SIPROTEC 7SC80
Feeder Automation Controller

V4.0

Technical Data

Extract from manual E50417-G1140-C486-A1, chapter 4

Energy Automation

SIEMENS

Note

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

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Preface

Purpose of this Manual

This manual describes the functions, operation, installation, and commissioning of 7SC80 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 Feeder Automation Controller 7SC80; firmware version V4.0.

Additional Standards IEEE C37.90 (see Chapter 4 "Technical Data")
UL approval according standard UL 508 is pending.

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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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Safety Information

This manual does not constitute a complete index of all required safety measures for operation of the equipment (module, device), as special operational conditions may require additional measures. However, it comprises important information that should be noted for purposes of personal safety as well as avoiding material damage. Information that is highlighted by means of a warning triangle and according to the degree of danger, is illustrated as follows.

DANGER!

Danger indicates that death, severe personal injury or substantial material damage will result if proper precautions are not taken.

WARNING!

indicates that death, severe personal injury or substantial property damage may result if proper precautions are not taken.

Caution!

indicates that minor personal injury or property damage may result if proper precautions are not taken. This particularly applies to damage to or within the device itself and consequential damage thereof.

Note

indicates information on the device, handling of the device, or the respective part of the instruction manual which is important to be noted.

WARNING!

Qualified Personnel

Commissioning and operation of the equipment (module, device) as set out in this manual may only be carried out by qualified personnel. Qualified personnel in terms of the technical safety information as set out in this manual are persons who are authorized to commission, activate, to ground and to designate devices, systems and electrical circuits in accordance with the safety standards.

Use as prescribed

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

The successful and safe operation of the device is dependent on proper handling, storage, installation, operation, and maintenance.

When operating an electrical equipment, certain parts of the device are inevitably subject to dangerous voltage. Severe personal injury or property damage may result if the device is not handled properly.

Before any connections are made, the device must be grounded to the ground terminal.

All circuit components connected to the voltage supply may be subject to dangerous voltage.

Dangerous voltage may be present in the device even after the power supply voltage has been removed (capacitors can still be charged).

Operational equipment with exposed current transformer circuits may not be operated.

The limit values as specified in this manual or in the operating instructions may not be exceeded. This aspect must also be observed during testing and commissioning.

Technical Data

4

This chapter provides the technical data of the device SIPROTEC 7SC80 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_{Nom}	50 Hz or 60 Hz	(adjustable)
Frequency operating range (independent of the nominal frequency)		25 Hz to 70 Hz	
Nominal current	I_{Nom}	1 A or 5 A	
Consumption per phase and ground path - for I_{Nom} = 1 A - for I_{Nom} = 5 A		 ≤ 0.1 VA ≤ 0.5 VA	
Current overload capability - thermal (rms) - dynamic (peak value)		 500 A for 1 s 150 A for 10 s 20 A continuous 1250 A (half-cycle)	

Voltage Inputs

Measuring range		0 V to 250 V
Consumption	at 100 V	approx. 0.005 VA
Voltage overload capability		
– thermal (rms)		230 V continuous

4.1.2 Auxiliary Voltage

Direct Voltage

Power supply via integrated converter		
Rated auxiliary direct voltage V_{PS}	DC 24 V to 48 V	DC 60 V to 250 V
Permissible voltage ranges	DC 19 V to 60 V	DC 48 V to 300 V
Overvoltage category, IEC 60255-27	III	
Permissible AC ripple voltage, peak to peak, IEC 60255-11	15 % of the auxiliary voltage	

Power consumption	quiescent	energized
7SC80	approx. 5 W	approx. 12 W
Bridging time for failure/short circuit, IEC 60255-11 (if cabinet battery is not connected)	≥ 50 ms	

Alternating Voltage

Power supply via integrated converter		
Rated auxiliary alternating voltage V_{PS}	AC 115 V	AC 230 V
Permissible voltage ranges	AC 92 V to 132 V	AC 184 V to 265 V
Overvoltage category, IEC 60255-27	III	

Power consumption (for AC 115 V/230 V)	< 15 VA
Bridging time for failure/short circuit	≥ 100 ms

4.1.3 Binary Inputs and Outputs

Binary Inputs

Variant	Quantity
7SC80	12 (routable)
Range of rated direct voltage	DC 0 V to 300 V, AC 0 V to 200 V
Current consumption, energized (independent of operating voltage)	approx. 0.4 mA
Pickup time Response time of binary output after trigger signal from binary input	approx. 3 ms approx. 9 ms
Dropout time Response time of binary output after trigger signal from binary input	approx. 4 ms approx. 5 ms
Secured switching thresholds	V high > DC 17 V V low < DC 12 V
Maximum admissible voltage	DC 300 V
Input pulse suppression	220 V induced above 220 nF at a recovery time between two switching operations ≥ 60 ms

Output Relays

Signal/command relay, alarm relay		
Quantity and data	depending on the order variant (routable)	
7SC80	8 BO	
Switching capability CLOSE	1000 W/1000 VA	
Switching capability TRIP	40 W or 30 VA at L/R ≤ 40 ms	
Switching voltage AC and DC	250 V	
Permissible current per contact (continuous)	8 A	
Permissible current per contact (close and hold)	30 A for 0.5 s (make 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

User Interface

Connection	At the front, non-isolated, USB type B socket for connecting a personal computer operation for DIGSI V4.82 and higher via USB 2.0 full speed
Operation	with DIGSI
Transmission speed	up to 12 Mbit/s max.
Bridgeable distance	5 m

Port F

Ethernet electrical (EN 100) for IEC61850 and DIGSI		
	Connection	At housing, 2 x RJ45 connector socket 100BaseT in acc. with IEEE802.3
	Test voltage (for socket)	500 V; 50 Hz
	Transmission speed	100 Mbit/s
	Bridgeable distance	20 m
Ethernet optical (EN 100 SM) for IEC61850 and DIGSI		
	Connection	At housing, duplex-LC, 100BaseF in acc. with IEEE802.3
	Transmission speed	100 Mbit/s
	Optical wavelength	1300 nm
	Bridgeable distance	max. 24 km

GPS Connection

Connection	SMB socket (subminiature B) at device
	Active GPS antenna 5 V, max. 50 mA

4.1.5 Electrical Tests

Regulations

Standards: see also individual tests	
Protection devices	Bay units
IEC 60255 EN 60255/EN 50263 DIN 57435/DIN EN 50263 IEC TS 61000-6-5 IEC/EN 61000-4 IEC 60694 IEC 61850-3 ANSI/IEEE Std C37.90 IEC 61010-1 VDE 0435	IEC 60870 EN 60870 DIN EN 60870 IEC TS 61000-6-5 IEC/EN 61000-4 IEC 60694 IEC 61850-3

Insulation Test

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

EMC Tests for Immunity (Type Tests)

