

7SD503 Line differential protection with three pilot-wires



Fig. 1
7SD503 line differential protection

Application

The 7SD503 line differential protection is a fast and selective differential protection unit for cables and overhead lines.

It is the successor of the 7SD74 static differential protection and works with it if external pilot-wire monitoring is used. The connection between two 7SD503 units is made via three pilot-wires, i.e. existing pilot-wire connections can be used.

Design

Within its compact dimensions the unit contains:

- All components for measured-value acquisition and evaluation
- Summation current transformer
- Operation and display panel
- Binary input options
- 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 7SD503 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 100 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 7SD503 acquires the secondary pulsating current I_{M1} of the local station, that of the remote station I_{M2} and the sum of the pulsating currents as a differential I_{diff} in the central pilot-wire. 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} 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
- Optional integrated pilot-wire monitoring
- Overload protection with thermal characteristic
- Two-stage definite-time/inverse time overcurrent protection as standby with pulsating I_{M1}
- Real-time clock and permanently stored status and fault indications in the event of auxiliary voltage failure. Previous LSA interface (Siemens-specific) or VDEW/ZVEI interface with the substation control and protection.
- Protection of three-end pilot-wires with two devices at each end of the line is possible.

Differential Relays

7SD503 Line differential protection with three pilot-wires

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 VDEW/ZVEI 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 7SD503 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 commands of the differential protection are 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.
- 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.

