGIO		IEC 61850 generic communication I/O functions	16	16	16	16
MVEXP		Measured value expander block	66	66	66	66
SPVNZBAT		Station battery supervision	0–1	1	1	1
SSIMG	63	Insulation gas monitoring function	0–2	2	2	2
SSIML	71	Insulation liquid monitoring function	0–2	2	2	2
SSCBR		Circuit breaker condition monitoring	0–3	2	3	2
I103MEAS		Measurands for IEC60870-5-103	1	1	1	1
I103MEASUSR		Measurands user defined signals for IEC60870-5-103	3	3	3	3
I103AR		Function status auto-recloser for IEC60870-5-103	1	1	1	1
I103EF		Function status earth-fault for IEC60870-5-103	1	1	1	1
I103FLTPROT		Function status fault protection for IEC60870-5-103	1	1	1	1
I103IED		IED status for IEC60870-5-103	1	1	1	1
I103SUPERV		Supervison status for IEC60870-5-103	1	1	1	1
I103USRDEF		Status for user defined signals for IEC60870-5-103	20	20	20	20
Metering						
PCGGIO		Pulse counter	16	16	16	16
ETPMMTR		Function for energy calculation and demand handling	3	3	3	3

Station communication

IEC 61850 or Function name	ANSI	Function description	Transformer			
			RET650	RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
Station communication						
IEC61850-8-1		IEC 61850 communication protocol	1	1	1	1
DNPGEN		DNP3.0 communication general protocol	1	1	1	1
RS485DNP		DNP3.0 for RS-485 communication protocol	1	1	1	1
CH1TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
CH2TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
CH3TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
CH4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
OPTICALDNP		DNP3.0 for optical RS-232 communication protocol	1	1	1	1
MSTSERIAL		DNP3.0 for serial communication protocol	1	1	1	1
MST1TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
MST2TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
MST3TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
MST4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
RS485GEN		RS485	1	1	1	1
OPTICALPROT		Operation selection for optical serial	1	1	1	1
RS485PROT		Operation selection for RS485	1	1	1	1
DNPFREC		DNP3.0 fault records for TCP/IP communication protocol	1	1	1	1
OPTICAL103		IEC60870-5-103 Optical serial communication	1	1	1	1
RS485103		IEC60870-5-103 serial communication for RS485	1	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59	59
GOOSEBINRCV		GOOSE binary receive	4	4	4	4
GOOSEVCTRCONF		GOOSE VCTR configuration for send and receive	1	1	1	1
VCTRSEND		Voltage control sending block for GOOSE	1	1	1	1
GOOSEVCTRRCV		Voltage control receiving block for GOOSE	3	3	3	3
ETHFRNT ETHLAN1 GATEWAY		Ethernet configuration of front port, LAN1 port and gateway	1	1	1	1
ETHLAN1_AB		Ethernet configuration of LAN1 port	1			
PRPSTATUS		System component for parallell redundancy protocol	1			
CONFPROT		IED Configuration Protocol	1	1	1	1
ACTIVLOG		Activity logging parameters	1	1	1	1
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1	1

IEC 61850 or Function name	ANSI	Function description	Transformer			
			RET650	RET650 (A01) 2W/1CB	RET650 (A05) 3W/1CB	RET650 (A07) OLTC
AGSAL		Generic security application component	1	1	1	1
GOOSEDPRCV		GOOSE function block to receive a double point value	32	32	32	32
GOOSEINTRCV		GOOSE function block to receive an integer value	32	32	32	32
GOOSEMVRCV		GOOSE function block to receive a measurand value	16	16	16	16
GOOSESPRCV		GOOSE function block to receive a single point value	64	64	64	64

Basic IED functions

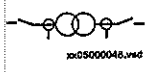
IEC 61850/Function block name	Function description	
Basic functions included in all products		
INTERRSIG	Self supervision with internal event list	1
SELFSUPEVLST	Self supervision with internal event list	1
TIMESYNCHGEN	Time synchronization	1
SNTP	Time synchronization	1
DTSBEGIN, DTSEND, TIMEZONE	Time synchronization, daylight saving	1
IRIG-B	Time synchronization	1
SETGRPS	Setting group handling	1
ACTVGRP	Parameter setting groups	1
TESTMODE	Test mode functionality	1
CHNGLCK	Change lock function	1
PRIMVAL	Primary system values	1
SMAI_20_1 - SMAI_20_12	Signal matrix for analog inputs	2
3PHSUM	Summation block 3 phase	12
GBASVAL	Global base values for settings	6
ATHSTAT	Authority status	1
ATHCHCK	Authority check	1
AUTHMAN	Authority management	1
FTPACCS	FTPS access with password	1
DOSFRNT	Denial of service, frame rate control for front port	1
DOSLAN1	Denial of service, frame rate control for LAN1A and LAN1B ports	1
DOSSCKT	Denial of service, socket flow control	1

4. Differential protection

Transformer differential protection T2WPDIF/T3WPDIF
The Transformer differential protection, two-winding T2WPDIF and Transformer differential protection, three-winding T3WPDIF are provided with internal CT ratio matching and vector group compensation and settable zero sequence current elimination.

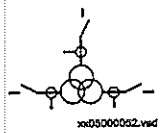
The function can be provided with two or three three-phase sets of current inputs. All current inputs are provided with percentage bias restraint features, making the IED suitable for two- or three-winding transformer arrangements.

Two-winding applications

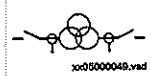


two-winding power transformer

Three-winding applications



three-winding power transformer with all three windings connected



three-winding power transformer with unconnected delta tertiary winding

Figure 4. CT group arrangement for differential protection and other protections

The setting facilities cover the application of the differential protection to all types of power transformers and auto-transformers with or without load tap changer as well as shunt reactors and local feeders within the station. An adaptive stabilizing feature is included for heavy through-faults.

Stabilization is included for inrush and overexcitation currents respectively, cross blocking is also available. Adaptive stabilization is also included for system recovery inrush and CT saturation during external faults. A high set unrestrained differential current protection element is included for a very high speed tripping at a high internal fault currents.

Included is an innovative sensitive differential protection element based on the theory of symmetrical components. This element offers the best possible coverage of power transformer windings turn to turn faults.

Restricted earth fault protection REFPDIF
Restricted earth-fault protection, low impedance REFPDIF
Restricted earth-fault protection, low-impedance function REFPDIF can be used on all directly or low-impedance earthed windings. The REFPDIF function provides high sensitivity and high speed tripping as it protects each winding separately and thus does not need inrush stabilization.

The low-impedance function is a percentage biased function with an additional zero sequence current directional comparison criterion. This gives excellent sensitivity and stability during through faults. The function allows the use of different CT ratios and magnetizing characteristics on the phase and neutral CT cores. Unlike high impedance restricted earth fault it allows for mixing with other functions and protection IEDs on the same CT cores.

1Ph High impedance differential protection HZPDIF
The 1Ph High impedance differential protection HZPDIF functions can be used when the involved CT cores have the same turns ratio and similar magnetizing characteristics. Each utilizes an external summation of the currents in the interconnected CTs, a series resistor, and a voltage dependent resistor which are mounted externally connected to the IED.

The external resistor unit shall be ordered under accessories.

HZPDIF can be used as high impedance REF protection.

5. Impedance protection

Power swing detection ZMRPSB
Power swings may occur after disconnection of heavy loads or trip of big generation plants.

Power swing detection function ZMRPSB is used to detect power swings and initiate block of all distance protection zones. Occurrence of earth-fault currents during a power swing inhibits the ZMRPSB function to allow fault clearance.

Underimpedance protection for generators and transformers ZGCPDIS
The underimpedance protection for generators and transformers ZGCPDIS, has the offset mho characteristic as a three zone back-up protection for detection of phase-to-phase short circuits in transformers and generators. The full scheme three zones have independent measuring phase-to-phase loops and settings that gives high flexibility for all types of applications.

All three zones can be individually definite time delayed.

A load encroachment characteristic is available for the third zone as shown in figure 5.

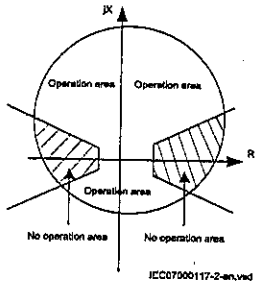


Figure 5. Load encroachment influence on the offset mho Z3 characteristic

Load encroachment LEPDIS
Heavy load transfer is common in many power networks and may make fault resistance coverage difficult to achieve. In such a case, Load encroachment LEPDIS function can be used to enlarge the resistive setting of the underimpedance measuring zones without interfering with the load.

Each of the three measuring phase-to-phase loops has its own load encroachment characteristic.

6. Current protection

Instantaneous phase overcurrent protection, 3-phase output PHPIOC
The instantaneous three phase overcurrent function has a low transient overreach and short tripping time to allow use as a high set short-circuit protection function.

Four step phase overcurrent protection, 3-phase output OC4PTOC
The four step phase overcurrent protection function OC4PTOC has an inverse or definite time delay independent for step 1 and 4 separately. Step 2 and 3 are always definite time delayed.

All IEC and ANSI inverse time characteristics are available.

The directional function is voltage polarized with memory. The function can be set to be directional or non-directional independently for each of the steps.

Second harmonic blocking level can be set for the function and can be used to block each step individually

Instantaneous residual overcurrent protection EFPIOC
The Instantaneous residual overcurrent protection EFPIOC has a low transient overreach and short tripping times to allow use for instantaneous earth-fault protection, with the reach limited to less than typical eighty percent of the transformer impedance at minimum source impedance. EFPIOC can be configured to measure the residual current from the three-phase current inputs or the current from a separate current input. EFPIOC can be blocked by activating the input BLOCK.

