Numerical circuit breaker failure protection relay 7SV512

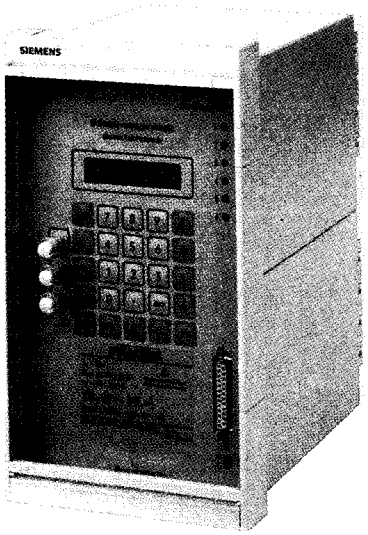

Fig.1
Circuit breaker failure protection relay 7SV512

Application

The 7SV512 is a numerical relay used for circuit breaker failure protection. This condition is when the circuit breaker fails to correctly open and clear the fault after single– or three–pole trip commands have been issued by the protection. It is then necessary to trip the relevant busbar zone (section) to ensure fault clearance. Generally, the monitoring of the current suffices as the criteria for the indication that the circuit breaker has successfully cleared the fault ("current condition"). However, under certain fault conditions, (e.g. overvoltage) little or no current may flow making the measurement of current unreliable for indication of the circuit breaker status ("no current condition"). The 7SV512 will operate correctly for both of these conditions. The high security of the relay (against overfunction) is achieved with a unique microprocessor independent "trip release function" in conjunction with a fast current reset time and a 2–out–of–4 current measurement check. An independent pole discrepancy protection is included. The relay is suitable for use at all voltage levels and in all applications. The current transformers can be either of the closed iron core or linear type. The relay can be incorporated in conventional switchgear systems and modern substation control systems e.g. Siemens LSA 678.

Construction

Within its compact construction, the device contains:

- Inputs and circuitry necessary for digitization and evaluation of the current
- Operator panel with display field
- Event (alarm) and trip (command) output contacts
- Binary inputs
- Serial interfaces
- Power supply converter (DC/DC converter)

The device can be supplied in two case variations. The option 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 included:

- Circuit breaker failure protection (single– or three–pole with/without current)
- End fault protection
- Pole discrepancy protection
- Complete relay self monitoring
- Disturbance recording
- Fault and operating data (event records)
- Parameter set changeover facility (4 sets of parameters)
- Display of on–line measured current values
- Real–time clock with non–volatile annunciation memory (option)

With the following features:

- 2–out–of–4 current check
- Phase selective for single– and three–pole operation
- Fast reset time with no overshoot
- Very sensitive current detection
- Independently settable delay times for operation with and without current
- Single or two stage time delay of the busbar trip command
- Microprocessor independent trip release function (hardware interlock)
- Cross trip stage (1st stage of the 2 stage operation)
- Circuit breaker defective input facilitates a separate busbar trip time delay
- Inter–trip facility (via teleprotection interface)
- End fault protection with inter–trip
- "No current" condition control using the circuit breaker auxiliary contacts

Mode of operation

Proven sample and hold techniques, in conjunction with anti–aliasing filters are used, providing a reliable platform for the data acquisition in the 7SV512.

With the application of a powerful microprocessor and digital filtering, the influence of high frequency transients, and DC current components are suppressed. The measured values are calculated using finite impulse response (FIR) filters.

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Serial interfaces

The relay is supplied with two serial interfaces.

The RS232 serial interface on the front panel of the relay is suitable for communication with a PC. A software package (DIGSI®) is available for convenient menu driven parameter setting, relay commissioning, transfer and evaluation of fault operation details, and reading 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 e.g. Siemens LSA 678, or to a central data processing unit.

Settings

All setting parameters can be entered via the integrated operator panel or via a PC connected to the front serial interface of the relay. The settings and marshallings are stored in a non–volatile memory, and are thus secured against interruption/loss of the DC supply voltage.

