

7SJ511 Numerical overcurrent-time protection relay (Version V3)

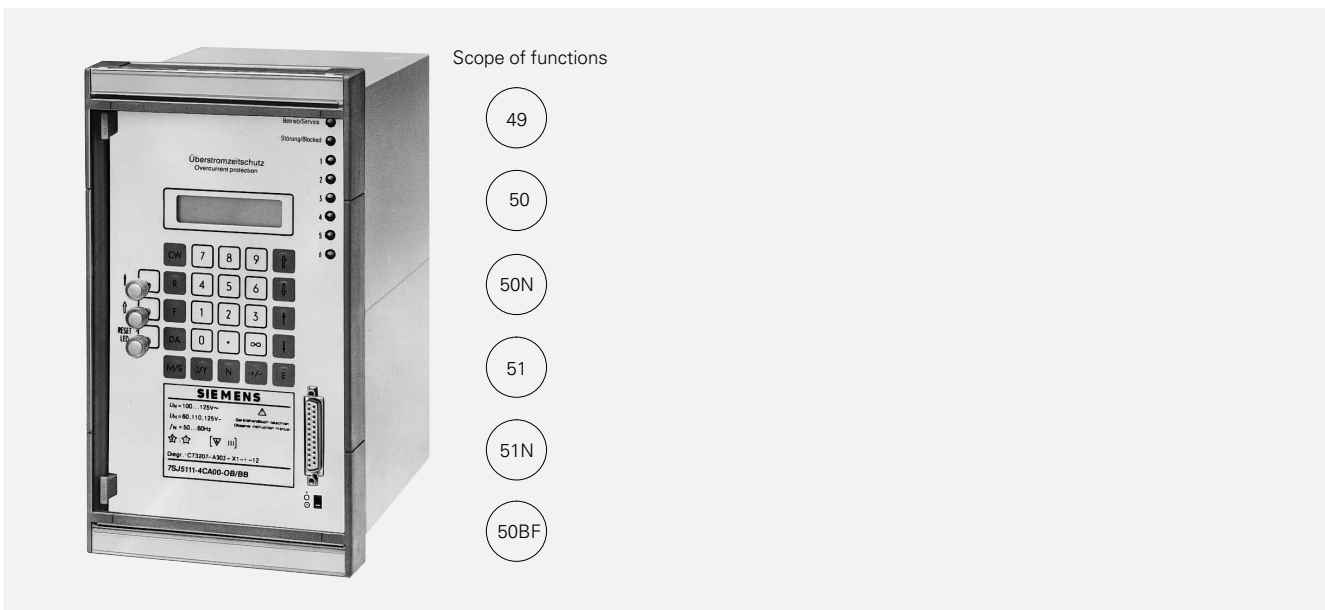


Fig. 1
7SJ511 numerical overcurrent-time protection relay

Application

The 7SJ511 is used as a definite-time or inverse definite minimum time (IDMT) overcurrent protection in medium-voltage distribution systems with single-end infeed. It is also used as back-up for differential protection schemes applied to lines, transformers and generators.

Construction

Within its compact design, the unit contains:

- All components for analog value acquisition and numeric evaluation
- Operating panel
- Indication and command outputs
- Binary inputs
- Serial interfaces for parameterization and connection to substation control and protection
- Auxiliary voltage converter.

The device can be provided in two housings. The model for panel surface mounting is equipped with terminals accessible from the front. The options for flush mounting have rear connection terminals and are available with or without glass cover.

Scope of functions

- 49
- 50
- 50N
- 51
- 51N
- 50BF

Implemented functions/features

The following functions are available:

- Definite-time/inverse time overcurrent protection
- Definite-time/inverse time earth-fault protection
- Overload protection (with memory)
- Reverse interlocking (busbar protection scheme)
- Circuit-breaker failure protection
- Trip circuit test function
- Display of on-load measured current values
- Fault recording.

Mode of operation

With the use of a powerful micro-controller and digital analog value preparation and processing, the effect of high frequency transients and transient DC components is largely eliminated.

If definite-time characteristics are used the measuring method involves evaluation of the fundamental. If dependent time characteristics are chosen there is a choice between r.m.s value or fundamental calculation.

Serial interfaces

The device is equipped with two serial interfaces.

A PC can be connected to the front port to ease setup of the relay using DIGSI. This program, which runs under MS-WINDOWS, can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and 1 event log containing up to 30 events.

The 7SJ511 can be hooked up to a substation automation system. The system interface for linking to the SINAUT LSA substation control and protection system or a protection master unit uses the protocol IEC 870-5-103 (standard of the Association of German Power Utilities, VDEW/ZVEI recommendation). The connection can be either via an 820 nm fibre optics interface or an electrical RS232C interface.

Self monitoring

Hardware and software are constantly monitored and irregularities immediately detected and signalled. In this way a very high degree of safety, reliability and availability is achieved.

Overcurrent and Distance Relays

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Convenient setting

The menu driven HMI or connected OC is used for setting parameters. The parameters are stored in a non-volatile memory so that the setting is retained even if the supply voltage is cut off.

