# SIPROTEC 5 V1.1
# Distance Protection and Line Differential Protection and Overcurrent Protection for 3-Pole Tripping 7SA84, 7SD84, 7SA86, 7SD86, 7SL86, 7SJ86

**Technical Data**

**Extract from manual C53000-G5040-C010-2, 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.

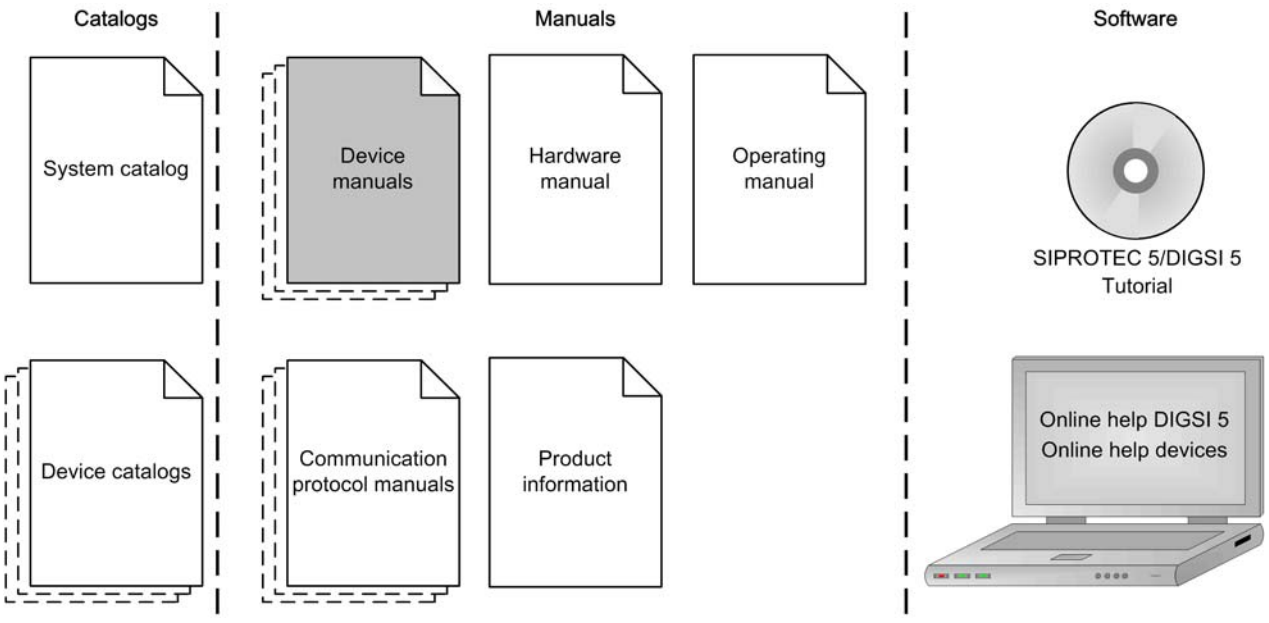
### Target Group

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.

Phone: +49 (1805) 24-7000

Fax: +49 (1805) 24-2471

Email: support.ic@siemens.com

### Training Courses

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

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Siemens Power Academy

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Phone: +49 (911) 433-7415

Fax: +49 (911) 433-5482

Email: td.power-academy.energy@siemens.com

Internet: http://www.siemens.com/energy/power-academy

### 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.

# 11 Technical Data

# 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<br>25 A for 3 min<br>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:<br>PS201 – Power supply of the base module and of the 1st device row<br>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/<br>DC 220 V/DC 250 V<br>or<br>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<br>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<br>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<br>DC $V_{high} \geq 19$ V |
| | Range 2 for 110 V and 125 V Operating voltage | DC $V_{low} \leq 44$ V<br>DC $V_{high} \geq 88$ V |
| | Range 3 for 220 V and 250 V Operating voltage | DC $V_{low} \leq 88$ V<br>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<br>Off: 30 VA; 40 W ohmic;<br>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<br>DC 48 V, 0.8 A, general purpose<br>DC 240 V, 0.1 A, general purpose<br>AC 240 V, 5 A, general purpose<br>AC 120 V, 248.7 W<br>AC 250 V, 373 W<br>B300<br>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<br>Off: 30 VA; 40 W ohmic;<br>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<br>AC 277 V, 6 A, general purpose<br>AC 277 V, 522.2 W<br>AC 347 V, 4.5 A, general purpose<br>B300<br>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<br>Q300 |

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

## 11.1.5 Design Data

### Masses

| | Device Size<br>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)<br>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<br>Rear panel IP50 |
| For operator protection | IP2X for current terminals<br>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 ferrules 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<br>Off | |
| PPS synchronization | Telegr. and PPS<br>Telegr. or PPS<br>PPS synchronization off | |
| Blocking of the asymmetrical run-times | Yes<br>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<br>G703-T1 with 1.455 MBit/s<br>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<br>1.455 MBit/s at G703-T1<br>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 |
| $0.8 \leq f/f_{rated} \leq 0.9$<br>$1.1 \leq f/f_{rated} \leq 1.2$ | 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 |
| $0.8 \leq f/f_{rated} \leq 0.9$<br>$1.1 \leq f/f_{rated} \leq 1.2$ | 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 faults in a grounded system | Block leading phase from ground<br>Block lagging phase from ground<br>Release all loops involved<br>Release phase-to-ground loops involved<br>Release phase-to-phase loops involved |
| For double ground faults in isolated or resonant-grounded system | C(A) acyclic<br>A(C) acyclic<br>B(A) acyclic<br>A(B) acyclic<br>C(B) acyclic<br>B(C) acyclic<br>C(A) cyclic<br>A(C) cyclic<br>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 |
| Measuring tolerances for sinusoidal values | | ± 5 % | |

### Distance Measurement

| | | | |
|---|---|---|---|
| Characteristic | | Quadrilateral or MHO characteristic | |
| Minimum line 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 |
| $\varphi_{Dist}$ = Angle of distance-protection characteristic | | 30.0° to 90.0° | Increments of 0.1° |
| Quadrilateral setting ranges | | | |
| X reach = reach 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 | |
| $\alpha_{Pole}$ = Zone inclination | | 0° to 45° | Increments of 1° |
| Direction 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 | |
| Measuring tolerances for sinusoidal values | | $\left\|\frac{\Delta X}{X}\right\| \le 5\% \quad \text{for } 30^\circ \le \varphi_{Sc} \le 90^\circ$ [FoTolerX-011110-enUS-01.tif] | |
| | | $\left\|\frac{\Delta R}{R}\right\| \le 5\% \quad \text{for } 30^\circ \le \varphi_{Sc} \le 60^\circ$ [FoTolerR-090212-enUS-01.tif] | |
| | | $\left\|\frac{\Delta Z}{Z}\right\| \le 5\% \quad \text{for } -30^\circ \le \varphi_{Sc} - \varphi_L \le 30^\circ$ [FoTolerZ-011110-enUS-01.tif] | |

**Times**

| | | |
|---|---|---|
| Shortest operate time | Approx. 17 ms (50 Hz)/15 ms (60 Hz) with fast relays and<br>Approx. 12 ms (50 Hz)/10 ms (60 Hz) with high-speed relays | |
| Release 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 time delays. | | |

# 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,<br>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<br>5.5 power-system cycles in case of symmetrical faults<br>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<br>Permissive underreach transfer trip via pickup, not directed<br>Permissive underreach transfer trip via extended measuring range<br>Intertripping underreach protection | |
| Transmission-signal extension<br>Delay (1-phase)<br>Delay (multi-ph.) | 0.00 s to 60.00 s<br>0.00 s to 60.00 s<br>0.00 s to 60.00 s | Increments of 0.01 s<br>Increments of 0.01 s<br>Increments of 0.01 s |

### Permissive Overreach Transfer Trip

| | | |
|---|---|---|
| Adjustable process | Permissive overreach transfer trip scheme<br>Directional-comparison method<br>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<br>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 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 |

### 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 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 forwards, $\beta$ | | 0° to 360° | Increments of 1° |
| Lower limit angle forwards, $\alpha$ | | 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 |

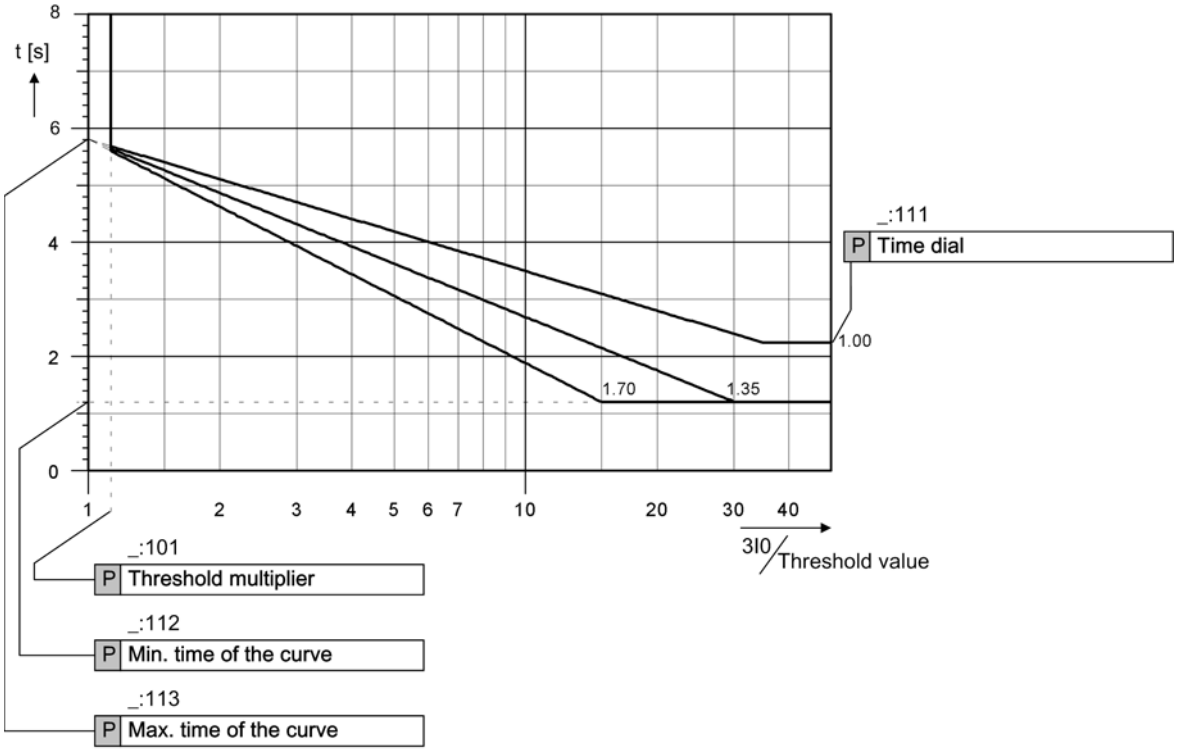
You can select from the following tripping time and release time characteristic curves:

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: type C | 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 | |
| Uniformly 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

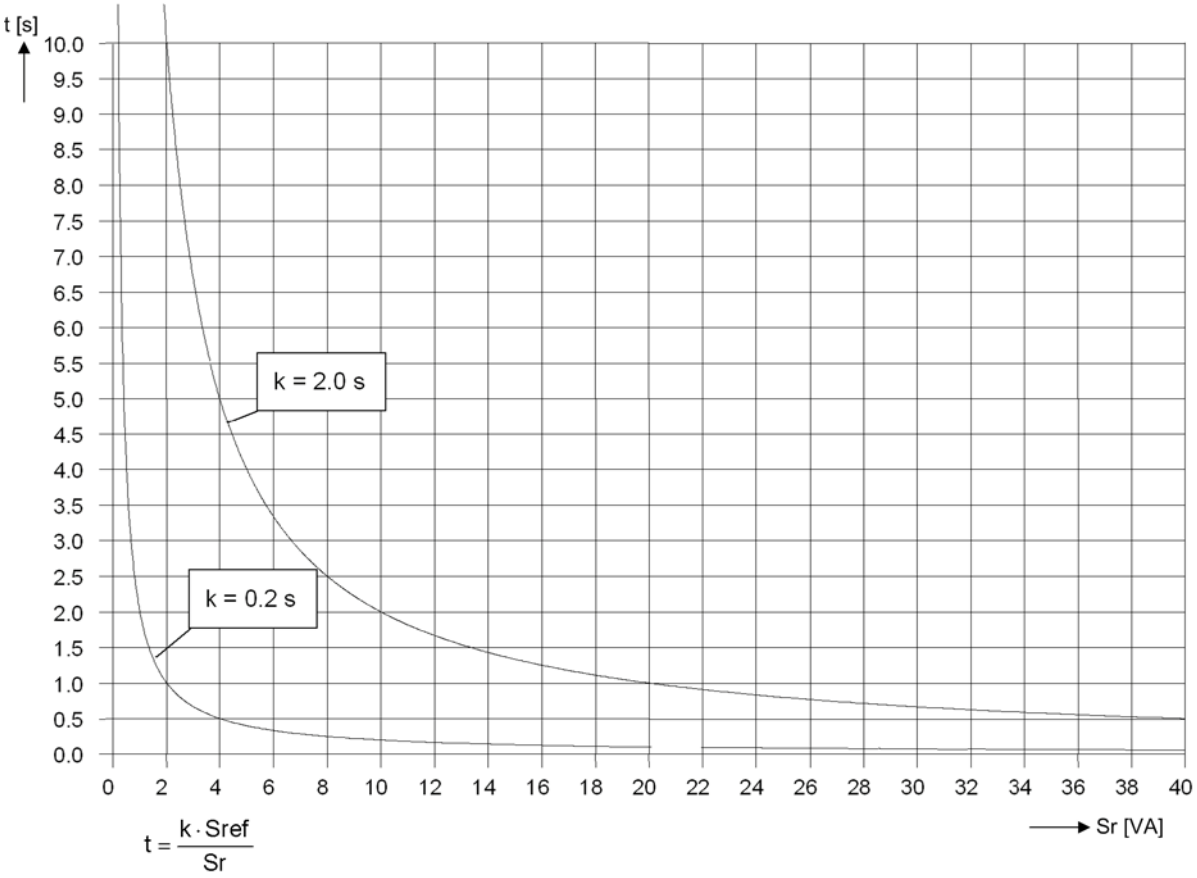



Figure 11-2 Operate Curve of the Zero-Power Protection

### 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

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

| | |
|---|---|
| $f_{rated} \pm 20$ % | Active |
| Outside of $f_{rated} \pm 20$ % | Not active |

### Tolerances

| | |
|---|---|
| Threshold values: | |
| Response, dropout threshold value for zero-sequence current 3I0 with normal-sensitive ground-current converter | 1 % of setting value or 1 % of rated current |
| Response, dropout threshold value for zero-sequence current 3I0 with sensitive ground-current converter | 1 % of setting value or 0.2 % 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 voltage V2 | 1 % of the setting value or 1 V |
| Minimum negative-sequence 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,<br>Characteristic curves according to IEC, ANSI/IEEE, and logarithmic inverse characteristic curve<br>For $\leq 2$ $I/I_{3I0P} \leq 20$ and $T_{3I0P} \geq 1$ s | 5 % of the set point value $\pm$ 10 ms |
| Current-dependent time delay,<br>Characteristic curve: logarithmic-inverse | 3 % of the set point value $\pm$ 10 ms |
| S0-dependent time delay | 3 % of the set point value $\pm$ 10 ms |

| | |
|---|---|
| Limit angle for direction determination via angular measurement between measuring and reference value | $\pm 1.5^{o}$ |
| Zero power for forwards direction | 5 % of the setting value $\pm$ 0.02 VA |

### Setting Parameters for Thresholds

| | |
|---|---|
| Transient excess pickup in method of measurement = fundamental component over 1 cycle filter (standard filter), for $\tau > 100$ 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

| | |
|---|---|
| Tripping time with time delay = 0 ms<br>- at 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 time delays | 1 % of the setting value or 10 ms |

# 11.13 Automatic Reclosing

| | | |
|---|---|---|
| Function specifications | Cyclic Automatic Reclosing Function<br>Automatic reclosing function with adaptive dead time (ADT)<br>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<br>With trip command, with action time<br>With pickup, without action time<br>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<br>With pickup | |
| Reaction to evolving faults | Blocks automatic reclosing function<br>Start, evolving fault, dead time | |
| Action times (separated for all cycles) | 0.00 s to 300.00 s or<br>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<br>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<br>Internal<br>External | |
| Transmission delay, inter closing command | 0.00 s to 300.00 s or<br>oo (ineffective) | Increments of 0.01 s |
| Dead-line checking/reduced dead time | Without<br>Reduced dead time (RDT)<br>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 frequency<br>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<br>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

| | |
|---|---|
| Currents, method of measurement = fundamental component | 1 % of setting value or 5 mA ($I_{rated}$ = 1 A)<br>or 25 mA ($I_{rated}$ = 5 A), ($f_{rated}$ ± 10 %) |
| Currents, method of measurement = RMS value<br>Up to 30th harmonic<br><br>Up to 35th harmonic<br><br>(33 % part of harmonic, referring to fundamental component) | <br>1 % of setting value or 5 mA ($I_{rated}$ = 1 A)<br>or 25 mA ($I_{rated}$ = 5 A), ($f_{rated}$ ± 10 %)<br>2 % of setting value or 10 mA ($I_{rated}$ = 1 A)<br>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 frequency, for $\tau$ > 100 ms (with complete unbalance) | < 5 % |

# 11.15 Inverse Time-Overcurrent Protection, Phases

### Setting Values

| | | | |
|---|---|---|---|
| Method of measurement | | Fundamental frequency<br>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<br>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 |