Self monitoring

Extensive hardware and software monitoring functions are integrated in the 7SV512. Any irregularities in the hardware or software are immediately detected and alarmed. As a result, the security, reliability and availability of the protection relay are significantly improved.

The monitoring functions include:

- Hardware monitoring with:
  - Monitoring of the analog to digital (A to D) converters
  - Command / trip relay supervision
  - Monitoring of the memory modules
- Software monitoring with extensive routines and watchdog functions
- Current symmetry supervision
- Current summation supervision

Circuit breaker failure protection

The circuit breaker failure protection is the main function in the 7SV512. The circuit breaker failure function is phase selectively processed. The initiation is via the binary inputs connected to the protection. When a valid initiation is received and current is flowing:

1. Above the current set value ("current condition"), the relay measures the time taken for the current to drop below this set value. If this time exceeds a settable time (T1) it will issue a local trip command (cross trip) to re–trip its respective circuit breaker. If this is unsuccessful and a second timer (T2 current) times out, before the current drops below the set value, it will issue a busbar trip command. The current measurement is only valid when current is flowing in at least 2–out–of–4 of the current inputs. The plausibility check with single phase faults can be done either, with measured residual (earth) current, or with the calculated negative sequence current.
2. Below the current set value, the relay if required, switches over to the "no current condition" and operates with the connected circuit breaker auxiliary contacts. The sequence is then as described above. A seperate busbar trip time delay (T2, no current) can be set for this condition.

Once the relay has been initiated, for example with a "current condition", then this condition is maintained until the fault detection input resets.

An initiation input is only taken as valid when both the fault detection input and the trip input are present (i.e. 2–out–of–2). A false initiation is thus prevented.

Additionally the microprocessor independent "trip release function" (hardware interlock) prevents any incorrect tripping due to possible errors within the microprocessor, when no valid initiation input exists. Figure 2 gives an overview of this function.

Of great importance in circuit breaker failure protection is the reset speed of the current detector of the relay, once the circuit breaker has successfully cleared the fault. The fast current reset of the 7SV512 is ensured, even with a large DC offset, by the versatile digital filtering. Current with a slow decay (long time constant) is therefore of no consequence, and the current detector will still reset within the specified time.

Should the circuit breaker be unable to trip, (e.g. due to no hydraulic pressure), the busbar trip command can be issued quicker using a separately settable time stage. This time stage is enabled via a binary input, of the 7SV512, connected to the circuit breaker mechanism.

If one of the relay supervision functions (e.g. current summation or hardware monitoring) picks up, the circuit breaker failure protection can, if necessary, be blokked after a settable duration.

With all the above mentioned security checks and interlocks a high degree of safety against maloperation is achieved with this critical protection function.

End fault protection

This function is required for cases where a fault occurs between the circuit breaker and the current transformer once the circuit breaker is open. An independently settable time delay is started after a valid initiation is received and the circuit breaker auxiliary contacts indicate that the circuit breaker has opened, but current is still flowing. After the expiry of this time delay an inter–trip signal is given to the remote end.

Pole discrepancy protection

This function ensures that any one or two poles of a circuit breaker do not remain open for longer than an independently settable time (i.e unsymmetrical conditions). This time stage is initiated when current (above the set value) is flowing in any 1 or 2 phases, but not in all 3 phases. Additionally, the circuit breaker auxiliary contacts (if connected) are interrogated and must show the same condition as the current measurement. Should this time delay expire, then a three pole trip command is issued. This function is normally used when single pole auto–reclosing is practiced.

Parameter set changeover

With the help of a binary input, the integrated operator panel or with DIGSI, 1 of the 4 completely separate sets of parameter settings can be activated. This facility enables, for example, matching of the relay's parameter settings to the changing of the network configuration.

Display of in–service measured values

The 7SV512 provides the possibility of displaying the on–line measurements of the currents I_{L1}, I_{L2}, I_{L3} and I_E.

