
# SIPROTEC Compact 7SK80 Motor Protection

V4.6

**Technical Data**

**Extract from manual E50417-G1140-C344-A4, chapter 4**

Energy Automation

SIEMENS

**Note**

For safety purposes, please note instructions and warnings in the Preface.




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Siemens Aktiengesellschaft

Order no.: E50417-G1140-C344-A4

# Preface

### Purpose of this Manual

This manual describes the functions, operation, installation, and commissioning of 7SK80 devices. In particular, one will find:

- Information regarding the configuration of the scope of the device and a description of the device functions and settings → Chapter 2;
- Instructions for Installation and Commissioning → Chapter 3;
- Compilation of the Technical Data → Chapter 4;
- As well as a compilation of the most significant data for advanced users → Appendix A.

General information with regard to design, configuration, and operation of SIPROTEC 4 devices are set out in the SIPROTEC 4 System Description /1/.

### Target Audience

Protection engineers, commissioning engineers, personnel concerned with adjustment, checking, and service of selective protective equipment, automatic and control facilities, and personnel of electrical facilities and power plants.

### Applicability of this Manual

This manual applies to: SIPROTEC 4 Multifunctional Protection Device with Motor Protection 7SK80; Firmware Version V4.6

### Indication of Conformity

| | |
|---|---|
| CE | This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage Directive 2006/95 EC).<br>This conformity is proved by tests conducted by Siemens AG in accordance with the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for EMC directive, and with the standard EN 60255-27 for the low-voltage directive.<br>The device has been designed and produced for industrial use.<br>The product conforms with the international standards of the series IEC 60255 and the German standard VDE 0435. |

**Additional Standards**

IEEE C37.90 (see Chapter 4 "Technical Data")
This product is UL-certfied with the values as stated in the Technical Data.
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### Additional Support

Should further information on the System SIPROTEC 4 be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the local Siemens representative.

Our Customer Support Center provides a 24-hour service.

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### Training Courses

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

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# Technical Data 4

This chapter provides the technical data of the device SIPROTEC 7SK80 and its individual functions, including the limit values that may not be exceeded under any circumstances. The electrical and functional data for the maximum functional scope are followed by the mechanical specifications with dimensioned drawings.

# 4.1 General Device Data

## 4.1.1 Analog Inputs

### Current Inputs

| | | | |
|---|---|---|---|
| Nominal Frequency | $f_N$ | 50 Hz or 60 Hz | (adjustable) |
| Frequency working range (independent of the nominal frequency) | | 25 Hz to 79 Hz | |
| Nominal current | $I_{Nom}$ | 1 A or 5 A | |
| Ground current, sensitive | $I_{Ns}$ | ≤ 1,6· $I_{Nom}$ linear range [1] | |
| Burden per phase and ground path<br>- at $I_{Nom}$ = 1 A<br>- at $I_{Nom}$ = 5 A<br>- for sensitive ground fault detection at 1 A | | <br>≤ 0.05 VA<br>≤ 0.3 VA<br>≤ 0.05 VA | |
| Load capacity current path<br>- thermal (rms)<br><br><br>- dynamic (peak value) | | <br>500 A for 1 s<br>150 A for 10 s<br>20 A continuous<br>1250 A (half-cycle) | |
| Load capacity input for sensitive ground fault detection $I_{Ns}$ [1] | | | |
| - thermal (rms)<br><br><br>- dynamic (peak value) | | 300 A for 1 s<br>100 A for 10 s<br>15 A continuous<br>750 A (half-cycle) | |

[1] only in models with input for sensitive ground fault detection (see ordering data in Appendix A.1)

### Temperature Detectors at the I/O 2 Extension Module (only 7SK805/7SK806)

| |
|---|
| See chapter Temperature Detection |

### Voltage inputs

| | | |
|---|---|---|
| Nominal voltage | | 34 V – 225 V (adjustable) for connection of phase-to-ground voltages<br>34 V – 200 V (adjustable) for connection of phase-to-phase voltages |
| Measuring Range | | 0 V to 200 V |
| Burden | at 100 V | approx. 0.005 VA |
| Overload capacity in the voltage path | | |
| – thermal (rms) | | 230 V continuous |

## 4.1.2 Auxiliary Voltage

### DC Voltage

| Voltage supply via an integrated converter | | |
|---|---|---|
| Nominal auxiliary DC voltage $V_{Aux}$– | 24 V to 48 V | 60 V to 250 V |
| Permissible voltage ranges | 19 V to 60 V | 48 V to 300 V |
| Overvoltage category, IEC 60255-27 | III | |
| AC ripple voltage peak to peak, IEC 60255-11 | 15 % of auxiliary voltage | |

| Power input | Quiescent | Energized |
|---|---|---|
| 7SK80 | approx. 5 W | approx. 12 W |
| Bridging time for failure/short-circuit, IEC 60255–11 | ≥ 50 ms at V ≥ 110 V | |
| | ≥ 10 ms at V < 110 V | |

### AC Voltage

| Voltage supply via an integrated converter | | |
|---|---|---|
| Nominal auxiliary AC voltage $V_H$ | 115 V | 230 V |
| Permissible voltage ranges | 92 V to 132 V | 184 V to 265 V |
| Overvoltage category, IEC 60255-27 | III | |

| Power input (at 115 V / 230 V) | Quiescent | Energized |
|---|---|---|
| 7SK80 | approx. 5 VA | approx. 12 VA |
| Bridging time for failure/short-circuit | ≥ 10 ms at V = 115 V / 230 V | |

## 4.1.3 Binary Inputs and Outputs

### Binary Inputs

| Variant | Quantity | |
|---|---|---|
| 7SK801/803/805/806 | 3 (configurable) | |
| 7SK802/804 | 7 (configurable) | |
| | | |
| Nominal Direct Voltage Range | 24 V to 250 V | |
| Current input, energized (independent of the control voltage) | Approx. 0.4 mA | |
| Pickup time<br>Response time of BO, triggered from BI | Approx. 3 ms<br>Approx. 9 ms | |
| Dropout time<br>Response time of BO, triggered from BI | Approx. 4 ms<br>Approx. 5 ms | |
| | | |
| Secured switching thresholds | (adjustable) | |
| for nominal voltages | 24 V to 125 V | V high > 19 V<br>V low < 10 V |
| for nominal voltages | 110 V to 250 V | V high > 88 V<br>V low < 44 V |
| for nominal voltages | 220 V and 250 V | V high > 176 V<br>V low < 88 V |
| Maximum Permissible Voltage | 300 V | |
| Input interference suppression | 220 Vdc across 220nF at a recovery time between two switching operations ≥ 60 ms | |

### Output Relay

| Signal/command Relay, Alarm Relay | | |
|---|---|---|
| Quantity and data | depending on the order variant (allocatable) | |
| Order variant | NO contact | NO/NC selectable |
| 7SK801/803/805/806 | 3 | 2 (+ 1 life contact not allocatable) |
| 7SK802/804 | 6 | 2 (+ 1 life contact not allocatable) |
| Switching capability MAKE | 1000 W / 1000 VA | |
| Switching capability BREAK | 40 W or 30 VA at L/R ≤ 40 ms | |
| Switching voltage AC and DC | 250 V | |
| Permissible current per contact (continuous) | 5 A | |
| Permissible current per contact (close and hold) | 30 A for 1 s (NO contact) | |
| Interference suppression capacitor at the relay outputs 2.2 nF, 250 V, ceramic | Frequency | Impedance |
| | 50 Hz | $1{,}4 \cdot 10^6\ \Omega \pm 20\ \%$ |
| | 60 Hz | $1{,}2 \cdot 10^6\ \Omega \pm 20\ \%$ |

## 4.1.4 Communication Interfaces

### Operator Interface

| | |
|---|---|
| Terminal | Front side, non-isolated, USB type B socket for connecting a personal computer<br>Operation from DIGSI V4.82 via USB 2.0 full speed |
| Operation | With DIGSI |
| Transmission speed | up to 12 Mbit/s max. |
| Bridgeable distance | 5 m |

### Port A

| | | |
|---|---|---|
| Ethernet electrical for DISGI or RTD box | Operation | With DIGSI |
| | Connection | Front case bottom, mounting location "A", RJ45 socket<br>100BaseT in acc. with IEEE802.3<br>LED yellow: 10/100 Mbit/s (on/off)<br>LED green: connection/no connection (on/off) |
| | Test voltage | 500 V; 50 Hz |
| | Transmission speed | 10/100 Mbit/s |
| | Bridgeable distance | 20 m (66 ft) |

### Port B

| | | |
|---|---|---|
| IEC 60870-5-103<br>single | | |
| | RS232/RS485/FO depending on the order variant | Isolated interface for data transfer to a control center |
| RS232 | | |
| | Terminal | Back case bottom, mounting location "B", 9-pin DSUB socket |
| | Test voltage | 500 V; 50 Hz |
| | Transmission speed | min. 1 200 Bd, max. 115 000 Bd;<br>factory setting 9 600 Bd |
| | Bridgeable distance | 15 m |
| RS485 | | |
| | Terminal | Back case bottom, mounting location "B", 9-pin DSUB socket |
| | Test voltage | 500 V; 50 Hz |
| | Transmission speed | min. 1 200 Bd, max. 115 000 Bd;<br>factory setting 9 600 Bd |
| | Bridgeable distance | max. 1 km |

| | | |
|---|---|---|
| Fiber optic cable (FO) | | |
| | FO connector type | ST connector |
| | Terminal | Back case bottom, mounting location "B" |
| | Optical wavelength | λ = 820 nm |
| | Laser Class 1 according to EN 60825-1/-2 | When using glass fiber 50/125 µm or glass fiber 62.5/125 µm |
| | Permissible optical signal attenuation | max. 8 dB, with glass fiber 62.5/125 µm |
| | Bridgeable distance | max. 1.5 km |
| | Character idle state | Configurable; factory setting „Light off“ |
| IEC 60870-5-103 redundant RS485 | | |
| | Isolated interface for data transfer to a control center | |
| | Terminal | Back case bottom, mounting location "B", RJ45 socket |
| | Test voltage | 500 V; 50 Hz |
| | Transmission speed | min. 2,400 Bd, max. 57,600 Bd; factory setting 19,200 Bd |
| | Bridgeable distance | max. 1 km |
| Profibus RS485 (DP) | | |
| | Terminal | Back case bottom, mounting location "B", 9-pin DSUB socket |
| | Test voltage | 500 V; 50 Hz |
| | Transmission speed | Up to 1.5 MBd |
| | Bridgeable distance | 1 000 m (3 300 ft) at ≤ 93.75 kBd<br>500 m (1 600 ft) at ≤ 187.5 kBd<br>200 m (660 ft) at ≤ 1.5 MBd |
| Profibus FO (DP) | | |
| | FO connector type | ST connector<br>Double ring |
| | Terminal | Back case bottom, mounting location "B" |
| | Transmission speed | Up to 1.5 MBd |
| | Recommended: | > 500 kBd with normal casing |
| | Optical wavelength | λ = 820 nm |
| | Laser Class 1 according to EN 60825-1/-2 | When using glass fiber 50/125 µm or glass fiber 62.5/125 µm |
| | Permissible optical signal attenuation | max. 8 dB, with glass fiber 62.5/125 µm |
| | Bridgeable distance | max. 2 km |
| DNP3.0 /MODBUS RS485 | | |
| | Terminal | Back case bottom, mounting location "B", 9-pin DSUB socket |
| | Test voltage | 500 V; 50 Hz |
| | Transmission speed | Up to 19.200 Baud |
| | Bridgeable distance | max. 1 km |

| | | |
|---|---|---|
| DNP3.0 /MODBUS FO | | |
| | FO connector type | ST connector transmitter/receiver |
| | Terminal | Back case bottom, mounting location "B" |
| | Transmission speed | Up to 19 200 Baud |
| | Optical wavelength | $\lambda$ = 820 nm |
| | Laser Class 1 according to EN 60825-1/-2 | When using glass fiber 50/125 μm or glass fiber 62.5/125 μm |
| | Permissible optical signal attenuation | max. 8 dB, with glass fiber 62.5/125 μm |
| | Bridgeable distance | max. 1.5 km |
| Ethernet electrical (EN 100) for IEC61850 and DIGSI | | |
| | Terminal | Back case bottom, mounting location "B", 2 x RJ45 socket 100BaseT in acc. with IEEE802.3 |
| | Test voltage (with regard to the socket) | 500 V; 50 Hz |
| | Transmission speed | 100 MBit/s |
| | Bridgeable distance | 20 m |
| Ethernet optical (EN 100) for IEC61850 and DIGSI | | |
| | Terminal | Back case bottom, mounting location "B", LC connector 100BaseF in acc. with IEEE802.3 |
| | Transmission speed | 100 MBit/s |
| | Optical wavelength | 1300 nm |
| | Bridgeable distance | max. 2 km (1.24 mi) |

## 4.1.5 Electrical Tests

### Standards

| | |
|---|---|
| Standards: | IEC 60255<br>ANSI/IEEE Std C37.90 see individual functions<br>VDE 0435<br>for more standards see also individual functions |

### Insulation test

| | |
|---|---|
| Standards: | IEC 60255-27 and IEC 60870-2-1 |
| Voltage test (routine test) of all circuits except auxiliary voltage, binary inputs and communication ports | 2.5 kV, 50 Hz |
| Voltage test (routine test) of auxiliary voltage and binary inputs | DC: 3.5 kV |
| Voltage test (routine test) of isolated communication ports only (A and B) | 500 V, 50 Hz |
| Impulse voltage test (type test) of all process circuits (except for communication ports) against the internal electronics | 6 kV (peak value);<br>1.2/50 μs; 0.5 J;<br>3 positive and 3 negative impulses at intervals of 1 s |
| Impulse voltage test (type test) of all process circuits against each other (except for communication ports) and against the PE terminal of class III | 5 kV (peak value);<br>1.2/50 μs; 0.5 J;<br>3 positive and 3 negative impulses at intervals of 1 s |

### Insulation test RTD inputs

| | |
|---|---|
| RTD (Pt 100 inputs) | 500 V, 50 Hz |

**EMC Tests for Immunity (Type Tests)**

| | | |
|---|---|---|
| Standards: | | IEC 60255-6 and -22, (product standards)<br>IEC/EN 61000-6-2<br>VDE 0435<br>For more standards see also individual functions |
| 1 MHz test, Class III IEC 60255-22-1, IEC 61000-4-18, IEEE C37.90.1 | | 2.5 kV (Peak); 1 MHz; τ = 15 μs; 400 Surges per s; Test duration 2 s; $R_i$ = 200 Ω |
| Electrostatic discharge, Class IV<br>IEC 60255-22-2, IEC 61000-4-2 | | 8 kV contact discharge; 15 kV air discharge, both polarities; 150 pF; $R_i$ = 330 Ω |
| Radio frequency electromagnetic field, amplitude-modulated, Class III<br>IEC 60255-22-3, IEC 61000-4-3 | | 10 V/m; 80 MHz to 2.7 GHz; 80 % AM;<br>1 kHz |
| Fast transient bursts, Class IV<br>IEC 60255-22-4, IEC 61000-4-4, IEEE C37.90.1 | | 4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities: $R_i$ = 50 Ω; test duration 1 min |
| High energy surge voltages (SURGE), Installation Class III IEC 60255-22-5, IEC 61000-4-5 | | Impulse: 1.2/50 μs |
| | Auxiliary voltage | common mode: 4 kV; 12 Ω; 9 μF<br>Diff. mode:1 kV; 2 Ω; 18 μF |
| | Measuring inputs, binary inputs and relay outputs | common mode: 4 kV; 42 Ω; 0,5 μF<br>Diff. mode: 1 kV; 42 Ω; 0,5 μF |
| HF on lines, amplitude-modulated, Class III<br>IEC 60255-22-6, IEC 61000-4-6 | | 10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz |
| Power system frequency magnetic field<br>IEC 61000-4-8, Class IV; | | 30 A/m continuous; 300 A/m for 3 s; |
| Radiated Electromagnetic Interference<br>IEEE Std C37.90.2 | | 20 V/m; 80 MHz to 1 GHz; 80 % AM; 1 kHz |
| Damped oscillations<br>IEC 61000-4-18 | | 2.5 kV (peak value); 100 kHz; 40 pulses per s; Test Duration 2 s; Ri = 200 Ω |

**EMC Test for Noise Emission (Type Test)**

| | |
|---|---|
| Standard: | IEC/EN 61000-6-4 |
| Radio noise voltage to lines, only auxiliary voltage<br>IEC-CISPR 11 | 150 kHz to 30 MHz Limit Class A |
| Interference field strength<br>IEC-CISPR 11 | 30 MHz to 1000 MHz Limit Class A |
| Harmonic currents on the network lead at AC 230 V<br>IEC 61000-3-2 | Device is to be assigned Class D (applies only to devices with > 50 VA power consumption) |
| Voltage fluctuations and flicker on the network lead at AC 230 V<br>IEC 61000-3-3 | Limit values are kept |

## 4.1.6 Mechanical Stress Tests

### Vibration and Shock Stress during Stationary Operation

| | |
|---|---|
| Standards: | IEC 60255-21 and IEC 60068 |
| Oscillation<br>IEC 60255-21-1, Class II;<br>IEC 60068-2-6 | Sinusoidal<br>10 Hz to 60 Hz: ± 0,075 mm amplitude; 60 Hz to 150 Hz: 1g acceleration<br>frequency sweep rate 1 octave/min 20 cycles in 3 orthogonal axes. |
| Shock<br>IEC 60255-21-2, Class I;<br>IEC 60068-2-27 | Semi-sinusoidal<br>5 g acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes |
| Seismic Vibration<br>IEC 60255-21-3, Class II;<br>IEC 60068-3-3 | Sinusoidal<br>1 Hz to 8 Hz: ±7.5 mm amplitude (horizontal axis)<br>1 Hz to 8 Hz: ±3.5 mm amplitude (vertical axis)<br>8 Hz to 35 Hz: 2 g acceleration (horizontal axis)<br>8 Hz to 35 Hz: 1 g acceleration (vertical axis)<br>Frequency sweep 1 octave/min<br>1 cycle in 3 orthogonal axes |

### Vibration and Shock Stress during Transport

| | |
|---|---|
| Standards: | IEC 60255-21 and IEC 60068 |
| Oscillation<br>IEC 60255-21-1, Class 2;<br>IEC 60068-2-6 | Sinusoidal<br>5 Hz to 8 Hz: ± 7.5 mm amplitude;<br>8 Hz to 150 Hz: 2 g acceleration<br>Frequency sweep 1 octave/min<br>20 cycles in 3 orthogonal axes |
| Shock<br>IEC 60255-21-2, Class 1;<br>IEC 60068-2-27 | Semi-sinusoidal<br>15 g acceleration, duration 11 ms,<br>each 3 shocks (in both directions of the 3 axes) |
| Continuous Shock<br>IEC 60255-21-2, Class 1;<br>IEC 60068-2-29 | Semi-sinusoidal<br>10 g acceleration, duration 16 ms,<br>each 1000 shocks (in both directions of the 3 axes) |

## 4.1.7 Climatic Stress Tests

### Temperatures

| | |
|---|---|
| Standards: | IEC 60255-6 |
| Type test (in acc. with IEC 60068-2-1 and -2, Test Bd for 16 h) | –25 °C to +85 °C or –13 °F to +185 °F |
| Permissible temporary operating temperature (tested for 96 h) | –20 °C to +70 °C or –4 °F to +158 °F (clearness of the display may be impaired from +55 °C or +131 °F) |
| Recommended for permanent operation (in acc. with IEC 60255-6) | –5 °C to +55 °C or +23 °F to +131 °F |
| Limit temperatures for storage | –25 °C to +55 °C or –13 °F to +131 °F |
| Limit temperatures for transport | –25 °C to +70 °C or –13 °F to +158 °F |
| Storage and transport with factory packaging | |

### Humidity

| | |
|---|---|
| Permissible humidity | Mean value per year ≤ 75 % relative humidity;<br>on 56 days of the year up to 93 % relative humidity; condensation must be avoided! |
| Siemens recommends that all devices be installed such that they are not exposed to direct sunlight, nor subject to large fluctuations in temperature that may cause condensation to occur. | |

## 4.1.8 Service conditions

The protection device is designed for installation in normal relay rooms and plants so that electromagnetic compatibility (EMC) is ensured if installation is done properly.

