SIPROTEC 5 V1.1

Distance Protection, Line Differential Protection and Breaker Management for 1-Pole and 3-Pole Tripping 7SA87, 7SD87, 7SL87, 7VK87

Technical Data

Extract from manual C53000-G5040-C011-2, chapter 11

Energy Automation

SIEMENS

Preface

Purpose of the Manual

This manual describes the protective, automation, control, and supervision functions of the SIPROTEC 5 devices for distance protection and line-differential protection.

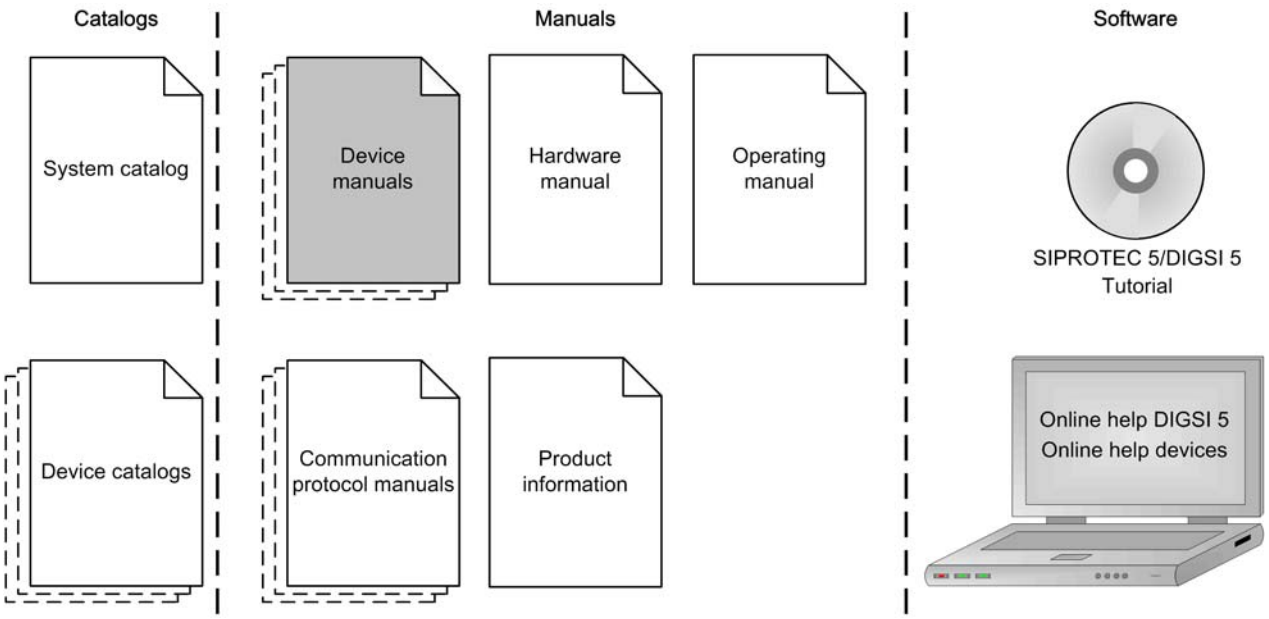
Target Group

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

Scope

This manual applies for devices of the SIPROTEC 5 range, configuration version V1.0

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 components and device combinations of the SIPROTEC 5 range.
- Operating manual

  The operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.
- Communication protocol manuals

  The communication protocol manuals include a description of specific protocols for communication within the SIPROTEC 5 range and with higher-level control centers.
- Product information

  The product information includes general information about device installation, technical data, limit values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.
- DIGSI 5 online help

  The DIGSI 5 online help contains a help package for DIGSI 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 components 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.
- System catalogue

  The system catalogue describes the SIPROTEC 5 system features.
- Device catalogs

  The device catalogues describe device-specific features such as functional scope, hardware and applications.

Indication of Conformity

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This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2006/95/EC).
This conformity has been proved by tests performed according to the Council Directive in accordance with the generic standards EN 61000-6-2 and EN 61000-6-4 (for EMC directive) and with the standard EN 60255-27 (for Low Voltage Directive) by Siemens AG.
The device is designed and manufactured for application in an industrial environment.
The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

Other Standards

IEEE Std C 37.90

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

File E194016

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Additional Support

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

Support

Our Customer Support Center provides a 24-hour service.

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Safety Information

This manual is not a complete index of all safety measures required for operation of the equipment (module, device). However, it comprises important information that must be noted for purposes of personal safety, as well as in order 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 medium-severe or slight injuries.

NOTICE

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

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

NOTE

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

Qualified Electrical Engineering Personnel

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

Use as Prescribed

The equipment (device, module) may only be used 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).
- Equipment with exposed current transformer circuits must not be operated. Prior to disconnecting the equipment, ensure that the current transformer circuits are short-circuited.
- The limit values stated in the document may not be exceeded. This must also be considered during testing and commissioning.

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11.1 General Device Data

11.1.1 Analog Inputs

Current Inputs

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
Protection-class current transformer	Rated current I_{rated}	Measuring range (device-dependent)
	5 A	500 A
	5 A	100 A
	1 A	100 A
	1 A	20 A
Instrument transformer	Rated current I_{rated}	Measuring range
	5 A	8 A
	1 A	1.6 A
Consumption per current circuit at rated current	Approx. 0.1 VA	
Thermal rating (protection-class current and instrument transformers)	500 A for 1 s	
	150 A for 10 s	
	20 A continuously 25 A for 3 min 30 A for 2 min	
Dynamic load carrying capacity	1250 A one half wave	
Measuring Accuracy	See Technical Data **Operational Measured Values**	

Voltage Input

All current, voltage, and power data are specified as RMS values.	
Rated frequency f_{rated}	50 Hz, 60 Hz
Measuring range	200 V
Input impedance	200 kΩ
Thermal rating	230 V continuously
Measuring Accuracy	See Technical Data **Operational Measured Values**

Measurement Transformer Inputs (via Module ANAI-CA-4EL)

Connector type	8-pole terminal multiple contact strip
Differential current input channels	4
Measuring range	DC -24 mA to +24 mA
Measuring Accuracy	0.5 % of 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	AC 500 V, DC 700 V
Permissible overload	DC 100 mA continuously
Measurement repetition	200 ms

Current inputs (via module ANAI-CA-4EL)

Value	Setting Range
Rated current measuring range	± 20 mA
Maximum current measuring range	± 24 mA
Tolerances	± 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

11.1.2 Supply Voltage

Integrated Power Supply			
The following modules contain a power supply: PS201 – Power supply of the base module and of the 1st device row CB202 – Plug-in module assembly with integrated power supply, for example to accommodate communication modules			
Auxiliary rated voltage $V_{AuxRated}$	DC 24 V/DC 48 V	DC 60 V/DC 110 V/DC 125 V/ DC 220 V/DC 250 V or AC 115 V/AC 230 V, 50 Hz/60 Hz	
Permissible voltage ranges	DC 19 V to 60 V	DC 48 V to 300 V AC 80 V to 265 V	
Overvoltage category, IEC 60255-27		III	
Superimposed alternating voltage, peak-to-peak, IEC 60255-11	≤ 15 % of the DC auxiliary rated voltage (applies only to direct voltage)		
Inrush current		≤ 18 A	
Recommended external protection		Miniature circuit breaker 6 A, characteristic C according to IEC 60898	
Internal fuse		2 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 base module without plug-in modules	13 W	33 VA	24 VA
1/6 expansion module	3 W	6 VA	6 VA
1/6 plug-in module assembly without plug-in modules	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 on outage or short circuit of the auxiliary voltage	At least 50 ms		

11.1.3 Binary Inputs

Rated voltage range	DC 24 V to 250 V (bipolar)	
Current consumption, picked up	Approx. 0.6 mA DC (independently of the operating voltage)	
Pickup time	Approx. 3 ms	
Dropout time	Approx. 4 ms	
Switching thresholds	Adjustable with DIGSI 5	
	Range 1 for 24 V, 48 V, and 60 V Operating voltage	DC $V_{low} \leq 10$ V DC $V_{high} \geq 19$ V
	Range 2 for 110 V and 125 V Operating voltage	DC $V_{low} \leq 44$ V DC $V_{high} \geq 88$ V
	Range 3 for 220 V and 250 V Operating voltage	DC $V_{low} \leq 88$ V DC $V_{high} \geq 176$ V
Maximum permitted voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. In order to ensure EMC, use the terminals shown in the terminal diagrams/connection diagrams to connect the binary inputs to the common potential.		

11.1.4 Relay Outputs

Standard Relay (Type S)

Switching capacity	On: 1000 W/VA Off: 30 VA; 40 W ohmic; 25 W/VA at L/R ≤ 40 ms
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[1])	≤ 10 ms
Rated data of the output contacts	DC 24 V, 8 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, 248.7 W AC 250 V, 373 W B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V

1. OOT (Output Operating Time) additional delay of the output medium used

Fast Relay (Type F)

Switching capacity	On: 1000 W/VA Off: 30 VA; 40 W ohmic; 25 W/VA at L/R ≤ 40 ms
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[1])	≤ 5 ms
Rated data of the output contacts	AC 120 V, 8.5 A, general purpose AC 277 V, 6 A, general purpose AC 277 V, 522.2 W AC 347 V, 4.5 A, general purpose B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V

1. OOT (Output Operating Time) additional delay of the output medium used

High-Speed Relay with Semiconductor Acceleration (Type HS)

Switching capacity	On/Off: 1000 W/VA
Contact voltage	AC 200 V, DC 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[1])	≤ 1 ms
Rated data of the output contacts	B150 Q300

1. OOT (Output Operating Time) additional delay of the output medium used

11.1.5 Design Data

Masses

	Device Size **Weight**				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	4.8 kg	8.1 kg	11.4 kg	14.7 kg	18.0 kg
Surface-mounting device with integrated on-site operation panel	7.8 kg	12.6 kg	17.4 kg	22.2 kg	27.0 kg
Surface-mounting device with detached on-site operation panel	5.1 kg	8.7 kg	12.3 kg	15.9 kg	19.5 kg

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

Base-Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth in mm (in inches)
Flush-mounting device	145 x 268 x 228.5 (5.71 x 10.55 x 9)
Surface-mounting device with integrated on-site operation panel	145 x 314 x 337 (5.71 x 12.36 x 13.27)
Surface-mounting device with detached on-site operation panel	145 x 314 x 230 (5.71 x 12.36 x 9.06)

Dimensions of the Device Rows

Type of Construction (Maximum Dimensions)	Width x Height x Depth in mm (in inches)				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	145 x 268 x 228.5 (5.71 x 10.55 x 9)	220 x 268 x 228.5 (8.66 x 10.55 x 9)	295 x 268 x 228.5 (11.61 x 10.55 x 9)	370 x 268 x 228.5 (14.57 x 10.55 x 9)	445 x 268 x 228.5 (17.52 x 10.55 x 9)
Surface-mounting device with integrated on-site operation panel	145 x 314 x 337 (5.71 x 12.36 x 13.27)	220 x 314 x 337 (8.66 x 12.36 x 13.27)	295 x 314 x 337 (11.61 x 12.36 x 13.27)	370 x 314 x 337 (14.57 x 12.36 x 13.27)	445 x 314 x 337 (17.52 x 12.36 x 13.27)
Surface-mounting device with detached on-site operation panel	145 x 314 x 230 (5.71 x 12.36 x 9.06)	220 x 314 x 230 (8.66 x 12.36 x 9.06)	295 x 314 x 230 (11.61 x 12.36 x 9.06)	370 x 314 x 230 (14.57 x 12.36 x 9.06)	445 x 314 x 230 (17.52 x 12.36 x 9.06)

Expansion-Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth in mm (in inches)
Flush-mounting device	75 x 268 x 228.5 (2.95 x 10.55 x 9)
Surface-mounting device with integrated on-site operation panel	75 x 314 x 337 (2.95 x 12.36 x 13.27)
Surface-mounting device with detached on-site operation panel	75 x 314 x 230 (2.95 x 12.36 x 9.06)

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

Fiber-optic cable	R = 50 mm (1.97 in) Pay attention to the length of the cable protection sleeve, which you must also include in calculations.
D-Sub cable	R = 50 mm (1.97 in) (minimum bending radius)

Degree of Protection According to IEC 60529

For the equipment in the surface-mounting housing	IP50
For the equipment in the flush-mounting housing	Front IP51 Rear panel IP50
For operator protection	IP2X for current terminals IP1X for voltage terminals
Degree of pollution, IEC 60255-27	2

UL Note

Type 1 if mounted into a door or front cover of an enclosure.

Tightening Torques for Terminal Screws

Type of Cable [1]	**Current Terminal**	**Voltage Terminal**
Power line with ring-type lug	2.7 Nm	No ring-type lug
Stranded wires with bootlace fer-rules or pin-type lugs	2.7 Nm	1.0 Nm
Solid conductor, bare (2 mm^2 (0.08 in^2))	2.0 Nm	1.0 Nm

1. Use copper cables only.

11.2 Protection Interface and Protection Topology

Setting Values

Mode	On Off	
PPS synchronization	Telegr. and PPS Telegr. or PPS PPS synchronization off	
Blocking of the asymmetrical run-times	Yes No	
Maximum signal runtime threshold	0.1 ms to 30.0 ms	Increments of 0.1 ms
Maximum runtime difference	0.000 ms to 3.000 ms	Increments of 0.001 ms
Failure indication after	0.05 s to 2.00 s	Increments of 0.01 s
Failure indication after	0.0 s to 6.0 s	Increments of 0.1 s
Max. error rate/h	0.000 % to 100.000 %	Increments of 0.001 %
Max. error rate/min	0.000 % to 100.000 %	Increments of 0.001 %
PPS failure indication after	0.5 s to 60.0 s	Increments of 0.1 s

Transmission Rate

Direct connection:	
Transmission rate	2048 kBit/s
Connection via communication networks:	
Supported network interfaces	G703.1 with 64 kBit/s G703-T1 with 1.455 MBit/s G703-E1 with 2.048 MBit/s
	X.21 with 64 kBit/s or 128 kBit/s or 512 kBit/s
	Pilot wires with 128 kBit/s
Transmission rate	64 kBit/s at G703.1 1.455 MBit/s at G703-T1 2.048 MBit/s at G703-E1
	512 kBit/s or 128 kBit/s or 64 kBit/s at X.21
	128 kBit/s for pilot wires

Transmission Times

Priority 1		
Response time, total about		
For 2 ends	Minimum	8 ms
	Typical	10 ms
For 3 ends	Minimum	10 ms
	Typical	14 ms
For 6 ends	Minimum	15 ms
	Typical	18 ms
Fallback time, total about		
For 2 ends	Typical	20 ms
For 3 ends	Typical	20 ms
For 6 ends	Typical	26 ms

Priority 2		
Response time, total about		
For 2 ends	Minimum	9 ms
	Typical	16 ms
For 3 ends	Minimum	12 ms
	Typical	18 ms
For 6 ends	Minimum	17 ms
	Typical	23 ms
Fallback time, total about		
For 2 ends	Typical	24 ms
For 3 ends	Typical	25 ms
For 6 ends	Typical	32 ms

Priority 3[1]		
Response time, total about		
For 2 ends	Minimum	
	Typical	100 ms
For 3 ends	Minimum	
	Typical	150 ms
For 6 ends	Minimum	
	Typical	200 ms
Fallback time, total about		
For 2 ends	Typical	100 ms
For 3 ends	Typical	150 ms
For 6 ends	Typical	200 ms

1. Times cannot be determined because the signals are transmitted in fragments.

11.3 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
	DCF 77
	PI
	SNTP
	IEC 60870-5-103
	DNP3
Time zone 1, Time zone 2	Local
	UTC
Fault indication after	0 s to 3 600 s
Time zone and daylight saving time	Transfer of PC settings
	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	-120 to 120 [steps of 15]

11.4 Line Differential Protection

Tripping Thresholds, Idiff Stage

Threshold value	10.0 % to 2 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %
Threshold value upon switching	10.0 % to 2 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %

Tripping Thresholds, Idiff Fast Stage

Threshold value	80.0 % to 10 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %
Threshold value upon switching	80.0 % to 10 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %

Trigger-Value Tolerances

When using up to 3 line ends	5 % of setting value or 1 % of I_{rated} for each line end
When using up to 6 line ends	10 % of setting value or 1 % of I_{rated} for each line end

Operating Times

The operate times depend on the number of line ends, the communication speed, and the configured output contacts. The following data assume a transmission rate of at least 512 kbit/s and trip command output via high-speed standard relays (type HS).

