

## 7SD502 Line differential protection with two pilot-wires



Fig. 1  
7SD502 line differential protection

### Application

The 7SD502 line differential protection is a fast and selective differential protection unit for cables and overhead lines.

It is the successor of the 7SD22 and 7SD76 static differential protection. Combination with 7SD76 or 7SD22 is not possible, i.e. 7SD502s must be used at both ends of the line. The connection between 7SD502s is made via a balanced pair of pilot-wires, i.e. existing pilot-wire connections can be used.

### Design

Within its compact dimensions the unit contains all components for analog value acquisition and evaluation, the summation current transformer, the pilot-wire trimming resistors, the operating and display panel, the indication and command outputs, binary inputs and the auxiliary voltage converter.

The unit can be supplied in two different housings. The one for flush mounting in a panel or cubicle has connections at the rear. The other for surface mounting on a panel has screw terminals accessible from the front.

### Method of operation

The summation current transformer integrated in the housing of the 7SD502 permits the connection of any secondary currents of the primary current transformer (see Fig. 2). The three primary windings of the summation current transformer have the winding ratio 2 : 1 : 3. With  $1 \times I_N$  as the three-phase, balanced short-circuit current, the secondary single-phase current  $I_{M1}$  of the summation current transformer is 20 mA. The summation current transformer principle gives different short-circuit sensitivities depending on the connection, e.g. different weightings can be assigned to the earth fault.

The 7SD502 acquires the secondary pulsating current  $I_{M1}$  of its own substation, the current  $I_a$  via the pilot-wires and the current  $I_b$  in the trimming resistor  $R_b$ . The pulsating current  $I_{M2}$  of the remote station is calculated from these quantities. With three-end protection, the boosting current  $I_{b00}$  is acquired at the third line end and included in the calculation.

The line is shut down if the protection system finds that the differential current  $I_{diff}$  obtained by adding  $I_{M1}$  and  $I_{M2}$  indicates a short-circuit in the protection zone.

Digital measured-value processing with consistent evaluation of the fundamental of the measured quantities largely eliminates the influence of high frequency transient phenomena, transient DC components and differing current transformer saturation.

### Features

- Selective short-circuit protection for overhead lines and cables
- Acquisition of pulsating current behind the summation current transformer and of currents via the pair of pilot-wires
- Sensitivity to single-phase faults under rated current
- 100 % protection against all types of short-circuit within the protection zone
- Circuit-breaker intertripping and remote tripping of the remote station
- Integrated pilot-wire monitoring
- Software-controlled adaptation of the sensitivity of the differential protection to different wire resistances. This makes pilot-wire trimming unnecessary
- Overload protection with thermal characteristic
- Two-stage definite-time/dependent time overcurrent protection as standby
- Real-time clock and permanently stored status and fault indications in the event of auxiliary voltage failure. VDEW/ZVEI interface to the control system
- Protection of three-end pilot-wires with two devices at each end of the line is possible.

# Differential Relays

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### Serial interfaces

The device is equipped with two serial interfaces.

The operating interface on the front panel is suitable for the connection of a WINDOWS capable PC. The DIGSI operating and analysis software allows easy setting, fault recording evaluation and commissioning. The system interface is an 820 nm fibre-optic interface for linking to the SINAUT LSA substation control and protection system or a protection master unit (protocol to IEC 870-5-103 recommendation). The operator with DIGSI can also be connected to the system interface.

### Parameter setting

Using the integrated operating and display panel or a PC all parameter settings can be made under user guidance. The parameters are written to a non-volatile memory so that they are retained even after the supply voltage has been switched off.

### Self-monitoring

The hardware and software are constantly monitored and irregularities are detected and signalled immediately. This considerably enhances safety, reliability and availability.

