SIPROTEC 5

V8.01 and higher

Merging Unit 6MU85

Technical Data

Extract from manual C53000-G5040-C074-1, chapter 12

Smart Infrastructure

SIEMENS

NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

Document version: C53000-G5040-C074-1.02

Edition: 01.2020

Version of the product described: V8.01 and higher

Preface

Purpose of the Manual

This manual describes the protection, automation, control, and monitoring functions of the SIPROTEC 5 devices.

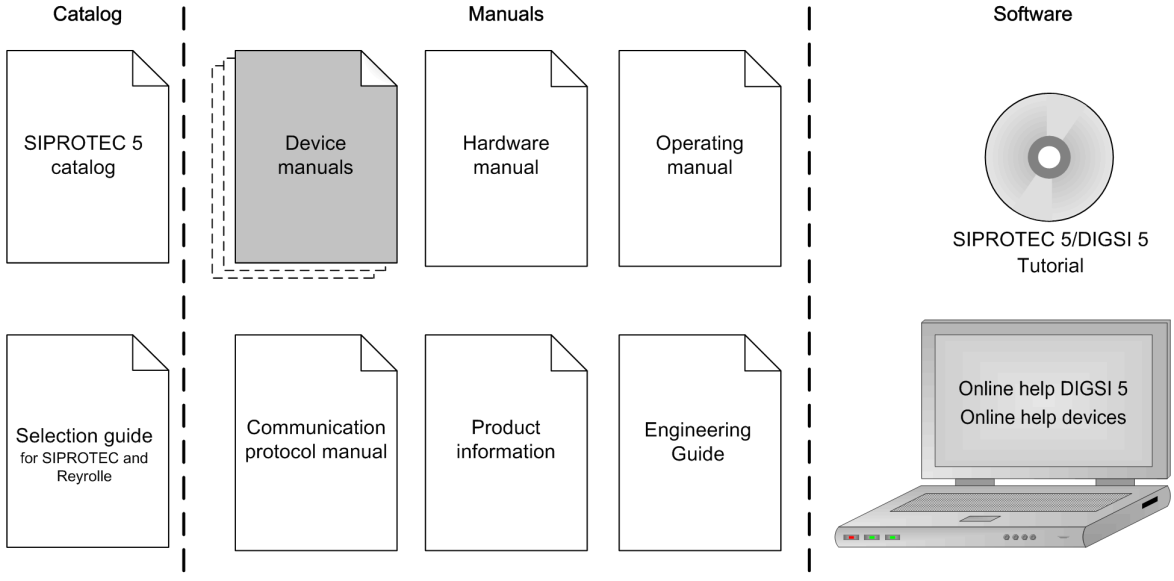
Target Audience

Protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, selective protection and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the SIPROTEC 5 device family.

Further Documentation



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- Device manuals
  Each Device manual describes the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.
- Hardware manual
  The Hardware manual describes the hardware building blocks and device combinations of the SIPROTEC 5 device family.
- Operating manual
  The Operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.

- Communication protocol manual
  The Communication protocol manual contains a description of the protocols for communication within the SIPROTEC 5 device family and to higher-level network control centers.
- Product information
  The Product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.
- Engineering Guide
  The Engineering Guide describes the essential steps when engineering with DIGSI 5. In addition, the Engineering Guide shows you how to load a planned configuration to a SIPROTEC 5 device and update the functionality of the SIPROTEC 5 device.
- DIGSI 5 online help
  The DIGSI 5 online help contains a help package for DIGSI 5 and CFC.
  The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles and editors. The help package for CFC includes an introduction to CFC programming, basic examples of working with CFC, and a reference chapter with all the CFC blocks available for the SIPROTEC 5 range.
- SIPROTEC 5/DIGSI 5 Tutorial
  The tutorial on the DVD contains brief information about important product features, more detailed information about the individual technical areas, as well as operating sequences with tasks based on practical operation and a brief explanation.
- SIPROTEC 5 catalog
  The SIPROTEC 5 catalog describes the system features and the devices of SIPROTEC 5.
- Selection guide for SIPROTEC and Reyrolle
  The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

Indication of Conformity

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States concerning electromagnetic compatibility (EMC Directive 2014/30/EU), restriction on usage of hazardous substances in electrical and electronic equipment (RoHS Directive 2011/65/EU), and electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the product standard EN 60255-26 (for EMC directive), the standard EN 50581 (for RoHS directive), and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

Standards

IEEE Std C 37.90

The technical data of the product is approved in accordance with UL.

For more information about the UL database, see *ul.com*

You can find the product with the **UL File Number E194016**.

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Additional Support

For questions about the system, contact your Siemens sales partner.

Customer Support Center

Our Customer Support Center provides a 24-hour service.

Siemens AG
Customer Support Center
Humboldtstrasse 59
90459 Nuremberg
Germany
E-mail: *support.energy@siemens.com*

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

Siemens AG
Siemens Power Academy TD
Humboldtstrasse 59
90459 Nuremberg
Germany

Phone: +49 (911) 433-7415
Fax: +49 (911) 433-7929
E-mail: *poweracademy@siemens.com*
Internet: *www.siemens.com/poweracademy*

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:

DANGER

DANGER means that death or severe injury **will** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.

WARNING

WARNING means that death or severe injury **may** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.

CAUTION

CAUTION means that medium-severe or slight injuries **can** occur if the specified measures are not taken.

✧ Comply with all instructions, in order to avoid moderate or minor injuries.

NOTICE

NOTICE means that property damage **can** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid property damage.

NOTE

Important information about the product, product handling or a certain section of the documentation which must be given attention.

Qualified Electrical Engineering Personnel

Only qualified electrical engineering personnel may commission and operate the equipment (module, device) described in this document. Qualified electrical engineering personnel in the sense of this manual are people who can demonstrate technical qualifications as electrical technicians. These persons may commission, isolate, ground and label devices, systems and circuits according to the standards of safety engineering.

Proper Use

The equipment (device, module) may be used only for such applications as set out in the catalogs and the technical description, and only in combination with third-party equipment recommended and approved by Siemens.

Problem-free and safe operation of the product depends on the following:

- Proper transport
- Proper storage, setup and installation
- Proper operation and maintenance

When electrical equipment is operated, hazardous voltages are inevitably present in certain parts. If proper action is not taken, death, severe injury or property damage can result:

- The equipment must be grounded at the grounding terminal before any connections are made.
- All circuit components connected to the power supply may be subject to dangerous voltage.
- Hazardous voltages may be present in equipment even after the supply voltage has been disconnected (capacitors can still be charged).
- Operation of equipment with exposed current-transformer circuits is prohibited. Before disconnecting the equipment, ensure that the current-transformer circuits are short-circuited.
- The limiting values stated in the document must not be exceeded. This must also be considered during testing and commissioning.

Used Symbols on Device

No.	Symbol	Description
1		Direct current, IEC 60417, 5031
2		Alternating current, IEC 60417, 5032
3		Direct and alternating current, IEC 60417, 5033
4		Earth (ground) terminal, IEC 60417, 5017
5		Protective conductor terminal, IEC 60417, 5019

No.	Symbol	Description
6		Caution, risk of electric shock
7		Caution, risk of danger, ISO 7000, 0434
8		Protective Insulation, IEC 60417, 5172, Safety Class II devices
9		Guideline 2002/96/EC for electrical and electronic devices
10	EAC	Guideline for the Eurasian Market

12 Technical Data

12.1 General Device Data

12.1.1 Analog Inputs

GIS Low-Power Current Input (via Module IO240)

All current, voltage, and power data are specified as RMS values.	
Rated frequency f_{rated}	50 Hz 60 Hz
Rated current I_{rated} - 50 Hz	Min. 13 mV Max. 332 mV
Rated current I_{rated} - 60 Hz	Min. 15.4 mV Max. 386 mV
Measuring range	$50 \cdot I_{rated}$ (Protection channel) $1.6 \cdot I_{rated}$ (Metering channel)
Power consumption per current circuit at rated current	Max. 40 mVA Burden = 9.5 kΩ
Thermal rating	Max. input voltage = 20 V
Accuracy	Class 5TPE (Protection channel) Class 0.2S (Metering channel)

Voltage Input

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz 16.7 Hz (for rail devices only)	
Input and output modules	IO102, IO202, IO208, IO211, IO214	IO215
Measuring range	0 V to 200 V	0 V to 7.07 V
Burden	< 0.1 VA	< 0.01 VA
Thermal rating	230 V continuously	20 V continuously

GIS Low-Power Voltage Input (via Module IO240)

All current, voltage, and power data are specified as RMS values.	
Rated frequency f_{rated}	50 Hz 60 Hz
Rated voltage V_{rated} - 50 Hz	Min. 0.25 mA Max. 2.00 mA
Rated voltage V_{rated} - 60 Hz	Min. 0.30 mA Max. 2.20 mA
Measuring range	$2 \cdot V_{rated}$
Power consumption per current circuit at rated current	Max. 1 mVA Burden = 50 Ω
Thermal rating	Max. input current = 4.4 mA
Accuracy	Class 0.1

Measuring-Transducer Inputs (via Module ANAI-CA-4EL)

Insulation class	SELV (Safety Extra Low Voltage) (according to IEC 60255-27)
Connector type	8-pin terminal spring

Differential current input channels	4
Measuring range	DC -25.6 mA to +25.6 mA
Fault	< 0.5 % of the measuring range
Input impedance	140 Ω
Conversion principle	Delta-sigma (16 bit)
Permissible potential difference between channels	DC 20 V
Galvanic separation from ground/ housing	DC 700 V
Permissible overload	DC 100 mA continuously
Measured-value repetition	200 ms

Inputs for Optical Sensors for Arc Protection (via Module ARC-CD-3FO)

Connector type	AVAGO AFBR-4526Z
Number of transceivers	3
Fiber type	Plastic Optical Fiber (POF) 1 mm
Receiver	
Maximum	-10 dBm ± 2 dBm
Minimum	-40 dBm ± 2 dBm
Spectrum	400 nm to 1100 nm
Attenuation	In the case of plastic optical fibers, you can expect a path attenuation of 0.2 dB/m. Additional attenuation comes from the plug and sensor head.
Optical budget[20]	Minimal 25 dB
Analog sampling rate	16 kHz
ADC type	10-bit successive approximation
Transmitter	
Type	LED
Wavelength	λ = 650 nm
Transmitter power	Minimum 0 dBm Maximum 2 dBm
Numerical aperture	0.5 [21]
Signal rate connection test	1 pulse per second
Pulse duration connection test	11 µs

High-Speed Measuring-Transducer Inputs, Voltage/Current (via IO210, IO212)

NOTE

Current and voltage must not be connected at the same time to one measuring-transducer input. Instead, only connect either current or voltage. For EMC reasons, do not connect a line to an unused input (current or voltage).

Use shielded cables.

20 All values in combination with sensors approved by Siemens.

21 Numerical aperture (NA = sin θ (launch angle))

Table 12-1 High-Speed Measuring-Transducer Inputs, Voltage

Differential voltage input channels	IO210: 4[22] IO212: 8[23]
Measuring range	DC -10 V to +10 V
Fault	< 0.5 % of the measuring range
Input impedance	48 kΩ
Max. permissible voltage with respect to ground on the measuring inputs	300 V
Permissible overload	DC 20 V continuously DC 60 V continuously (IO210 MT3 terminal point C9)

Table 12-2 High-Speed Measuring-Transducer Inputs, Current

Differential current input channels	IO210: 4[24] IO212: 8[25]
Measuring range	DC -20 mA to +20 mA
Fault	< 0.5 % of the measuring range
Input impedance, current	12 Ω
Permissible potential difference between channels	DC 3.5 kV
Galvanic separation with respect to ground/housing	DC 3.5 kV
Permissible current overload	DC 100 mA continuously

Table 12-3 Common Data for the Fast Measuring-Transducer Inputs, Voltage/Current

Conversion principle	Delta-sigma (16 bit)
Insulation test voltage between the channels	DC 3.5 kV
Insulation test voltage with respect to ground/housing	DC 3.5 kV
Measured-value repetition	62.5 µs
Insulation class IO210	ELV (Extra Low Voltage) (as per IEC 60255-27)
Insulation class IO212	SELV (as per IEC 60255-27)

Temperature Inputs

Settings	Value	Note
Insulation class	PELV (Protective Extra Low Voltage) (acc. to IEC 60255-27)	–
Measurement mode	• Pt 100 Ω • Ni 100 Ω • Ni 120 Ω 3-wire connection, shielded cables	–
Connector type	16-pin, 17-pin terminal spring	–

22 The IO210 has 4 high-speed measuring-transducer inputs. They can be used either as a voltage or current input.
23 The IO212 has 8 high-speed measuring-transducer inputs. They can be used either as a voltage or current input.
24 The IO210 has 4 high-speed measuring-transducer inputs. They can be used either as a voltage or current input.
25 The IO212 has 8 high-speed measuring-transducer inputs. They can be used either as a voltage or current input.