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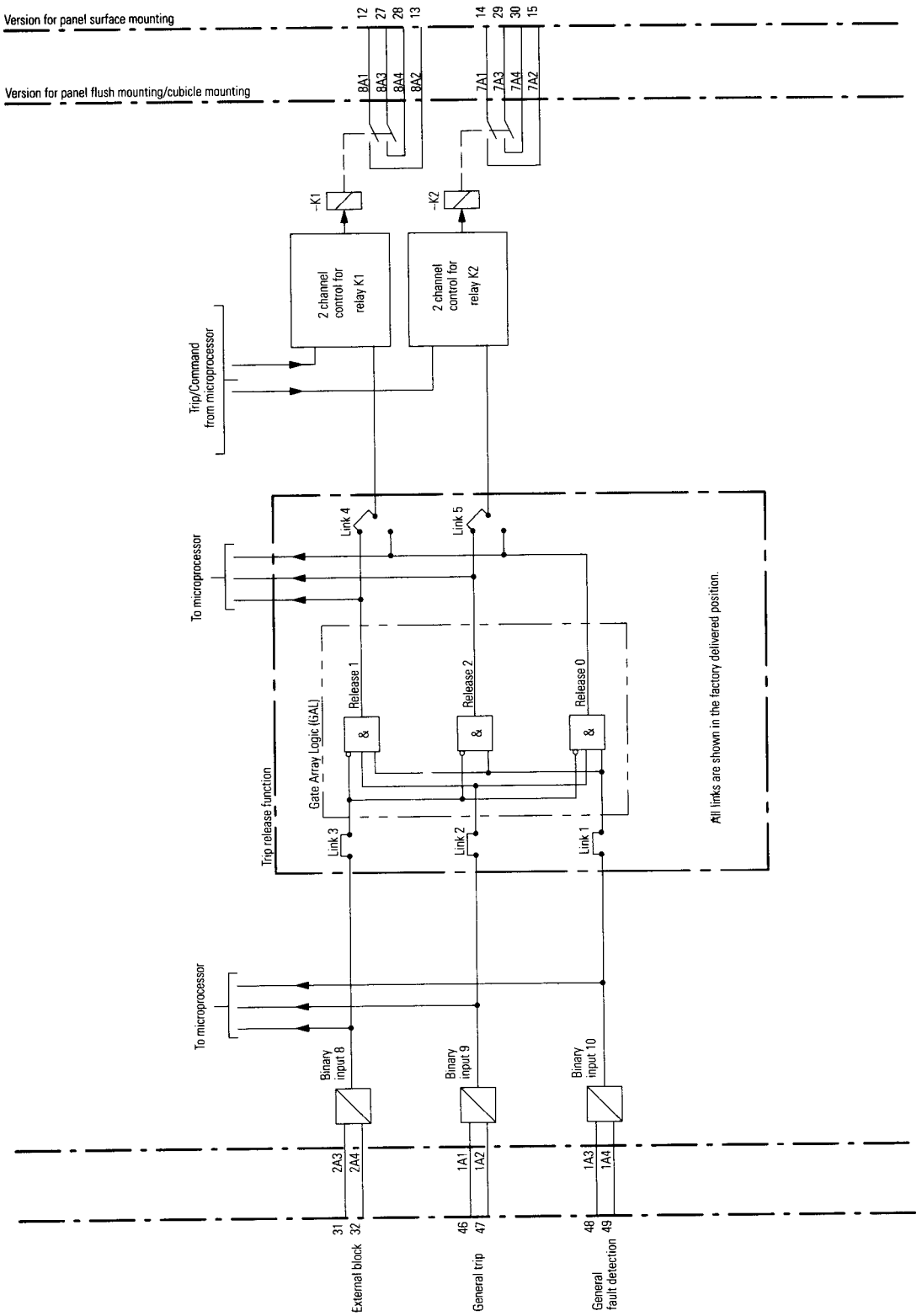

Fig.2
Diagram showing the trip release function

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Fault reports

The relay saves event lists (operational records) and fault reports. All the following alarms in memory are protected against loss of the auxiliary supply, when the option with the real–time clock and non–volatile annunciation memory is taken. (When this option is not taken then the following are lost when the auxiliary supply is removed.)