Operate times of the Idiff stage		
When using 2 line ends	Minimum (50/60 Hz)	27/24 ms
	Typical (50/60 Hz)	29/26 ms
When using 3 line ends	Minimum (50/60 Hz)	27/24 ms
	Typical (50/60 Hz)	31/28 ms
When using 6 line ends	Minimum (50/60 Hz)	32/28 ms
	Typical (50/60 Hz)	38/35 ms
Dropout times of the Idiff stage		
For all line ends	Typical	35 ms to 50 ms

Operate times of the Idiff fast stage		
When using 2 line ends	Minimum	9 ms
	Typical	12 ms
When using 3 line ends	Minimum	9 ms
	Typical	12 ms
When using 6 line ends	Minimum	14 ms
	Typical	20 ms
Dropout times of the Idiff fast stage		
For all line ends	Typical	35 ms to 50 ms

Time Delays

Delay of the Idiff stage	0.00 s to 60.00 s	Increments of 0.01 s
Delay of the Idiff fast stage	0.00 s	Not adjustable
Delay of 1-phase pickup in resonant-grounded/isolated systems	0.00 s to 0.50 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

Self-Stabilization

Transformer error for each line end of the protected object		
Error transmission ratio	1.00 to 10.00	Increments of 0.01
Transformer error A	0.5 % to 50.0 %	Increments of 0.1 %
Transformer error B (class)	0.5 % to 50.0 %	Increments of 0.1 %
Other stabilizing values (adaptive self-stabilization)	Frequency deviations, runtime differences, harmonics, synchronism quality, jitter	

Adjustments for Transformers in the Protection Range

Vector-group adjustment (V and I)	0 to 11	Increments of 1
Residual-current elimination	Yes or no	

Adjustment of the Charging-Current Compensation

Additional Stab current Ic-stab/Ic-rated	1.0 to 4.0	Increments of 0.1
Total line length	0.1 km to 1 000.0 km	Increments of 0.1 km

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	Operating range with rated accuracy
$0.8 \leq f/f_{rated} \leq 0.9$ $1.1 \leq f/f_{rated} \leq 1.2$	Normal operating range without rated accuracy
$0.0 \leq f/f_{rated} \leq 0.8$	Stable operation without rated accuracy

11.5 Stub-Differential Protection

Tripping Thresholds of the Idiff Stage

Threshold value	10.0 % to 2 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %

Tripping Thresholds of the Idiff Fast Stage

Threshold value	80.0 % to 10 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %

Tolerances of the Tripping Thresholds

5 % of setting value or 1 % of I_{rated}

Operating Times

The reported operate times assume the issuance of commands via high-speed relays (type HS).

Operate times of the Idiff stage	
Minimum (50/60 Hz)	27/24 ms
Typical (50/60 Hz)	29/26 ms
Dropout times of the Idiff stage	
Typical	35 ms to 50 ms

Operate times of the Idiff fast stage	
Minimum	9 ms
Typical	12 ms
Dropout times of the Idiff fast stage	
Typical	35 ms to 50 ms

Time Delays

Tripping delay of the Idiff stage	0.00 s to 60.00 s	Increments of 0.01 s
Tolerance	1 % of the setting value or 10 ms	

Self-Stabilization

Transformer error for each line end of the protected object		
Error transmission	1.00 to 10.00	Increments of 0.01
Transformer error A	0.5 % to 50.0 %	Increments of 0.1 %
Transformer error B (class)	0.5 % to 50.0 %	Increments of 0.1 %
Other stabilizing values (adaptive self-stabilization)	Frequency deviations, harmonic components	

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	Operating range with rated accuracy
$0.8 \leq f/f_{rated} \leq 0.9$ $1.1 \leq f/f_{rated} \leq 1.2$	Normal operating range without rated accuracy
$0.0 \leq f/f_{rated} \leq 0.8$	Stable operation without rated accuracy

11.6 Distance Protection

Residual Compensation

Kr	-0.33 to 11.00	Increments of 0.01
Kx	-0.33 to 11.00	Increments of 0.01
K0	0.000 to 11.000	Increments of 0.001
Angle (K0)	-180.00° to +180.00°	Increments of 0.01
	Configurable separately for each zone	

Parallel-Line Matching

KmR	0.00 to 8.00	Increments of 0.01
KmX	0.00 to 8.00	Increments of 0.01
Km0	0.000 to 8.000	Increments of 0.001
Angle (Km0)	-180.00° to +180.00°	Increments of 0.01

Phase Preference

For double ground fault in a grounded network	Block leading phase from ground Block lagging phase from ground Release all loops involved Release phase-to-ground loops involved Release phase-to-phase loops involved
For double ground fault in isolated or resonant-grounded system	C(A) acyclic A(C) acyclic B(A) acyclic A(B) acyclic C(B) acyclic B(C) acyclic C(A) cyclic A(C) cyclic All loops involved

Ground-Fault Detection

Threshold value 3I0>	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Threshold value V0>		0.300 V to 35.000 V	Increments of 0.001 V
Measurement tolerances for sinusoidal values		± 5%	

Distance Measurement

Characteristic		Polygonal or MHO characteristic	
Minimum phase current I>	For I_{rated} = 1 A	0.030 A to 100.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 500.00 A	Increments of 0.01 A
φ_{Dist} = Angle of distance-protection characteristic		30.0° to 90.0°	Increments of 0.1°
Polygonal setting ranges			
X range = Range of reactance	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	

R (ph-ph) = Phase-to-phase resistance reserve	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
R (ph-gnd) = Phase-to-ground resistance reserve	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
α_{Pole} = Zone inclination		0° to 45°	Increments of 1°
Direction determination for polygon:			
For all fault types		With actual short-circuit, buffered or cross-polarized voltages	
Directional sensitivity		Dynamically unlimited, stationary about 1 V	
Every zone can be configured as forward, backward or non-directional.			
Setting ranges for MHO characteristic:			
Z_r impedance range	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.00 Ω	
Polarization		With buffered or cross-polarized voltages	
Every zone can be configured as forward or backward.			
Load cutout (for impedance pickup):			
R_{load} = Minimum load resistance	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
φload = Maximum load angle		20.0° to 60.0°	Increments of 0.1°
Dropout ratios			
- Currents		Approx. 0.95	
- Impedances		Approx. 1.05	
Measured-value correction		For ground-current coupling in parallel lines	
Measurement tolerances for sinusoidal values		$\left\lvert\frac{\Delta X}{X}\right\rvert \leq 5\% \quad \text{for } 30^\circ \leq \varphi_{Sc} \leq 90^\circ$ [FoTolerX-011110-enUS-01.tif]	
		$\left\lvert\frac{\Delta R}{R}\right\rvert \leq 5\% \quad \text{for } 30^\circ \leq \varphi_{Sc} \leq 60^\circ$ [FoTolerR-090212-enUS-01.tif]	
		$\left\lvert\frac{\Delta Z}{Z}\right\rvert \leq 5\% \quad \text{for } -30^\circ \leq \varphi_{Sc} - \varphi_L \leq 30^\circ$ [FoTolerZ-011110-enUS-01.tif]	

Times

Shortest operate time	Approx. 17 ms (50 Hz)/15 ms (60 Hz) with fast relays and Approx. 12 ms (50 Hz)/10 ms (60 Hz) with high-speed relays	
Dropout time	Approx. 30 ms	
Incremental times	0.00 s to 60.00 s; ∞ for all zones	Increments of 0.01 s
Timer tolerance	1 % of the setting or 10 ms	
The times set are pure delay times.		

11.7 Power-Swing Blocking

General

Measuring principle	Cyclic monitoring of impedance curves for monotony, continuity, and jump
Detectable power-swing frequency	0.1 Hz to 12 Hz for symmetrical operation, Up to 7 Hz during 1-pole dead times and unbalanced faults
Power-swing blocking	Can be set separately for each distance-protection zone

Times

Power-swing detection time	≥ 2.5 power-system cycles
Dropout time	5.5 power-system cycles in case of unbalanced faults 5.5 power-system cycles in case of symmetrical faults Max. 5 s after leaving the pickup range of the distance protection

11.8 Teleprotection with Distance Protection

Permissive Underreach Transfer Trip

Adjustable process	Permissive underreach transfer trip via pickup, directed Permissive underreach transfer trip via pickup, not directed Permissive underreach transfer trip via extended measuring range Intertripping underreach protection	
Transmission-signal extension Delay (1-phase) Delay (multi-ph.)	0.00 s to 60.00 s 0.00 s to 60.00 s 0.00 s to 60.00 s	Increments of 0.01 s Increments of 0.01 s Increments of 0.01 s

Permissive Overreach Transfer Trip

Adjustable process	Permissive overreach transfer trip scheme Directional-comparison method Directional unblock method	
Transmission extension	0.00 s to 60.00 s	Increments of 0.01 s
Transmission delay	0.000 s to 60.000 s	Increments of 0.001 s
Transient blocking time	0.00 s to 60.00 s	Increments of 0.01 s
Wait time for transient blocking	0.00 s to 60.00 s	Increments of 0.01 s
Delay (1-phase)	0.00 s to 60.00 s	Increments of 0.01 s
Delay (multi-ph.)	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	
The times set are pure delay times.		

Blocking Method

Transmission extension	0.00 s to 60.00 s	Increments of 0.01 s
Release delay	0.000 s to 60.000 s	Increments of 0.001 s
Trans. Blocking time	0.00 s to 60.00 s	Increments of 0.01 s
Trans. Block. waiting time	0.00 s to 60.00 s	Increments of 0.01 s
Delay (1-phase)	0.00 s to 60.00 s	Increments of 0.01 s
Delay (multi-ph.)	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	
The times set are pure delay times.		

11.9 Teleprotection with Ground-Fault Protection

Permissive Overreach Transfer Trip

Adjustable process	Permissive overreach transfer trip, directed Unblock method, directed	
Transmission extension	0.00 s to 60.00 s	Increments of 0.01 s
Transmission delay	0.00 s to 60.00 s	Increments of 0.01 s
Transient blocking time	0.00 s to 60.00 s	Increments of 0.01 s
Wait time for transient blocking	0.00 s to 60.00 s	Increments of 0.01 s
Delay	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	
The times set are pure delay times.		

Permissive Overreach Transfer Trip via Protection Interface

Phase selective for 2 or 3 line ends		
Adjustable process	Directional comparison	
Transmission extension	0.00 s to 60.00 s	Increments of 0.01 s
Release delay	0.000 s to 60.000 s	Increments of 0.001 s
Transient blocking time	0.00 s to 60.00 s	Increments of 0.01 s
Wait time for transient blocking	0.00 s to 60.00 s	Increments of 0.01 s
Delay	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	
The times set are pure delay times.		

11.10 Echo and Tripping in the Event of Weak Infeed

Undervoltage

Value	Setting Range	Increment
V< threshold value	0.300 V to 340.000 V	0.001 V
Dropout ratio	Approx. 1.1	-
Response tolerance	≤ 5 % of the setting value	-

Times

Value	Setting Range	Increment
Response tolerance	1 % of the setting value or 10 ms	
Echo blocking duration	0.00 s to 60.00 s	0.01 s
Echo/tripping delay	0.00 s to 60.00 s	0.01 s
Echo pulse duration	0.00 s to 60.00 s	0.01 s

11.11 Ground-Fault Protection for High-Resistance Ground Faults in Grounded-Neutral Systems

Setting Values for All Stage Types

Direction	Forwards, backwards, non-directional	
Method of measurement	Fundamental component over 1 cycle filter (standard filter)	
	Fundamental component over 2 cycle filters	
Stabilization with phase currents	0 % to 30 %	Increments of 1 %

Measured value (pickup value)	For converter type I-sensitive and $I_{N\text{-rated}}$ = 1 A	For $I_{L\text{-rated}}$ = 1 A	0.003 A to 100.000 A	Increments of 0.001 A
		For $I_{L\text{-rated}}$ = 5 A	0.003 A to 500.000 A	Increments of 0.001 A
	For converter type I-sensitive and $I_{N\text{-rated}}$ = 5 A	For $I_{L\text{-rated}}$ = 1 A	0.015 A to 100.000 A	Increments of 0.001 A
		For $I_{L\text{-rated}}$ = 5 A	0.015 A to 500.000 A	Increments of 0.001 A
	For converter type I-protection and $I_{N\text{-rated}}$ = 1 A		0.030 A to 100.000 A	Increments of 0.001 A
	For converter type I-protection and $I_{N\text{-rated}}$ = 5 A		0.150 A to 500.000 A	Increments of 0.001 A

Extension time of the blocking after outgoing 1-pole pause	0.000 s to 60.000 s	Increments of 0.001 s

Setting Values for Stage Type 3I0 Definite Time-Overcurrent Protection

Time delay	0.000 s to 60.000 s	Increments of 0.001 s

Setting Values for Stage Type 3I0-IEC/ANSI

Type of characteristic curve	Characteristic curve according to IEC (see *Table 11-1*) and ANSI (see *Table 11-2*)	
Time multiplier	0.05 to 15.00	Increments of 0.01
Additional delay	0.000 s to 60.000 s	Increments of 0.001 s

Setting Values for Stage Type 3I0 Logarithmic Inverse

Characteristic curve: see *Figure 11-1*		
Threshold-value multiplier	1.00 to 4.00	Increments of 0.01
Time multiplier	0.00 to 15.00	Increments of 0.01
Minimum time of the characteristic curve	0.000 s to 60.000 s	Increments of 0.001 s
Maximum time of the characteristic curve	0.000 s to 60.000 s	Increments of 0.001 s
Additional delay	0.000 s to 60.000 s	Increments of 0.001 s