We also recommend:

- All contacts and relays that operate in the same cubicle, cabinet, or relay panel as the numerical protective device should always be equipped with proper surge suppression components.
- For substations with operating voltages of 100 kV and higher, all external cables should be shielded with a conductive shield grounded at both ends. No special measures are normally required in a medium-voltage substation.
- Do not withdraw or insert individual modules or boards while the protective device is energized. When handling modules outside the case, the standards for components sensitive to electrostatic discharge (**E**lectrostatically **S**ensitive **D**evices) must be observed. They are not endangered inside the case.
- Only temperature sensors with 3-wire connection and shielded connection cables may be connected. Connect the cable shield as short as possible at the terminal D-14 designed for this purpose.

## 4.1.9 Design

| | |
|---|---|
| Case | 7XP20 |
| Dimensions | see dimensional drawings, Section 4.22 |

| Device | Case | Size | Weight |
|---|---|---|---|
| 7SK80**-*B | for panel surface mounting | $^1/_6$ | 4.5 kg (9.9 lb) |
| 7SK80**-*E | for panel flush mounting | $^1/_6$ | 4 kg (8.8 lb) |

| | |
|---|---|
| Protection type acc. to IEC 60529 | |
| For equipment in the surface-mounting case | IP 50 |
| For equipment in flush mounting case | Front IP 51<br>Rear IP 50 |
| for operator protection | IP 2x for current terminal<br>IP 1x for voltage terminal |
| Degree of pollution, IEC 60255-27 | 2 |

## 4.1.10 UL-certification conditions

| | | |
|---|---|---|
| Qutput Relais | DC 24 V | 5 A General Purpose |
| | DC 48 V | 0,8 A General Purpose |
| | DC 240 V | 0,1 A General Purpose |
| | AC 240 V | 5 A General Purpose |
| | AC 120 V | 1/3 hp |
| | AC 250 V | 1/2 hp |
| | B300, R300 | |
| | | |
| Voltage Inputs | Input voltage range | 300 V |
| | | |
| Battery | Servicing of the circuitry involving the batteries and replacement of the lithium batteries shall be done by a trained technician.<br>Replace Battery with VARTA or Panasonic Cat. Nos. CR 1/2 AA or BR 1/2 AA only. Use of another Battery may present a risk of fire or explosion. See manual for safety instructions.<br>Caution: The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C (212°F) or incinerate.<br>Dispose of used battery promptly. Keep away from children. | |
| | | |
| Climatic Stress | Surrounding air temperature | tsurr: max. 70 °C (158 °F), normal operation |
| | | |
| Design | Field Wires of Control Circuits shall be separated from other circuits with respect to the end use requirements! | |
| | Type 1 if mounted into a door or front cover of an enclosure. | |

## 4.2 Definite-Time Overcurrent Protection 50(N)

### Operating Modes

| | |
|---|---|
| Three-phase | Standard |
| Two-phase | Phases A and C |

### Measuring Method

| | |
|---|---|
| All elements | First harmonic, r.m.s. value (true RMS) |
| 51Ns-3 | Additional instantaneous values |

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Pickup current 50–1, 50–2 (phases) | for $I_{Nom}$ = 1 A | 0.10 A to 35.00 A or ∞ (disabled) | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.50 A to 175.00 A or ∞ (disabled) | |
| Pickup current 50–3 (phases) | for $I_{Nom}$ = 1 A | 1.0 A to 35.00 A or ∞ (disabled) | |
| | for $I_{Nom}$ = 5 A | 5.0 A to 175.00 A or ∞ (disabled) | |
| Pickup Current 50N–1, 50N–2 (ground) | for $I_{Nom}$ = 1 A | 0.05 A to 35.00 A or ∞ (disabled) | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.25 A to 175.00 A or ∞ (disabled) | |
| Pickup Current 50N–3 (ground) | for $I_{Nom}$ = 1 A | 0.25 A to 35.00 A or ∞ (disabled) | |
| | for $I_{Nom}$ = 5 A | 1.25 A to 175.00 A or ∞ (disabled) | |
| Time delays T | | 0.00 s to 60.00 s or ∞ (disabled) | Increments 0.01 s |
| Dropout time delays 50 T DROP-OUT, 50N T DROP-OUT | | 0.00 s to 60.00 s | Increments 0.01 s |

### Times

| | |
|---|---|
| Pickup times (without inrush restraint, with restraint + 1 period) | |
| First harmonic, rms value<br>- for 2 x setting value<br>- for 10 x setting value<br>Instantaneous value<br>- for 2 x setting value<br>- for 10 x setting value | <br>approx. 30 ms<br>Approx. 20 ms<br><br>approx. 16 ms<br>approx. 16 ms |
| Dropout Times<br>First harmonic, rms value<br>Instantaneous value | <br>approx. 30 ms<br>approx. 40 ms |

### Dropout Ratio

| | |
|---|---|
| Dropout ratio for<br>- first harmonic, rms value<br>- instantaneous value | <br>approx. 0,95 for $I/I_{Nom} \geq 0.3$<br>approx. 0,90 for $I/I_{Nom} \geq 0.3$ |

### Tolerances

| | |
|---|---|
| Pickup times | 3 % of setting value or 15 mA at $I_{Nom}$ = 1 A<br>or 75 mA at $I_{Nom}$ = 5 A |
| Time delays T | 1 % or 10 ms |

### Influencing Variables for Pickup and Dropout

| | |
|---|---|
| Auxiliary DC voltage in range $0.8 \le V_{Aux}/V_{AuxNom} \le 1.15$ | 1 % |
| Temperature in range –5 °C (41 °F) $\le \Theta_{amb} \le$ 55 °C (131 °F) | 0.5 %/10 K |
| Frequency in range of 50 Hz to 70 Hz | |
| Frequency in range $0.95 \le f/f_{Nom} \le 1.05$ | 1 % |
| Frequency outside range $0.95 \le f/f_{Nom} \le 1.05$ | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic<br>at instantaneous value of 50-3/50N-3 elements | <br>1 %<br>1 %<br>Increased tolerances |
| Transient overreaction for $\tau$ > 100 ms (with full displacement) | <5 % |

# 4.3 Inverse-Time Overcurrent Protection 51(N)

### Operating Modes

| | |
|---|---|
| Three-phase | Standard |
| Two-phase | Phases A and C |

### Measuring Technique

| | |
|---|---|
| All elements | First harmonic, rms value (true rms) |

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Pickup currents 51 (phases) | for $I_{Nom}$ = 1 A | 0.10 A to 4.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.50 A to 20.00 A | |
| Pickup currents 51N (ground) | for $I_{Nom}$ = 1 A | 0.05 A to 4.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.25 A to 20.00 A | |
| Time multiplier T for 51, 51N for IEC characteristics | | 0.05 s to 3.20 s or ∞ (disabled) | Increments 0.01 s |
| Time multiplier T for 51, 51N for ANSI characteristics | | 0.50 s to 15.00 s or ∞ (disabled) | Increments 0.01 s |

### Trip Time Curves acc. to IEC

Acc. to IEC 60255-3 or BS 142, Section 3.5.2 (see also Figures 4-1 and 4-2)

**INVERSE** (Type A)

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

**VERY INVERSE** (Type B)

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

**EXTREMELY INV.** (Type C)

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

**LONG INVERSE** (Type B)

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

Where:
- $t$ Trip time in seconds
- $T_p$ Setting Value of the Time Multiplier
- $I$ Fault Current
- $I_p$ Setting Value of the Pickup Current

The tripping times for $I/I_p \geq 20$ are identical with those for $I/I_p = 20$

For zero sequence current, read 3I0p instead of $I_p$ and $T_{3I0p}$ instead of $T_p$;
for ground fault, read $I_{Ep}$ instead of $I_p$ and $T_{IEp}$ instead of $T_p$

| | |
|---|---|
| Pickup threshold | approx. 1.10 · $I_p$ |

### Dropout Time Characteristics with Disk Emulation acc. to IEC

| | | |
|---|---|---|
| Acc. to IEC 60255-3 or BS 142, Section 3.5.2 (see also Figures 4-1 and 4-2) | | |
| **INVERSE** (Type A) | $t_{Reset} = \frac{9.7}{1-(I/I_p)^2} \cdot T_p$ | [s] |
| **VERY INV.** (Type B) | $t_{Reset} = \frac{43.2}{1-(I/I_p)^2} \cdot T_p$ | [s] |
| **EXTREMELY INV.** (Type C) | $t_{Reset} = \frac{58.2}{1-(I/I_p)^2} \cdot T_p$ | [s] |
| **LONG INVERSE** (Type B) | $t_{Reset} = \frac{80}{1-(I/I_p)^2} \cdot T_p$ | [s] |
| | Where:<br>$t_{Reset}$ Reset Time<br>$T_p$ Setting Value of the Time Multiplier<br>$I$ Fault Current<br>$I_p$ Setting Value of the Pickup Current | |
| The dropout time curves apply to $(I/Ip) \leq 0.90$ | | |
| For zero sequence current, read 3I0p instead of $I_p$ and $T_{3I0p}$ instead of $T_p$;<br>for ground fault, read $I_{Ep}$ instead of $I_p$ and $T_{IEp}$ instead of $T_p$ | | |

### Dropout Setting

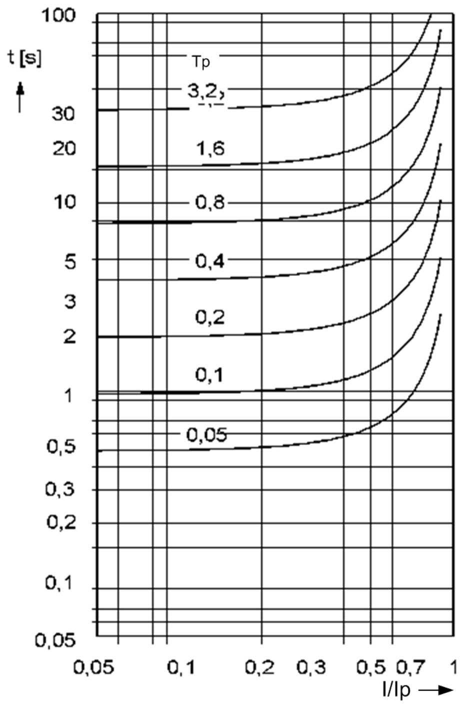
| | |
|---|---|
| IEC without Disk Emulation | approx. 1.05 · setting value $I_p$ for $I_p/I_N \geq 0.3$, this corresponds to approx. 0.95 · pickup value |
| IEC with Disk Emulation | approx. 0.90 · $I_p$ setting value |

### Tolerances

| | |
|---|---|
| Pickup/dropout thresholds $I_p$, $I_{Ep}$ | 3 % of setting value or 15 mA for $I_{Nom}$ = 1 A, or 75 mA for $I_{Nom}$ = 5 A |
| Trip time for $2 \leq I/I_p \leq 20$ | 5 % of reference (calculated) value +2 % current tolerance, or 30 ms |
| Dropout time for $I/Ip \leq 0.90$ | 5 % of reference (calculated) value +2 % current tolerance, or 30 ms |

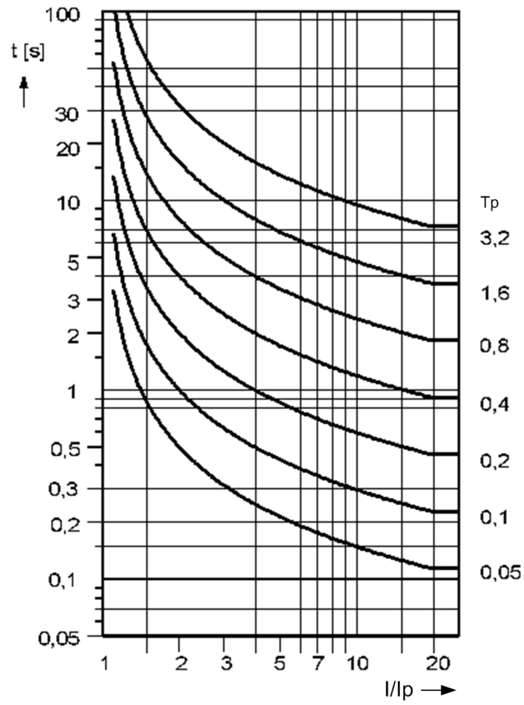
### Influencing Variables for Pickup and Dropout

| | |
|---|---|
| Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$ | 1 % |
| Temperature in range 23.00 °F (-5 °C) ≤ $\Theta_{amb}$ ≤ 131.00 °F (55 °C) | 0.5 %/10 K |
| Frequency in range of 50 Hz to 70 Hz | |
| Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$ | 1 % |
| Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$ | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |
| Transient overreaction during fundamental harmonic measuring procedure for $\tau$ > 100 ms (with full displacement) | <5 % |



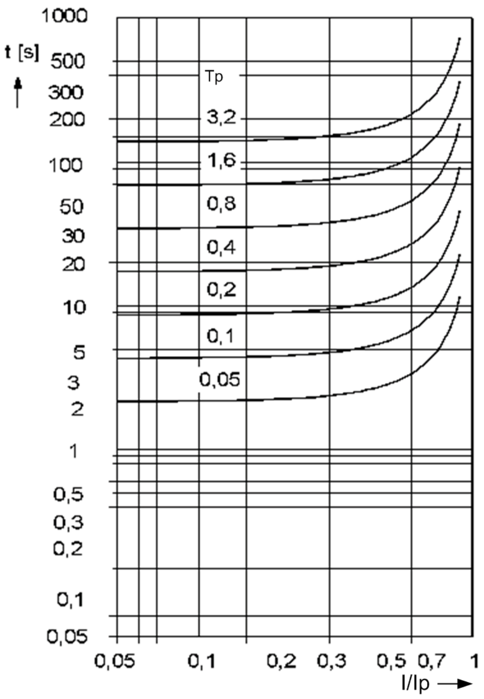

**Dropout normal inverse:**
**Type A**

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



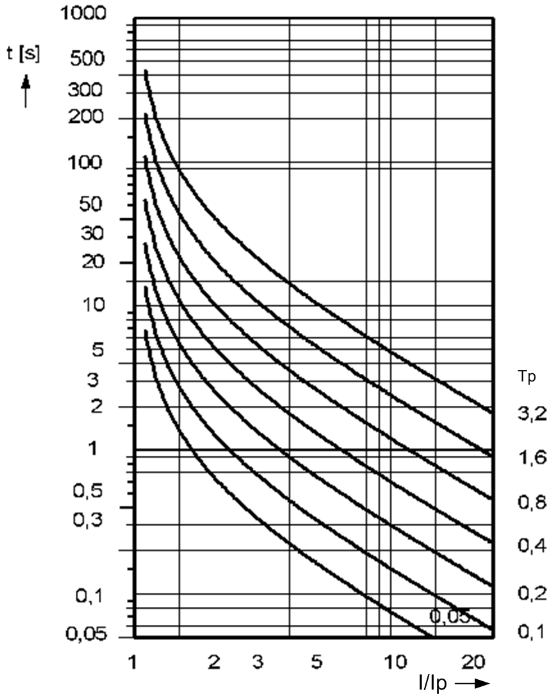

**Normal Inverse:**
**Type A**

$$t = \frac{0{,}14}{(I/I_p)^{0.02}-1} \cdot T_p \ [s]$$




**Reset Very Inverse:**
**Type B**

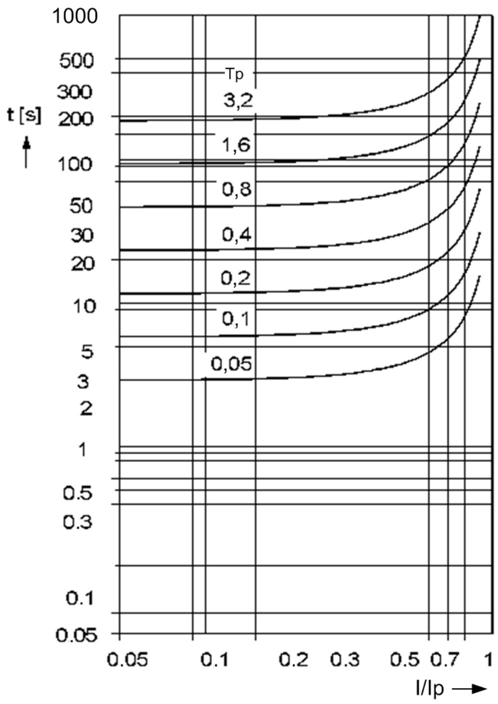
$$t = \frac{43.2}{1-(I/I_p)^2} \cdot T_p \ [s]$$



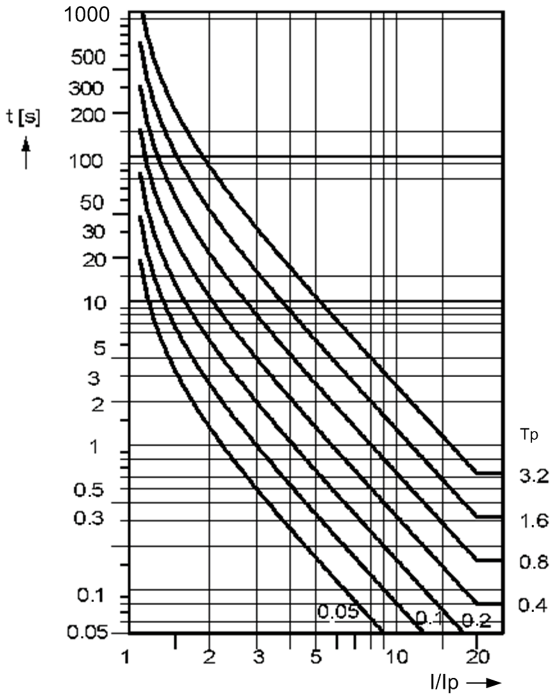

**VERY INVERSE:**
**Type B**

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

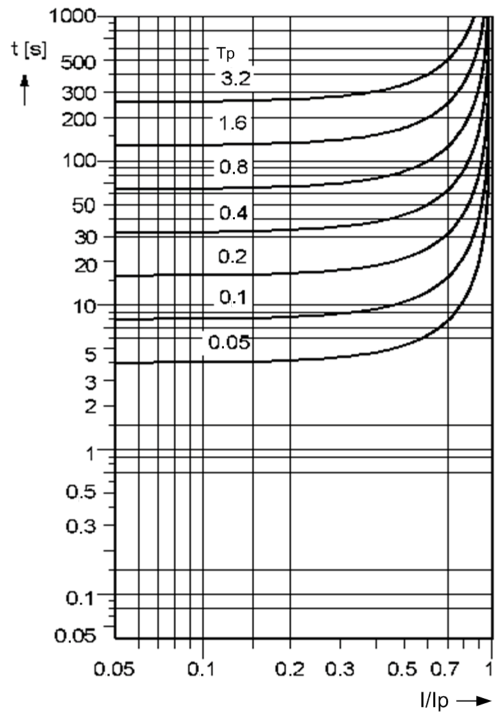
Figure 4-1 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to IEC