### Differential protection for lines and cables

The differential protection of the 7SD502 contains the following functions:

- The summation current transformer principle makes the sensitivity dependent on the type of error. Single-phase errors are dealt with higher priority and weighted with higher sensitivity because of the dimensioning of the summation current transformer.
- For differential protection, an overcurrent enable can be parameterized. The close/open command of the differential protection is only given when a settable value for the pulsating current  $I_{M1}$  is exceeded.
- Response characteristic for three-phase, balanced short-circuit current as shown in Fig. 3. The response value  $I_{diff>}$  and the gradient of the characteristic branches are parameterizable.
- Calculated compensation of the pilot-wire capacity.
- High stability with different current transformer saturations during an external short-circuit because of the use of an integrated saturation detector.
- Insensitive to DC components and high-frequency transient phenomena because the fundamental is filtered out of the measured quantities using digital filters.

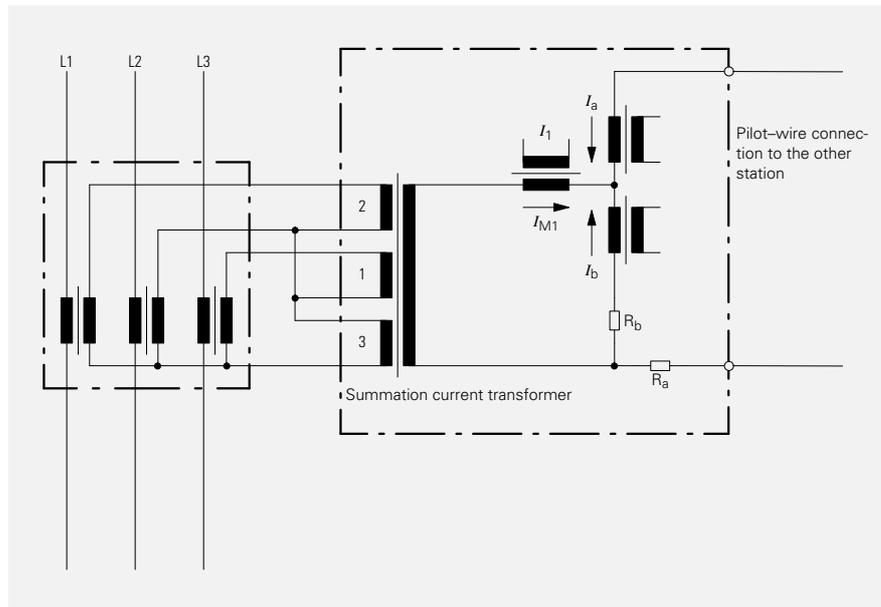


Fig. 2  
Connection principle of the 7SD502

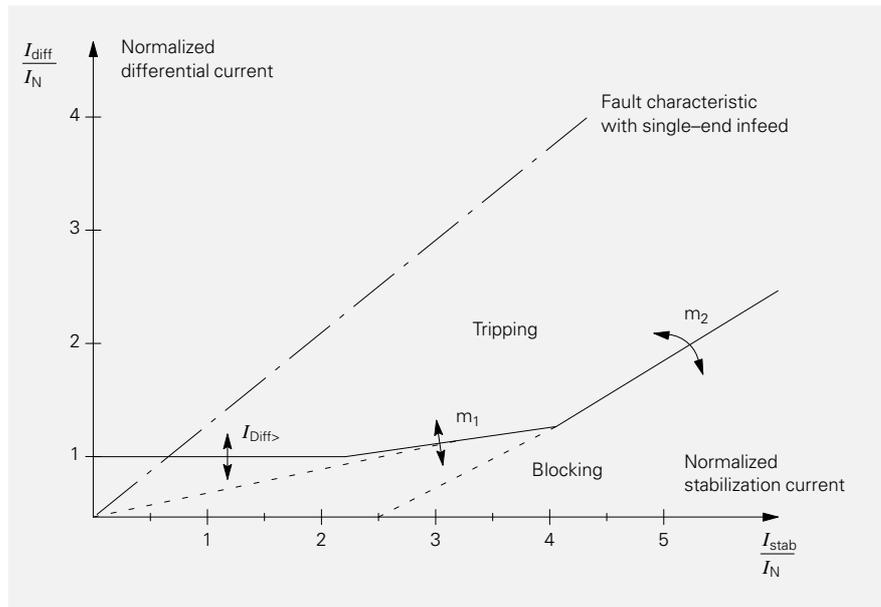


Fig. 3  
7SD502 line differential protection

### Pilot-wire connection to remote station/pilot-wire monitoring

The connection to the remote station is made using a balanced pair of wires (e.g. telephone wires). The pilot-wire connection is part of the differential protection. For this reason the pilot-wires are constantly monitored by a pilot-wire monitoring function integrated into the 7SD502. To achieve this, 2 kHz pulses with a defined pulse width ratio are transmitted to the remote station via the pilot-wires. The pulse length and pulse level are evaluated using a filter processor so

that any break in the pilot-wire is detected reliably. Both stations have the same priority and alternate between functioning as a sender and receiver.

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### Circuit-breaker intertripping and remote tripping