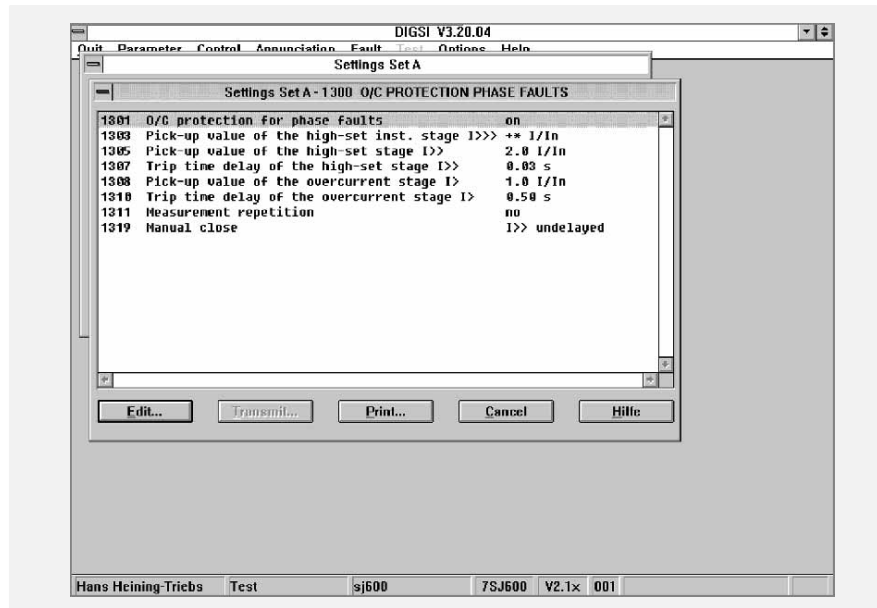


Fig. 2 Settings window using DIGSI

Oscillographic fault recording of up to 8 records (5 seconds maximum)

The "Fault recording" function is used to record the phase currents in the event of a power system fault. Either pickup, tripping or binary input can be selected to trigger waveform capture. The maximum length of a record can be programmed. The recorded traces of the phase and ground currents and pickup and drop-off of internal events can be transmitted to a PC for convenient analysis using DIGRA.

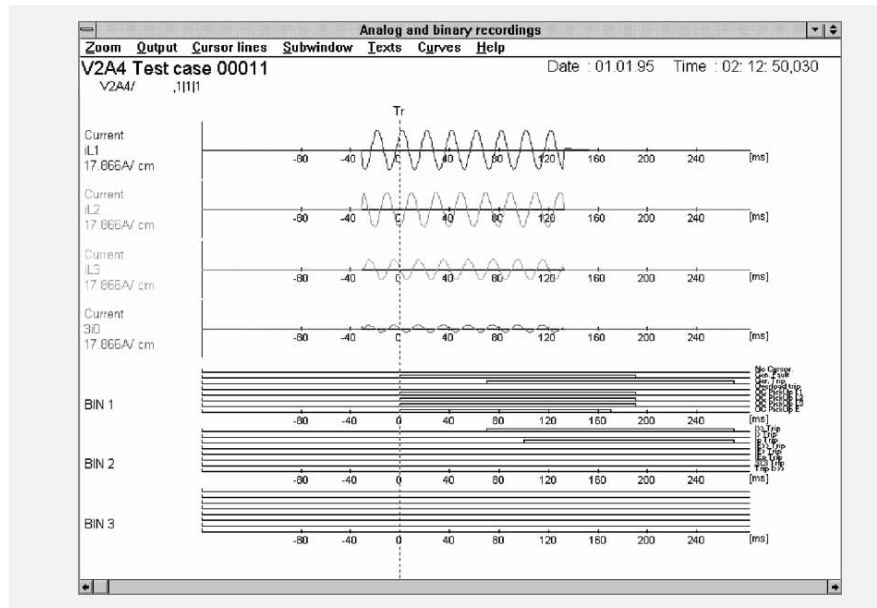


Fig. 3 Analog and binary traces

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Overcurrent-time protection

IEC curves

The function is based on phase-selective measurement of the three phase currents and the earth current. Either definite-time or inverse-time maximum current protection can be used. In addition to the overcurrent stage there is a high current state both for the phases ($I > I_p$, $I \gg I_p$) and for the earth ($I_E > I_{E_p}$, $I_E \gg I_{E_p}$).

The high current state always has definite-time characteristics:

If the 11th place of the order number is 0 (country-specific presettings: German/English), the following tripping characteristics can be selected (to BS 142, or IEC 255-4):

- normal inverse (Fig. 4)

$$t = t_p \cdot \frac{0.14}{(I/I_p)^{0.02} - 1}$$

- very inverse (Fig. 5)

$$t = t_p \cdot \frac{13.5}{(I/I_p)^2 - 1}$$

- extremely inverse (Fig. 6)

$$t = t_p \cdot \frac{80}{(I/I_p)^2 - 1}$$

t tripping time
 t_p time multiplier 0 – 10 s
 I fault current
 I_p current setting 0.1 – 4 I_N