Setting Values for Stage Type S0-Inverse

Characteristic curve: see *Figure 11-2*		
Threshold-value multiplier	1.00 to 4.00	Increments of 0.01
S ref for Sr-characteristic	1.000 VA to 100.000 VA	Increments of 0.001 VA
k factor	0.000 s to 60.000 s	Increments of 0.001 s
Additional delay	0.000 s to 60.000 s	Increments of 0.001 s

Setting Values for Direction Determination

At angular measurement between measuring and reference values:			
Minimum zero voltage V0		0.150 V to 20.000 V	Increments of 0.001 V
Minimum transformer neutral-point current IY	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Minimum negative-sequence system voltage V2		0.150 V to 20.000 V	Increments of 0.001 V
Minimum negative-sequence system current I2	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Upper limit angle forwards, β		0° to 360°	Increments of 1°
Lower limit angle forwards, α		0° to 360°	Increments of 1°
At angular measurement with zero power S0:			
Zero power for forwards direction		0.10 VA to 10.00 VA	Increments of 0.01 VA
Compensation angle		0° to 360°	Increments of 1°

Characteristic Curves

Extension of operate time when operating with transformer inrush-current detection	Approx. 10 ms

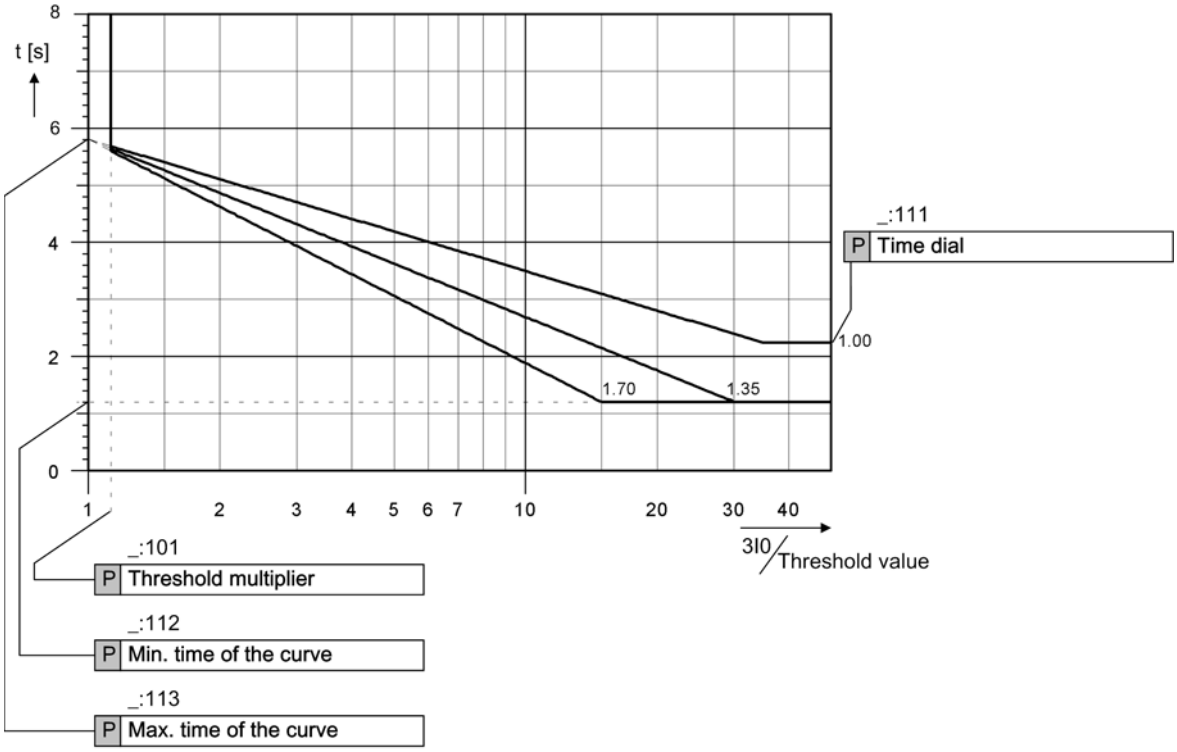
You can select from the following tripping-time and release-time characteristic curves:

Table 11-1 Standard Characteristic Curves to IEC

Normal inverse: type A	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-3*
Very inverse: type B	
Extremely inverse: type C	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-4*
Long time inverse	

Table 11-2 Standard Characteristic Curves to ANSI/IEEE

Extremely inverse	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-5*
Long time inverse: type B	
Long time inverse	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-6*
Moderately inverse	
Very inverse	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-7*
Extremely inverse	
Uniformily inverse	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-8*



t = Maximum time of the characteristic curve – time multiplier • ln (3I0/threshold value)

[LoGFPke1-030311-enUS-01.tif]

Figure 11-1 Operate Curves of the Independent Overcurrent Protection with Logarithmic Inverse Characteristic Curve

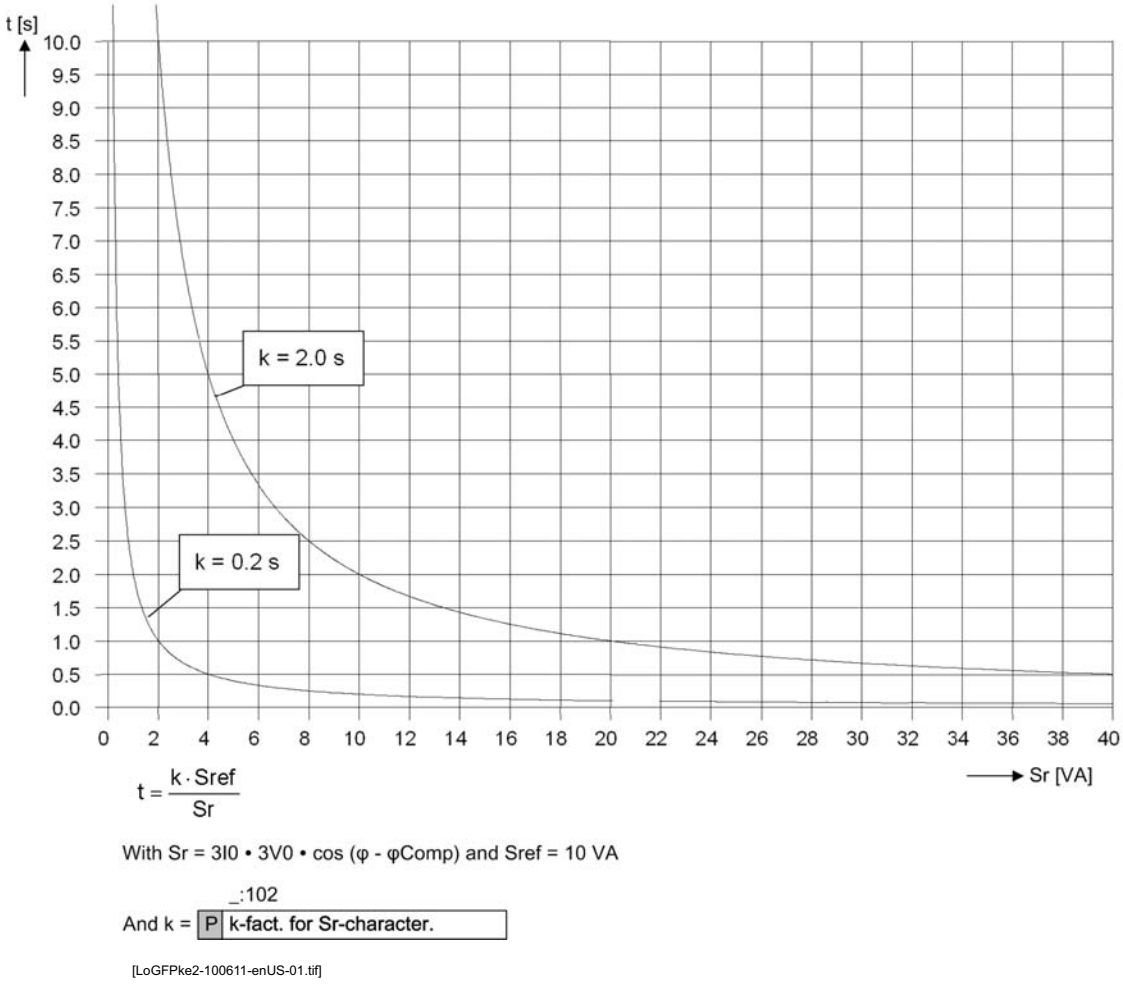


Figure 11-2 Operate Curve of the Zero-Power Protection

Dropout Ratios

Threshold 3I0 (pickup value):	
Stage type 3I0-IEC/ANSI	0.95 · threshold
Stage type 3I0 logarithmic inverse	0.95 · threshold
Stage type S0 inverse	0.95 · threshold

Values for Stage Type 3I0 Definite Time-Overcurrent Protection

Operate time with time delay = 0 ms	Fundamental component over 1 cycle filter (standard filter)	Approx. 25 ms + OOT [1] at 50 Hz Approx. 25 ms + OOT at 60 Hz
	Fundamental component over 2 cycle filter	Approx. 30 ms + OOT
Extension of operate time when operating with transformer inrush-current detection		Approx. 10 ms
Dropout time	Fundamental component over 1 cycle filter (standard time)	Approx. 20 ms + OOT
	Fundamental component over 2 cycle filter	Approx. 40 ms + OOT

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

Operating Range

f_{rated} ± 20 %	Active
Outside of f_{rated} ± 20 %	Not active

Tolerances

Threshold values:	
Response threshold value, release threshold value for zero-sequence system current 3I0 with normal-sensitive ground-current transformer	1 % of setting value or 1 % of rated current
Response threshold value, release threshold value for zero-sequence system current 3I0 with sensitive ground-current transformer	1 % of setting value or 0.5 % of rated current
Minimum zero voltage V0	1 % of the setting value or 1 V
Minimum transformer neutral-point current IY	1 % of setting value or 1 % of rated current
Minimum negative-sequence system voltage V2	1 % of the setting value or 1 V
Minimum negative-sequence system current I2	1 % of setting value or 1 % of rated current
Times:	
Independent time delays	1 % of the setting or 10 ms
Current-dependent time delay, Characteristic curves to IEC, ANSI/IEEE, and logarithmic inverse characteristic curve For $\leq 2\ I/I_{3I0P} \leq 20$ and $T_{3I0P} \geq 1$ s	5 % of the set point value ± 10 ms
Current-dependent time delay, Characteristic curve: logarithmic-inverse	3 % of the set point value ± 10 ms
S0-dependent time delay	3 % of the set point value ± 10 ms

Limit angle for direction determination via angular measurement between measuring and reference value	± 1.5°
Zero power for forwards direction	5 % of the setting value or 0.02 VA

Setting Parameters for Thresholds

Transient excess pickup in method of measurement = fundamental component over 1 cycle filter (standard filter), for τ > 100 ms (with complete displacement)	< 5 %

11.12 External Trip

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Times

Operate time with time delay = 0 ms – with initiation via binary input signal	Approx. 5 ms + OOT [1].

1. OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays, see Section *11.1.4 Relay Outputs*

Tolerance

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

11.13 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 parameter	
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 switching	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 closing command	0.00 s to 300.00 s or oo (ineffective)	Increments of 0.01 s
Dead-line checking/reduced dead time	Without Reduced dead time (RDT) Dead-line checking	
Voltage-supervision warning time	0.10 s to 30.00 s	Increments of 0.01 s
Limiting value for error-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

11.14 Definite-Time Overcurrent Protection, Phases

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	For I_{rated} = 1 A	0.030 A to 100.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 500.00 A	Increments of 0.01 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

Times

Tripping time with time delay = 0 ms	Approx. 25 ms + OOT [1] at 50 Hz Approx. 22 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

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

Operating Ranges

10 Hz to 80 Hz	According to specified tolerances
Outside 10 Hz to 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of 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 Up to 30th harmonic Up to 35th harmonic (33 % part of harmonic, referring to fundamental component)	 1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%) 2 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Time delays	1 % of the setting value or 10 ms

Influencing Variables for the Thresholds

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

11.15 Inverse-Time Overcurrent Protection, Phases

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	For I_{rated} = 1 A	0.030 A to 100.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 500.00 A	Increments of 0.01 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01

Tripping Time Characteristic Curves and Dropout Time Characteristic Curves according to IEC