It is possible to open the circuit-breaker at the other end if the infeed conditions at that end are weak. Remote tripping can also be initiated by a circuit-breaker standby protection relay or transformer differential protection relay linked via a binary input.

For both functions the integrated pilot-wire monitoring function is required. It works in both directions, but not at the same time.

### Thermal overload protection

Thermal overload protection with a pre-warning stage is integrated for the thermal protection of cables. It functions with pulsating current acquired behind the summation current transformer. This pulsating current is an image of the three-phase balanced load in normal or overload operation.

The tripping time characteristics (see Fig. 4) are exponential functions to IEC 255-8 and they take account of heat loss due to the service current and the accompanying drop in temperature of the cooling medium. The previous load is therefore taken into account in the tripping time on overload. A settable warning stage can output a current or temperature-dependent indication before the tripping point is reached.

### Standby overcurrent-time protection

An overcurrent-time protection is used as standby protection with a choice of definite-time or inverse-time characteristics. The protection has two stages, i.e. an overcurrent stage ( $I>$ ) and a high-current stage ( $I>>$ ). The high-current stage always has a definite-time characteristic. Both stages can be disabled via a binary input. The response value of the standby protection is derived from the pulsating quantity so that there are different response values depending on the fault.

### Fault recording

The digital measured values of the pulsating current of the local station, of the remote station, and of the second remote station in a three-ended pilot-wire scheme are stored along with the differential and stabilization current in the event of a fault. The current progressions can either be directly transferred to a PC or read out by the SINAUT LSA station control system. If the VDEW/ZVEI interface to the control system is used, up to eight fault recordings are stored. The fault recording buffer is a circulating buffer with a maximum length so that the oldest fault recordings are overwritten if a further network fault occurs after the buffer is full.