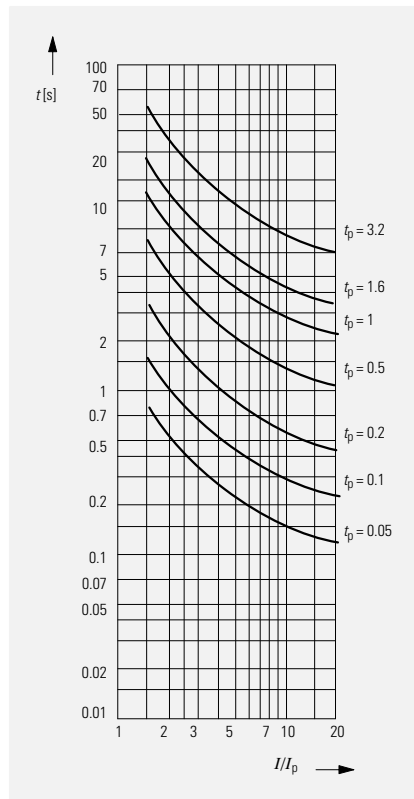


Fig. 4
Tripping time characteristics, normal inverse (IEC 255-4)

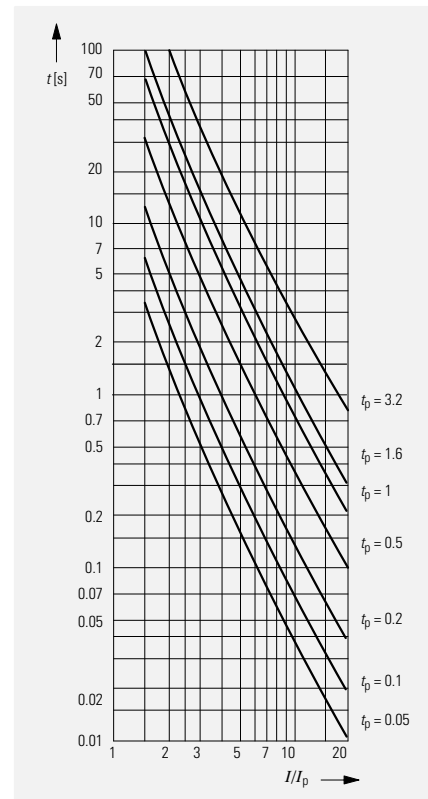


Fig. 6
Tripping time characteristics, extremely inverse (IEC 255-4)

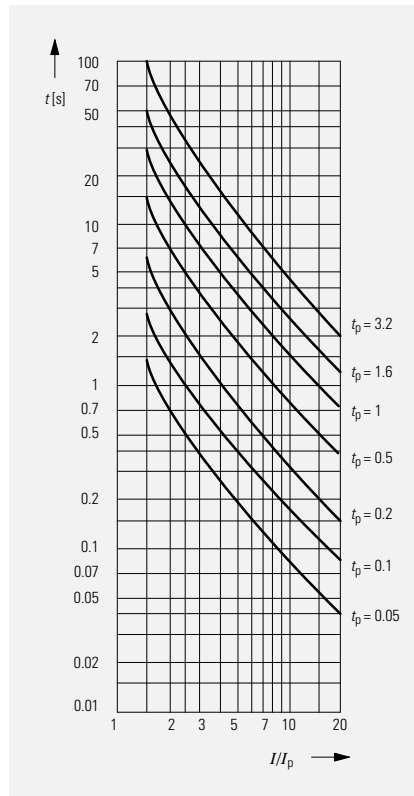


Fig. 5
Tripping time characteristics, very inverse (IEC 255-4)

Overcurrent and Distance Relays

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US Curves

The following inverse-time characteristics have been adapted to the requirements of the US market. The US-version has a "1" in the 11th place of the order number.

$$t = \left(\frac{A}{(I/I_p)^N - 1} + B \right) \cdot D$$

t tripping time
 I_p current setting
 A, B, N parameters

- I -Squared- T Curve (Fig. 7)

$$t = \frac{50.7 D + 10.14}{(I/I_p)^2}$$

t tripping time
 I_p current setting
 D time dial setting

Curve type	A	B	N
Inverse	8.9341	0.17966	2.0938
Short inverse	0.2663	0.03393	1.2969
Long inverse	5.6143	2.18592	1.0000
Moderately inverse	0.054196	0.09328	0.0200
Very inverse	19.138	0.48258	2.0000
Extremely inverse	28.2785	0.12173	2.0000
Definite inverse	0.4797	0.21359	1.5625

