Relion® 670 series

Transformer protection RET670 2.0 IEC
Type test certificate

Power and productivity
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This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit. (http://www.openssl.org/)

This product includes cryptographic software written/developed by: Eric Young (eay@cryptsoft.com) and Tim Hudson (tjh@cryptsoft.com).

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standard EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

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Section 1 General

1.1 Type test data

This document certifies that the product described below is in accordance with, and conforms to the data stated in this Type Test Certificate and corresponding data in the Type Test Report and Product Guide.

The product has been tested according to relevant parts of the standards stated below.

Product/Type	Transformer protection IED Type RET670 v2.0
Product Guide	1MRK 504 141-BEN
User's Manuals	1MRK 504 138-UEN 1MRK 504 139-UEN 1MRK 504 140-UEN
Function	Transformer protection
Manufactured by	ABB AB, Sweden
Author/department	Rune Östlund, TP/TD
Date of issue	2014-09-01
Approved by	ABB AB Product Manager Lars Frisk
Standards	IEC 60255, IEC 61000, IEC 60068, IEC 60529, IEC 60870, IEC 61810, IEC 61850, ANSI C37.90, ANSI C37.112, ANSI C37.118, SS 4361503

1.2 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.

Section 2 Energizing quantities, rated values and limits

2.1 Analog inputs

Table 1: 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) × I_r
Operative range	(0-100) x I_r	
Permissive overload	4 × I_r cont. 100 × I_r for 1 s *)	
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%
*) max. 350 A for 1 s when COMBITEST test switch is included.		

Table 2: TRM - Energizing quantities, rated values and limits for measuring transformer modules

Quantity	Rated value	Nominal range
Current	I_r = 1 or 5 A	(0-1.8) × $I_r$at I_r = 1 A (0-1.6) × $I_r$at I_r = 5 A
Permissive overload	1.1 × I_r cont. 1.8 × I_r for 30 min at I_r = 1 A 1.6 × 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 3: 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 4: OEM - Optical ethernet module

Quantity	Rated value
Number of channels	1 or 2 (port A, B for IEC 61850-8-1 / IEEE C37.118 and port C, D for IEC 61850-9-2LE / IEEE C37.118)
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

2.2 Auxiliary DC voltage

Table 5: 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	< 10 A during 0.1 s	-

2.3 Binary inputs and outputs

Table 6: 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, 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. 0.5 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 1–20 ms	

Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.

Table 7: 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	
Debounce filter	Settable 1-20 ms	

Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.

Table 8: 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. 0.5 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 1-20 ms	

Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.

Table 9: 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

Maximum 72 outputs may be activated simultaneously. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life.Maximum two relays per BOM/IOM should be activated continuously due to power dissipation.

Table 10: 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

Maximum 72 outputs may be activated simultaneously. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM should be activated continuously due to power dissipation.

Table 11: 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 1.0 s	 5 A 10 A	 5 A 10 A
Making capacity at capacitive load with the maximum capacitance of 0.2 µF : 0.2 s 1.0 s	 30 A 10 A	 30 A 10 A
Breaking capacity for DC with L/R ≤ 40 ms	48 V/1 A 60 V/0.75 A	110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Operating time	< 1 ms	< 1 ms

Table 12: SOM - Static Output module data (reference standard: IEC 61810-2): Electromechanical relay outputs

Function of quantity	Trip and signal relays
Max system voltage	250 V AC/DC
Number of outputs	6
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity: Continuous 1.0 s	 8 A 10 A
Making capacity at capacitive load with the maximum capacitance of 0.2 µF: 0.2 s 1.0 s	 30 A 10 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

Maximum 72 outputs may be activated simultaneously with influencing factors within nominal range. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM/SOM should be activated continuously due to power dissipation.

Table 13: BOM - 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

Maximum 72 outputs may be activated simultaneously. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM should be activated continuously due to power dissipation.