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

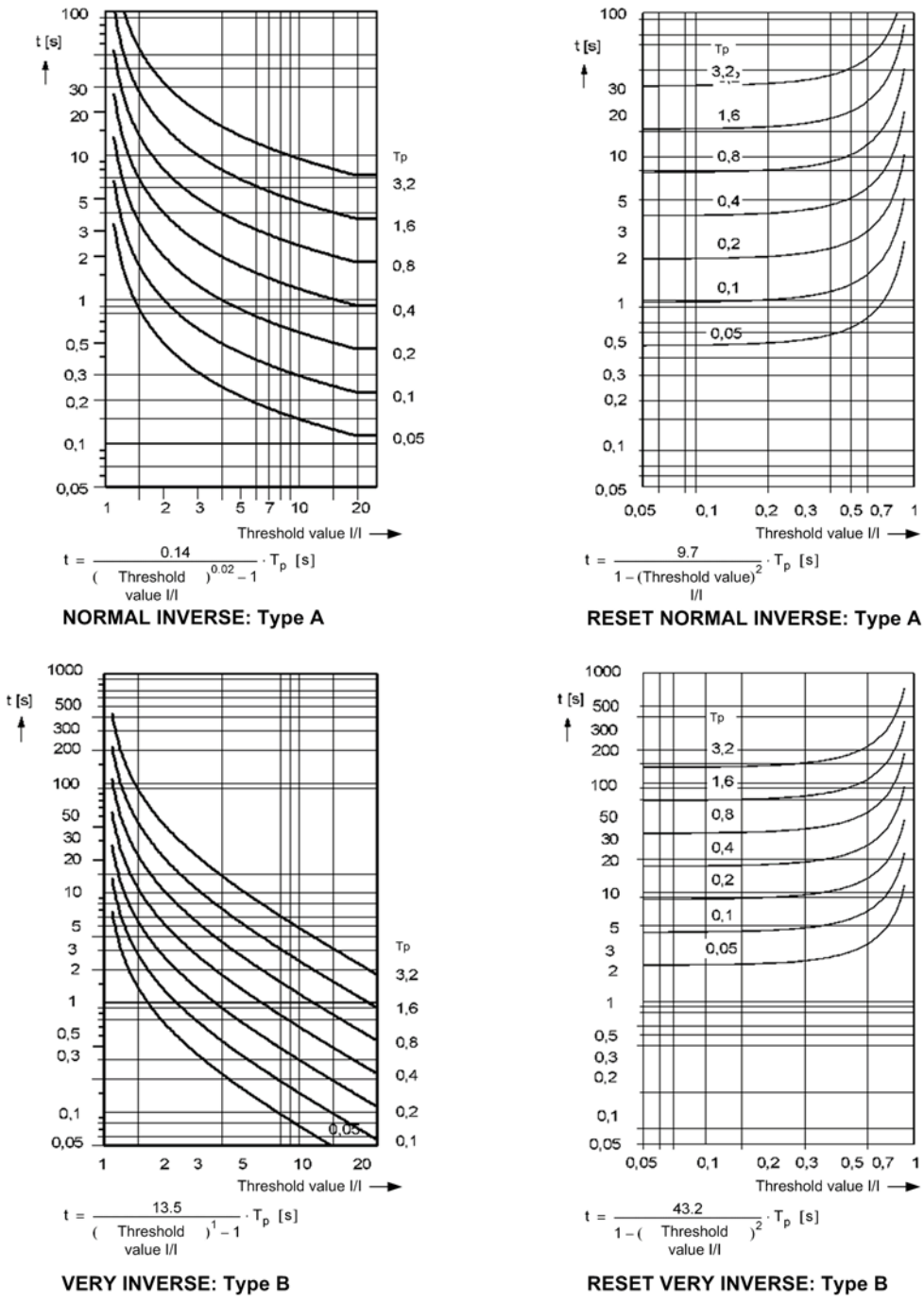


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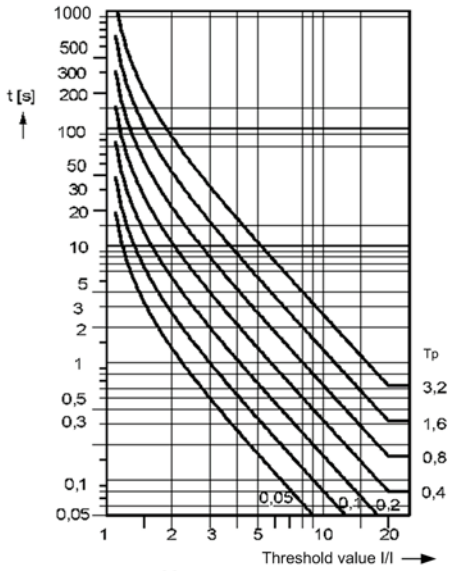
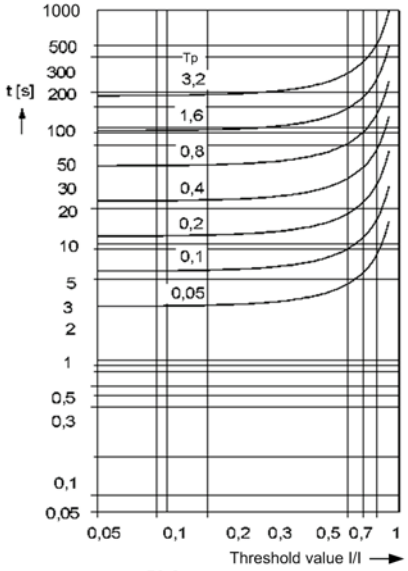
Figure 11-3 Operate Curves and Dropout-Time Characteristic Curves According to IEC



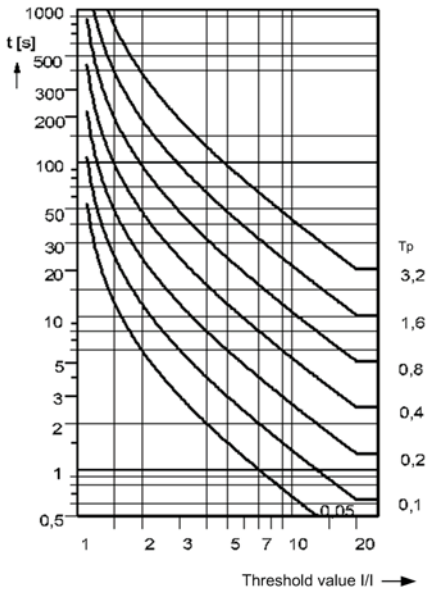
$$t = \frac{80}{\left(\frac{\text{Threshold value}}{I/I}\right)^2 - 1} \cdot T_p \ [s]$$

EXTREMELY INVERSE: Type C



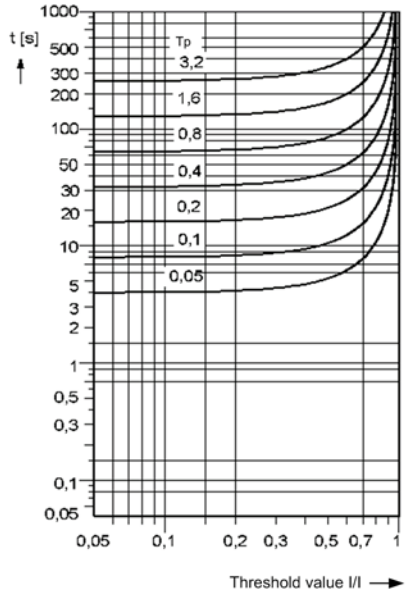
$$t = \frac{58.2}{1 - \left(\frac{\text{Threshold value}}{I/I}\right)^2} \cdot T_p \ [s]$$

RESET EXTREMELY INVERSE: Type C



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

LONG-TIME INVERSE: Type B



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

RESET LONG-TIME INVERSE: Type B

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Figure 11-4 Operate Curves and Dropout-Time Characteristic Curves According to IEC

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

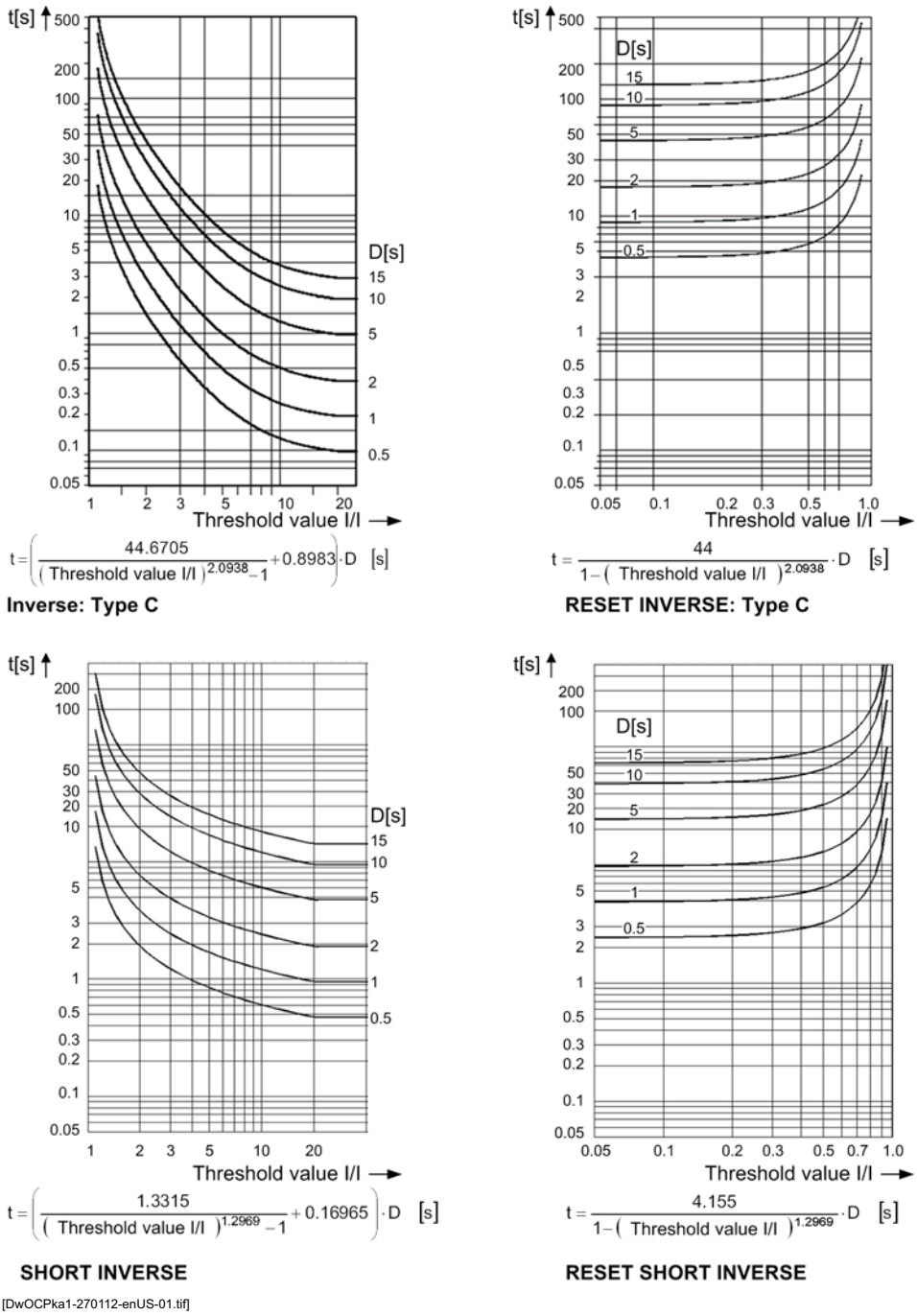

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Figure 11-5 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

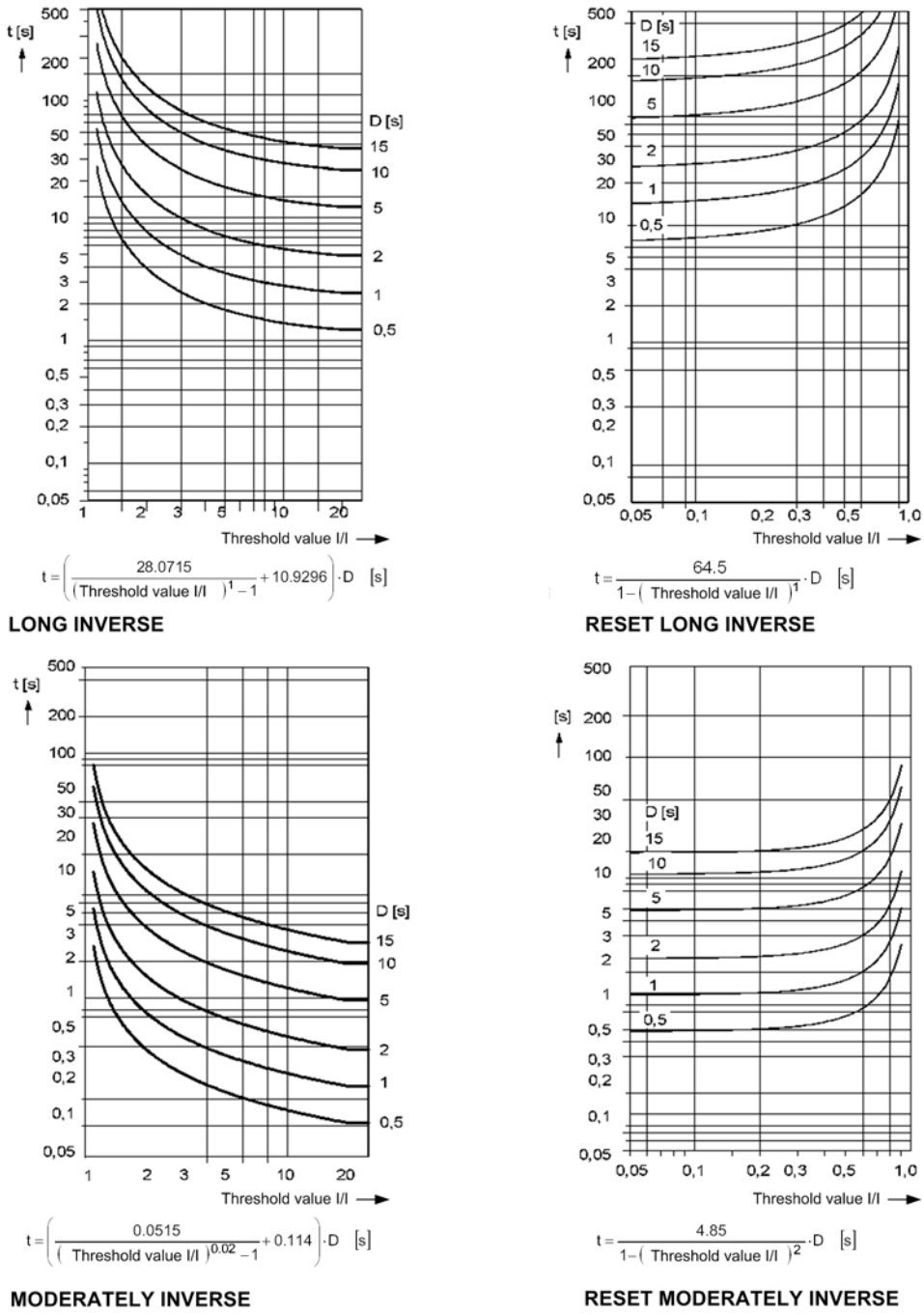

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Figure 11-6 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