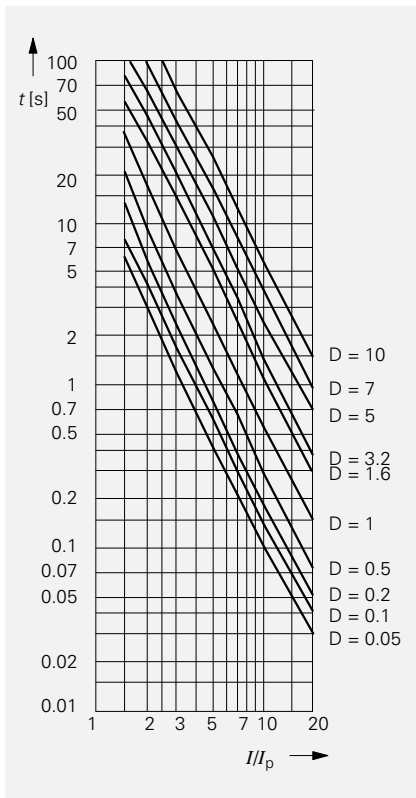


Fig. 7
Tripping time characteristic, I -squared- T curve

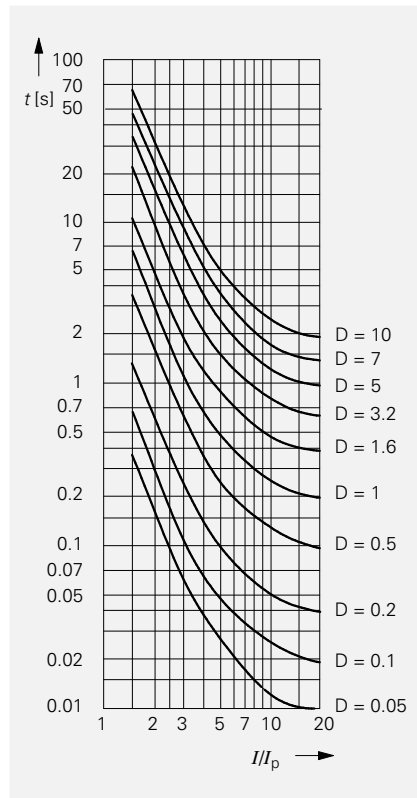


Fig. 8
Tripping time characteristic, inverse

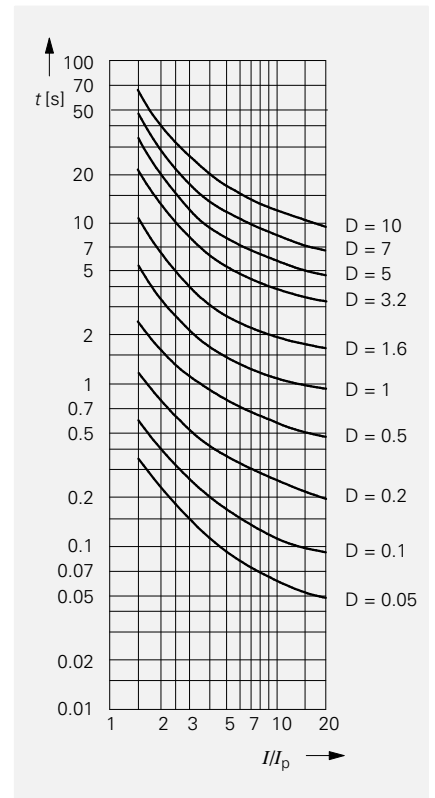


Fig. 9
Tripping time characteristic, moderately inverse

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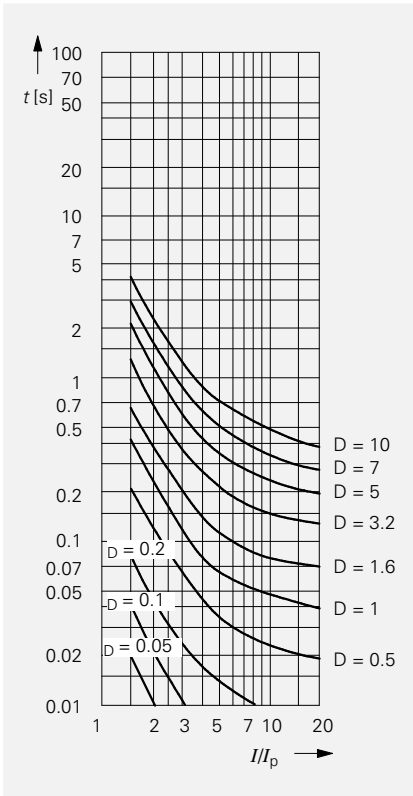


