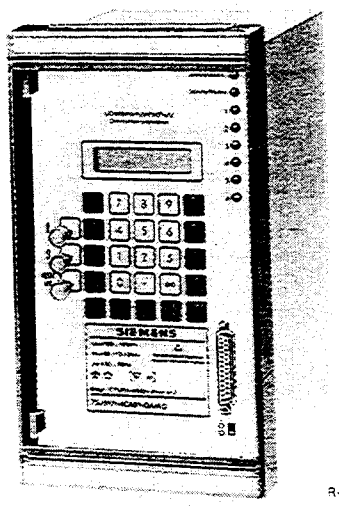
SIEMENS

Digital overcurrent-time protection relay 7SJ512



R-R2-024

Fig. 1
Digital overcurrent-time protection relay 7SJ512

Application

The 7SJ512 is a digital relay used for definite-time or inverse definite minimum time (IDMT) overcurrent protection in medium-voltage distribution systems. It is also used in back-up protection schemes applied to lines, transformers and generators.
The system which the 7SJ512 is protecting, can be solidly earthed, unearthed or compensated. The relay can be implemented in conventional switchgear as well as with the substation control system LSA 678.

Construction

Within its compact construction, the device contains:

- Inputs and circuitry necessary for digital capture and evaluation of measureands
- Operator panel with display field
- Event/alarm and trip/command output contacts
- Binary input options
- Serial interfaces
- Power supply converter (DC/DC converter).

The device can be supplied in two case variations. The variant for flush mounting or mounting in a cubicle has rear connection terminals. The model for surface mounting is supplied with two-tier terminals accessible from the front.

Implemented functions/features

The following functions are available:

- Definite-time/IDMT overcurrent protection
- Reverse interlocking (busbar protection scheme)
- Circuit-breaker failure protection
- Trip test, reclose test
- Earth-fault protection
- Sensitive earth-fault protection and directional function using the sensitive earth-current input for compensated and isolated networks, as well as high impedance starpoint earthing
- Auto-reclose
- Optional directional element
- Inrush stabilization
- Dynamic parameter switching.

Mode of operation

With the application of a powerful microprocessor and digital filtering, the influence of high frequency transients, displacement voltages and current components can be suppressed to a large degree.

When the definite time characteristic is selected, the measured values are calculated using Fourier analysis. When using the inverse definite minimum time characteristic, either effective (r.m.s.) values or fundamental values (from a Fourier analysis) can be selected for grading.

Serial interfaces

The relay is supplied with two serial interfaces.

The RS 232 serial interface on the front panel of the relay is suited for communication with a PC. A software package is available for convenient parameter setting, relay commissioning, transfer and evaluation of fault operation details, and retrieval of the fault wave forms stored in the relay.

The system interface on the rear of the relay is optionally available as a fibre optic interface for connection to either the substation control system LSA 678 or to a central protection unit.

Settings

All setting parameters can be entered via the integrated operator panel or via a PC. The settings are stored in a non-volatile memory to insure that they are secure even during interruption of the DC supply voltage.

Self monitoring

All important hardware and software components are monitored continuously. Any irregularities in the hardware or program sequence are immediately detected and alarmed. As a result, a very high security, reliability and availability of the protection relay is achieved.

Overcurrent-time protection

The function is based on a phase-selective measurement of the three phase currents and the earth current. According to the specific requirement, either the definite-time or the IDMT overcurrent mode can be selected. Both the definite-time and the IDMT protection modes have two levels of operation, i.e. apart from the overcurrent element ($I>$), a high-set element ($I\gg$) is also provided.

The following IDMT characteristics are available in the relay (according to BS 142 or IEC 255-4):

Normal inverse

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

Very inverse

$$t = \frac{13.5}{I/I_p - 1} \cdot t_p$$

Extremely inverse

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

User specific

Characteristics defined by 60 current/time pairs, entered by the user

Only for earth-faults:

Long-time earth-fault

$$t = \frac{120}{I/I_p - 1} \cdot t_p$$

Residual dependent time

$$t = 5.8 - 1.35 \cdot \ln I/I_p$$

t tripping time
t_p time multiplier
I fault current
I_p current setting

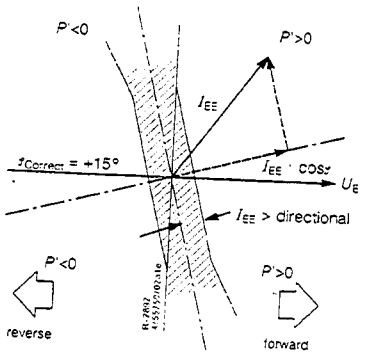


Fig. 2
Directional determination using cosine measurements

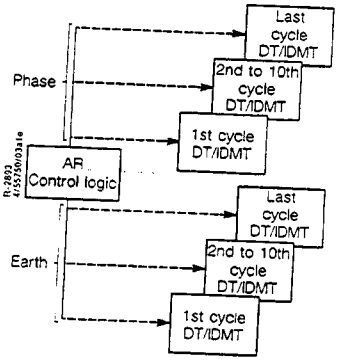


Fig. 3
Auto-reclose function

Sensitive earth-fault protection

A sensitive earth-fault current input is provided for isolated and compensated networks. The sensitive earth current I_{EE} and the displacement voltage U_e are measured and used to determine the direction of the fault current.

The designation of the fault direction is achieved using a reactive power measurement (a sine measurement with imaginary earth current for isolated networks) and an active power measurement (a cosine measurement with real earth current for compensated networks). The influence of harmonics and the DC component are removed through filtering. The earth-fault detection can be directly allocated to alarm contacts or trip contacts. To adapt to special network conditions, the directional characteristic can be adjusted with a correction angle (see Fig. 2). The directional determination made by the relay when using the correction angle results from the sign of the active power P' (the power as defined by the directional characteristic). In order for the relay to decide on the direction of a fault, the directional earth element must first pick up.

The sensitive earth-fault function can be used in the following four ways:

- Sensitive earth-fault (SEF) overcurrent ($I_{EE}>$) with definite-time overcurrent or with IDMT using the following characteristics:
  Normal inverse
  Very inverse
  Extremely inverse
  Long-time earth-fault
  Residual dependent time
  User specific
- SEF "high-set" overcurrent ($I_{EE}\gg$) using definite time
- Directional earth-fault protection with instantaneous and high-set instantaneous overcurrent
- Tripping due to displacement voltage.

Auto-reclose function

The 7SJ512 can be equipped with an auto-reclose function. The relay trips three-pole and can make up to ten reclose attempts, one rapid auto-reclose (RAR), and up to nine delayed auto-reclosures (DAR). If the fault still exists after the last set reclose attempt, the relay trips without reclosing (see Fig. 3).

The following functions are possible:

- Three-pole reclose with every type of fault
- Separate settings for ph-ph and ph-gnd faults
- Multiple reclose attempts (1 RAR, and up to 9 DARs with different dead times during the individual attempts)
- Separate protection configurations and reclose triggers for the RAR and DARs for the following functions:
  - High-set phase overcurrent
  - Normal phase overcurrent (directional or non-directional)
  - High-set earth-fault
  - Normal earth-fault (directional or non-directional)
  - Second stage sensitive earth-fault ("high-set" sensitive earth element)
  - Sensitive earth-fault (directional or non-directional)
- Blocking of reclosing with binary input and high-set pick-up.

Directional element (option)

The directional element of the 7SJ512 is phase-selective and separate for the earth-fault protection. These directional earth-fault and phase overcurrent elements work in parallel to the non-directional (overcurrent and high-set overcurrent) elements. The non-directional overcurrent element serves as a back-up protection. The following functions are possible with the directional option:

- Independently set tripping direction for phase and earth overcurrent
- Definite-time or IDMT characteristics selectable for directional tripping
- Calculation of the displacement voltage from the line voltage without using an open delta transformer
- Directional determination using the measured currents and the sound phase line-line voltages.
  The corresponding phase voltage is dependent upon the type of fault that the relay detects. The relay determines the type of fault by using voltage memory or actual voltage.

Inrush stabilization

When switching on a transformer the 7SJ512 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.

Dynamic parameter switching

With the help of a binary input, the pick-up values of the relay can be quickly switched to a new set of values. It is thereby possible to match certain parameters to specific system conditions, even during a fault. The following fault detectors can be changed in this manner:

- High-set element for phase and earth
- Normal overcurrent element for phase and earth
- High-set element for sensitive earth
- Normal overcurrent element for sensitive earth.

Parameter set switching

With the help of a binary input, the integrated operator panel or with the PC, 4 completely separate sets of parameter settings can be switched in or out. When changing a network configuration with a contact, it is possible to simultaneously match the relay's parameter settings via a binary input on the relay.