Four step residual overcurrent protection, zero sequence and negative sequence direction EF4PTOC
The four step residual overcurrent protection, zero or negative sequence direction (EF4PTOC) has a settable inverse or definite time delay independent for step 1 and 4 separately. Step 2 and 3 are always definite time delayed.

All IEC and ANSI inverse time characteristics are available.

EF4PTOC can be set directional or non-directional independently for each of the steps.

The directional part of the function can be set to operate on following combinations:

- Directional current (I3PDir) versus Polarizing voltage (U3PPol)
- Directional current (I3PDir) versus Polarizing current (I3PPol)
- Directional current (I3PDir) versus Dual polarizing (UPol +ZPol x IPol) where ZPol = RPol + jXPol

IDir, UPol and IPol can be independently selected to be either zero sequence or negative sequence.

Second harmonic blocking level can be set for the function and can be used to block each step individually.

Thermal overload protection, two time constant TRPTTR
If a power transformer or generator reaches very high temperatures the equipment might be damaged. The insulation within the transformer/generator will have forced ageing. As a consequence of this the risk of internal phase-to-phase or phase-to-earth faults will increase. High temperature will degrade the quality of the transformer/generator insulation.

The thermal overload protection estimates the internal heat content of the transformer/generator (temperature) continuously. This estimation is made by using a thermal model of the transformer/generator with two time constants, which is based on current measurement.

Two warning levels are available. This enables actions in the power system to be done before dangerous temperatures are reached. If the temperature continues to increase to the trip value, the protection initiates a trip of the protected transformer/generator.

Estimated time to trip before operation is presented.

Breaker failure protection CCRBRF, 3-phase activation and output
CCRBRF can be current based, contact based, or an adaptive combination of these two conditions.

Breaker failure protection, 3-phase activation and output (CCRBRF) ensures fast back-up tripping of surrounding breakers in case the own breaker fails to open. CCRBRF can be current based, contact based, or an adaptive combination of these two conditions.

Current check with extremely short reset time is used as check criterion to achieve high security against inadvertent operation.

Contact check criteria can be used where the fault current through the breaker is small.

Breaker failure protection, 3-phase activation and output (CCRBRF) current criteria can be fulfilled by one or two phase currents the residual current, or one phase current plus residual current. When those currents exceed the user defined settings, the function is triggered. These conditions increase the security of the back-up trip command.

CCRBRF function can be programmed to give a three-phase re-trip of the own breaker to avoid inadvertent tripping of surrounding breakers.

Pole discordance protection CCRPLD
Circuit breakers and disconnectors can end up with the phases in different positions (close-open), due to electrical or mechanical failures. An open phase can cause negative and zero sequence currents which cause thermal stress on rotating machines and can cause unwanted operation of zero sequence or negative sequence current functions.

Normally the own breaker is tripped to correct such a situation. If the situation persists the surrounding breakers should be tripped to clear the unsymmetrical load situation.

The pole discordance function operates based on information from the circuit breaker logic with additional criteria from phase selective current unsymmetry.

Directional over/underpower protection GOPPDOP/ GUPPDUP
The directional over-/under-power protection GOPPDOP/ GUPPDUP can be used wherever a high/low active, reactive or apparent power protection or alarming is required. The functions can alternatively be used to check the direction of active or reactive power flow in the power system. There are a number of applications where such functionality is needed. Some of them are:

- detection of reversed active power flow
- detection of high reactive power flow

Each function has two steps with definite time delay.

Negative sequence based overcurrent function DNSPTOC
Negative sequence based overcurrent function DNSPTOC is typically used as sensitive earth-fault protection of power lines, where incorrect zero sequence polarization may result from mutual induction between two or more parallel lines.

Additionally, it is applied in applications on cables, where zero sequence impedance depends on the fault current return paths, but the cable negative sequence impedance is practically constant.

The directional function is current and voltage polarized. The function can be set to forward, reverse or non-directional independently for each step. Both steps are provided with a settable definite time delay.

DNSPTOC protects against all unbalanced faults including phase-to-phase faults. The minimum start current of the function must be set to above the normal system unbalance level in order to avoid unwanted operation.

7. Voltage protection

Two step undervoltage protection UV2PTUV
Undervoltages can occur in the power system during faults or abnormal conditions. Two step undervoltage protection (UV2PTUV) function can be used to open circuit breakers to prepare for system restoration at power outages or as long-time delayed back-up to primary protection.

UV2PTUV has two voltage steps, where step 1 is settable as inverse or definite time delayed. Step 2 is always definite time delayed.

UV2PTUV has a high reset ratio to allow settings close to system service voltage.

Two step overvoltage protection OV2PTOV
Overvoltages may occur in the power system during abnormal conditions such as sudden power loss, tap changer regulating failures, and open line ends on long lines.

Two step overvoltage protection (OV2PTOV) function can be used to detect open line ends, normally then combined with a directional reactive over-power function to supervise the system voltage. When triggered, the function will cause an alarm, switch in reactors, or switch out capacitor banks.

OV2PTOV has two voltage steps, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

OV2PTOV has a high reset ratio to allow settings close to system service voltage.

Two step residual overvoltage protection ROV2PTOV
Residual voltages may occur in the power system during earth faults.

Two step residual overvoltage protection ROV2PTOV function calculates the residual voltage from the three-phase voltage input transformers or measures it from a single voltage input

transformer fed from an open delta or neutral point voltage transformer.

ROV2PTOV has two voltage steps, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

Overexcitation protection OEXPVPH
When the laminated core of a power transformer or generator is subjected to a magnetic flux density beyond its design limits, stray flux will flow into non-laminated components that are not designed to carry flux. This will cause eddy currents to flow. These eddy currents can cause excessive heating and severe damage to insulation and adjacent parts in a relatively short time. The function has settable inverse operating curves and independent alarm stages.

8. Frequency protection

Underfrequency protection SAPTUF
Underfrequency occurs as a result of a lack of sufficient generation in the network.

Underfrequency protection SAPTUF measures frequency with high accuracy, and is used for load shedding systems, remedial action schemes, gas turbine startup and so on. Separate definite time delays are provided for operate and restore.

SAPTUF is provided with undervoltage blocking.

Overfrequency protection SAPTOF
Overfrequency protection function SAPTOF is applicable in all situations, where reliable detection of high fundamental power system frequency is needed.

Overfrequency occurs because of sudden load drops or shunt faults in the power network. Close to the generating plant, generator governor problems can also cause over frequency.

SAPTOF measures frequency with high accuracy, and is used mainly for generation shedding and remedial action schemes. It is also used as a frequency stage initiating load restoring. A definite time delay is provided for operate.

SAPTOF is provided with an undervoltage blocking.

Rate-of-change frequency protection SAPFRC
The rate-of-change frequency protection function SAPFRC gives an early indication of a main disturbance in the system. SAPFRC measures frequency with high accuracy, and can be used for generation shedding, load shedding and remedial action schemes. SAPFRC can discriminate between a positive or negative change of frequency. A definite time delay is provided for operate.

SAPFRC is provided with an undervoltage blocking.

9. Secondary system supervision

Fuse failure supervision SDDRFUF
The aim of the fuse failure supervision function SDDRFUF is to block voltage measuring functions at failures in the secondary circuits between the voltage transformer and the IED in order to avoid inadvertent operations that otherwise might occur.

The fuse failure supervision function basically has three different detection methods, negative sequence and zero sequence based detection and an additional delta voltage and delta current detection.

The negative sequence detection is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence measuring quantities, a high value of negative sequence voltage $3U_2$ without the presence of the negative-sequence current $3I_2$.

The zero sequence detection is recommended for IEDs used in directly or low impedance earthed networks. It is based on the zero sequence measuring quantities, a high value of zero sequence voltage $3U_0$ without the presence of the zero sequence current $3I_0$.

For better adaptation to system requirements, an operation mode setting has been introduced which makes it possible to select the operating conditions for negative sequence and zero sequence based function. The selection of different operation modes makes it possible to choose different interaction possibilities between the negative sequence and zero sequence based detection.

A criterion based on delta current and delta voltage measurements can be added to the fuse failure supervision function in order to detect a three phase fuse failure, which in practice is more associated with voltage transformer switching during station operations.

Breaker close/trip circuit monitoring TCSSCBR
The trip circuit supervision function TCSSCBR is designed to supervise the control circuit of the circuit breaker. The trip circuit supervision generates a current of approximately 1 mA through the supervised control circuit. The validity supervision of a control circuit is provided for power output contacts, T2 and T3.

The trip circuit supervision operates after a settable definite operating time and resets after a settable definite time when the fault disappears.

10. Control

Apparatus control APC
The apparatus control function APC8 for up to 8 apparatuses is used for control and supervision of circuit breakers,

disconnectors and earthing switches within a bay. Permission to operate is given after evaluation of conditions from other functions such as interlocking, synchrocheck, operator place selection and external or internal blockings.

Apparatus control features:
- Select-Execute principle to give high reliability
- Selection function to prevent simultaneous operation
- Selection and supervision of operator place
- Command supervision
- Block/deblock of operation
- Block/deblock of updating of position indications
- Substitution of position indications
- Overriding of interlocking functions
- Overriding of synchrocheck
- Operation counter
- Suppression of Mid position

Two types of command models can be used:
- Direct with normal security
- SBO (Select-Before-Operate) with enhanced security

Direct commands are received with no prior select command. SBO commands are received with a select command first and on successful selection, a proceeding operate command.

In normal security, the command is processed and the resulting position is not supervised. However with enhanced security, the command is processed and the resulting position is supervised.

Control operation can be performed from the local HMI under authority control if so defined.