Fig. 10
Tripping time characteristic, short inverse

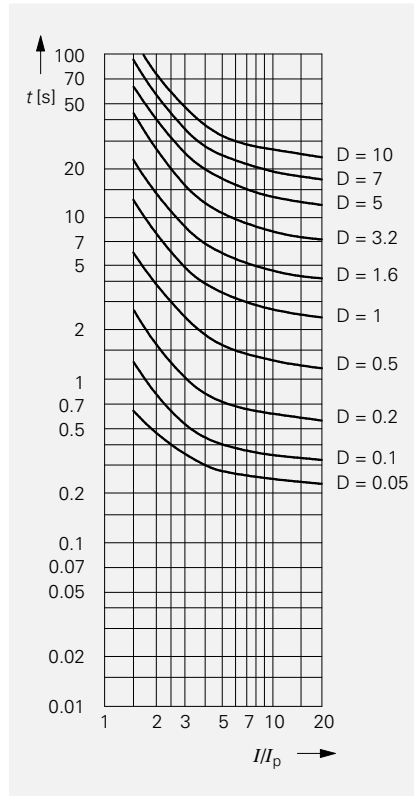


Fig. 12
Tripping time characteristic, long inverse

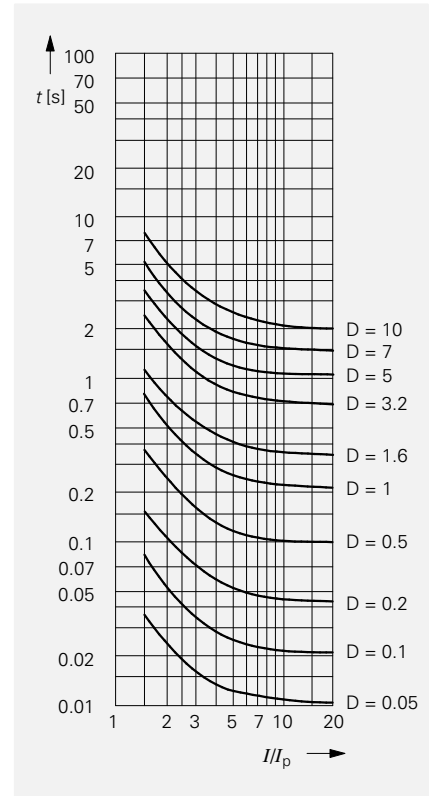


Fig. 14
Tripping time characteristic, definite inverse

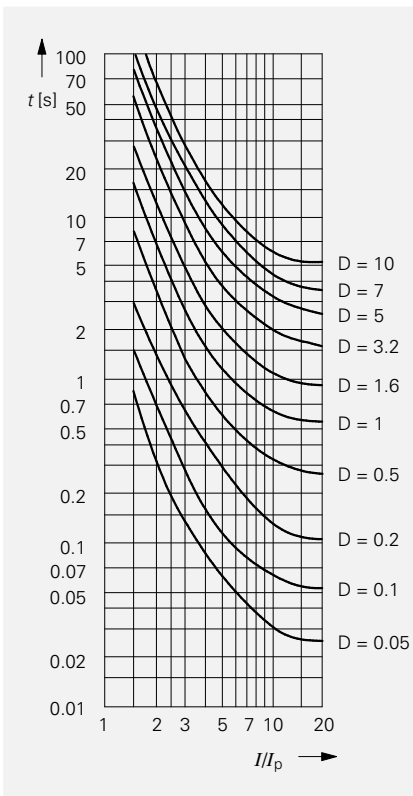


Fig. 11
Tripping time characteristic, very inverse

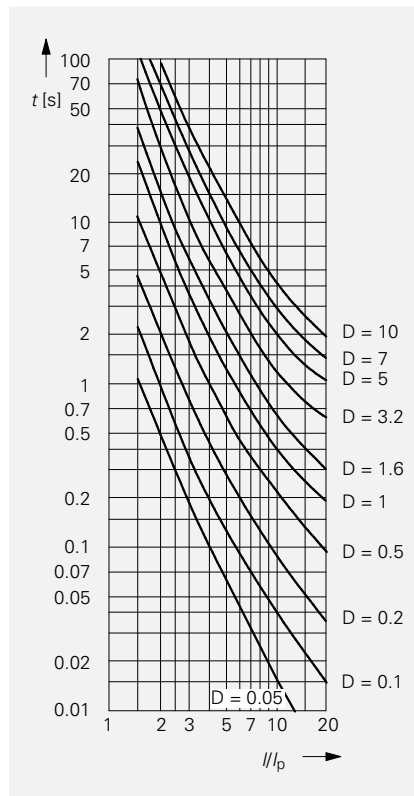


Fig. 13
Tripping time characteristic, extremely inverse

Overcurrent and Distance Relays

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Earth–fault protection

For protection against high–resistance earth–faults in earthed networks, it is possible to monitor the earth current via an independent fourth input current transformer. As for the phase current protection, a choice may be made between the definite–time and the IDMT overcurrent characteristics, both having definite–time high–set overcurrent characteristic.

Intermittent earth–fault protection with firmware V3.1

Intermittent (re–striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short–circuits. During intermittent activity, however, starpoint resistors in networks that are impedance–earthed may undergo thermal overloading. The normal earth–fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.

The selectivity required with intermittent earth faults is achieved by summing the durations of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE} evaluates the rms value, referred to one systems period.

Reverse interlocking

Blocking of any stage (e.g. $I >>$) is possible via a binary input. Thus, the numerical overcurrent protection 7SJ511 can be used as a fast busbar protection in wye connected networks or in open ring networks (ring open at one location), using the reverse interlock principle. This can be used in medium–voltage systems, in power station auxiliary supplement networks, etc., in which cases a transformer feeds from a higher–voltage system onto a busbar with several outgoing feeders.

Thermal overload protection

For the protection of cables or machines, an overload protection with a pre–warning stage for temperature and current is implemented. The temperature of the equipment to be protected is determined using a thermal homogeneous body model that contains energy input to the equipment and energy output to the environment. In this way currents that change over time and pre–loading can be taken into account (overload protection with memory).

Using a parameter, it is possible to select whether the maximum of the phase–related conductor temperature or the mean value of these is to be taken as the determining value. It is also possible to calculate the temperature from the maximum value of the conductor current.