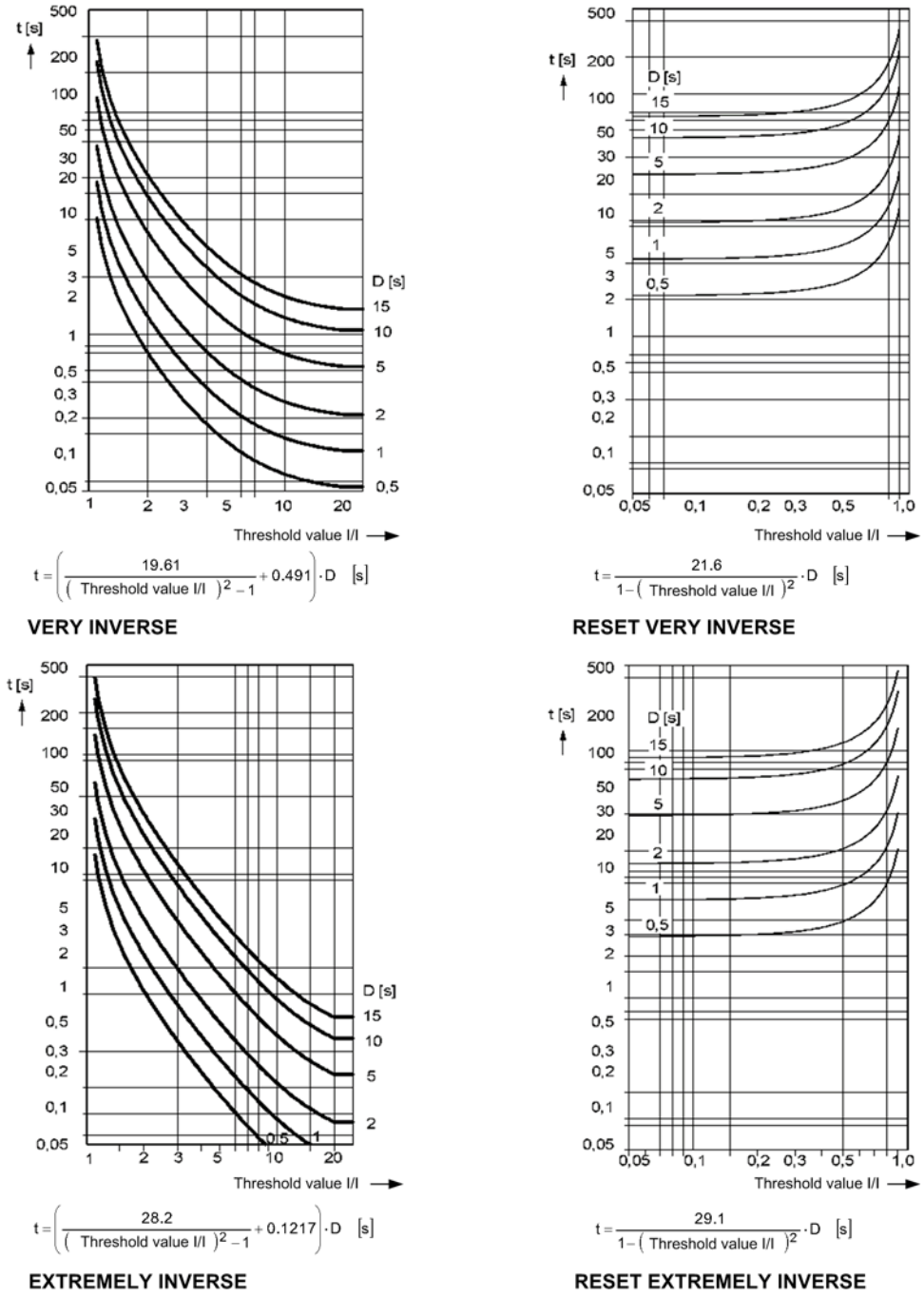

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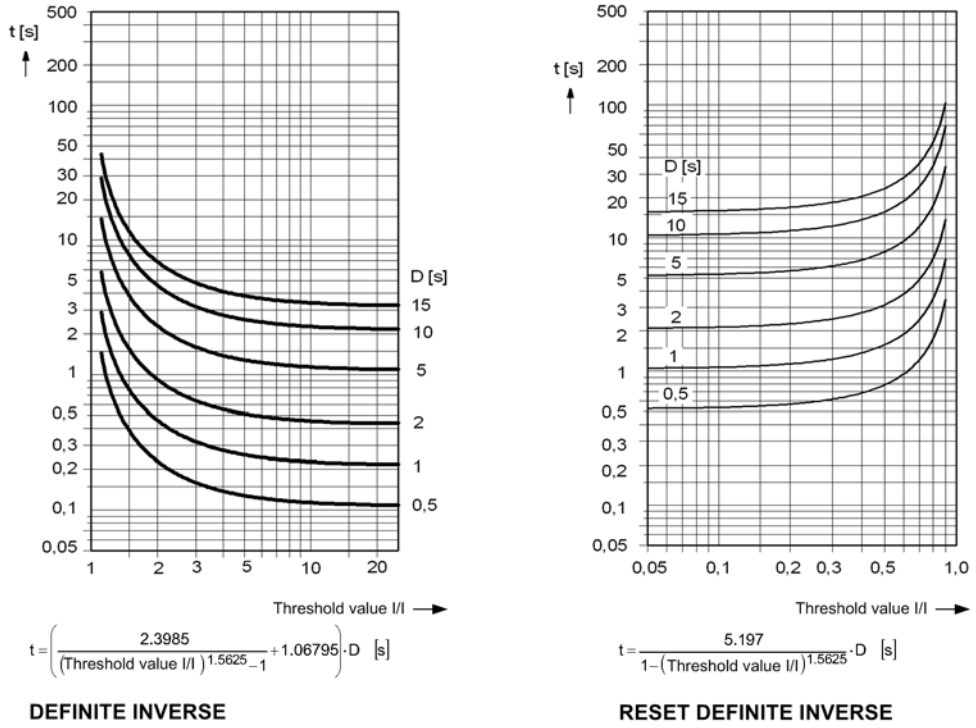
Figure 11-7 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



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

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Figure 11-8 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Tolerances

Currents, method of measurement = fundamental component	1% of setting or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Currents, method of measurement = RMS value Up to 30th harmonic Up to 35th harmonic (33 % part of harmonic, referring to fundamental component)	 1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%) 2 % of setting or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of set point value or +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of set point value or +2 % current tolerance or 30 ms

Influencing Variables for the Thresholds

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

11.16 Overcurrent Protection, Phases with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	For I_{rated} = 1 A	0.030 A to 100.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 500.00 A	Increments of 0.01 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0,05 to 15,00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 to 66.67 p. u.	Increments 0.01 p. u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 to 0.95 p. u.	Increments 0.01 p. u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Tolerances

Currents, method of measurement = fundamental component	1% of setting or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Currents, method of measurement = RMS value Up to 30th harmonic Up to 35th harmonic (33 % part of harmonic, referring to fundamental component)	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%) 2 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of set point value or +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of set point value or +2 % current tolerance or 30 ms

Influencing Variables for the Thresholds

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

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

11.17 Definite Time-Overcurrent Protection, Ground

Setting Values

Method of measurement		Fundamental frequency RMS value	–
Threshold value	For I_{rated} = 1 A	0.030 A to 100.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 500.00 A	Increments of 0.01 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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[1] 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

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

Operating Ranges

10 Hz to 80 Hz	According to specified tolerances
Outside 10 Hz to 80 Hz	Active

Tolerances

3I0 measured via I4[1], method of measurement = fundamental component	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[1], method of measurement = RMS value Up to 30th harmonic Up to 35th harmonic (33 % part of harmonic, referring to fundamental component)	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) 2 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

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

Influencing Variables for the Thresholds

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

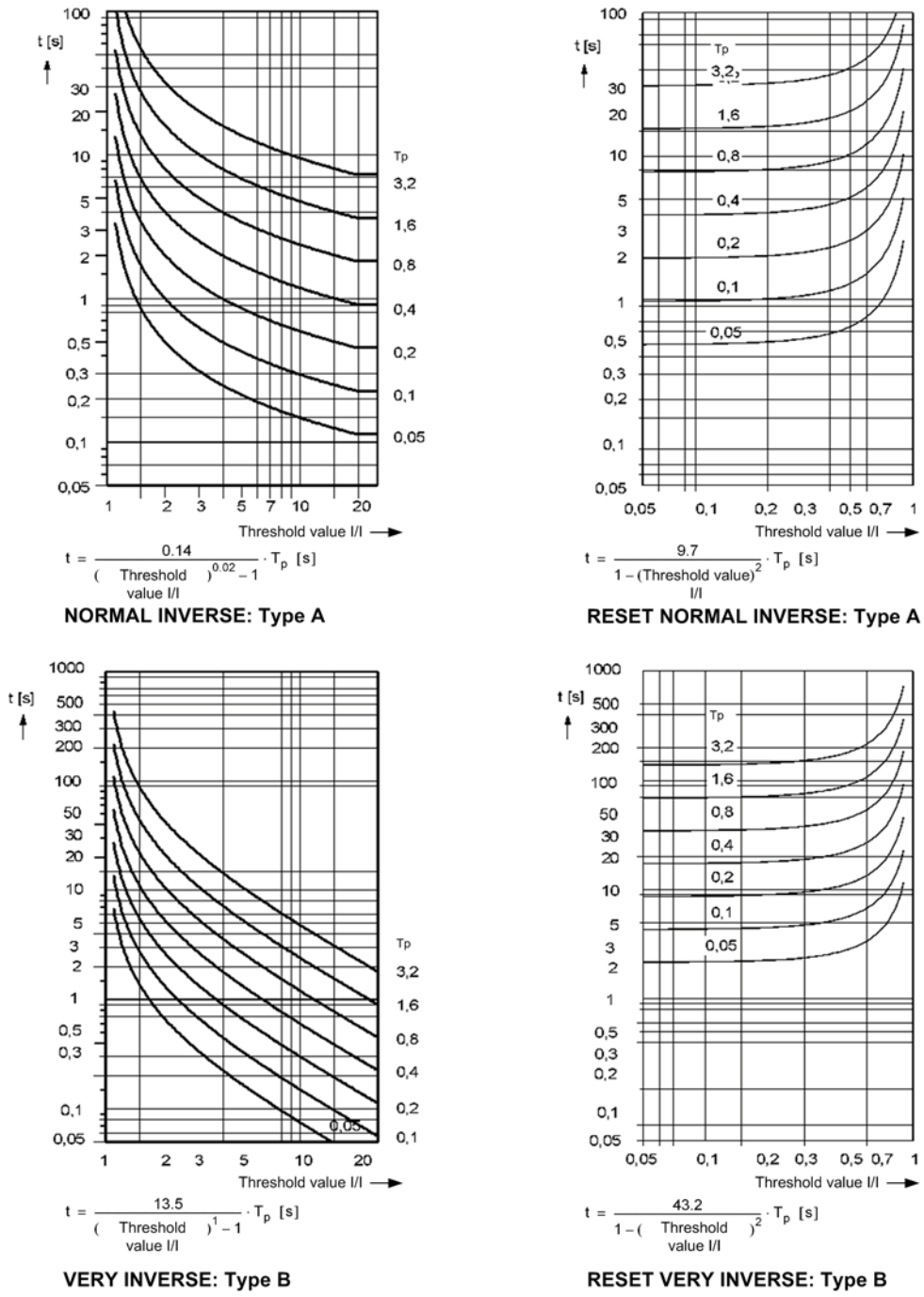
11.18 Inverse Time-Overcurrent Protection, Ground

Setting Values

Method of measurement		Fundamental frequency RMS value	–
Threshold value	For I_{rated} = 1 A	0.030 A to 100.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 500.00 A	Increments of 0.01 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01

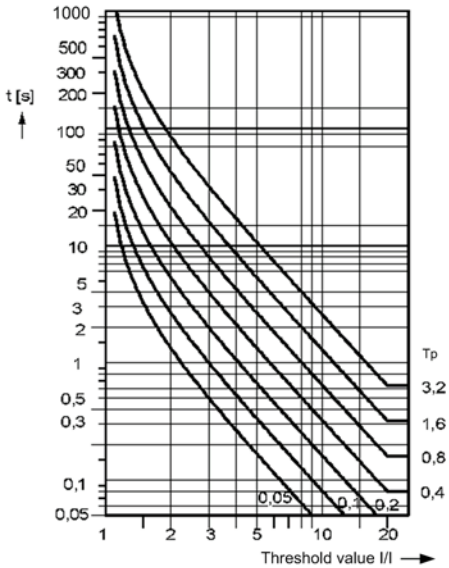
Operate Curves and Dropout-Time Characteristic Curves According to IEC

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



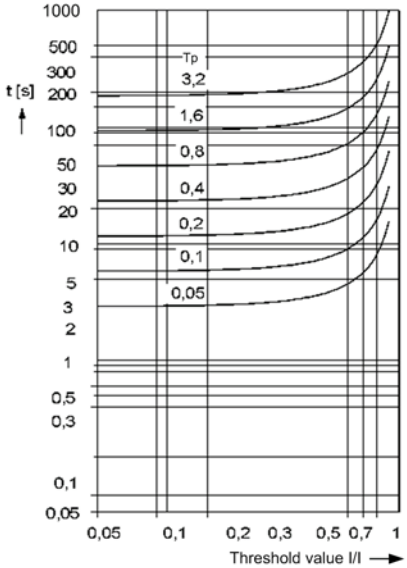
[DwOCPki1-030311-enUS-01.tif]

Figure 11-9 Operate Curves and Dropout-Time Characteristic Curves According to IEC



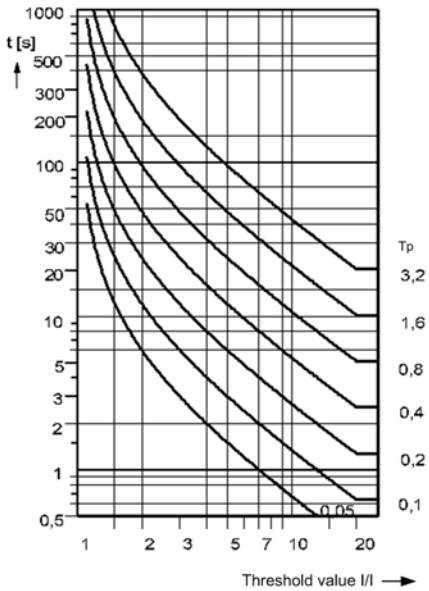
$$t = \frac{80}{\left(\frac{\text{Threshold value}}{I/I}\right)^2 - 1} \cdot T_p \ [s]$$

EXTREMELY INVERSE: Type C



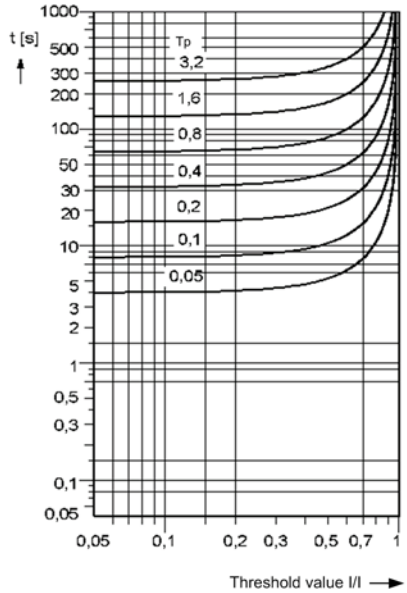
$$t = \frac{58.2}{1 - \left(\frac{\text{Threshold value}}{I/I}\right)^2} \cdot T_p \ [s]$$