Disturbance recording

Digital measured values for phase currents, earth current, line voltages and displacement voltages are stored starting 100 ms (83 ms in 60 Hz systems) before fault detection until the end of the fault or until 3 s (2.5 s in 60 Hz systems) of fault buffer has been filled. The fault data has a 1 ms (0.83 ms in 60 Hz systems) resolution.
Time markers for specific relay reactions, such as general fault detection, trip and reset aid in the analysis of disturbances. A disturbance recording saved in the relay will be overwritten by a new fault's disturbance recording. Therefore the most recent fault is always stored in the relay. The disturbance data can be transferred to the substation control system LSA 678 or a PC for evaluation.

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

The relay is supplied with a number of trip/command and alarm/event output relays. For user specific alarms, flags and trips, all command relays, signal relays and LEDs are freely marshallable. A number of annunciations can be grouped together to create a special annunciation for flags, alarms and trips. The LEDs can be allocated to show instantaneous conditions (self-resetting), or to stay lit until the LEDs are manually reset (latched). All LED information, which is set to remain lit until the LEDs are manually reset (latched), are restored at power-up if the relay loses auxiliary power. All binary inputs can also be freely marshalled.

Measured values and watchdog functions

A large number of measured value and monitoring functions are integrated in the 7SJ512:

- Monitoring of the phase rotation
- Operational measurements of I_{L1}, I_{L2}, I_{L3}, (active I_{EE} and reactive I_{EE})
- Operational measurements of U_{L1}, U_{L2}, U_{L3}, U_E
- Active, reactive and apparent power measurements
- Frequency measurement
- Trip monitoring with the circuit-breaker
- cos phi measurement.

The relay saves an events list (operational record), fault reports and a wave form for analysis of disturbances. All of the following alarms in memory are protected against loss of the auxiliary supply.

- Time
  The relay contains an internal clock with battery back-up which can be synchronized using a binary input. All alarms are time and data stamped.
- Fault reports
  The fault reports of the last three disturbances are always available.
- Operational reports
  All annunciations which do not belong to the fault reports are saved in the operational reports.
- Earth-fault recording
  If the sensitive earth-fault element is enabled, this record will be available for each earth fault.
- Switching statistics
  The number of three-pole trips, RARs and DARs as well as the sum of currents interrupted in each phase are indicated.
- Automatic display on the LCD
  An operating mode exists, where 2 operational measured values can be displayed on the LCD. These values are regularly updated by the relay. After a fault, two user-selectable fault event data can be automatically displayed on the LCD.

Digital overcurrent-time protection relay 7SJ512

Technical data

Input circuits	Rated current I_N	1 A or 5 A
	Rated voltage U_N	100 V to 125 V
	Rated frequency f_N	50 Hz or 60 Hz
	Thermal overload capability in voltage path, continuous	140 V
	in current path, continuous	4 x I_N
	1 s	100 x I_N
	in current path for sensitive earth-fault detection, continuous	15 A
	10 s	100 A
	1 s	300 A
	Dynamic overload capability (half cycle)	250 x I_N
	Burden, voltage inputs	Approx. 0.5 VA
	current inputs at $I_N = 1$ A	Approx. 0.1 VA
	at $I_N = 5$ A	Approx. 0.2 VA
	Earth-fault detection at 1 A	Approx. 0.3 VA
Voltage supply via integrated DC/DC converter	Rated auxiliary voltage U_H/permissible tolerance	24, 48 V DC/ 19 to 56 V DC 60, 110 V, 125 V DC/ 48 to 144 V DC 220, 250 V DC/ 176 to 288 V DC
	Max. ripple at rated voltage	≤ 12 %
	Power consumption, quiescent	Approx. 12 W
	energised	Approx. 23 W
	Max. bridging time during loss of auxiliary voltage	≥ 50 ms for $U_H \geq 110$ V DC
Binary inputs	Number, without directional option	8 (marshallable)
	with directional option	5 (marshallable)
	Voltage range	24 V to 250 V DC
	Current consumption independent of operating voltage	Approx. 2.5 mA
Alarm/event contacts	Number of relays	8 (marshallable)
	with 1 C/O contact each	6 (marshallable)
	with 1 NO contact each	2 (marshallable)
	Alarm/event relay with C/O contact	1
	Switching capacity make/break	20 W/VA
	Switching voltage	250 V AC/DC
	Permissible current, continuous	1 A
Command contacts	Number of relays, with 2 NO contacts each	2 (marshallable)
	with 1 NO contact each	2 (marshallable)
	Switching capacity make	1000 W/VA
	break	30 W/VA
	Switching voltage	250 V AC/DC
	Permissible current continuous	5 A
	0.5 s	30 A
LEDs	Ready indication green	1
	Blocked indication red	1
	Marshallable LEDs red	6
Serial interfaces	Operator interface	Non-isolated, 25-pole D-type subminiature front port for connection to a PC
	Baud rate	1200 Bd to 19200 Bd
	System interface	Potential-free interface for connection to a central unit
	Baud rate	4800 Bd to 19200 Bd
	Fibre optic connection	Integrated FSMA connector for connection to fibre optic cables
	Optical wavelength	820 nm
	Permissible attenuation	Max. 8 dB with glass fibre 62.5/125 µm
	Distance	Max. 2 km
Construction of unit	Case, dimensions	7XP20, see dimension drawings
	Weight flush mounting/cubicle mounting	Approx. 9.5 kg
	surface mounting	Approx. 11 kg
	Degree of protection according to DIN 40050	IP 51
Standards	DIN VDE 0435, Part 303 and IEC 255-5 or IEC 255-6	–
Insulation tests	High-voltage test	2 kV (rms), 50 Hz; 1 min or alternatively 2.8 kV DC; 1 min
	Impulse voltage test	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative shots at intervals of 5 s