Standards:		IEC 60255-6 and -22, (product standards) IEC/EN 61000-6-2 VDE 0435 For additional standards, see the individual tests
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 IEC 60255-22-2, IEC 61000-4-2		8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with amplitude-modulated HF field, class III IEC 60255-22-3, IEC 61000-4-3		10 V/m; 80 MHz to 2.7 GHz 80 % AM; 1 kHz
Fast transient disturbance variables/burst, class IV IEC 60255-22-4, IEC 61000-4-4, IEEE C37.90.1		4 kV; 5 ns/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 installation class III IEC 60255-22-5, IEC 61000-4-5 [1]		Pulse: 1.2 µs/50 µs
	Auxiliary voltage	common mode: 4 kV; 12 Ω; 9 µF diff. mode:1 kV; 2 Ω; 18 µF
	Measuring inputs, binary inputs and relay outputs	common mode: 4 kV; 42 Ω; 0.5 µF diff. mode: 1 kV; 42 Ω; 0.5 µF
[1] For the device variants 24 V/48 V, provide a protection for a possible surge dissipation (for example, in case of lightning strokes) by external measures.		
Line-conducted HF, amplitude-modulated, class III IEC 60255-22-6, IEC 61000-4-6		10 V; 150 kHz to 80 MHz: 80 % AM; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV;		30 A/m; continuous; 300 A/m for 3 s;
Radiated electromagnetic interference IEEE Std C37.90.2		20 V/m; 80 MHz to 1 GHz; 80 % AM; 1 kHz For an irradiation in the range of 500 MHz, a higher measured-value deviation can occur. The maximum measured deviation is 6 %.
Damped oscillations IEC 61000-4-18		2.5 kV (peak); 100 kHz; 40 pulses per s; test duration 2 s; Ri = 200 Ω

EMC Tests for Noise Emission (Type Test)

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

4.1.6 Mechanical Tests

Vibration and Shock Stress during Steady-State Operation

Standards:	IEC 60255-21 IEC 60068 IEC 60721	IEC 60870
Vibration IEC 60255-21-1, class 1; IEC 60068-2-6	sinusoidal 10 Hz to 60 Hz: ± 0.075 mm amplitude; 60 Hz to 150 Hz: 1 g acceleration frequency sweep rate 1 octave/min, 20 cycles in 3 orthogonal axes	
Shock IEC 60255-21-2, class 1; IEC 60068-2-27	semi-sinusoidal 15 g acceleration, duration 11 ms, 3 shocks in each direction of the 3 axes	
Seismic vibration IEC 60255-21-3, class 2 IEC 60068-3-3	sinusoidal 1 Hz to 8 Hz: ± 8.0 mm amplitude (horizontal axis) 1 Hz to 8 Hz: ± 4.0 mm amplitude (vertical axis) 8 Hz to 35 Hz: 2 g acceleration (horizontal axis) 8 Hz to 35 Hz: 1 g acceleration (vertical axis) frequency sweep rate 1 octave/min, 1 cycle in 3 orthogonal axes	

Vibration and Shock Stress during Transport

Standards:	IEC 60255-21 IEC 60068 IEC 60721	IEC 60870
Vibration IEC 60255-21-1, class 1; IEC 60068-2-6	sinusoidal 5 Hz to 8 Hz: ±3.5 mm amplitude; 8 Hz to 150 Hz: 1 g acceleration frequency sweep rate 1 octave/min, 20 cycles in 3 orthogonal axes	
Shock IEC 60255-21-2, class 1; IEC 60068-2-27	semi-sinusoidal acceleration 15 g, duration 11 ms, 3 shocks in each direction of the 3 orthogonal axes	
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	semi-sinusoidal acceleration 10 g, duration 16 ms, 1000 shocks in each direction of the 3 orthogonal axes	

4.1.7 Climatic Stress Tests

Temperatures

Standards:	IEC 60255-6 and IEC 60870
Type test (in acc. with IEC 60086-2-1 and -2, test Bd for 16 h)	–50 °C to +85 °C
temporarily admissible during operation (tested for 96 h)	–40°C bis +70 °C[1)]
recommended for permanent operation (in acc. with IEC 60255-6)	–40 °C to +55 °C[1)]
Limit temperatures for storage	–25 °C to +55 °C
Limit temperatures during transport	–20 °C to +70 °C
Storage and transport in factory packaging	
[1)] The lithium battery CR2032 mounted by default is admitted for –30°C to +70°C.	

Humidity

Permissible humidity	Mean value per year ≤ 75 % relative humidity; on 30 days of the year up to 95 % relative humidity; condensation must be avoided!
Siemens recommends installing the devices in a place where they are not exposed to direct sunlight or great temperature variations that could lead to condensation. **If condensation is anticipated, the control cabinet into which the 7SC80 is installed must be equipped with a cabinet heating.**	

4.1.8 Service Conditions

The device is designed for installation in standard relay rooms and compartments so that the electromagnetic compatibility (EMC) is ensured when the device is installed correctly.

Siemens also recommends:

- All contactors and relays that operate in the same cabinet or on the same relay panel as the digital protection devices must generally be equipped with suitable surge suppression components.
- For substations with operating voltages of 100 kV and above, all external cables must be shielded with a conductive shield grounded at both ends. For substations with lower operating voltages no special measures are normally required.
- Do not withdraw or insert individual modules while the protection device is energized. When handling modules outside the housing, the standards for components sensitive to electrostatic discharge (**E**lectrostatically **S**ensitive **D**evices) must be observed. There is no risk in the installed condition.

4.1.9 Constructive Design

Dimensions	See dimensional drawings, Section 4.16

Device	Housing	Weight
7SC80	For panel flush mounting and panel surface mounting	4.5 kg

Degree of protection in acc. with IEC 60529	
For equipment in surface-mounting housing or flush-mounting housing	IP 40
For operator protection	IP 2x for current terminal IP 1x for voltage terminal
Degree of pollution, IEC 60255-27	2

4.1.10 UL certification conditions

Output relays	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. Replace battery with type CR2032 lithium battery; 3 V, 230 mAh only. Use of another battery may present a risk of fire or explosion. See the manual for safety instructions. Caution: The battery used in this device may present a fire or chemical burn hazard if handled incorrectly. Do not recharge, disassemble, heat above 100 °C (212 °F) or incinerate. Dispose of used battery promptly. Keep away from children.	
Climatic stress	Surrounding air temperature	tsurr: max. 70 °C (158 °F), normal operation
Constructive design	Field wires of control circuits must 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, 50N

Operating Modes

Three-phase	Standard
Two-phase	Phases A and C

Method of Measurement

All elements	Fundamental wave, true RMS value
50-3, 50N-3	Additional instantaneous values

Setting Ranges/Increments

Current pickup 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)	
Current pickup 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)	
Current pickup 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)	
Current pickup 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)	
Delay times T		0.00 s to 60.00 s or ∞ (disabled)	Increments 0.01 s
Dropout delay times 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 inrush restraint + 1 cycle)	
Fundamental component, RMS value - for setting value x 2 - for setting value x 10 Instantaneous value - for setting value x 2 - for setting value x 10	 approx. 30 ms approx. 20 ms approx. 16 ms approx. 16 ms
Dropout times Fundamental component, RMS value Instantaneous value	 approx. 30 ms approx. 40 ms

Dropout Ratio

Dropout ratio for - fundamental component, RMS value - instantaneous value	 approx. 0.95 for $I/I_{Nom} \geq 0.3$ approx. 0.90 for $I/I_{Nom} \geq 0.3$

Tolerances

Current pickup	3 % of setting value or 15 mA at I_{Nom} = 1 A or 75 mA at I_{Nom} = 5 A
Delay times T	1 % or 10 ms

Influencing Variables for Pickup and Dropout Values

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequencies outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic for instantaneous values of 50-3/50N-3 elements	 1 % 1 % increased tolerances
Transient overreaction for τ > 100 ms (with full displacement)	<5 %

4.3 Directional Overcurrent Protection 67, 67N

Overcurrent Elements

The same specifications apply as for non-directional overcurrent protection of the elements 50-1, 50-2, 50N-1 and 50N-2 (see previous sections).