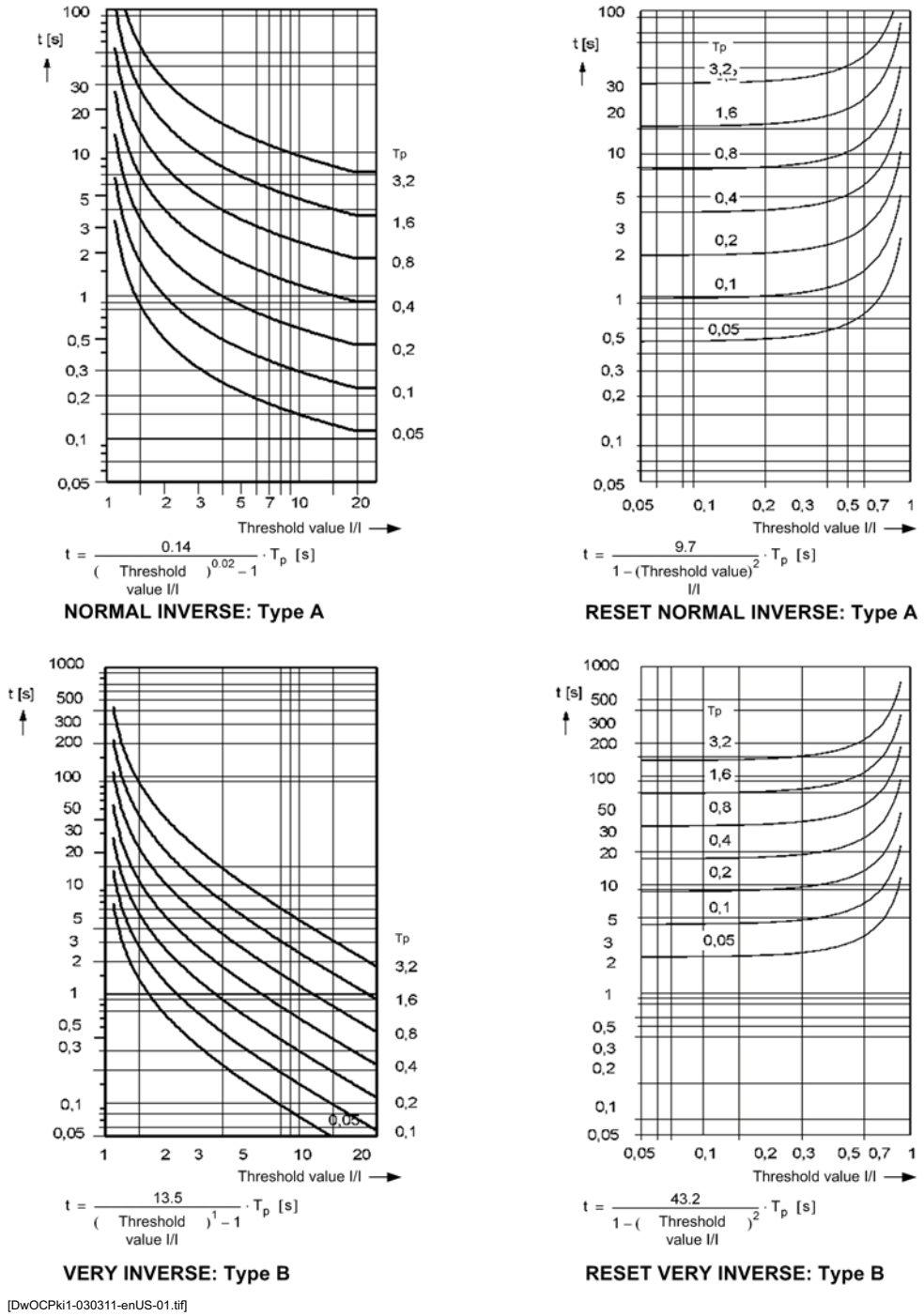



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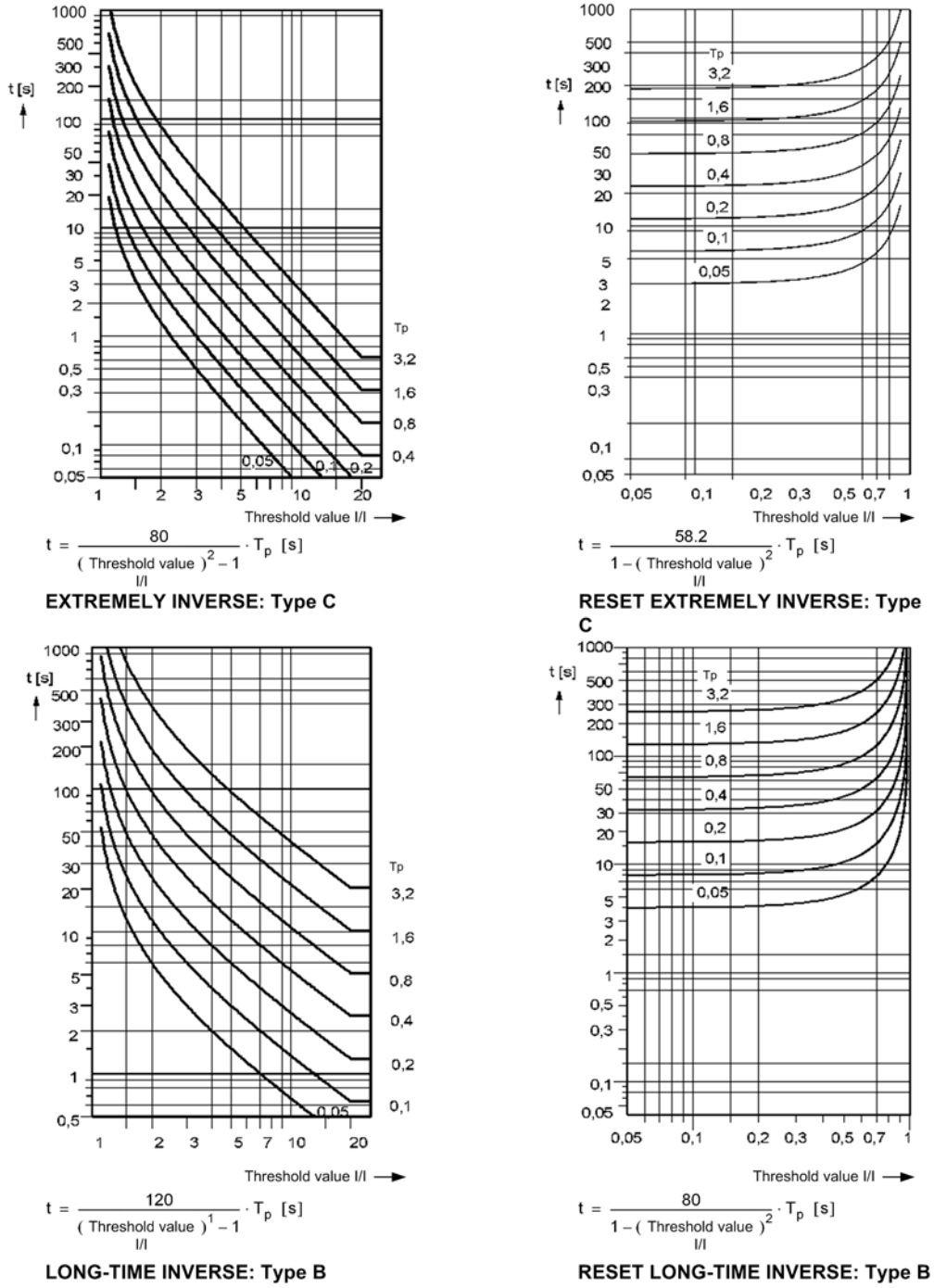
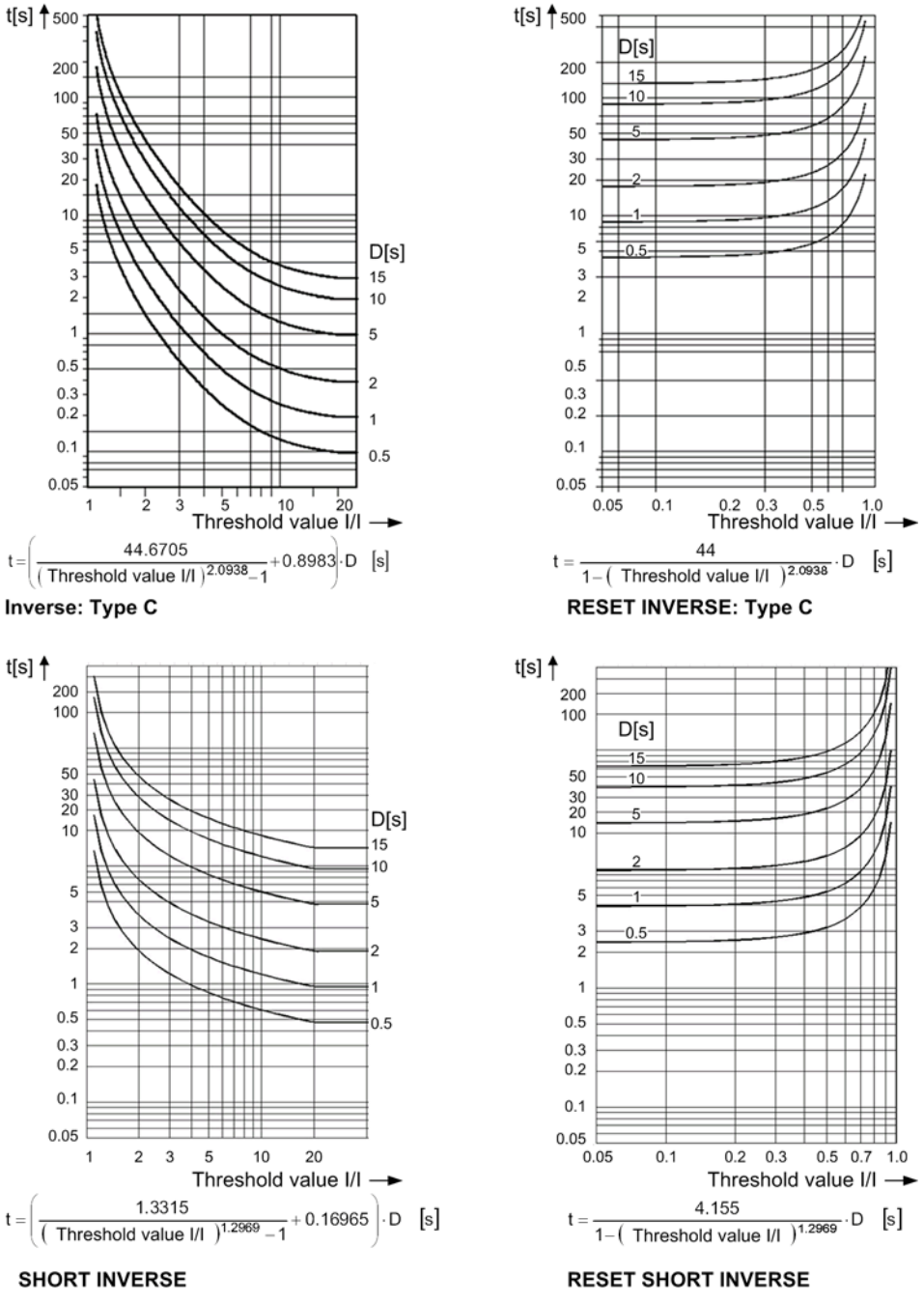
Figure 11-3 Operate Curves and Dropout-Time Characteristic Curves According to IEC




[DwOCPki2-030311-enUS-01.tif]