Settings	Value	Note
Temperature measuring range	-65 °C to +710 °C	For PT100
	-50 °C to +250 °C	For NI100
	-50 °C to +250 °C	For NI120

Temperature Inputs (via Module IO240)

Settings	Value
Sensor Type	PT100 (Class F 0.3 EN 60751) 4-wire shielded cable connection
Measurement range	-50 °C to +150 °C Shot circuit and broken-wire detection
Accuracy	±1 °C

LPIT Digital Input (via Module IO240)

Shield Cover Input	
Sensor type	Dry contact input
Measurement type	Output voltage of 1 mA current injection @ max. DC 5 V

12.1.2 Supply Voltage

Integrated Power Supply			
For modular devices, the following modules contain a power supply: PS201 – Power supply of the base module and of the 1st device row PS203 – Power supply of the 2nd device row PS204 – Redundant power supply CB202 – Plug-in module assembly with integrated power supply, for example, to accommodate communication modules			
Permissible voltage ranges (PS201, PS203, PS204, CB202)	DC 19 V to DC 60 V	DC 48 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz	
Auxiliary rated voltage V_H (PS201, PS203, PS204, CB202)	DC 24 V/DC 48 V	DC 60 V/DC 110 V/DC 125 V/DC 220 V/ DC 250 V or AC 100 V/AC 115 V/AC 230 V, 50 Hz/60 Hz	
Permissible voltage ranges (PS101) Only for non-modular devices	DC 19 V to DC 60 V	DC 48 V to 150 V	DC 88 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz
Auxiliary rated voltage V_H (PS101) Only for non-modular devices	DC 24 V/DC 48 V	DC 60 V/DC 110 V/ DC 125 V	DC 110 V/ DC 125 V/ DC 220 V/DC 250 V or AC 100 V/AC 115 V/ AC 230 V, 50 Hz/60 Hz
Superimposed alternating voltage, peak-to-peak, IEC 60255-11, IEC 61000-4-17	≤ 15 % of the DC auxiliary rated voltage (applies only to direct voltage)		
Inrush current	≤ 18 A		

Integrated Power Supply			
Recommended external protection	Miniature circuit breaker 6 A, characteristic C according to IEC 60898		
Internal fuse			
–	DC 24 V to DC 48 V	DC 60 V to DC 125 V	DC 24 V to DC 48 V AC 100 V to AC 230 V
PS101 Only for non-modular devices	4 A inert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	
PS201, PS203, CB202 (to device version xA)	4 A inert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	
PS201, PS203, PS204, CB202 (Device version xB and higher)	4 A inert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	3.15 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	
Power consumption (life relay active)			
–	DC	AC 230 V/50 Hz	AC 115 V/50 Hz
1/3 module, non-modular Without plug-in modules	7 W	16 VA	12.5 VA
1/3 base module, modular Without plug-in modules	13 W	55 VA	40 VA
1/6 expansion module	3 W	6 VA	6 VA
1/6 plug-in module assembly without plug-in modules (modules CB202)	3.5 W	14 VA	7 VA
Plug-in module for base module or plug-in module assembly (for example, communication module)	< 5 W	< 6 VA	< 6 VA
Stored-energy time for auxiliary voltage outage or short circuit, modular devices IEC 61000-4-11 IEC 61000-4-29		For V ≥ DC 24 V ≥ 50 ms For V ≥ DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 50 ms	
Stored-energy time for auxiliary voltage outage or short circuit, non-modular devices IEC 61000-4-11 IEC 61000-4-29		For V ≥ DC 24 V ≥ 20 ms For V ≥ DC 60 V ≥ 50 ms For V ≥ AC 115 V ≥ 200 ms	

12.1.3 Binary Inputs

Standard Binary Input

Rated voltage range	DC 24 V to 250 V The binary inputs of SIPROTEC 5 are bipolar, with the exception of the binary inputs on the modules IO230, IO231, and IO233.	
Current consumption, excited	Approx. DC 0.6 mA to 2.5 mA (independent of the control voltage)	
Power consumption, max.	0.6 W	
Pickup time	Approx. 3 ms	
Dropout time[26]	Capacitive load (supply-line capacitance)	Dropout time
	< 5 nF	< 4 ms
	< 10 nF	< 6 ms
	< 50 nF	< 10 ms
	< 220 nF	< 35 ms
Control voltage for all modules with binary inputs, except module IO233	Adapt the binary-input threshold to be set in the device to the control voltage.	
	Range 1 for 24 V, 48 V, and 60 V Control voltage	V_{low} ≤ DC 10 V V_{high} ≥ DC 19 V
	Range 2 for 110 V and 125 V Control voltage	V_{low} ≤ DC 44 V V_{high} ≥ DC 88 V
	Range 3 for 220 V and 250 V Control voltage	V_{low} ≤ DC 88 V V_{high} ≥ DC 176 V
Control voltage for binary inputs of the IO233 module	Range for 125 V Control voltage	V_{low} ≤ DC 85 V V_{high} ≥ DC 105 V
Maximum permitted voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. To ensure EMC immunity, use the terminals shown in the terminal diagrams/connection diagrams to connect the binary inputs to the common potential.		

Special Binary Input with Maximized Robustness against Electrical Disturbances and Failures (IO216)

Rated voltage range	DC 220 V The special binary inputs of the SIPROTEC 5 with maximized robustness against electrical disturbances and failures are bipolar and available only on the module IO216.
Input impedance	50 kΩ to 60 kΩ
Rejection pulse charge	> 200 µC
Current consumption, excited	Approx. DC 1.2 mA to 2.0 mA (additionally to the current consumption of the input impedance)
Power consumption, max.	1.5 W at DC 242 V
Pickup time	Approx. 3 ms

26 For time-critical applications with low-active signals, consider the specified dropout times. If necessary, provide for active discharge of the binary input (for example, a resistor in parallel to the binary input or using a change-over contact).

Dropout time[27]	Capacitive load (supply-line capacitance)	Dropout time
	< 5 nF	< 3 ms
	< 10 nF	< 4 ms
	< 50 nF	< 5 ms
	< 220 nF	< 10 ms
Control voltage for the module IO216	Range for 220 V control voltage	
	Threshold pickup	158 V to 170 V
	Threshold dropout	132 V to 154 V
Maximum permitted voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. To ensure EMC immunity, use the terminals shown in the terminal diagrams/connection diagrams to connect the binary inputs to the common potential.		

12.1.4 Relay Outputs

Standard Relay (Type S)

Making capacity	Max. 1000 W (L/R = 40 ms) Max. 3600 VA (power factor ≤ 0.35, 50 Hz to 60 Hz)
Breaking capacity	Max. 30 W (L/R = 40 ms) Max. 360 VA (power factor ≤ 0.35, 50 Hz to 60 Hz)
AC and DC contact voltage	250 V
Permissible current per contact (continuous)	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Make time: typical: 8 ms; maximum: 10 ms Break time: typical: 2 ms; maximum: 5 ms
Max. rated data of the output contacts in accordance with UL certification	DC 24 V, 5 A, General Purpose DC 48 V, 0.8 A, General Purpose DC 240 V, 0.1 A, General Purpose AC 240 V, 5 A, General Purpose AC 120 V, 1/6 hp AC 250 V, 1/2 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V

Fast Relay (Type F)

Making capacity	Max. 1000 W (L/R = 40 ms) Max. 3600 VA (power factor ≤ 0.35, 50 Hz to 60 Hz)
Breaking capacity	Max. 30 W (L/R = 40 ms) Max. 360 VA (power factor ≤ 0.35, 50 Hz to 60 Hz)
AC and DC contact voltage	250 V

27 For time-critical applications with low-active signals, consider the specified dropout times. If necessary, provide for active discharge of the binary input (for example, a resistor in parallel to the binary input or using a change-over contact).

Permissible current per contact (continuous)	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Make time: typical: 4 ms; maximum: 5 ms Break time: typical: 2 ms; maximum: 5 ms
Rated data of the output contacts in accordance with UL certification	DC 24 V, 5 A, General Purpose DC 48 V, 0.8 A, General Purpose DC 240 V, 0.1 A, General Purpose AC 120 V, 5 A, General Purpose AC 250 V, 5 A, General Purpose AC 250 V, 0.5 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Supervision	2-channel activation with cyclic testing (only for make contact)

High-Speed Relay with Semiconductor Acceleration (Type HS)

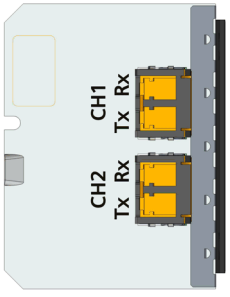
Making capacity	Max. 2500 W (L/R = 40 ms) Max. 3600 VA (power factor ≤ 0.35, 50 Hz to 60 Hz)
Breaking capacity	Max. 2500 W (L/R = 40 ms) Max. 360 VA (power factor ≤ 0.35, 50 Hz to 60 Hz)
Contact voltage	AC 200 V, DC 250 V
Permissible current per contact (continuous)	5 A (according to UL certification) 10 A (no UL certification; AWG 14 / 2.5-mm^2 (0.0039-in^2) copper conductors necessary)
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Make time, typical: 0.2 ms; maximum: 0.2 ms Break time, typical: 9 ms; maximum: 9 ms
Rated data of the output contacts in accordance with UL certification	B150 Q300

Power Relay (for Direct Control of Motor Switches)

Switching power for permanent and periodic operation		
250 V/4.0 A	1000 W	In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
220 V/4.5 A	1000 W	
110 V/5.0 A	550 W	
60 V/5.0 A	300 W	
48 V/5.0 A	240 W	
24 V/5.0 A	120 W	

Turn on switching power for 30 s, recovery time until switching on again is 15 minutes. For short-term switching operations, an impulse/pause ratio of 3 % must be considered.		
100 V/9.0 A 60 V/10.0 A 48 V/10.0 A 24 V/10.0 A	1000 W 600 W 480 W 240 W	Continuous and inching operation is not permitted. In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
AC and DC contact voltage		250 V
Permissible continuous current per contact		5 A
Permissible current per contact (switching on and holding)		30 A for 1 s
Short-time current across closed contact		250 A for 30 ms
Total permissible current for contacts connected to common potential		5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used		≤ 16 ms
Rated data of the output contacts in accordance with UL certification		DC 300 V, 4.5 A - 30 s ON, 15 min OFF DC 250 V, 1 hp motor - 30 s ON, 15 min OFF DC 110 V, 3/4 hp motor - 30 s ON, 15 min OFF DC 60 V, 10 A, 1/2 hp motor - 30 s ON, 15 min OFF DC 48 V, 10 A, 1/3 hp motor - 30 s ON, 15 min OFF DC 24 V, 10 A, 1/6 hp motor - 30 s ON, 15 min OFF
Interference suppression capacitors across the contacts		4.7 nF, ± 20 %, AC 250 V
The power relays operate in interlocked mode, that is, only one relay of each switching pair picks up at a time thereby avoiding a power-supply short circuit.		

12.1.5 ETH-BD-2FO

Description	Communication module for the transmission of Ethernet protocols via 2 optical interfaces, suitable for Process-bus client, Merging Unit, and ultrafast GOOSE
Product code	P1Zxxxxxxxxx
Figure	
Connector type	2 x duplex LC
Wavelength	λ = 1300 nm
Baud rate	100 Mbit/s

Protocol	DIGSI 5 protocol (secure Web service protocol) IEC 61850 (MMS and GOOSE) IEC 61850-8-1 (9-2 Client and 9-2 Merging Unit) IEC 60870-5-104 You can switch other network services such as RSTP, PRP, SNTP, and IEEE 1588v2/PTP on and off.
Max. line length	2 km for 62.5 µm/125 µm optical fibers

Transmitter Power	**Minimum**	**Typical**	**Maximum**
50 µm/125 µm, NA[28] = 0.2	-24.0 dBm	-21.0 dBm	-17.0 dBm
62.5 µm/125 µm, NA[28] = 0.275	-20.0 dBm	-17.0 dBm	-14.0 dBm

Receiver sensitivity	Maximum -12.0 dBm Minimum -31.0 dBm
Optical budget	Minimum 7.0 dB for 50 µm/125 µm, NA[28] = 0.2 Minimum 11.0 dB for 62.5 µm/125 µm, NA[28] = 0.275
Interface design	Corresponds to IEEE 802.3, 100Base-FX
Laser class 1 as per EN 60825-1/-2	With the use of 62.5 µm/125 µm and 50 µm/125 µm optical fibers

NOTE

The firmware must be updated to version ≥ V7.90 if using the ETH-BD-2FO module. If the module is connected to a device with a previous version, a hardware failure is reported that disappears with an FW update to V7.90. As this is not an actual hardware failure, there is no need to send in the device.

The ETH-BD-2FO module offers the possibility of replacing the SFPs (Small Form-Factor Pluggable) delivered by default for a communication route of up to 2 km by SFPs that can be ordered separately in order to adapt the interface to different transmission media and longer routes.

SFP with Optical Interface for 24 km, Single Mode

Description	SFP for distances up to 24 km when using singlemode optical fibers
Product code	P1Zxxxxxxxxx
Connector type	Duplex LC
Wavelength	λ = 1300 nm
Baud rate	100 Mbit/s
Protocol	See information for the module ETH-BD-2FO
Max. line length	24 km for 9 µm/125 µm optical fibers

Distance 24 km	
Laser class 1 as per EN 60825-1/-2	With the use of 9 µm/125 µm optical fibers

Transmitter Power	**Minimum**	**Maximum**
Transmitter power coupled in singlemode optical fibers	-15 dBm	-8 dBm
Receiver sensitivity	-8 dBm	-31dBm
Optical budget	16 dB	–

28 Numerical Aperture (NA = sin θ [launch angle])

SFP with Electrical Interface

Description	SFP with RJ45 connector, for Ethernet protocols via an electrical interface
Product code	P1Zxxxxxxxxx
Connector type	RJ45
Baud rate	100 Mbit/s
Protocol	See information for the module ETH-BD-2FO
Max. line length	20 m with Ethernet patch cable CAT 6 S/FTP, F/FTP, or SF/FTP
Interface design	Corresponds to IEEE 802.3, 100Base-TX

Removing SFP Pluggable Transceivers

CAUTION

Risk of burns due to high temperatures of the SFP pluggable transceivers

Noncompliance with the safety notes may result in medium or light injuries.

- ✧ The SFP pluggable transceivers can be disconnected and plugged in while in operation. Siemens recommends switching off the device.
- ✧ Allow the SFP pluggable transceiver to cool as much as possible.

- ✧ Remove the connecting cables or the dust protection cap that was plugged on in the delivery state from the SFP pluggable transceiver.
- ✧ In order to release the interlocking, open the bracket on the SFP pluggable transceiver.
- ✧ Pull on the bracket in order to pull the SFP pluggable transceiver out of the slot. The removal must be possible with free movement and without great exertion of force.
- ✧ Provide the SFP pluggable transceiver with the dust protection cap so that the optics are protected from contamination.

Mounting SFP Pluggable Transceivers

- ✧ Check whether the bracket on the SFP pluggable transceiver is closed.
  The bracket must be closed.
- ✧ Insert the pluggable transceiver into the slot until it audibly locks in place.
  The SFP is securely fixed in the slot.

NOTE

Check for secure positioning of the transceiver in the slot and whether it is locked in place in order to avoid unintentional removal by pulling on the connection line.