Determination of Direction

Moreover, the following data apply for determining the fault direction:

For Phase Faults

Type	with cross-polarized voltages; with voltage memory (memory depth 2 seconds) for measuring voltages that are too small
Forward range	$V_{ref,rot} \pm 86°$
Rotation of the reference voltage $V_{ref,rot}$	–180° to +180° increments 1°
Dropout difference	3°
Directional sensitivity	unlimited for single-phase and two-phase faults for three-phase faults dynamically unlimited, steady-state approx. 7 V phase-to-phase

For Ground Faults

Type	with zero-sequence system quantities $3V_0$, $3I_0$
Forward range	$V_{ref,rot} \pm 86°$
Rotation of the reference voltage $V_{ref,rot}$	–180° to +180° increments 1°
Dropout difference	3°
Directional sensitivity	$V_{Gnd} \approx 2.5$ V displacement voltage, measured $3V_0 \approx 5$ V displacement voltage, calculated

Type	with negative-sequence system quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot} \pm 86°$
Rotation of the reference voltage $V_{ref,rot}$	–180° to +180° increments 1°
Dropout difference	3°
Directional sensitivity	$3V_2 \approx 5$ V negative-sequence voltage $3I_2 \approx 45$ mA negative-sequence current for $I_{Nom} = 1$ A $3I_2 \approx 225$ mA negative-sequence current for $I_{Nom} = 5$ A

Times

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

Tolerances

Angle error for phase and ground faults	±3° electrical

Influencing Variables

Frequency influence - without memory voltage	 approx. 1° in the range from 25 Hz to 50 Hz

4.4 Inrush Restraint

Influenceable Functions

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

Setting Ranges/Increments

Restraining factor I_{2f}/I	10 % to 45 %	Increments 1 %

Function 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

Crossblock

Crossblock I_A, I_B, I_C	ON/OFF

4.5 Voltage Protection 27, 59

Setting Ranges/Increments

Undervoltages 27-1, 27-2 phase-specific phase x 27-1, phase x 27-2			
Measured quantity used with three-phase connection		- Positive-sequence system of voltages - Smallest phase-to-phase voltage - Smallest phase-to-ground voltage	
Connection of phase-to-ground voltages: - Evaluation of phase-to-ground voltages - Evaluation of phase-to-phase voltages - Evaluation of positive sequence system		 10 V to 200 V 10 V to 385 V 10 V to 385 V	 Increments 1 V Increments 1 V Increments 1 V
Connection of phase-to-phase voltages		10 V to 385 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 max. 225 V for phase-to-ground voltage Minimum hysteresis 0.6 V	
Time delays 27-1, 27-2		0.00 s to 100.00 s or ∞ (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 phase-specific phase x 59-1, phase x 59-2			
Measured quantity used with three-phase connection		- Positive sequence system of voltages - Negative sequence system of voltages - Largest phase-to-phase voltage - Largest phase-to-ground voltage	
Connection of phase-to-ground voltages: - Evaluation of phase-to-ground voltages - Evaluation of phase-to-phase voltages - Evaluation of positive sequence system - Evaluation of negative sequence system		 20 V to 240 V 20 V to 415 V 20 V to 240 V 2 V to 240 V	 Increments 1 V Increments 1 V Increments 1 V Increments 1 V
Connection of phase-to-phase voltages: - Evaluation of phase-to-phase voltages - Evaluation of positive sequence system - Evaluation of negative sequence system		 20 V to 240 V 20 V to 240 V 2 V to 240 V	 Increments 1 V Increments 1 V Increments 1 V
Dropout ratio r for 59-1, 59-2[1]		0.90 to 0.99	Increments 0.01
Dropout threshold for (r · 59-1) or (r · 59-2)		max. 240 V for phase-to-phase voltage max. 415 V for phase-to-ground voltage Minimum hysteresis 0.6 V	
Time delay 59-1, 59-2 Phase-specific delay time Phx 59-1		0.00 s to 100.00 s or ∞ (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 - Overvoltage 59-1, 59-2 - Overvoltage 59-1 V_1, 59-2 V_1, 59-1 V_2, 59-2 V_2 - Undervoltage phase x 27-1, phase x 27-2 - Overvoltage phase x 59-1, phase x 59-2	approx. 50 ms approx. 50 ms approx. 60 ms
Dropout times	
- Undervoltage 27-1, 27-2, 27-1 V_1, 27-2 V_1 - Overvoltage 59-1, 59-2 - Overvoltage 59-1 V_1, 59-2 V_1, 59-1 V_2, 59-2 V_2 - Undervoltage phase x 27-1, phase x 27-2 - Overvoltage phase x 59-1, phase x 59-2	approx. 50 ms approx. 50 ms approx. 60 ms

Tolerances

Voltage limit values	3 % of setting value or 1 V
Delay times T	1 % of setting value or 10 ms

Influencing Variables

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) $\leq \Theta_{amb}$ $\leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequency outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.6 Voltage Protection for Vx

Setting Ranges/Increments

Undervoltages 27-1, 27-2		
Measured quantity used	Connected single-phase phase-to-ground voltage	
Connection: single-phase	10 V to 200 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. 225 V Minimum hysteresis 0.6 V	
Time delays 27-1 Delay, 27-2 Delay	0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s
Overvoltages 59-1, 59-2		
Measured quantity used with single-phase connection	Connected single-phase phase-to-ground voltage	
Connection: single-phase	20 V to 240 V	Increments 1 V
Dropout ratio r for 59-1, 59-2[1)]	0.90 to 0.99	Increments 0.01
Dropout threshold for (r · 59-1) or (r · 59-2)	max. 260 V for phase-to-ground voltage Minimum hysteresis 0.6 V	
Time delay 59-1 Delay, 59-2 Delay Phase-specific Ph x 59-1 Delay, Ph x 59-2 Delay	0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s

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

Times

Pickup times	
- Undervoltage 27-1, 27-2 - Overvoltage 59-1, 59-2	approx. 50 ms approx. 50 ms
Dropout times	
- Undervoltage 27-1, 27-2 - Overvoltage 59-1, 59-2	approx. 50 ms approx. 50 ms

Tolerances

Voltage limit values	3 % of setting value or 1 V
Delay times T	1 % of setting value or 10 ms