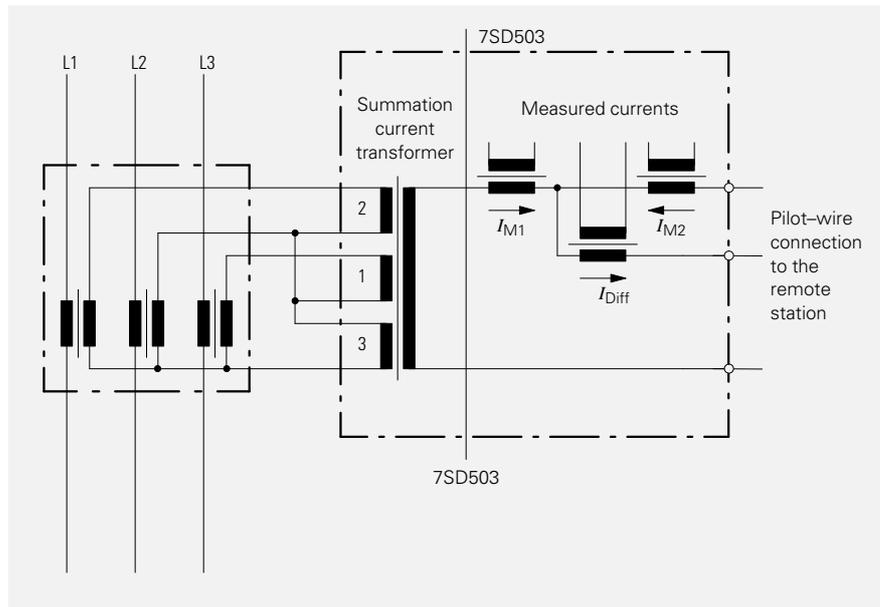


Fig. 2 Connection principle 7SD503

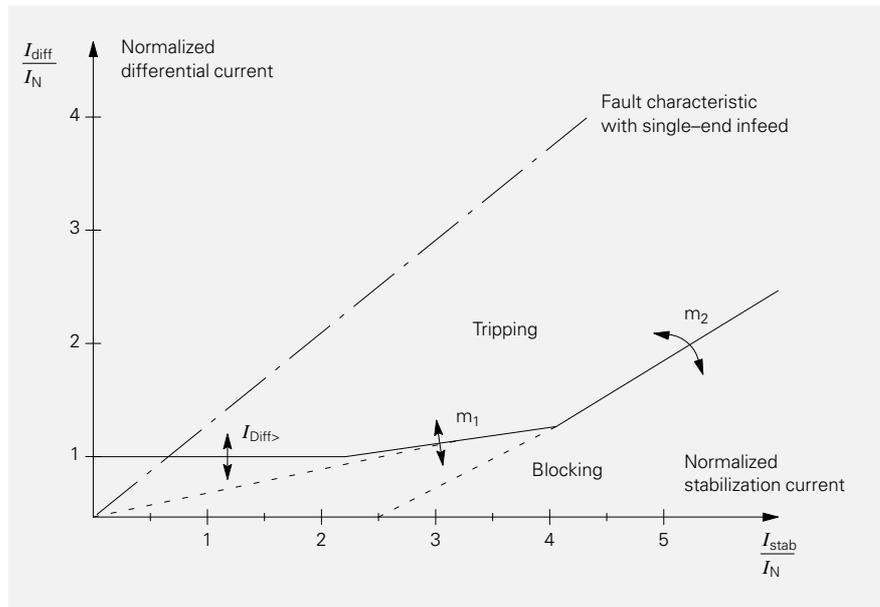


Fig. 3 7SD503 line differential protection

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 7SD503. 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.

If 7SD503 and, e.g., 7SD74 are to be used together, external pilot-wire monitoring is required. Circuit-breaker intertripping and remote tripping are then no longer available.

7SD503 Line differential protection with three pilot-wires

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.

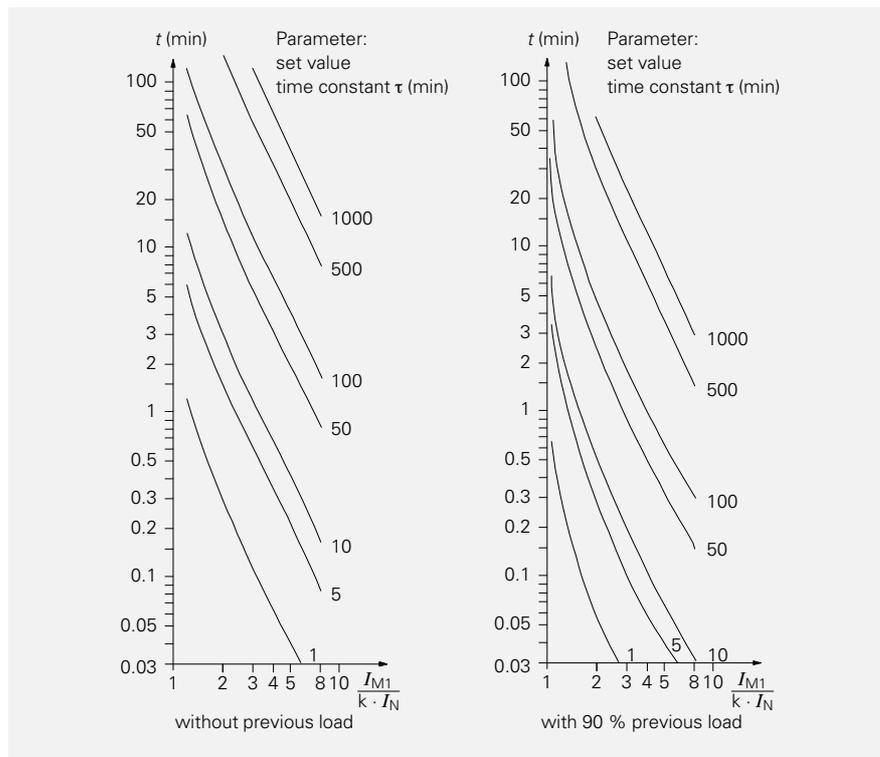


Fig. 4
Tripping time characteristics of the overload protection function

Indications

The 7SD503 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.

Marshallable 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.