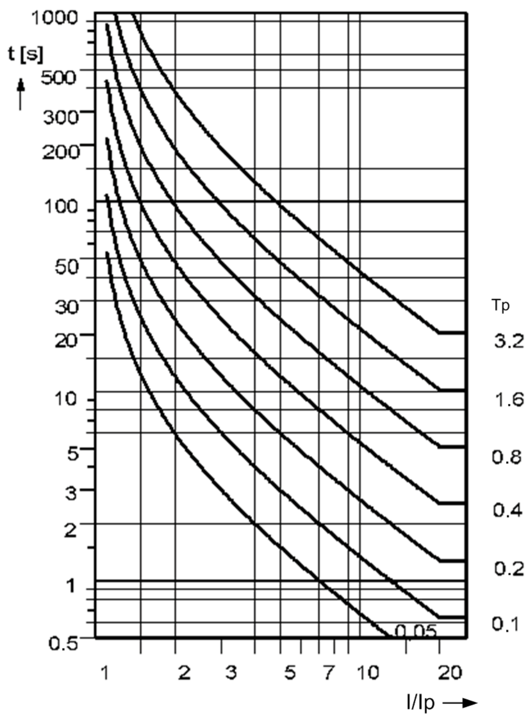

**Reset Extremely Inverse: Type C** $t = \frac{58.2}{1-(I/I_p)^2} \cdot T_p \ [s]$




**Extremely Inverse: Type C** $t = \frac{80}{(I/I_p)^2-1} \cdot T_p \ [s]$




**Reset long inverse: Type B** $t = \frac{80}{1-(I/I_p)^2} \cdot T_p \ [s]$




**Long time Inverse: Type B** $t = \frac{120}{(I/I_p)^1-1} \cdot T_p \ [s]$

Figure 4-2 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to IEC

**Trip Time Curves acc. to ANSI**

| Acc. to ANSI/IEEE (see also Figures 4-3 to 4-6) | |
|---|---|
| **INVERSE** | $t = \left(\frac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966\right) \cdot D \quad [s]$ |
| **SHORT INVERSE** | $t = \left(\frac{0.2663}{(I/I_p)^{1.2969} - 1} + 0.03393\right) \cdot D \quad [s]$ |
| **LONG INVERSE** | $t = \left(\frac{5.6143}{(I/I_p) - 1} + 2.18592\right) \cdot D \quad [s]$ |
| **MODERATELY INV.** | $t = \left(\frac{0.0103}{(I/I_p)^{0.02} - 1} + 0.0228\right) \cdot D \quad [s]$ |
| **VERY INVERSE** | $t = \left(\frac{3.922}{(I/I_p)^{2} - 1} + 0.0982\right) \cdot D \quad [s]$ |
| **EXTREMELY INV.** | $t = \left(\frac{5.64}{(I/I_p)^{2} - 1} + 0.02434\right) \cdot D \quad [s]$ |
| **DEFINITE INV.** | $t = \left(\frac{0.4797}{(I/I_p)^{1.5625} - 1} + 0.21359\right) \cdot D \quad [s]$<br>Where:<br>t Trip Time<br>D Setting Value of the Time Multiplier<br>I Fault Current<br>$I_p$ Setting Value of the Pickup Current |
| The tripping times for $I/I_p \geq 20$ are identical with those for $I/I_p = 20$. | |
| For zero sequence current read 3I0p instead of $I_p$ and $T_{3I0p}$ instead of $T_p$;<br>for ground fault read $I_{Ep}$ instead of $I_p$ and $T_{IEp}$ instead of $T_p$ | |
| Pickup Threshold | approx. $1.10 \cdot I_p$ |

### Dropout Time Characteristics with Disk Emulation acc. to ANSI/IEEE

| Acc. to ANSI/IEEE (see also Figures 4-3 to 4-6) | |
|---|---|
| **INVERSE** | $t_{Reset} = \left(\frac{8.8}{1-(I/I_p)^{2.0938}}\right) \cdot D \quad [s]$ |
| **SHORT INVERSE** | $t_{Reset} = \left(\frac{0.831}{1-(I/I_p)^{1.2969}}\right) \cdot D \quad [s]$ |
| **LONG INVERSE** | $t_{Reset} = \left(\frac{12.9}{1-(I/I_p)^{1}}\right) \cdot D \quad [s]$ |
| **MODERATELY INV.** | $t_{Reset} = \left(\frac{0.97}{1-(I/I_p)^{2}}\right) \cdot D \quad [s]$ |
| **VERY INVERSE** | $t_{Reset} = \left(\frac{4.32}{1-(I/I_p)^{2}}\right) \cdot D \quad [s]$ |
| **EXTREMELY INV.** | $t_{Reset} = \left(\frac{5.82}{1-(I/I_p)^{2}}\right) \cdot D \quad [s]$ |
| **DEFINITE INV.** | $t_{Reset} = \left(\frac{1.03940}{1-(I/I_p)^{1.5625}}\right) \cdot D \quad [s]$ |
| for $0.5 < (I/I_p) \leq 0.90$ | Where:<br>$t_{Reset}$ Reset time<br>D Setting value of the multiplier<br>I Fault Current<br>$I_p$ Setting value of the pickup current |
| The dropout time curves apply to $(I/Ip) \leq 0.90$ | |
| For zero sequence current read 3I0p instead of $I_p$ and $T_{3I0p}$ instead of $T_p$;<br>for ground fault read $I_{Ep}$ instead of $I_p$ and $T_{IEp}$ instead of $T_p$ | |

### Dropout Setting

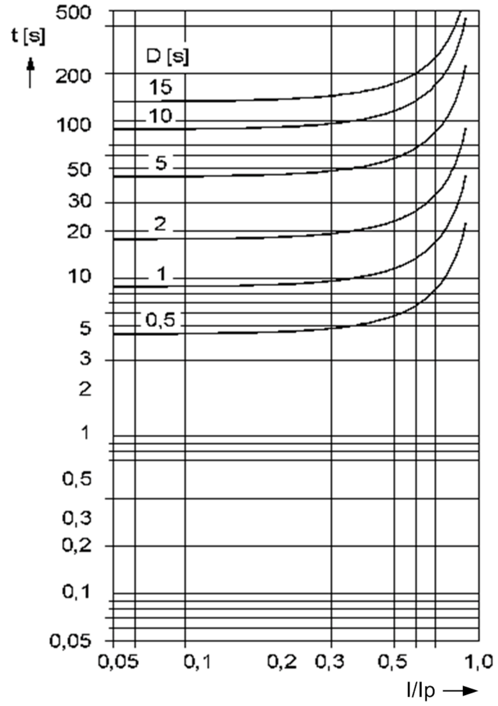
| | |
|---|---|
| ANSI without Disk Emulation | approx. 1.05 · setting value $I_p$ for $I_p/I_N \geq 0.3$; this corresponds to approx. 0.95 · pickup value |
| ANSI with Disk Emulation | approx. 0.90 · $I_p$ setting value |

### Tolerances

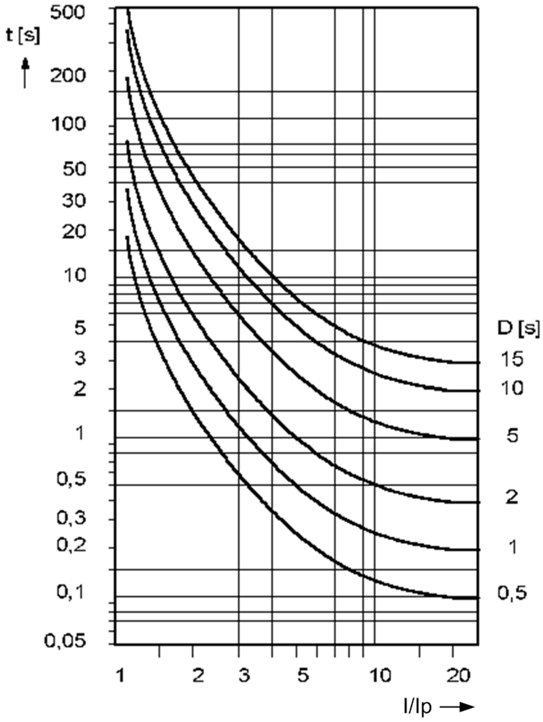
| | |
|---|---|
| Pickup/dropout thresholds $I_p$, $I_{Ep}$ | 3 % of setting value or 15 mA for $I_N$ = 1 A, or 75 mA for $I_N$ = 5 A |
| Trip time for $2 \leq I/I_p \leq 20$ | 5 % of reference (calculated) value +2 % current tolerance, or 30 ms |
| Dropout time for $I/Ip \leq 0.90$ | 5 % of reference (calculated) value +2 % current tolerance, or 30 ms |

### Influencing Variables for Pickup and Dropout

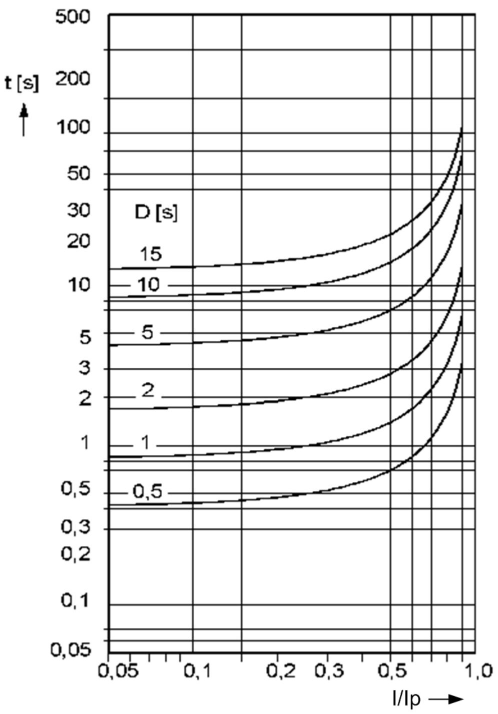
| | |
|---|---|
| Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$ | 1 % |
| Temperature in range 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C) | 0.5 %/10 K |
| Frequency in range of 50 Hz to 70 Hz | |
| Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$ | 1 % |
| Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$ | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1%<br>1% |
| Transient overreaction during fundamental harmonic measuring procedure for $\tau$ > 100 ms (with full displacement) | <5 % |



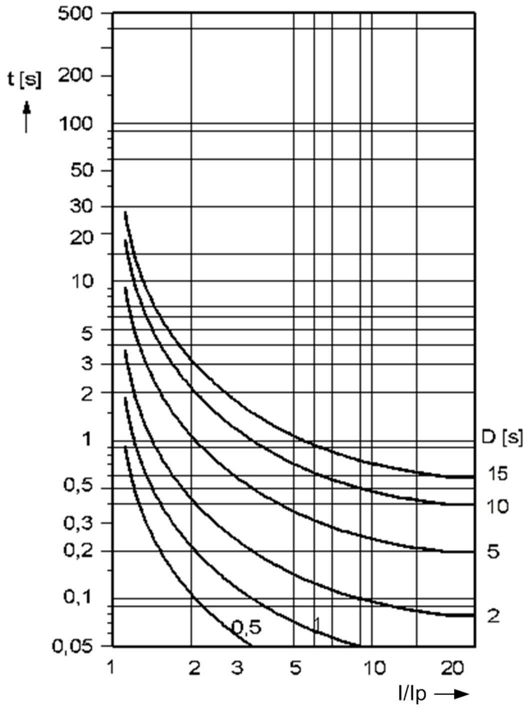

**RESET INVERSE** $$t = \frac{8.8}{1-(I/I_p)^{2.0938}} \cdot D \ [s]$$




**INVERSE** $$t = \left(\frac{8.9341}{(I/I_p)^{2.0938}-1} + 0.17966\right) \cdot D \ [s]$$

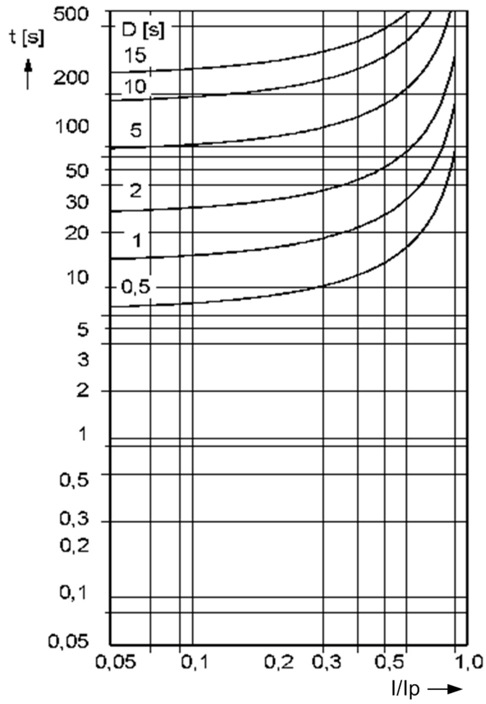



**RESET SHORT INVERSE** $$t = \frac{0.831}{1-(I/I_p)^{1.2969}} \cdot D \ [s]$$



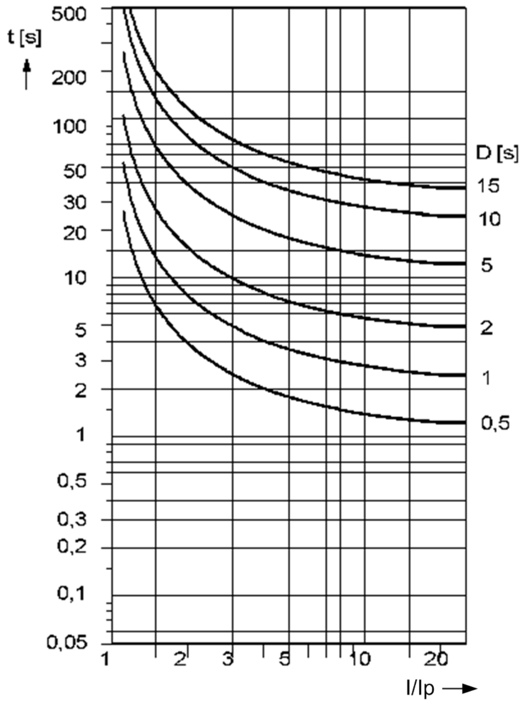

**SHORT INVERSE** $$t = \left(\frac{0.2663}{(I/I_p)^{1.2969}-1} + 0.03393\right) \cdot D \ [s]$$

Figure 4-3 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to ANSI/IEEE



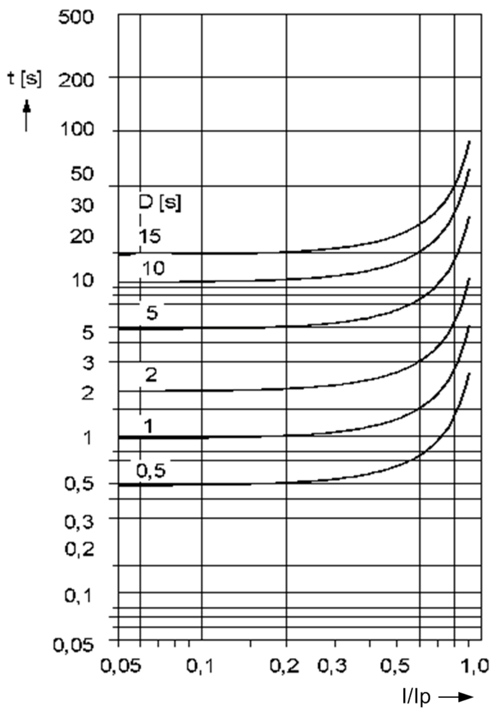

**RESET LONG INVERSE**

$$t = \left(\frac{12.9}{1-(I/I_p)^1}\right) \cdot D \ [s]$$



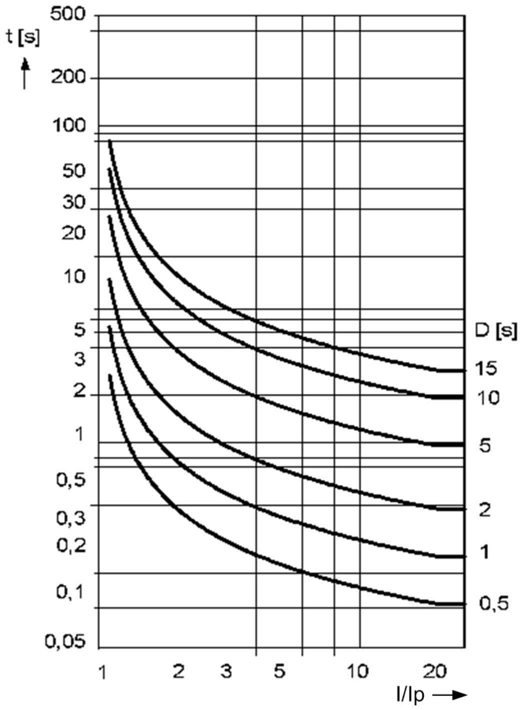

**LONG INVERSE**

$$t = \left(\frac{5.6143}{(I/I_p)-1} + 2.18592\right) \cdot D \ [s]$$




**RESET MODERATELY INVERSE**

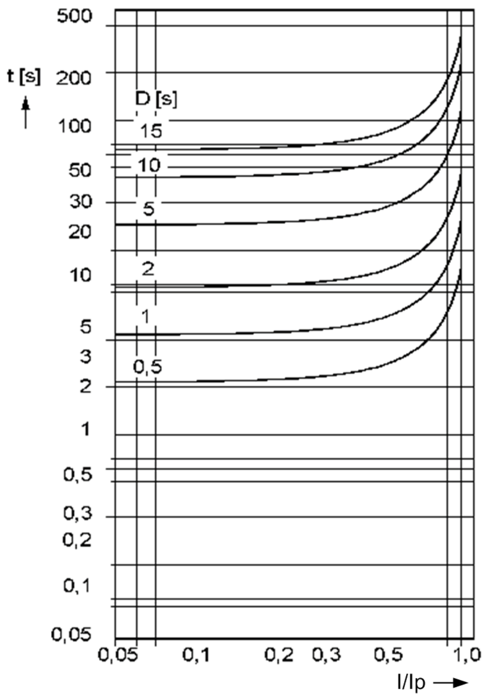
$$t = \left(\frac{0.97}{1-(I/I_p)^2}\right) \cdot D \ [s]$$



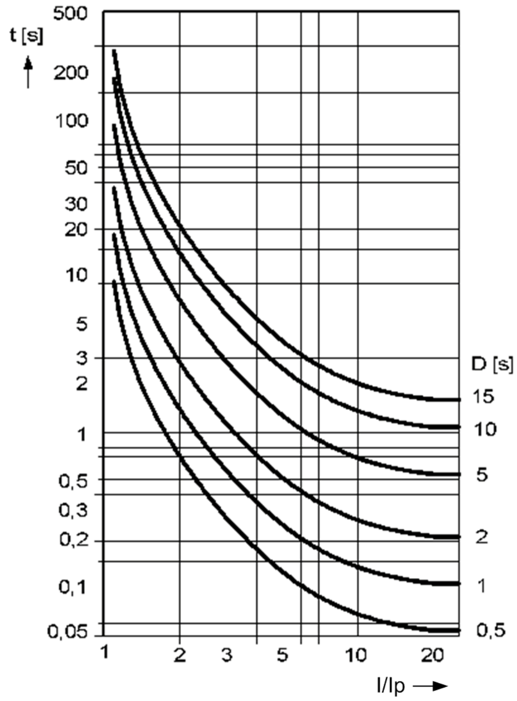

**MODERATELY INVERSE**

$$t = \left(\frac{0.0103}{(I/I_p)^{0.02}-1} + 0.0228\right) \cdot D \ [s]$$

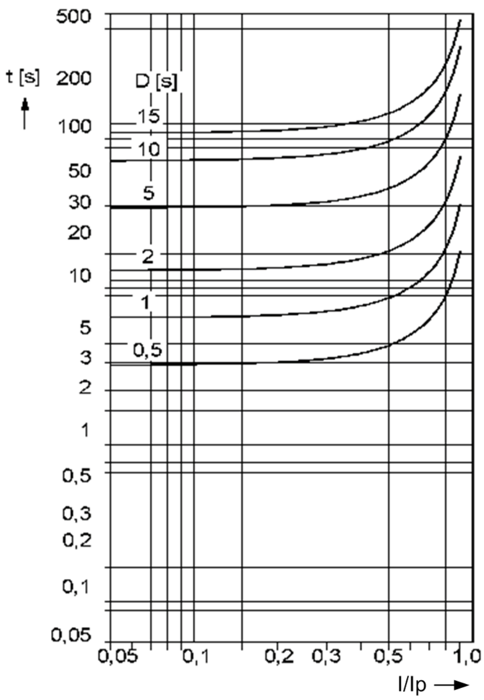
Figure 4-4 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to ANSI/IEEE