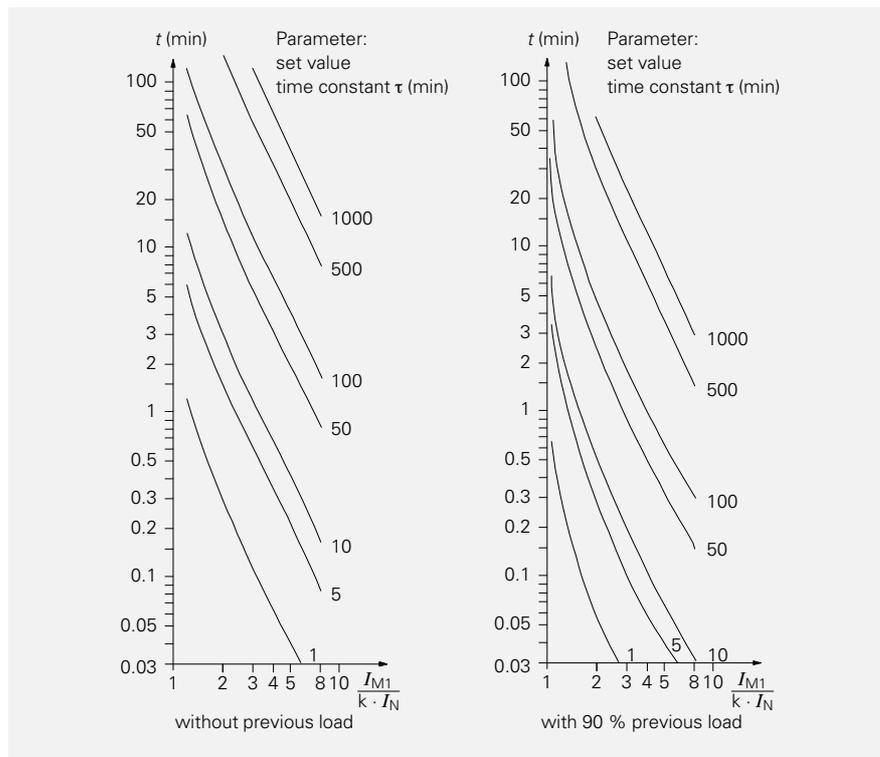


Fig. 4  
Tripping time characteristics of the overload protection function

### Indications

The 7SD502 unit provides detailed data for the analysis of faults and for checking statuses. All the following indications are backed up against supply voltage failure.

- Clock time  
As a standard a battery-backed clock is used that can be synchronized via a binary input or the system interface. A date and time is assigned to all indications.
- Fault indications  
Fault indications are available for faults stored in the unit.
- Status indication  
All indications that are not directly related to a fault are stored in the status indication buffer.

### Marshalleable command and alarm relay, LEDs, binary inputs

All input/output relays including the LEDs are user-specific and can be marshalled independently. Several events can be programmed simultaneously on one input/output relay.

### Commissioning

The following commissioning aids are provided:

- Display of pulsating currents the differential and stabilization current with absolute value and phase.
- Software-controlled level alignment of the pilot-wire monitoring function and testing of the circuit-breaker intertripping and remote tripping command functions.
- Measuring of the loop-resistance and capacity of the pilot-wires.