Influencing Variables

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequency outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.7 Negative Sequence Protection 46-1, 46-2 (Definite Time Characteristic)

Setting Ranges/Increments

Unbalanced load elements 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 Delay, 46-2 Delay		0.00 s to 60.00 s or ∞ (disabled)	Increments 0.01 s
Dropout time delays 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	approx. 35 ms
Dropout times	approx. 35 ms

Dropout Ratio

Element 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 direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequency outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %
Transient overreaction for τ > 100 ms (with full displacement)	<5 %

4.8 Negative Sequence Protection 46-TOC (Inverse Time Characteristic)

Setting Ranges/Increments

Pickup value 46-TOC PICKUP	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 46-TOC TIMEDIAL (IEC)		0.05 s to 3.20 s or ∞ (disabled)	Increments 0.01 s
Time Multiplier 46-TOC TIMEDIAL (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 4-1

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

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

EXTREMELY INV. $t_{TRIP} = \frac{80}{(I_2 / I_{2p})^{2} - 1} \cdot T_{I2p}$ [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. $1.10 \cdot I_{2p}$

Trip Time Curves acc. to ANSI

It can be selected one of the represented trip time characteristic curves in the figures 4-2 and 4-3 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:

t_{TRIP}	Trip Time
D_{I2p}	Setting Value of the Time Multiplier
I_2	Negative Sequence Currents
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 thresholds 46-TOC PICKUP	3 % of setting value or 15 mA for I_{Nom} = 1 A or 75 mA at I_{Nom} = 5 A
Time for 2 £ I/46-TOC PICKUP £ 20	5 % of set point 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 4-2 and 4-3 each on the left side of the figure

INVERSE

$$t_{Reset} = \left(\frac{8.8}{1 - (I_2 / I_{2p})^{2.0938}} \right) \cdot D_{I2p} \quad [s]$$

MODERATELY INV.

$$t_{Reset} = \left(\frac{0.97}{1 - (I_2 / I_{2p})^{2}} \right) \cdot D_{I2p} \quad [s]$$

VERY INVERSE

$$t_{Reset} = \left(\frac{4.32}{1 - (I_2 / I_{2p})^{2}} \right) \cdot D_{I2p} \quad [s]$$

EXTREMELY INV.

$$t_{Reset} = \left(\frac{5.82}{1 - (I_2 / I_{2p})^{2}} \right) \cdot D_{I2p} \quad [s]$$

Where:

t_{Reset}	Reset Time
D_{I2p}	Setting Value of the Time Multiplier
I_2	Negative Sequence Current
I_{2p}	Setting Value of the Pickup Current

The dropout time constants apply to $(I_2/I_{2p}) \leq 0.90$

Dropout Value

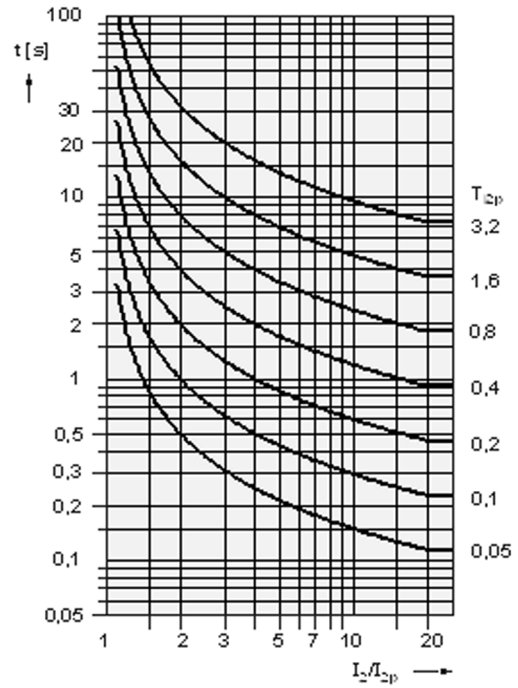
IEC and ANSI (without Disk Emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold I_2
ANSI with Disk Emulation	Approx. 0.90 · I_{2p} setting value

Tolerances

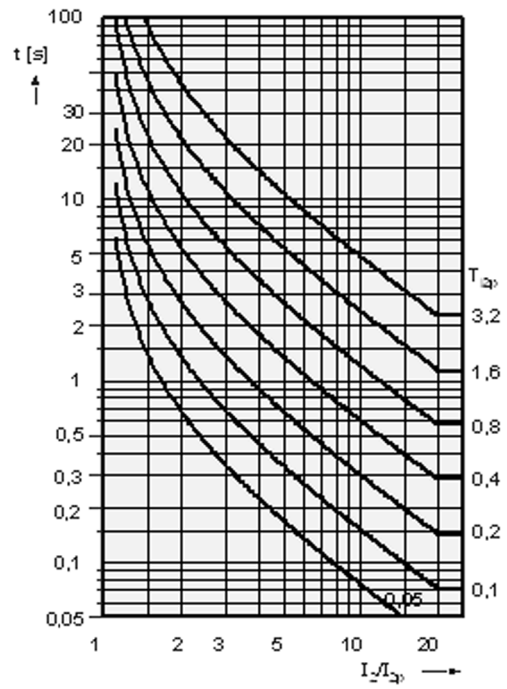
Dropout value 46-TOC Drop-Out	3 % of setting value or 15 mA for I_{Nom} = 1 A or 75 mA for I_{Nom} = 5 A
Time for 46/46-TOC ≤ 0.90	5 % of set point value + 2 % current tolerance or 30 ms

Influencing Variables for Pickup Values

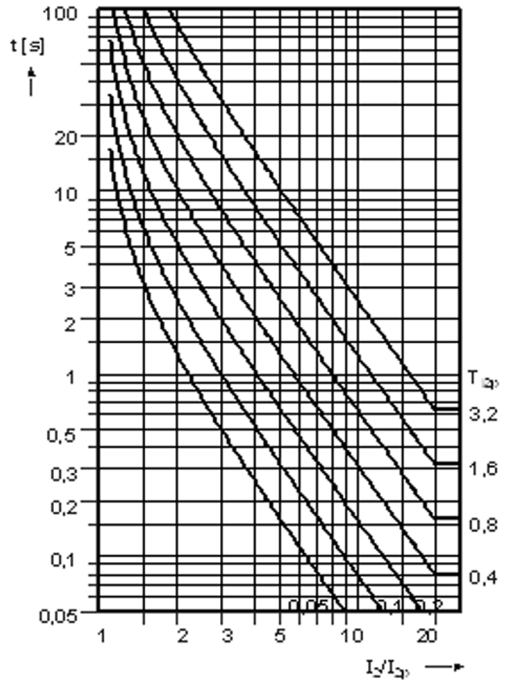
Power supply direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequencies outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %
Transient overreaction for τ > 100 ms (with full displacement)	<5 %