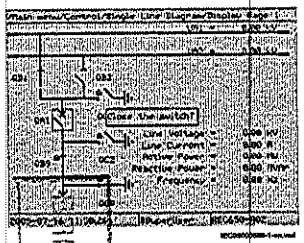


Figure 6. Select before operation with confirmation of command

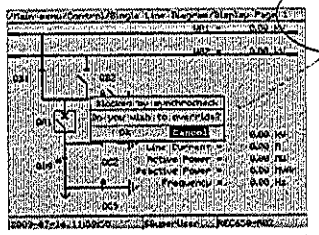


Figure 7. Overriding of synchrocheck

The switch controller SCSWI initializes and supervises all functions to properly select and operate switching primary apparatuses. Each of the 8 switch controllers SCSWI may handle and operate on one three-phase apparatus.

Each of the 3 circuit breaker controllers SXCBR provides the actual position status and pass the commands to the primary circuit breaker and supervises the switching operation and positions.

Each of the 7 circuit switch controllers SXSWI provides the actual position status and pass the commands to the primary disconnectors and earthing switches and supervises the switching operation and positions.

Interlocking
The interlocking functionality blocks the possibility to operate high-voltage switching devices, for instance when a disconnector is under load, in order to prevent material damage and/or accidental human injury.

Each control IED has interlocking functions for different switchyard arrangements, each handling the interlocking of one bay. The interlocking functionality in each IED is not dependent on any central function. For the station-wide interlocking, the IEDs communicate via the station bus or by using hard wired binary inputs/outputs.

The interlocking conditions depend on the primary bus configuration and status of any breaker or switch at any given time.

Bay control QCBAY
The Bay control QCBAY function is used together with Local remote and local remote control functions to handle the selection of the operator place per bay. QCBAY also provides blocking functions that can be distributed to different apparatuses within the bay.

Local remote LOCREM /Local remote control LOCREMCTRL
The signals from the local HMI or from an external local/remote switch are applied via the function blocks LOCREM

and LOCREMCTRL to the Bay control QCBAY function block. A parameter in function block LOCREM is set to choose if the switch signals are coming from the local HMI or from an external hardware switch connected via binary inputs.

Voltage control TR8ATCC and TCMYLTC
Automatic voltage control for tap changer TR8ATCC and Tap changer control and supervision, 6 binary inputs TCMYLTC are used for control of power transformers with a on-load tap changer. The functions provide automatic regulation of the voltage on the secondary side of transformers or alternatively on a load point further out in the network.

Control of a single transformer, as well as control of up to two transformers within a single RET650, or parallel control of up to four transformers in two or even four separate RET650 is possible. Note that the last alternative is achieved by using the GOOSE interbay communication on the IEC 61850-8-1 protocol. For parallel control of power transformers, three alternative methods are available, the master-follower method, the circulating current method and the reverse reactance method.

In RET650 a local HMI page with voltage control status and manual control possibilities is available. Manual control is under authority control if so defined.

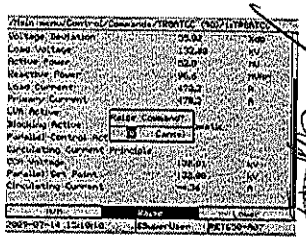


Figure 8. Manual control via local HMI

Voltage control includes many extra features such as possibility of to avoid simultaneous tapping of parallel transformers, extensive tap changer monitoring including contact wear and hunting detection, monitoring of the power flow in the transformer so that for example, the voltage control can be blocked if the power reverses etc.

In manual operating mode it is possible to give raise- or lower-commands to the load tap changer from the local HMI. Such facilities are pre-defined in the factory.

Circuit breaker control for circuit breakers, CBC2, CBC3 and CBC4
The CBC2, CBC 3 and CBC4 consists of 3 functions each:

- SCILO - The Logical node for interlocking. SCILO function contains the logic to enable a switching operation, and provides the information to SCSWI wether it is permitted to operate due to actual switchyard topology. The interlocking conditions are generated in separate function blocks containing the interlocking logic.
- SCSWI - The Switch controller initializes and supervises all functions to properly select and operate switching primary apparatuses. The Switch controller may handle and operate on one three-phase device.
- SXCBR - The circuit breaker controller SXCBR provides the actual position status and pass the commands to the primary circuit breaker and supervises the switching operation and positions.

Logic rotating switch for function selection and LHMI presentation SLGGIO
The logic rotating switch for function selection and LHMI presentation SLGGIO (or the selector switch function block) is used to get an enhanced selector switch functionality compared to the one provided by a hardware selector switch. Hardware selector switches are used extensively by utilities, in order to have different functions operating on pre-set values. Hardware switches are however sources for maintenance issues, lower system reliability and an extended purchase portfolio. The logic selector switches eliminate all these problems.

Selector mini switch VSGGIO
The Selector mini switch VSGGIO function block is a multipurpose function used for a variety of applications, as a general purpose switch.

VSGGIO can be controlled from the menu or from a symbol on the single line diagram (SLD) on the local HMI.

IEC 61850 generic communication I/O functions DPGGIO
The IEC 61850 generic communication I/O functions DPGGIO function block is used to send double indications to other systems or equipment in the substation using IEC61850. It is especially used in the interlocking and reservation station-wide logics.

Single point generic control 8 signals SPC8GGIO
The Single point generic control 8 signals SPC8GGIO function block is a collection of 8 single point commands, designed to bring in commands from REMOTE (SCADA) to those parts of the logic configuration that do not need extensive command receiving functionality (for example, SCSWI). In this way, simple commands can be sent directly to the IED outputs, without confirmation. The commands can be pulsed or steady with a settable pulse time.

AutomationBits AUTOBITS
The Automation bits function AUTOBITS is used to configure the DNP3 protocol command handling. Each of the 3 AUTOBITS available has 32 individual outputs available, each can be mapped as a binary output point in DNP3.

Function commands for IEC60870-5-103, I103CMD, I103IEDCMD, I103USRCMD, I103GENCMD, I103POSCMD IEC60870-5-103 function and command logic blocks are available for configuration of the IED. The output signals are predefined or user defined depending on selected function block.

11. Logic

Tripping logic common 3-phase output SMPPTRC
A function block for protection tripping is provided for each circuit breaker involved in the tripping of the fault. It provides a settable pulse prolongation to ensure a three-phase trip pulse of sufficient length, as well as all functionality necessary for correct co-operation with autoreclosing functions.

The trip function block also includes a settable latch functionality for breaker lock-out.

Trip matrix logic TMAGGIO
The 12 Trip matrix logic TMAGGIO function each with 32 inputs are used to route trip signals and other logical output signals to the tripping logics SMPPTRC and SPTPTRC or to different output contacts on the IED.

TMAGGIO 3 output signals and the physical outputs allows the user to adapt the signals to the physical tripping outputs according to the specific application needs for settable pulse or steady output.

Configurable logic blocks
A number of logic blocks and timers are available for the user to adapt the configuration to the specific application needs.

- OR function block. Each block has 6 inputs and two outputs where one is inverted.
- INVERTER function blocks that inverts the input signal.
- PULSETIMER function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.
- GATE function block is used for whether or not a signal should be able to pass from the input to the output.
- XOR function block. Each block has two outputs where one is inverted.
- LOOPDELAY function block used to delay the output signal one execution cycle.
- TIMERSET function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay and must be On for the input signal to activate the output with the appropriate time delay.
- AND function block. Each block has four inputs and two outputs where one is inverted
- SRMEMORY function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. The SET input has priority if both SET and RESET inputs are operated simultaneously.
- RSMEMORY function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. The RESET input has priority if both SET and RESET are operated simultaneously.

Configurable logic Q/T
A number of logic blocks and timers, with the capability to propagate timestamp and quality of the input signals, are available. The function blocks assist the user to adapt the IEDs configuration to the specific application needs.

- ORQT OR function block that also propagates timestamp and quality of input signals. Each block has six inputs and two outputs where one is inverted.
- INVERTERQT function block that inverts the input signal and propagates timestamp and quality of input signal.
- PULSETIMERQT Pulse timer function block can be used, for example, for pulse extensions or limiting of operation of outputs. The function also propagates timestamp and quality of input signal.
- XORQT XOR function block. The function also propagates timestamp and quality of input signals. Each block has two outputs where one is inverted.
- TIMERSETQT function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay. The function also propagates timestamp and quality of input signal.
- ANDQT AND function block. The function also propagates timestamp and quality of input signals. Each block has four inputs and two outputs where one is inverted.
- SRMEMORYQT function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return

to the state before the interruption, or be reset. The function also propagates timestamp and quality of input signal.

- RSMEMORYQT function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. The function also propagates timestamp and quality of input signal.
- INVALIDQT function which sets quality invalid of outputs according to a "valid" input. Inputs are copied to outputs. If input VALID is 0, or if its quality invalid bit is set, all outputs invalid quality bit will be set to invalid. The timestamp of an output will be set to the latest timestamp of INPUT and VALID inputs.
- INDCOMBSPQT combines single input signals to group signal. Single position input is copied to value part of SP_OUT output. TIME input is copied to time part of SP_OUT output. Quality input bits are copied to the corresponding quality part of SP_OUT output.
- INDEXTSPQT extracts individual signals from a group signal input. Value part of single position input is copied to SI_OUT output. Time part of single position input is copied to TIME output. Quality bits in common part and indication part of inputs signal is copied to the corresponding quality output.

Fixed signal function block
The Fixed signals function FXDSIGN generates nine pre-set (fixed) signals that can be used in the configuration of an IED, either for forcing the unused inputs in other function blocks to a certain level/value, or for creating certain logic. Boolean, integer, floating point, string types of signals are available.

Boolean 16 to Integer conversion B16I
Boolean 16 to integer conversion function B16I is used to transform a set of 16 binary (logical) signals into an integer.