# Differential Relays

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### Technical data

<b>Input circuits</b>	Rated current $I_N$ Rated frequency $f_N$ , settable Maximum load of current inputs thermal continuous $\leq 10$ s $\leq 1$ s dynamic half-wave	1 or 5 A 50 or 60 Hz 4 x $I_N$ 20 x $I_N$ 100 x $I_N$ 250 x $I_N$
<b>Auxiliary DC voltage</b>	Rated auxiliary voltage $V_{aux}$  Permissible range of the rated auxiliary voltage  Permissible maximum ripple at rated auxiliary voltage Power consumption not energized energized Stored energy time at $V_{aux} \geq 110$ V	24, 48 V or 60, 110, 125 V or 220, 250 V 19 to 56 V 48 to 144 V 176 to 288 V $\geq 12$ % approx. 9 W approx. 10.5 W $\geq 50$ ms
<b>Binary inputs</b>	Marshallable 7SD502 DC operating voltage Current consumption	2/4 with/without pilot-wire monitoring 24 to 250 V approx. 2.5 mA
<b>Alarm contacts</b>	Number of alarm relays 7SD502 Contacts per relay Making/breaking power Switching voltage Permissible current	marshallable 5 See connection diagrams 20 W/VA 250 V AC/DC 1 A
<b>Command contacts</b>	Number of tripping relays 7SD502 Contacts per relay Making power Breaking power Switching voltage Permissible current	marshallable 2/4 with/without pilot-wire monitoring See dimension drawings 1000 W/VA 30 W/VA 250 V AC/DC 5 A 30 A continuous 0.5 s
<b>LEDs</b>	Ready display Fault display Marshallable LEDs 7SD502	green red red 1 1 6
<b>Design</b>	Housing, dimensions Terminals Panel/cubicle flush mounting Panel surface mounting Degree of protection to EN 60 529	7XP20, see dimension drawings crimp-connections two-tier screw terminals IP51
<b>Serial interfaces</b>	Operating interface V.24 (RS232C)  System interface Protocol Safety Transmission rate Method Connection of fibre-optic cables  Optical wavelength Permissible path attenuation Distance	Front connector, not isolated, 25-pin, suitable for connection of a PC  Isolated, for connecting to a central unit DIN 19 244 or IEC 870-5-103 Hamming distance $d = 4$ 4 800, 9 600 or 19 000 Bd Asynchronous Two integrated FSMA plug connectors for fibre-optic connection  820 nm max. 8 dB with glass fibre 62.5/125 $\mu$ m max. 1.5 km at 3 dB system reserve
<b>CE-conformity, standards</b>	This product is in conformity with the directives of the Council of the European Communities on the approximation of the laws of the Member States relating to the electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (low-voltage directive 73/23/EEC). The product conforms with the international standard IEC 255 and the national standard DIN 57 435 part 303 (corresponding to VDE 0435 part 303).  The relay is designed for use in an industrial environment, for installation in standard relay rooms and compartments so that with proper installation electro-magnetic compatibility (EMC) is ensured.	Conformity is proved by tests performed by Siemens AG in line with article 10 of the Council Directives in accordance with the generic standards EN 50081 and EN 50082 for the EMC directive 89/336/EEC and standard 60255-6 for the low-voltage directive.
<b>Insulation tests</b> IEC 255-5, DIN 57 435 part 303	High-voltage test (routine test), except d.c. voltage supply input High-voltage test (routine test), only d.c. voltage supply input Impulse voltage test (type test), all circuits, class III	2 kV (rms), 50 Hz 2.8 kV DC 5 kV (peak), 1.2/50 $\mu$ s, 0.5 J, 3 positive and 3 negative shots at intervals of 5 s



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### Technical data (continued)

<b>Setting ranges</b> <b>Overcurrent protection definite-time</b>	Overcurrent pulsating current $I_{M1>}$ High current pulsating current $I_{M1>>}$ Delay times Tolerances Response value for current Timing interval Release time	$I_{N1}/I_N = 0.1$ to 30 $I_{N1}/I_N = 0.1$ to 30 0 to 32 s or inactive  $\pm 5\%$ from set value $\pm 1\%$ or $\pm 10$ ms approx. 30 ms
<b>Overcurrent protection inverse-time</b>	Overcurrent pulsating current $I_{M1>}$ Time multiplier $t_p$ Energizing threshold Characteristic to IEC 255-4, Section 3.5.2 or BS 142 Linear measuring range Tolerances Energizing threshold Time interval	$I_p/I_N = 0.1$ to 20 0.05 to 32 s $6.0 \times I_p$ Normal, strong or extremely dependent $40 \times I_N$  $\pm 5\%$ $\pm 5\%$ for 2 ( $I/I_p >$ ) $\leq 20$ and $t_p = 1$ or 30 ms
<b>Measurement</b>	Operating currents Measuring range Tolerances  Overload protection values Winding temperature Measuring range Tolerances	$I_{M1}, I_{M2}, I_{M3}, I_{diff}, I_{stab}$ 0 to 240 % $I_N$ $\leq 2\%$ from rated value + 1 % /km pilot-wire  $\Theta/\Theta_{trip}$ calculated 0 to 240 % $\leq 3\%$ with respect to $\Theta_{trip}$
<b>Fault logging</b>	Fault indication	Storage of the last 8 faults
<b>Fault recording</b>	Line currents (instantaneous values) Time resolution of the instantaneous values  Max. number of recordings Signal start	$i_{M1}, i_{M2}, i_{M3}, i_{diff}, i_{stab}$ 1.66 at $f_N = 50$ Hz 1.39 at $f_N = 60$ Hz 8 in 19 s recording buffer Energizing, PC/LSA operation, tripping, binary input