Technical data (contin.)

Disturbance tests	High-frequency test (1 MHz test) IEC 255-22-1, Class III		2.5 kV (peak); 1 MHz; $\tau = 15$ µs; 400 shots per second; curation 2 s
	Electrostatic discharge (ESD test) IEC 255-22-2, Class III		8 kV (peak); 5/30 ns; 10 positive discharges
	Electromagnetic fields (Radiated electr. magn. field test) IEC 255-22-3, Class III		Frequency 27 to 500 MHz: 10 V/m
	Fast transient test IEC 255-22-4, Class III		2 kV (peak); 5/50 ns; 5 kHz; 4 mJ per impulse; 1 min per polarity
Radio interference	DIN VDE 0871, limit class B		–
Climatic conditions	Permissible ambient temperature	in service	– 5° C to +55° C
		during storage	–25° C to +55° C
		during transport	–25° C to +70° C
	Humidity rating		Code letter F to DIN 40040, condensation not permissible
Mechanical stress tests DIN 40046	Permissible mechanical stress	in service	10 to 60 Hz: 0.035 mm amplitude 60 to 500 Hz: 0.5 g acceleration
		during transport	5 Hz to 8 Hz: 7.5 mm amplitude 8 Hz to 500 Hz: 2 g acceleration
Setting ranges			
Definite-time overcurrent protection	Overcurrent phase $I>$ earth $I_E>$		$I/I_N = 0.1$ to 25 $= 0.05$ to 25
	High-set current phase $I\gg$ earth $I_E\gg$		$I/I_N = 0.1$ to 25 $= 0.05$ to 25
	Delay times		0 to 60 s or infinity
	Tolerances		
	Current pick-up value		± 5% of set value
	Time		± 1% or ± 10 ms
	Reset time		Approx. 30 ms
Inverse time overcurrent protection	Overcurrent phase $I>$ earth $I_E>$		$I_p/I_N = 0.1$ to 4 $I_{Ep}/I_N = 0.05$ to 4 $I/I_N = 0.1$ to 25 $= 0.05$ to 25
	High-set current phase $I\gg$ earth $I_E\gg$		
	Time multiplier t_p		0.05 to 3.2 s
	Pick-up value		1.1 x I_p
	Characteristics according to IEC 255-4, Section 3.5.2 or BS 142		Normal inverse, very inverse, extremely inverse, $I/I_p = 1$ to 20, definite time characteristic above 20 x I_p
	User specific characteristic		input of 60 current/time pairs
	Additional characteristics for earth faults		
	Long time inverse		$I/I_p = 1$ to 20, definite time characteristics above 20 x I_p
	Pick-up value		1.1 x I_p
	Residual dependent time		$I/I_p = 1$ to 40, definite time characteristic above 40 x I_p
	Pick-up value		k x I_p, k = 1 to 4
	Linear current range		25 x I_N
	Tolerances		
	Pick-up value		± 5%
	Time		≤ 5% for $2 \leq (I/I_p>) \leq 20$ and $t_p = 1$
Earth-fault detection	Earth-fault detection with displacement voltage $U_E>$		3 to 130 V
	Faulted phase indication (only with directional option)		
	U_{PH-E} < the faulted phase		10 to 100 V
	U_{PH-E} > the healthy phase		10 to 100 V
	Measuring tolerance according to DIN VDE 0435, Part 303 (for sinusoidal quantities)		≤ 5% of set value
	Directional determination		
	Measuring principle		Active/reactive power calculation
	Earth-fault current $I_{EE}>/I_{EEP}$ (Active and reactive)		3 mA to 1600 mA
	Angle correction for core balance CT error		0 to 5° for 2 CT operating points
	Adjustment of directional characteristic		–45 to +45°
	Measuring tolerance according to DIN VDE 0435, Part 303 (for sinusoidal quantities)		≤ 10% of set value