Boolean 16 to Integer conversion with logic node representation B16IFCVI
Boolean 16 to integer conversion with logic node representation function B16IFCVI is used to transform a set of 16 binary (logical) signals into an integer. The block input will freeze the output at the last value.

Integer to Boolean 16 conversion IB16A
Integer to boolean 16 conversion function IB16A is used to transform an integer into a set of 16 binary (logical) signals.

Integer to Boolean 16 conversion with logic node representation IB16FCVB
Integer to boolean conversion with logic node representation function IB16FCVB is used to transform an integer to 16 binary (logic) signals.

IB16FCVB function can receive remote values over IEC61850 when the operator position input PSTO is in position remote. The block input will freeze the output at the last value.

Elapsed time integrator with limit transgression and overflow supervision TEIGGIO
The function TEIGGIO is used for user defined logics and it can also be used for different purposes internally in the IED . An application example is the integration of elapsed time during the measurement of neutral point voltage or neutral current at earth fault conditions.

Settable time limits for warning and alarm are provided. The time limit for overflow indication is fixed.

12. Monitoring

IEC61850 generic communication I/O function SPGGIO
IEC61850 generic communication I/O functions SPGGIO is used to send one single logical signal to other systems or equipment in the substation.

IEC61850 generic communication I/O function 16 inputs SP16GGIO
IEC 61850 generic communication I/O functions 16 inputs SP16GGIO function is used to send up to 16 logical signals to other systems or equipment in the substation.

Measurements CVMMXN, CMMXU, VNMMXU, VMMXU, CMSQI, VMSQI
The measurement functions are used to get on-line information from the IED. These service values make it possible to display on-line information on the local HMI and on the Substation automation system about:

- measured voltages, currents, frequency, active, reactive and apparent power and power factor
- primary and secondary phasors
- current sequence components
- voltage sequence components

Event counter CNTGGIO
Event counter CNTGGIO has six counters which are used for storing the number of times each counter input has been activated.

Event counter with limit supervison L4UFCNT
The 12 Up limit counter L4UFCNT provides a settable counter with four independent limits where the number of positive and/ or negative flanks on the input signal are counted against the

setting values for limits. The output for each limit is activated when the counted value reaches that limit.

Overflow indication is included for each up-counter.

Disturbance report DRPRDRE
Complete and reliable information about disturbances in the primary and/or in the secondary system together with continuous event-logging is accomplished by the disturbance report functionality.

Disturbance report DRPRDRE, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a, maximum of 40 analog and 96 binary signals.

The Disturbance report functionality is a common name for several functions:

- Event list
- Indications
- Event recorder
- Trip value recorder
- Disturbance recorder

The Disturbance report function is characterized by great flexibility regarding configuration, starting conditions, recording times, and large storage capacity.

A disturbance is defined as an activation of an input to the AnRADR or BnRBDR function blocks, which are set to trigger the disturbance recorder. All connected signals from start of pre-fault time to the end of post-fault time will be included in the recording.

Every disturbance report recording is saved in the IED in the standard Comtrade format as a reader file HDR, a configuration file CFG, and a data file DAT. The same applies to all events, which are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings. The disturbance report files may be uploaded to PCM600 for further analysis using the disturbance handling tool.

Event list DRPRDRE
Continuous event-logging is useful for monitoring the system from an overview perspective and is a complement to specific disturbance recorder functions.

The event list logs all binary input signals connected to the Disturbance recorder function. The list may contain up to 1000 time-tagged events stored in a ring-buffer.

Indications DRPRDRE
To get fast, condensed and reliable information about disturbances in the primary and/or in the secondary system it is important to know, for example binary signals that have changed status during a disturbance. This information is used in the short perspective to get information via the local HMI in a straightforward way.

There are three LEDs on the local HMI (green, yellow and red), which will display status information about the IED and the Disturbance recorder function (triggered).

The Indication list function shows all selected binary input signals connected to the Disturbance recorder function that have changed status during a disturbance.

Event recorder DRPRDRE
Quick, complete and reliable information about disturbances in the primary and/or in the secondary system is vital, for example, time-tagged events logged during disturbances. This information is used for different purposes in the short term (for example corrective actions) and in the long term (for example functional analysis).

The event recorder logs all selected binary input signals connected to the Disturbance recorder function. Each recording can contain up to 150 time-tagged events.

The event recorder information is available for the disturbances locally in the IED.

The event recording information is an integrated part of the disturbance record (Comtrade file).

Trip value recorder DRPRDRE
Information about the pre-fault and fault values for currents and voltages are vital for the disturbance evaluation.

The Trip value recorder calculates the values of all selected analog input signals connected to the Disturbance recorder function. The result is magnitude and phase angle before and during the fault for each analog input signal.

The trip value recorder information is available for the disturbances locally in the IED.

The trip value recorder information is an integrated part of the disturbance record (Comtrade file).

Disturbance recorder DRPRDRE
The Disturbance recorder function supplies fast, complete and reliable information about disturbances in the power system. It facilitates understanding system behavior and related primary and secondary equipment during and after a disturbance. Recorded information is used for different purposes in the short perspective (for example corrective actions) and long perspective (for example functional analysis).

The Disturbance recorder acquires sampled data from selected analog- and binary signals connected to the Disturbance recorder function (maximum 40 analog and 96 binary signals). The binary signals available are the same as for the event recorder function.

The function is characterized by great flexibility and is not dependent on the operation of protection functions. It can record disturbances not detected by protection functions. Up

to 9,9 seconds of data before the trigger instant can be saved in the disturbance file.

The disturbance recorder information for up to 100 disturbances are saved in the IED and the local HMI is used to view the list of recordings.

Measured value expander block MVEXP
The current and voltage measurements functions (CVMMXN, CMMXU, VMMXU and VNMMXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGGIO) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The measure value expander block MVEXP has been introduced to enable translating the integer output signal from the measuring functions to 5 binary signals: below low-low limit, below low limit, normal, above high limit or above high-high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

Station battery supervision SPVNZBAT
The station battery supervision function SPVNZBAT is used for monitoring battery terminal voltage.

SPVNZBAT activates the start and alarm outputs when the battery terminal voltage exceeds the set upper limit or drops below the set lower limit. A time delay for the overvoltage and undervoltage alarms can be set according to definite time characteristics.

SPVNZBAT operates after a settable operate time and resets when the battery undervoltage or overvoltage condition disappears after settable reset time.

Insulation gas monitoring function SSIMG
Insulation gas monitoring function SSIMG is used for monitoring the circuit breaker condition. Binary information based on the gas pressure in the circuit breaker is used as input signals to the function. In addition, the function generates alarms based on received information.

Insulation liquid monitoring function SSIML
Insulation liquid monitoring function SSIML is used for monitoring the circuit breaker condition. Binary information based on the oil level in the circuit breaker is used as input signals to the function. In addition, the function generates alarms based on received information.

Circuit breaker monitoring SSCBR
The circuit breaker condition monitoring function SSCBR is used to monitor different parameters of the circuit breaker. The breaker requires maintenance when the number of operations has reached a predefined value. The energy is calculated from the measured input currents as a sum of I^yt values. Alarms are generated when the calculated values exceed the threshold settings.

The function contains a block alarm functionality.

The supervised and presented breaker functions include
- breaker open and close travel time
- spring charging time
- number of breaker operations
- accumulated I^yt per phase with alarm and lockout
- remaining breaker life per phase
- breaker inactivity

13. Metering

Pulse counter logic PCGGIO
Pulse counter (PCGGIO) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the BIO (binary input/output) module and then read by the PCGGIO function. A scaled service value is available over the station bus.

Function for energy calculation and demand handling ETPMMTR
Outputs from the Measurements (CVMMXN) function can be used to calculate energy consumption. Active as well as reactive values are calculated in import and export direction. Values can be read or generated as pulses. Maximum demand power values are also calculated by the function.

14. Human Machine interface

Local HMI

Figure 9. Local human-machine interface

The LHMI of the IED contains the following elements:
- Display (LCD)
- Buttons
- LED indicators
- Communication port for PCM600

The LHMI is used for setting, monitoring and controlling.

The Local human machine interface, LHMI includes a graphical monochrome LCD with a resolution of 320x240 pixels. The character size may vary depending on selected language. The amount of characters and rows fitting the view depends on the character size and the view that is shown.

The LHMI is simple and easy to understand. The whole front plate is divided into zones, each with a well-defined functionality:

- Status indication LEDs
- Alarm indication LEDs which can indicate three states with the colors green, yellow and red, with user defined and also printable label. All LEDs are configurable from the PCM600 tool
- Liquid crystal display (LCD)
- Keypad with push buttons for control and navigation purposes, switch for selection between local and remote control and reset
- Five user programmable function buttons
- An isolated RJ45 communication port for PCM600

15. Basic IED functions

Self supervision with internal event list
The Self supervision with internal event list INTERRSIG and SELFSUPEVLST function reacts to internal system events generated by the different built-in self-supervision elements. The internal events are saved in an internal event list presented on the LHMI and in PCM600 event viewer tool.

Time synchronization
Use a common global source for example GPS time synchronization inside each substation as well as inside the area of the utility responsibility to achieve a common time base for the IEDs in a protection and control system. This makes comparison and analysis of events and disturbance data between all IEDs in the power system possible.

Time-tagging of internal events and disturbances are an excellent help when evaluating faults. Without time synchronization, only the events within the IED can be compared to one another. With time synchronization, events and disturbances within the entire station, and even between line ends, can be compared during evaluation.

In the IED, the internal time can be synchronized from a number of sources:

- SNTP
- IRIG-B
- DNP
- IEC60870-5-103

Parameter setting groups ACTVGRP
Use the four different groups of settings to optimize the IED operation for different power system conditions. Creating and switching between fine-tuned setting sets, either from the local HMI or configurable binary inputs, results in a highly adaptable IED that can be applied to a variety of power system scenarios.