Differential Relays

7SD503 Line differential protection with three pilot-wires

Technical data

Input circuits	Rated current I_N Rated frequency f_N , settable Maximum load of current inputs thermal continuous ≤ 10 s ≤ 1 s dynamic half-wave	1 or 5 A 50 or 60 Hz $4 \times I_N$ $20 \times I_N$ $100 \times I_N$ $250 \times I_N$
Auxiliary DC voltage	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 ≥ 12 % approx. 9 W approx. 10.5 W ≥ 50 ms
Binary inputs	Marshallable 7SD503 DC operating voltage Current consumption	2/4 with/without pilot-wire monitoring 24 to 250 V approx. 2.5 mA
Alarm contacts	Number of alarm relays 7SD503 Contacts per relay Making/breaking power Switching voltage Permissible current	marshallable 5 See connection diagram 20 W/VA 250 V AC/DC 1 A
Command contacts	Number of tripping relays 7SD503 Contacts per relay Making power Breaking power Switching voltage Permissible current	marshallable 2/4 with/without pilot-wire monitoring See dimension drawing 1000 W/VA 30 W/VA 250 V AC/DC 5 A continuous 0.5 s 30 A
LEDs	Ready display Fault display Marshallable LEDs 7SD503	green red red 1 1 6
Design	Housing, dimensions Terminals Panel/cabinet flush mounting Panel surface mounting Degree of protection to EN 60 529	7XP20, see dimension drawings Crimp connections Two-tier screw terminals IP51
Serial interfaces	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 optical 820 nm interface, for connecting to a central unit Siemens-specific or acc. to VDEW/ZVEI recommendation Hamming distance $d' = 4$ 4800, 9600 or 19000 Bd Serial, asynchronous Two integrated FSMA plug connectors for fibre-optic connection 820 nm max. 8 dB with glass fibre 62.5/125 μ m max. 1.5 km at 3 dB system reserve
CE-conformity, standards	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.

7SD503 Line differential protection with three pilot-wires

Technical data (continued)

Insulation tests 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 μ s, 0.5 J, 3 positive and 3 negative shots at intervals of 5 s
EMC-tests; immunity (type test) Standards: IEC 255-6, IEC 255-22 (international product standard) EN 50082-2 (generic standard) VDE 0435 part 303 (German product standard)	High frequency test with 1 MHz interference IEC 255-22-1, class III and VDE 0435 part 303, class III Electrostatic discharge IEC 255-22-2, class III and IEC 1000-4-2, class III Radio-frequency electromagnetic field, non-modulated report IEC 255-22-3, class III Radio-frequency electromagnetic field, amplitude modulated IEC 1000-4-3, class III Radio-frequency electromagnetic field, puls modulated ENV 50204, class III Fast transients IEC 255-22-4 class III, IEC 1000-4-4 class III Conducted disturbances induced by radio-frequency fields, amplitude modulated IEC 1000-4-6, class III Power frequency magnetic field IEC 1000-4-8, class IV IEC 255-6	2.5 kV (peak), 1 MHz, $\tau = 15 \mu$ s, 400 shots/s, duration 2 s 4/6 kV contact discharge, 8 kV air discharge, both polarities, 150 pF, $R_1 = 330 \Omega$ 10 V/m, 27 to 500 MHz 10 V/m, 80 to 1 000 MHz, AM 80 %, 1 kHz, 10 V/m, 900 MHz, repetition frequency 200 Hz, duty cycle 50 % 2 kV, 5/50 ns, 5 kHz, burst length = 15 ms, repetition rate 300 ms, both polarities, $R_1 = 50 \Omega$, duration 1 min 10 V, 150 kHz to 80 MHz, AM 80 %, 1 kHz, 30 A/m, continuous, 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz
EMC-tests; emission (type test) Standard: EN 50081-* (European generic standard)	Conducted interference voltage, auxiliary voltage CISPR 22, EN 55022 and VDE 0878 part 22 Interference field strength CISPR 11, EN 55011 and VDE 0875 part 11	150 kHz to 30 MHz, class B 30 to 1 000 MHz, class A
Climatic stress tests	Permissible ambient temperature during service during storage during transport Permissible humidity	-5 to +55 °C -25 to +55 °C -25 to +70 °C mean value per year ≤ 75 % relative humidity, on 30 days per year up to 95 % relative humidity, condensation not permissible
Mechanical stress tests IEC 255-21-1, IEC 68-2	Permissible mechanical stress during service during transport	10 to 60 Hz, 0,035 mm amplitude 60 to 500 Hz, 0,5 g acceleration 5 to 8 Hz, 7,5 mm amplitude 8 to 500 Hz, 2 g acceleration
Current differential protection	Setting ranges response value $I_{diff>}/I_N$ Times Response times (double-end infeed) at $I = 4 \times$ set value $I_{diff>}/I_N$ at $I = 10 \times$ set value $I_{diff>}/I_N$ Additional time delay of the tripping command Minimum command duration Release value $I_{diff>}/I_N$ Tolerance of the response characteristics (stationary, single-end infeed) Frequency range $f_N = 50$ Hz $f_N = 60$ Hz	0.5 to 2.5 (in steps of 0.01) approx. 23 to 33 ms approx. 16 to 26 ms 0 to 60 s (step 0.01 s) 0.05 to 32 s (step 0.01 s) approx. 0.9 x set value ± 3 % of the set value + 0.5 % /km pilot-wire 45 to 55 Hz 55 to 65 Hz
Overload protection	Setting ranges Factor k to IEC 255.8 Step 0.01 Time constant τ Step 0.1 min Temperature warning stage $\Theta_{alarm}/\Theta_{trip}$ Tripping temp. Current warning stage I_{alarm} Tripping time characteristic Release conditions Tolerances	1 to 5 1 to 999.9 min 50 to 100 % $I_{alarm} \geq I_{max} = k \cdot I_N$ $t = \tau \lg \frac{I^2 - I_{pre}^2}{I^2 - (k \cdot I_N)^2}$ Θ/Θ_{alarm} approx. 0.99 Θ/Θ_{trip} approx. 0.99 I/I_{alarm} approx. 0.97 Class 10 % to IEC
Maximum pilot-wire resistance,	Permissible range for the resistance of a pilot-wire	200 Ω per wire
Pilot-wire monitoring	Pulse-code modulated 2 kHz send current Max. send level Min. receive level	8 mA = 100 % 0.1 mA