12.1.6 Design Data

Masses

	Device Size Weight of the Modular Devices				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	4.4 kg	7.2 kg	9.9 kg	12.7 kg	15.5 kg

	Device Size Weight of the Modular Devices				
Surface-mounted device with integrated on-site operation panel	7.4 kg	11.7 kg	15.9 kg	20.2 kg	24.5 kg
Surface-mounted device with detached on-site operation panel	4.7 kg	7.8 kg	10.8 kg	13.9 kg	17.0 kg

	Size	Weight
Detached on-site operation panel	1/3	1.9 kg
Detached on-site operation panel	1/6	1.1 kg

	Device Size Weight of the Non-Modular Devices 7xx81, 7xx82
Type of construction	1/3
Flush-mounting device	3.6 kg
Bracket for non-modular surface-mounted variant	1.9 kg

Dimensions of the Base and 1/3 Modules

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth (incl. Current Terminal), Width and Depth Each Rounded up to the Next Full mm (in Inches)
Flush-mounting device	150 mm x 266 mm x 229 mm (5.91 x 10.47 x 9.02)
Surface-mounted device with integrated on-site operation panel	150 mm x 314 mm x 337 mm (5.91 x 12.36 x 13.27)
Surface-mounted device with detached on-site operation panel	150 mm x 314 mm x 230 mm (5.91 x 12.36 x 9.06)

Dimensions of the Device Rows

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth (incl. Current Terminal), Width and Depth Each Rounded up to the Next Full mm (in Inches)				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	150 mm x 266 mm x 229 mm (5.91 x 10.47 x 9.02)	225 mm x 266 mm x 229 mm (8.86 x 10.47 x 9.02)	300 mm x 266 mm x 229 mm (11.81 x 10.47 x 9.02)	375 mm x 266 mm x 229 mm (14.76 x 10.47 x 9.02)	450 mm x 266 mm x 229 mm (17.72 x 10.47 x 9.02)
Surface-mounted device with integrated on-site operation panel	150 mm x 314 mm x 337 mm (5.91 x 12.36 x 13.27)	225 mm x 314 mm x 337 mm (8.86 x 12.36 x 13.27)	300 mm x 314 mm x 337 mm (11.81 x 12.36 x 13.27)	375 mm x 314 mm x 337 mm (14.76 x 12.36 x 13.27)	450 mm x 314 mm x 337 mm (17.72 x 12.36 x 13.27)
Surface-mounted device with detached on-site operation panel	150 mm x 314 mm x 230 mm (5.91 x 12.36 x 9.06)	225 mm x 314 mm x 230 mm (8.86 x 12.36 x 9.06)	300 mm x 314 mm x 230 mm (11.81 x 12.36 x 9.06)	375 mm x 314 mm x 230 mm (14.76 x 12.36 x 9.06)	450 mm x 314 mm x 230 mm (17.72 x 12.36 x 9.06)

Expansion Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth, Width and Depth Each Rounded up to the Next Full mm (in Inches)
Flush-mounting device	75 mm x 266 mm x 229 mm (2.95 x 10.47 x 9.02)
Surface-mounted device with integrated on-site operation panel	75 mm x 314 mm x 337 mm (2.95 x 12.36 x 13.27)
Surface-mounted device with detached on-site operation panel	75 mm x 314 mm x 230 mm (2.95 x 12.36 x 9.06)

Plug-In Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth (in Inches)
USART-Ax-xEL, ETH-Bx-xEL	61 mm x 45 mm x 120.5 mm (2.4 x 1.77 x 4.74)
USART-Ax-xFO, ETH-Bx-xFO (without protection cover)	61 mm x 45 mm x 132.5 mm (2.4 x 1.77 x 5.22)
ANAI-CA-4EL	61 mm x 45 mm x 119.5 mm (2.4 x 1.77 x 4.7)
ARC-CD-3FO	61 mm x 45 mm x 120.5 mm (2.4 x 1.77 x 4.74)

Minimum Bending Radii of the Connecting Cables Between the On-Site Operation Panel and the Base Module

Fiber-optic cable	R = 50 mm Pay attention to the length of the cable protection sleeve, which you must also include in calculations.
D-Sub cable	R = 50 mm (minimum bending radius)

Degree of Protection According to IEC 60529

For equipment in the surface-mounted housing	IP54[29] for front
For equipment in the flush-mounting housing	IP54[29] for front
For operator protection (back side)	IP2x for current terminal (installed) IP2x for voltage terminal (installed)
Degree of pollution, IEC 60255-27	2
Maximum operating altitude above sea level	2000 m (6561.68 ft)

UL Note

Type 1 if mounted into a door or front cover of an enclosure. When expanding the device with the 2nd device row, then they must be mounted completely inside an enclosure.

29 The provided plug-in label must be used for expansion modules with LEDs.

Tightening Torques for Terminal Screws

Type of Line	Current Terminal	Voltage Terminal with Spring-Loaded Terminals	Voltage Terminal with Screw Connection
Stranded wires with ring-type lug	2.7 Nm	No ring-type lug	No ring-type lug
Stranded wires with boot-lace ferrules or pin-type lugs	2.7 Nm	1.0 Nm	0.6 Nm
Solid conductor, bare (2 mm^2)	2.0 Nm	1.0 Nm	–
Bare stranded wire	Not permitted	1 Nm	0.6 Nm

NOTE

For current and voltage terminals, the maximum speed of the tool must not exceed 640 rpm.

NOTE

Use copper cables only.

Torques for Other Screw Types

Screw Type	Torque
M4 x 20	1.2 Nm
M4 x 8	1.2 Nm
M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 8	0.39 Nm
Collar screw, M4 x 20	0.7 Nm

12.2 Date and Time Synchronization

Date format	DD.MM.YYYY (Europe)
	MM/DD/YYYY (USA)
	YYYY-MM-DD (China)
Time source 1, time source 2	None
	IRIG-B 002(003) IRIG-B 006(007) IRIG-B 005(004) with extension according to IEEE C37.118-2005
	DCF77
	PI (protection interface) [30]
	SNTP
	IEC 60870-5-103
	DNP3
	IEEE 1588
	T104
Time zone 1, time zone 2	Local
	UTC
Failure indication after	0 s to 3600 s
Time zone and daylight saving time	Manually setting the time zones
Time zone offset with respect to GMT	-720 min to 840 min
Switching over to daylight saving time	Active
	Inactive
Beginning of daylight saving time	Input: day and time
End of daylight saving time	Input: day and time
Offset daylight saving time	0 min to 120 min [steps of 15]

30 If provided

12.3 Circuit-Breaker Failure Protection

Starting Conditions

For circuit-breaker failure protection	1-pole tripping internal or external[31]
	3-pole tripping internal or external[32]

Setting Values

Phase-current threshold values	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value sensitive	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Supervision time of release signal		0.00 s to 1.00 s	Increments of 0.01 s
Time delays T1		0.000 s to 60.000 s	Increments of 0.001 s
Time delays T2		0.050 s to 60.000 s	Increments of 0.001 s
Supervision times of binary inputs		0.05 s to 60.00 s	Increments of 0.01 s

Dropout

The larger dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies to the current threshold values.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Circuit-Breaker Supervision

Supervision of circuit-breaker auxiliary-contact position	
For 3-pole CB tripping	1 input each for make contact and break contact
For 1-pole CB tripping	1 input each for auxiliary contact per pole or 1 input for each series connection make contact and break contact

NOTE

The circuit-breaker failure protection can also work without the circuit-breaker auxiliary contacts stated.

Auxiliary contacts are required for circuit-breaker failure protection in cases where the current flow is absent or too low for tripping (for example with a transformer or a Buchholz protection).

31 Via binary inputs

32 Via binary inputs

Times

Pickup time, in the case of an internal start Pickup time, in the case of an external start	< 1 ms < 5 ms
Typical dropout time	< 15 ms
Dropout time, via circuit-breaker auxiliary-contact criterion[33]	< 5 ms

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Threshold values, dropout thresholds	2 % of the setting value or 1 % of the rated current
Times	1 % of the setting value or 10 ms

33 When using transformer connection type **2ph, 2p. CT + IN-sep**, slightly expanded tolerances occur

12.4 Circuit-Breaker Restrike Protection

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Monitoring duration		1.00 s to 600.00 s	Increments of 0.01 s
Position recognition delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Trip delay time		0.05 s to 60.00 s	Increments of 0.01 s
Retrip delay time		0.00 s to 60.00 s	Increments of 0.01 s
Minimum operate (trip) time		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Threshold	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

12.5 Circuit-Breaker Supervision

Setting Values

Supervision time	1.00 s to 180.00 s	Increments of 0.01 s

12.6 Overcurrent Protection, Phases

12.6.1 Stage with Definite-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value[34]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Operate delay		0.00 s to 100.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT [35] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

34 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

35 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[36] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [37]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [38]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [39]
Time delays	1 % of the setting value or 10 ms

36 In case that the filter response exactly matches the user-defined gain factors

37 In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.

38 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

39 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.6.2 Stage with Inverse-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

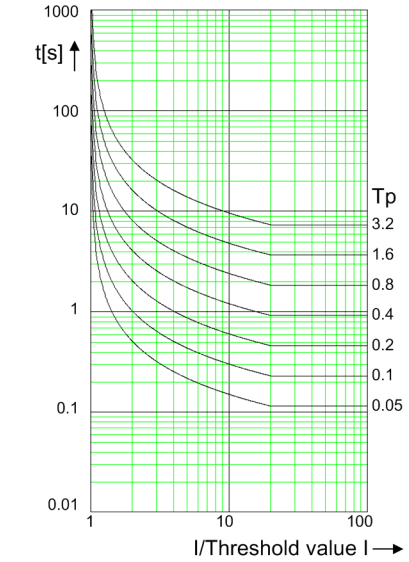
Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

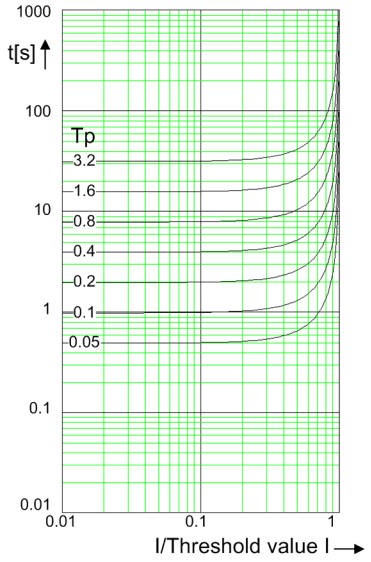
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

NORMAL INVERSE: Type A



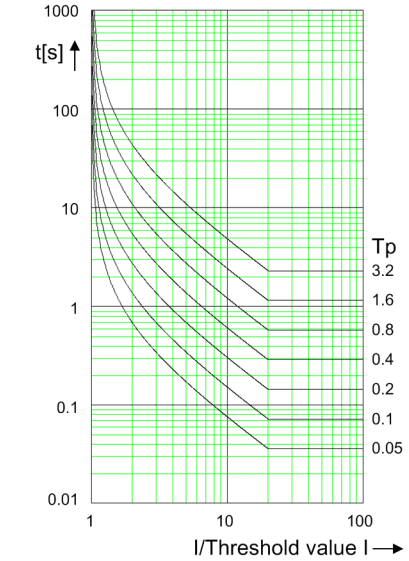
$$t = \frac{0.14}{(I/\text{Threshold value } I)^{0.02} - 1} \cdot T_p \ [s]$$

RESET NORMAL INVERSE: Type A



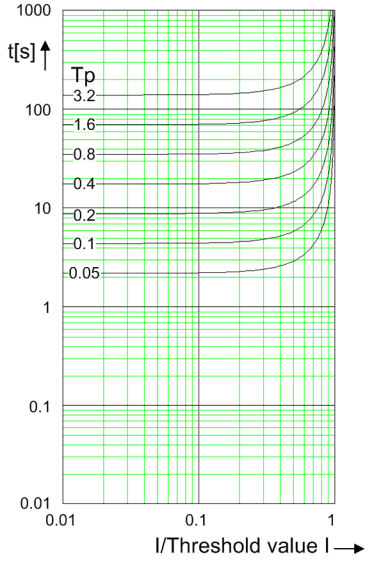
$$t = \frac{9.7}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

VERY INVERSE: Type B



$$t = \frac{13.5}{(I/\text{Threshold value } I)^{1} - 1} \cdot T_p \ [s]$$

RESET VERY INVERSE: Type B

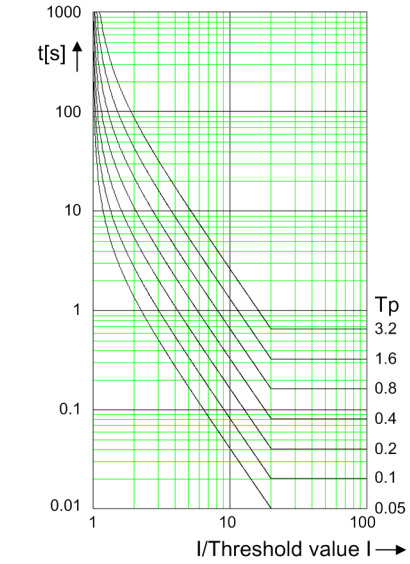


$$t = \frac{43.2}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

[dwocpki1-080213-01.tif, 1, en_US]

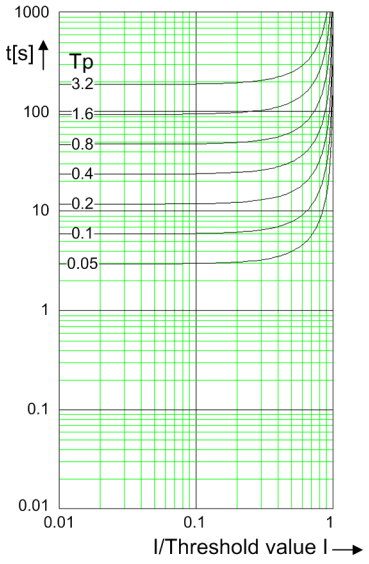
Figure 12-1 Operate Curves and Dropout-Time Characteristic Curves According to IEC

EXTREMELY INVERSE: Type C



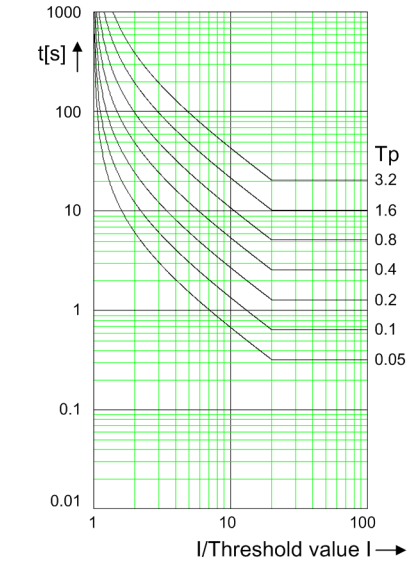
$$t = \frac{80}{(I/\text{Threshold value } I)^2 - 1} \cdot T_p \ [s]$$