Test mode functionality TESTMODE
The protection and control IEDs may have many included functions. To make the testing procedure easier, the IEDs include the feature that allows individual blocking of all functions except the function(s) the shall be tested.

There are two ways of entering the test mode:

- By configuration, activating an input signal of the function block TESTMODE
- By setting the IED in test mode in the local HMI

While the IED is in test mode, all protection functions are blocked.

Any function can be unblocked individually regarding functionality and event signaling. This enables the user to follow the operation of one or several related functions to check functionality and to check parts of the configuration, and so on.

Forcing of binary outputs, wether from the LHMI or from the PCM600 is only possible when the IED is in test mode.

Change lock function CHNGLCK
Change lock function CHNGLCK is used to block further changes to the IED configuration and settings once the commissioning is complete. The purpose is to block inadvertent IED configuration changes beyond a certain point in time.

The change lock function activation is normally connected to a binary input.

Authorization
The user categories and roles with user rights as defined by IEC 62359–8 for role based access control are pre-defined in the IED.

The IED users can be created, deleted and edited only with PCM600.

Password policies are set in the PCM600 IED user management tool.

At delivery, the IED user has full access as SuperUser until users are created with PCM600.

Authority status ATHSTAT
Authority status ATHSTAT function is an indication function block for user log-on activity.

User denied attempt to log-on and user successful log-on are reported.

Authority check ATHCHCK
To safeguard the interests of our customers, both the IED and the tools that are accessing the IED are protected, by means of authorization handling. The authorization handling

of the IED and the PCM600 is implemented at both access points to the IED:

- local, through the local HMI
- remote, through the communication ports

The IED users can be created, deleted and edited only with PCM600 IED user management tool.

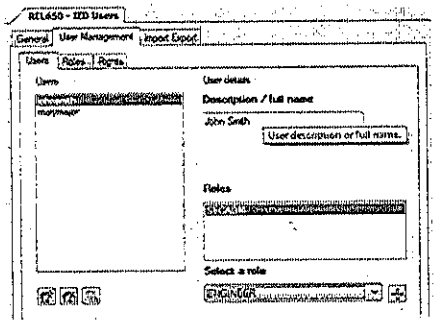


Figure 10. PCM600 user management tool

AUTHMAN
This function enables/disables the maintenance menu. It also controls the maintenance menu log on time out.

FTP access with SSL FTPACCS
The FTP Client defaults to the best possible security mode when trying to negotiate with SSL.

The automatic negotiation mode acts on port number and server features. It tries to immediately activate implicit SSL if the specified port is 990. If the specified port is any other, it tries to negotiate with explicit SSL via AUTH SSL/TLS.

Using FTP without SSL encryption gives the FTP client reduced capabilities. This mode is only for accessing disturbance recorder data from the IED.

If normal FTP is required to read out disturbance recordings, create a specific account for this purpose with rights only to do File transfer. The password of this user will be exposed in clear text on the wire.

Generic security application AGSAL
As a logical node AGSAL is used for monitoring security violation regarding authorization, access control and inactive association including authorization failure. Therefore, all the information in AGSAL can be configured to report to 61850 client.

Activity logging ACTIVLOG
ACTIVLOG contains all settings for activity logging.

There can be 6 external log servers to send syslog events to. Each server can be configured with IP address; IP port number and protocol format. The format can be either syslog (RFC 5424) or Common Event Format (CEF) from ArcSight.

Security alarm SECALARM
The function creates and distributes security events for mapping the security events on protocols such as DNP3.

It is possible to map respective protocol to the signals of interest and configure them for monitoring with the Communication Management tool (CMT) in PCM600. No events are mapped by default.

Parameter names:
- EVENTID: Event ID of the generated security event
- SEQNUMBER: Sequence number of the generated security event

Security events
All user operations are logged as events. These events can be sent to external security log servers using SYSLOG data formats. The log servers can be configured using PCM600.

16. Station communication

IEC 61850-8-1 communication protocol
The IED supports the communication protocols IEC 61850-8-1 and DNP3 over TCP/IP. All operational information and controls are available through these protocols. However, some communication functions, for example, horizontal communication (GOOSE) between the IEDs, is only enabled by the IEC 61850-8-1 communication protocol.

The IED is equipped with optical Ethernet rear port(s) for the substation communication standard IEC 61850-8-1. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. Peer-to-peer communication according to GOOSE is part of the standard. Disturbance files uploading is provided.

Disturbance files are accessed using the IEC 61850-8-1 protocol. Disturbance files are also available to any Ethernet based application via FTP in the standard Comtrade format. Further, the IED can send and receive binary values, double point values and measured values (for example from MMXU functions), together with their quality bit, using the IEC 61850-8-1 GOOSE profile. The IED meets the GOOSE performance requirements for tripping applications in substations, as defined by the IEC 61850 standard. The IED

interoperates with other IEC 61850-compliant IEDs, and systems and simultaneously reports events to five different clients on the IEC 61850 station bus.

The Denial of Service functions DOSLAN1 and DOSFRNT are included to limit the inbound network traffic. The communication can thus never compromise the primary functionality of the IED.

The event system has a rate limiter to reduce CPU load. The event channel has a quota of 10 events/second after the initial 30 events/second. If the quota is exceeded the event channel transmission is blocked until the event changes is below the quota, no event is lost.

All communication connectors, except for the front port connector, are placed on integrated communication modules. The IED is connected to Ethernet-based communication systems via the fibre-optic multimode LC connector(s) (100BASE-FX).

The IED supports SNTP and IRIG-B time synchronization methods with a time-stamping accuracy of ±1 ms.

- Ethernet based: SNTP and DNP3
- With time synchronization wiring: IRIG-B

The IED supports IEC 60870-5-103 time synchronization methods with a time stamping accuracy of ±5 ms.

Table 1. Supported station communication interfaces and protocols

Protocol	Ethernet	Serial	
	100BASE-FX LC	Glass fibre (ST connector)	EIA-485
IEC 61850-8-1	•	-	-
DNP3	•	•	•
IEC 60870-5-103	-	•	•

• = Supported

Horizontal communication via GOOSE for interlocking
GOOSE communication can be used for exchanging information between IEDs via the IEC 61850-8-1 station communication bus. This is typically used for sending apparatus position indications for interlocking or reservation signals for 1-of-n control. GOOSE can also be used to exchange any boolean, integer, double point and analog measured values between IEDs.

DNP3 protocol
DNP3 (Distributed Network Protocol) is a set of communications protocols used to communicate data between components in process automation systems. For a detailed description of the DNP3 protocol, see the DNP3 Communication protocol manual.

IEC 60870-5-103 communication protocol
IEC 60870-5-103 is an unbalanced (master-slave) protocol for coded-bit serial communication exchanging information with a control system, and with a data transfer rate up to 19200 bit/s. In IEC terminology, a primary station is a master and a secondary station is a slave. The communication is based on a point-to-point principle. The master must have software that can interpret IEC 60870-5-103 communication messages.

IEC 60870-5-103 protocol can be configured to use either the optical serial or RS485 serial communication interface on the COM03 or the COM05 communication module. The functions Operation selection for optical serial OPTICALPROT and Operation selection for RS485 RS485PROT are used to select the communication interface.

The function IEC60870-5-103 Optical serial communication, OPTICAL103, is used to configure the communication parameters for the optical serial communication interface. The function IEC60870-5-103 serial communication for RS485, RS485103, is used to configure the communication parameters for the RS485 serial communication interface.

IEC 62439-3 Parallel Redundancy Protocol
Redundant station bus communication according to IEC 62439-3 Edition 2 is available as option in the Customized 650 Ver 1.3 series IEDs, and the selection is made at ordering. Redundant station bus communication according to IEC 62439-3 Edition 2 uses both ports LAN1A and LAN1B on the COM03 module.

Select COM03 for redundant station bus according to IEC 62439-3 Edition 2 protocol, at the time of ordering. IEC 62439-3 Edition 2 is NOT compatible with IEC 62439-3 Edition 1.

17. Hardware description

See ordering for details about available mounting alternatives.

Layout and dimensions
Mounting alternatives
- 19" rack mounting kit

Rack mounting a single 3U IED

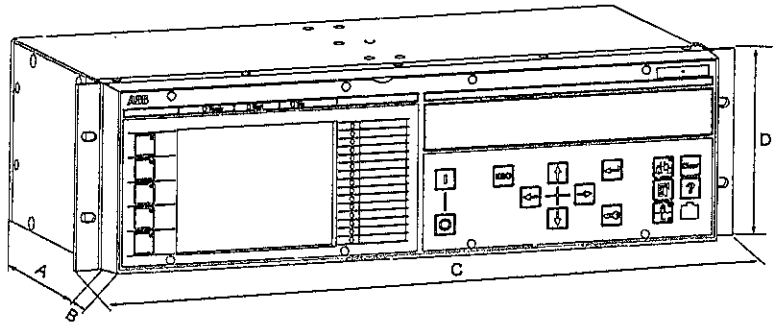


Figure 11. Rack mounted 3U IED

A 224 mm + 12 mm with ring-lug connectors
B 22.5 mm
C 482 mm
D 132 mm, 3U

18. Connection diagrams

Connection diagrams
The connection diagrams are delivered on the IED Connectivity package DVD as part of the product delivery.

The latest versions of the connection diagrams can be downloaded from http://www.abb.com/substationautomation.