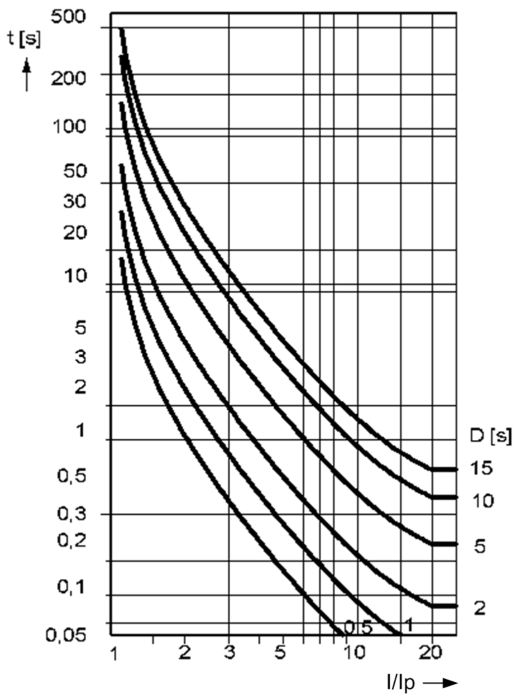

**RESET VERY INVERSE** $t = \left(\frac{4.32}{1-(I/I_p)^2}\right) \cdot D \ [s]$




**VERY INVERSE:** $t = \left(\frac{3.922}{(I/I_p)^2-1} + 0.0982\right) \cdot D \ [s]$

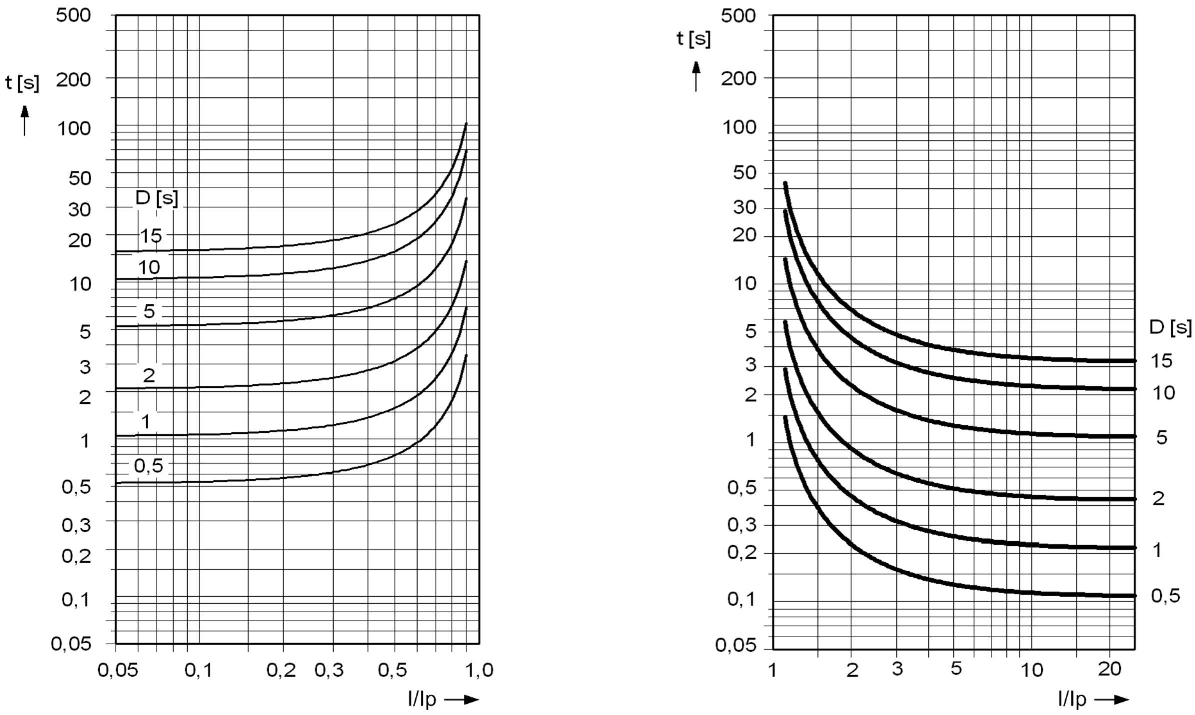



**RESET EXTREMELY INVERSE** $t = \left(\frac{5.82}{1-(I/I_p)^2}\right) \cdot D \ [s]$




**EXTREMELY INVERSE** $t = \left(\frac{5.64}{(I/I_p)^2-1} + 0.02434\right) \cdot D \ [s]$

Figure 4-5 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to ANSI/IEEE




**RESET DEFINITE INVERSE**

$$t = \left(\frac{1.0394}{1-(I/I_p)^{1.5625}}\right) \cdot D \quad [s]$$

**DEFINITE INVERSE**

$$t = \left(\frac{0.4797}{(I/I_p)^{1.5625}-1} + 0.21359\right) \cdot D \quad [s]$$

Note:
For earth fault read IEP instead of Ip and DIEp instead of DIp.

Figure 4-6 Dropout time and trip time curve of the inverse time overcurrent protection, acc. to ANSI/IEEE

# 4.4 Directional Ground Overcurrent Protection 67N

### Time Overcurrent Elements

| |
|---|
| The same specifications and characteristics apply as for non-directional time overcurrent protection (see previous Sections). |

### Determination of Direction

| |
|---|
| Moreover, the following data apply to direction determination: |

### For Ground Faults

| | |
|---|---|
| Polarization | with zero sequence quantities $3V_0$, $3I_0$ |
| Forward range | $V_{ref,rot}$ ± 86° |
| Rotation of the reference voltage $V_{ref,rot}$ | -180° to +180°<br>Increments 1° |
| Dropout difference | 3° |
| Directional sensitivity | $V_N \approx$ 2.5 V displacement voltage, measured<br>$3V_0 \approx$ 5 V displacement voltage, calculated |

| | |
|---|---|
| Polarization | with negative sequence quantities $3V_2$, $3I_2$ |
| Forward range | $V_{ref,rot}$ ± 86° |
| Rotation of the reference voltage $V_{ref,rot}$ | -180° to +180°<br>Increments 1° |
| Dropout difference | 3° |
| Directional sensitivity | $3V_2 \approx$ 5 V negative sequence voltage<br>$3I_2 \approx$ 45 mA negative sequence current with $I_{Nom}$ = 1 A<br>$3I_2 \approx$ 225 mA negative sequence current with $I_{Nom}$ = 5 A |

### Times

| | |
|---|---|
| Pickup times (without inrush restraint, with restraint + 1period) | |
| 67N-1, 67-2, 67N-2<br>- for 2 x setting value<br>- for 10 x setting value | <br>approx. 45 ms<br>approx. 40 ms |
| Dropout times<br>67N-1, 67N-2 | <br>approx. 40 ms |

### Tolerances

| | |
|---|---|
| Phase-angle error for ground faults | ±3° electrical |

### Influencing variables

| | |
|---|---|
| Frequency influence | approx. 1° in the range of 0.95 < $f/f_N$ < 1.05 |

# 4.5 Inrush Restraint

### Controlled Functions

| | |
|---|---|
| Overcurrent elements | 50-1, 50N-1, 51, 51N, 67-1, 67N-1 |

### Setting Ranges / Increments

| | | |
|---|---|---|
| Stabilization factor $I_{2f}/I$ | 10 % to 45 % | Increments 1 % |

### Functional Limits

| | | | |
|---|---|---|---|
| Lower function limit phases | for $I_{Nom}$ = 1 A | at least one phase current (50 Hz and 100 Hz) ≥ 50 mA | |
| | for $I_{Nom}$ = 5 A | at least one phase current (50 Hz and 100 Hz) ≥ 125 mA | |
| Lower function limit ground | for $I_{Nom}$ = 1 A | Ground current (50 Hz and 100 Hz) ≥ 50 mA | |
| | for $I_{Nom}$ = 5 A | Ground current (50 Hz and 100 Hz) ≥ 125 mA | |
| Upper function limit, configurable | for $I_{Nom}$ = 1 A | 0.30 A to 25.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 1.50 A to 125.00 A | Increments 0.01 A |

### Cross-blocking

| | |
|---|---|
| Cross-blocking $I_A$, $I_B$, $I_C$ | ON/OFF |

# 4.6 Dynamic Cold Load Pickup

### Timed changeover of settings

| | |
|---|---|
| Controlled elements | Non-directional time overcurrent protection (separate phase and ground settings) 50(N), 51(N) |
| Initiation criteria | Current criterion BkrClosed I MIN |
| | Interrogation of the circuit breaker position |
| | Binary input |
| Time control | 3 time elements ($T_{CB\ Open.}$, $T_{Active}$, $T_{Stop}$) |
| Current control | Current threshold BkrClosed I MIN (reset on current falling below threshold: monitoring with timer) |

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Current Control | for $I_{Nom}$ = 1 A | 0.04 A to 1.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.20 A to 5.00 A | |
| Time Until Changeover To Dynamic Settings $T_{CB\ OPEN}$ | | 0 s to 21600 s (= 6 h) | Increments 1 s |
| Period Dynamic Settings are Effective After a Reclosure $T_{Active}$ | | 1 s to 21600 s (= 6 h) | Increments 1 s |
| Fast Reset Time $T_{Stop}$ | | 1 s to 600 s (= 10 min) or ∞ (fast reset inactive) | Increments 1 s |
| Dynamic Settings of Pickup Currents and Time Delays or Time Multipliers | | Adjustable within the same ranges and with the same increments as the directional and non-directional time overcurrent protection | |

## 4.7 Voltage Protection 27, 59

### Setting ranges / increments

| | | | |
|---|---|---|---|
| Undervoltages 27-1, 27-2 | | | |
| Measured quantity used | | - Positive sequence system of the voltages<br>- Smallest phase-to-phase voltage<br>- Smallest phase-to-Ground voltage | |
| Connection of phase-to-Ground voltages:<br>- Evaluation of phase-to-Ground voltages<br>- Evaluation of phase-to-phase voltages<br>- Evaluation of positive sequence system | | <br>10 V to 120 V<br>10 V to 210 V<br>10 V to 210 V | <br>Increments 1 V<br>Increments 1 V<br>Increments 1 V |
| Connection of phase-to-phase voltages | | 10 V to 120 V | Increments 1 V |
| Connection: Single-phase | | 10 V to 120 V | Increments 1 V |
| Dropout ratio r for 27-1, 27-2 [1)] | | 1.01 to 3.00 | Increments 0.01 |
| Dropout threshold for (r· 27-1) or (r· 27-2) | | max. 130 V for phase-to-phase voltage<br>max. 225 V for phase-to-Ground voltage<br>Minimum hysteresis 0.6 V | |
| Time delays T 27-1, T 27-2 | | 0.00 s to 100.00 s or<br>∞ (disabled) | Increments 0.01 s |
| Current criterion "BkrClosed I MIN" | for $I_{Nom}$ = 1 A | 0.04 A to 1.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.20 A to 5.00 A | |
| Overvoltages 59-1, 59-2 | | | |
| Measured quantity used | | - Positive sequence system of the voltages<br>- Negative sequence system of the voltages<br>- Largest phase-to-phase voltage<br>- Largest phase-to-Ground voltage | |
| Connection of phase-to-Ground voltages:<br>- Evaluation of phase-to-Ground voltages<br>- Evaluation of phase-to-phase voltages<br>- Evaluation of positive sequence system<br>- Evaluation of negative sequence system | | <br>20 V to 150 V<br>20 V to 260 V<br>20 V to 150 V<br>2 V to 150 V | <br>Increments 1 V<br>Increments 1 V<br>Increments 1 V<br>Increments 1 V |
| Connection of phase-to-phase voltages:<br>- Evaluation of phase-to-phase voltages<br>- Evaluation of positive sequence system<br>- Evaluation of negative sequence system | | <br>20 V to 150 V<br>20 V to 150 V<br>2 V to 150 V | <br>Increments 1 V<br>Increments 1 V<br>Increments 1 V |
| Connection: Single-phase | | 20 V to 150 V | Increments 1 V |
| Dropout ratio r for 27-1, 27-2 [1)] | | 0.90 to 0.99 | Increments 0.01 V |
| Dropout threshold for (r· 59-1) or (r· 59-2) | | max. 150 V for phase-to-phase voltage<br>max. 260 V for phase-to-Ground voltage<br>Minimum hysteresis 0.6 V | |
| Time delay T 59-1, T 59-2 | | 0.00 s to 100.00 s or<br>∞ (disabled) | Increments 0.01 s |

[1)] $r = V_{dropout}/V_{pickup}$

### Times

| | |
|---|---|
| Pickup Times | |
| - Undervoltage 27-1, 27-2, 27-1 $V_1$, 27-2 $V_1$<br>- Overvoltage 59-1, 59-2<br>- Overvoltage 59-1 $V_1$, 59-2 $V_1$, 59-1 $V_2$ , 59-2 $V_2$ | Approx. 50 ms<br>Approx. 50 ms<br>Approx. 60 ms |
| Dropout Times | |
| - Undervoltage 27-1, 27-2, 27-1 $V_1$, 27-2 $V_1$<br>- Overvoltage 59-1, 59-2<br>- Overvoltage 59-1 $V_1$, 59-2 $V_1$, 59-1 $V_2$ , 59-2 $V_2$ | Approx. 50 ms<br>Approx. 50 ms<br>Approx. 60 ms |

### Tolerances

| | |
|---|---|
| Pickup Voltage Limits | 3 % of setting value or 1 V |
| Delay times T | 1 % of setting value or 10 ms |

### Influencing Variables

| | |
|---|---|
| Auxiliary DC voltage in range $0.8 \leq V_{Aux}/V_{AuxNom} \leq 1.15$ | 1 % |
| Temperature in range –5 °C (41 °F) $\leq \Theta_{amb} \leq$ 55 °C (131 °F) | 0.5 %/10 K |
| Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$ | 1 % |
| Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$ | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |

# 4.8 Negative Sequence Protection 46-1, 46-2

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Unbalanced load tripping element 46-1,46-2 | for $I_{Nom}$ = 1 A | 0.10 A to 3.00 A or ∞ (disabled) | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.50 A to 15.00 A or ∞ (disabled) | |
| Delay Times 46-1, 46-2 | | 0.00 s to 60.00 s or ∞ (disabled) | Increments 0.01 s |
| Dropout Delay Times 46 T DROP-OUT | | 0.00 s to 60.00 s | Increments 0.01 s |

### Functional Limit

| | | |
|---|---|---|
| Functional Limit | for $I_{Nom}$ = 1 A | all phase currents ≤ 10 A |
| | for $I_{Nom}$ = 5 A | all phase currents ≤ 50 A |

### Times

| | |
|---|---|
| Pickup Times<br>Dropout Times | Approx. 35 ms<br>Approx. 35 ms |

### Dropout Ratio

| | |
|---|---|
| Characteristic 46-1, 46-2 | Approx. 0.95 for $I_2/I_{Nom} \geq 0.3$ |

### Tolerances

| | |
|---|---|
| Pickup values 46-1, 46-2 | 3 % of setting value or 15 mA for $I_{Nom}$ = 1 A, or 75 mA for $I_{Nom}$ = 5 A |
| Time Delays | 1 % or 10 ms |

### Influencing Variables for Pickup Values

| | |
|---|---|
| Auxiliary DC voltage in range $0.8 \leq V_{Aux}/V_{AuxNom} \leq 1.15$ | 1 % |
| Temperature in range –5 °C (41 °F) ≤ $\Theta_{amb}$ ≤ 55 °C (131 °F) | 0.5 %/10 K |
| Frequency in range of 50 Hz to 70 Hz | |
| Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$ | 1 % |
| Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$ | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |
| Transient overreaction for τ > 100 ms (with full displacement) | <5 % |

# 4.9 Negative Sequence Protection 46-TOC

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Pickup value 46-TOC ($I_{2p}$) | for $I_{Nom}$ = 1 A | 0.10 A to 2.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.50 A to 10.00 A | |
| Time Multiplier $T_{I2p}$ (IEC) | | 0.05 s to 3.20 s or ∞ (disabled) | Increments 0.01 s |
| Time Multiplier $D_{I2p}$ (ANSI) | | 0.50 s to 15.00 s or ∞ (disabled) | Increments 0.01 s |

### Functional Limit

| | | |
|---|---|---|
| Functional Limit | for $I_{Nom}$ = 1 A | all phase currents ≤ 10 A |
| | for $I_{Nom}$ = 5 A | all phase currents ≤ 50 A |

### Trip Time Curves acc. to IEC

See also Figure 4-7

**INVERSE**

$$t_{TRIP} = \frac{0.14}{(I_2/I_{2p})^{0.02} - 1} \cdot T_{I2p} \quad [s]$$

**VERY INVERSE**

$$t_{TRIP} = \frac{13.5}{(I_2/I_{2p})^{1} - 1} \cdot T_{I2p} \quad [s]$$

**EXTREMELY INV.**

$$t_{TRIP} = \frac{80}{(I_2/I_{2p})^{2} - 1} \cdot T_{I2p} \quad [s]$$

Where:
$t_{TRIP}$ Trip Time
$T_{I2p}$ Setting Value of the Time Multiplier
$I_2$ Negative Sequence Current
$I_{2p}$ Setting Value of the Pickup Current

The trip times for $I_2/I_{2p} \geq 20$ are identical to those for $I_2/I_{2p} = 20$.

| | |
|---|---|
| Pickup Threshold | Approx. 1.10· $I_{2p}$ |

**Trip Time Curves acc. to ANSI**

| | |
|---|---|
| It can be selected one of the represented trip time characteristic curves in the figures 4-8 and 4-9 each on the right side of the figure. | |
| **INVERSE** | $t_{TRIP} = \left( \frac{8.9341}{(I_2/I_{2p})^{2.0938} - 1} + 0.17966 \right) \cdot D_{I2p} \quad [s]$ |
| **MODERATELY INVERSE** | $t_{TRIP} = \left( \frac{0.0103}{(I_2/I_{2p})^{0.02} - 1} + 0.0228 \right) \cdot D_{I2p} \quad [s]$ |
| **VERY INVERSE** | $t_{TRIP} = \left( \frac{3.922}{(I_2/I_{2p})^{2} - 1} + 0.0982 \right) \cdot D_{I2p} \quad [s]$ |
| **EXTREMELY INV.** | $t_{TRIP} = \left( \frac{5.64}{(I_2/I_{2p})^{2} - 1} + 0.02434 \right) \cdot D_{I2p} \quad [s]$ |
| | Where:<br>$t_{TRIP}$ Trip Time<br>$D_{I2p}$ Setting Value of the Time Multiplier<br>$I_2$ Negative Sequence Currents<br>$I_{2p}$ Setting Value of the Pickup Current |
| The trip times for $I_2/I_{2p} \geq 20$ are identical to those for $I_2/I_{2p} = 20$. | |
| Pickup Threshold | Approx. $1.10 \cdot I_{2p}$ |

**Tolerances**

| | |
|---|---|
| Pickup threshold $I_{2p}$ | 3 % of setting value or 15 mA for $I_{Nom}$ = 1 A<br>or 75 mA at $I_{Nom}$ = 5 A |
| Time for $2 \leq I/I_{2p} \leq 20$ | 5 % of reference (calculated) value +2 % current tolerance, or 30 ms |