Differential Relays

7SD503 Line differential protection with three pilot-wires

Technical data (continued)

<p>Setting ranges</p> <p>Overcurrent protection definite-time</p> <p>Overcurrent pulsating current $I_{M1>}$ High current pulsating current $I_{M1>>}$ Delay times Tolerances Response value for current Timing interval Release time</p> <p>Overcurrent protection inverse-time</p> <p>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</p>	<p>Overcurrent pulsating current $I_{M1>}$ High current pulsating current $I_{M1>>}$ Delay times Tolerances Response value for current Timing interval Release time</p> <p>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</p>	<p>$I_{M1}/I_N = 0.1$ to 30 $I_{n1}/I_N = 0.1$ to 30 0 to 32 s or inactive</p> <p>$\pm 5\%$ from set value $\pm 1\%$ or ± 10 ms approx. 30 ms</p> <p>$I_p/I_N = 0.1$ to 20 0.05 to 32 s $1.06 \times I_p$ Normal, strong or extremely dependent $40 \times I_N$</p> <p>$\pm 5\%$ $\pm 5\%$ for $2(I/I_p) \leq 20$ and $t_p = 1$ or 30 ms</p>
<p>Measurement</p> <p>Operating currents Measuring range Tolerances</p> <p>Overload protection values Winding temperature Measuring range Tolerances</p>	<p>Operating currents Measuring range Tolerances</p> <p>Overload protection values Winding temperature Measuring range Tolerances</p>	<p>$I_{M1}, I_{M2}, I_{M3}, I_{diff}, I_{stab}$ 0 to 240 % I_N $\leq 2\%$ from rated value of the local station + 0.5 % /km pilot-wire</p> <p>Θ/Θ_{trip} calculated 0 to 240 % $\leq 3\%$ with respect to Θ_{trip}</p>
<p>Fault logging</p>	<p>Fault indication</p>	<p>Storage of the last 8 faults</p>
<p>Fault recording</p>	<p>Line currents (instantaneous values) Time resolution of the instantaneous values</p> <p>Max. number of recordings Start signal</p>	<p>$i_{M1}, i_{M2}, i_{M3}, i_{diff}, i_{stab}$ 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</p>