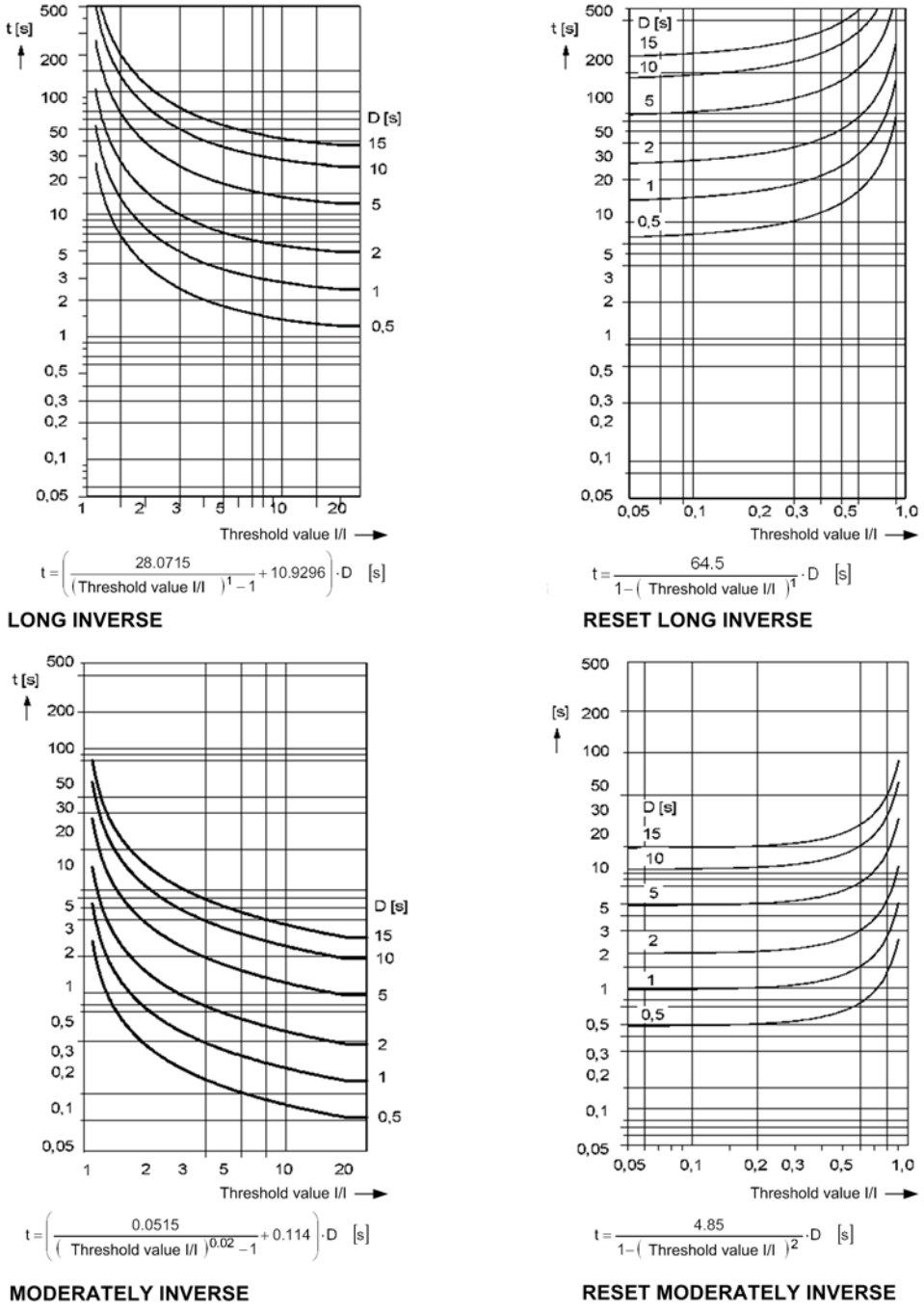
Figure 11-4 Operate Curves and Dropout-Time Characteristic Curves According to IEC

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



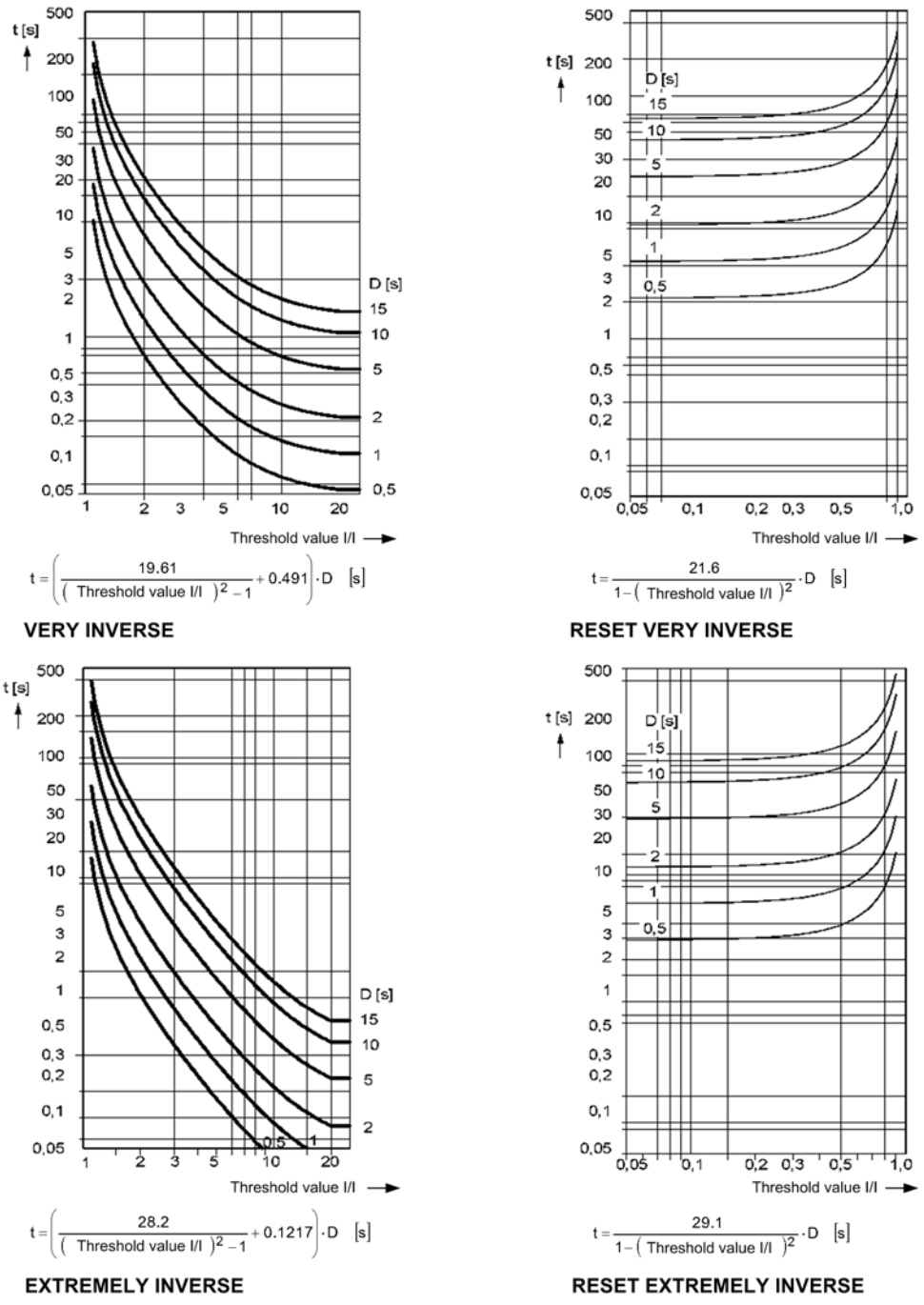

[DwOCPka1-270112-enUS-01.tif]

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



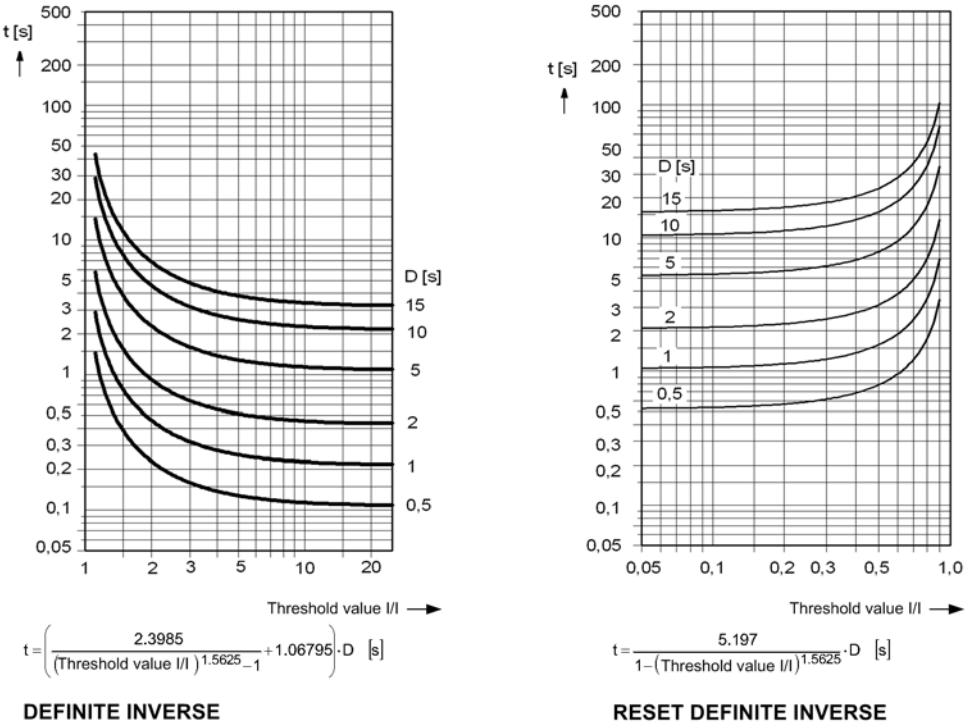

[DwOCPka2-110611-enUS-01.tif]

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




[DwOCPka3-030311-enUS-01.tif]

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.