Technical data (contin.)

Directional elements	Directional definite-time and IDMT overcurrent protection with back-up non-directional high-set element	
	Pick-up for definite-time phase	I/I_N = 0.1 to 25
	definite-time earth	= 0.05 to 25
	inverse time phase	I_P/I_N = 0.1 to 4
	inverse time earth	= 0.05 to 4
	Characteristics according to IEC 255-4, Section 3.5.2 or BS 142	Normal inverse, very inverse, extremely inverse
	Additional characteristics for earth faults	Long time inverse, residual dependent time
	Directional determination	
	Phase I_{L1}	With I_{L1} and $U_{L3} - U_{L2}$
	Phase I_{L2}	With I_{L2} and $U_{L1} - U_{L3}$
	Phase I_{L3}	With I_{L3} and $U_{L2} - U_{L1}$
	Earth I_E	With I_E and $U_E/U_{L1} + U_{L2} + U_{L3}$
	Times	
	Shortest tripping time	Approx. 30 ms
	Reorientation time after current reversal	Approx. 30 ms
	Tripping time delay	0 to 320 s
	Timer tolerance	≤ 1% of set value or 10 ms
	Tolerances	
	Current pick-up value	5% of set value
	Time	≤ 5% for $2 \leq (I/I_E>) \leq 20$ and $1\text{ s} \leq t_{IE} \leq 30\text{ s}$
Auto-reclose function	Number of possible auto-reclosures, 3-pole	1 RAR (rapid auto-reclose), and up to 9 DARs (delayed auto-reclose)
	Configuration modes for phase faults	
	Initiation possible with	High-set overcurrent $I\gg$
		Normal overcurrent definite time $I>$, or inverse time I_p non-directional
	with directional option	Normal overcurrent definite time $I>$ or inverse time I_p directional
	Configuration modes for earth faults	
	Initiation possible with	High-set overcurrent $I_E\gg$
		Normal overcurrent definite time $I_E>$ or inverse time I_{EP} non-directional
	with directional option	Normal overcurrent definite time $I_E>$ or inverse time I_{EP} directional
	with sensitive earth-fault option	High-set overcurrent $I_{EE}\gg$, directional or non-directional
		Normal overcurrent definite time $I_{EE}>$ or inverse time I_{EEp} directional or non-directional
	Action time, dead time RAR	0.01 s to 320 s
	Dead time DAR	0.01 s to 1800 s
	Reclaim time	0.5 s to 320 s
	Close command duration	0.01 s to 320 s
Disturbance recording	Measured values	i_{L1}, i_{L2}, i_{L3}, i_E, u_{L1}, u_{L2}, u_{L3}, u_E
	Trigger	Trip, fault detection, binary input
	Recording period (50 Hz)	−100 ms to max. 2900 ms
	Recording period (60 Hz)	−83 ms to max. 2417 ms
	Holding time	Until next fault
Additional functions	Operating values for	
	Current	I_{L1}, I_{L2}, I_{L3}, I_E
	Voltage	U_{L1}, U_{L2}, U_{L3}, U_E
	Power	Active/Reactive/Apparent
	Frequency	f
	Power factor	cos φ
	Active/Reactive I_{EE}	I_{EEw}, I_{EEb}
	Effective range — Current	10 to 240 % I_N
	Voltage	10 to 120 % U_N
	Power	10 to 120 % P_N
	Tolerance	≤ 2 % of respective rated value