Circuit–breaker failure protection

After the issue of a trip command by the relay or upon the excitation of a digital input by an external protection, the breaker failure current check function is initiated.

If current is still detected after the set time (e.g. in the case of a breaker failure), an alarm relay or a command relay (for breaker failure tripping) is energized.

Inrush stabilization

When switching on a transformer the 7SJ511 can distinguish between inrush and real short–circuits. Inrush is particularly noticeable by its relatively high second harmonic content. In the case of a short–circuit, the second harmonic content is almost non–existent. The harmonic stabilization operates independently for each of the three phases. When using inrush stabilization on one phase, it is also possible to block the remaining phases (cross block). When using inrush detection the pick–up of the high–set element stays active, and the normal overcurrent element is blocked.

Fault recording

The digitized analog values of phase currents and earth current are stored in the event of a fault. The analog values recorded can be transferred to a PC where they can be displayed, analyzed and archived using DIGSI. As an option they can be read out by the SINAUT LSA substation control and protection system.

The serial interface conforms to VDEW/ZVEI. Up to eight fault recordings can be stored. The fault recording buffer is a circulating buffer with a maximum length so that when it is full every new network fault overwrites the oldest recorded fault. A total of 5 seconds are available for the recording duration.

Indications

The 7SJ511 supplies detailed data for analyzing faults and checking states during operation. All the following indications are protected against supply voltage failure, in case there is a battery–backed clock.

- Time
Time can be synchronized via a binary input or the serial interface. The date and time are assigned to all indications.
- Fault indications
The indications of the faults in the device are available with a resolution of 1 ms.
- Operational indications
All indications that do not immediately refer to a fault (e.g. operating or switching actions) are stored in the operational indication buffer (resolution 1 ms).

Circuit–breaker trip circuit test function

The integrity of the circuit–breaker trip circuit can be tested via an operator initiated trip command. This test can be initiated via the front panel keyboard or operator serial interface, but only after input of a code word.

Marshalling of command and alarm/event relays, LEDs and binary inputs

All input/output relays and indicating LEDs may be functionally allocated according to the user's requirements. Several indications can be assigned to one output relay, LED or binary input simultaneously. In this case they are ORed.

Measuring, monitoring and testing functions

The following functions are available for commissioning, operational measurement and monitoring:

- Measuring of currents: I_{L1} , I_{L2} , I_{L3} , I_E
- Monitoring of current sum and current symmetry.
- Tripping test with circuit–breaker.

Overcurrent and Distance Relays

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Technical data (continued)

Definite-time overcurrent protection	Overcurrent	phase $I >$ earth $I_{E >}$	$I/I_N = 0.1$ to 25 $I/I_N = 0.1$ to 25
	High set current	phase I earth I_E	$I/I_N = 0.1$ to 25 $I/I_N = 0.1$ to 25
Inverse-time overcurrent protection	Delay times		0 to 60 s or infinity
	Tolerances		
	Current pick-up value		$\pm 5\%$ of set value
	Time		$\pm 1\%$ or ± 10 ms
	Reset time		approx. 30 ms
	Overcurrent	phase I_p earth $I_{E p}$	$I_p/I_N = 0.1$ to 4 $I_p/I_N = 0.1$ to 4
High set current	phase $I \gg$ (DMT) earth $I_E \gg$ (DMT)	$I/I_N = 0.1$ to 25 $I/I_N = 0.1$ to 25	
Time multiplier t_p		0,05 to 3,2 s	
Pick-up value		$1.1 \times I_p$	
Characteristics according to IEC255-4, paragraph 3.5.2 or BS142 (if 11th place of order number = 0)		normal inverse, very inverse, extremely inverse	
US curves (if 11th place of order number = 1)		I_p : 0.1 to 4, D: 0 to 10s	
Linear current range		$25 \times I_N$	
Tolerances			
Pick-up value		$\pm 5\%$	
Time		$\leq 5\%$ for $2 \leq (I/I_p) \leq 20$ and $t_p = 1$	
Shortest operating time ²⁰¹		<30 ms	

Selection and ordering data

7SJ511 numerical overcurrent-time protection relay	Order No. 7SJ511 □ - □ □ A □ □ - □ □
Rated current at 50/60 Hz AC 1 A 5 A	↑ 1 5
Auxiliary voltage for converter 24/48 V DC 60/110/125 V DC 220/250 V DC	2 4 5
Design structure 7XP2030-1 housing for switchboard mounting 7XP2030-2 housing for switchboard/cubicle mounting with Weidmüller terminals 7XP2030-2 housing for switchboard/cubicle mounting with Weidmüller terminals without glass cover	B C E
Language: country-specific presets German/English; 50 Hz (Europe) English; 60 Hz (USA)	0 1
Real-time clock non-volatile alarm memory software generation Without without version V 2.1x With with version V2.1x Without without version V3 With with version V3	0 1 2 3
Scope of function without intermittend earth-fault protection with intermittend earth-fault protection	0 2
Serial system interface Without With isolated RS 232C (V.24) interface (wire-connected) With integrated fibre-optic connection	A B C

Operating program DIGSI (other languages on request)