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



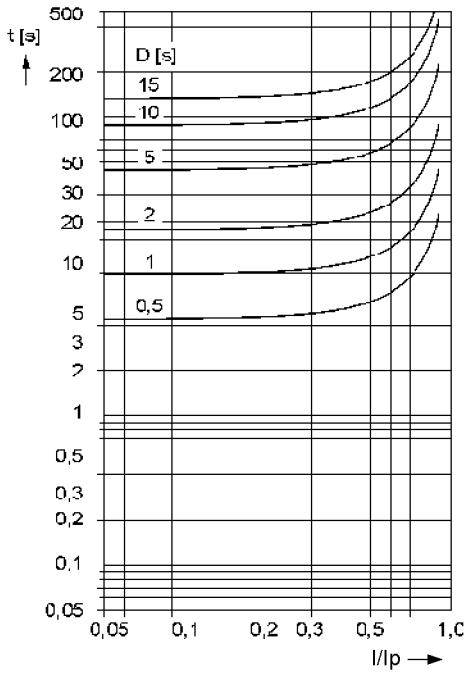
IEC VERY INVERSE: $t = \frac{13,5}{(I_2/I_{2p})^{1}-1} \cdot T_{I2p}$ [s]



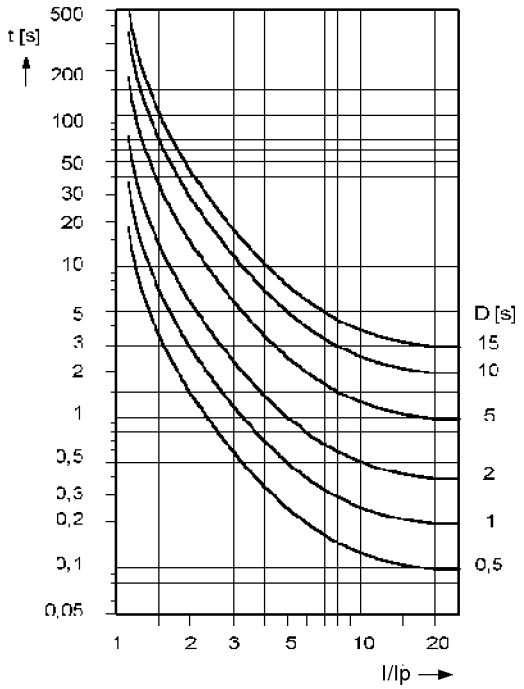
IEC EXTREMELY INVERSE: $t = \frac{80}{(I_2/I_{2p})^{2}-1} \cdot T_{I2p}$ [s]

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

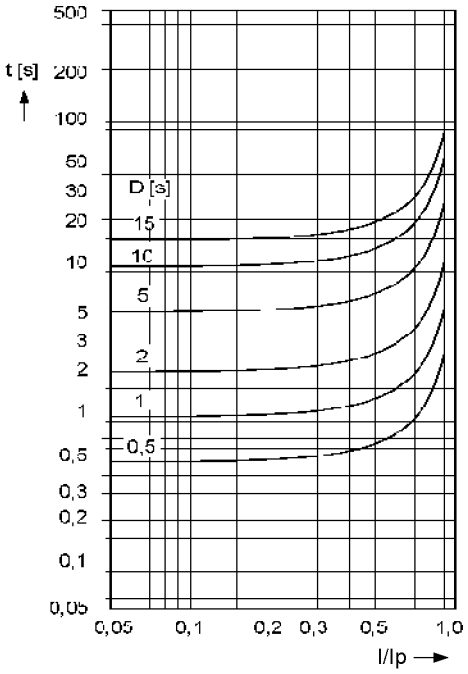
Figure 4-1 Trip time characteristics of the inverse time negative sequence element 46-TOC, acc. to IEC



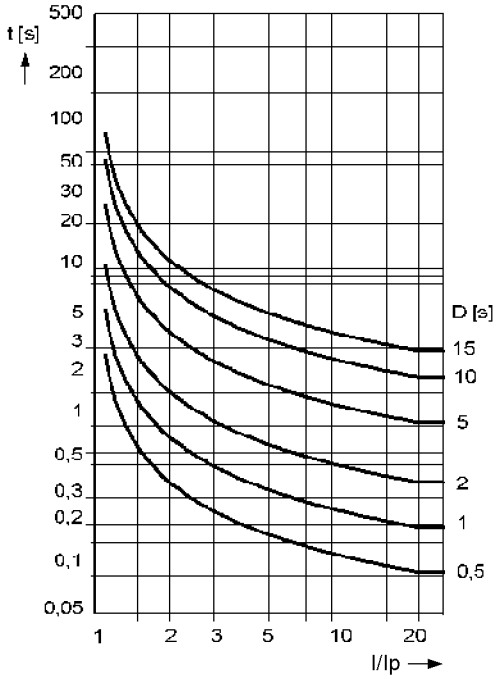
RESET INVERSE $t = \left(\frac{8.8}{1-(I_2/I_{2p})^{2.0938}}\right) \cdot D \ [s]$



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

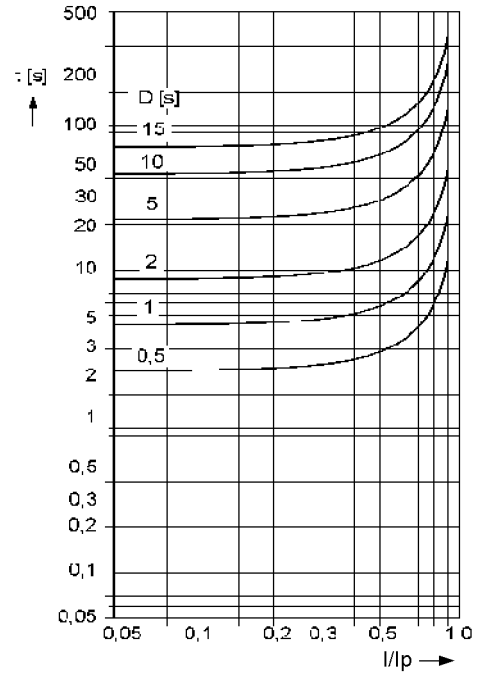


RESET MODERATELY INVERSE $t = \left(\frac{0.97}{1-(I_2/I_{2p})^{2}}\right) \cdot D \ [s]$

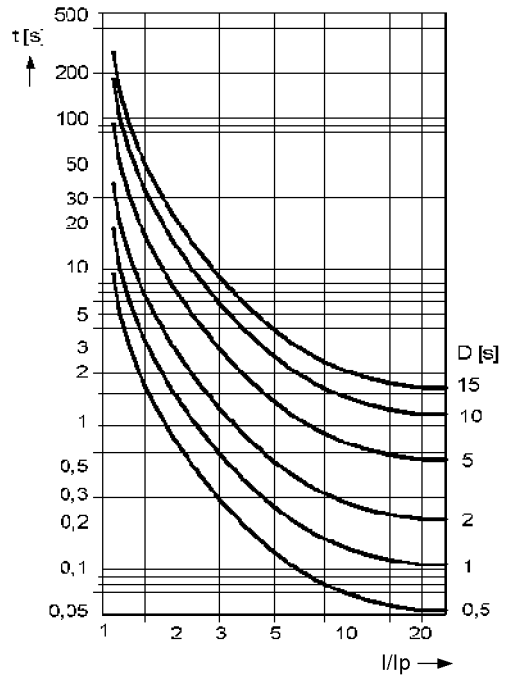


MODERATELY INVERSE $t = \left(\frac{0.0103}{(I_2/I_{2p})^{0.02}-1} + 0.0228\right) \cdot D \ [s]$