RESET EXTREMELY INVERSE: Type C



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

LONG-TIME INVERSE: Type B



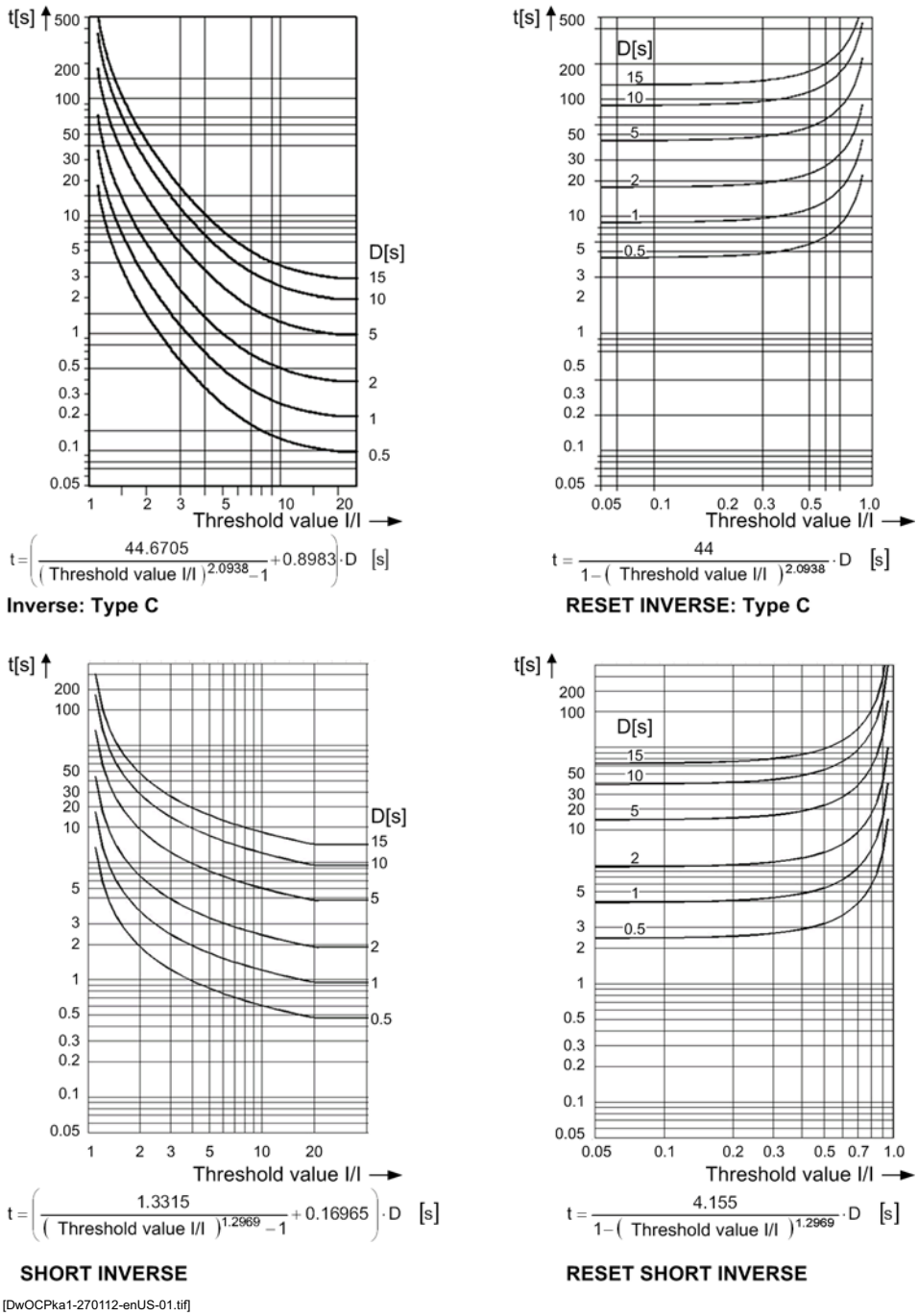
$$t = \frac{80}{1 - \left(\frac{\text{Threshold value}}{I/I}\right)^2} \cdot T_p \ [s]$$

RESET LONG-TIME INVERSE: Type B

[DwOCPki2-030311-enUS-01.tif]

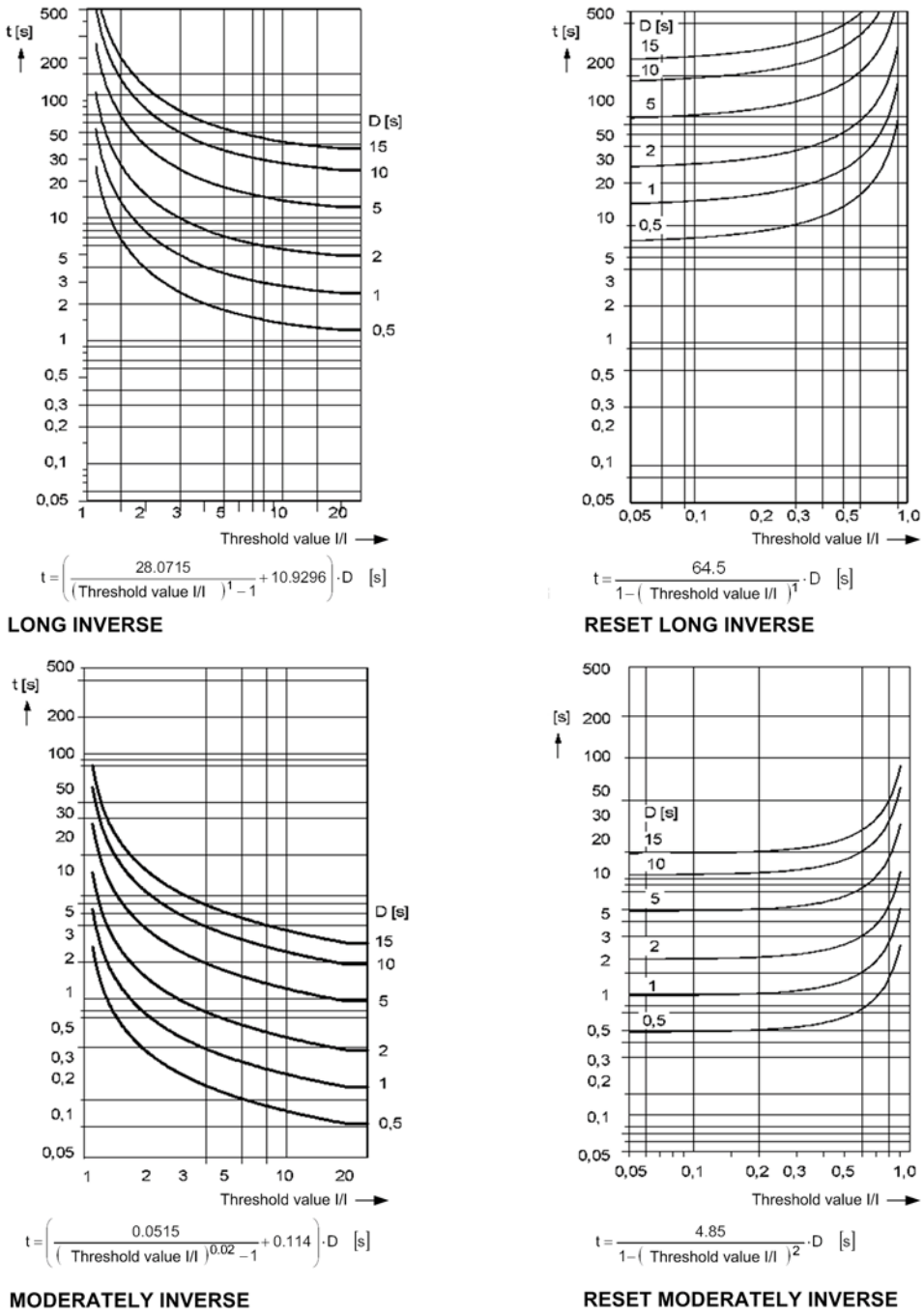
Figure 11-10 Operate Curves and Dropout-Time Characteristic Curves According to IEC

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



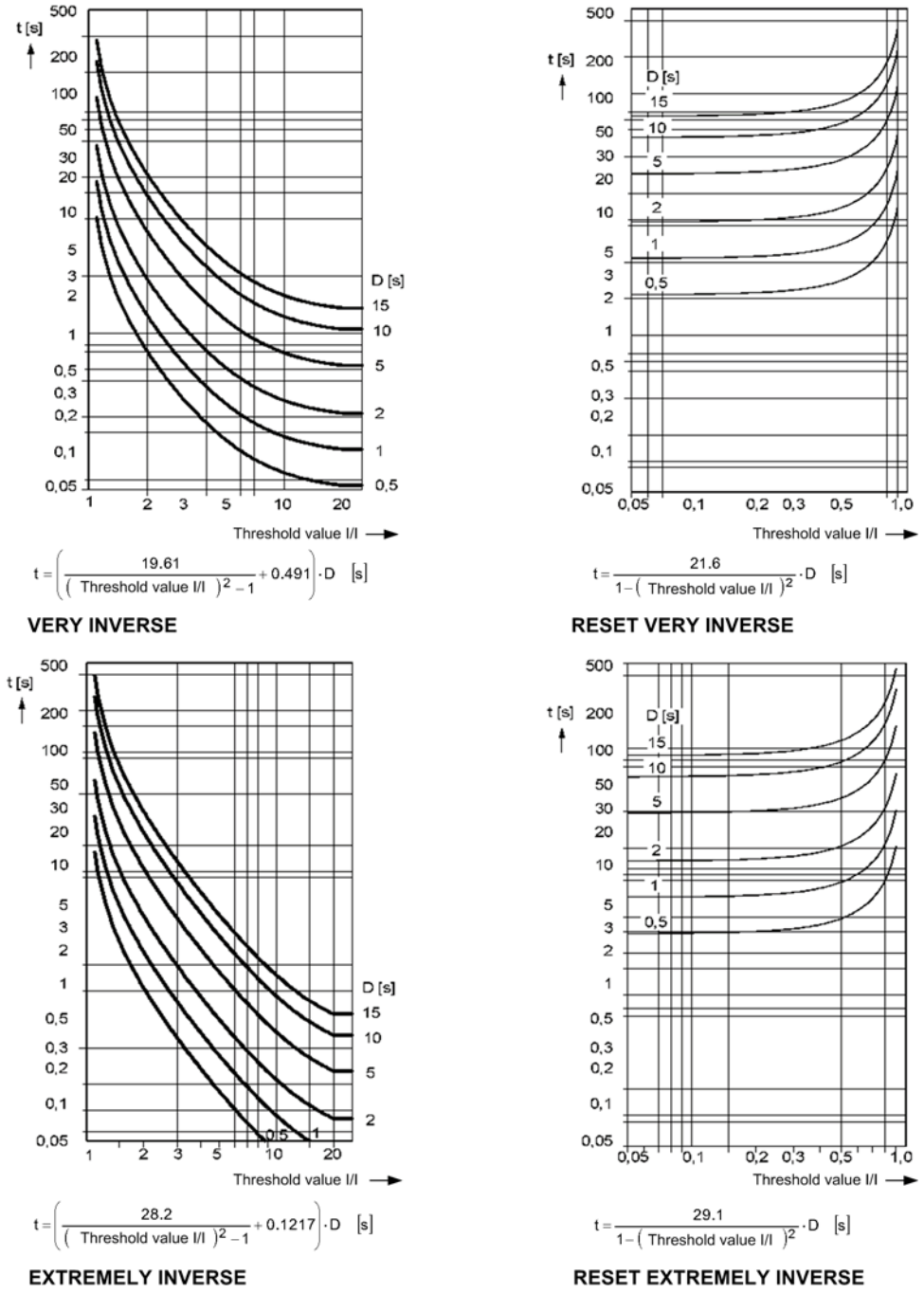
[DwOCPka1-270112-enUS-01.tif]

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



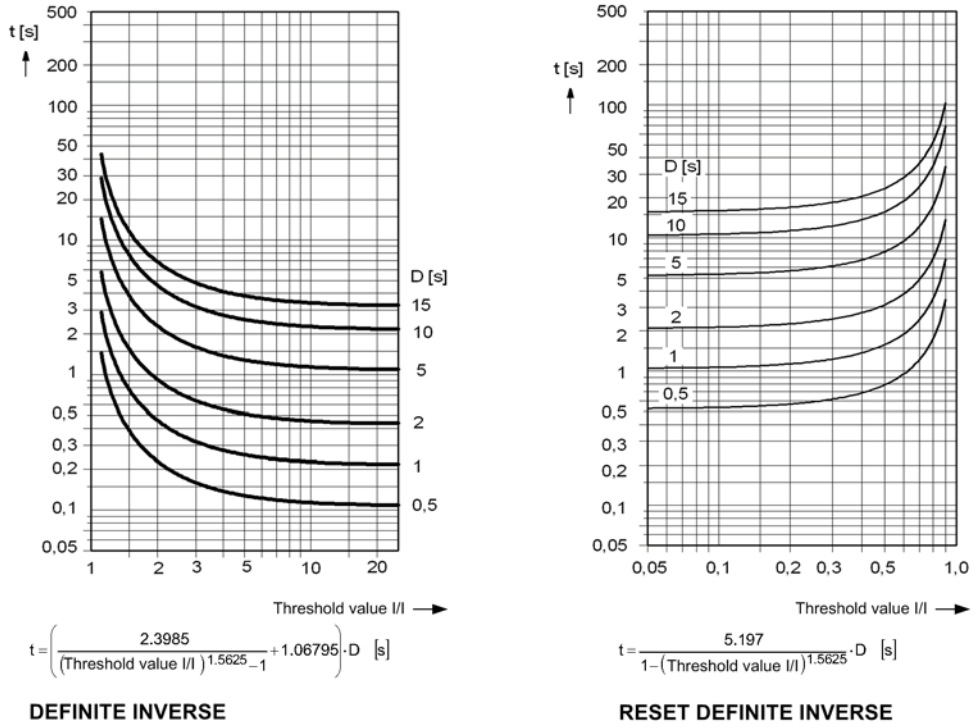
[DwOCPka2-110611-enUS-01.tif]

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



[DwOCPka3-030311-enUS-01.tif]

Figure 11-13 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



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

[DwOCPka4-050711-enUS-01.tif]

Figure 11-14 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Tolerances

3I0 measured via I4[1], method of measurement = fundamental component	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[1], method of measurement = RMS value Up to 30th harmonic Up to 35th harmonic (33 % part of harmonic, referring to fundamental component)	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) 2 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of set point value or +2 % current tolerance or 30 ms
Dropout time for 2 ≤ I/I threshold value ≤ 0.90	5 % of set point value or +2 % current tolerance or 30 ms

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

Influencing Variables for the Thresholds

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

11.19 Overcurrent Protection, Ground with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental frequency RMS value	–
Threshold value	For I_{rated} = 1 A	0.030 A to 100.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 500.00 A	Increments of 0.01 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 to 66.67 p. u.	Increments of 0.01 p. u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 to 0.95 p. u.	Increments of 0.01 p. u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Tolerances

3I0 measured via I4[1], method of measurement = fundamental component	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[1], method of measurement = RMS value Up to 30th harmonic Up to 35th harmonic (33 % part of harmonic, referring to fundamental component)	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) 2 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of set point value or +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of set point value or +2 % current tolerance or 30 ms

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

Influencing Variables for the Thresholds

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

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

11.20 Directional Time-Overcurrent Protection, Phases

Setting Values for the Function

Rotation angle of the reference voltage	-180° to +180°	Increments of 1°

Setting Values for All Stage Types

Direction		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	For I_{rated} = 1 A	0.030 A to 100.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 500.00 A	Increments of 0.01 A

Setting Values for Overcurrent-Protection Stage Type (Definite Time)

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

Setting Values for IEC/ANSI Characteristic Curve Stage Type (Inverse Time)

Type of characteristic curve	Characteristic curve according to IEC (see *Table 11-3*) and ANSI (see *Table 11-4*)	
Dropout	Disk emulation Instantaneous	–
Time multiplier	0.05 to 15.00	Increments of 0.01

Setting Values for Stage Type with User-Defined Characteristic Curve (Inverse Time)