[DwOCPka4-050711-enUS-01.tif]

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

### 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<br>Up to 30th harmonic<br><br>Up to 35th harmonic<br><br>(33 % part of harmonic, referring to fundamental component) | <br>1 % of setting value or 5 mA ($I_{rated}$ = 1 A) or 25 mA ($I_{rated}$ = 5 A), ($f_{rated}$ ± 10 %)<br>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 % |

# 11.16 Overcurrent Protection, Phases with User-Defined Characteristic

### Setting Values

| | | | |
|---|---|---|---|
| Method of measurement | | Fundamental frequency<br>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<br>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

| | |
|---|---|
| Currents, method of measurement = fundamental component | 1 % of setting value or 5 mA ($I_{rated}$ = 1 A)<br>or 25 mA ($I_{rated}$ = 5 A), ($f_{rated} \pm 10$ %) |
| Currents, method of measurement = RMS value<br>Up to 30th harmonic<br><br>Up to 35th harmonic<br><br>(33 % part of harmonic, referring to fundamental component) | <br>1 % of setting value or 5 mA ($I_{rated}$ = 1 A)<br>or 25 mA ($I_{rated}$ = 5 A), ($f_{rated} \pm 10$ %)<br>2 % of setting value or 10 mA ($I_{rated}$ = 1 A)<br>or 50 mA ($I_{rated}$ = 5 A), ($f_{rated} \pm 10$ %) |
| 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 $\tau$ > 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<br>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<br>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)<br>or 25 mA ($I_{rated}$ = 5 A), ($f_{rated} \pm 10$ %) |
| 3I0 measured via I4[1], method of measurement = RMS value<br>Up to 30th harmonic<br><br>Up to 35th harmonic<br><br>(33 % part of harmonic, referring to fundamental component) | <br>1 % of setting value or 5 mA ($I_{rated}$ = 1 A)<br>or 25 mA ($I_{rated}$ = 5 A), ($f_{rated} \pm 10$ %)<br>2 % of setting value or 10 mA ($I_{rated}$ = 1 A)<br>or 50 mA ($I_{rated}$ = 5 A), ($f_{rated} \pm 10$ %) |
| 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 $\tau$ > 100 ms (with complete unbalance) | < 5 % |

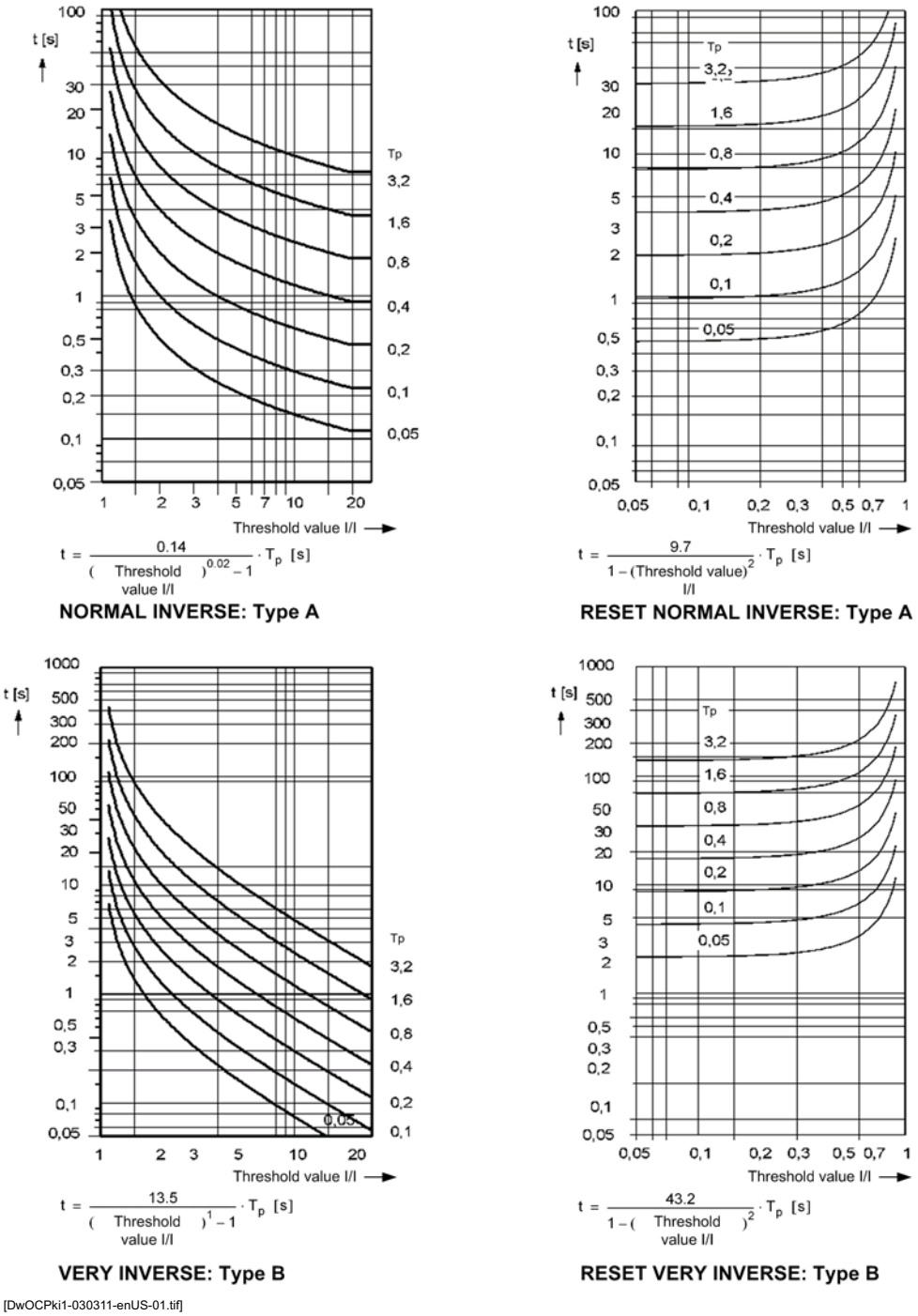
# 11.18 Inverse Time-Overcurrent Protection, Ground

### 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 |

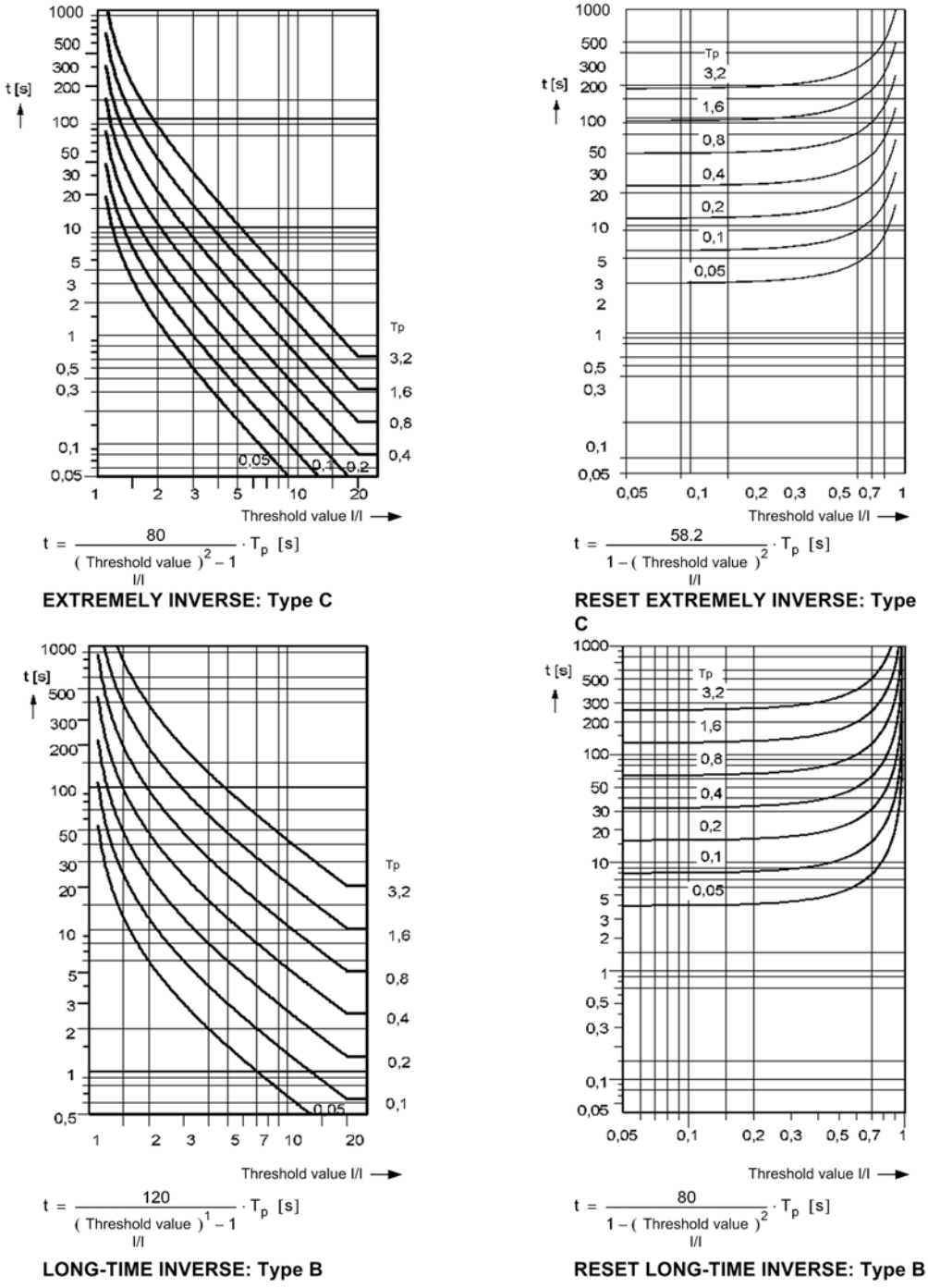
### Operate Curves and Dropout-Time Characteristic Curves According to IEC

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




[DwOCPki1-030311-enUS-01.tif]