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### Selection and ordering data

<b>7SD502 numerical two pilot-wire differential protection</b>	Order No. <b>7SD502</b> □ - □ □ <b>A</b> <b>1</b> <b>1</b> - <b>0</b> □ <b>A</b> <b>0</b>
Rated current, 50 to 60 Hz 1 A 5 A	↑ 1 5
Rated auxiliary voltage 24, 48 V DC 60, 110, 125 V DC 220, 250 V DC	↑ 2 4 5
Construction Housing 7XP2040 for panel surface mounting Housing 7XP2040 for panel and cubicle flush mounting Housing 7XP2040 for panel and cubicle flush mounting (without glass cover)	↑ <b>B</b> <b>C</b> <b>E</b>
Integrated pilot-wire monitoring/CB intertripping with	↑ 1
Serial system interface without with	↑ <b>A</b> <b>C</b>

### Operation software (German and English are standard, other languages on request)

DIGSI program (suitable for all protection relays 7UM..., 7UT..., 7SJ..., 7SA..., ...)	German English	<b>7XS5020-0AA00</b> <b>7XS5020-1AA00</b>
Test version:	German English	<b>7XS5021-0AA00</b> <b>7XS5021-1AA00</b>
Connecting cables for protection relays (25-pin) – PC (9-pin); (other variations supplied on request)		<b>7XV5100-2</b>

### Documentation

<b>German:</b> Katalogblatt LSA 2.2.1: Handbuch:	Leitungsdifferentialschutz 7SD502 mit zwei Hilfsadern Leitungsdifferentialschutz 7SD502 (V 3.0) mit zwei Hilfsadern	<b>E50001-K5722-A111-A2</b> <b>C53000-G1100-C95-3</b>
<b>English:</b> Catalog LSA 2.2.1: Manual:	7SD502 Line differential protection with two pilot-wires 7SD502 Line differential protection with two pilot-wires	<b>E50001-K5722-A111-A2-7600</b> <b>C53000-G1176-C95-2</b>