Time multiplier	0.05 to 15.00	Increments of 0.01
X values of the operate curve	1.00 to 66.67 p. u.	Increments of 0.01 p. u.
Y values of the operate curve	0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve	2 to 30	Increments of 1
X values of the dropout characteristic curve	0.05 to 0.95 p. u.	Increments of 0.01 p. u.
Y values of the dropout characteristic curve	0.00 s to 999.00 s	Increments of 0.01 s

Tripping-Time and Dropout Time Characteristic Curves

You can select from the following tripping-time and dropout time characteristic curves:

Table 11-3 Standard Characteristic Curves to IEC

Normal inverse: type A	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-3*
Very inverse: type B	

Extremely inverse: type C	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-4*
Long time inverse	

Table 11-4 Standard Characteristic Curves to ANSI/IEEE

ANSI extremely inverse	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-5*
Long time inverse: type B	
Long time inverse	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-6*
ANSI moderately inverse	
ANSI definte inverse	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-7*
ANSI short time inverse	
ANSI long time inverse	See section *11.15 Inverse-Time Overcurrent Protection, Phases*, *Figure 11-8*

Direction Determination

Type	With cross-polarized 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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT [1] at 50 Hz Approx. 22 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

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

Operating Ranges

10 Hz to 80 Hz	According to specified tolerances
Outside 10 Hz to 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of 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 Up to 30th harmonic Up to 35th harmonic (33 % part of harmonic, referring to fundamental component)	 1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%) 2 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Definite-time operate time	1setting value% of the setting value or 10 ms

Inverse-time operate time according to IEC, ANSI, user-defined characteristic curve	5 % of set point value +2 % current tolerance or 10 ms
Inverse-time dropout time according to IEC, ANSI, user-defined characteristic curve	5 % of set point value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for the Thresholds

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

11.21 Instantaneous High-Current Tripping

Setting Values

Threshold value	0.030 A to 100.000 A at I_{rated} = 1 A 0.15 A to 500.00 A at I_{rated} = 5 A	Increments of 0.001 A at I_{rated} = 1 A Increments of 0.01 A at I_{rated} = 5 A
Dropout ratio	0.50 to 0.90	Increments of 0.01

Times

Operate time for current > 2·√2· threshold value	Approx. 8 ms + OOT[1]

1. OOT (Output Operating Time) Additional time delay of the used output medium, for example, 5 ms with quick relay

Operating Range

f_{rated} ± 10 %	According to specified tolerances
Behavior outside the operating range	Active starting at f ≥ 36.3 Hz

Tolerances

Response tolerance, current	5 % of setting value or 10 mA at I_{rated} = 1 A 5 % of setting value or 50 mA at I_{rated} = 5 A
Time delays	1 % of the setting value or 10 ms

11.22 Directional Negative-Sequence Protection with Definite-Time Delay

Setting Values

Direction	Forward, reverse, non-directional	
Stabilization with phase currents	0 % to 30 %	Increments of 1 %

Threshold value (pickup value) at $I_{N\text{-}rated}$ = 1 A	0.030 A to 100.000 A	Increments of 0.001 A
Threshold value (pickup value) at $I_{N\text{-}rated}$ = 5 A	0.15 A to 500.00 A	Increments of 0.01 A

Extension time of the blocking after a 1-pole pause	0.00 s to 60.00 s	Increments of 0.01 s

Settings for Determining the Direction

Minimum negative-sequence voltage V2		0.150 V to 20.000 V	Increments of 0.001 V
Minimum negative-sequence current I2	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Upper limit angle forward, β		0° to 360°	Increments of 1°
Lower limit angle forward, α		0° to 360°	Increments of 1°

Dropout Ratio

Approx. 0.95

Times

Operate time with time delay = 0 ms	Approx. 40 ms + OOT [1] at 50 Hz Approx. 40 ms + OOT at 60 Hz
Dropout time	Approx. 39 ms + OOT

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

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Outside 10 Hz to 80 Hz	Not active

Tolerances

Threshold values:	
Negative-sequence voltage V2	1 % of the setting value or 0.5 V
Negative-sequence current I2	2 % of setting value or 10 mA at I_{rated} = 1 A
	1 % of setting value or 5 mA at I_{rated} = 5 A
Times	
Independent time delays	1 % of the setting value or 10 ms

Limit angle in determining the direction	5°

11.23 Overvoltage Protection with 3-Phase Voltage

Setting Values

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup value	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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

1. OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside the operating range	Active

Tolerances

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

11.24 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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

1. OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside the operating range	Active, but more insensitive

Tolerances

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

11.25 Overvoltage Protection with Negative-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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

1. OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Outside 10 Hz to 80 Hz	Active

Tolerances

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

11.26 Overvoltage Protection with Positive-Sequence Voltage and Compounding

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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

1. OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside the operating range	Active, but more insensitive

Tolerances

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

11.27 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 failure	Yes No	
Determ. ph. aff. by grd. flt.	Yes No	
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
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< faulted 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

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[1] 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. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.06 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

1. OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside 10 Hz to 80 Hz	Active

Tolerances

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

11.28 Overvoltage Protection with Any Voltage

Setting Values

Measured value	Measured voltage at transformer 1 Measured voltage at transformer 2 Measured voltage at transformer 3 Measured voltage at transformer 4 Calculated voltage V_{AB} Calculated voltage V_{BC} Calculated voltage V_{CA}	
Method of measurement	Fundamental component RMS value	
Pickup value	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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

1. OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside the operating range	Active, but more insensitive

Tolerances

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

11.29 Undervoltage Protection with 3-Phase Voltage

Setting Values

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Current-flow criterion	On Off	
Threshold value I>	0.030 A to 10.000 A at I_{rated} = 1 A 0.15 A to 50.00 A at I_{rated} = 5 A	Increments of 0.001 A Increments of 0.01 A
Pickup value	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

Times

Operate time	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

1. OOT (Output Operating Time) additional delay of the output medium is used. For example 5 ms with quick relay, see chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside the operating range	Inactive
In the case of a pickup before leaving the operating range	Seal-in; 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 0.5 V in the range f_{rated} ± 10 %
	1 % of the setting value or 1.0 V in the frequency range between 10 Hz and 80 Hz
Currents	1 % of the setting value or 5 mA in the range f_{rated} ± 10 % (Valid for terminal Current 4 x Protection up to 100 I_{rated})
	1 % of the setting value or 5 mA in the range f_{rated} ± 10 % (Valid for terminal Current 4 x Measurement up to 20 I_{rated})
Time delays	1 % of the setting value or 10 ms

11.30 Undervoltage Protection with Positive-Sequence Voltage

Setting Values

Pickup value	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
Current-flow criterion	On/Off	
Threshold value I>	0.030 A to 10.000 A at I_{rated} = 1 A 0.15 A to 50.00 A at I_{rated} = 5 A	Increments of 0.001 A Increments of 0.01 A

Times

Operate time	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

1. OOT (Output Operating Time) additional delay of the output medium is used, for example, 5 ms with quick relay, see chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside the operating range	Inactive
In the case of a pickup before leaving the operating range	Seal-in; 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 0.5 V in the range f_{rated} ± 10 %
	1 % of the setting value or 1.0 V in the frequency range between 10 Hz and 80 Hz
Currents	1 % of the setting value or 5 mA in the range f_{rated} ± 10 % (Valid for terminal Current 4 x Protection up to 100 I_{rated})
	1 % of the setting value or 5 mA in the range f_{rated} ± 10 % (Valid for terminal Current 4 x Measurement up to 20 I_{rated})
Time delays	1 % of the setting value or 10 ms

11.31 Undervoltage Protection with Any Voltage

Setting Values

Measured value	Measured voltage at transformer 1 Measured voltage at transformer 2 Measured voltage at transformer 3 Measured voltage at transformer 4 Calculated voltage V_{AB} Calculated voltage V_{BC} Calculated voltage V_{CA}	
Method of measurement	Fundamental component RMS value	
Pickup value	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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

1. OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with quick relay, see chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside the operating range	Inactive
In the case of a pickup before leaving the operating range	Seal-in; 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 0.5 V
Time delays	1 % of the setting value or 10 ms

11.32 Fault Locator

Setting Values

You can find the following settings in the line data of the **line** protection function group: • The reactance per unit length of the line per kilometer or per mile • The line length for the correct output of the fault distance as a percentage of the line length • The ground impedance adjustment factors in the setting format Kr and Kx or K0 and angle (K0)	
Parallel-line compensation (optional)	For connection or disconnection
Consideration of the load current for 1-phase short circuits to ground	Correction of the X value, for connection and disconnection

Fault Distance

Output of the fault distance (line length)	In Ω primary In km, miles, or in percent. [1]

1. The output of the fault distance in km, miles, and percent presupposes a homogenous line.

Tolerances

Measuring tolerances during sinusoidal measurands and error duration > 25 ms	2.5 % of the line length At $30° \leq \varphi_K \leq 90°$ and $V_K/V_{rated} \geq 0.1$

11.33 Overfrequency Protection

Setting Values

Pickup values f>	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f>	Angle difference method 50 Hz 60 Hz	Approx. 70 ms + OOT [1]. Approx. 60 ms + OOT
	Filtering method 50 Hz 60 Hz	Approx. 75 ms + OOT Approx. 75 ms + OOT
Dropout times f>	60 ms to 80 ms	

1. OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays, see Section *11.1.4 Relay Outputs*

Dropout Ratio

Minimum voltage	Approx. 1.05

Operating Ranges

In voltage range	5 V to 230 V (phase-to-phase)	
In frequency range	Angle difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f>	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f>)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

11.34 Underfrequency Protection

Setting Values

Pickup values f<	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f<	Angle difference method 50 Hz 60 Hz	80 ms/60 ms Approx. 70 ms + OOT [1]. Approx. 60 ms + OOT
	Filtering method 50 Hz 60 Hz	95 ms/80 ms Approx. 75 ms + OOT Approx. 75 ms + OOT
Dropout times f<	60 ms to 80 ms	

1. OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays, see Section *11.1.4 Relay Outputs*

Dropout Ratio

Minimum voltage	Approx. 1.05

Operating Ranges

In voltage range	5 V to 230 V (phase-to-phase)	
In frequency range	Angle difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f<	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T (f<)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

11.35 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

11.36 Thermal Overload Protection

Setting Ranges/Increments

Current warning threshold	0.030 A to 100.000 A	Increments of 0.001 A
Thermal warning threshold	50 % to 100 %	Increments of 1 %
Dropout threshold operate indication	50 % to 99 %	Increments of 1 %
Emergency startup seal-in time	0 s to 15 000 s	Increments of 10 s
K factor according to IEC 60225-8	0.10 to 4.00	Increments of 0.01
Thermal time constant	30 s to 60 000 s	Increments of 1 s
Cooling time constant	30 s to 60 000 s	Increments of 1 s
Thermal Imax	0.030 A to 10.000 A	Increments of 0.001 A
Cooling Imin	0.000 A to 10.000 A	Increments of 0.001 A

Dropout Ratios

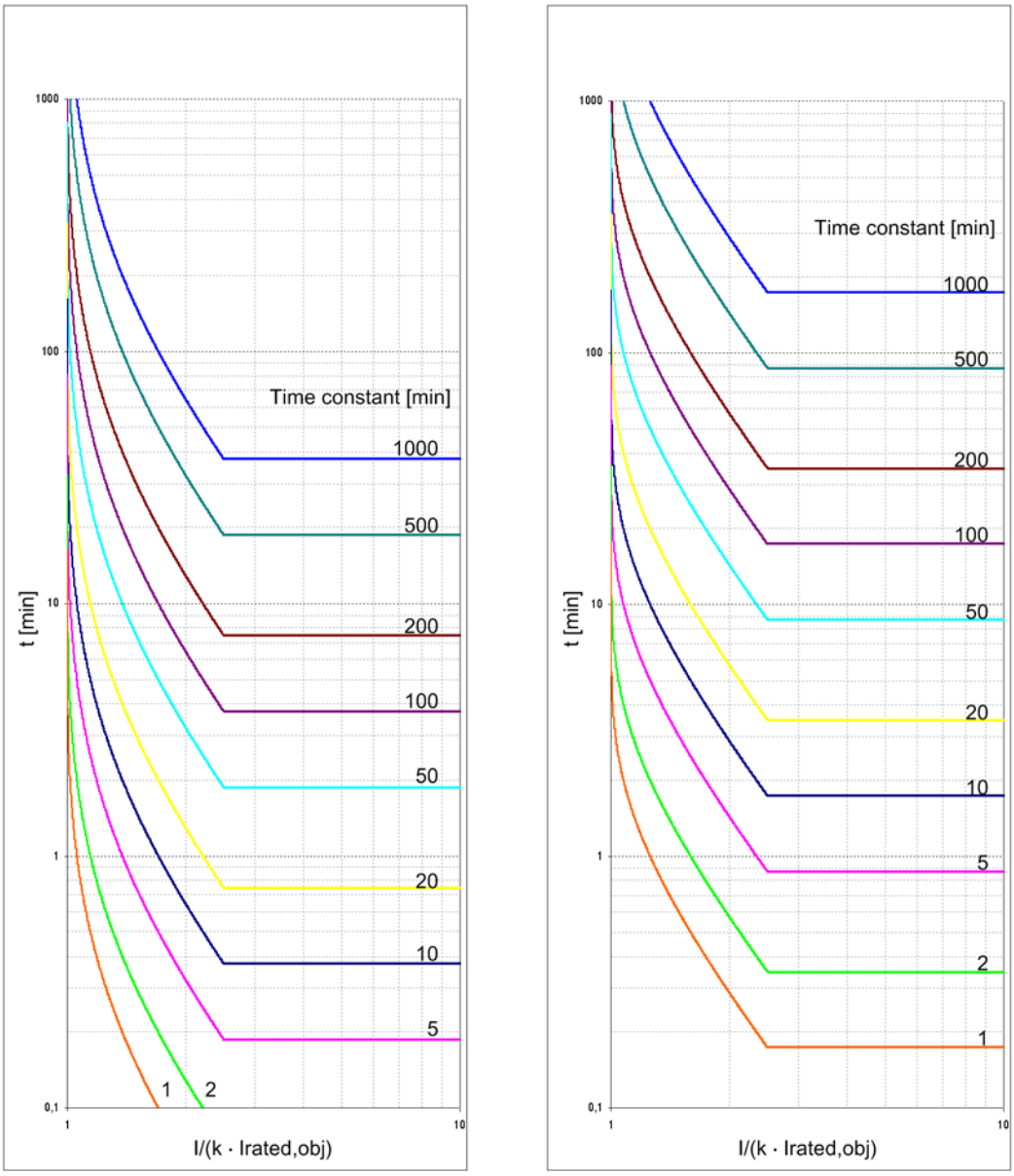
Tripping threshold (fixed to 100 %)	Dropout if operate indication dropout threshold falls short
Thermal warning threshold	Approx. 0.99 of the setting value
Current warning threshold	Approx. 0.95 of the setting value

Tolerances

With reference to k* I_{rated}	For I_{rated} = 1 A	2 % or 10 mA, class 2 % according to IEC 60255-8
	For I_{rated} = 5 A	2 % or 50 mA, class 2 % according to IEC 60255-8
With reference to operate time		3 % or 1 s, class 3 % according to IEC 60255-8 for $I/(k * I_{rated}) > 1.25$

Operate Curve

Operate curve	$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj.}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - 1}$$ [FoAuslos-211010-enUS-01.tif]	
Where:	t	Operate time
	τ_{th}	Time constant
	I	Current load current
	$I_{preload}$	Preload current
	k	Setting factor according to VDE 0435 Part 3011 or IEC 60255-8 (K factor)
	$I_{rated, obj}$	Rated current of the protected object



With 80 % preload and with Imax, therm = 2,5*k*Irated

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \quad [min]$$

Without preload and with Imax, therm = 2,5*k*Irated

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \quad [min]$$

[DwAuslKe-100611-enUS-01.tif]

Figure 11-15 Operate Curve of the Overload Protection

11.37 Circuit-Breaker Failure Protection

Starting Conditions

For circuit-breaker failure protection	1-pole internal or external tripping [1]
	3-pole internal or external tripping [2]

1. Using binary inputs
2. Via binary inputs

Setting Values

Phase-current threshold value	For I_{rated} = 1 A	0.03 A to 100.00 A	Increments of 0.01 A
	For I_{rated} = 5 A	0.25 A to 500.00 A	
Ground-current threshold value	For I_{rated} = 1 A	0.03 A to 100.00 A	Increments of 0.01 A
	For I_{rated} = 5 A	0.25 A to 500.00 A	
Supervision time of release signal		0.06 s to 1.00 s	Increments of 0.01 s
Time delays		0.05 s to 60.00 s	Increments of 0.01 s

Dropout Ratios

Current-threshold values	Approx. 0.95

Circuit-Breaker Supervision

Position supervision of the circuit-breaker auxiliary contacts	
For 3-pole CB tripping	1 input each for the make and break contact
For 1-pole CB tripping	1 input each for auxiliary contact per pole or 1 input each for series connection make 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 for tripping in cases where the current flow is absent or too low (for example with a transformer or a Buchholz protection).