2.4 Influencing factors

Table 14: 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 +70 °C	-

Table 15: 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–∞ s			Correct behaviour at power down
Restart time			<300 s

Table 16: 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	±10.0%
Harmonic frequency dependence for high impedance differential protection (10% content)	2nd, 3rd and 5th harmonic of f_r	±10.0%
Harmonic frequency dependence for overcurrent protection	2nd, 3rd and 5th harmonic of f_r	±3.0% / Hz

Section 3 Type tests according to standards

Table 17: 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 18: Insulation

Test	Type test values	Reference standard
Dielectric test	2.0 kV AC, 1 min.	IEC 60255-27 ANSI C37.90
Impulse voltage test	5 kV, 1.2/50 μs, 0.5 J	
Insulation resistance	>100 MΩ at 500 VDC	

Table 19: 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 Ab 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 Bb for 16 h at +85°C	IEC 60068-2-2
Change of temperature test	Test Nb for 5 cycles at -25°C to +70°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 20: CE compliance

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

Table 21: 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

Section 4 Control

Table 22: Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, φ_{line} - φ_{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 ≤ 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 ≤ 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%	-
Table continues on next page		

Function	Range or value	Accuracy
Maximum voltage for energizing	(50.0-180.0)% of UBase	± 0.5% of U_r at U ≤ 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 23: Voltage control TR1ATCC and TR8ATCC

Function	Range or value	Accuracy
Transformer reactance	(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 UBase	± 0.25 % of U_r
Outer voltage deadband	(0.2–9.0)% of UBase	-
Inner voltage deadband	(0.1–9.0)% of UBase	-
Upper limit of busbar voltage	(80–180)% of UBase	± 0.5% of U_r
Lower limit of busbar voltage	(70–120)% of UBase	± 0.5% of U_r
Undervoltage block level	(50–120)% of UBase	± 0.5% of U_r
Time delay (long) for automatic control commands	(3–1000) s	± 0.2% or ± 600 ms whichever is greater
Time delay (short) for automatic control commands	(1–1000) s	± 0.2% or ± 600 ms whichever is greater
Minimum operating time in inverse mode	(3–120) s	± 0.2% or ± 600 ms whichever is greater
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 UBase	-
Load voltage auto correction	(-20.0–20.0)% of UBase	-
Duration time for the reverse action block signal	(30–6000) s	± 0.2% or ± 600 ms whichever is greater
Current limit for reverse action block	(0–100)% of I1Base	-
Overcurrent block level	(5–250)% of I1Base	± 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	-

Table continues on next page

Function	Range or value	Accuracy
Level for number of counted raise/lower within 24 hours	(0–100) 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 at (10-200)% of S_r and (85-120)% of UBase	(-9999.99–9999.99) MW	± 1.0% of S_r
Alarm level of reactive power in forward and reverse direction at (10-200)% of S_r and (85-120)% of UBase	(-9999.99–9999.99) MVAr	± 1.0% of S_r
Time delay for alarms from power supervision	(1–6000) s	± 0.2% or ± 600 ms whichever is greater
Tap position for lowest and highest voltage	(1–63)	-
mA for lowest and highest voltage tap position	(0.000–25.000) mA	-
Type of code conversion	BIN, BCD, GRAY, SINGLE, mA	-
Time after position change before the value is accepted	(1–60) s	± 0.2% or ± 200 ms whichever is greater
Tap changer constant time-out	(1–120) s	± 0.2% or ± 200 ms whichever is greater
Raise/lower command output pulse duration	(0.5–10.0) s	± 0.2% or ± 200 ms whichever is greater

Section 5 Differential protection

Table 24: Transformer differential protection T2WPDIF, T3WPDIF

Function	Range or value	Accuracy
Operating characteristic	Adaptable	±1.0% of Ir at I ≤ Ir ±1.0% of I at I > Ir
Reset ratio	> 90%	-
Unrestrained differential current limit	(100-5000)% of *IBase* on high voltage winding	±1.0% of set value
Minimum pickup	(5-60)% of IBase	±1.0% of Ir
Second harmonic blocking	(5.0-100.0)% of fundamental differential current	±1.0% of I_r Note: fundamental magnitude = 100% of I_r
Fifth harmonic blocking	(5.0-100.0)% of fundamental differential current	±5.0% of I_r Note: fundamental magnitude = 100% of I_r
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 at 0 to 10 x IdMin, restrained function	Min. = 25 ms Max. = 35 ms	-
*Reset time at 10 to 0 x IdMin, restrained function	Min. = 5 ms Max. = 15 ms	-
*Operate time at 0 to 10 x Idunre, unrestrained function	Min. = 5 ms Max. = 15 ms	-
*Reset time at 10 to 0 x Idunre, unrestrained function	Min. = 15 ms Max. = 30 ms	-
**Operate time, unrestrained negative sequence function	Min. = 10 ms Max. = 20 ms	-
**Reset time, unrestrained negative sequence function	Min. = 10 ms Max. = 30 ms	-
Critical impulse time	2 ms typically at 0 to 5 x IdMin	-
*Note: Data obtained with single input current group. **Note: Data obtained with two input current groups. The rated symmetrical currents are applied on both sides as pre- and after-fault currents. The fault is performed by increasing one phase current to double on one side and decreasing same phase current to zero on the other side.		