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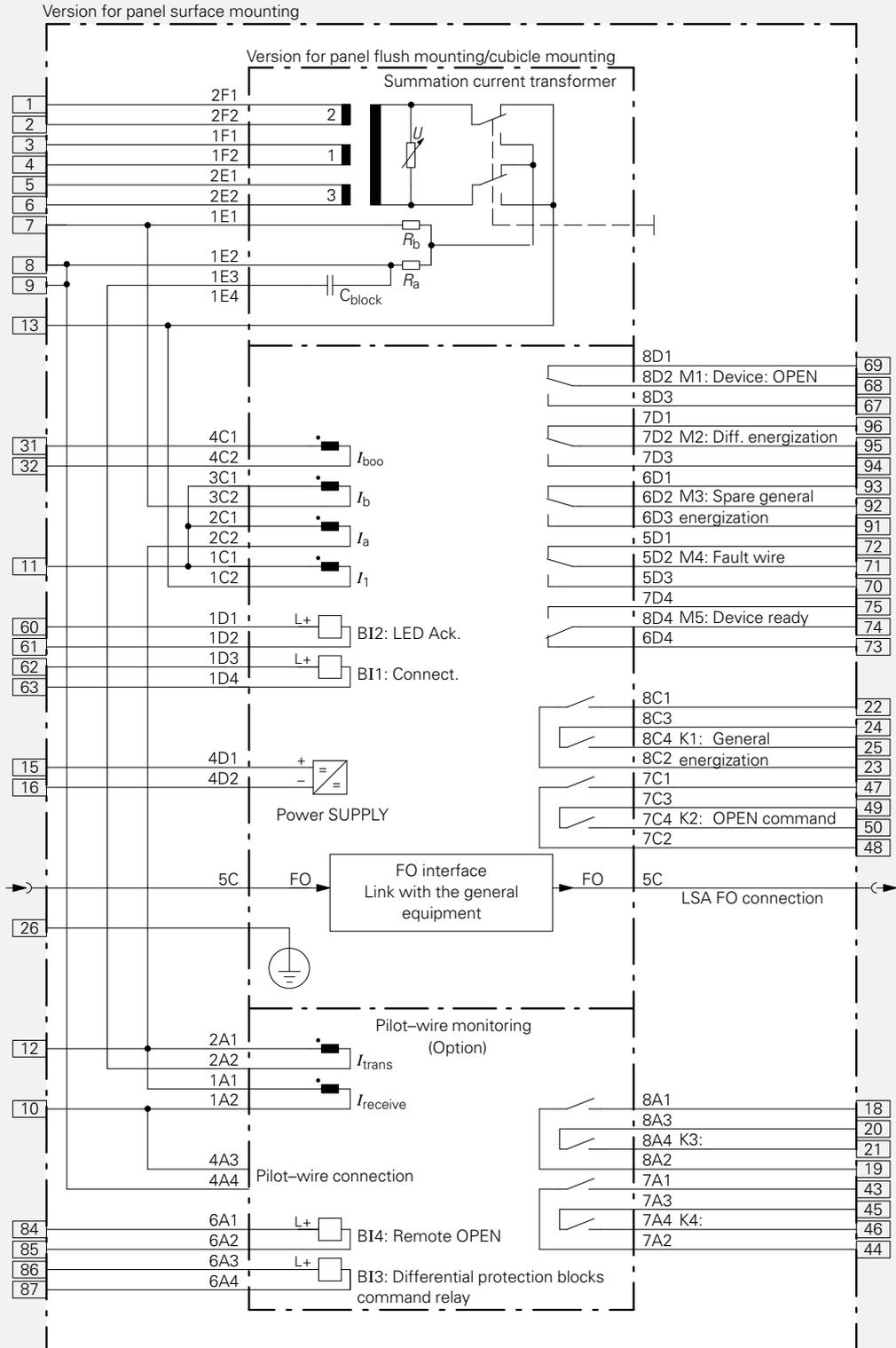


Fig. 5 Connection diagram of 7SD502 (with wiring as set in factory)