### Dropout Time Curves with Disk Emulation acc. to ANSI

| Representation of the possible dropout time curves, see figure 4-8 and 4-9 each on the left side of the figure |
|---|
| **INVERSE** $t_{Reset} = \left(\frac{8.8}{1-(I_2/I_{2p})^{2.0938}}\right) \cdot D_{I2p}$ [s] |
| **MODERATELY INV.** $t_{Reset} = \left(\frac{0.97}{1-(I_2/I_{2p})^{2}}\right) \cdot D_{I2p}$ [s] |
| **VERY INVERSE** $t_{Reset} = \left(\frac{4.32}{1-(I_2/I_{2p})^{2}}\right) \cdot D_{I2p}$ [s] |
| **EXTREMELY INV.** $t_{Reset} = \left(\frac{5.82}{1-(I_2/I_{2p})^{2}}\right) \cdot D_{I2p}$ [s] |
| Where:<br>$t_{Reset}$ Reset Time<br>$D_{I2p}$ Setting Value of the Time Multiplier<br>$I_2$ Negative Sequence Current<br>$I_{2p}$ Setting Value of the Pickup Current |
| The dropout time constants apply to $(I_2/I_{2p}) \leq 0.90$ |

### Dropout Value

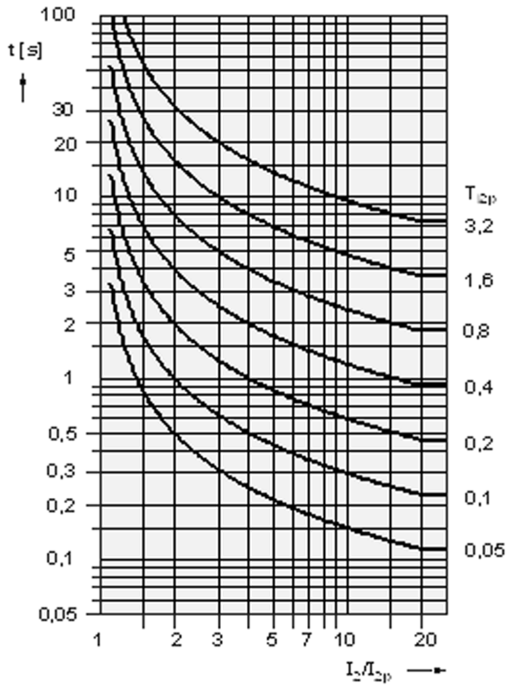
| | |
|---|---|
| IEC and ANSI (without Disk Emulation) | Approx. 1.05 · $I_{2p}$ setting value, which is approx. 0.95 · pickup threshold$I_2$ |
| ANSI with Disk Emulation | Approx. 0.90 · $I_{2p}$ setting value |

### Tolerances

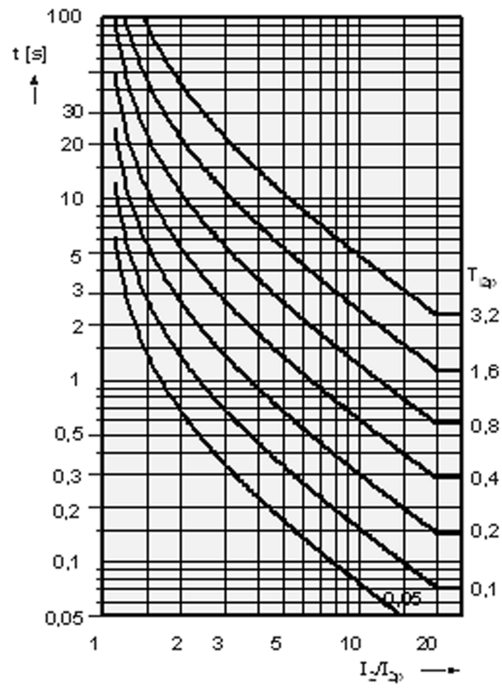
| | |
|---|---|
| Dropout value $I_{2p}$ | 3 % of setting value or 15 mA for $I_{Nom}$ = 1 A<br>or 75 mA for $I_{Nom}$ = 5 A |
| Time for $I_2/I_{2p} \leq 0.90$ | 5 % of reference (calculated) value +2 % current tolerance, or 30 ms |

### Influencing Variables for Pickup Values

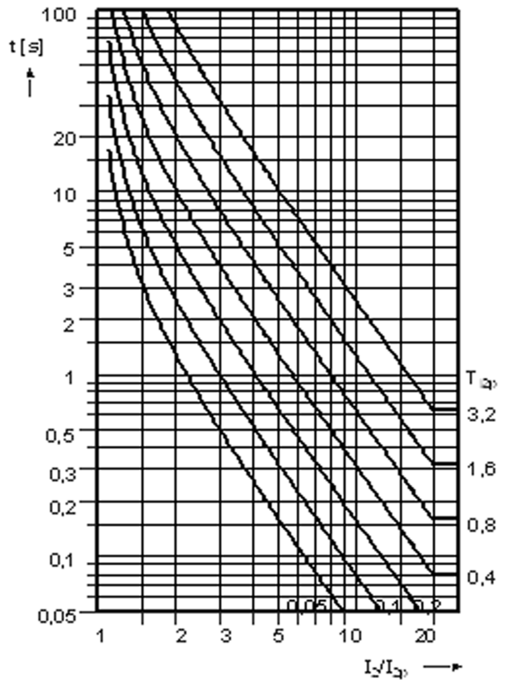
| | |
|---|---|
| Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$ | 1 % |
| Temperature in range 23.00 °F (-5 °C) ≤ $\Theta_{amb}$ ≤ 131.00 °F (55 °C) | 0.5 %/10 K |
| Frequency in range of 50 Hz to 70 Hz | |
| Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$ | 1 % |
| Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$ | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |
| Transient overreaction for $\tau$ > 100 ms (with full displacement) | <5 % |




**IEC INVERSE:** $t = \frac{0,14}{(I_2/I_{2p})^{0,02} - 1} \cdot T_{I2p}$ [s]



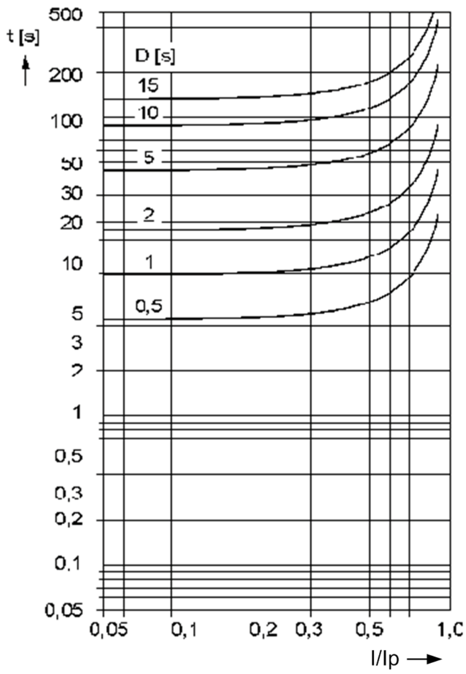

**IEC VERY INVERSE:** $t = \frac{13,5}{(I_2/I_{2p})^{1} - 1} \cdot T_{I2p}$ [s]

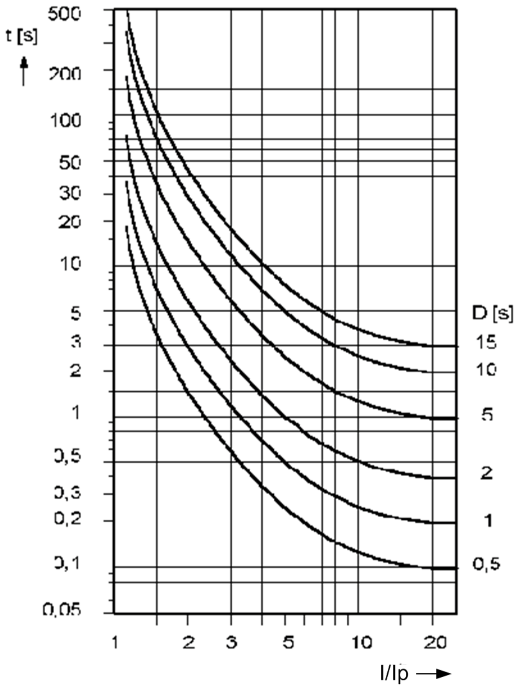



**IEC EXTREMELY INVERSE:** $t = \frac{80}{(I_2/I_{2p})^{2} - 1} \cdot T_{I2p}$ [s]

| | |
|---|---|
| $t$ | Tripping Time |
| $T_{I2p}$ | Setting Value of the Time Factor |
| $I_2$ | Inverse current |
| $I_{2p}$ | Pickup current of unbalanced load protection |

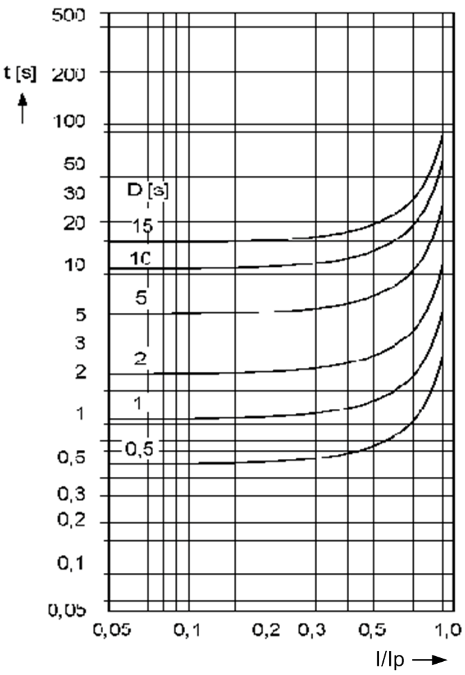
Figure 4-7 Trip time characteristics of the inverse time negative sequence element 46-TOC, acc. to IEC

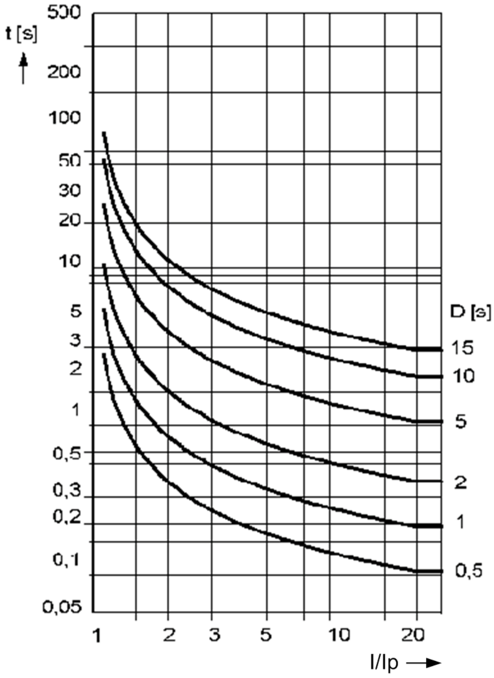



**RESET INVERSE** $t = \left(\frac{8.8}{1-(I_2/I_{2p})^{2.0938}}\right) \cdot D\ [s]$

**INVERSE** $t = \left(\frac{8.9341}{(I_2/I_{2p})^{2.0938}-1} + 0.17966\right) \cdot D\ [s]$

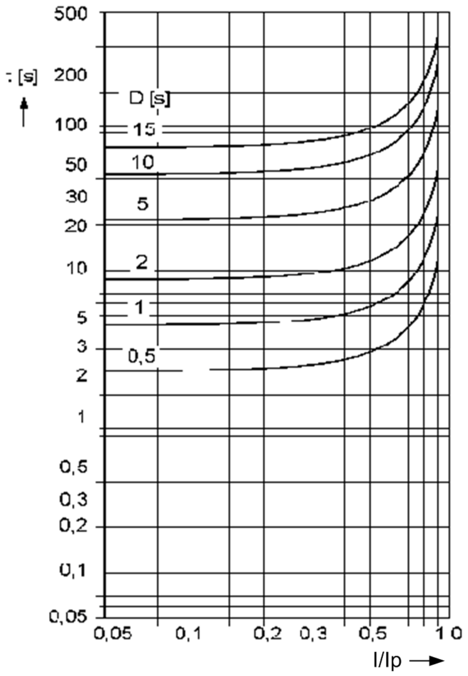


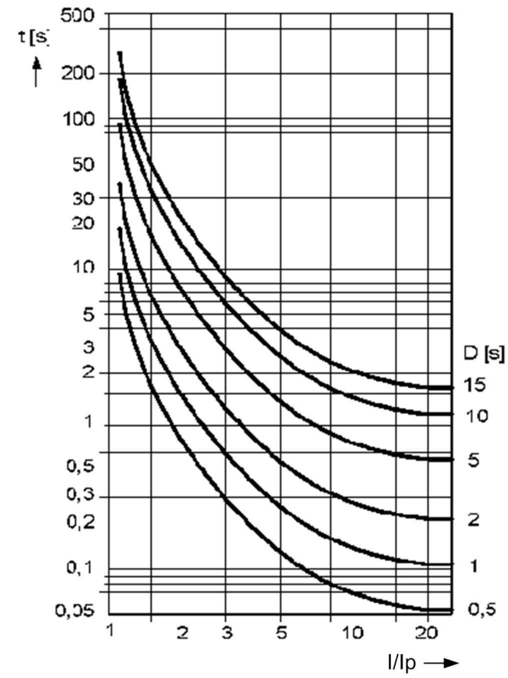

**RESET MODERATELY INVERSE** $t = \left(\frac{0.97}{1-(I_2/I_{2p})^{2}}\right) \cdot D\ [s]$

**MODERATELY INVERSE** $t = \left(\frac{0.0103}{(I_2/I_{2p})^{0.02}-1} + 0.0228\right) \cdot D\ [s]$

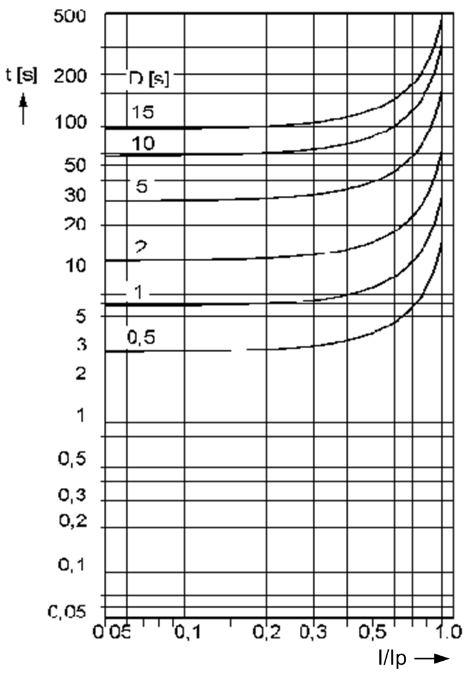
Figure 4-8 Dropout time and trip time characteristics of the inverse time unbalanced load stage, acc. to ANSI



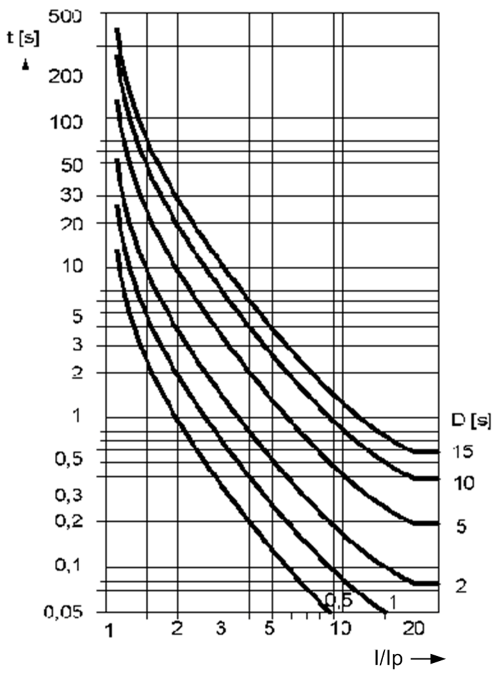

**RESET VERY INVERSE** $t = \left(\frac{4.32}{1-(I_2/I_{2p})^2}\right)\cdot D\ [s]$




**VERY INVERSE:** $t = \left(\frac{3.922}{(I_2/I_{2p})^2-1}+0.0982\right)\cdot D\ [s]$




**RESET EXTREMELY INVERSE** $t = \left(\frac{5.82}{1-(I_2/I_{2p})^2}\right)\cdot D\ [s]$




**EXTREMELY INVERSE** $t = \left(\frac{5.64}{(I_2/I_{2p})^2-1}+0.02434\right)\cdot D\ [s]$

Figure 4-9 Dropout time and trip time characteristics of the inverse time unbalanced load stage, acc. to ANSI

# 4.10 Motor Starting Protection 48

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Startup current of the motor $I_{STARTUP}$ | for $I_{Nom}$ = 1 A | 0.50 A to 16.00 A | Increment 0.01 A |
| | for $I_{Nom}$ = 5 A | 2.50 A to 80.00 A | |
| Pickup threshold $I_{MOTOR\ START}$ | for $I_{Nom}$ = 1 A | 0.40 A to 10.0 A | Increment 0.01 A |
| | for $I_{Nom}$ = 5 A | 2.00 A to 50.00 A | |
| Permissible startup time $T_{Max.STARTUP}$ | | 1.0 s to 180.0 s | Increments 0.1 s |
| Permissible locked rotor time $T_{LOCKED\ ROTOR}$ | | 0.5 s to 180.0 s or ∞ (disabled) | Increments 0.1 s |
| Maximum startup time with warm motor $T_{Max.STARTUP\ W}$ | | 0.5 s to 180.0 s or ∞ (disabled) | Increments 0.1 s |
| Maximum startup time with cold motor | | 0 % to 80 % or ∞ (disabled) | Increments 1 % |

### Trip Curve

Trip time characteristics for $I > I_{MOTOR\ START}$

$$t_{TRIP} = \left(\frac{I_{STARTUP}}{I_{rms}}\right)^2 \cdot T_{Max.STARTUP}$$

Where:

| | |
|---|---|
| $I_{STARTUP.}$ | Motor starting current setting. |
| $I$ | Actual current flowing. |
| $I_{MOTOR\ START}$ | Pickup threshold setting, used to detect motor startup. |
| $t_{TRIP}$ | Trip time in seconds. |
| $T_{Max.STARTUP}$ | Tripping time for nominal startup current |

### Dropout Ratio

| | |
|---|---|
| Dropout ratio | Approx. 0.95 |

### Tolerances

| | |
|---|---|
| Pickup threshold | 3 % of setting value or 15 mA for $I_N$ = 1 A, or 75 mA for $I_N$ = 5 A |
| Time delay | 5 % or 30 ms |

### Influencing variables

| | |
|---|---|
| Power supply direct voltage in range $0.8 \le V_{PS}/V_{PSNom} \le 1.15$ | 1 % |
| Temperature in range $-5\ °C \le \Theta_{amb} \le 55\ °C$ | 0.5 %/10 K |
| Frequency in range of $0.95 \le f/f_{Nom} \le 1.05$ | 1 % |
| Frequency outside range of $0.95 \le f/f_{Nom} \le 1.05$ | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |

# 4.11 Motor Restart Inhibit 66

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Motor starting current relative to nominal motor current $I_{Start}/I_{Motor\ Nom.}$ | | 1.1 to 10.0 | Increment 0.1 |
| Nominal motor current $I_{Motor\ Nom.}$ | for $I_{Nom}$ = 1 A | 0.20 A to 1.20 A | Increment 0.01 A |
| | for $I_{Nom}$ = 5 A | 1.00 A to 6.00 A | |
| Max. permissible starting time $T_{START\ max.}$ | | 1 s to 320 s | Increments 1 s |
| Equilibrium time $T_{Equal}$ | | 0.0 min to 320.0 min | Increments 0.1 min |
| Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$ | | 0.2 min to 120.0 min | Increments 0.1 min |
| Maximum permissible number of warm startups $n_{WARM}$ | | 1 to 4 | Increment 1 |
| Difference between cold and warm startups $n_{COLD}$ - $n_{WARM}$ | | 1 to 2 | Increment 1 |
| Extension of Time Constant at stop $k_{\tau\ at\ STOP}$ | | 0.2 to 100.0 | Increment 0.1 |
| Extension of Time constant at running $k_{\tau\ at\ RUNNING}$ | | 0.2 to 100.0 | Increment 0.1 |