RESET EXTREMELY INVERSE: Type C



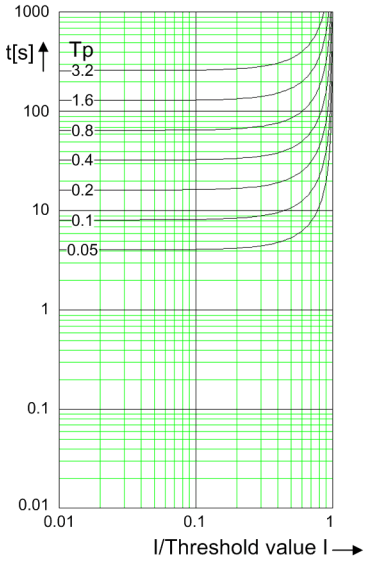
$$t = \frac{58.2}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

LONG-TIME INVERSE: Type B



$$t = \frac{120}{(I/\text{Threshold value } I)^1 - 1} \cdot T_p \ [s]$$

RESET LONG-TIME INVERSE: Type B



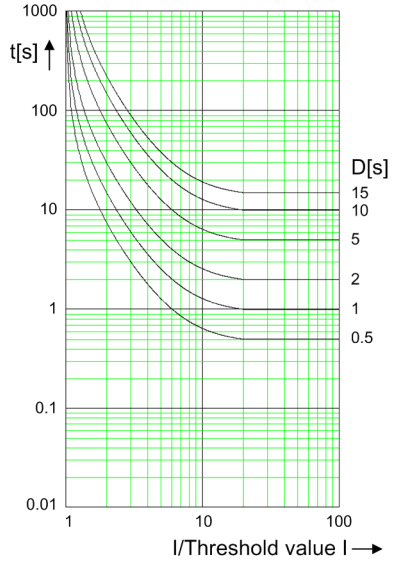
$$t = \frac{80}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

[dwocpki2-080213-01.tif, 1, en_US]

Figure 12-2 Operate Curves and Dropout-Time Characteristic Curves According to IEC

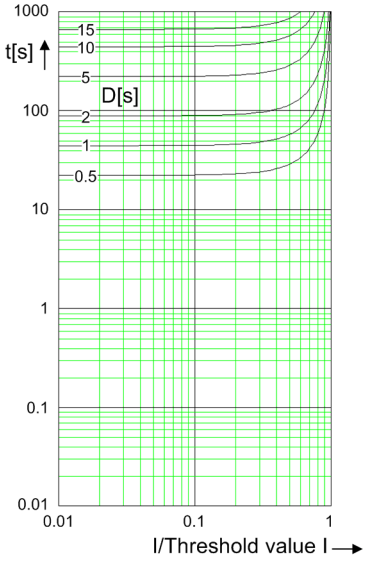
Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Inverse: Type C



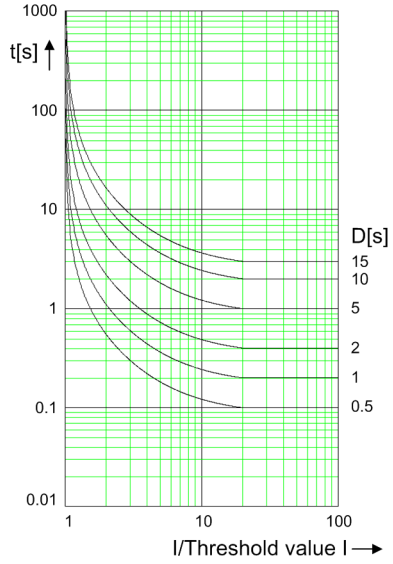
$$t = \left(\frac{44.6705}{\left(\text{I/Threshold value I} \right)^{2.0938} - 1} + 0.8983 \right) \cdot D \quad [s]$$

RESET INVERSE: Type C



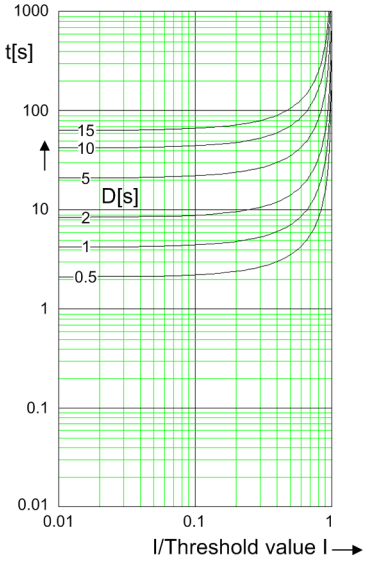
$$t = \frac{44}{1 - \left(\text{I/Threshold value I} \right)^{2.0938}} \cdot D \quad [s]$$

SHORT INVERSE



$$t = \left(\frac{1.3315}{\left(\text{I/Threshold value I} \right)^{1.2969} - 1} + 0.16965 \right) \cdot D \quad [s]$$

RESET SHORT INVERSE

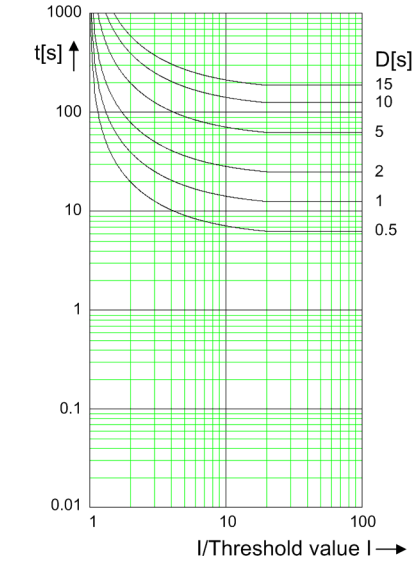


$$t = \frac{4.155}{1 - \left(\text{I/Threshold value I} \right)^{1.2969}} \cdot D \quad [s]$$

[dwocpka1-080213-01.tif, 2, en_US]

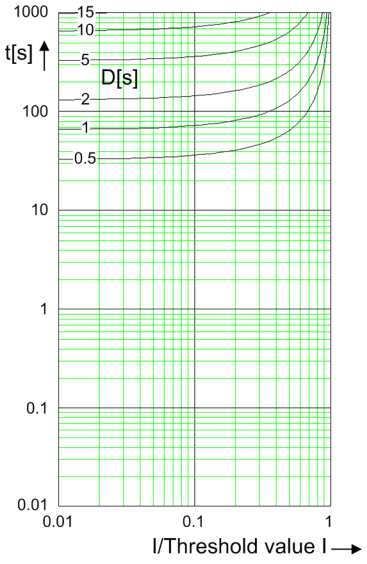
Figure 12-3 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

LONG INVERSE



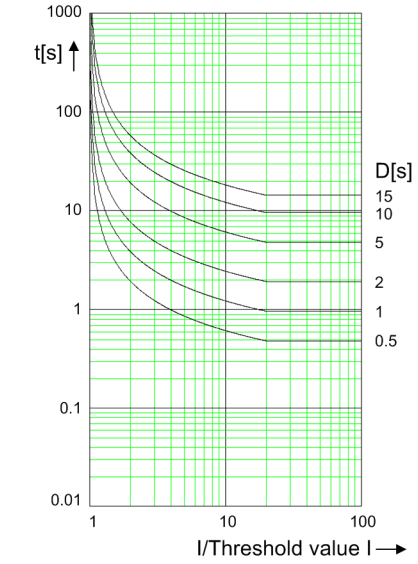
$$t = \left(\frac{28.0715}{\left(\text{I/Threshold value I} \right)^{1} - 1} + 10.9296 \right) \cdot D \quad [s]$$

RESET LONG INVERSE



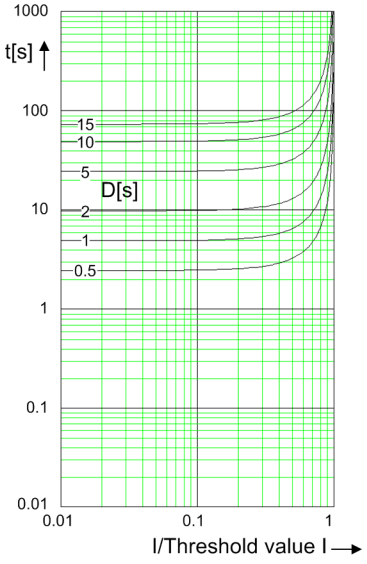
$$t = \frac{64.5}{1 - \left(\text{I/Threshold value I} \right)^{1}} \cdot D \quad [s]$$

MODERATELY INVERSE



$$t = \left(\frac{0.0515}{\left(\text{I/Threshold value I} \right)^{0.02} - 1} + 0.114 \right) \cdot D \quad [s]$$

RESET MODERATELY INVERSE

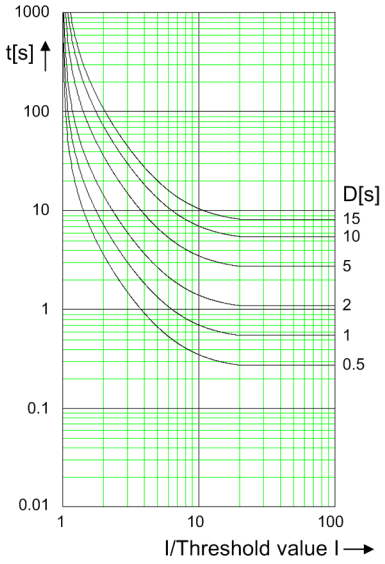


$$t = \frac{4.85}{1 - \left(\text{I/Threshold value I} \right)^{2}} \cdot D \quad [s]$$

[dwocpka2-080213-01.tif, 2, en_US]

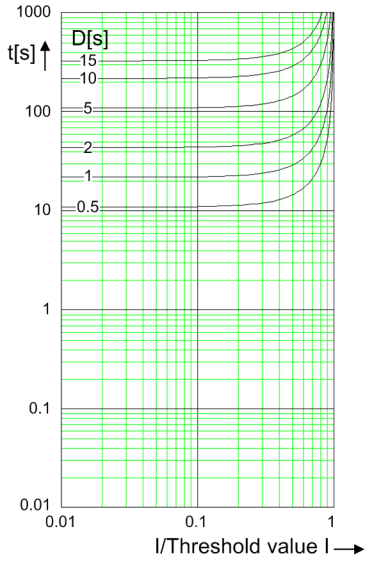
Figure 12-4 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

VERY INVERSE



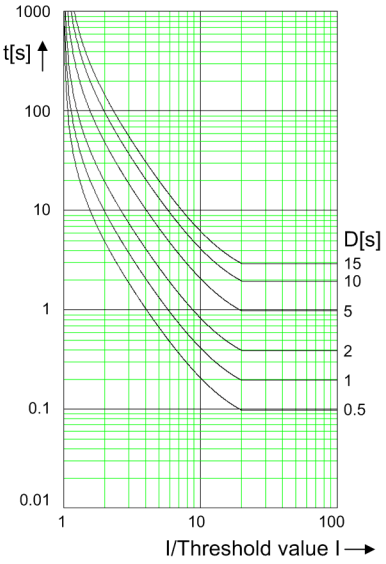
$$t = \left(\frac{19.61}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.491 \right) \cdot D \quad [s]$$

RESET VERY INVERSE



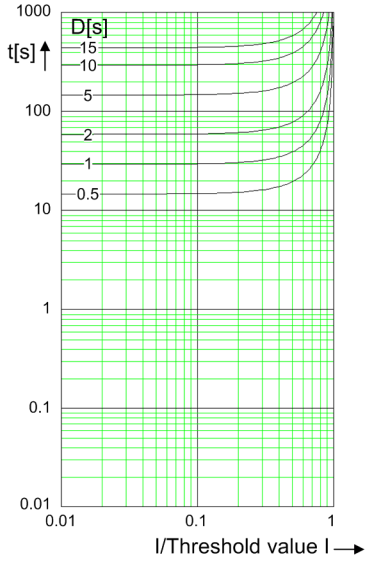
$$t = \frac{21.6}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

EXTREMELY INVERSE



$$t = \left(\frac{28.2}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.1217 \right) \cdot D \quad [s]$$

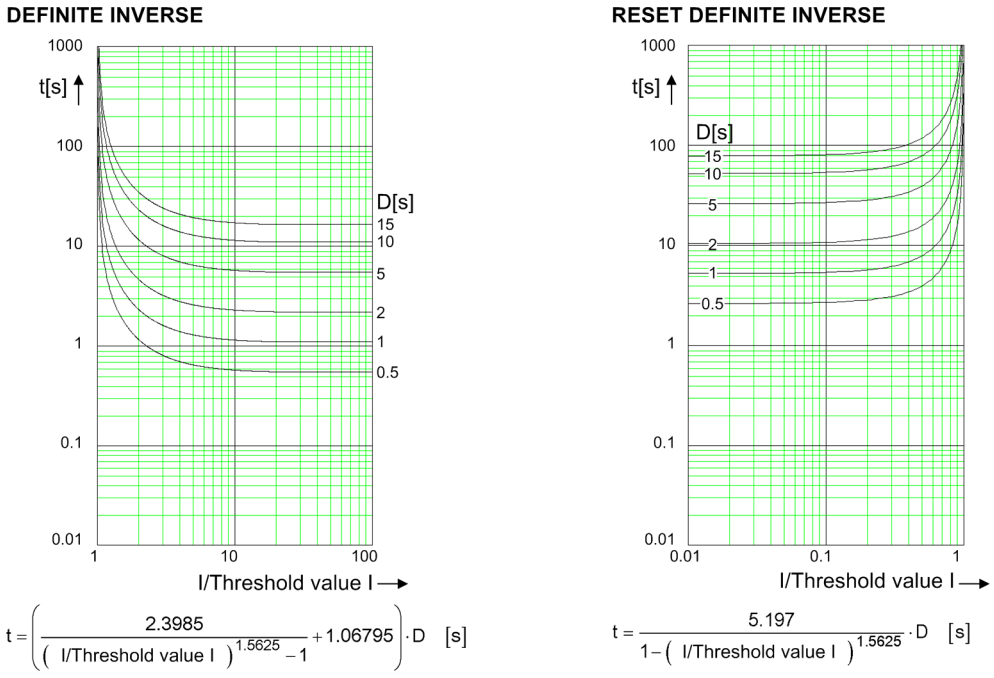
RESET EXTREMELY INVERSE



$$t = \frac{29.1}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

[dwocpka3-080213-01.tif, 2, en_US]

Figure 12-5 Tripping Characteristic Curves and Dropout Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead ot the I threshold.