## Dimension drawings in mm

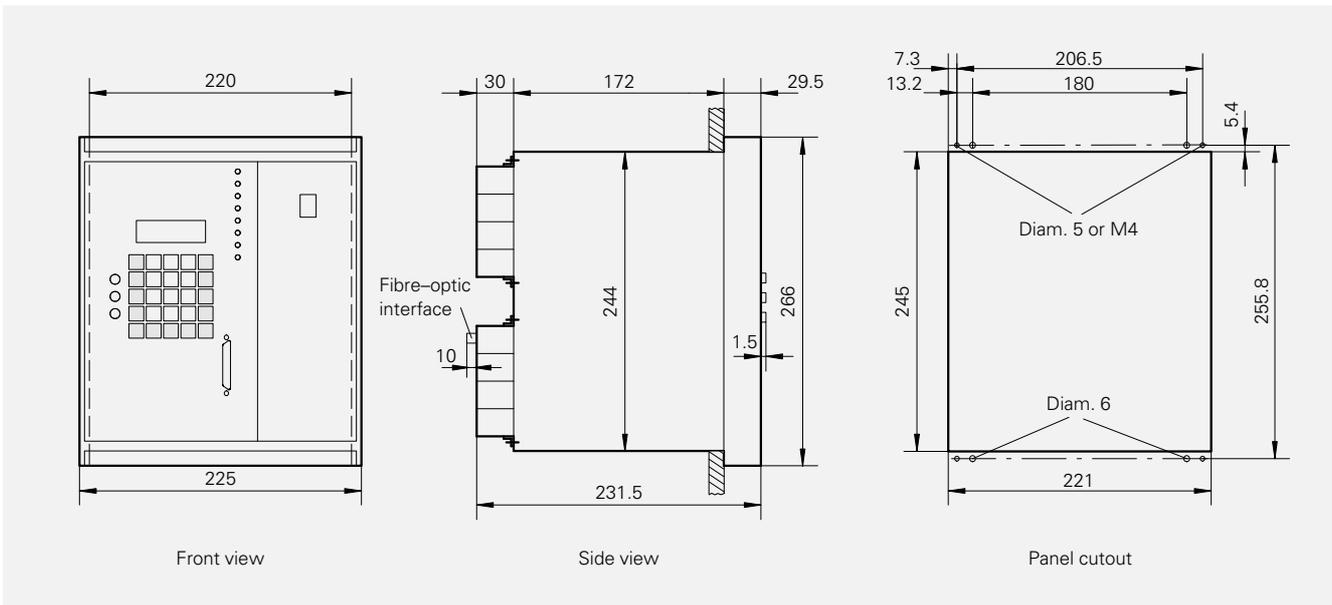


Fig. 6  
7SD502 with housing 7XP2040-2 (for panel flush mounting or cubicle mounting)

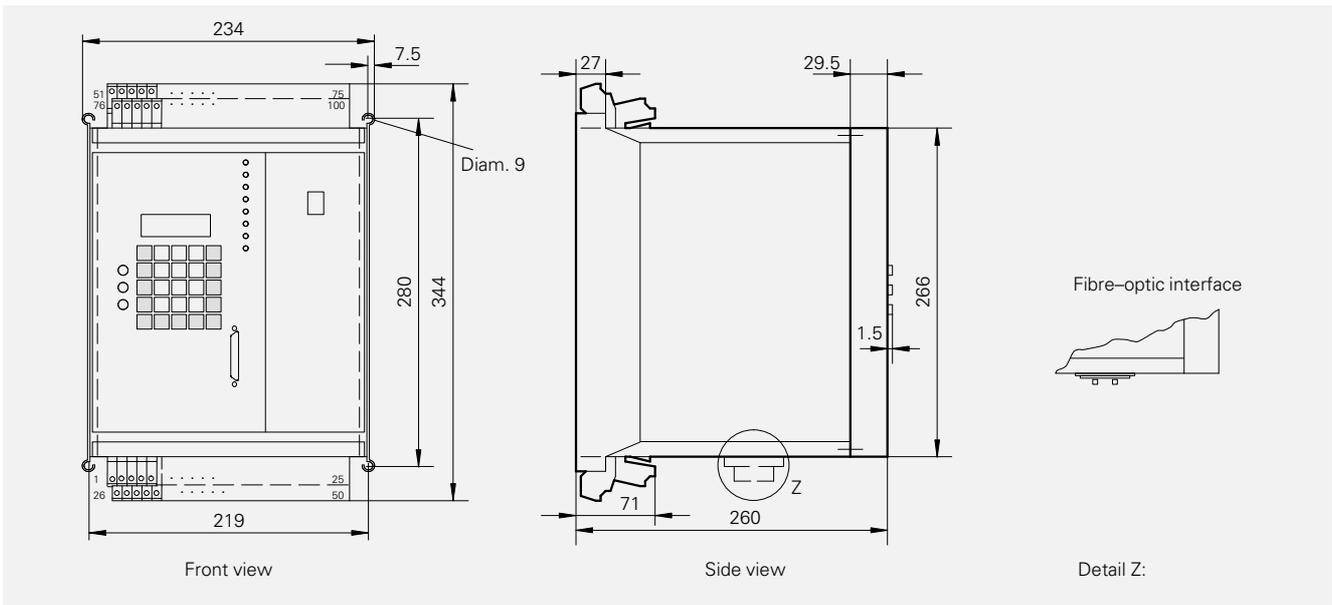


Fig. 7  
7SD502 with housing 7XP2040-1 (for panel surface mounting)

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