### Restart Threshold

$$\Theta_{Restart} = \left(\frac{I_{STARTUP}}{I_{MOTNom} \cdot k_R}\right)^2 \cdot \left(1 - e^{-\frac{(n_{cold} - 1) \cdot T_{start\ max}}{\tau_R}}\right)$$

| | |
|---|---|
| Where: | $\Theta_{RESTART}$ = Temperature limit below which restarting is possible<br>$k_R$ = k-factor for the rotor<br>$I_{STARTUP}$ = Startup current<br>$I_{MotNom}$ = Motor nominal current<br>$T_{start\ max}$ = Max. startup time<br>$\tau_R$ = Thermal rotor time constant<br>$n_{cold}$ = Max. number of cold starts |

### Tolerances

| | |
|---|---|
| Restart inhibit time | 5 % or 2 s |
| Trip on rotor overload | 5 % or 2 s |

### Influencing variables

| | |
|---|---|
| Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$ | 1 % |
| Temperature in range $-5\ °C \leq \Theta_{amb} \leq 55\ °C$ | 0.5 %/10 K |
| Frequency in range of $0.95 \leq f/f_{Nom} \leq 1.05$ | 1 % |
| Frequency outside range of $0.95 \leq f/f_{Nom} \leq 1.05$ | Increased tolerances |

# 4.12 Load Jam Protection

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Tripping threshold | for $I_{Nom}$ = 1 A | 0.50 A to 12.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 2.50 A to 60.00 A | |
| Alarm threshold | for $I_{Nom}$ = 1 A | 0.50 A to 12.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 2.50 A to 60.00 A | |
| Trip delay | | 0.00 s to 600.00 s | Increments 0.01 s |
| Message delay | | 0.00 s to 600.00 s | Increments 0.01 s |
| Blocking duration after motor start | | 0.00 s to 600.00 s | Increments 0.01 s |

### Timers

| | |
|---|---|
| Pickup time | approx. 55 ms |
| Dropout time | approx. 30 ms |

### Dropout ratio

| | |
|---|---|
| Dropout ratio tripping stage | approx. 0.95 |
| Dropout ratio warning stage | approx. 0.95 |

### Tolerances

| | | |
|---|---|---|
| Pickup threshold | for $I_{Nom}$ = 1 A | 3 % of setting value or 15 mA |
| | for $I_{Nom}$ = 5 A | 3 % of setting value or 75 mA |
| Time delay | | 1 % or 10 ms |

### Influencing variables

| | |
|---|---|
| Power supply direct voltage in range $0.8 \le V_{PS}/V_{PSNom} \le 1.15$ | 1 % |
| Temperature in range $-5\ °C \le \Theta_{amb} \le 55\ °C$ | 0.5 %/10 K |
| Frequency in range of $0.95 \le f/f_{Nom} \le 1.05$ | 1 % |
| Frequency outside range of $0.95 \le f/f_{Nom} \le 1.05$ | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |

# 4.13 Frequency Protection 81 O/U

### Setting ranges / increments

| | | |
|---|---|---|
| Number of frequency elements | 4; each can be set to f> or f< | |
| Pickup values f> or f< for $f_{Nom}$ = 50 Hz | 40.00 Hz to 60.00 Hz | Increments 0.01 Hz |
| Pickup values f> or f< for $f_{Nom}$ = 60 Hz | 50.00 Hz to 70.00 Hz | Increments 0.01 Hz |
| Dropout threshold = \|pickup threshold - dropout threshold\| | 0.02 Hz to 1.00 Hz | Increments 0.01 Hz |
| Delay times T | 0.00 s to 100.00 s or ∞ (disabled) | Increments 0.01 s |
| Undervoltage blocking | 10 V to 150 V | Increments 1 V |

### Times

| | |
|---|---|
| Pickup times f>, f< | approx. 100 ms at $f_{Nom}$ = 50 Hz<br>approx. 80 ms at $f_{Nom}$ = 60 Hz |
| Dropout times f>, f< | approx. 100 ms at $f_{Nom}$ = 50 Hz<br>approx. 80 ms at $f_{Nom}$ = 60 Hz |

### Dropout Difference

| | |
|---|---|
| Δf = I pickup value - dropout value I | 0.02 Hz to 1 Hz |

### Dropout Ratio

| | |
|---|---|
| Dropout Ratio for Undervoltage Blocking | approx. 1.05 |

### Tolerances

| | |
|---|---|
| Pickup frequencies 81/O or 81U<br>Undervoltage blocking<br>Time delays 81/O or 81/U | 15 mHz (with $V = V_{nom}$, $f = f_{Nom} \pm 5$ Hz)<br>3 % of setting value or 1 V<br>1 % of setting value or 10 ms |

### Influencing Variables

| | |
|---|---|
| Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$ | 1 % |
| Temperature in range 23.00 °F (-5 °C) ≤ $\Theta_{amb}$ ≤ 131.00 °F (55 °C) | 0.5 %/10 K |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |

## 4.14 Thermal Overload Protection 49

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| K-Factor per IEC 60255-8 | | 0.10 to 4.00 | Increments 0.01 |
| Time Constant $\tau_{th}$ | | 1.0 min to 999.9 min | Increments 0.1 min |
| Thermal Alarm $\Theta_{Alarm}/\Theta_{Trip}$ | | 50% to 100% of the trip excessive temperature | Increments 1 % |
| Current Overload $I_{Alarm}$ | for $I_{Nom}$ = 1 A | 0.10 A to 4.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.50 A to 20.00 A | |
| Extension kτ Factor when Machine Stopped | | 1.0 to 10.0 relative to the time constant for the machine running | Increments 0.1 |
| Emergency Time $T_{Emergency}$ | | 10 s to 15000 s | Increments 1 s |
| Nominal Overtemperature (for $I_{Nom}$) | | 40 °C to 200 °C = –13 °F to +185 °F | Increments 1 °C |

### Trip Characteristic

Trip Characteristic Curve for $(I/k \cdot I_{Nom}) \leq 8$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{Nom}}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_{Nom}}\right)^2}{\left(\frac{I}{k \cdot I_{Nom}}\right)^2 - 1}$$

Where:

| | |
|---|---|
| $t$ | Trip Time in minutes |
| $\tau_{th}$ | Heating-up Time Constant |
| $I$ | Actual Load Current |
| $I_{pre}$ | Preload Current |
| $k$ | Setting Factor per IEC 60255-8 |
| $I_{Nom}$ | Nominal Current of the Protected Object |

### Dropout Ratios

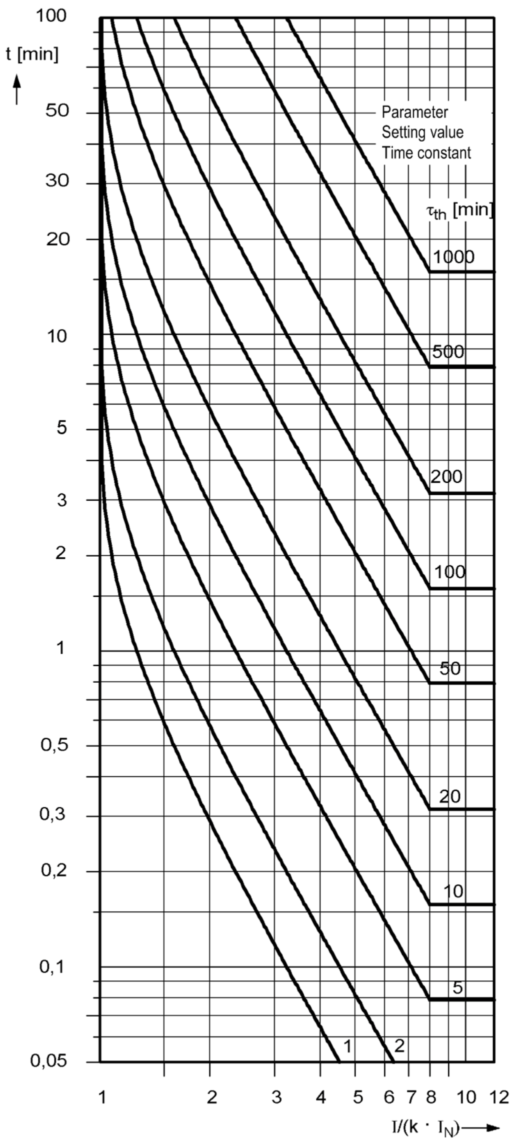
| | |
|---|---|
| $\Theta/\Theta_{Trip}$ | Drops out with $\Theta_{Alarm}$ |
| $\Theta/\Theta_{Alarm}$ | Approx. 0.99 |
| $I/I_{Alarm}$ | Approx. 0.97 |

### Tolerances

| | |
|---|---|
| Referring to $k \cdot I_{Nom}$ | 3 % or 15 mA for $I_{Nom}$ = 1 A, or 75 mA for $I_{Nom}$ = 5 A, 2 % class according to IEC 60255-8 |
| Referring to trip time | 3 % or 1 s for $I/(k \cdot I_{Nom}) > 1.25$; 3 % class according to IEC 60255-8 |

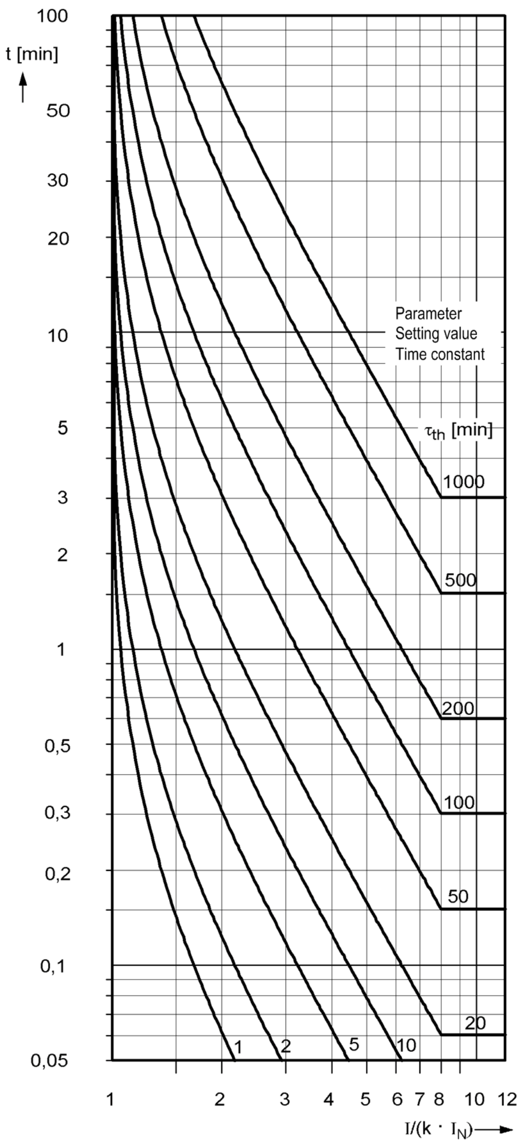
### Influencing Variables Referring to $k \cdot I_{Nom}$

| | |
|---|---|
| Auxiliary DC voltage in range 0,8 ≤ $V_{Aux}/V_{AuxNom}$ ≤ 1.15 | 1 % |
| Temperature in range –5 °C (41 °F) ≤ $\Theta_{amb}$ ≤ 55 °C (131 °F) | 0.5 %/10 K |
| Frequency in range of 50 Hz to 70 Hz | |
| Frequency in range 0.95 ≤ $f/f_{Nom}$ ≤ 1.05 | 1 % |
| Frequency outside range 0.95 ≤ $f/f_{Nom}$ ≤ 1.05 | Increased tolerances |




**without pre-load:**

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




**with 90 % pre-load:**

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

Figure 4-10 Trip time curves for the thermal overload protection (49)

# 4.15 Ground Fault Protection 64, 67N(s), 50N(s), 51N(s)

### Displacement Voltage Element For all Types of Ground Faults

| | | |
|---|---|---|
| Displacement voltage, measured | V0 > 1.8 V to 200.0 V | Increments 0.1 V |
| Displacement voltage, calculated | $3V_0$ > 10.0 V to 225.0 V | Increments 0.1 V |
| Pickup delay T-DELAY Pickup | 0.04 s to 320.00 s or ∞ | Increments 0.01 s |
| Additional tripping delay 64-1 DELAY | 0.10 s to 40000.00 s or ∞ (disabled) | Increments 0.01 s |
| Operating time | approx. 50 ms | |
| Dropout value | 0.95 or (pickup value – 0.6 V) | |
| Measurement tolerance<br>V0 > (measured)<br>3V0 > (calculated) | <br>3 % of setting value or 0.3 V<br>3 % of setting value or 3 V | |
| Operating time tolerances | 1 % of setting value or 10 ms | |

### Phase Detection for Ground Faults on an Ungrounded System

| | | |
|---|---|---|
| Measuring Principle | Voltage measurement (phase-Ground) | |
| $V_{PHASE\ MIN}$ (Ground Fault Phase) | 10 V to 100 V | Increments 1V |
| $V_{PHASE\ MAX}$ (Healthy Phase) | 10 V to 100 V | Increments 1V |
| Measurement Tolerance acc. to VDE 0435, Part 303 | 3 % of setting value or 1 V | |

### Ground Fault Pickup for All Types of Ground Faults (Definite Time Characteristic)

| | | |
|---|---|---|
| Pickup current 50Ns-2 PICKUP, 50Ns-1 PICKUP<br>for sensitive 1 A transformer<br>for sensitive 5 A transformer<br>for normal 1 A transformer<br>for normal 5 A transformer | <br>0.001 A to 1.600 A<br>0.005 A to 8.000 A<br>0.05 A to 35.00 A<br>0.25 A to 175.00 A | <br>Increments 0.001 A<br>Increments 0.005 A<br>Increments 0.01 A<br>Increments 0.05 A |
| Time delay 50Ns-2 DELAY, 50Ns-1 DELAY | 0.00 s to 320.00 s or ∞ (disabled) | Increments 0.01 s |
| Dropout time delay 50Ns T DROP-OUT | 0.00 s to 60.00 s | Increments 0.01 s |
| Operating time | ≤ 50 ms (non-directional)<br>≤ 50 ms (directional) | |
| Dropout ratio | approx. 0.95 for 50Ns > 50 mA | |
| Measurement tolerance<br>sensitive<br><br><br>non-sensitive | <br>3 % of setting value or 1 mA for $I_{Nom}$ = 1 A, or 5 mA for $I_{Nom}$ = 5 A<br>for setting values < 10 mA approx. 20 %<br>3 % of setting value or 15 mA for $I_{Nom}$ = 1 A, or 75 mA for $I_{Nom}$ = 5 A | |
| Operating time tolerance | 1 % of setting value or 10 ms | |

### Ground Fault Pickup for All Types of Ground Faults (Inverse Time Characteristic)

| | | |
|---|---|---|
| User-defined characteristic (defined by a maximum of 20 value pairs of current and time delay in direction measurement method "cos phi and sin phi") | | |
| Pickup current 51Ns<br>for sensitive 1 A transformer<br>for sensitive 5 A transformer<br>for normal 1 A transformer<br>for normal 5-A transformer | <br>0.001 A to 1.400 A<br>0.005 A to 7.000 A<br>0.05 A to 4.00 A<br>0.25 A to 20.00 A | <br>Increments 0.001 A<br>Increments 0.005 A<br>Increments 0.01 A<br>Increments 0.05 A |
| Time multiplier $T_{51Ns}$ | 0.10 s to 4.00 s or ∞ (disabled) | Increments 0.01 s |
| Pickup threshold | Approx. 1.10 · $I_{51Ns}$ | |
| Dropout ratio | Approx. 1.05 · $I_{51Ns}$ for $I_{51Ns}$ > 50 mA | |
| Measurement tolerance<br>sensitive<br><br><br>non-sensitive | <br>3 % of setting value or 1 mA for $I_{Nom}$ = 1 A, or 5 mA for $I_{Nom}$ = 5 A<br>for setting values < 10 mA approx. 20 %<br>3 % of setting value or 15 mA for $I_{Nom}$ = 1 A, or 75 mA for $I_{Nom}$ = 5 A | |
| Operating time tolerance in linear range | 7 % of reference (calculated) value for 2 ≤ $I/I_{51Ns}$ ≤ 20 + 2 % current tolerance, or 70 ms | |

### Influencing Variables

| | |
|---|---|
| Auxiliary DC voltage in range<br>0,8 ≤ $V_{Aux}/V_{AuxNom}$ ≤ 1.15 | 1 % |
| Temperature in range<br>–5 °C (41 °F) ≤ $\Theta_{amb}$ ≤ 55 °C (131 °F) | 0.5 %/10 K |
| Frequency in range 0.95 ≤ $f/f_{Nom}$ ≤ 1.05 | 1 % |
| Frequency outside range 0.95 ≤ $f/f_{Nom}$ ≤ 1.05 | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |
| Note: When using the sensitive transformer, the linear range of the measuring input for sensitive ground fault detection is from 0.001 A to 1.6 A or 0.005 A to 8.0 A, depending on parameter 205 CT SECONDARY. The function is however still preserved for larger currents. | |

### Direction Determination for all Types of Ground Fault with cos φ / sin φ Measurement

| | | |
|---|---|---|
| Direction measurement | - $I_N$ and $V_N$ measured<br>- $3I_0$ and $3V_0$ calculated | |
| Measuring principle | Active/reactive power measurement | |
| Measuring release RELEASE DIRECT.<br>(current component perpendicular (90º) to directional limit line)<br>for sensitive 1 A transformer<br>for sensitive 5 A transformer<br>for normal 1 A transformer<br>for normal 5-A transformer | 0.001 A to 1.600 A<br>0.005 A to 8.000 A<br>0.05 A to 35.00 A<br>0.25 A to 175.00 A | Increments 0.001 A<br>Increments 0.005 A<br>Increments 0.01 A<br>Increments 0.05 A |
| Dropout ratio | Approx. 0.80 | |
| Measurement method | cos φ and sin φ | |
| Directional limit line PHI CORRECTION | -45.0° to +45.0° | Increments 0.1° |
| Dropout delay RESET DELAY | 1 s to 60 s | Increments 1 s |

### Direction Determination for all Types of Ground Fault with V0 φ / I0 φ Measurement

| | | |
|---|---|---|
| Direction measurement | - $I_N$ and $V_N$ measured<br>- $3I_0$ and $3V_0$ calculated | |
| Measuring principle | U0 / I0 phase angle measurement | |
| 50Ns-1 element | | |
| Minimum voltage 50Ns-1 Vmin<br>V0 measured<br>3V0 calculated | <br>0.4 V to 50 V<br>10 V to 90 V | <br>Increments 0.1 V<br>Increments 1 V |
| Phase angle 50Ns-1 Phi | - 180° to 180° | Increments 1° |
| Delta phase angle 50Ns-1 DeltaPhi | 0° to 180° | Increments 1° |
| 50Ns-2 element | | |
| Minimum voltage 50Ns-2 Vmin<br>V0 measured<br>3V0 calculated | <br>0.4 V to 50 V<br>10 V to 90 V | <br>Increments 0.1 V<br>Increments 1 V |
| Phase angle 50Ns-2 Phi | - 180° to 180° | Increments 1° |
| Delta phase angle 50Ns-2 DeltaPhi | 0° to 180° | Increments 1° |

### Angle Correction

| | | |
|---|---|---|
| Angle correction for cable converter in two operating points F1/I1 and F2/I2: | | |
| Angle correction F1, F2<br>(for resonant-grounded system) | 0.0° to 5.0° | Increments 0.1° |
| Current values I1, I2 for angle correction<br>for sensitive 1 A transformer<br>for sensitive 5 A transformer<br>for normal 1 A transformer<br>for normal 5 A transformer | <br>0.001 A to 1.600 A<br>0.005 A to 8.000 A<br>0.05 A to 35.00 A<br>0.25 A to 175.00 A | <br>Increments 0.001 A<br>Increments 0.005 A<br>Increments 0.01 A<br>Increments 0.05 A |
| Measurement tolerance<br>sensitive<br><br><br>non-sensitive | <br>3 % of setting value or 1 mA for $I_{Nom}$ = 1 A, or 5 mA for $I_{Nom}$ = 5 A<br>for setting values < 10 mA approx. 20 %<br>3 % of setting value or 15 mA for $I_{Nom}$ = 1 A, or 75 mA for $I_{Nom}$ = 5 A | |
| Angle tolerance | 3° | |
| Note: Due to the high sensitivity, the linear range of the measuring input $I_{Nom}$ with integrated sensitive input transformer is from 0.001 · $I_{Nom}$ to 1.6 · $I_{Nom}$. For currents greater than 1.6 · $I_{Nom}$, correct direction determination can no longer be guaranteed. | | |

# 4.16 Breaker Failure Protection 50BF

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Pickup threshold 50-1 BF | for $I_{Nom}$ = 1 A | 0.05 A to 20.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.25 A to 100.00 A | |
| Pickup threshold 50N-1 BF | for $I_{Nom}$ = 1 A | 0.05 A to 20.00 A | Increments 0.01 A |
| | for $I_{Nom}$ = 5 A | 0.25 A to 100.00 A | |
| Time delay 50 BF trip timer | | 0.06 s to 60.00 s or ∞ | Increments 0.01 s |

### Times

| | |
|---|---|
| Pickup times<br>- for internal start<br>- for external start<br><br>Dropout time<br>Dropout ratio 50-1, 50N-1 | <br>Included in time delay<br>Included in time delay<br><br>approx. 25 ms [1)]<br>= 0.95 (minimum hysteresis between Pickup and dropout ≥ 32.5 mA) |

### Tolerances

| | |
|---|---|
| Pickup threshold 50-1 BF, 50N-1 BF | 3 % of setting value,<br>or 15 mA for $I_{Nom}$ = 1 A<br>or 75 mA for $I_{Nom}$ = 5 A |
| Time delay 50 BF trip timer | 1 % or 20 ms |

### Influencing Variables for Pickup Values

| | |
|---|---|
| Auxiliary DC voltage in range $0.8 \leq V_{Aux}/V_{AuxNom} \leq 1.15$ | 1 % |
| Temperature in range –5 °C (41 °F) ≤ $\Theta_{amb}$ ≤ 55 °C (131 °F) | 0.5 %/10 K |
| Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$ | 1 % |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |

[1)] A further delay for the current may be caused by compensation in the secondary CT circuit.