Connection diagrams for Customized products

Connection diagram, 650 series 1.3 1MRK006501-AD

Connection diagrams for Configured products

Connection diagram, RET650 1.3, (2W/1CB) A01
1MRK006501-GD

Connection diagram, RET650 1.3, (3W/1CB) A05
1MRK006501-FD

Connection diagram, RET650 1.3, (2OLTCControl) A07
1MRK006501-ED

19. Technical data

General

Definitions	
Reference value	The specified value of an influencing factor to which are referred the characteristics of the equipment
Nominal range	The range of values of an influencing quantity (factor) within which, under specified conditions, the equipment meets the specified requirements
Operative range	The range of values of a given energizing quantity for which the equipment, under specified conditions, is able to perform its intended functions according to the specified requirements

Energizing quantities, rated values and limits

Analog inputs

Table 2. Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Operating range		Rated frequency ± 5 Hz	
Current inputs	Rated current, I_n	0.1/0.5 A[1]	1/5 A[2]
	Thermal withstand capability:		
	• Continuously	4 A	20 A
	• For 1 s	100 A	500 A *)
	• For 10 s	20 A	100 A
	Dynamic current withstand:		
	• Half-wave value	250 A	1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage, U_n	100 V AC/ 110 V AC/ 115 V AC/ 120 V AC	
	Voltage withstand:		
	• Continuous	420 V rms	
	• For 10 s	450 V rms	
	Burden at rated voltage	<0.05 VA	

*) max. 350 A for 1 s when COMBITEST test switch is included.

1) Residual current
2) Phase currents or residual current

Auxiliary AC and DC voltage

Table 3. Power supply

Description	PSM01	PSM02	PSM03
U_{aux} nominal	24, 30V DC	48, 60, 110, 125 V DC	100, 110, 120, 220, 240 V AC, 50 and 60 Hz 110, 125, 220, 250 V DC
U_{aux} variation	80...120% of U_n (19.2...36 V DC)	80...120% of U_n (38.4...150 V DC)	85...110% of U_n (85...264 V AC) 80...120% of U_n (88...300 V DC)
Maximum load of auxiliary voltage supply	35 W for DC 40 VA for AC		
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 and 120 Hz)		
Maximum interruption time in the auxiliary DC voltage without resetting the IED	50 ms at U_{aux}		
Resolution of the voltage measurement in PSM module	1 bit represents 0,5 V (+/- 1 VDC)	1 bit represents 1 V (+/- 1 VDC)	1 bit represents 2 V (+/- 1 VDC)

Binary inputs and outputs

Table 4. Binary inputs

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	24...250 V DC
Current drain	1.6...1.8 mA
Power consumption/input	<0.38 W
Threshold voltage	15...221 V DC (parametrizable in the range in steps of 1% of the rated voltage)

Table 5. Signal output and IRF output

IRF relay change over - type signal output relay	
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	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U<48/110/220 V DC	≤0.5 A/≤0.1 A/≤0.04 A

Table 6. Power output relays without 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 U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A

Table 7. Power output relays with TCS function

Description	Value
Rated voltage	250 V 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 U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A
Control voltage range	20...250 V DC
Current drain through the supervision circuit	~1.0 mA
Minimum voltage over the TCS contact	20 V DC

Table 8. Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
100BASE-TX	-	CAT 6 S/FTP or better	100 MBits/s
100BASE-FX	TCP/IP protocol	Fibre-optic cable with LC connector	100 MBits/s

Table 9. Fibre-optic communication link

Wave length	Fibre type	Connector	Permitted path attenuation[1]	Distance
1300 nm	MM 62.5/125 µm glass fibre core	LC	<8 dB	2 km

1) Maximum allowed attenuation caused by connectors and cable together

Table 10. X8/IRIG-B and EIA-485 interface

Type	Protocol	Cable
Tension clamp connection	IRIG-B	Shielded twisted pair cable Recommended: CAT 5, Belden RS-485 (9841- 9844) or Alpha Wire (Alpha 6222-6230)
Tension clamp connection	IEC 60870-5-103 DNP3.0	Shielded twisted pair cable Recommended: DESCAFLEX RD-H(ST)H-2x2x0.22mm², Belden 9729, Belden 9829

Table 11. IRIG-B

Type	Value	Accuracy
Input impedance	430 Ohm	-
Minimum input voltage HIGH	4.3 V	-
Maximum input voltage LOW	0.8 V	-

Table 12. EIA-485 interface

Type	Value	Conditions
Minimum differential driver output voltage	1.5 V	-
Maximum output current	60 mA	-
Minimum differential receiver input voltage	0.2 V	-
Supported bit rates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	-
Maximum number of 650 IEDs supported on the same bus	32	-
Max. cable length	925 m (3000 ft)	Cable: AWG24 or better, stub lines shall be avoided

Table 13. Serial rear interface

Type	Counter connector
Serial port (X9)	Optical serial port, type ST for IEC 60870-5-103 and DNP serial

Table 14. Optical serial port (X9)

Wave length	Fibre type	Connector	Permitted path attenuation[1]
820 nm	MM 62.5/125 µm glass fibre core	ST	6.8 dB (approx. 1700m length with 4 db / km fibre attenuation)
820 nm	MM 50/125 µm glass fibre core	ST	2.4 dB (approx. 600m length with 4 db / km fibre attenuation)

1) Maximum allowed attenuation caused by fibre

Influencing factors

Ingress protection

Table 15. Ingress protection

Description	Value
IED front	IP 54
IED rear	IP 21
IED sides	IP 42
IED top	IP 42
IED bottom	IP 21

Table 16. Environmental conditions

Description	Value
Operating temperature range	-25...+55°C (continuous)
Short-time service temperature range	-40...+70°C (<16h) Note: Degradation in MTBF and HMI performance outside the temperature range of -25...+55°C
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85°C

Table 17. Environmental tests

Description		Type test value	Reference
Cold tests	operation	96 h at -25°C 16 h at -40°C	IEC 60068-2-1/ANSI C37.90-2005 (chapter 4)
	storage	96 h at -40°C	
Dry heat tests	operation	16 h at +70°C	IEC 60068-2-2/ANSI C37.90-2005 (chapter 4)
	storage	96 h at +85°C	
Damp heat tests	steady state	240 h at +40°C humidity 93%	IEC 60068-2-78
	cyclic	6 cycles at +25 to +55°C humidity 93...95%	IEC 60068-2-30

Type tests according to standards

Table 18. Electromagnetic compatibility tests

Description	Type test value	Reference
100 kHz and 1 MHz burst disturbance test		IEC 61000-4-18, level 3 IEC 60255-22-1 ANSI C37.90.1-2012
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2, level 4 IEC 60255-22-2 ANSI C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference tests		
• Conducted, common mode	10 V (emf), f=150 kHz...80 MHz	IEC 61000-4-6 , level 3 IEC 60255-22-6
• Radiated, amplitude-modulated	20 V/m (rms), f=80...1000 MHz and f=1.4...2.7 GHz	IEC 61000-4-3, level 3 IEC 60255-22-3 ANSI C37.90.2-2004
Fast transient disturbance tests		IEC 61000-4-4 IEC 60255-22-4, class A ANSI C37.90.1-2012
• Communication ports	4 kV	
• Other ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-22-5
• Communication	1 kV line-to-earth	
• Other ports	2 kV line-to-earth, 1 kV line-to-line	
• Power supply	4 kV line-to-earth, 2 kV line-to-line	
Power frequency (50 Hz) magnetic field		IEC 61000-4-8, level 5
• 3 s	1000 A/m	
• Continuous	100 A/m	
Pulse magnetic field immunity test	1000A/m	IEC 61000-4-9, level 5
Damped oscillatory magnetic field	100A/m, 100 kHz and 1MHz	IEC 6100-4-10, level 5
Power frequency immunity test		IEC 60255-22-7, class A IEC 61000-4-16
• Common mode	300 V rms	
• Differential mode	150 V rms	
Voltage dips and short interruptionsc on DC power supply	Dips: 40%/200 ms 70%/500 ms Interruptions: 0-50 ms: No restart 0...∞ s : Correct behaviour at power down	IEC 60255-11 IEC 61000-4-11

Table 18. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
Voltage dips and interruptions on AC power supply	Dips: 40% 10/12 cycles at 50/60 Hz 70% 25/30 cycles at 50/60 Hz Interruptions: 0–50 ms: No restart 0...∞ s: Correct behaviour at power down	IEC 60255–11 IEC 61000–4–11
Electromagnetic emission tests		EN 55011, class A IEC 60255-25 ANSI C63.4, FCC
• Conducted, RF-emission (mains terminal)		
0.15...0.50 MHz	< 79 dB(µV) quasi peak < 66 dB(µV) average	
0.5...30 MHz	< 73 dB(µV) quasi peak < 60 dB(µV) average	
• Radiated RF-emission, IEC		
30...230 MHz	< 40 dB(µV/m) quasi peak, measured at 10 m distance	
230...1000 MHz	< 47 dB(µV/m) quasi peak, measured at 10 m distance	

Table 19. Insulation tests

Description	Type test value	Reference
Dielectric tests:		IEC 60255-5 ANSI C37.90-2005
• Test voltage	2 kV, 50 Hz, 1 min 1 kV, 50 Hz, 1 min, communication	
Impulse voltage test:		IEC 60255-5 ANSI C37.90-2005
• Test voltage	5 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J 1 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J, communication	
Insulation resistance measurements		IEC 60255-5 ANSI C37.90-2005
• Isolation resistance	>100 MΩ, 500 V DC	
Protective bonding resistance		IEC 60255-27
• Resistance	<0.1 Ω (60 s)	

Table 20. Mechanical tests

Description	Reference	Requirement
Vibration response tests (sinusoidal)	IEC 60255-21-1	Class 1
Vibration endurance test	IEC60255-21-1	Class 1
Shock response test	IEC 60255-21-2	Class 1
Shock withstand test	IEC 60255-21-2	Class 1
Bump test	IEC 60255-21-2	Class 1
Seismic test	IEC 60255-21-3	Class 2

Product safety

Table 21. Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005)