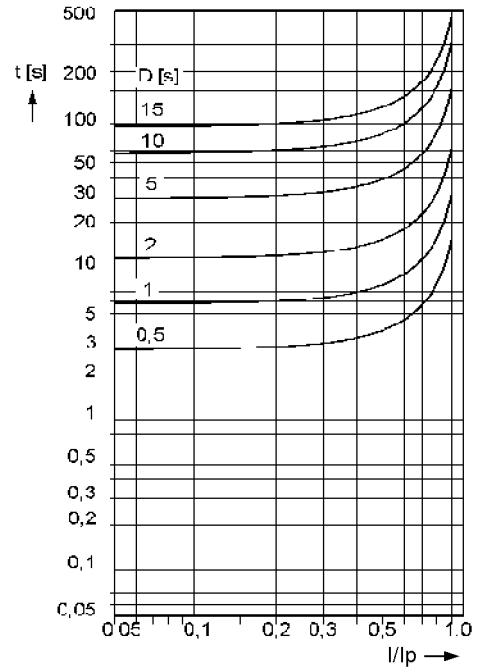
Figure 4-2 Dropout time and trip time characteristics of the inverse time unbalanced load stage, acc. to ANSI



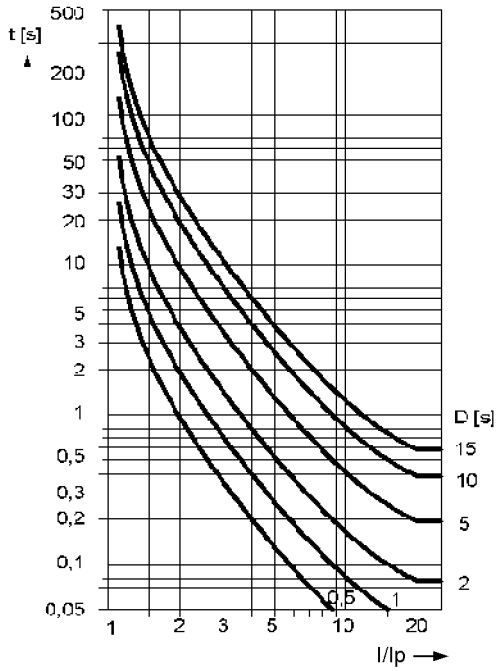
RESET VERY INVERSE $t = \left(\frac{4.32}{1-(I_2/I_{2p})^2}\right) \cdot D \ [s]$



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 4-3 Dropout time and trip time characteristics of the inverse time unbalanced load stage, acc. to ANSI

4.9 Frequency Protection 81

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 with three-phase connection: Positive-sequence component V_1	10 V to 150 V	Increments 1 V

Times

Pickup times f>, f<	approx. 100 ms for f_{Nom} = 50 Hz approx. 80 ms for f_{Nom} = 60 Hz
Dropout times f>, f<	approx. 100 ms for f_{Nom} = 50 Hz approx. 80 ms for 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

Frequencies f>, f< Undervoltage blocking Delay times T(f>, f<)	approx. 20 mHz (for V = V_{Nom}, f = $f_{Nom} \pm$ 5 Hz) 3 % of setting value or 1 V 1 % of setting value or 10 ms

Influencing Variables

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

4.10 Fault Locator

Output of the fault distance		in Ω primary and secondary in km or miles of line length or in % of the line length [1)]	
Trigger		with tripping, with dropout or from an external source via binary input	
Reactance per unit length setting (secondary)	for I_{Nom} = 1 A	0.0050 to 9.5000 Ω/km	Increments 0.0001
		0.0050 to 15.0000 Ω/mile	Increments 0.0001
	for I_{Nom} = 5 A	0.0010 to 1.9000 Ω/km	Increments 0.0001
		0.0010 to 3.0000 Ω/mile	Increments 0.0001
For the remaining parameters refer to the Power System Data 2.			
When configuring mixed lines, the reactance per unit length value must be set for each line section (A1 to A3).			
Measurement tolerance as per VDE 0435, Part 303 for sinusoidal measured quantities		2.5 % fault location (without intermediate infeed) $30° \leq \varphi_K \leq 90°$ and $V_K/V_{Nom} \geq 0.1$ and $I_K/I_{Nom} \geq 1.0$	

1) Homogeneous lines or correctly configured line sections are assumed when the fault distance is given in km, miles or %!

4.11 Breaker Failure Protection 50BF

Setting Ranges/Increments

Pickup threshold 50BF Pickup	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 50NBF Pickup	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 - for internal start - for external start dropout time dropout ratio	 is included in the delay time is included in the delay time approx. 25 ms [1] = 0.95 (minimum hysteresis between pickup and tripping ≥ 32.5 mA)

Tolerances

Pickup threshold 50BF Pickup, 50NBF Pickup	3 % of setting value or 15 mA for I_{Nom} = 1 A or 75 mA for I_{Nom} = 5 A
Time delay 50 BF TRIP Timer	1 % or 20 ms

Influencing Variables for Pickup Values

Auxiliary direct voltage in the range of $0.8 \le V_{PS}/V_{PSNom} \le 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range of $0.95 \le f/f_{Nom} \le 1.05$	1 %
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

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

4.12 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_{N2}, V, V_N, P forward, P reverse, Q forward, Q reverse, cosφ
without fixed phase reference	f, df/dt, binary input
Method of measurement for I, V	Fundamental component, true RMS value, positive-sequence system, negative-sequence system, zero-sequence system
Pickup when	exceeding threshold value or falling below threshold value

Setting Ranges/Increments

Pickup thresholds:			
Current I, I_1, I_2, $3I_0$, I_N	for I_{Nom} = 1 A	0.05 A to 40.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.25 A to 200.00 A	
Ratio I_2/I_1		15 % to 100 %	Increments 1%
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_{Nom} = 1 A	2.0 W to 10000 W	Increments 0.1 W
	for I_{Nom} = 5 A	10 W to 50000 W	
Power factor cosφ		-0.99 to +0.99	Increments 0.01
Frequency	for f_{nom} = 50 Hz for f_{nom} = 60 Hz	40.0 Hz to 60.0 Hz 50.0 Hz to 70.0 Hz	Increments 0.01 Hz 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 current > 0.03 A
	for I_{Nom} = 5 A	Positive-sequence 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
Ratio I_2/I_1 measurement	for I_{Nom} = 1 A	Positive-sequence current or negative-sequence current > 0.1 A
	for I_{Nom} = 5 A	Positive-sequence current or negative-sequence current > 0.5 A