Table 25: 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>Trip^2/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 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 startup signal at 0 to 2 x U_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater

Section 6 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 CVT's 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 x Zreach to 2 x Zreach	Min. = 20 ms Max. = 50 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*	-

Table continues on next page

Function	Range or value	Accuracy
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 CCVT's 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 x Zreach to 2 x Zreach	Min. = 20 ms Max. = 50 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 ≤ 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	Max 4 with selectable direction	-
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 CVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	± 0.2% or ± 60 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 CCVT's 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_r Current range: (0.5–30) x I_r 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_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 CVT's 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 x Zreach to 2 x Zreach	Min. = 20 ms Max. =50 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_r at I ≤ I_r ±1.0% of I at I > I_r
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_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, 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: 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/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_r

Table 36: 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 37: Out-of-step protection OOSPPAM

Function	Range or value	Accuracy
Impedance reach	(0.00 - 1000.00)% of Zbase	±2.0% of $U_r/(\sqrt{3} \cdot I_r)$
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 38: Pole slip protection PSPPPAM

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

Table 39: 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_r
Reset ratio, undervoltage	< 105%	-
Operate value, residual voltage	(5 - 300)% of UBase	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Reset ratio, residual voltage	> 95%	-
Operate value, residual current	(10 - 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%	-

Table continues on next page

Function	Range or value	Accuracy
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, NoPref Cyclic: 1231c, 1321c Acyclic: 123a, 132a, 213a, 231a, 312a, 321a	

Table 40: Underimpedance protection for generators and transformersZGVPDIS Technical data

Function	Range or value	Accuracy
Number of zones	3	-
Forward reach	(3.0 - 200.0)% of Z_r where Z_r=UBase/√3*IBase	±5.0% of set impedance Conditions: Voltage range: (0.1 - 1.1) x U_r Current range: (0.5 - 30) x I_r
Reverse reach	(3.0 - 200.0)% of Z_r where Z_r=UBase/√3*IBase	±5.0% of set impedance Conditions: Voltage range: (0.1 - 1.1) x U_r Current range: (0.5 - 30) x I_r
Impedance angle	(5 - 90) degrees	-
Reset ratio	105% typically	-
Start time at 1.2 to 0.8 x set impedance	Min. = 15 ms Max. = 35 ms	-
Independent time delay to operate at 1.2 to 0.8 x set impedance	(0.000 – 60.000) s	±0.2% or ±40 ms whichever is greater

Section 7 Current protection

Table 41: Instantaneous phase overcurrent protection PHPIOC

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

Table 42: Four step phase overcurrent protection OC4PTOC

Function	Setting range	Accuracy
Operate current	(5-2500)% of *IBase*	± 1.0% of I_r at I ≤ 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 ≤ 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 121, table 122 and table 123	16 curve types	See table 121, table 122 and table 123
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	

Table continues on next page

Function	Setting range	Accuracy
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 43: Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	±1.0% of I_r at I ≤ 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 44: 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 < I_r ± 1.0% of I at I > I_r
Reset ratio	> 95% at (1-2500)% of *IBase*	-
Operate current for directional comparison	(1–100)% of *IBase*	For RCA ± 60 degrees: ± 2.5% of I_r at I ≤ I_r ± 2.5% of I < I_r
Independent time delay for step 1, 2, 3, and 4	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater at 0 to 2 x I_{set}
Inverse characteristics, see table 121, table 122 and table 123	18 curve types	See table 121, table 122 and table 123
Second harmonic restrain operation	(5–100)% of fundamental	± 2.0% of I_r
Relay characteristic angle	(-180 to 180) degrees	± 2.0 degrees
Minimum polarizing voltage	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing current	(2-100)% of *IBase*	± 1.0% of I_r
Table continues on next page		