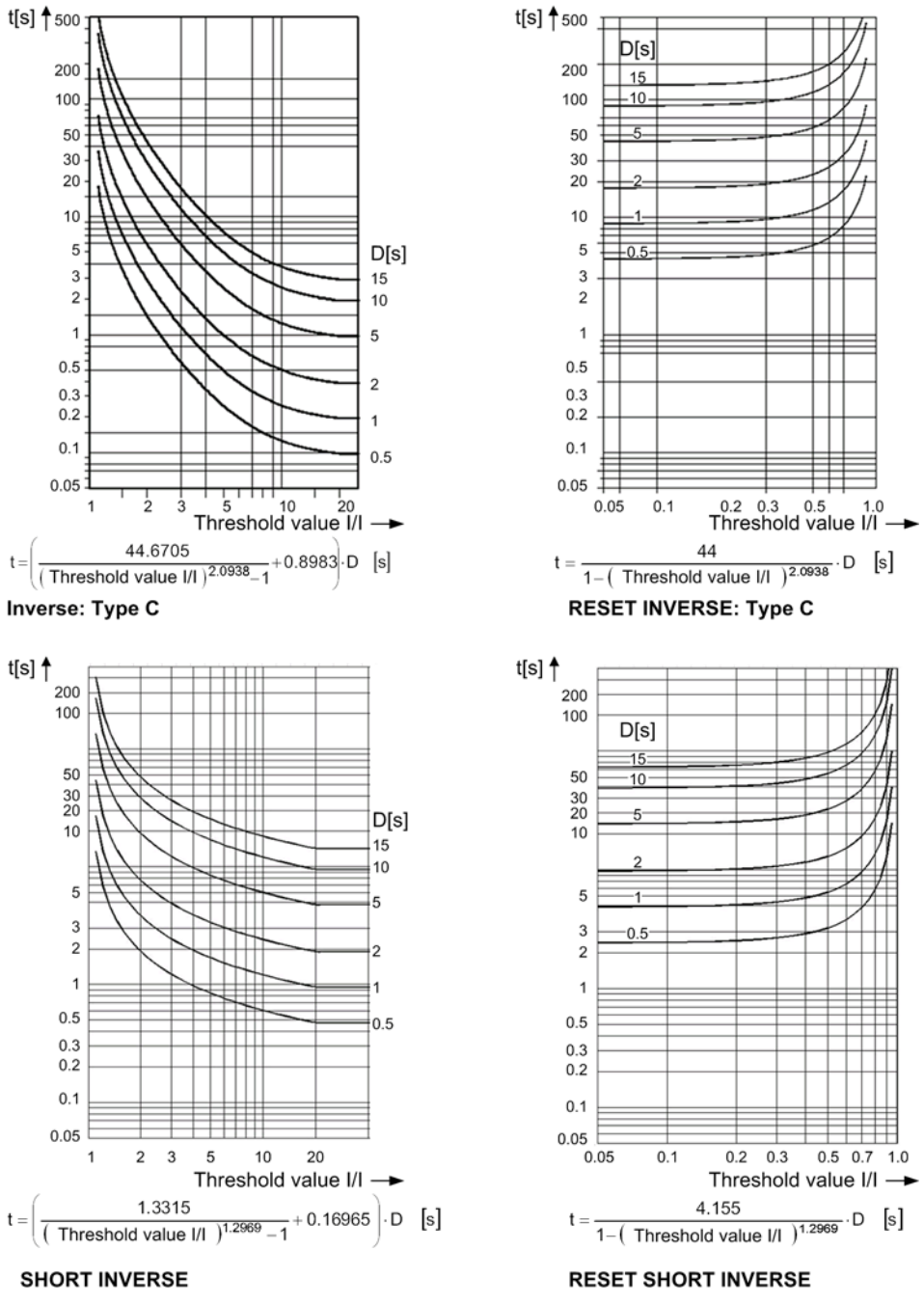
Figure 11-9 Operate Curves and Dropout-Time Characteristic Curves According to IEC




[DwOCPki2-030311-enUS-01.tif]

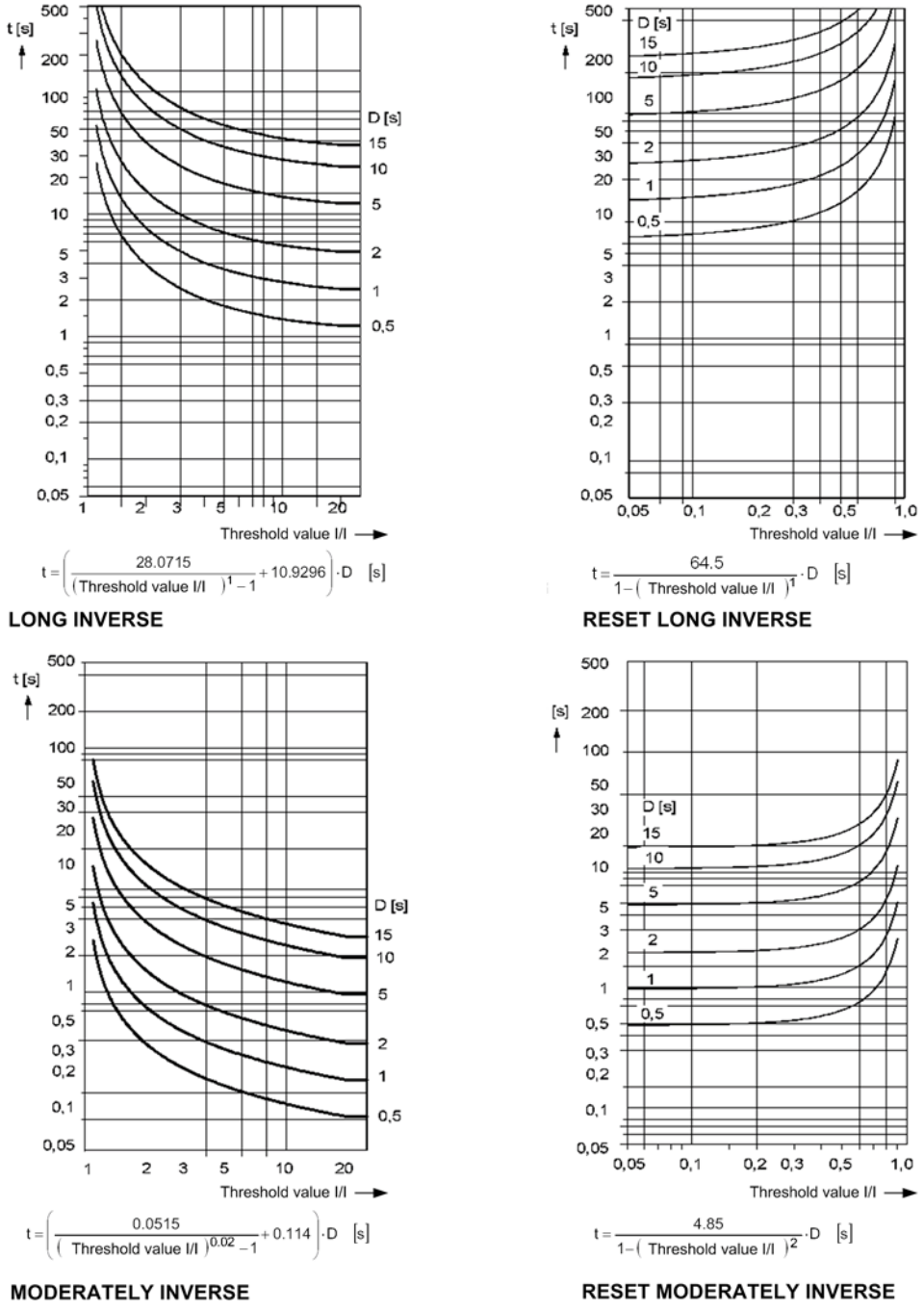
Figure 11-10 Operate Curves and Dropout-Time Characteristic Curves According to IEC

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



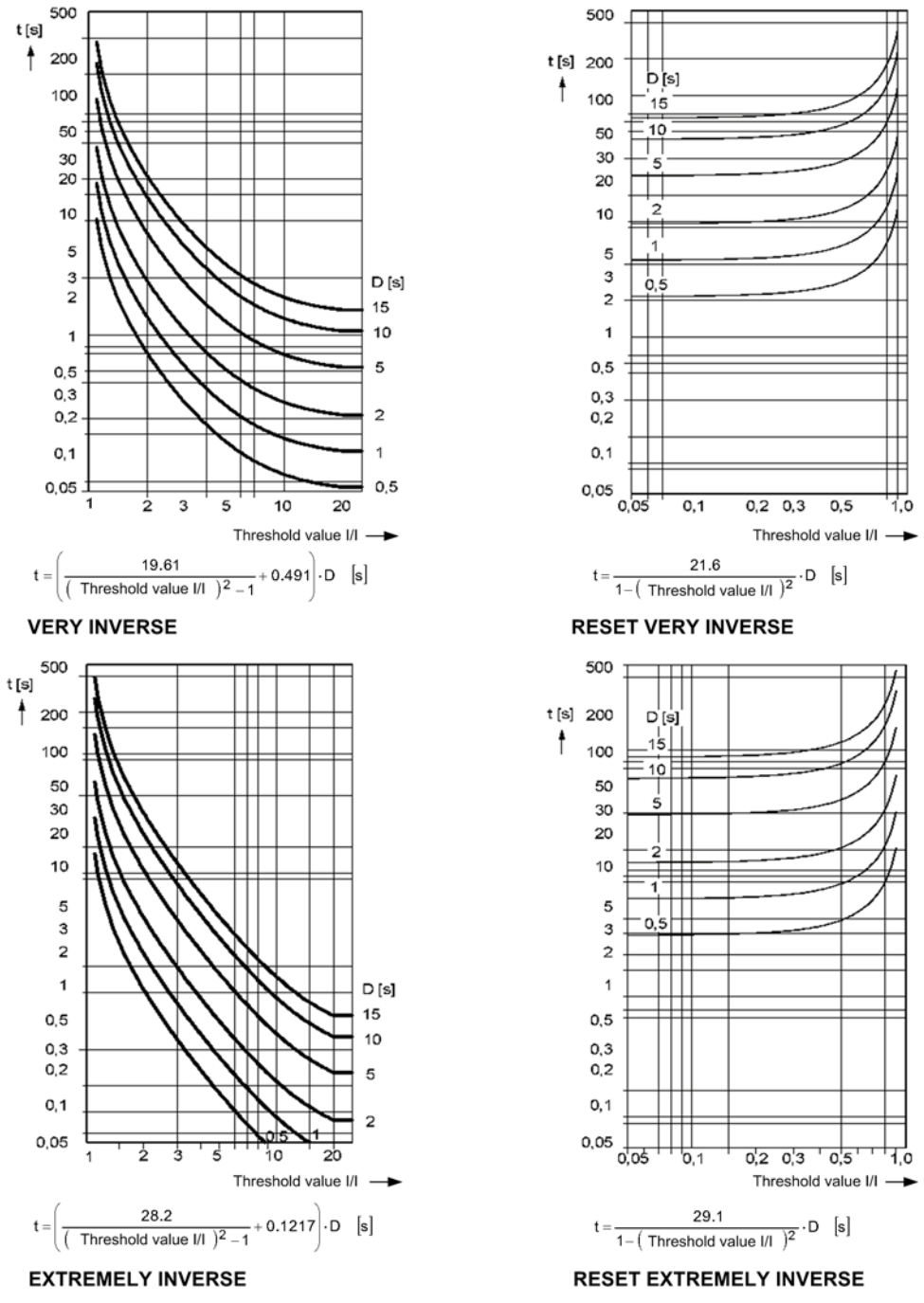

[DwOCPka1-270112-enUS-01.tif]