[dwocpka4-080213-01.tif, 2, en_US]

Figure 12-6 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[40] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [41]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [42]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [43]
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

40 In case that the filter response exactly matches the user-defined gain factors

41 In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.

42 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

43 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

12.7 Overcurrent Protection, Ground

12.7.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[44]	1 A @ 50 and 100 Irated	0.010 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.002 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[45] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

44 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

45 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

3I0 measured via I4[46], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[47], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.7.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[48]	1 A @ 50 and 100 Irated	0.010 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.002 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

46 Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2

47 Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2

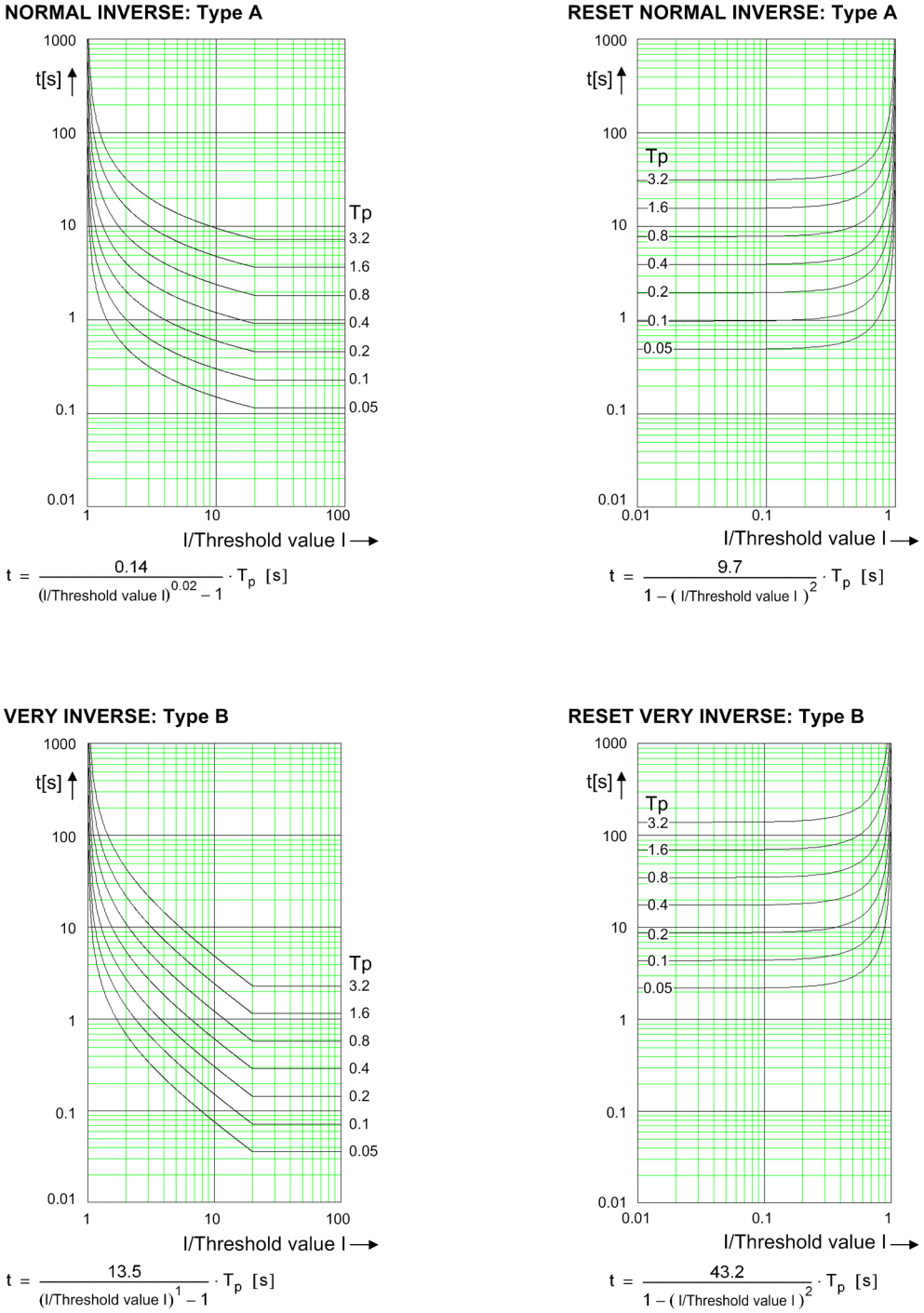
48 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

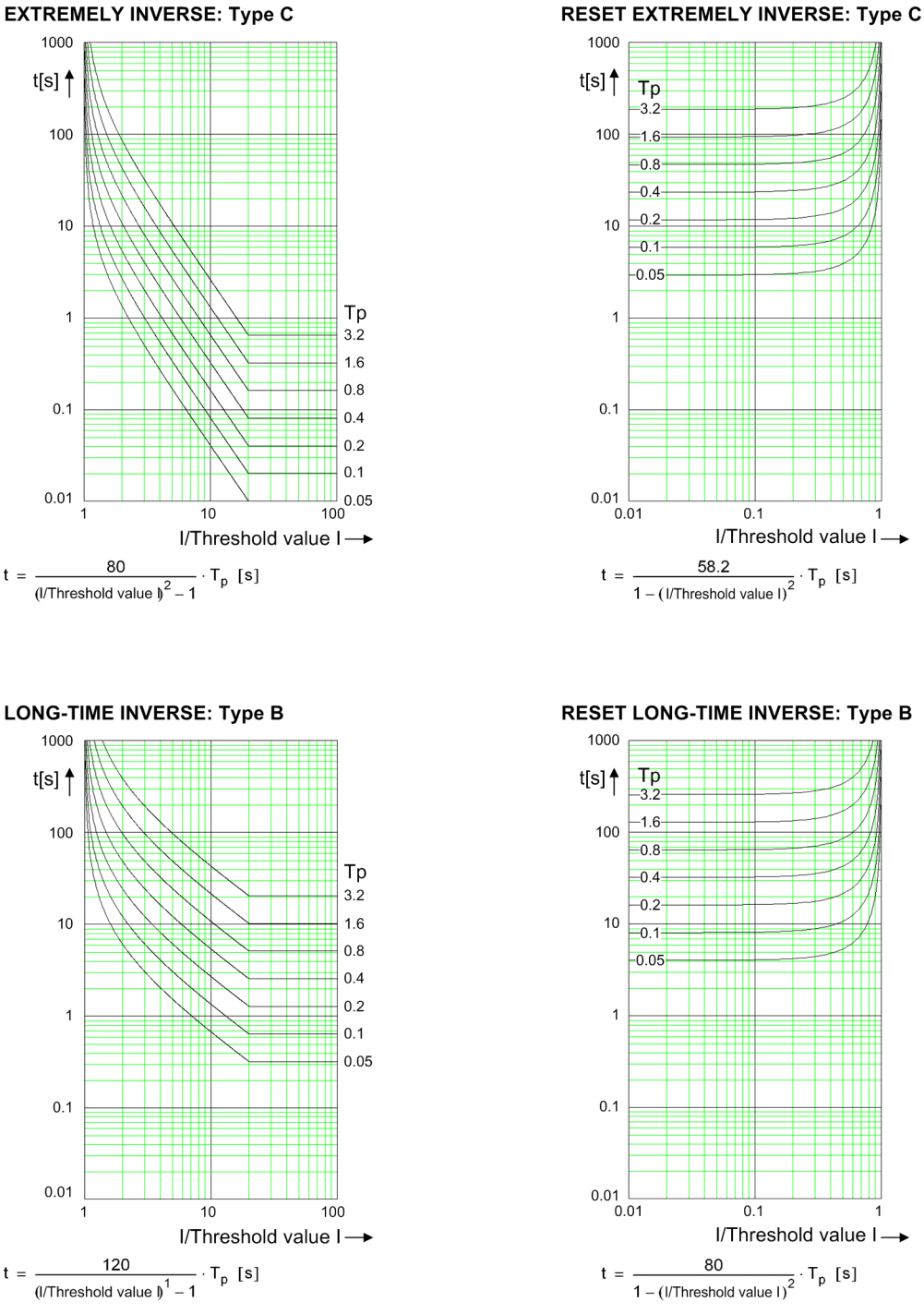
Operate Curves and Dropout Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms



[dwocpki1-080213-01.tif, 1, en_US]

Figure 12-7 Operate Curves and Dropout Characteristic Curves According to IEC

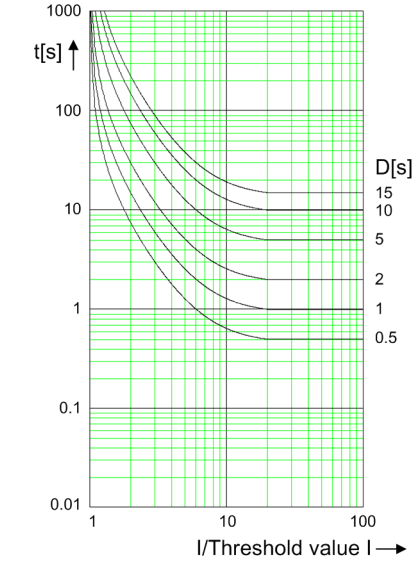


[dwocpki2-080213-01.tif, 1, en_US]

Figure 12-8 Operate Curves and Dropout Characteristic Curves According to IEC

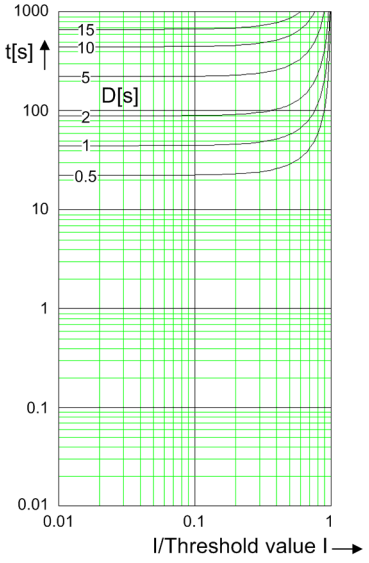
Operate Curves and Dropout Characteristic Curves According to ANSI/IEEE

Inverse: Type C



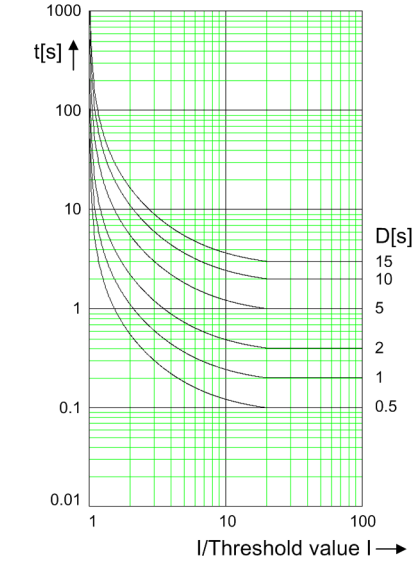
$$t = \left(\frac{44.6705}{\left(\text{I/Threshold value I} \right)^{2.0938} - 1} + 0.8983 \right) \cdot D \quad [s]$$

RESET INVERSE: Type C



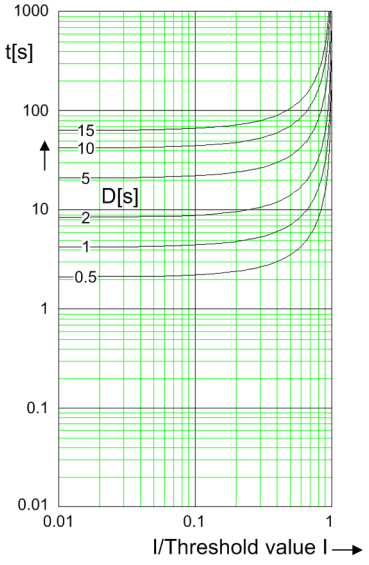
$$t = \frac{44}{1 - \left(\text{I/Threshold value I} \right)^{2.0938}} \cdot D \quad [s]$$

SHORT INVERSE



$$t = \left(\frac{1.3315}{\left(\text{I/Threshold value I} \right)^{1.2969} - 1} + 0.16965 \right) \cdot D \quad [s]$$

RESET SHORT INVERSE

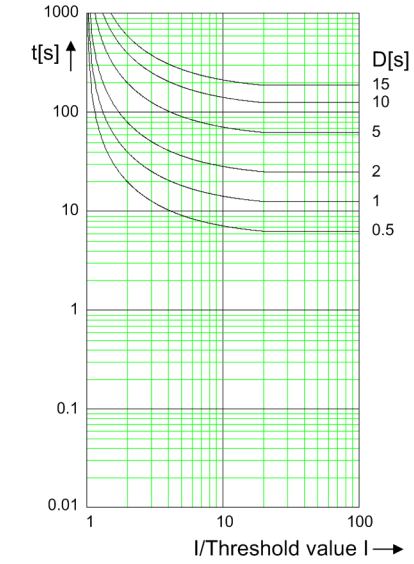


$$t = \frac{4.155}{1 - \left(\text{I/Threshold value I} \right)^{1.2969}} \cdot D \quad [s]$$

[dwocpka1-080213-01.tif, 2, en_US]

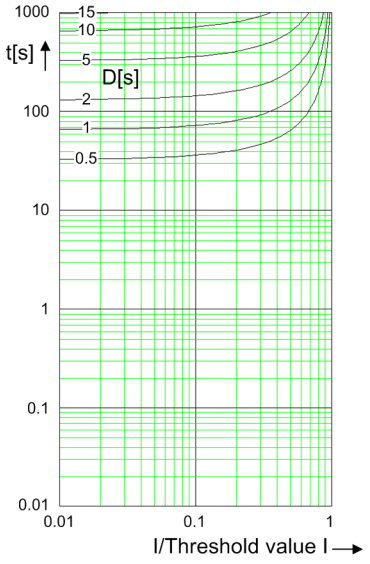
Figure 12-9 Operate Curves and Dropout Characteristic Curves According to ANSI/IEEE