Times

Pickup times:	
Current, voltage (phase quantities) 2 times pickup value 10 times pickup value	 approx. 30 ms approx. 20 ms
Current, voltage (symmetrical components) 2 times pickup value 10 times pickup value	 approx. 40 ms approx. 30 ms
Power typical maximum (small signals and thresholds)	 approx. 120 ms 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 typical maximum	 < 50 ms < 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
	for I_{Nom} = 5 A	3% of setting value or 2.5 W
Power factor		3°
Frequency		approx. 15 mHz
Frequency change		5% of setting value or approx. 0.05 Hz/s
Times		1% of setting value or 10 ms

Influencing Variables for Pickup Values

Auxiliary direct voltage in the range of $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in the range of 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in the range from 25 Hz to 70 Hz	
Frequency in the range of $0.95 \leq f/f_{Nom} \leq 1.05$ (f_{Nom} = 50 Hz or 60 Hz)	1 %
Frequency outside the range of $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.13 User-defined Functions (CFC)

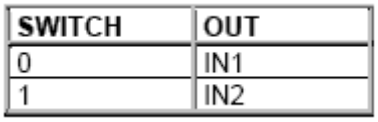
Function Blocks and Their Possible Assignments to Task Levels

Function block	Explanation	Task level			
		MW_ BEARB	PLC1_ BEARB	PLC_ BEARB	SFS_ BEARB
ABSVALUE	Magnitude Calculation	X	—	—	—
ADD	Addition	X	X	X	X
ALARM	Alarm	X	X	X	X
AND	AND - Gate	X	X	X	X
BLINK	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	Cancel command	X	X	X	X
CMD_CHAIN	Switching Sequence	—	X	X	—
CMD_INF	Command Information	—	—	—	X
CMD_INF_EXE	Command information in real-time	—	—	—	X
COMPARE	Metered value comparison	X	X	X	X
CONNECT	Connection	—	X	X	X
COUNTER	Counter	X	X	X	X
DI_GET_STATUS	Decode status of 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	Convert double-point indication with status into four single-point 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		X	—	—	—
LONG_TIMER	Timer (max.1193h)	X	X	X	X
LOOP	Feedback Loop	X	X	—	X

Function block	Explanation	Task level			
		MW_ BEARB	PLC1_ BEARB	PLC_ BEARB	SFS_ BEARB
LOWER_SETPOINT	Lower Limit	X	—	—	—
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	Edge detector	X	X	X	X
RS_FF	RS- Flipflop	—	X	X	X
RS_FF_MEMO	RS- Flipflop with status 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 status 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	—	—	—

Device-Specific CFC Blocks

Table 4-1 ASWITCH – This block is used to switch between two REAL inputs (RMS values).

	Name	Type	Description	Default function
Input	SWITCH	BOOL	Analog value selection	FALSE
	IN1	REAL	Analog value	0.0
	IN2	REAL	Analog value	0.0
Output	OUT	REAL	Selected analog value	
Task levels:		Recommendation: Into task levels PLC1_BEARB and PLC_BEARB, because these levels are directly triggered. Note: If you use thi block in the task levels MW_BEARB and SFS_BEARB, a change of the SWITCH signal is only recognized if the signal lasts longer than the processing cycle of the task level.		
Behavior of inputs and outputs:				

SWITCH	OUT
0	IN1
1	IN2

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 iisued 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 then, the blocks will not then start with the starting pulse.

Maximum Number of TICKS on the Task Levels

Task level	Limit in TICKS [1]
MW_BEARB (measured value processing)	10000
PLC1_BEARB (slow PLC processing)	6000
PLC_BEARB (fast PLC processing)	500
SFS_BEARB (switchgear interlocking)	10000

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

Processing Times in TICKS for the Individual Elements

Individual element		Number of TICKS
Block, basic requirement		5
Each input more than 3 inputs for generic modules		1
Combination with input signal border		6
Combination with output signal border		7
Additionally for each chart		1
Arithmetic	ABS_VALUE	5
	ADD	26
	SUB	26
	MUL	26
	DIV	54
	SQUARE_ROOT	83
Base 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_INF_EXE	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
Integrated total	COUNTER	6
Time and clock pulse	TIMER	5
	TIMER_LONG	5
	TIMER_SHORT	8
	ALARM	21
	BLINK	11

Routable in Matrix

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

4.14 Additional Functions

Operational Measured Values

Currents I_A; I_B; I_C Positive sequence component I_1 Negative sequence component I_2 I_N or 3I0	in A (kA) primary and in A secondary or in % I_{Nom}
Range Tolerance[1)]	10 % to 150 % I_{Nom} 1.5 % of measured value or 1 % I_{Nom} and from 151 % to 200 % I_{Nom} 3 % of measured value
Voltages (phase-to-ground) V_{A-N}, V_{B-N}, V_{C-N} Voltages (phase-to-phase) V_{A-B}, V_{B-C}, V_{C-A}, V_{SYN} V_{delta}, V_{ph-gnd}, V_x or V_0 positive sequence component V_1 negative sequence component V_2	in kV primary, in V secondary or in % V_{Norm}
Range Tolerance[1)]	10 % to 120 % of V_{Nom} 1.5 % of measured value or 0.5 % V_{Nom}
S, apparent power	in kVAr (MVAR or GVAR) primary and in % of S_{Nom}
Range Tolerance[1)]	0 % to 120 % S_{Nom} 1.5 % of S_{Nom} 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 Tolerance[1)]	0 % to 120 % S_{Nom} 2 % of S_{Nom} for V/V_{Nom} and I/I_{Nom} = 50 to 120 % and | cos φ | = 0.707 to 1 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 Tolerance[1)]	0 % to 120 % S_{Nom} 2 % of S_{Nom} for V/V_{Nom} and I/I_{Nom} = 50 to 120 % and | sin φ | = 0.707 to 1 with $S_{Nom} = \sqrt{3} \cdot V_{Nom} \cdot I_{Nom}$
cos φ, power factor[2)]	total and phase-segregated
Range Tolerance[1)]	–1 to +1 2 % for | cos φ | ≥ 0.707
Angle φ_A; φ_B; φ_C,	in degrees (°)
Range Tolerance[1)]	0 to 180° 0.5°
Frequency f	in Hz
Range Tolerance[1)]	$f_{Nom} \pm 5$ Hz 20 mHz

1) for nominal frequency

2) display of cos φ from I/I_{Nom} and V/V_{Nom} greater than 10 %

Long-Term Mean Values

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

Min./Max. Memory

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 Using keypad Via communication
Min/Max Values for Current	I_A; I_B; I_C; I_1 (positive sequence component)
Min/Max Values for Voltages	V_{A-N}; V_{B-N}; V_{C-N}; V_1 (Positive Sequence Component); 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	Θ/Θ_{Trip}
Min/Max Values for Mean Values	I_{Admd}; I_{Bdmd}; I_{Cdmd}; I_1 (positive sequence component); S_{dmd}; P_{dmd}; Q_{dmd}

Fuse Failure Monitor

Setting range of the displacement voltage 3V0 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 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 0.5 - 175 A for I_{Bdmd} = 5A
Operation of the fuse failure monitor	depends on the MLFB and configuration with measured or calculated values V_N and I_N