# 4.17 Flexible Protection Functions

### Measured Values / Modes of Operation

| | |
|---|---|
| Three-phase | I, $3I_0$, I1, I2, I2/I1, V, $3V_0$, V1, V2, P forward, P reverse, Q forward, Q reverse, cosφ |
| Single-phase | I, $I_N$, $I_{Ns}$,$I_{N2}$, V, $V_N$,$V_x$, P forward, P reverse, Q forward, Q reverse, cosφ |
| Without fixed phase reference | f, df/dt, binary input |
| Measurement method for I, V | Fundamental,<br>r.m.s. value (true RMS),<br>positive sequence system,<br>negative sequence system,<br>zero sequence system |
| Pickup on | exceeding threshold value or<br>falling below threshold value |

### Setting Ranges / Increments

| | | | |
|---|---|---|---|
| Pickup thresholds: | | | |
| Current I, $I_1$, $I_2$, $3I_0$, $I_N$ | for $I_N$ = 1 A | 0.05 A to 40.00 A | Increments 0.01 A |
| | for $I_N$ = 5 A | 0.25 A to 200.00 A | |
| Relationship $I_2/I_1$ | | 15 % to 100 % | Increments 1% |
| Sensitive ground current $I_{Ns}$ | | 0.001 A to 1.500 A | Increments 0.001 A |
| Voltage V, $V_1$, $V_2$, $3V_0$ | | 2.0 V to 260.0 V | Increments 0.1 V |
| Displacement voltage $V_N$ | | 2.0 V to 200.0 V | Increments 0.1 V |
| Power P, Q | for $I_N$ = 1 A | 2.0 W to 10000 W | Increment 0.1 W |
| | for $I_N$ = 5 A | 10 W to 50000 W | |
| Power factor cosφ | | -0.99 to +0.99 | Increments 0.01 |
| Frequency | for $f_{Nom}$ = 50 Hz<br>for $f_{Nom}$ = 60 Hz | 40.0 Hz to 60.0 Hz<br>50.0 Hz to 70.0 Hz | Increments 0.01 Hz<br>Increments 0.01 Hz |
| Frequency change df/dt | | 0.10 Hz/s to 20.00 Hz/s | Increments 0.01 Hz/s |
| Dropout ratio > element | | 1.01 to 3.00 | Increments 0.01 |
| Dropout ratio < element | | 0.70 to 0.99 | Increments 0.01 |
| Dropout difference f | | 0.02 Hz to 1.00 Hz | Increments 0.01 Hz |
| Pickup delay (standard) | | 0.00 s to 60.00 s | Increments 0.01 s |
| Pickup delay for $I_2/I_1$ | | 0.00 s to 28800.00 s | Increments 0.01 s |
| Command delay time | | 0.00 s to 3600.00 s | Increments 0.01 s |
| Dropout delay | | 0.00 s to 60.00 s | Increments 0.01 s |

### Function Limits

| | | |
|---|---|---|
| Power measurement three-phase | for $I_{Nom}$ = 1 A | Positive sequence system current > 0.03 A |
| | for $I_{Nom}$ = 5 A | Positive sequence system current > 0.15 A |
| Power measurement single-phase | for $I_{Nom}$ = 1 A | Phase current > 0.03 A |
| | for $I_{Nom}$ = 5 A | Phase current > 0.15 A |
| Relationship $I_2/I_1$ measurement | for $I_{Nom}$ = 1 A | Positive or negative sequence system current > 0.1 A |
| | for $I_{Nom}$ = 5 A | Positive or negative sequence system current > 0.5 A |

**Times**

| | |
|---|---|
| Pickup times: | |
| Current, voltage (phase quantities)<br>for 2 times the setting value<br>for 10 times the setting value | <br>approx. 30 ms<br>approx. 20 ms |
| Current, voltage (symmetrical components)<br>for 2 times the setting value<br>for 10 times the setting value | <br>approx. 40 ms<br>approx. 30 ms |
| Power<br>typical<br>maximum (small signals and threshold values) | <br>approx. 120 ms<br>approx. 350 ms |
| Power factor | 300 to 600 ms |
| Frequency | approx. 100 ms |
| Frequency change for 1.25 times the setting value | approx. 220 ms |
| Binary input | approx. 20 ms |
| | |
| Dropout times: | |
| Current, voltage (phase quantities) | < 20 ms |
| Current, voltage (symmetrical components) | < 30 ms |
| Power<br>typical<br>maximum | <br>< 50 ms<br>< 350 ms |
| Power factor | < 300 ms |
| Frequency | < 100 ms |
| Frequency change | < 200 ms |
| Binary input | < 10 ms |

**Tolerances**

| | | |
|---|---|---|
| Pickup thresholds: | | |
| Current | for $I_{Nom}$ = 1 A | 3% of setting value or 15 mA |
| | for $I_{Nom}$ = 5 A | 3% of setting value or 75 mA |
| Current (symmetrical components) | for $I_{Nom}$ = 1 A | 4% of setting value or 20 mA |
| | for $I_{Nom}$ = 5 A | 4% of setting value or 100 mA |
| Current ($I_2/I_1$) | | 4% of setting value |
| Voltage | | 3% of setting value or 0.2 V |
| Voltage (symmetrical components) | | 4% of setting value or 0.2 V |
| Power | for $I_{Nom}$ = 1 A | 3% of setting value or 0.5 W<br>(for nominal values) |
| | for $I_{Nom}$ = 5 A | 3% of setting value or 2.5 W<br>(for nominal values) |
| Power factor | | 3° |
| Frequency | | 15 mHz |
| Frequency change | | 5% of setting value or 0.05 Hz/s |
| Times | | 1% of setting value or 10 ms |

### Influencing Variables for Pickup Values

| | |
|---|---|
| Auxiliary DC voltage in range 0.8 ≤ $V_{Aux}/V_{AuxNom}$ ≤ 1.15 | 1 % |
| Temperature in range –5 °C (41 °F) ≤ $\Theta_{amb}$ ≤ 55 °C (131 °F) | 0.5 %/10 K |
| Frequency in range 0.95 ≤ $f/f_{Nom}$ ≤ 1.05 | 1 % |
| Frequency outside range 0.95 ≤ $f/f_{Nom}$ ≤ 1.05 | Increased tolerances |
| Harmonics<br>- up to 10 % 3rd harmonic<br>- up to 10 % 5th harmonic | <br>1 %<br>1 % |

# 4.18 Temperature Detection

### Temperature Detectors

| | |
|---|---|
| Connectable RTD-boxes | 1 or 2 |
| Number of temperature detectors per RTD-box | Max. 6 |
| Measuring method | Pt 100 Ω or Ni 100 Ω or Ni 120 Ω<br>selectable 2 or 3 phase connection |
| Mounting identification | „Oil“ or „Ambient“ or „Stator“ or „Bearing“ or „Other“ |

### Temperature Detectors with Direct Connection (only 7SK805/7SK806)

| | |
|---|---|
| Number of temperature detectors at the<br>I/O 2 extension module | max. 5 |
| Measurement method | Pt 100 Ω or Ni 100 Ω or Ni 120 Ω<br>3-wire connection, shielded cable |
| Installation identification | „Oil“ or „Ambient“ or „Stator“ or „Bearing“ or „Other“ |

### Operational Measured Values via External Temperature Detection

| | | |
|---|---|---|
| Number of measuring points | | Maximal of 12 temperature measuring points |
| | Temperature Unit | °C or °F, adjustable |
| | Measuring Range<br>– for Pt 100<br>– for Ni 100<br>– for Ni 120 | <br>–199 °C to 800 °C (–326 °F to 1472 °F)<br>–54 °C to 278 °C (–65 °F to 532 °F)<br>–52 °C to 263 °C (–62 °F to 505 °F) |
| | Resolution | 1 °C or 1 °F |
| | Tolerance | ± 0.5 % of measured value ± 1 digit |

### Operational Measured Values via the I/O 2 Extension Module

| | | |
|---|---|---|
| Number of Measuring Points | | Max. 5 temperature measuring points |
| | Temperature Unit | °C or °F, adjustable |
| | Measuring Range<br>- for Pt 100<br>- for Ni 100 or Ni 120 | <br>–65 °C to 710 °C (–85 °F to 1310 °F)<br>–50 °C to 250 °C (–58 °F to 482 °F) |
| | Resolution<br>at temperatures ≥ 100 °C<br>at temperatures < 100 °C | <br>± 0.5 % of measured value ± 1 °C or 1 °F<br>±1.5 °C |
| | Tolerance | ± 0.5 % of measured value ± 1 digit |
| | Current sensor | 3.58 mA |
| | Line resistance | 14 Ω |

### Thresholds for Indications

| | | |
|---|---|---|
| for each measuring point | | |
| Stage 1 | –50 °C to 250 °C<br>–58 °F to 482 °F<br>or ∞ (no message) | (increment 1 °C)<br>(increment 1 °F) |
| Stage 2 | –50 °C to 250 °C<br>–58 °F to 482 °F<br>or ∞ (no message) | (increment 1 °C)<br>(increment 1 °F) |

# 4.19 User-defined Functions (CFC)

### Function Modules and Possible Assignments to Task Levels

| Function Module | Explanation | Task Level | | | |
|---|---|---|---|---|---|
| | | MW_ BEARB | PLC1_ BEARB | PLC_ BEARB | SFS_ BEARB |
| ABSVALUE | Magnitude Calculation | X | — | — | — |
| ADD | Addition | X | X | X | X |
| ALARM | Alarm clock | X | X | X | X |
| AND | AND - Gate | X | X | X | X |
| FLASH | Blink block | X | X | X | X |
| BOOL_TO_CO | Boolean to Control (conversion) | — | X | X | — |
| BOOL_TO_DI | Boolean to Double Point (conversion) | — | X | X | X |
| BOOL_TO_IC | Bool to Internal SI, Conversion | — | X | X | X |
| BUILD_DI | Create Double Point Annunciation | — | X | X | X |
| CMD_CANCEL | Command cancelled | X | X | X | X |
| CMD_CHAIN | Switching Sequence | — | X | X | — |
| CMD_INF | Command Information | — | — | — | X |
| COMPARE | Metered value comparison | X | X | X | X |
| CONNECT | Connection | — | X | X | X |
| COUNTER | Counter | X | X | X | X |
| DI_GET_STATUS | Decode double point indication | X | X | X | X |
| DI_SET_STATUS | Generate double point indication with status | X | X | X | X |
| D_FF | D- Flipflop | — | X | X | X |
| D_FF_MEMO | Status Memory for Restart | X | X | X | X |
| DI_TO_BOOL | Double Point to Boolean (conversion) | — | X | X | X |
| DINT_TO_REAL | Adaptor | X | X | X | X |
| DIST_DECODE | Conversion double point indication with status to four single indications with status | X | X | X | X |
| DIV | Division | X | X | X | X |
| DM_DECODE | Decode Double Point | X | X | X | X |
| DYN_OR | Dynamic OR | X | X | X | X |
| INT_TO_REAL | Conversion | X | X | X | X |
| LIVE_ZERO | Live-zero, non-linear Curve | X | — | — | — |
| LONG_TIMER | Timer (max.1193h) | X | X | X | X |
| LOOP | Feedback Loop | X | X | — | X |
| LOWER_SETPOINT | Lower Limit | X | — | — | — |

| Function Module | Explanation | Task Level | | | |
|---|---|---|---|---|---|
| | | MW_ BEARB | PLC1_ BEARB | PLC_ BEARB | SFS_ BEARB |
| MUL | Multiplication | X | X | X | X |
| MV_GET_STATUS | Decode status of a value | X | X | X | X |
| MV_SET_STATUS | Set status of a value | X | X | X | X |
| NAND | NAND - Gate | X | X | X | X |
| NEG | Negator | X | X | X | X |
| NOR | NOR - Gate | X | X | X | X |
| OR | OR - Gate | X | X | X | X |
| REAL_TO_DINT | Adaptor | X | X | X | X |
| REAL_TO_INT | Conversion | X | X | X | X |
| REAL_TO_UINT | Conversion | X | X | X | X |
| RISE_DETECT | Rise detector | X | X | X | X |
| RS_FF | RS- Flipflop | — | X | X | X |
| RS_FF_MEMO | RS- Flipflop with state memory | — | X | X | X |
| SQUARE_ROOT | Root Extractor | X | X | X | X |
| SR_FF | SR- Flipflop | — | X | X | X |
| SR_FF_MEMO | SR- Flipflop with state memory | — | X | X | X |
| ST_AND | AND gate with status | X | X | X | X |
| ST_NOT | Inverter with status | X | X | X | X |
| ST_OR | OR gate with status | X | X | X | X |
| SUB | Substraction | X | X | X | X |
| TIMER | Timer | — | X | X | — |
| TIMER_SHORT | Simple timer | — | X | X | — |
| UINT_TO_REAL | Conversion | X | X | X | X |
| UPPER_SETPOINT | Upper Limit | X | — | — | — |
| X_OR | XOR - Gate | X | X | X | X |
| ZERO_POINT | Zero Supression | X | — | — | — |

### General Limits

| Description | Limit | Comment |
|---|---|---|
| Maximum number of all CFC charts considering all task levels | 32 | If the limit is exceeded, the device rejects the parameter set with an error message, restores the last valid parameter set and restarts using that parameter set. |
| Maximum number of all CFC charts considering one task level | 16 | When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up. |
| Maximum number of all CFC inputs considering all charts | 400 | When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up. |
| Maximum number of reset-resistant flipflops D_FF_MEMO | 350 | When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up. |

### Device-specific Limits

| Description | Limit | Comment |
|---|---|---|
| Maximum number of synchronous changes of chart inputs per task level | 165 | When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up. |
| Maximum number of chart outputs per task level | 150 | |

### Additional Limits

| Additional limits [1] for the following CFC blocks: | | |
|---|---|---|
| Task Level | Maximum Number of Modules in the Task Levels | |
| | TIMER[2) 3)] | TIMER_SHORT[2) 3)] |
| MW_BEARB | — | — |
| PLC1_BEARB | 15 | 30 |
| PLC_BEARB | | |
| SFS_BEARB | — | — |

1) When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

2) The following condition applies for the maximum number of timers: (2 · number of TIMER + number of TIMER_SHORT) < 30. TIMER and TIMER_SHORT hence share the available timer resources within the frame of this inequation. The limit does not apply to the LONG_TIMER.

3) The time values for the blocks TIMER and TIMER_SHORT must not be selected shorter than the time resolution of the device of 10 ms, as the blocks will not then start with the starting pulse.

### Maximum Number of TICKS in the Task Levels

| Task level | Limit in TICKS [1] |
|---|---|
| MW_BEARB (measured value processing) | 10000 |
| PLC1_BEARB (slow PLC processing) | 2000 |
| PLC_BEARB (fast PLC processing) | 400 |
| SFS_BEARB (interlocking) | 10000 |

1) When the sum of TICKS of all blocks exceeds the limits mentioned before, an error message is output in the CFC.