LONG INVERSE



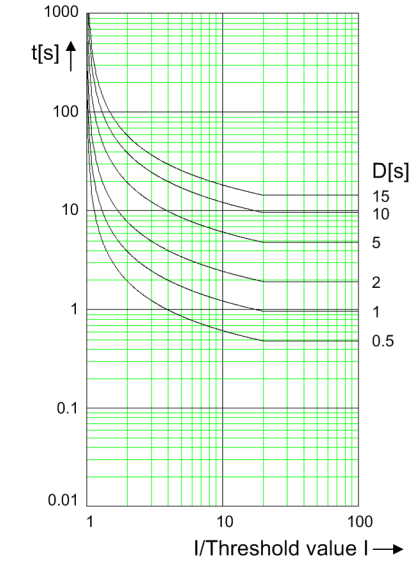
$$t = \left(\frac{28.0715}{\left(\text{I/Threshold value I} \right)^{1} - 1} + 10.9296 \right) \cdot D \quad [s]$$

RESET LONG INVERSE



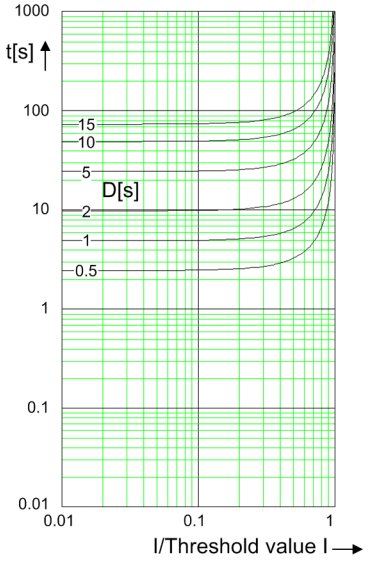
$$t = \frac{64.5}{1 - \left(\text{I/Threshold value I} \right)^{1}} \cdot D \quad [s]$$

MODERATELY INVERSE



$$t = \left(\frac{0.0515}{\left(\text{I/Threshold value I} \right)^{0.02} - 1} + 0.114 \right) \cdot D \quad [s]$$

RESET MODERATELY INVERSE

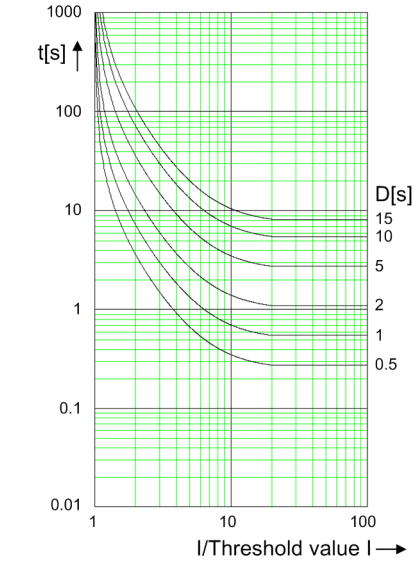


$$t = \frac{4.85}{1 - \left(\text{I/Threshold value I} \right)^{2}} \cdot D \quad [s]$$

[dwocpka2-080213-01.tif, 2, en_US]

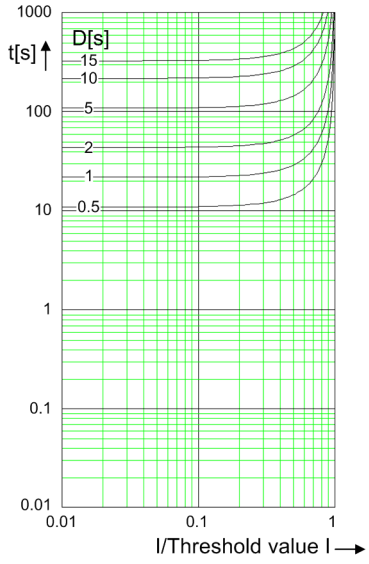
Figure 12-10 Operate Curves and Dropout Characteristic Curves According to ANSI/IEEE

VERY INVERSE



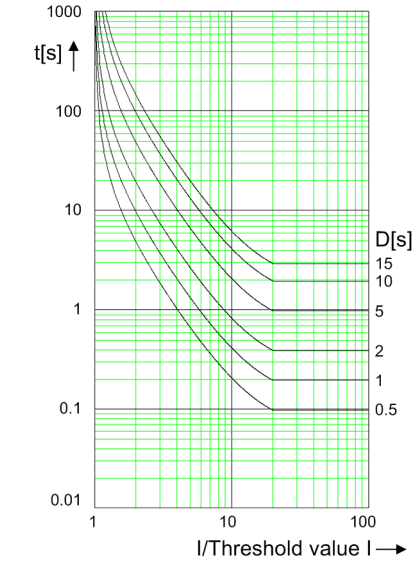
$$t = \left(\frac{19.61}{\left(\frac{I}{I/\text{Threshold value I}} \right)^2 - 1} + 0.491 \right) \cdot D \quad [s]$$

RESET VERY INVERSE



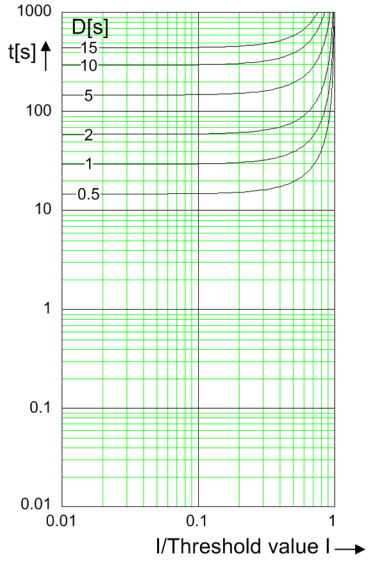
$$t = \frac{21.6}{1 - \left(\frac{I}{I/\text{Threshold value I}} \right)^2} \cdot D \quad [s]$$

EXTREMELY INVERSE



$$t = \left(\frac{28.2}{\left(\frac{I}{I/\text{Threshold value I}} \right)^2 - 1} + 0.1217 \right) \cdot D \quad [s]$$

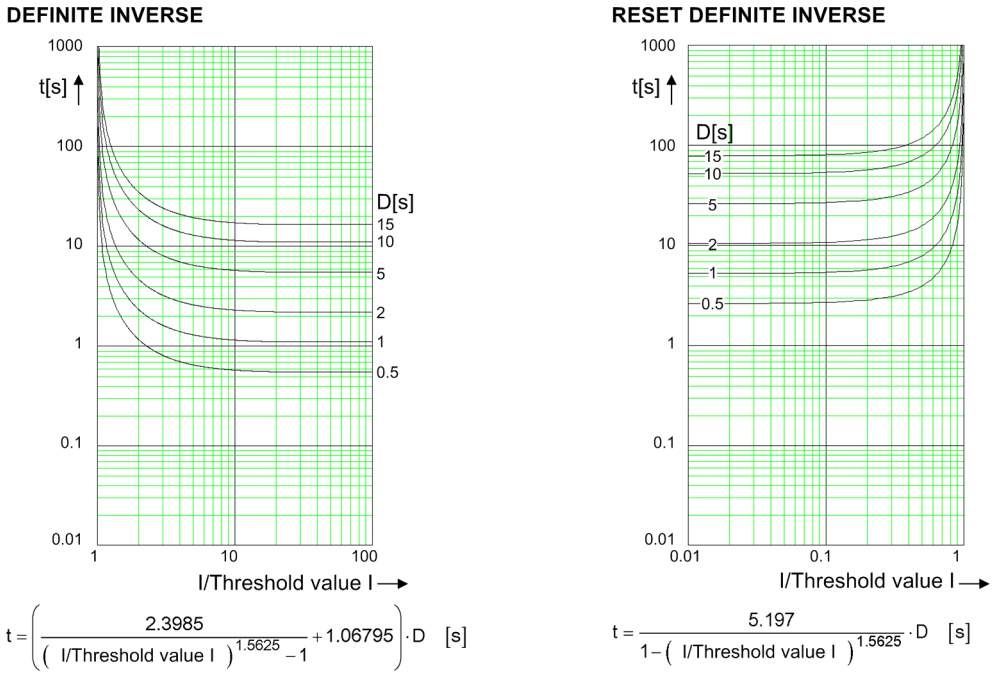
RESET EXTREMELY INVERSE



$$t = \frac{29.1}{1 - \left(\frac{I}{I/\text{Threshold value I}} \right)^2} \cdot D \quad [s]$$

[dwocpka3-080213-01.tif, 2, en_US]

Figure 12-11 Operate Curves and Dropout Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead ot the I threshold.

[dwocpka4-080213-01.tif, 2, en_US]

Figure 12-12 Operate Curves and Dropout Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

3I0 measured via I4[49], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[50], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

49 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

50 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for 2 ≤ I/threshold value I ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.8 Directional Overcurrent Protection, Phases

12.8.1 Stage with Definite-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value[51]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Direction Determination

Type	With healthy voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

51 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [52] at 50 Hz Approx. 31 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delay	1 % of the setting value or 10 ms
Direction-determination angle error	1 °

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.8.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage	-180° to +180°	Increments of 1°
Directional mode	Forward Backward	–
Method of measurement	Fundamental component RMS value	–

52 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Threshold value[53]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	See chapter *12.6.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-1*
Very inverse: type B	
Extremely inverse: type C	See chapter *12.6.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-2*
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	See chapter *12.6.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-3*
Short inverse	
Long inverse	See chapter *12.6.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-4*
Moderately inverse	
Very inverse	See chapter *12.6.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-5*
Extremely inverse	
Definite inverse	See chapter *12.6.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-6*

Direction Determination

Type	With healthy voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°

53 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [54] at 50 Hz Approx. 31 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/threshold value I ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/threshold value I ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

54 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

12.9 Directional Overcurrent Protection, Ground

12.9.1 Stage with Definite-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.2 Stage with Inverse-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Type of characteristic curve		Characteristic curves according to IEC and ANSI	

Dropout	Disk emulation Instantaneous	–
Time multiplier	0.00 to 15.00	Increments of 0.01
Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	Refer to the respective figure of the technical data for the non-dir-OC-ground function *12.7.2 Stage with Inverse-Time Characteristic Curve*
Very inverse: type B	
Extremely inverse: type C	
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	Refer to the respective figure of the technical data for the non-dir-OC-ground function *12.7.2 Stage with Inverse-Time Characteristic Curve*
Short inverse	
Long inverse	
Moderately inverse	
Very inverse	
Extremely inverse	
Definite inverse	

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.10 Voltage Protection

12.10.1 Overvoltage Protection with 3-Phase Voltage

Setting Values for the Function

Stabilization counter	0 to 10	Increments of 1

Setting Values for Stage Type Definite-Time Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value[55]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 300.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Setting Values for Stage Type Inverse-Time Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value	0.300 V to 340.000 V	Increments of 0.001 V
Pickup factor	1.00 to 1.20	Increments of 0.01
Characteristic constant k	0.00 to 300.00	Increments of 0.01
Characteristic constant α	0.010 to 5.000	Increments of 0.001
Characteristic constant c	0.000 to 5.000	Increments of 0.001
Time multiplier	0.05 to 15.00	Increments of 0.01
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s
Reset time	0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve for Stage Type Inverse-Time Overvoltage Protection

$$T_{op} = T_{inv} + T_{add}$$

Where

T_{op} Operate delay

T_{inv} Inverse-time delay

T_{add} Additional time delay (parameter **`Additional time delay`**)

55 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c \right) [s]$$

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (parameter **`Time dial`**)
V	Measured voltage
V_{thresh}	Threshold value (parameter **`Threshold`**)
k	Curve constant k (parameter **`Charact. constant k`**)
α	Curve constant α (parameter **`Charact. constant α`**)
c	Curve constant c (parameter **`Charact. constant c`**)

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[56] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances for Stage Type Definite-Time Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

56 OOT (Output Operating Time): additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Tolerances for Stage Type Inverse-Time Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Operate time for 1.2 ≤ V/V threshold value ≤ 20	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

12.10.2 Overvoltage Protection with Positive-Sequence Voltage

Setting Values

Pickup value	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[57] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

12.10.3 Overvoltage Protection with Negative-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle

57 OOT (Output Operating Time): additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Setting Values

Pickup value of V2	0.300 V to 200.000 V	Increments of 0.001 V
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT [58] (depends on the measuring-window length) at 50 Hz 48 ms to 185 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout time	20 ms to 70 ms + OOT (depends on the measuring-window length)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

12.10.4 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

Setting Values

Method of measurement	RMS value Fundamental component Fundamental component over 2 cycle filters	
Block. on measuring-voltage outage	Yes No	
Determ. ph. aff. by grd. flt.	Yes No	
Threshold value[59]	0.300 V to 340.000 V	Increments of 0.001 V

58 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

59 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 320.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-gnd. vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[60] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout time	
Standard filter, true RMS	Approx. 20 ms + OOT at 50 Hz Approx. 17 ms + OOT at 60 Hz
2 cycle filters	Approx. 31 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

60 OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.10.5 Overvoltage Protection with Any Voltage

Setting Values

Measured value[61]	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Pickup value[62]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[63] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

61 If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the measured-value parameter is not visible.

62 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

63 OOT (Output Operating Time): additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

12.10.6 Undervoltage Protection with 3-Phase Voltage

Setting Values for Stage Type Definite Time-Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value[64]		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01

Setting Values for Stage Type Inverse Time-Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value		0.300 V to 175.000 V	Increments of 0.001 V
Pickup factor		0.80 to 1.00	Increments of 0.01
Characteristic constant k		0.00 to 300.00	Increments of 0.01
Characteristic constant α		0.010 to 5.000	Increments of 0.001
Characteristic constant c		0.000 to 5.000	Increments of 0.001
Time multiplier		0.05 to 15.00	Increments of 0.01
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s
Reset time		0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve

$T_{op}=T_{Inv}+T_{add}$

Where:

T_{op} Operate delay

64 If you have selected the **Method of measurement** = **RMS value**, do not set the threshold value to less than 10 V.

T_{Inv}	Inverse-time delay
T_{add}	Additional time delay (Parameter **Additional time delay**)