EMC compliance

Table 22. EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Differential protection

Table 23. Transformer differential protection T2WPDIF, T3WPDIF

Function	Range or value	Accuracy
Operating characteristic	Adaptable	± 1.0% of Ir for I < Ir ± 1.0% of I for I > Ir
Reset ratio	>94%	-
Unrestrained differential current limit	(1.00-50.00)x*IBase* on high voltage winding	± 1.0% of set value
Base sensitivity function	(0.05 - 0.60) x *IBase*	± 1.0% of Ir
Minimum negative sequence current	(0.02 - 0.20) x *IBase*	± 1.0% of Ir
Operate angle, negative sequence	(30.0 - 90.0) degrees	± 1.0 degrees
Second harmonic blocking	(5.0-100.0)% of fundamental differential current	± 2.0% of applied harmonic magnitude
Fifth harmonic blocking	(5.0-100.0)% of fundamental differential current	± 12.0% of applied harmonic magnitude
Connection type for each of the windings	Y or D	-
Phase displacement between high voltage winding, W1 and each of the windings, W2 and W3. Hour notation	0-11	-
Operate time, restrained function	25 ms typically at 0 to 5 x set level	-
Reset time, restrained function	25 ms typically at 5 to 0 x set level	-
Operate time, unrestrained function	20 ms typically at 0 to 5 x set level	-
Reset time, unrestrained function	25 ms typically at 5 to 0 x set level	-

Table 24. Restricted earth-fault protection, low impedance REFPDIF

Function	Range or value	Accuracy
Operate characteristic	Adaptable	± 1% of IBase if Ibias < 1.25 IBase (i.e. base sensitivity in section 1 of the operate - restrain characteristic) ± 2% of theoretical operate value (Idiff) if Ibias >= 1.25 IBase (i.e. sections 2 and 3) (The above is valid if IBase is equal to the protected winding rated current.)
Reset ratio	0.95	-
Directional characteristic, for zero sequence directional function	ROA ± 60 to ± 90 degrees	± 1 degrees at Ibias = IBase ± 2 degrees at Ibias = 2 * IBase ± 3 degrees at Ibias = 4 * IBase (The above is valid if IBase is equal to the protected winding rated current.)
Operate time, trip function	25 ms typically at 0 to 10 x IdMin	-
Reset time, trip function	30 ms typically at 10 to 0 x IdMin	-

Table 25. 1Ph High impedance differential protection HZPDIF

Function	Range or value	Accuracy
Operate voltage	(20-400) V I=U/R	± 1.0% of I_r
Reset ratio	>95%	-
Maximum continuous power	U>Trip²/SeriesResistor ≤200 W	-
Operate time	10 ms typically at 0 to 10 x U_d	-
Reset time	100 ms typically at 10 to 0 x U_d	-
Critical impulse time	2 ms typically at 0 to 10 x U_d	-

Impedance protection

Table 26. Power swing detection ZMRPSB

Function	Range or value	Accuracy
Reactive reach	(0.10-3000.00) Ω/phase	± 2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach	(0.10–1000.00) Ω/phase	
Timers	(0.000-60.000) s	± 0.5% ± 10 ms
Minimum operate current	(5-30)% of IBase	± 1.0% of I_r

Table 27. Underimpedance protection for generators and transformers ZGCPDIS

Function	Range or value	Accuracy
Number of zones	3	-
Forward positive sequence impedance	(0.005-3000.000) Ω/phase	± 2.0% static accuracy Conditions: • Voltage range: (0.1-1.1) x U_r • Current range: (0.5-30) x I_r • Angle: at 85 degrees
Reverse positive sequence impedance	(0.005-3000.000) Ω/phase	-
Angle for positive sequence impedance,	(10-90) degrees	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time	25 ms typically	-
Reset ratio	105% typically	-

Table 28. Load enchroachment LEPDIS

Function	Range or value	Accuracy
Load encroachment criteria: Load resistance, forward and reverse Safety load impedance angle	(1.00–3000.00) Ω/phase (5-85) degrees	± 5.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r
Reset ratio	105% typically	-

Current protection

Table 29. Instantaneous phase overcurrent protection, 3-phase output PHPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 5 x I_{set}	-
Reset time	40 ms typically at 5 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 30. Four step phase overcurrent protection, 3-phase output OC4PTOC

Function	Setting range	Accuracy
Operate current	(5-2500)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Min. operating current	(5-10000)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
2nd harmonic blocking	(5–100)% of fundamental	± 2.0% of I_r
Independent time delay	(0.000-60.000) s	± 0.5% ±25 ms
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ±25 ms
Inverse characteristics, see table 69, table 70 and table 71	15 curve types	1) ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \le k \le 3.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$
Operate time, nondirectional start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, nondirectional start function	35 ms typically at 2 to 0 x I_{set}	-
Operate time, directional start function	50 ms typically at 0 to 2 x I_{set}	-
Reset time, directional start function	35 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

1) Note: Timing accuracy only valid when 2nd harmonic blocking is turned off

Table 31. Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of IBase	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 5x I_{set}	-
Reset time	40 ms typically at 5 to 0x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 32. Four step residual overcurrent protection EF4PTOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate current for directional comparison, Zero sequence	(1–100)% of *IBase*	± 2.0% of I_r
Operate current for directional comparison, Negative sequence	(1–100)% of *IBase*	± 2.0% of I_r
Min. operating current	(1-10000)% of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Timers	(0.000-60.000) s	± 0.5% ±25 ms
Inverse characteristics, see table 69, table 70 and table 71	15 curve types	1) ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$
Minimum polarizing voltage, Zero sequence	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing voltage, Negative sequence	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing current, Zero sequence	(2–100)% of *IBase*	±1.0% of I_r
Minimum polarizing current, Negative sequence	(2–100)% of *IBase*	±1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, non-directional start function	30 ms typically at 0.5 to 2 x I_{set}	-
Reset time, non-directional start function	30 ms typically at 2 to 0.5 x I_{set}	-
Operate time, directional start function	30 ms typically at 0,5 to 2 x I_N	-
Reset time, directional start function	30 ms typically at 2 to 0,5 x I_N	-

1) Note: Timing accuracy only valid when 2nd harmonic blocking is turned off.

Table 33. Thermal overload protection, two time constants TRPTTR

Function	Range or value	Accuracy
Base current 1 and 2	(30–250)% of *IBase*	± 1.0% of I_r
Operate time: $t = \tau \cdot ln\left(\frac{I^2 - I_p^2}{I^2 - I_{ref}^2}\right)$ (Equation 1)	I_p = load current before overload occurs Time constant τ = (1–500) minutes	IEC 60255–8, ±5% + 200 ms
I = actual measured current Ip = load current before overload occurs Iref = reference load current		
Alarm level 1 and 2	(50–99)% of heat content trip value	± 2.0% of heat content trip
Operate current	(50–250)% of *IBase*	± 1.0% of I_r
Reset level temperature	(10–95)% of heat content trip	± 2.0% of heat content trip

Table 34. Breaker failure protection, 3-phase activation and output CCRBRF

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±10 ms
Operate time for current detection	20 ms typically	-
Reset time for current detection	10 ms maximum	-

Table 35. Pole discordance protection CCRPLD

Function	Range or value	Accuracy
Operate value, current asymmetry level	(0-100) %	± 1.0% of I_r
Reset ratio	>95%	-
Time delay	(0.000-60.000) s	± 0.5% ± 25 ms

Table 36. Directional over/underpower protection GOPPDOP, GUPPDUP

Function	Range or value	Accuracy
Power level	(0.0–500.0)% of *SBase*	± 1.0% of S_r at $S < S_r$ ± 1.0% of S at $S > S_r$
	(1.0-2.0)% of *SBase*	< ± 50% of set value
	(2.0-10)% of *SBase*	< ± 20% of set value
Characteristic angle	(-180.0–180.0) degrees	2 degrees
Timers	(0.010 - 6000.000) s	± 0.5% ± 25 ms

Table 37. Negative sequence based overcurrent function DNSPTOC

Function	Range or value	Accuracy
Operate current	(2.0 - 200.0) % of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95 %	-
Low polarizing voltage level	(0.0 - 5.0) % of *UBase*	< ± 0.5% of U_r
Relay characteristic angle	(-180 - 180) degrees	± 2.0 degrees
Relay operate angle	(1 - 90) degrees	± 2.0 degrees
Timers	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Operate time, non-directional	30 ms typically at 0 to 2 x I_{set} 20 ms typically at 0 to 10 x I_{set}	-
Reset time, non-directional	40 ms typically at 2 to 0 x I_{set}	-
Operate time, directional	30 ms typically at 0 to 2 x I_{set} 20 ms typically at 0 to 10 x I_{set}	-
Reset time, directional	40 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time	15 ms typically	-
Dynamic overreach	< 10% at t = 300 ms	-

Voltage protection

Table 38. Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1–100)% of *UBase*	± 0.5% of U_r
Reset ratio	<102%	-
Inverse time characteristics for low and high step, see table 73	-	See table 73
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Definite time delays, step 2	(0.000-60.000) s	± 0.5% ±25 ms
Minimum operate time, inverse characteristics	(0.000–60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 1.2 to 0.5U_{set}	-
Reset time, start function	40 ms typically at 0.5 to 1.2 xU_{set}	-
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 39. Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and 2	(1-200)% of *UBase*	± 0.5% of U_r at U < U_r ± 0.5% of U at U > U_r
Reset ratio	>98%	-
Inverse time characteristics for steps 1 and 2, see table 72	-	See table 72
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Definite time delays, step 2	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time, inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	40 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