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



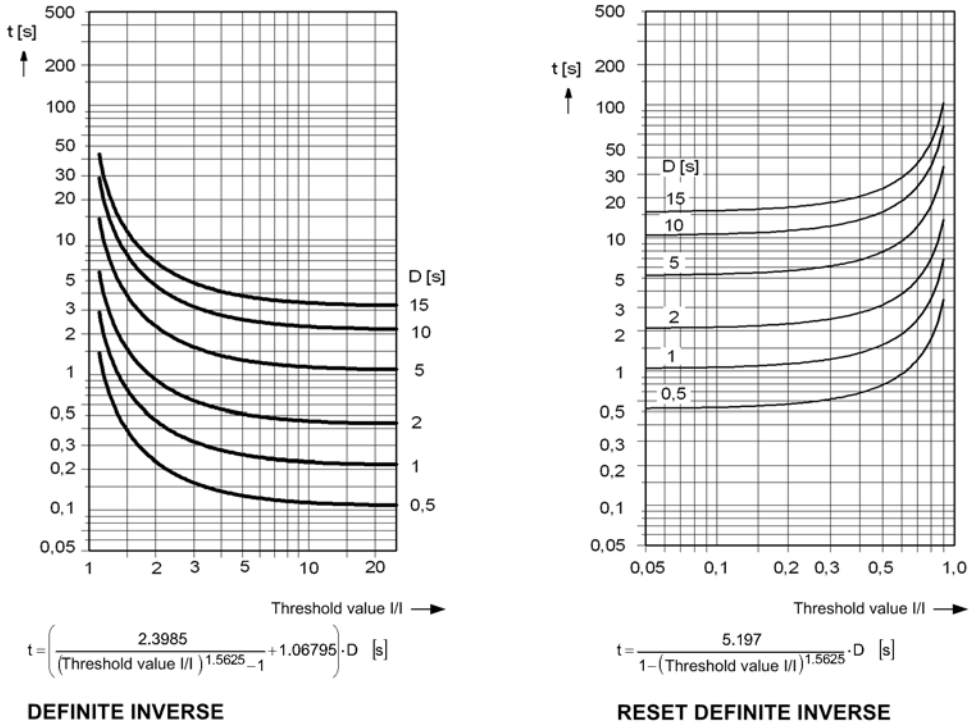

[DwOCPka2-110611-enUS-01.tif]

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

| | | | |
|---|---|---|---|
| Directional mode | | Forward<br>Reverse | – |
| Method of measurement | | Fundamental component<br>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 the Definite Time-Overcurrent Protection Stage Type

| | | |
|---|---|---|
| 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 the IEC/ANSI Characteristic Curve Stage Type (Inverse-Time)

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

### Setting Values for the 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

| | |
|---|---|
| Extremely inverse: type C | 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 | |
| Uniformly inverse | See section *11.15 Inverse Time-Overcurrent Protection, Phases*, *Figure 11-8* |

### Direction Determination

| | |
|---|---|
| Type | With cross-polarized voltages<br>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<br>Dynamically unlimited, stationary for 3-phase short circuits<br>Approx. 13 V phase-to-phase |

### Times

| | |
|---|---|
| Tripping time with time delay = 0 ms | Approx. 25 ms + OOT [1] at 50 Hz<br>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

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

| | |
|---|---|
| Current-dependent tripping time according to IEC, ANSI, user-defined characteristic curve | 5 % of set point value +2 % current tolerance or 10 ms |
| Current-dependent dropout time according to IEC, ANSI, user-defined characteristic curve | 5 % of set point value +2 % current tolerance or 10 ms |
| Angle error of direction determining | 1° |

**Influencing Quantities for Thresholds**

| | |
|---|---|
| Transient excess pickup in method of measurement = fundamental component, for $\tau$ > 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<br>0.15 A to 500.00 A at $I_{rated}$ = 5 A | Increments of 0.001 A at $I_{rated}$ = 1 A<br>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<br>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, $\beta$ | | 0° to 360° | Increments of 1° |
| Lower limit angle forward, $\alpha$ | | 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<br>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<br>Phase-to-ground | |
| Method of measurement | Fundamental component<br>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<br>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<br>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<br>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 set 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<br>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<br>Fundamental component<br>Fundamental component via 2 cycle filters | |
| Block on measuring-voltage failure | Yes<br>No | |
| Determ. ph. aff. by grd. flt. | Yes<br>No | |
| Threshold value | 0.300 V to 200.000 V | Increments of 0.001 V |
| Delay time | 0.00 s to 60.00 s | Increments of 0.1 s |
| Pickup Delay | 0.00 s to 320.00 s | Increments of 0.1 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<br>Approx. 22 ms + OOT at 60 Hz |
| 2 cycle filters | Approx. 45 ms + OOT at 50 Hz<br>Approx. 39 ms + OOT at 60 Hz |
| Dropout time | |
| Standard filter, true RMS | Approx. 20 ms + OOT at 50 Hz<br>Approx. 16.6 ms + OOT at 60 Hz |
| 2 cycle filters | Approx. 31.06 ms + OOT at 50 Hz<br>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<br>Measured voltage at transformer 2<br>Measured voltage at transformer 3<br>Measured voltage at transformer 4<br>Calculated voltage $V_{AB}$<br>Calculated voltage $V_{BC}$<br>Calculated voltage $V_{CA}$ | |
| Method of measurement | Fundamental component<br>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<br>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<br>Phase-to-ground | |
| Method of measurement | Fundamental component<br>RMS value | |
| Current-flow criterion | On<br>Off | |
| Threshold value I> | 0.030 A to 10.000 A at $I_{rated}$ = 1 A<br>0.15 A to 50.00 A at $I_{rated}$ = 5 A | Increments of 0.001 A<br>Increments of 0.01 A |
| Pickup value | 0.300 V to 175.000 V | Increments of 0.001 V |
| Delay time | 0.00 s to 60.00 s | Increments of 0.01 s |
| Dropout ratio | 1.01 to 1.20 | Increments of 0.01 |

### Times

| | |
|---|---|
| Tripping time | Approx. 25 ms + OOT[1] at 50 Hz<br>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;<br>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 $f_{rated} \pm 10$ % |
| | 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 $f_{rated} \pm 10$ %<br>(Valid for connecting terminal 4 x protection to 100 $I_{rated}$) |
| | 1 % of the set value or 5 mA in the range $f_{rated} \pm 10$ %<br>(Valid for connecting terminal 4 x measurement to 20 $I_{rated}$) |
| Time delays | 1 % of the setting value or 10 ms |

# 11.30 Undervoltage Protection with Positive-Sequence Voltage

### Setting Values

| | | |
|---|---|---|
| Measured value | Phase-to-phase<br>Phase-to-ground | |
| Method of measurement | Fundamental component<br>RMS value | |
| Current-flow criterion | On<br>Off | |
| Threshold value I> | 0.030 A to 10.000 A at $I_{rated}$ = 1 A<br>0.15 A to 50.00 A at $I_{rated}$ = 5 A | Increments of 0.001 A<br>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<br>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;<br>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 $f_{rated} \pm 10$ % |
| | 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 $f_{rated} \pm 10$ %<br>(Valid for terminal current 4 x protection to 100 $I_{rated}$) |
| | 1 % of the setting value or 5 mA in the range $f_{rated} \pm 10$ %<br>(Valid for terminal current 4 x measurement 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<br>Measured voltage at transformer 2<br>Measured voltage at transformer 3<br>Measured voltage at transformer 4<br>Calculated voltage $V_{AB}$<br>Calculated voltage $V_{BC}$<br>Calculated voltage $V_{CA}$ | |
| Method of measurement | Fundamental component<br>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<br>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;<br>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:<br>• The reactance per unit length of the line per kilometer or per mile<br>• The line length for the correct output of the fault distance as a percentage of the line length<br>• 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<br>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<br>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<br>60 Hz | <br>Approx. 70 ms + OOT [1].<br>Approx. 60 ms + OOT |
| | Filtering method<br>50 Hz<br>60 Hz | <br>Approx. 75 ms + OOT<br>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<br>50 Hz<br>60 Hz | 80 ms/60 ms<br>Approx. 70 ms + OOT [1].<br>Approx. 60 ms + OOT |
| | Filtering method<br>50 Hz<br>60 Hz | 95 ms/80 ms<br>Approx. 75 ms + OOT<br>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