$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{thresh}} \right)^{\alpha}} + c \right) [s]$$

[fo_UVP3ph_1_3pol_inverse, 2, en_US]

Where

T_{Inv}	Inverse-time delay
T_p	Time multiplier (Parameter **Time dial**)
V	Measured undervoltage
V_{thresh}	Threshold value (Parameter **Threshold**)
k	Curve constant k (Parameter **Charact. constant k**)
α	Curve constant α (Parameter **Charact. constant α**)
c	Curve constant c (Parameter **Charact. constant c**)

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 25 ms + OOT[65] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances for Stage Type Definite Time-Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

65 OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances for Stage Type Inverse Time-Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Operate time for 0 < V/V_{Thresh} < 0.9	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

12.10.7 Undervoltage Protection with Positive-Sequence Voltage

Setting Values

Threshold value		0.300 V to 200.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01
Current-flow criterion		On Off	
Threshold value I>	I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[66] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 90 Hz	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

66 OOT (Output Operating Time): additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

12.10.8 Undervoltage Protection with Any Voltage

Setting Values

Measured value	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated phase-to-phase voltage V_{AB} Calculated phase-to-phase voltage V_{BC} Calculated phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Threshold value[67]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[68] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz

67 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

68 OOT (Output Operating Time): additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

12.10.9 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V

Setting Values for Stage Types

Pickup value of V2/V1	0.50 % to 100.00 %	Increments of 0.01 %
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT[69] (depends on the measuring-window length) at 50 Hz 48 ms to 190 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout times	22 ms to 55 ms + OOT (depends on the measuring-window length) at 50 Hz 18 ms to 45 ms + OOT (depends on the measuring-window length) at 60 Hz

69 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

12.11 Inrush-Current Detection

Setting Values

Operating limit I_{max}	0.030 A to 35.000 A at I_{rated} = 1 A 0.15 A to 175.00 A at I_{rated} = 5 A	Increments of 0.001 A Increments of 0.01 A
Content 2nd harmonic	10% to 45%	Increments of 1 %
Duration of the crossblock function	0.03 s to 200.00 s	Increments of 0.01 s

Times

Operating times	Approx. 29 ms

Pickup

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	Setting value or at least $I_{1st\ harm}$ = 10 mA sec. and $I_{2nd\ harm}$ = 10 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 50 mA sec. and $I_{2nd\ harm}$ = 50 mA sec. (I_{rated} = 5 A)

Dropout

The greater dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overcurrent protection and a dropout ratio of 105 % applies for the undercurrent protection.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	0.75 or $I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 25 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Current measurement I_{max}	1 % of the setting value or 5 mA
Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	1 % of the setting value
Time delays	1 % of the setting value or 10 ms

12.12 2nd Harmonic Detection Ground

Setting Values

Measured value	IN measured 3I0 calculated	
2nd harmonic content	10 % to 45 %	Increments of 1%

Times

Operating times	Approx. 29 ms

Pickup

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	Setting value or at least $I_{1st\ harm}$ = 10 mA sec. and $I_{2nd\ harm}$ = 10 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 50 mA sec. and $I_{2nd\ harm}$ = 50 mA sec. (I_{rated} = 5 A)

Dropout

The greater dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overcurrent protection and a dropout ratio of 105 % applies for the undercurrent protection.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Harmonics: $I_{2nd\ harm}/I_{1st\ harm}$	0.75 or $I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 25 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Harmonics: $I_{2nd\ harm}/I_{1st\ harm}$	1 % of the setting value for setting values $I_{2nd\ harm}/I_{1st\ harm}$

12.13 External Trip Initiation

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Times

Operate time with time delay = 0 ms - At initiation via binary input signal	Approx. 10 ms + OOT [70].

Tolerance

Sequence tolerance for delay times	1 % of the setting value or 10 ms

70 OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

12.14 Automatic Reclosing

Function specifications	Cyclic automatic reclosing function Automatic reclosing function with adaptive dead time (ADT) Operation with External Automatic Reclosing Function	
Number of reclosings	Max. 8, per individual settings	
Type (depending on the order variation)	1-pole, 3-pole, or 1-/3-pole	
Operating mode of the automatic reclosing function	With trip command, without action time With trip command, with action time With pickup, without action time With pickup, with action time	
Reclaim time after reclosing	0.50 s to 300.00 s	Increments of 0.01 s
Blocking time after dynamic blocking	0.5 s	-
Blocking time after manual closure	0.00 s to 300.00 s	Increments of 0.01 s
Start supervision time	0.01 s to 300.00 s	Increments of 0.01 s
Circuit-breaker supervision time	0.01 s to 300.00 s	Increments of 0.01 s
Evolving-fault detection	With trip command With Pickup	
Reaction to evolving faults	Blocks Automatic reclosing function Start, evolving fault, dead time	
Action times (separated for all cycles)	0.00 s to 300.00 s or oo (ineffective)	Increments of 0.01 s
Dead times after trip command (separated for all types and all cycles)	0.00 s to 1 800.00 s or oo (ineffective)	Increments of 0.01 s
Dead time after evolving-fault detection (separated for all cycles)	0.00 s to 1 800.00 s	Increments of 0.01 s
Synchrocheck after 3-pole dead time	None Internal External	
Transmission delay, inter close command	0.00 s to 300.00 s or oo (ineffective)	Increments of 0.01 s
Dead-line check/reduced dead time	Without Reduced dead time (VWE) Dead line checking	
Voltage supervision warning time	0.10 s to 30.00 s	Increments of 0.01 s
Limiting value for fault-free line	0.3 V to 340.0 V	Increments of 0.1 V
Limiting value for zero potential	0.3 V to 340.0 V	Increments of 0.1 V

12.15 Current-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[71] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Currents	3 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

71 OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.16 Voltage-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[72] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Voltages	2 % of the setting value or 0.100 V for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

72 OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.17 Measuring-Voltage Failure Detection

Setting Values

3ph.fail. - VA,VB,VC <		0.300 V to 340 000 V	Increments of 0.001 V
3ph.fail. - phs.curr.release	1 A @ 50 and100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
3ph.fail. - phs.curr. jump	1 A @ 50 and100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Asym.fail. - time delay		0.00 s to 30.00 s	Increments of 0.01 s
SO 3ph.fail. - time delay		0.00 s to 30.00 s	Increments of 0.01 s

Dropout

The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies to the current threshold value and a dropout ratio of 105 % applies to the voltage threshold value.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 10 ms + OOT[73] at 50 Hz Approx. 10 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Times

Use in function group **Line**	
Pickup time	Approx. 10 ms + OOT[74] at 50 Hz Approx. 9 ms + OOT at 60 Hz

Use in other function group types	
Pickup time	Approx. 20 ms + OOT[75] at 50 Hz Approx. 18 ms + OOT at 60 Hz

73 OOT (Output Operating Time) Additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

74 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

75 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Voltages	0.5 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

12.18 Voltage-Transformer Circuit Breaker

Setting Values

Response time	0.000 s to 0.030 s	Increments of 0.001 s

12.19 Voltage-Balance Supervision

Setting Values

Release threshold	0.300 V to 170.000 V	Increments of 0.001 V
Threshold min/max	0.58 to 0.95	Increments of 0.01
Delay failure indication	0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overvoltage dropout ratio	Approx. 0.97
Undervoltage dropout ratio	Approx. 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.20 Voltage-Sum Supervision

Setting Values

Threshold	0.300 V to 170.000 V	Increments of 0.001 V
Delay failure indication	0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Dropout ratio	Approx. 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.21 Voltage Phase-Rotation Supervision

Setting Values

Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s
Phase-rotation direction	A B C A C B	

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.22 Current-Balance Supervision

Setting Values

Release threshold	I_{rated}= 1 A	0.030 A to 35.000 A	Increments of 0.001 A
	I_{rated}= 5 A	0.15 A to 175.00 A	Increments of 0.01 A
Threshold min/max		0.10 to 0.95	Increments of 0.01
Delay failure indication		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overcurrent dropout ratio	Approx. 0.97
Undercurrent dropout ratio	Approx. 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.23 Current-Sum Supervision

Setting Values

Slope factor		0.00 to 0.95	Increments of 0.01
Threshold	1 A @ 50 and100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and100 Irated	0.15 A to 50.00 A	Increments 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Delay failure indication		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Dropout ratio	Approx. 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.24 Current Phase-Rotation Supervision

Setting Values

Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s
Phase-rotation direction	A B C A C B	

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.25 Temperature Supervision

Setting Values

Pickup value	-50 °C to 250 °C -58 °F to 482 °F	Increments of 1°C Increments of 1°F
Time delay	0 s to 60 s or ∞	Increments of 1 s

Dropout

Dropout differential	3 °C or 6 °F

Tolerances

Tripping delay	±1 % of the setting value or ±10 ms
Measured temperature value	±0.5 % of the setting value or ±1 °C or ±2 °F

12.26 Instantaneous Tripping at Switch onto Fault

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Tolerances

Times	< 1 % of the setting value or 10 ms

12.27 Broken-Wire Detection

Setting Values

Value	Setting Range	Increment
`Mode of blocking`	***Blocking*** ***Automatic blocking*** ***No blocking***	-
`Delta value for autoblock`	0.004 I/I_{rated} to 5.000 I/I_{rated}	0.001

12.28 Trip-Circuit Supervision

Setting Values

Number of monitored circuits per circuit-breaker function group	1 to 3	
Operating mode per circuit	With 1 binary input With 2 binary inputs	
Pickup and dropout time	Approx. 1 s to 2 s	
Adjustable indication delay with 1 binary input	1.00 s to 600.00 s	Increments of 0.01 s
Adjustable indication delay with 2 binary inputs	1.00 s to 30.00 s	Increments of 0.01 s

12.29 Analog Channel Supervision via Fast Current Sum

Times

Pickup times	Approx. 2 ms (faster than the fastest protection function)
Dropout time	Approx. 100 ms

Blockings

Blocked functions	All functions that process the measured values from this current measuring point (for example, differential protection).

12.30 Operational Measured Values and Statistical Values

The following applies to the tolerances of currents and voltages:

- The values apply both to the RMS values and the absolute value and phase angle of the fundamental components.
- The values were determined for pure sinusoidal signals – without harmonics.
- All measured values have an additional tolerance of 1 DIGIT.

Voltages

V_A, V_B, V_C Voltage range	V secondary < 200 V secondary
Secondary rated voltage Measuring range Frequency range	100 V to 125 V (0.1 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above-mentioned measuring range
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above-mentioned measuring range
V_{AB}, V_{BC}, V_{CA} Voltage range	V secondary < 200 V
Secondary rated voltage Measuring range Frequency range	100 V to 125 V (0.1 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above-mentioned measuring range
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above-mentioned measuring range

Currents, Instrument Transformers

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.1 % of the measured value in the above-mentioned measuring range

Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above-mentioned measuring range

Currents, Protection-Class Current Transformer

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 100 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 5) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above-mentioned measuring range
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above-mentioned measuring range

Currents, Sensitive Ground-Current Transformer

$3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.1 % of the measured value in the above-mentioned measuring range
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above-mentioned measuring range

Phase Angle

ΦV	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz
Tolerance ΦV	0.2° at rated voltage
ΦI	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz
Tolerance ΦI	0.2° at rated current

Power Values

Active power P	W secondary
Voltage range Current range Frequency range Power factor	(0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz |cosφ| ≥ 0.707
Tolerance	0.5 % of S_{rated} in the above-mentioned measuring range
Reactive power Q	var secondary
Voltage range Current range Frequency range Power factor	(0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz |cosφ| ≤ 0.707
Tolerance	0.5 % of S_{rated} in the above-mentioned measuring range
Apparent power S	VA secondary
Voltage range Current range Frequency range 	(0.8 to 1.2) · V_{rated} (0.01 to 2) · I_{rated} 45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of S_{rated} in the above-mentioned measuring range

Power Factor

Voltage range	(0.8 to 1.2) · V_{rated}
Current range	(0.1 to 2) · I_{rated}
Frequency range	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.02 in the above-mentioned measuring range

Frequency

Frequency f	Hz
Range	f_{rated} - 0.20 Hz ≤ f ≤ f_{rated} + 0.20 Hz
Tolerance	± 2 mHz at V = V_{rated} or at I = I_{rated}
Range	f_{rated} - 3.00 Hz ≤ f < f_{rated} + 3.00 Hz
Tolerance	± 5 mHz at V = V_{rated} or at I = I_{rated}
Range	25 Hz to 80 Hz; operational measured values 10 Hz to 90 Hz; functional measured values, system frequency
Tolerance	± 10 mHz at V = V_{rated} or at I = I_{rated}

Statistical Values of the Device

Device operating hours	h
Range	0 to 9999999 h
Tolerance	1 h

Statistical Values of the Circuit Breaker

Op.cnt. (operation counter)	
Range	0 to 999999999
Tolerance	None
∑I Off (sum of the primary currents switched off)	A, kA, MA, GA, TA, PA primary
Range	0 to 9.2e+15
Operating hours	h
Range	0 to 9999999 h
Tolerance	1 h
Circuit breaker open hours	h
Range	0 to 9999999 h
Tolerance	1 h

Statistical Values of the Disconnector

Op.cnt. (operation counter)	
Range	0 to 999999999
Tolerance	None

12.31 Analog-Units Function Group

20-mA Unit Ether. 7XV5674-0KK00-1AA1

Max. number of connected 20-mA units	4
Max. number of channels per 20-mA unit	12

20-mA Unit Serial 7XV5674-0KK30-1AA1 (RS485) and 7XV5674-0KK40-1AA1 (Fiberglass)

Max. number of connected 20-mA units	4
Max. number of channels per 20-mA unit	12

RTD Unit (Ziehl TR1200) 7XV5662-6AD10

Max. number of connected RTD units	4
Max. number of sensors per RTD unit	12
Sensor type	Pt 100 to EN 60751; connection of Ni 100 and Ni 120 sensors possible. The measured values must be converted in the evaluation unit.

RTD Unit (Ziehl TR1200 IP) 7XV5662-8AD10

Max. number of connected RTD units	4
Max. number of sensors per RTD unit	12
Sensor type	Pt 100 to EN 60751; connection of Ni 100 and Ni 120 sensors possible. The measured values must be converted in the evaluation unit.