DIGSI Version V3 for Windows, full version for 10 PCs and update for 3 years,	German English	7XS5020-0AA00 7XS5020-1AA00
DIGSI Version V3 for Windows, demo-/testversion,	German English	7XS5021-0AA00 7XS5021-1AA00

Documentation

English: Catalog LSA 2.1.3: 7SJ511 numerical overcurrent-time protection relay (Version V3) Manual: 7SJ511 (V3) numerical overcurrent-time protection relay	E50001-K5712-A131-A2-7600 C53000-G1176-C101-1
German: Katalogblatt LSA 2.1.3: Digitaler Überstromzeitschutz 7SJ511 (Version V3) Handbuch: Digitaler Überstromzeitschutz 7SJ511 (Version V3)	E50001-K5712-A131-A2 C53000-G1100-C101-2

Overcurrent and Distance Relays

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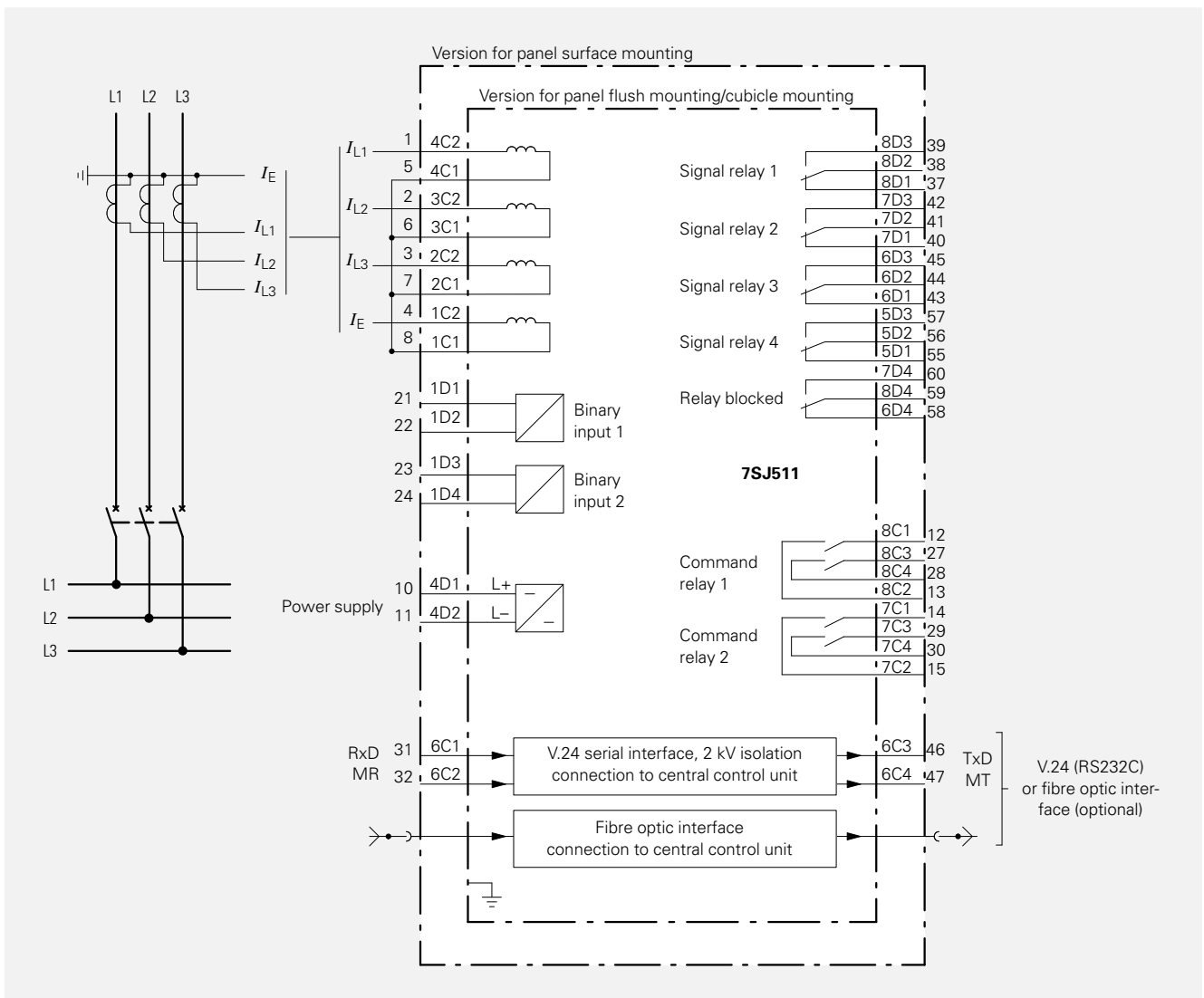