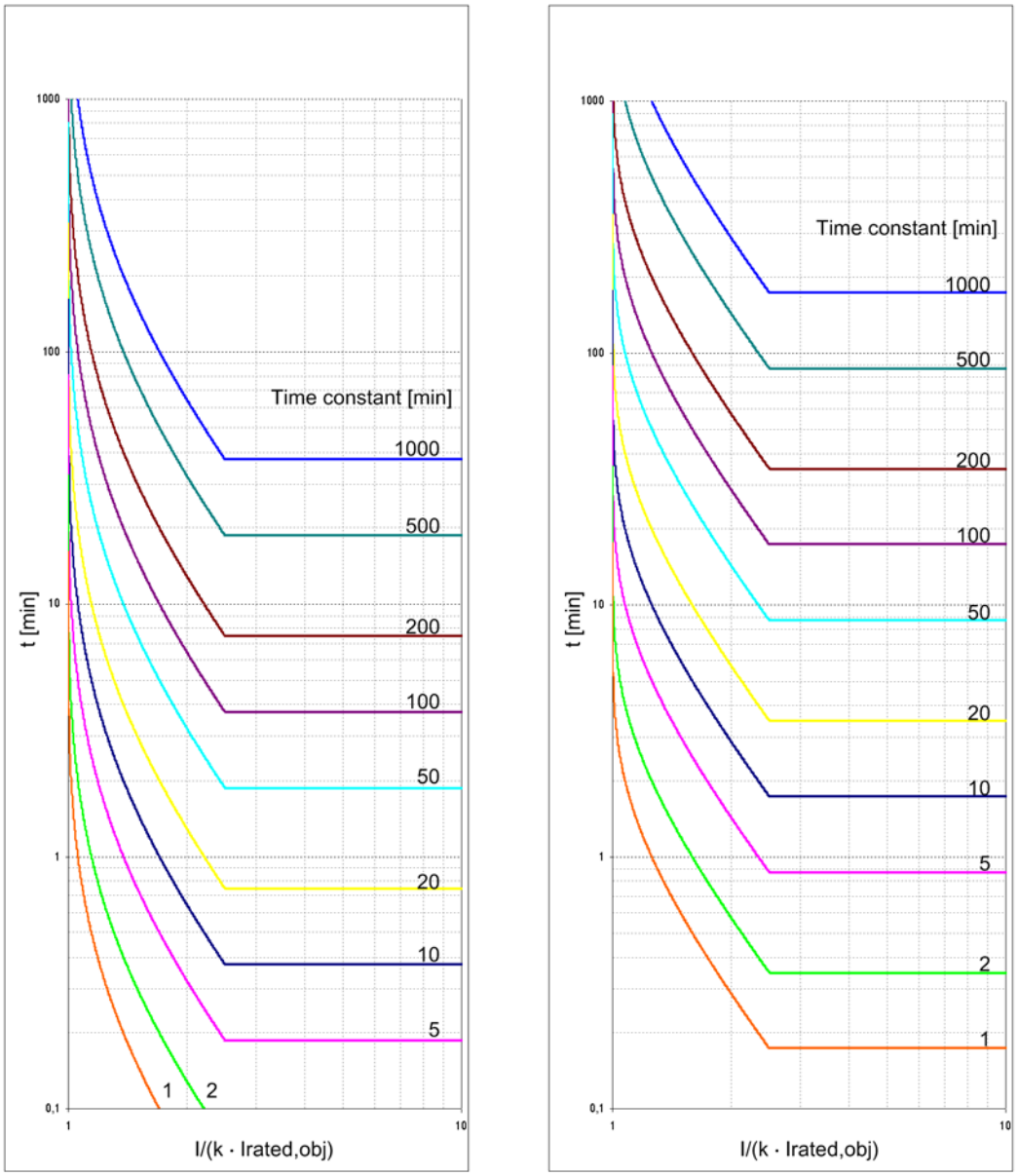
| | |
|---|---|
| Tripping threshold (fixed to 100 %) | Dropout if operate indication dropout threshold falls short |
| Thermal warning threshold | Approx. 0.99 of the setting value |
| Current warning threshold | Approx. 0.95 of the setting value |

### 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 |
| | $\tau_{th}$ | 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 | 3-pole internal or external tripping [1] |

1. 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 | 0.15 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 | 0.15 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 |

**NOTE**

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

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

### Times

| | |
|---|---|
| Pickup time, in the case of an internal start<br>Pickup time, in the case of an external start | < 1 ms<br>< 5 ms |
| Dropout time [1] via the current-flow criterion, for sinusoidal quantities | < 10 ms |
| Dropout time, via the flow current criterion, under all conditions | < 15 ms |
| Dropout time, via 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<br>0.15 A to 500.00 A at $I_{rated}$ = 5 A | Increments of 0.001 A<br>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<br>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<br>Power of phase A<br>Power of phase B<br>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<br>Lower stage: 1.01 to 1.10 | Increments of 0.01<br>Increments of 0.01 |

### Times

| | |
|---|---|
| Pickup times | Approx. 60 ms for f = 50 Hz<br>Approx. 50 ms for f = 60 Hz |
| Dropout times | Approx. 60 ms for f = 50 Hz<br>Approx. 50 ms for f = 60 Hz |

### Tolerances

| | |
|---|---|
| Power | 0.5 % $S_{rated}$ ± 3 % of setting value<br>($S_{rated}$: 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<br>- up to 10 % of 3rd harmonics<br>- up to 10 % of 5th harmonics | <br>≤ 1 %<br>≤ 1 % |

# 11.41 Current-Jump Detection

### Times

| | |
|---|---|
| Pickup time | Approx. 10 ms at 50 Hz<br>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<br>50 mA ($I_{rated}$ = 5 A), ($f_{rated} \pm$ 10 %)<br>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<br>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<br>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<br>∞ (ineffective) | Increments of 0.01 s |
| Superv. time de-energized switching | 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<br>V>, for voltage present | 3.000 V to 170.000 V (phase-to-phase)<br>3.000 V to 340.000 V (phase-to-phase) | Increments of 0.001 V<br>Increments of 0.001 V |
| Differential values, changeover thresholds asynchronous/synchronous: | | |
| Voltage differences<br>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 $\alpha 2 > \alpha 1$;<br>$\alpha 2 < \alpha 1$ | 0° to 90° | Increments of 1° |
| $\Delta$f 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<br>• Range<br>• Tolerance [1] | In kV primary, in V secondary or in % $V_{rated}$<br>10 % to 120 % of $V_{rated}$<br>≤ 1 % of the measured value or 0.5 % $V_{rated}$ |
| Voltage to be synchronized V2<br>• Range<br>• Tolerance [1] | In kV primary, in V secondary or in % $V_{rated}$<br>10 % to 120 % of $V_{rated}$<br>≤ 1 % of the measured value or 0.5 % $V_{rated}$ |
| Frequency of the voltage V1f1<br>• Range<br>• Tolerance [1] | f1 in Hz<br>25 Hz ≤ f ≤ 70 Hz<br>10 mHz |
| Frequency of the voltage V1f2<br>• Range<br>• Tolerance [1] | f2 in Hz<br>25 Hz ≤ f ≤ 70 Hz<br>10 mHz |
| Voltage difference V2-V1<br>• Range<br>• Tolerance [1] | In kV primary, in V secondary or in % $V_{rated}$<br>10 % to 120 % of $V_{rated}$<br>≤ 1 % of the measured value or 0.5 % $V_{rated}$ |
| Frequency difference f2-f1<br>• Range<br>• Tolerance [1] | In mHz<br>$f_{rated}$ ± 10 %<br>5 mHz |
| Angular difference λ2-λ1<br>• Range<br>• Tolerance [1] | In °<br>-180° to +180°<br>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<br>10° for Δf > 1 Hz |

# 11.44 Broken-Wire Detection

### Setting Values

| Value | Setting Range | Increment |
|---|---|---|
| Mode of blocking | *Blocking*<br>*Automatic blocking*<br>*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<br>0.15 A to 450.00 A at $I_{rated}$ = 5 A | Increments of 0.001 A<br>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<br>0.15 A to 50.00 A at $I_{rated}$ = 5 A | Increments of 0.001 A<br>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<br>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<br>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<br>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<br>0.15 A to 50.00 A at $I_{rated}$ = 5.00 A | Increments of 0.001 A<br>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<br>0.15 A to 50.00 A at $I_{rated}$ = 5 A<br>$I_{min} \leq I_{min\ (distance\ protection)}$ | Increments of 0.001 A<br>Increments of 0.01 A |
| 3-ph fault–Jump phase current | 0.030 A to 100.000 A at $I_{rated}$ = 1 A<br>0.15 A to 50.00 A at $I_{rated}$ = 5 A | Increments of 0.001 A<br>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<br>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<br>Frequency range | 10 % to 200 % of $V_{rated}$<br>47.5 Hz to 52.5 Hz at $f_{rated}$ = 50 Hz<br>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<br>Frequency range | 10 % to 200 % of $V_{rated}$<br>47.5 Hz to 52.5 Hz at $f_{rated}$ = 50 Hz<br>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<br>Rated range<br>Measuring ranges<br>Frequency range | Measurement from 0.1 A to 25 A<br>1 A, 5 A<br>100 · Ir, 1.6 · Ir<br>47.5 Hz to 52.5 Hz at $f_{rated}$ = 50 Hz<br>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<br>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<br>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<br><br>Rated-current range<br>Current measuring ranges<br>Frequency range | 50 % to 120 % and<br>ABS (cos φ) ≤ 0.07<br>1 A, 5 A<br>100 · Ir, 1.6 · Ir<br>47.5 Hz to 52.5 Hz at $f_{rated}$ = 50 Hz<br>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<br>ABS (cos $\varphi$) $\leq$ 0.07 |
| Tolerance Q | 1 % $P_{rated}$ with $I/I_{rated}$ and $V/V_{rated}$ |
| Power factor $\lambda$ | ° |
| 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 $W_p$<br>Reactive energy $W_q$ | kWh, MWh, GWh<br>kvarh, Mvarh, Gvarh |
| Range | ≤ 2 % for I > 0.1 $I_{rated}$,<br>V > 0.1 $V_{rated}$<br>$\|\cos\varphi\| \geq 0.707$ |
| 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 ° |

■