Digital overcurrent-time protection relay 7SJ512

Selection and ordering data

Digital overcurrent-time protection relay 7SJ512	Order No. 7SJ512 □ – □ □ A 0 1 – □ □ A 0
Rated current at 50/60 Hz AC	
1 A	1
5 A	5
Rated auxiliary voltage U_H for built-in converter	
24, 48 V DC	2
60, 110, 125 V DC	4
220, 250 V DC	5
Construction	
for panel surface mounting	B
for panel flush mounting/cubicle mounting	C
Version	
AR + SEF	0
AR + SEF + DO	1
Serial system interface (isolated, electrical interface on request)	
Without	A
With integrated fibre optic interface (820 nm)	C

AR: Auto-reclosing
SEF: Sensitive earth-fault detection
DO: Directional option

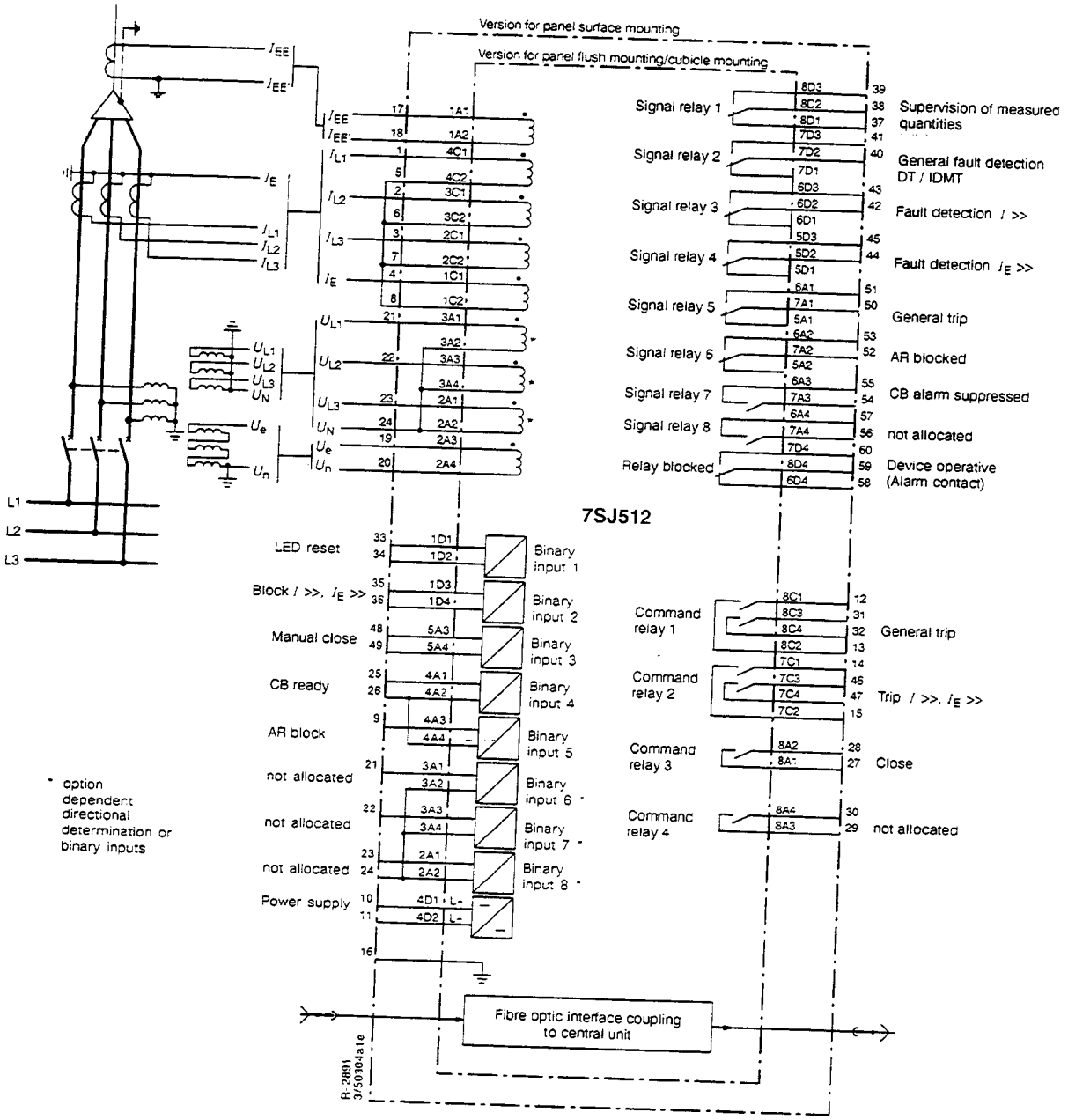


Fig. 4
Connection diagram, digital overcurrent-time protection relay 7SJ512

Dimension drawings in mm

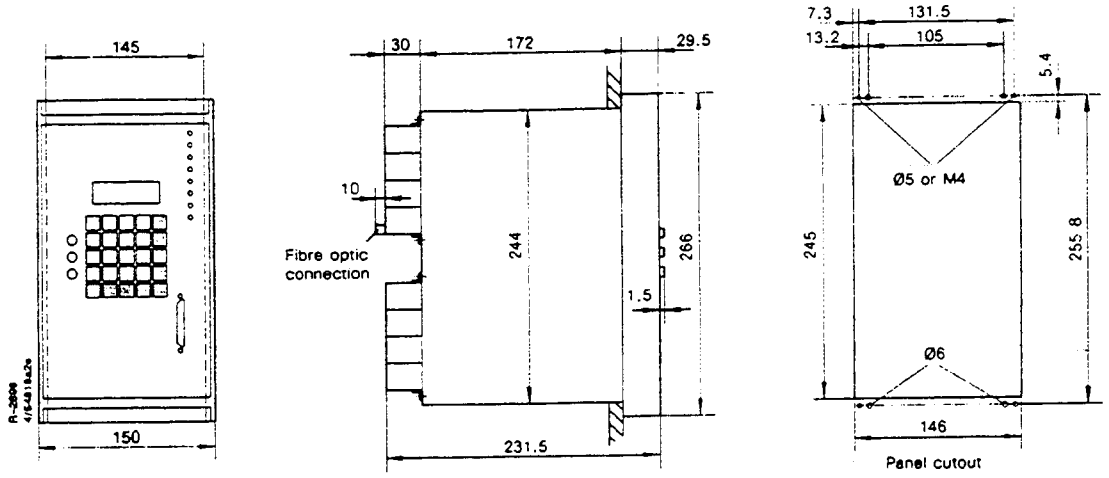


Fig. 5
7SJ512 with housing 7XP2030-2 (for panel flush mounting/cubicle mounting)

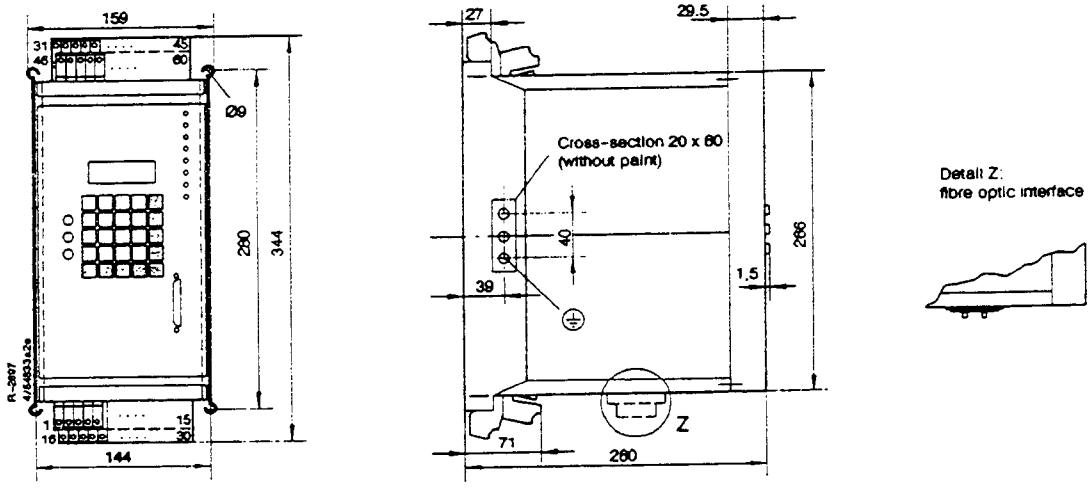


Fig. 6
7SJ512 with housing 7XP2030-1 (for panel surface mounting with two-tier terminals)

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