Fig. 15 Connection diagram, 7SJ511 numerical overcurrent–time protection relay

Dimension drawings in mm

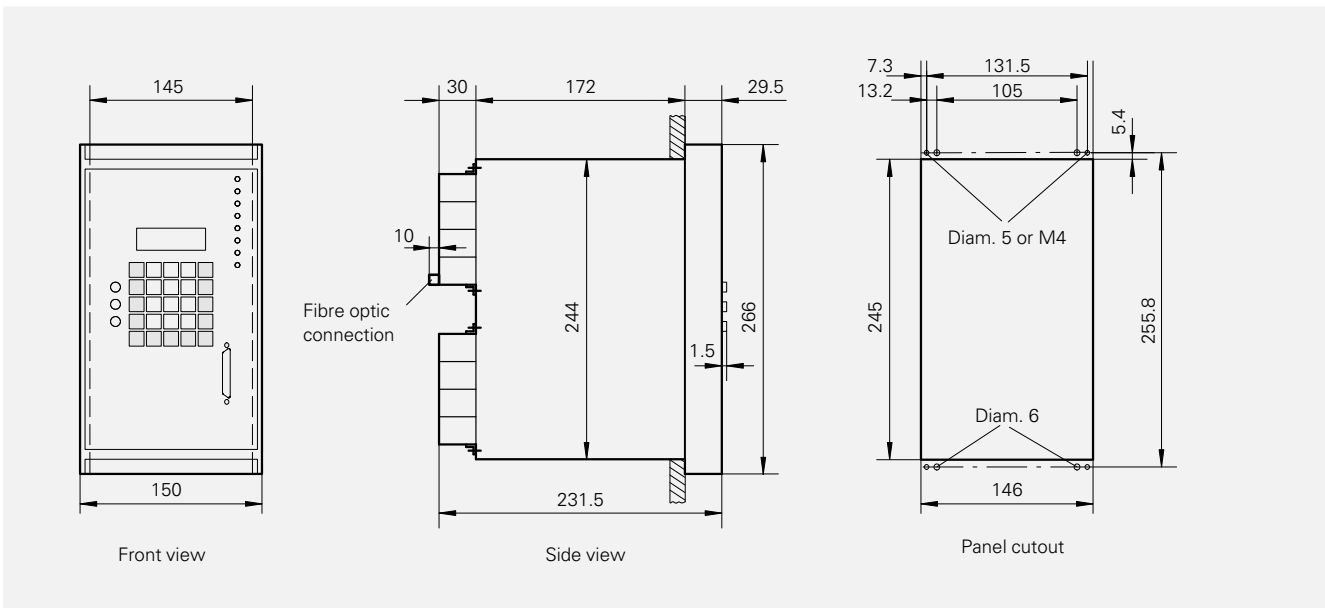


Fig. 16
7SJ511 with housing 7XP2030-2 (for panel flush mounting or cubicle mounting)

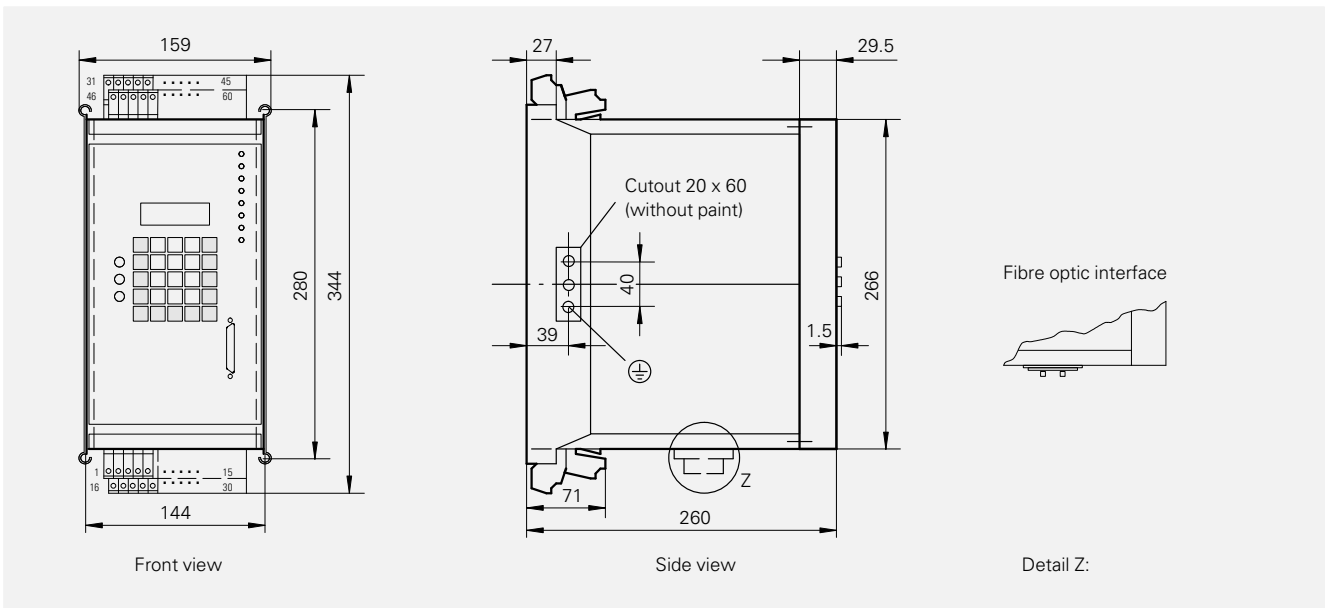


Fig. 17
7SJ511 with housing 7XP2030-1 (for panel surface mounting with two-tier terminals)

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