### Processing Times in TICKS Required by the Individual Elements

| Individual Element | | Number of TICKS |
|---|---|---|
| Block, basic requirement | | 5 |
| Each input more than 3 inputs for generic modules | | 1 |
| Connection to an input signal | | 6 |
| Connection to an output signal | | 7 |
| Additional for each chart | | 1 |
| Arithmetic | ABS_VALUE | 5 |
| | ADD | 26 |
| | SUB | 26 |
| | MUL | 26 |
| | DIV | 54 |
| | SQUARE_ROOT | 83 |
| Basic logic | AND | 5 |
| | CONNECT | 4 |
| | DYN_OR | 6 |
| | NAND | 5 |
| | NEG | 4 |
| | NOR | 5 |
| | OR | 5 |
| | RISE_DETECT | 4 |
| | X_OR | 5 |
| Information status | SI_GET_STATUS | 5 |
| | CV_GET_STATUS | 5 |
| | DI_GET_STATUS | 5 |
| | MV_GET_STATUS | 5 |
| | SI_SET_STATUS | 5 |
| | DI_SET_STATUS | 5 |
| | MV_SET_STATUS | 5 |
| | ST_AND | 5 |
| | ST_OR | 5 |
| | ST_NOT | 5 |
| Memory | D_FF | 5 |
| | D_FF_MEMO | 6 |
| | RS_FF | 4 |
| | RS_FF_MEMO | 4 |
| | SR_FF | 4 |
| | SR_FF_MEMO | 4 |
| Control commands | BOOL_TO_CO | 5 |
| | BOOL_TO_IC | 5 |
| | CMD_INF | 4 |
| | CMD_CHAIN | 34 |
| | CMD_CANCEL | 3 |
| | LOOP | 8 |

| Individual Element | | Number of TICKS |
|---|---|---|
| Type converter | BOOL_TO_DI | 5 |
| | BUILD_DI | 5 |
| | DI_TO_BOOL | 5 |
| | DM_DECODE | 8 |
| | DINT_TO_REAL | 5 |
| | DIST_DECODE | 8 |
| | UINT_TO_REAL | 5 |
| | REAL_TO_DINT | 10 |
| | REAL_TO_UINT | 10 |
| Comparison | COMPARE | 12 |
| | LOWER_SETPOINT | 5 |
| | UPPER_SETPOINT | 5 |
| | LIVE_ZERO | 5 |
| | ZERO_POINT | 5 |
| Metered value | COUNTER | 6 |
| Time and clock pulse | TIMER | 5 |
| | TIMER_LONG | 5 |
| | TIMER_SHORT | 8 |
| | ALARM | 21 |
| | FLASH | 11 |

### Configurable in Matrix

| |
|---|
| In addition to the defined preassignments, indications and measured values can be freely configured to buffers, preconfigurations can be removed. |

# 4.20 Additional Functions

### Operational measured values

| | |
|---|---|
| Currents<br>$I_A$; $I_B$; $I_C$<br>Positive Sequence Component $I_1$<br>Negative Sequence Component $I_2$<br>$I_N$ or 3I0 | in A (kA) primary and in A secondary or in % of $I_{Nom}$ |
| Range<br>Tolerance [1)] | 10 % to 150 % $I_{Nom}$<br>1,5 % of measured value, or 1 % $I_{Nom}$<br>and 151 % to 200 % $I_{Nom}$ 3 % of measured value |
| Phase-to-ground voltages<br>$V_{A-N}$, $V_{B-N}$, $V_{C-N}$<br>Phase-to-phase voltages<br>$V_{A-B}$, $V_{B-C}$, $V_{C-A}$<br>$V_N$, $V_{ph-gnd}$, $V_x$ or $V_0$<br>Positive sequence component $V_1$<br>Negative sequence component $V_2$ | in kV primary, in V secondary or in % of $V_{Nom}$ |
| Range<br>Tolerance [1)] | 10 % to 120 % of $V_{Nom}$<br>1.5 % of measured value, or 0.5 % of $V_{Nom}$ |
| S, apparent power | in kVAr (MVAR or GVAR) primary and in % of $S_{Nom}$ |
| Range<br>Tolerance [1)] | 0 % to 120 % $S_{Nom}$<br>1 % of $S_{Nom}$<br>For $V/V_{Nom}$ and $I/I_{Nom}$ = 50 to 120% |
| P, active power | with sign, total and phase-segregated in kW (MW or GW) primary and in % $S_{Nom}$ |
| Range<br>Tolerance [1)] | 0 % to 120 % $S_{Nom}$<br>2 % of $S_{Nom}$<br>For $V/V_N$ and $I/I_{Nom}$ = 50 to 120% and \| cos φ \| = 0.707 to 1<br>With $S_{Nom} = \sqrt{3} \cdot V_{Nom} \cdot I_{Nom}$ |
| Q, reactive power | with sign, total and phase-segregated in kVAr (MVAr or GVAr) primary and in % $S_{Nom}$ |
| Range<br>Tolerance [1)] | 0 % to 120 % $S_{Nom}$<br>2 % of $S_{Nom}$<br>For $V/V_{Nom}$ and $I/I_{Nom}$ = 50 to 120% and \| sin φ \| = 0.707 to 1<br>With $S_{Nom} = \sqrt{3} \cdot V_{Nom} \cdot I_{Nom}$ |
| cos φ, power factor[2)] | total and phase-segregated |
| Range<br>Tolerance [1)] | –1 to +1<br>2 % for \| cos φ \| ≥ 0.707 |
| Angle $\varphi_A$; $\varphi_B$; $\varphi_C$, | in degrees ( ° ) |
| Range<br>Tolerance [1)] | 0 to 180°<br>0,5° |
| Frequency f | in Hz |
| Range<br>Tolerance [1)] | $f_{Nom}$ ± 5 Hz<br>20 mHz |
| Temperature overload protection<br>$\Theta / \Theta_{Trip}$ | in %. |
| Range<br>Tolerance [1)] | 0 % to 400 %<br>5% class accuracy per IEC 60255-8 |
| Currents of sensitive ground fault detection (total, active, and reactive current)<br>$I_{Ns}$, $I_{Ns\ real}$; $I_{Ns\ reactive}$ | in A (kA) primary and in mA secondary |

| | |
|---|---|
| Range<br><br>Tolerance [1] | 0 mA to 1600 mA<br>or 0 A to 8 A for $I_{Nom}$ = 5 A<br>3 % of measured value or 1 mA |
| Temperature<br>Restart inhibit<br>$\Theta_L / \Theta_{L\ Trip}$ | in %. |
| Range<br>Tolerance [1] | 0 % to 400 %<br>5% class accuracy per IEC 60255-8 |
| Restart threshold<br>$\Theta_{Restart} / \Theta_{L\ Trip}$ | in %. |
| Inhibit time $T_{Reclose}$ | in min |
| Phase angle between zero sequence voltage and sensitive ground current φ (3V0, INs) | in ° |
| Range<br>Tolerance [1] | - 180° to + 180°<br>± 1° |
| RTD box | See section (Temperature Detection via RTD Boxes) |

[1] at nominal frequency

[2] Display of cos φ above $I/I_{Nom}$ and $V/V_{Nom}$ greater than 10%

### Long-Term Averages

| | |
|---|---|
| Time Window | 5, 15, 30 or 60 minutes |
| Frequency of Updates | adjustable |
| Long-Term Averages | |
| of Currents<br>of Real Power<br>of Reactive Power<br>of Apparent Power | $I_{Admd}$; $I_{Bdmd}$; $I_{Cdmd}$; $I_{1dmd}$ in A (kA)<br>$P_{dmd}$ in W (kW, MW)<br>$Q_{dmd}$ in VAr (kVAr, MVAr)<br>$S_{dmd}$ in VAr (kVAr, MVAr) |

### Min / Max Report

| | |
|---|---|
| Storage of Measured Values | with date and time |
| Reset automatic | Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞) |
| Manual Reset | Using binary input<br>Using keypad<br>Via communication |
| Min/Max Values for Current | $I_A$; $I_B$; $I_C$;<br>$I_1$ (positive sequence component) |
| Min/Max Values for Voltages | $V_{A-N}$; $V_{B-N}$; $V_{C-N}$;<br>$V_1$ (Positive Sequence Component);<br>$V_{A-B}$; $V_{B-C}$; $V_{C-A}$ |
| Min/Max Values for Power | S, P; Q, cos φ; frequency |
| Min/Max Values for Overload Protection | $\Theta/\Theta_{Trip}$ |
| Min/Max Values for Mean Values | $I_{Admd}$; $I_{Bdmd}$; $I_{Cdmd}$;<br>$I_1$ (positive sequence component);<br>$S_{dmd}$; $P_{dmd}$; $Q_{dmd}$ |

### Fuse Failure Monitor

| | |
|---|---|
| Setting range of the displacement voltage 3U0 above which voltage failure is detected | 10 - 100 V |
| Setting range of the ground current above which no voltage failure is assumed | 0.1 - 1 A for $I_{Bdmd}$ = 1 A<br>0.5 - 5A for $I_{Bdmd}$ = 5A |
| Setting range of the pickup threshold I> above which no voltage failure is assumed | 0.1 - 35 A for $I_{Bdmd}$ = 1 A<br>0.5 - 175 A for $I_{Bdmd}$ = 5A |
| Measuring voltage monitoring | depends on the MLFB and configuration with measured and calculated values $V_N$ and $I_N$ |

### Broken-wire Monitoring of Voltage Transformer Circuits

| |
|---|
| suited for single-, two- or three-pole broken-wire detection of voltage transformer circuits;<br>only for connection of phase-Ground voltages |

### Local Measured Value Monitoring

| | |
|---|---|
| Current asymmetry | $I_{max}/I_{min}$ > symmetry factor, for I > $I_{limit}$ |
| Voltage asymmetry | $V_{max}/V_{min}$ > symmetry factor, for V > $V_{limit}$ |
| Current sum | $\mid i_A + i_B + i_C + k_I \cdot i_N \mid$ > limit value, with<br>$k_I = \frac{\text{Ignd-CT PRIM} / \text{Ignd-CT SEC}}{\text{CT PRIMARY} / \text{CT SECONDARY}}$ |
| Current phase sequence | Clockwise (ABC) / counter-clockwise (ACB) |
| Voltage phase sequence | Clockwise (ABC) / counter-clockwise (ACB) |

### Fault Event Recording

| |
|---|
| Recording of indications of the last 8 power system faults |
| Recording of indications of the last 3 power system ground faults |

### Time Allocation

| | |
|---|---|
| Resolution for Event Log (Operational Annunciations) | 1 ms |
| Resolution for Trip Log (Fault Annunciations) | 1 ms |
| Maximum Time Deviation (Internal Clock) | 0.01 % |
| Battery | Lithium battery 3 V/1 Ah, type CR 1/2 AA<br>Message „Battery Fault“ for insufficient battery charge |

### Fault Recording

| | |
|---|---|
| maximum of 8 fault records saved; memory maintained by buffer battery in the case of auxiliary voltage failure | |
| Recording time | 5 s per fault record, in total up to 18 s at 50 Hz<br>(max. 15 s at 60 Hz) |
| Intervals at 50 Hz<br>Intervals at 60 Hz | 1 instantaneous value each per 1.0 ms<br>1 instantaneous value each per 0.83 ms |

### Energy Counter

| | |
|---|---|
| Meter Values for Energy<br>Wp, Wq (real and reactive energy) | in kWh (MWh or GWh) and in kVARh (MVARh or GVARh) |
| Range | 28 bit or 0 to 2 68 435 455 decimal for IEC 60870-5-103 (VDEW protocol)<br>31 bit or 0 to 2 147 483 647 decimal for other protocols (other than VDEW) |
| Tolerance [1] | ≤ 2 % for $I > 0.1\ I_{Nom}$, $V > 0.1\ V_{Nom}$ and<br>$\lvert \cos \varphi \rvert \geq 0.707$ |

[1] At nominal frequency

### Switching statistics

| | |
|---|---|
| Stored number of trips | up to 9 decimal places |
| Accumulated interrupted current (separate for each breaker pole) | up to 4 decimal places |

### Motor Statistics

| | | |
|---|---|---|
| Total number of motor startups | 0 to 9999 | Resolution1 |
| Total operating time | 0 to 99999 h | Resolution1 h |
| Total down-time | 0 to 99999 h | Resolution1 h |
| Ratio operating time / down-time | 0 to 100 % | Resolution 0.1 % |
| Active energy and reactive energy | (see Operational Measured Values) | |
| Motor start-up data:<br>- Start-up time<br>- Start-up current (primary)<br>- Start-up voltage (primary) | of the last 5 start-ups<br>0.30 s to 9999.99 s<br>0 A to 1000 kA<br>0 V to 100 kV | <br>Resolution 10 ms ...<br>Resolution1 A<br>Resolution1 V |

### Operating Hours Counter

| | |
|---|---|
| Display Range | Up to 7 digits |
| Criterion | Overshoot of an adjustable current threshold (element 50-1, BkrClosed I MIN) |

### Circuit Breaker Monitoring

| | |
|---|---|
| Calculation method | on r.m.s. value basis: $\Sigma I$, $\Sigma I^x$, 2P;<br>on instantaneous value basis: $I^2t$ |
| Measured value acquisition/processing | phase-selective |
| Evaluation | one limit value each per subfunction |
| Saved number of statistical values | up to 13 decimal places |

### Trip Circuit Monitoring

| |
|---|
| With one or two binary inputs. |

### Commissioning Aids

| |
|---|
| - Phase rotation test<br>- Operational measured values<br>- Circuit breaker test by means of control function<br>- Creation of a test fault report<br>- Creation of messages |

### Clock

| | | |
|---|---|---|
| Time synchronization | | Binary input<br>Communication |
| Modes of operation for time tracking | | |
| No. | Mode of operation | Explanations |
| 1 | Internal | Internal synchronization using RTC (presetting) |
| 2 | IEC 60870-5-103 | External synchronization using port B (IEC 60870-5-103) |
| 3 | Pulse via binary input | External synchronization with pulse via binary input |
| 4 | Field bus (DNP, Modbus, VDEW Re-dundant) | External synchronization using field bus |
| 5 | NTP (IEC 61850) | External synchronization using port B (IEC 61850) |

### Group Switchover of the Function Parameters

| | |
|---|---|
| Number of available setting groups | 4 (parameter group A, B, C and D) |
| Switchover can be performed via | the keypad on the device<br>DIGSI using the operator interface<br>protocol using port B<br>binary input |

### IEC 61850 GOOSE (Inter-Relay Communication)

| |
|---|
| The GOOSE communication service of IEC 61850 is qualified for switchgear interlocking. Since the transmission time of GOOSE messages depends on both the number of IEC 61850 clients and the relay's pickup condition, GOOSE is not generally qualified for protection-relevant applications. The protective application is to be checked with regard to the required transmission time and cleared with the manufacturer. |

# 4.21 Breaker Control

| | |
|---|---|
| Number of Controlled Switching Devices | Depends on the number of binary inputs and outputs available |
| Interlocking | Freely programmable interlocking |
| Messages | Feedback messages; closed, open, intermediate position |
| Control Commands | Single command / double command |
| Switching Command to Circuit Breaker | 1-, 1½ - and 2-pole |
| Programmable Logic Controller | PLC logic, graphic input tool |
| Local Control | Control via menu control<br>assignment of function keys |
| Remote Control | Using Communication Interfaces<br>Using a substation automation and control system (e.g. SICAM)<br>Using DIGSI (e.g. via Modem) |

# 4.22 Dimensions

## 4.22.1 Panel Flush and Cubicle Mounting (Housing Size 1/6)

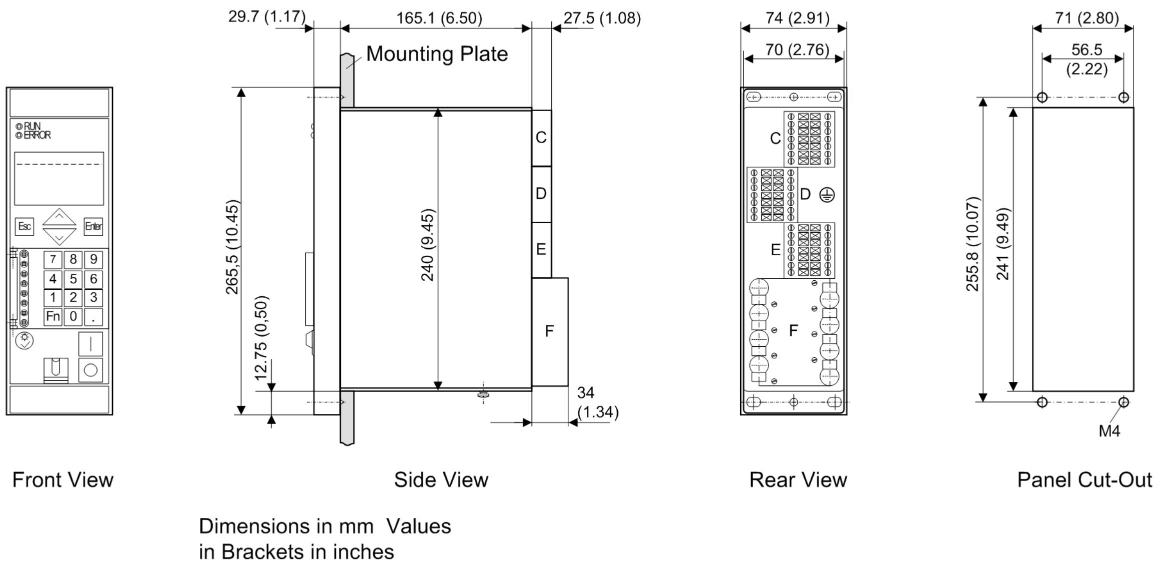



Figure 4-11 Dimensional drawing of a 7SK80 for panel flush or cubicle mounting (housing size $^{1}/_{6}$)

Note: An angle strip set (contains upper and lower mounting brackets) (Order-No. C73165-A63-D200-1) is necessary to install the device in a rack. Using the Ethernet interface it might be necessary to rework the lower mounting bracket.

Please consider enough space for the cabling of the communication modules at the bottom of the relay or below the relay.

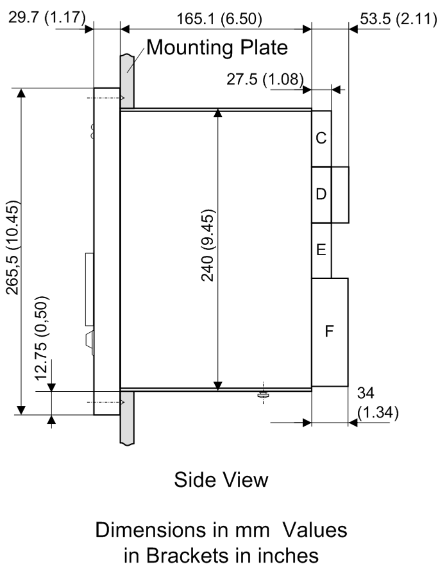



Figure 4-12 Dimensional drawing of a 7SK80 (Terminalblock "D" with cap)

## 4.22.2 Panel Surface Mounting (Housing Size 1/6)

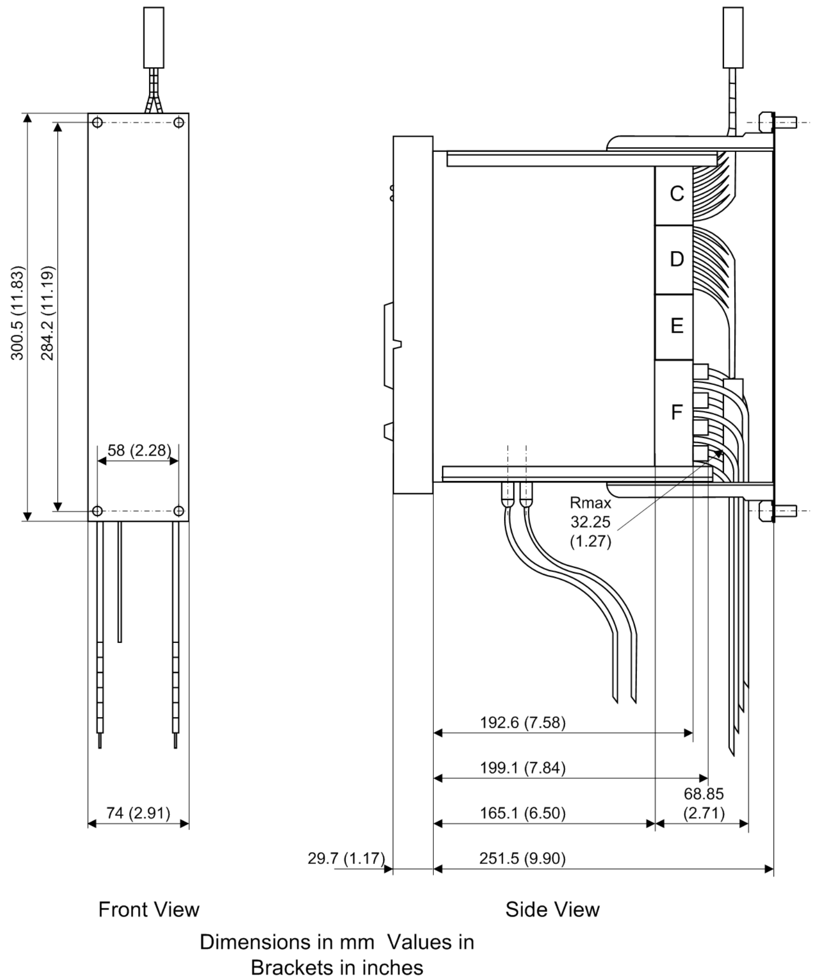



Figure 4-13 Dimensional drawing of a 7SK80 for panel surface mounting (housing size $^1/_6$)

## 4.22.3 Bottom view

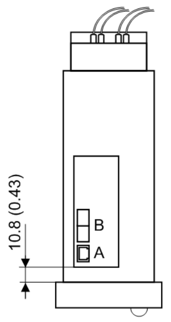



Figure 4-14 Bottom view of a 7SK80 (housing size $^{1}/_{6}$)

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