Local Measured Value Monitoring

Current unbalance	I_{max}/I_{min} > balance factor, for $I > I_{balance\ limit}$
Voltage unbalance	V_{max}/V_{min} > symmetry factor, for $V > V_{limit}$
Current sum	$\lvert i_A + i_B + i_C + k_I \cdot i_E \rvert$ > limit value, with $k_I = \frac{\text{Ignd-CT PRIM} / \text{Ignd-CT SEC}}{\text{CT PRIMARY} / \text{CT SECONDARY}}$
Current phase sequence	Clockwise/counter-clockwise phase sequence
Voltage phase sequence	Clockwise/counter-clockwise phase sequence

Fault Logging

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

Time Allocation

Resolution for operational indications	1 ms
Resolution for fault indications	1 ms
Maximum time deviation (internal clock)	0,01 %
Buffer battery	Lithium battery type CR2032, 3 V, 230 mAh indication „Fail Battery“ if the battery is not charged sufficiently

Fault Recording

max. 8 fault records saved by buffer battery also in the event of auxiliary voltage failure	
Storage period	6 s per fault record, in total up to 18 s at 50 Hz (max. 15 s at 60 Hz)
Sampling rate at 50 Hz Sampling rate at 60 Hz	each 1 instantaneous value per 1.0 ms each 1 instantaneous value per 0.83 ms

Energy Counter

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

[1)] At nominal frequency

Switching Statistics

Stored number of trips	up to 9 decimal places

Operating Hours Counter

Display range	up to 7 decimal places
Criterion	Exceeding an adjustable current threshold (CB I>)

Commissioning Aids

- Phase-sequence check - Operational measured values - Circuit breaker test via control - Creating a test fault record - Generating indications

Clock

Time synchronization		Binary input Communication
Operating modes of the clock management		
No.	Operating mode	Comments
1	Internal	Internal synchronization via RTC (default)
3	Pulse via binary input	External synchronization with pulse via binary input
5	NTP (IEC 61850)	External synchronization via port F (IEC 61850)
6	GPS	External synchronization via GPS

Setting Group Change Option of the Functional Settings

Number of available setting groups	4 (setting group A, B, C and D)
The change can be performed via	operation panel at the device DIGSI via user interface protocol via port F binary input

IEC 61850 GOOSE (inter-device communication)

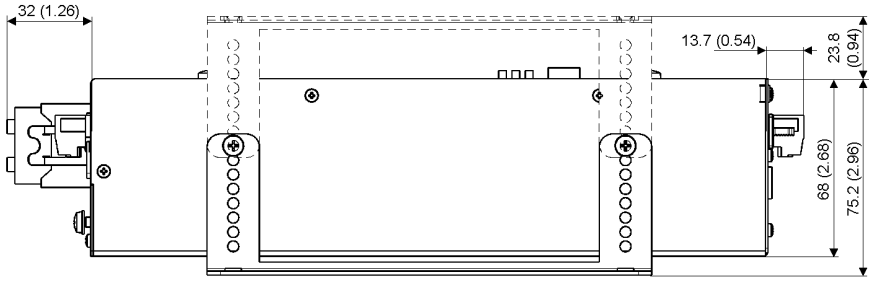
The GOOSE communication service of IEC 61850 is qualified for switchgear interlocking. Since the transmission time of GOOSE messages depends on both the number of IEC 61850 clients and the pickup condition of the device, GOOSE is not generally qualified for protection-relevant applications. The protection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

4.15 Switching Device Control

Number of 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-pole, 1½-pole and 2-pole
Programmable Logic Controller	PLC logic, graphic input tool
Local control	Control via menu Assignment of function keys
Remote control	via communication interfaces via systems control (e.g. SICAM) via DIGSI (e.g. via modem)

4.16 Dimensions

4.16.1 Feeder Automation Controller 7SC80



Dimensions in mm Values in Brackets in inches

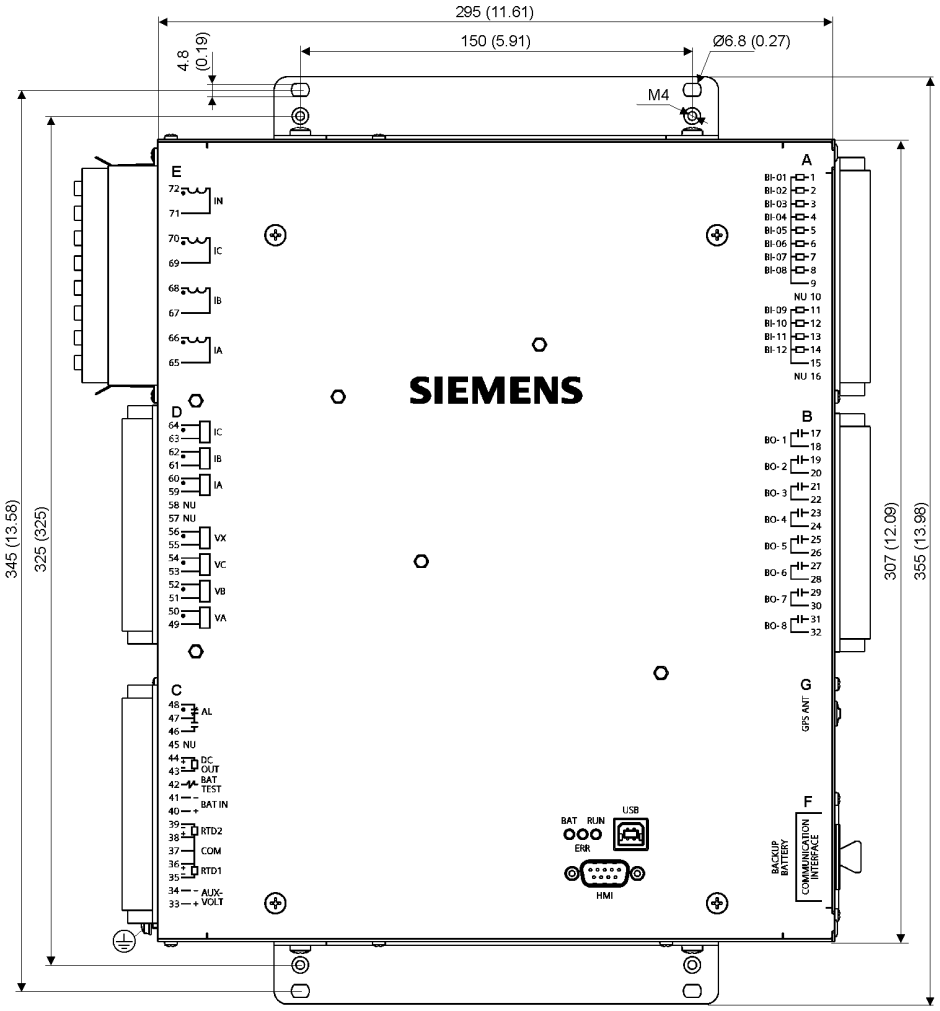


Figure 4-4 Dimensional drawing Feeder Automation Controller 7SC80

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