Function	Range or value	Accuracy
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 18 ms Max 28 ms	-
Reset time, start function at 2 to 0 x I_{set}	Min 18 ms Max 28 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 45: 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 121, table 122 and table 123	16 curve types	See table 121, table 122 and table 123
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 46: Sensitive directional residual overcurrent and power protection SDEPSDE

Function	Range or value	Accuracy
Operate level for $3I_0 \cdot \cos\varphi$ directional 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 $\cdot 3I_0 \cdot 3U_0 \cos\varphi$ 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 $\leq I_r$ ± 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 = 65 ms	
Reset time for non-directional residual overcurrent at 2 to 0 x Iset	Min = 40 ms Max = 65 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 = 65 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 ± 180 ms whichever is greater
Inverse characteristics	16 curve types	See table 121, table 122 and table 123
Relay characteristic angle RCA	(-179 to 180) degrees	± 2.0 degrees
Relay Open angle ROA	(0 to 90) degrees	± 2.0 degrees

Table 47: Thermal overload protection, one time constant LCPTTR/LFPTTR

Function	Range or value	Accuracy
Reference current	(2-400)% of IBase	±1.0% of I_r
Reference temperature	(0-300)°C, (0 - 600)°F	±1.0°C, ±2.0°F
Operate time: $t = \tau \ln \left[\frac{I^2 - I_p^2}{I^2 - I_p^2 - \frac{T_{Trip} - T_{Amb}}{T_{ref}} \cdot I_{ref}^2} \right]$ (Equation 1) T_{Trip}= set operate temperature T_{Amb} = ambient temperature T_{ref} = temperature rise above ambient at I_{ref} I_{ref} = reference load current I = actual measured current I_p = load current before overload occurs	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

Table 48: 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 2) I = actual measured current Ip = load current before overload occurs Iref = reference load current	I_p = load current before overload occurs Time constant τ = (0.10–500.00) minutes	±5.0% or ±200 ms whichever is greater
Alarm level 1 and 2	(50–99)% of heat content operate 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 49: Breaker failure protection 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%	-
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 50: Pole discordance protection CCPDSC

Function	Range or value	Accuracy
Operate current	(0–100)% of *IBase*	±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 51: Directional underpower protection GUPPDUP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of *SBase*	± 1.0% of S_r at S ≤ S_r ± 1.0% of S at S > S_r where $S_r = 1.732 \cdot U_r \cdot I_r$
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 52: Directional overpower protection GOPPDOP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of SBase	±1.0% of S_r at S ≤ 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 53: 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	±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	-

Table 54: Capacitor bank protection CBPGAPC

Function	Range or value	Accuracy
Operate value, overcurrent	(10-900)% of IBase	±2.0% of I_r at I ≤ I_r ±2.0% of I at I > I_r
Reset ratio, overcurrent	>95% at (100-900)% of IBase	-
Start time, overcurrent, at 0.5 to 2 x Iset	Min. = 5 ms Max. = 20 ms	-
Reset time, overcurrent, at 2 x Iset to 0.5	Min. = 25 ms Max. = 40 ms	-
Critical impulse time, overcurrent protection start	2 ms typically at 0.5 to 2 x Iset 1 ms typically at 0.5 to 10 x Iset	-
Impulse margin time, overcurrent protection start	10 ms typically	
Operate value, undercurrent	(5-100)% of IBase	±2.0% of I_r
Reset ratio, undercurrent	<105% at (30-100)% of IBase	-
Operate value, reconnection inhibit function	(4-1000)% of IBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Operate value, reactive power overload function	(10-900)%	±1.0% of S_r at S ≤ S_r ±1.0% of S at S > S_r
Operate value, voltage protection function for harmonic overload (Definite time)	(10-500)%	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Operate value, voltage protection function for harmonic overload (Inverse time)	(80-200)%	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Inverse time characteristic	According to IEC 60871-1 (2005) and IEEE/ANSI C37.99 (2000)	±20% or ±200 ms whichever is greater
Maximum trip delay, harmonic overload IDMT	(0.05-6000.00) s	±20% or ±200 ms whichever is greater
Minimum trip delay, harmonic overload IDMT	(0.05-60.00) s	±20% or ±200 ms whichever is greater
Independent time delay, overcurrent at 0 to 2 x Iset	(0.00-6000.00) s	±0.2% or ±30 ms whichever is greater
Independent time delay, undercurrent at 2 x Iset to 0	(0.00-6000.00) s	±0.2% or ±60 ms whichever is greater
Independent time delay, reactive power overload function at 0 to 2 x QOL>	(1.00-6000.00) s	±0.2% or ±100 ms whichever is greater
Independent time delay, harmonic overload at 0 to 2 x HOL>	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater

Table 55: Negative sequence time overcurrent protection for machines NS2PTOC

Function	Range or value	Accuracy
Operate current, step 1 - 2	(3-500)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	>95%	-
Operate time, start at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start at 10 x I_{set} to 0	Min. = 20 ms Max. = 35 ms	-
Time characteristics	Definite or Inverse	-
Inverse time characteristic, step 1 - 2 $I_2^2 t = K$	K=1.0-99.0	±2.0% or ±40 ms whichever is greater
Reset time, inverse characteristic, step 1 - 2 $I_2^2 t = K$	Reset Multiplier = 0.01-20.00	±5.0% or ±40 ms whichever is greater
Minimum operate time for inverse time characteristic, step 1 - 2	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Maximum trip delay at 0.5 x I_{set} to 2 x I_{set}, step 1 - 2	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay at 0.5 x I_{set} to 2 x I_{set}, step 1 - 2	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay for Alarm at 0.5 x I_{set} to 2 x I_{set}	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater

Table 56: 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 ≤ 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 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start overcurrent at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start overcurrent at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-

Table continues on next page

Function	Range or value	Accuracy
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, see tables 121 and 122	13 curve types	See tables 121 and 122
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 - 100.0)% 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	 10ms typically at 2 to 0 x U_{set} 15 ms typically	-

Section 8 Voltage protection

Table 57: Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1.0–100.0)% of *UBase*	±0.5% of U_r
Absolute hysteresis	(0.0–50.0)% of *UBase*	±0.5% of U_r
Internal blocking level, step 1 and step 2	(1–50)% of *UBase*	±0.5% of U_r
Inverse time characteristics for step 1 and step 2, see table 125	-	See table 125
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 58: 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 ≤ 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 ≤ U_r ±0.5% of U at U > U_r
Inverse time characteristics for steps 1 and 2, see table 124	-	See table 124
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 59: 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 ≤ 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 ≤ U_r ± 0.5% of U at U > U_r
Inverse time characteristics for low and high step, see table 126	-	See table 126
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

Table continues on next page

Function	Range or value	Accuracy
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 60: Overexcitation protection OEXPVPH

Function	Range or value	Accuracy
Operate value, start	(100–180)% of (*UBase*/f_{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*/f_{rated})	± 0.5% of U
Curve type	IEEE or customer defined $IEEE: t = \frac{(0.18 \cdot k)}{(M-1)^2}$ (Equation 3) where M = (E/f)/(Ur/fr)	± 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 61: 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 62: 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

Section 9 Frequency protection

Table 63: 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

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

(Equation 4)

U=$U_{measured}$

Table 64: 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	

Table continues on next page

Function	Range or value	Accuracy
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 65: 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

Section 10 Multipurpose protection

Table 66: 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	-
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	-
Start overcurrent, step 1 - 2	(2 - 5000)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Start undercurrent, step 1 - 2	(2 - 150)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Independent time delay, overcurrent at 0 to 2 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay, undercurrent at 2 to 0 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overcurrent (non-directional): Start time at 0 to 2 x I_{set} Reset time at 2 to 0 x I_{set} Start time at 0 to 10 x I_{set} Reset time at 10 to 0 x I_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms Min. = 5 ms Max. = 20 ms Min. = 20 ms Max. = 35 ms	 - - - -
Undercurrent: Start time at 2 to 0 x I_{set} Reset time at 0 to 2 x I_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Overcurrent: Inverse time characteristics, see table 121, 122 and table ""	 16 curve types	 See table 121, 122 and table ""
Overcurrent:		