7SD503 Line differential protection with three pilot-wires

Selection and ordering data

7SD503 numerical three pilot-wire differential protection	Order No. 7SD503 □ - □ □ A 1 1 - 0 □ A 0
Rated current at 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 C E
Integrated pilot-wire monitoring/CB intertripping with with	↑ 1
Serial system interface without with integrated optical 820 nm module	↑ A C

Operating program (German and English are standard, other languages on request)

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

Documentation

German: Katalogblatt LSA 2.2.2: Handbuch:	Leitungsdifferentialschutz 7SD503 mit drei Hilfsadern Leitungsdifferentialschutz 7SD503 (V 3.0) mit drei Hilfsadern	E50001-K5722-A121-A2 C53000-G1100-C96-3
English: Catalog LSA 2.2.2: Manual:	7SD503 Line differential protection with three pilot-wires 7SD503 Line differential protection with three pilot-wires	E50001-K5722-A121-A2-7600 C53000-G1176-C96-2

Differential Relays

7SD503 Line differential protection with three pilot-wires

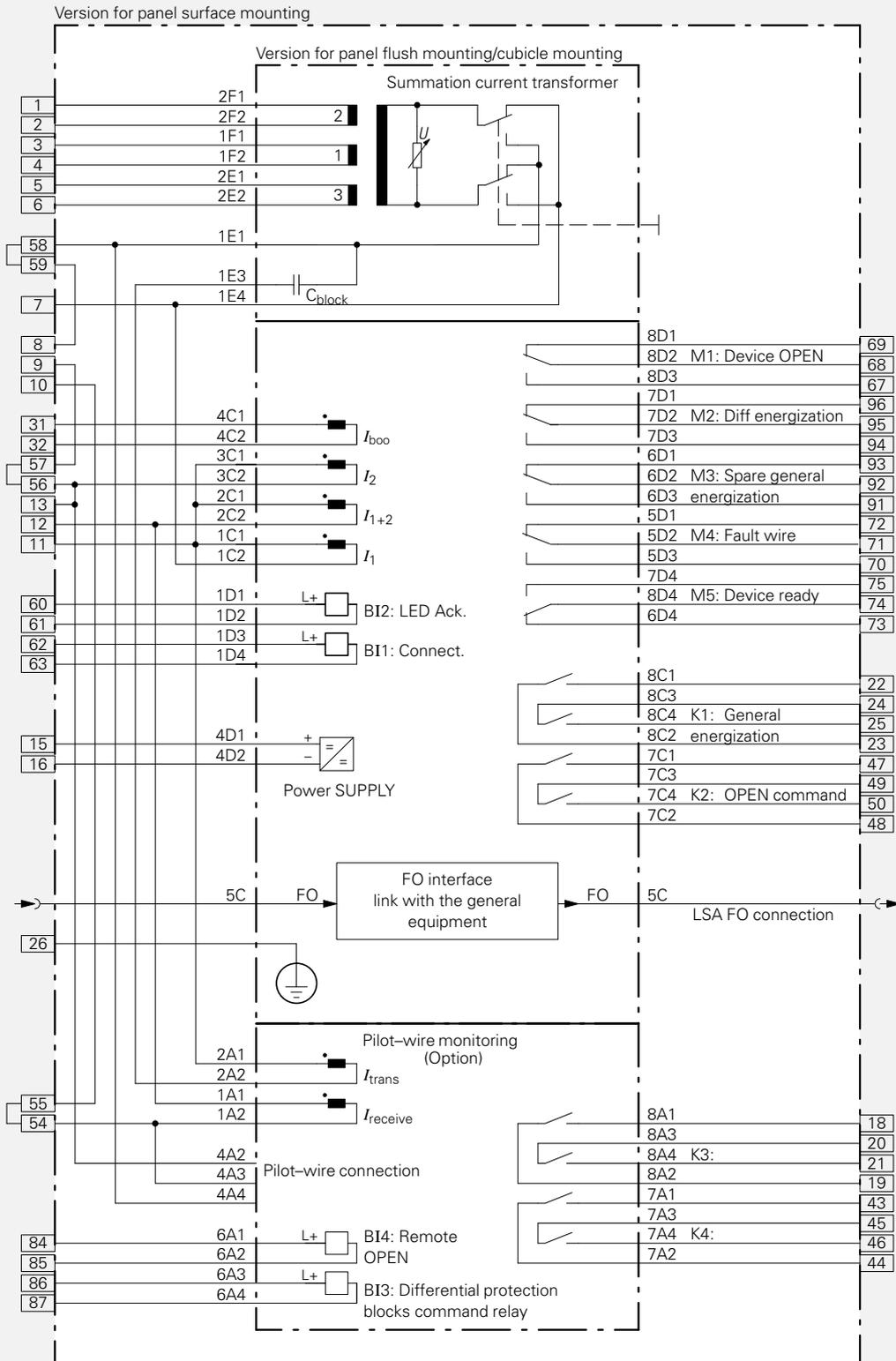


Fig. 5 Connection diagram of 7SD503 (with wiring as set in factory)

Dimension drawings in mm

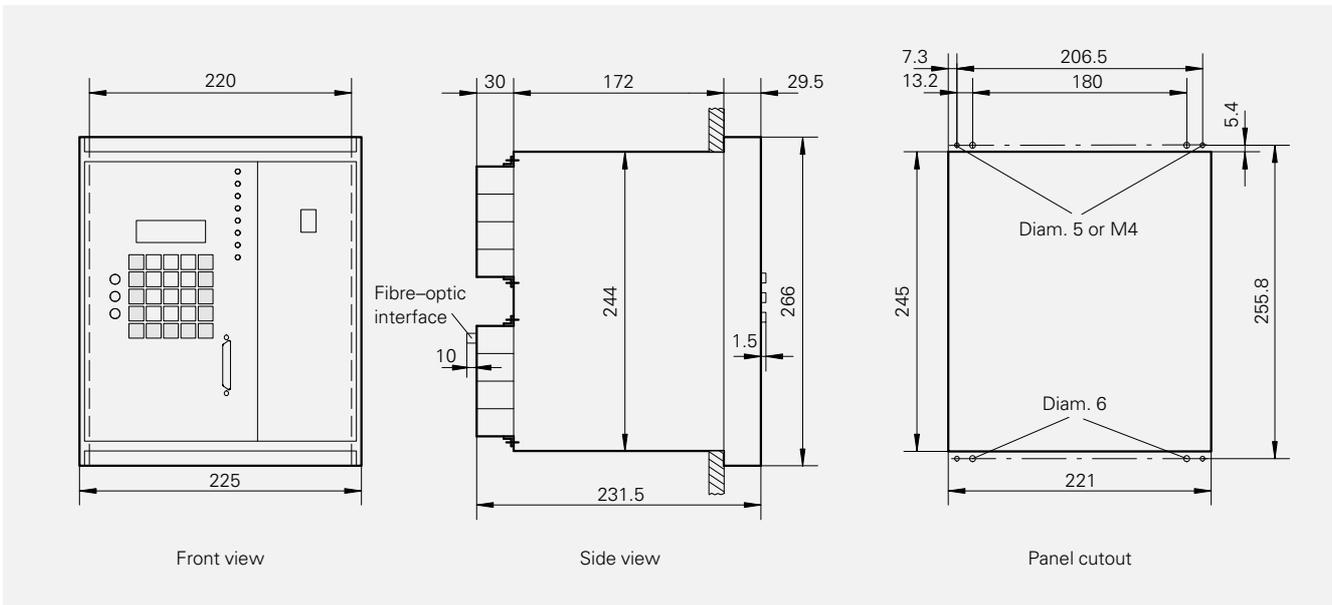


Fig. 6
7SD503 with housing 7XP2040-2 (for panel flush mounting or cubicle mounting)