Temperature Measured Values

Unit of measurement for temperature	°C or °F, adjustable
Pt 100	-199 °C to 800 °C (-326 °F to 1472 °F)
Ni 100	-54 °C to 278 °C (-65 °F to 532 °F)
Ni 120	-52 °C to 263 °C (-62 °F to 505 °F)
Resolution	1 °C or 1 °F
Tolerance	±0.5 % of the measured value ±1 K

12.32 Phasor Measurement Unit

Accuracy

IEEE Standard for Synchrophasor Measurements
IEEE Std C37.118.1a™-2014

Data Transfer

IEEE Standard for Synchrophasor Data transfer
IEEE Std C37.118.2™-2011

12.33 Measuring Transducers

Current Inputs

Value	Setting Range
Rated current measuring range	± 20 mA
Maximum current measuring range	± 24 mA
Tolerances • without trimming • with offset trimming • with full trimming	± 124 µA (0.62 % at 20 mA) ± 60 µA (0.3 % at 20 mA) ± 20 µA (0.1% at 20 mA)
Sampling rate	≥ 3 Hz
Number of channels per measuring transducer module	2 or 4
Analog-digital converter	16 Bit Sigma/Delta

12.34 Arc Protection

Setting Values

Threshold I>	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold 3I0>>	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
External trip initiation		no current light	
Operating mode		light only current and light	
Sensor		point sensor line sensor custom	
Threshold light		-28.00 dB to 0.00 dB	Increments of 0.01
Channel		Possible settings, application-dependent	

Dropout

The larger dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 90 % applies to the current threshold values.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Shortest operate time Operating mode = light only	Approx. 2.6 ms + OOT [76]
Shortest operate time Operating mode = Current and light	Approx. 4.0 ms + OOT at 50 Hz Approx. 3.8 ms + OOT at 60 Hz

76 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relay, see chapter *12.1.4 Relay Outputs*

12.35 Synchronization Function

Operating Modes

Synchrocheck
Switching synchronous systems
Switching asynchronous systems
De-energized switching
Direct closing command

Setting Values

Supervision/Delay times:		
Max.durat. sync.process	0.00 s to 3 600.00 s or ∞ (ineffective)	Increments of 0.01 s
Supervision time de-energized switching	0.00 s to 60.00 s	Increments of 0.01 s
Closure delay	0.00 s to 60.00 s	Increments of 0.01 s
Voltage threshold values:		
Upper voltage limit V_{max}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
Lower voltage limit V_{min}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
V<, for off-circuit conditions V>, for voltage present	0.300 V to 170.000 V (phase-to-phase) 0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V Increments of 0.001 V
Differential values, changeover thresholds asynchronous/synchronous/balancing:		
Voltage differences V2 > V1; V2 < V1	0.000 V to 170.000 V	Increments of 0.001 V
Frequency difference f2 > f1; f2 < f1	0.000 Hz to 2.000 Hz (synchronous) 0.000 Hz to 4.000 Hz (asynchronous)	Increments of 0.001 Hz
Angle difference α2 > α1; α2 < α1	0° to 90°	Increments of 1°
Adjustments of the sides:		
Angle adjustment	0.0° to 360.0°	Increments of 0.1°
Voltage adjustment	0.500 to 2.000	Increments of 0.001
Circuit breaker		
Closing time of the circuit breaker	0.01 s to 0.60 s	Increments of 0.01 s

Dropout Ratio

Min./max. operating limit	1 % of the setting value
Voltage differential	10 % of the setting value or 0.5 V
De-energized/energized	5 % of the setting value
Frequency difference	3 mHz
Angle difference	0.1°

Measured Values of the Synchronization Function

Reference voltage V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1 % of the measured value or 0.5 % V_{rated}
Voltage to be synchronized V2 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1 % of the measured value or 0.5 % V_{rated}
Frequency of the voltage V1f1 • Range • Tolerance at rated frequency	f1 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Frequency of the voltage V1f2 • Range • Tolerance at rated frequency	f2 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Voltage difference V2-V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage in relation to side 1 10 % to 120 % of V_{rated} ≤ 1 % of the measured value or 0.5 % V_{rated}
Frequency difference f2-f1 • Range • Tolerance at rated frequency	In mHz f_{rated} ± 10 % 1 mHz
Angle difference λ2-λ1 • Range • Tolerance at rated frequency	In ° -180° to +180° 0.5°

Times

Measuring time, after switching on the variables	Approx. 80 ms

Operating Range

Voltage	20 V to 340 V
Frequency	f_{rated} - 4 Hz ≤ f_{rated} ≤ f_{rated} + 4 Hz

Tolerances

Tolerances of the voltage settings	2 % of the pickup value or 1 V
Voltage difference V2>V1; V2<V1	1 V
Frequency difference f2>f1; f2<f1	10 mHz
Angle difference α2>α1; α2<α1	1°
Tolerance of all time settings	10 ms
Max. phase displacement angle	5° for Δf ≤ 1 Hz 10° for Δf > 1 Hz

12.36 Closing-Circuit Supervision

Setting Values

Operating mode per circuit	With 1 binary input With 2 binary inputs	
Adjustable indication delay with 1 binary input	1.00 s to 600.00 s	Increments of 0.01 s
Adjustable indication delay with 2 binary inputs	1.00 s to 30.00 s	Increments of 0.01 s

12.37 Circuit-Breaker Wear Monitoring

Setting Values

Threshold value	ΣI^x-method stage	0 to 10 000 000	Increments of 1
	2P-method stage	0 to 10 000 000	Increments of 1
	I^2t-method stage	0.00 I/Ir*s to 21 400 000.00 I/Ir*s	Increments of 0.01
CB opening time		0.001 s to 0.500 s	Increments of 0.001 s
CB break time		0.001 s to 0.600 s	Increments of 0.001 s
CB make time		0.001 s to 0.600 s	Increments of 0.001 s
Exponent for the ΣI^x method		1.0 to 3.0	Increments of 0.1
Switching cycles at I_{rated}		100 to 1 000 000	Increments of 1
Rated short-circuit breaking current I_{sc}		10 to 100 000	Increments of 1
Switching cycles at I_{sc}		1 to 1000	Increments of 1
Level of warning 1		1 % to 100 %	Increments of 1 %
Level of warning 2		1 % to 100 %	Increments of 1 %
Operating current threshold	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Delay correction time		-0.050 s to 0.050 s	Increments of 0.001 s

Tolerances

Tolerance of the measured value make time	± 2 ms

12.38 CFC

In order to estimate the tick consumption of a CFC chart, you can use the following formula:

$$T_{Chart} = 5 \cdot n_{Inp} + 5 \cdot n_{Outp} + T_{TLev} + \sum_i T_{int} + \sum_j T_{Block}$$

where:

n_{Inp} Number of indications routed as input in the CFC chart

n_{Outp} Number of indications routed as output in the CFC chart

T_{TLev} 101 Ticks in Fast Event-Triggered level
104 Ticks in Event-Triggered level
54 Ticks in Measurement level
74 Ticks in Interlocking level

T_{int} Number of internal connections between 2 CFC blocks in one chart

T_{Block} Used ticks per CFC block (see *Table 12-4*)

Table 12-4 Ticks of the Individual CFC Blocks

Element	Ticks
ABS_D	2.3
ABS_R	1.5
ACOS_R	6.9
ADD_D4	3.4
ADD_R4	3.3
ADD_XMV	6.4
ALARM	1.8
AND_SPS	1.1
AND10	2.9
APC_DEF	1.2
APC_EXE	1.0
APC_INFO	3.9
ASIN_R	1.3
ATAN_R	1.2
BLINK	1.3
BOOL_CNT	2.0
BOOL_INT	1.5
BSC_DEF	1.3
BSC_EXE	1.1
BSC_INFO	2.7
BUILD_ACD	2.9
BUILD_ACT	2.2
BUILD_BSC	1.2
BUILD_CMV	2.3
BUILD_DEL	2.1
BUILD_DPS	1.4
BUILD_ENS	1.3
BUILD_INS	0.5
BUILD_Q	0.8
BUILD_SPS	0.6

Element	Ticks
BUILD_WYE	3.2
BUILD_XMV	2.9
BUILDC_Q	3.0
CHART_STATE	5.9
CMP_DPS	1.5
CON_ACD	0.7
CON_ACT	0.5
CONNECT	0.4
COS_R	2.5
CTD	1.8
CTU	1.6
CTUD	2.3
DINT_REAL	3.0
DINT_UINT	3.0
DIV_D	2.9
DIV_R	1.6
DIV_XMV	2.2
DPC_DEF	0.4
DPC_EXE	0.4
DPC_INFO	1.1
DPC_OUT	1.3
DPS_SPS	1.0
DRAGI_R	1.7
ENC_DEF	3.6
ENC_EXE	3.8
EQ_D	1.0
EQ_R	1.9
EXP_R	1.5
EXPT_R	2.7
F_TRGM	0.3
F_TRIG	0.3
FF_D	0.9
FF_D_MEM	1.4
FF_RS	0.7
FF_RS_MEM	1.2
FF_SR	0.8
FF_SR_MEM	1.1
GE_D	0.9
GE_R	1.1
GT_D	0.9
GT_R	1.2
HOLD_D	1.1
HOLD_R	1.0
INC_INFO	0.9
LE_D	1.1
LE_R	1.1
LIML_R	1.5

Element	Ticks
LIMU_R	1.5
LN_R	3.3
LOG_R	1.2
LOOP	1.5
LT_D	0.9
LT_R	0.9
MAX_D	0.9
MAX_R	1.4
MEMORY_D	0.9
MEMORY_R	1.1
MIN_D	0.7
MIN_R	1.3
MOD_D	1.5
MUL_D4	2.5
MUL_R4	2.7
MUL_XMV	2.8
MUX_D	1.2
MUX_R	0.9
NAND10	3.5
NE_D	0.9
NE_R	0.9
NEG	1.2
NEG_SPS	0.8
NL_LZ	3.8
NL_MV	5.6
NL_ZP	2.7
NOR10	3.2
OR_DYN	1.1
OR_SPS	1.3
OR10	2.6
R_TRGM	0.4
R_TRIG	0.4
REAL_DINT	3.0
REAL_SXMV	3.0
SIN_R	0.8
SPC_DEF	0.4
SPC_EXE	0.4
SPC_INFO	0.4
SPC_OUT	0.4
SPLIT_ACD	3.4
SPLIT_ACT	1.0
SPLIT_BSC	1.3
SPLIT_CMV	2.2
SPLIT_DEL	2.0
SPLIT_DPS	1.0
SPLIT_INS	0.5
SPLIT_Q	0.7

Element	Ticks
SPLIT_SPS	0.8
SPLIT_WYE	2.6
SPLIT_XMV	2.1
SQRT_R	0.6
SUB_D	1.3
SUB_R	1.6
SUB_XMV	2.4
SUBST_B	1.0
SUBST_BQ	1.5
SUBST_D	1.0
SUBST_R	1.0
SUBST_XQ	1.4
SXMV_REAL	3.0
TAN_R	1.1
TLONG	2.2
TOF	1.0
TON	1.1
TP	2.5
TSHORT	1.9
UINT_DINT	3.0
XOR2	2.6

12.39 SIPROTEC 5 Process-Bus Client

Supported Sampled-Value Streams for 50 Hz and 60 Hz Rated Power Frequency			
Stream Type	**Sampling Rate**	**ASDU**	**Analog Channels**
IEC 61850-9-2 LE	80 samples/cycle	1	4 I, 4 V
IEC 61850-9-2 LE	256 samples/cycle	1	4 I, 4 V
IEC 61869-9	4000 Hz	1	Max. 32
IEC 61869-9	4800 Hz	1	Max. 32
IEC 61869-9	4800 Hz	2	Max. 32
IEC 61869-9	12 800 Hz	8	Max. 32
IEC 61869-9	15 360 Hz	8	Max. 32

Max. number of analog channels to be subscribed (Limitations of the individual device applies and supersede the max. usable analog channels)	60
Max. number of streams able to be subscribed per ETH-BD-2FO	32
Max. number of ETH-BD-2FO with Process-Bus Client functionality per SIPROTEC 5 device	4
Simultaneous support at same ETH-BD-2FO module of • IEEE 1588v2/PTP • GOOSE • Process-bus client functionality	YES
Simultaneous support at same ETH-BD-2FO module of • IEEE 1588v2/PTP • GOOSE • Merging Unit functionality • Process-bus client functionality	NO
Simultaneous support on different ETH-BD-2FO module of • IEEE 1588v2/PTP (only on one ETH-BD-2FO) • GOOSE • Merging Unit functionality • Process-bus client functionality	YES
Use of IEC 61850-8-1 MMS and Reports with MU functionality	NO

12.40 SIPROTEC 5 Merging Unit Functionality

Supported Sampled-Value Streams for 50 Hz and 60 Hz Rated Power Frequency			
Stream Type	**Sampling Rate**	**ASDU**	**Analog Channels**
IEC 61850-9-2 LE	80 samples/cycle	1	4 I, 4 V
IEC 61850-9-2 LE	256 samples/cycle	1	4 I, 4 V
IEC 61869-9	4000 Hz	1	Max. 32
IEC 61869-9	4800 Hz	1	Max. 32
IEC 61869-9	4800 Hz	2	Max. 32
IEC 61869-9	12 800 Hz	8	Max. 32
IEC 61869-9	15 360 Hz	8	Max. 32

NOTE

IEC 61869-9 limit of 24 analog channels is defined. This must be considered for third-party process-bus clients.

Number of published streams per ETH-BD-2FO	1
Max. number of ETH-BD-2FO with MU functionality per SIPROTEC 5 device	4
Simultaneous support at same ETH-BD-2FO module of • IEEE 1588v2/PTP • GOOSE • Merging Unit functionality	YES
Simultaneous support at same ETH-BD-2FO module of • IEEE 1588v2/PTP • GOOSE • Merging Unit functionality • Process-bus client functionality	NO
Simultaneous support on different ETH-BD-2FO module of • IEEE 1588v2/PTP (only on one ETH-BD-2FO) • GOOSE • Merging Unit functionality • Process-bus client functionality	YES
Use of IEC 61850-8-1 MMS and Reports with MU functionality	NO

12.41 Point-on-Wave Switching

You can find more information about the technical data of the **Point-on-wave switching** function in the Point-on-Wave Switching Function Manual.