Table continues on next page

Function	Range or value	Accuracy
Minimum operate time for inverse curves, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Voltage level where voltage memory takes over	(0.0 - 5.0)% of UBase	±0.5% of U_r
Start overvoltage, step 1 - 2	(2.0 - 200.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Start undervoltage, step 1 - 2	(2.0 - 150.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Independent time delay, overvoltage at 0.8 to 1.2 x U_{set}, step 1 - 2	(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}, step 1 - 2	(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} Reset time at 1.2 to 0.8 x U_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Undervoltage: Start time at 1.2 to 0.8 x U_{set} Reset time at 1.2 to 0.8 x U_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Overvoltage: Inverse time characteristics, see table 124	 4 curve types	 See table 124
Undervoltage: Inverse time characteristics, see table 125	 3 curve types	 See table 125
High and low voltage limit, voltage dependent operation, step 1 - 2	(1.0 - 200.0)% of UBase	±1.0% of U_r at U ≤ U_r ±1.0% of U at 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%	-

Table continues on next page

Function	Range or value	Accuracy
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	-

Section 11 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 ≤ 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 ≤ 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	–
Table continues on next page		

Function	Range or value	Accuracy
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	–

Section 12 Scheme communication

Table 70: 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 ±20 ms whichever is greater

Table 71: 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

Section 13 Logic

Table 72: 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 73: 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	80	-	-
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	8	-	-
Boolean 16 to integer with Logic Node	4	4	8	-	-
Integer to Boolean 16	4	4	8	-	-
Integer to Boolean 16 with Logic Node	4	4	8	-	-

Table 74: Configurable logic blocks Q/T

Logic block	Quantity with cycle time		Range or value	Accuracy
	medium	normal		
ANDQT	20	100	-	-
ORQT	20	100	-	-
INVERTERQT	20	100	-	-
XORQT	10	30	-	-
SRMEMORYQT	10	30	-	-
RSMEMORYQT	10	30	-	-
TIMERSETQT	10	30	(0.000-90000.000) s	± 0.5% ± 10 ms
PULSETIMERQT	10	30	(0.000-90000.000) s	± 0.5% ± 10 ms
INVALIDQT	6	6	-	-
INDCOMBSPQT	10	10	-	-
INDEXTSPQT	10	10	-	-

Table 75: 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
	8	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

Table 76: Number of TEIGAPC instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
TEIGAPC	4	4	4

Section 14 Monitoring

Table 77: 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≤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 Conditions: 0.8 x U_r < U < 1.2 U_r 0.2 x I_r < I < 1.2 I_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	
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 78: Phase current measurement CMMXU

Function	Range or value	Accuracy
Current at symmetrical load	(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
Phase angle at symmetrical load	(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 79: 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 80: 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 81: 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 82: Voltage sequence measurement VMSQI

Function	Range or value	Accuracy
Voltage positive sequence, U1	(10 to 300) V	± 0.5% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Voltage zero sequence, 3U0	(10 to 300) V	± 0.5% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Voltage negative sequence, U2	(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 83: 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 84: Insulation gas monitoring function SSIMG

Function	Range or value	Accuracy
Pressure alarm level	1.00-100.00	±10.0% of set value
Pressure lockout level	1.00-100.00	±10.0% of set value
Temperature alarm level	-40.00-200.00	±2.5% of set value
Temperature lockout level	-40.00-200.00	±2.5% of set value
Time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater

Table continues on next page

Function	Range or value	Accuracy
Reset time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for pressure lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for temperature lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater

Table 85: Insulation liquid monitoring function SSIML

Function	Range or value	Accuracy
Oil alarm level	1.00-100.00	±10.0% of set value
Oil lockout level	1.00-100.00	±10.0% of set value
Temperature alarm level	-40.00-200.00	±2.5% of set value
Temperature lockout level	-40.00-200.00	±2.5% of set value
Time delay for oil alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for oil alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for oil lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for temperature lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater

Table 86: Breaker monitoring SSCBR

Function	Range or value	Accuracy
Alarm level for open and close travel time	(0 – 200) ms	±3 ms
Alarm level for number of operations	(0 – 9999)	-
Independent time delay for spring charging time alarm	(0.00 – 60.00) s	±0.2% or ±30 ms whichever is greater
Independent time delay for gas pressure alarm	(0.00 – 60.00) s	±0.2% or ±30 ms whichever is greater
Independent time delay for gas pressure lockout	(0.00 – 60.00) s	±0.2% or ±30 ms whichever is greater
Table continues on next page		

Function	Range or value	Accuracy
CB Contact Travel Time, opening and closing		±3 ms
Remaining Life of CB		±2 operations
Accumulated Energy		±1.0% or ±0.5 whichever is greater

Table 87: 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 117
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 88: 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 89: Event list

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 90: Indications

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100

Table 91: 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 92: Trip value recorder

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	100

Table 93: 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

Table 94: Limit counter L4UFCNT

Function	Range or value	Accuracy
Counter value	0-65535	-
Max. count up speed	30 pulses/s (50% duty cycle)	-

Section 15 Metering

Table 95: 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 96: 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

Section 16 Station communication

Table 97: IEC 61850-9-2 communication protocol

Function	Value
Protocol	IEC 61850-9-2
Communication speed for the IEDs	100BASE-FX

Table 98: LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 99: SPA communication protocol

Function	Value
Protocol	SPA
Communication speed	300, 1200, 2400, 4800, 9600, 19200 or 38400 Bd
Slave number	1 to 899

Table 100: Ethernet communication

Function	Value
Protocol	Ethernet, TCP/IP
Communication speed	10/100 Mbit/s
Connectors	RJ45 shielded Ethernet connection

Table 101: IEC 60870-5-103 communication protocol

Function	Value
Protocol	IEC 60870-5-103
Communication speed	9600, 19200 Bd

Table 102: DNP 3.0 TCP/IP communication

Function	Value
Protocol	UDP, TCP/IP, Ethernet
Communication speed	100 Mbit/s
Connectors	RJ45 shielded Ethernet connection, Optical type ST Ethernet connection

Table 103: DNP 3.0 serial communication EIA-485

Function	Value
Protocol	DNP 3.0
Communication speed	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 Bd

Table 104: SLM – LON port

Quantity	Range or value
Optical connector	Glass fiber: type ST Plastic fiber: type HFBR snap-in
Fiber, optical budget	Glass fiber: 11 dB (1000m/3000 ft typically *) Plastic fiber: 7 dB (10m/35ft typically *)
Fiber diameter	Glass fiber: 62.5/125 μm Plastic fiber: 1 mm
*) depending on optical budget calculation	

Table 105: SLM – SPA/IEC 60870-5-103/DNP3 port

Quantity	Range or value
Optical connector	Glass fiber: type ST Plastic fiber: type HFBR snap-in
Fiber, optical budget	Glass fiber: 11 dB (1000m/3000ft m typically *) Plastic fiber: 7 dB (25m/80ft m typically *)
Fiber diameter	Glass fiber: 62.5/125 μm Plastic fiber: 1 mm
*) depending on optical budget calculation	

Table 106: 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 107: Galvanic RS485 communication module

Quantity	Range or value
Communication speed	2400–19200 bauds
External connectors	RS-485 6-pole connector Soft ground 2-pole connector

Table 108: IEC 62439-3 Edition 1 and Edition 2 parallel redundancy protocol

Function	Value
Communication speed	100 Base-FX

Section 17 Remote communication

Table 109: Line data communication module

Characteristic	Range or value		
Type of LDCM	Short range (SR)	Medium range (MR)	Long range (LR)
Type of fiber	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/2 mile *) 9 dB (typical distance about 2 km/1 mile *)	22 dB (typical distance 80 km/50 mile *)	26 dB (typical distance 110 km/68 mile *)
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 Mb/s / 64 kbit/s	2 Mb/s / 64 kbit/s	2 Mb/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			

Section 18 Hardware

18.1 IED

Table 110: Case

Material	Steel sheet
Front plate	Steel sheet profile with cut-out for HMI
Surface treatment	Aluzink preplated steel
Finish	Light grey (RAL 7035)