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Table 40. Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1	(1-200)% of *UBase*	± 0.5% of U_r at U < U_r ± 0.5% of U at U > U_r
Operate voltage, step 2	(1–100)% of *UBase*	± 0.5% of U_r at U < U_r ± 0.5% of U at U > U_r
Reset ratio	> 98%	-
Inverse time characteristics for low and high step, see table 74	-	See table 74
Definite time setting, step 1	(0.00–6000.00) s	± 0.5% ± 25 ms
Definite time setting, step 2	(0.000–60.000) s	± 0.5% ± 25 ms
Minimum operate time for step 1 inverse characteristic	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	40 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 1.2 xU_{set}	-
Impulse margin time	15 ms typically	-

Table 41. Overexcitation protection OEXPVPH

Function	Range or value	Accuracy
Operate value, start	(100–180)% of (*UBase*/I_{rated})	± 0.5% of U
Operate value, alarm	(50–120)% of start level	± 0.5% of U_r at U ≤ U_r ± 0.5% of U at U > U_r
Operate value, high level	(100–200)% of (*UBase*/I_{rated})	± 0.5% of U
Curve type	IEEE $IEEE: t = \frac{(0.18 \cdot k)}{(M-1)^2}$ (Equation 2) where M = (E/f)/(Ur/fr)	± 5% + 40 ms
Minimum time delay for inverse function	(0.000–60.000) s	± 0.5% ± 25 ms
Alarm time delay	(0.00–9000.00)	± 0.5% ± 25 ms

Frequency protection

Table 42. Under frequency protection SAPTUF

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz
Operate value, restore frequency	(45 - 65) Hz	± 2.0 mHz
Reset ratio	<1.001	-
Operate time, start function	At 50 Hz: 200 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz At 60 Hz: 170 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz	-
Reset time, start function	At 50 Hz: 60 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 50 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Operate time delay	(0.000-60.000)s	<250 ms
Restore time delay	(0.000-60.000)s	<150 ms

Table 43. Overfrequency protection SAPTOF

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz at symmetrical three-phase voltage
Reset ratio	>0.999	-
Operate time, start function	At 50 Hz: 200 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 170 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Reset time, start function	At 50 and 60 Hz: 55 ms typically at f_{set} +0.5 Hz to f_{set}-0.5 Hz	-
Timer	(0.000-60.000)s	<250 ms

Table 44. Rate-of-change frequency protection SAPFRC

Function	Range or value	Accuracy
Operate value, start function	(-10.00-10.00) Hz/s	± 10.0 mHz/s
Operate value, restore enable frequency	(45.00 - 65.00) Hz	± 2.0 mHz
Timers	(0.000 - 60.000) s	<130 ms
Operate time, start function	At 50 Hz: 100 ms typically At 60 Hz: 80 ms typically	-

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Secondary system supervision

Table 45. Fuse failure supervision SDDRFUF

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	± 1.0% of U_r
Operate current, zero sequence	(1-100)% of IBase	± 1.0% of I_r
Operate voltage, negative sequence	(1-100)% of UBase	± 0.5% of U_r
Operate current, negative sequence	(1-100)% of IBase	± 1.0% of I_r
Operate voltage change level	(1-100)% of UBase	± 5.0% of U_r
Operate current change level	(1-100)% of IBase	± 5.0% of I_r
Operate phase voltage	(1-100)% of UBase	± 0.5% of U_r
Operate phase current	(1-100)% of IBase	± 1.0% of I_r
Operate phase dead line voltage	(1-100)% of UBase	± 0.5% of U_r
Operate phase dead line current	(1-100)% of IBase	± 1.0% of I_r

Table 46. Breaker close/trip circuit monitoring TCSSCBR

Function	Range or value	Accuracy
Operate time delay	(0.020 - 300.000) s	± 0.5% ± 110 ms

Control

Table 47. Voltage control TR8ATCC, TCMYLTC

Function	Range or value	Accuracy
Transformer reactance on ATCC side	(0.1–200.0)Ω, primary	-
Time delay for lower command when fast step down mode is activated	(1.0–100.0) s	-
Voltage control set voltage	(85.0–120.0)% of UB2	±0.5% of U_r
Outer voltage deadband	(0.2–9.0)% of UB2	± 5.0% of set value
Inner voltage deadband	(0.1–9.0)% of UB2	± 5.0% of set value
Upper limit of busbar voltage	(80–180)% of UB2	± 0.5% of U_r
Lower limit of busbar voltage	(70–120)% of UB2	± 0.5% of U_r
Undervoltage block level	(0–120)% of UB2	± 0.5% of U_r
Time delay (long) for automatic control commands	(3–1000) s	± 0.5% ± 110 ms
Time delay (short) for automatic control commands	(1–1000) s	± 0.5% ± 110 ms
Minimum operating time in inverse mode	(3–120) s	± 0.5% ± 110 ms
Line resistance	(0.00–150.00)Ω, primary	-
Line reactance	(-150.00–150.00)Ω, primary	-
Load voltage adjustment constants	(-20.0–20.0)% of UB2	± 5.0% of set value
Load voltage auto correction	(-20.0–20.0)% of UB2	± 5.0% of set value
Overcurrent block level	(0–250)% of IBase	± 1.0% of I_r at I≤I_r ± 1.0% of I at I>I_r
Level for number of counted raise/lower within one hour	(0–30) operations/hour	-
Level for number of counted raise/lower within 24 hours	(0–200) operations/day	-
Time window for hunting alarm	(1–120) minutes	-
Hunting detection alarm, max operations/window	(3–30) operations/window	-
Alarm level of active power in forward and reverse direction	(-9999.99–9999.99) MW	± 1.0% of S_r
Alarm level of reactive power in forward and reverse direction	(-9999.99–9999.99) MVAr	± 1.0% of S_r
Time delay for alarms from power supervision	(1–6000) s	± 0.5% ± 110 ms
Tap position for lowest and highest voltage	(1–63)	-
Type of code conversion	Binary, BCD, Gray, ContactPerTap	-
Time after position change before the value is accepted	(1–60) s	± 0.5% ± 110 ms
Tap changer constant time-out	(1–120) s	± 0.5% ± 110 ms
Raise/lower command output pulse duration	(0.5–10.0) s	± 0.5% ± 110 ms

Logic

Table 48. Tripping logic common 3-phase output SMPPTRC

Function	Range or value	Accuracy
Trip action	3-ph	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 49. Configurable logic blocks

Logic block	Quantity with cycle time			Range or value	Accuracy
	5 ms	20 ms	100 ms		
AND	60	60	160	-	-
OR	60	60	160	-	-
XOR	10	10	20	-	-
INVERTER	30	30	80	-	-
SRMEMORY	10	10	20	-	-
RSMEMORY	10	10	20	-	-
GATE	10	10	20	-	-
PULSETIMER	10	10	20	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
TIMERSET	10	10	20	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
LOOPDELAY	10	10	20		

Table 50. Configurable logic Q/T

Logic block	Quantity with cycle time		Range or value	Accuracy
	20 ms	100 ms		
ANDQT	20	100	-	-
ORQT	20	100	-	-
XORQT	10	30	-	-
INVERTERQT	20	100	-	-
RSMEMORYQT	10	30	-	-
SRMEMORYQT	15	10	-	-
PULSETIMERQT	10	30	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
TIMERSETQT	10	30	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
INVALIDQT	6	6	-	-
INDCOMBSPQT	10	10	-	-
INDEXTSPQT	10	10	-	-

Table 51. Elapsed time integrator with limit transgression and overflow supervision TEIGGIO

Function	Cycle time (ms)	Range or value	Accuracy
Elapsed time integration	5	0 – 999999.9 s	±0.05% or ±0.01 s
	20	0 – 999999.9 s	±0.05% or ±0.04 s
	100	0 – 999999.9 s	±0.05% or ±0.2 s

Monitoring

Table 52. Technical data covering measurement functions: CVMMXN, CMMXU, VMMXU, CMSQI, VMSQI, VNMMXU

Function	Range or value	Accuracy
Voltage	(0.1–1.5) ×U_r	± 0.5% of U_r at U≤U_r ± 0.5% of U at U > U_r
Connected current	(0.2–4.0) × I_r	± 0.5% of I_r at I ≤ I_r ± 0.5% of I at I > I_r
Active power, P	0.1 x U_r< U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	± 1.0% of S_r at S ≤ S_r ± 1.0% of S at S > S_r
Reactive power, Q	0.1 x U_r< U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	± 1.0% of S_r at S ≤ S_r ± 1.0% of S at S > S_r
Apparent power, S	0.1 x U_r< U < 1.5 x U_r 0.2 x I_r< I < 4.0 x I_r	± 1.0% of S_r at S ≤ S_r ± 1.0% of S at S > S_r
Apparent power, S Three phase settings	cos phi = 1	± 0.5% of S at S > S_r ± 0.5% of S_r at S ≤ S_r
Power factor, cos (φ)	0.1 x U_r < U < 1.5 x U_r 0.2 x I_r< I < 4.0 x I_r	< 0.02

Table 53. Event counter CNTGGIO

Function	Range or value	Accuracy
Counter value	0-100000	-
Max. count up speed	10 pulses/s (50% duty cycle)	-

Table 54. Limit counter L4UFCNT

Function	Range or value	Accuracy
Counter value	0-65535	-
Max. count up speed	5-160 pulses/s	-

Table 55. Disturbance report DRPRDRE

Function	Range or value	Accuracy
Current recording	-	± 1.0% of I_r at I ≤ I_r ± 1.0% of I at I > I_r
Voltage recording	-	± 1.0% of U_r at U ≤ U_r ± 1.0% of U at U > U_r
Pre-fault time	(0.05–3.00) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–8.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See time synchronization technical data
Maximum number of analog inputs	30 + 10 (external + internally derived)	-
Maximum number of binary inputs	96	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	96	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 56. Event list DRPRDRE

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 57. Indications DRPRDRE

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100