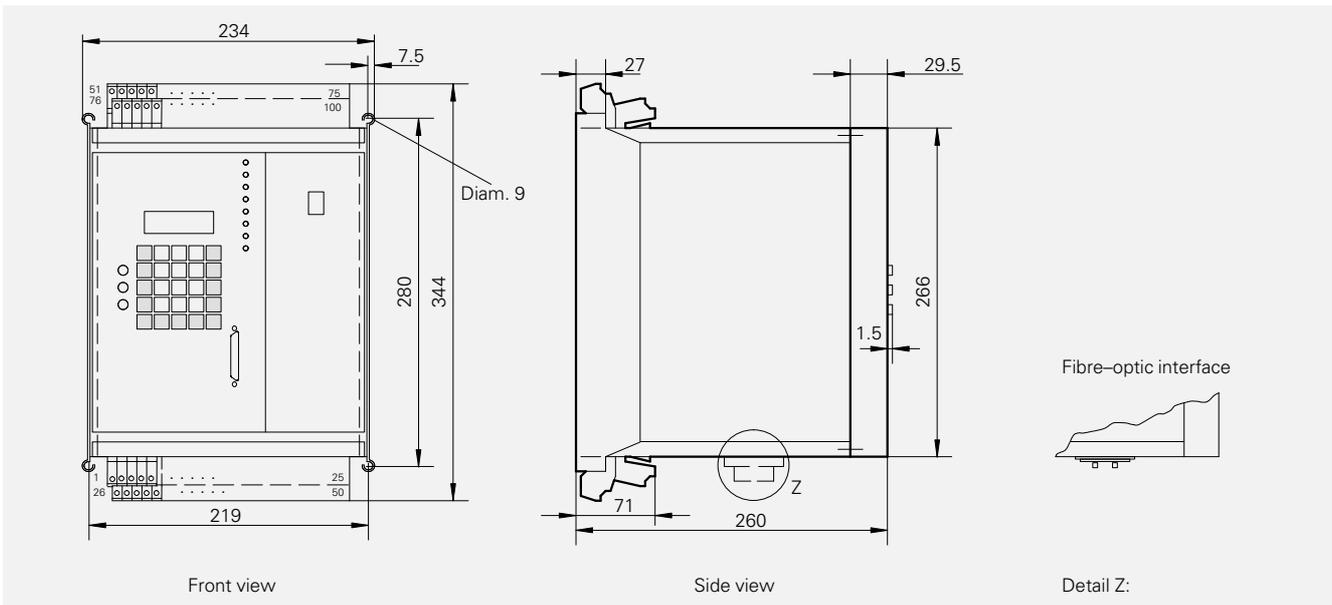


Fig. 7
7SD503 with housing 7XP2040-1 (for panel surface mounting)

Conditions of Sale and Delivery • Export Regulations • Trademarks • Dimensions

Conditions of Sale and Delivery

Subject to the General Conditions of Supply and Delivery for Products and Services of the Electrical and Electronic Industry and to any other conditions agreed upon with the recipients of catalogs.

■ The technical data, dimensions and weights are subject to change unless otherwise stated on the individual pages of this catalog.

The illustrations are for reference only.

We reserve the right to adjust the prices and shall charge the price applying on the date of delivery.

A 9.91 a

Export Regulations

In accordance with present provisions of the German Export List and the US Commercial Control List, export licences are not required for the products listed in this catalog.

An export licence may however be required due to country-specific application of the products.

Relevant are the criteria stated in the delivery note and the invoice.

Subject to change without notice.

Trademarks

All product designations used are trademarks or product names of Siemens AG or of other suppliers.

Dimensions

All dimensions in this catalog are given in mm.

Siemens online!

The Power Transmission and Distribution Group can also be found in the Internet:

<http://www.ev.siemens.de>

Responsible for

Technical contents: Claus Wagner,
Siemens AG, EV S V13, Nürnberg

General editing: Roland Reichel/Claudia Kühn-Sutiono,
Siemens AG, EV S SUP22, Nürnberg/EV BK T, Erlangen

Bereich
Energieübertragung und -verteilung
Geschäftsgebiet Sekundärsysteme
Postfach 48 06
D-90026 Nürnberg



Power
Transmission
and Distribution