Table 111: 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 112: Weight

Case size	Weight
6U, 1/2 x 19”	≤ 10 kg/22 lb
6U, 3/4 x 19”	≤ 15 kg/33 lb
6U, 1/1 x 19”	≤ 18 kg/40 lb

18.2 Electrical safety

Table 113: Electrical safety according to IEC 60255-27

Equipment class	I (protective earthed)
Overvoltage category	III
Pollution degree	2 (normally only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected)

18.3 Connection system

Table 114: CT and VT circuit connectors

Connector type	Rated voltage and current	Maximum conductor area
Screw compression type	250 V AC, 20 A	4 mm^2 (AWG12) 2 x 2.5 mm^2 (2 x AWG14)
Terminal blocks suitable for ring lug terminals	250 V AC, 20 A	4 mm^2 (AWG12)

Table 115: Auxiliary power supply and binary I/O connectors

Connector type	Rated voltage	Maximum conductor area
Screw compression type	250 V AC	2.5 mm^2 (AWG14) 2 × 1 mm^2 (2 x AWG18)
Terminal blocks suitable for ring lug terminals	300 V AC	3 mm^2 (AWG14)

Because of limitations of space, when ring lug terminal is ordered for Binary I/O connections, one blank slot is necessary between two adjacent IO cards. Please refer to the ordering particulars for details.

Section 19 Basic IED functions

Table 116: Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	40 events, first in-first out

Table 117: 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 118: GPS time synchronization module (GTM)

Function	Range or value	Accuracy
Receiver	–	±1µs 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 119: 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 end TNC in antenna end
Accuracy	+/-1µs

Table 120: IRIG-B

Quantity	Rated value
Number of channels IRIG-B	1
Number of optical channels	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	+/-10µs for IRIG-B 00x and +/-100µs for IRIG-B 12x
Input impedance	100 k ohm
Optical connector:	
Optical connector IRIG-B	Type ST
Type of fibre	62.5/125 µm multimode fibre
Supported formats	IRIG-B 00x
Accuracy	+/- 1µs

Section 20 Inverse characteristics

Table 121: ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^P - 1 \right)} + B \right) \cdot k + tDef$ Reset characteristic: $t = \frac{t_r}{\left(I^2 - 1 \right)} \cdot k$ $I = I_{measured}/I_{set}$	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	

Table 122: IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1 \right)} \right) \cdot k$ $I = I_{measured}/I_{set}$	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: $t = \left(\frac{A}{\left(I^{P} - C \right)} + B \right) \cdot k$ Reset characteristic: $t = \frac{TR}{\left(I^{PR} - CR \right)} \cdot k$ $I = I_{measured}/I_{set}$	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 123: 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 $t = 5.8 - \left(1.35 \cdot In \frac{I}{k} \right)$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	

Table 124: 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 125: 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 126: 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	

Table 127: ANSI Inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1 \right)} + B \right) \cdot k + tDef$ Reset characteristic: $t = \frac{t_r}{\left(I^{2} - 1 \right)} \cdot k$ $I = I_{measured}/I_{set}$	0.10 ≤ k ≤ 2.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	ANSI/IEEE C37.112 , ±5.0% or ±160 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	

Table 128: IEC Inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1 \right)} \right) \cdot k$ $I = I_{measured}/I_{set}$	$0.10 \le k \le 2.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	IEC 60255-151, ±5.0% or ±160 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: $t = \left(\frac{A}{\left(I^{P} - C \right)} + B \right) \cdot k$ Reset characteristic: $t = \frac{TR}{\left(I^{PR} - CR \right)} \cdot k$ $I = I_{measured}/I_{set}$	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	

The parameter setting *Characterist1 and 4/Reserved* shall not be used, since this parameter setting is for future use and not implemented yet.

Table 129: RI and RD type inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
RI type inverse characteristic $t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$ $I = I_{measured}/I_{set}$	$0.10 \le k \le 2.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	IEC 60255-151, ±5.0% or ±160 ms whichever is greater
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot ln\frac{I}{k}\right)$ $I = I_{measured}/I_{set}$		

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