Times

Pickup time, in the case of an internal start Pickup time, in the case of an external start	< 1 ms < 5 ms
Dropout time [1] using the current-flow criterion, for sinusoidal quantities	< 10 ms
Dropout time, using the current-flow criterion, under all conditions	< 15 ms
Dropout time, using circuit-breaker auxiliary contact criterion	< 5 ms

1. The dropout time is the time required by the CBFP function to detect that the CB is open. The time for mechanically switching a contact is not included.

Tolerances

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

11.38 Out-of-Step Protection

General

Value	Setting Range
Zones	Max. 4
Number of acceptable swings per zone	1 to 20
Maximum negative-sequence current	5.0 % to 100.0 % (Increments of 0.1 %)
Minimum positive sequence current	10.0 % to 400.0 % (Increments of 0.1 %)

Rectangle

Value	Setting Range	Increment
Re(Z): Width[1]	0.050 Ω to 600.000 Ω (at 1 A)	0.001 Ω
In(Z): Upper and lower limits[2]	-600.000 Ω to +600.000 Ω (at 1 A)	0.001 Ω
Inclination angle	60° to 90°	0.1°

1. The limits must be divided by 5 if the a transformer rated secondary current is 5 A.
2. The limits must be divided by 5 if the a transformer rated secondary current is 5 A.

Times

Value	Setting Range	Increment
Re-entry time	0.00 s to 60.00 s	0.01 s
Signal time	0.00 s to 60.00 s	0.01 s
Counter waiting time	0 ms to 1000 ms	10 ms

11.39 Inrush-Current Detection

Setting Values

Operating-range limit I_{max}	0.030 A to 100.000 A at I_{rated} = 1 A 0.15 A to 500.00 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 cross-blocking	0.03 s to 200.00 s	Increments of 0.01 s

Times

Pickup times	Approx. 29 ms

Dropout Ratios

Current measurement I_{max}	0.95 or 0.015 A at I_{rated} = 1 A 0.95 or 0.075 A at I_{rated} = 5 A
Harmonic: $I_{2nd\ Harm}/I_{1st\ harm}$	0.95

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside 10 Hz to 80 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 for settings of $I_{2nd\ Harm}/_{1st\ Harm}$
Time delays	1 % of the setting value or 10 ms

11.40 Power Protection (P, Q) 3-Phase

Setting Values

Measured value	Positive-sequence power Power of phase A Power of phase B Power of phase C	
Threshold value	-200.0 % to +200.0 %	Increments of 0.1
Tilt power characteristic	-89.0° to +89.0°	Increments of 0.1°
Dropout delay time	0.00 s to 60.00 s	Increments of 0.01 s
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	Upper stage: 0.90 to 0.99 Lower stage: 1.01 to 1.10	Increments of 0.01 Increments of 0.01

Times

Pickup times	Approx. 60 ms for f = 50 Hz Approx. 50 ms for f = 60 Hz
Dropout times	Approx. 60 ms for f = 50 Hz Approx. 50 ms for f = 60 Hz

Tolerances

Power	0.5 % S_{rated} ± 3 % of setting value (S_{rated}: Rated apparent power)
Time delays	1 % of the setting value or 10 ms

Variables that Influence the Pickup Values

Auxiliary direct voltage in the range $0.8 \leq V_{Aux}/V_{AuxRated} \leq 1.15$	≤ 1 %
Frequency in the range $0.95 \leq f/f_{rated} \leq 1.05$	≤ 1 %
Harmonics - up to 10 % of 3rd harmonics - up to 10 % of 5th harmonics	 ≤ 1 % ≤ 1 %

11.41 Current-Jump Detection

Times

Pickup time	Approx. 10 ms at 50 Hz Approx. 8 ms at 60 Hz

Working Area

10 Hz to 80 Hz	Function active
Behavior outside the operating range	Function 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

11.42 Voltage-Jump Detection

Times

Pickup time	Approx. 10 ms at 50 Hz Approx. 8 ms at 60 Hz

Working Area

10 Hz to 80 Hz	Function active
Behavior outside the operating range	Function 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

11.43 Synchronization Function

Operating Modes

Synchrocheck
Switching synchronous networks
Switching asynchronous networks
De-energized switching
Forced tripping

Setting Values

Supervision/Delay times:		
Max. duration of sync. process	0.00 s to 3 600.00 s or ∞ (ineffective)	Increments of 0.01 s
Superv. time de-energized switch-ing	0.00 s to 60.00 s	Increments of 0.01 s
Activation delay	0.00 s to 60.00 s	Increments of 0.01 s
Voltage threshold values:		
Upper voltage limit V_{max}	3.000 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
Lower voltage limit V_{min}	3.000 V to 170.000 V (phase-to-phase)	Increments of 0.001 V
V<, for off-circuit conditions V>, for voltage present	3.000 V to 170.000 V (phase-to-phase) 3.000 V to 340.000 V (phase-to-phase)	Increments of 0.001 V Increments of 0.001 V
Differential values, changeover thresholds asynchronous/synchronous:		
Voltage differences V2 > V1; V2 < V1	0.000 V to 170.000 V	Increments of 0.001 V
Frequency difference f2 > f1; f2 < f1	0.00 Hz to 2.00 Hz	Increments of 0.01 Hz
Angular difference $\alpha 2 > \alpha 1$; $\alpha 2 < \alpha 1$	0° to 90°	Increments of 1°
Δf threshold ASYN <-> SYN	0.01 Hz to 0.20 Hz	Increments of 0.01 Hz
Adjustments of the sides:		
Angle adjustment	0° to 360°	Increments of 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

Voltages	Approx. 0.9 (V>) or 1.1 (V<)
Voltage difference	110 % or 0.5 V
Frequency difference	105 % or 20 mHz
Angular difference	1°

Measured Values of the Synchronization Function

Reference voltage V1 • Range • Tolerance [1]	In kV primary, in V secondary or in % V_{rated} 10 % to 120 % of V_{rated} ≤ 1 % of the measured value or 0.5 % V_{rated}
Voltage to be synchronized V2 • Range • Tolerance [1]	In kV primary, in V secondary or in % V_{rated} 10 % to 120 % of V_{rated} ≤ 1 % of the measured value or 0.5 % V_{rated}
Frequency of the voltage V1f1 • Range • Tolerance [1]	f1 in Hz 25 Hz ≤ f ≤ 70 Hz 10 mHz
Frequency of the voltage V1f2 • Range • Tolerance [1]	f2 in Hz 25 Hz ≤ f ≤ 70 Hz 10 mHz
Voltage difference V2-V1 • Range • Tolerance [1]	In kV primary, in V secondary or in % V_{rated} 10 % to 120 % of V_{rated} ≤ 1 % of the measured value or 0.5 % V_{rated}
Frequency difference f2-f1 • Range • Tolerance [1]	In mHz f_{rated} ± 10 % 5 mHz
Angular difference λ2-λ1 • Range • Tolerance [1]	In ° -180° to +180° 0.5°

1. at rated frequency

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

11.44 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

11.45 Current-Balance Supervision

Setting Values

Release threshold value	0.030 A to 90.000 A at I_{rated} = 1 A 0.15 A to 450.00 A at I_{rated} = 5 A	Increments of 0.001 A Increments of 0.01 A
Threshold value min/max	0.10 to 0.95	Increments of 0.01
Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s

Times

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

11.46 Voltage-Balance Supervision

Setting Values

Release threshold value	0.300 V to 100.000 V	Increments of 0.001 V
Threshold value min/max	0.58 to 0.95	Increments of 0.01
Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s

Times

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

11.47 Current-Sum Supervision

Setting Values

Slope factor	0.00 to 0.95	Increments 0.01
Threshold value	0.030 A to 10.000 A at I_{rated} = 1 A 0.15 A to 50.00 A at I_{rated} = 5 A	Increments of 0.001 A Increments of 0.01 A
Tripping delay	0.00 s to 100.00 s	Increments of 1.00 s

Times

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

11.48 Voltage-Sum Supervision

Setting Values

Threshold value	0.300 V to 100.000 V	Increments of 0.001 V
Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s

Times

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

11.49 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

11.50 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 C B A	

Times

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

11.51 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

11.52 Supervision of Device-Internal Analog-Digital Converters

Setting Values

Slope factor	0.00 to 0.95	Increments of 0.01
Threshold value	0.030 A to 10.000 A at I_{rated} = 1.00 A 0.15 A to 50.00 A at I_{rated} = 5.00 A	Increments of 0.001 A Increments of 0.01 A

Times

Tripping time	Approx. 5 ms (faster than the fastest protection function)
Dropout time	Approx. 100 ms

Blockings

Blocked protection functions	Differential protection for lines, differential protection for transformers, motors, generators, busbars, ground-fault differential protection, overcurrent protection (high-current stage)

11.53 Measuring-Voltage Failure Detection

Setting Values

3-ph fault–VA,VB,VC <	0.300 V to 340.000 V	Increments of 0.001 V
3-ph fault–release phase current	0.030 A to 100.000 A at I_{rated} = 1 A 0.15 A to 50.00 A at I_{rated} = 5 A $I_{min} \leq I_{min\ (distance\ protection)}$	Increments of 0.001 A Increments of 0.01 A
3-ph fault–Jump phase current	0.030 A to 100.000 A at I_{rated} = 1 A 0.15 A to 50.00 A at I_{rated} = 5 A	Increments of 0.001 A Increments of 0.01 A
Asym. fault–time delay	0.00 s to 30.00 s	Increments of 0.01 s
Switching to 3-ph fault–delay time	0.00 s to 30.00 s	Increments of 0.01 s

Times

Pickup time	Approx. 10 ms + OOT[1] at 60 Hz Approx. 10 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

1. OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter *11.1.4 Relay Outputs*

Operating Range

10 Hz to 80 Hz	According to specified tolerances
Behavior outside the operating range	Active

Tolerances

	I_{max} secondary	I_{rated} secondary	Tolerance of I_{rated}	Tolerance of I_{min}
Currents	500 A	5 A	0.5 %	5 % of 0.15 A
	100 A	1 A or 5 A	0.5 %	5 % of 0.03 A
	20 A	1 A	0.2 %	5 % of 0.01 A

	V_{max} sec.	V_{rated} sec.	Tolerance of V_{rated}	Tolerance of V_{min}
Voltages	200 V	57.7 V	0.2 %	1 %

Tripping delay	1 % of the setting value or 10 ms

11.54 Voltage-Transformer Circuit Breaker

Setting Values

Response time	0.000 s to 0.030 s	Increments of 0.001 s

11.55 Operational Measured Values

Voltages

V_A, V_B, V_C	kV primary, V secondary, % of V_{rated}
Voltage range Frequency range	10 % to 200 % of V_{rated} 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	0.2 % of the measured value in the above ranges
V_{AB}, V_{BC}, V_{CA}	kV primary, V secondary, % of V_{rated}
Voltage range Frequency range	10 % to 200 % of V_{rated} 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	0.2 % of the measured value in the above ranges

Currents

I_A, I_B, I_C, 3_{I0}	A secondary
Current range Rated range Measuring ranges Frequency range	Measurement from 0.1 A to 25 A 1 A, 5 A 100 · Ir, 1.6 · Ir 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	0.2 % of the measured value in the above ranges

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

Ratings

Active power P	MW
Range P Rated-current range Current measuring ranges Frequency range	50 % to 120 % and ABS (cos φ) ≤ 0.07 1 A, 5 A 100 · Ir, 1.6 · Ir 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 P	0.5 % P_{rated} with I/I_{rated} and V/V_{rated}
P_A, P_B, P_C	-
Apparent power S	MVA
Range S	50 % to 120 %
Tolerance S	0.5 % S_{rated} with I/I_{rated} and V/V_{rated}
S_A, S_B, S_C	-
Reactive power Q	MVAr

Range Q	50 % to 120 % and ABS (cos φ) $\leq$ 0.07
Tolerance Q	1 % P_{rated} with I/I_{rated} and V/V_{rated}
Power factor λ	°
Tolerance	0.02
Q_A, Q_B, Q_C	-

Frequency

Frequency f	Hz and % f_{rated}
Range	10 Hz to 80 Hz
Tolerance	20 mHz in the range f_{rated} $\pm$ 10 % for rated variables

11.56 Energy Values

Setting Values

Active energy W_p Reactive energy W_q	kWh, MWh, GWh kvarh, Mvarh, Gvarh
Range	$\leq$ 2 % for I > 0.1 I_{rated}, V > 0.1 V_{rated} $\lvert\cos\varphi\rvert \geq 0.707$
Tolerance at rated frequency	1 %

11.57 Phasor Measurement Unit

Frequency

Frequency range	10 Hz to 80 Hz
Accuracy	5 mHz in a range from $0.7 \cdot f_{rated}$ to $1.2 \cdot f_{rated}$

Magnitudes, Phase Angles

Accuracy for magnitude measurements	0.1 %
Accuracy for phase-angle measurements	0.1 °

■