- Fault report

  The fault reports of the last three disturbances are always available from the relay
- Operational reports

  All annunciations which do not belong to the fault reports are saved in the operational reports
- Switching statistics

  The number of single– and three–pole trips, as well as the sum of currents interrupted in each phase can be read out
- Automatic information display

  When selected, two operational measured values can be displayed on the liquid crystal display (LCD). These values are regularly updated by the relay. After a fault, two sets of fault data can be automatically displayed on the LCD. The user can define which data should be displayed.

Real–time clock (option)

The internal clock with battery back–up is available as an option. The clock can be synchronized with the integrated operator panel, or with DIGSI® by using a binary input. All alarms are time and date stamped. When this option is not taken then time stamps are in relative time.

Disturbance recording

Digital measured values of phase and earth currents are stored, starting 100 ms (83 ms in 60 Hz systems) before fault detection until the end of the fault, or until 3 seconds (2.5 seconds in 60 Hz systems) of fault buffer has been filled. The fault data has a 1 ms (0.83 ms in 60 Hz systems) time resolution.

Time markers for specific relay reactions, such as general fault detection, trip, and reset, help analyzing disturbances on the system. A disturbance recording stored in the relay will be overwritten by a new fault occurrence. Therefore the most recent fault is always stored in the relay. The disturbance data can be transferred to the substation control system, e.g. Siemens LSA 678, or to a PC for evaluation.

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

The relay is supplied with a number of command (trip) and event (alarm) output relays, binary inputs and LED's.

For user specific alarms, flags and trips, all command relays, alarm relays and LEDs are freely marshallable. The only constraint is that if the trip release function (hardware interlock) is required then the binary inputs 8, 9, and 10 must be used (see Fig. 2). A number of annunciations can be grouped together to create a special (group) annunciation for flags, alarms and trips. The LEDs can be allocated to show instantaneous conditions (self–resetting), or to stay lit until they are manually reset (latched). In the event of loss of the auxiliary power supply, the flags (LED's) which have not been reset, are again restored with the restoration of the auxiliary power supply. (Only with the option of the real–time clock and non–volatile annunciation memory).

Technical data

Input circuits	Rated current I_N		1 A or 5 A
	Rated frequency f_N		50 Hz or 60 Hz (selectable)
	Thermal overload capability		
	in current path	continuous	4 x I_N
		for 10 s	20 x I_N
		for 1 s	100 x I_N
	Dynamic overload capability (half cycle)		250 x I_N
	Burden	current inputs	
		I_N = 1 A	approx. 0.1 VA
		I_N = 5 A	approx. 0.2 VA
Power supply via intergrated DC/DC converter	Rated auxiliary voltage U_H /(permissible tolerance)		DC 24 V, 48 V (19 V to 56 V) DC 60 V, 110 V, 125 V (48 V to 144 V) DC 220 V, 250 V (176 V to 288 V)
	Maximum permissible ripple	at rated voltage	≤ 12 %
		at voltage limit	≤ 6 %
	Power consumption (with 110 V DC)	quiescent	approx. 6.3 W
		energized	approx. 13.5 W
	Max. bridging time during loss of auxiliary voltage		> 50 ms for U_H > 110 V
Binary inputs	Number		10 (marshallable)
	Voltage range (selectable via links)		DC 24 V to 69 V and DC 69 V to 250 V
	Current consumption independent of operating voltage		approx. 2.5 mA
Alarm/event contacts	Number of relays (total)		8 (marshallable) each with 1 contact
	Contact breakdown number of C/O contacts		5 (marshallable)
	number of N/O contacts		3 (marshallable)
	Switching capacity	make/break	20 W/VA
	Switching voltage		AC/DC 250 V
	Permissible current	continuous	1 A

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Technical data

Command contacts (Trip)	Number of relays, each with 2 N/O contacts	5 (marshallable)
	Switching capacity make	1000 W/VA
	break	30 W/VA
	Switching voltage (max.)	AC/DC 250 V
	Permissible current, continuous	5 A
	0.5 s	30 A
LED displays	Ready indication green	1
	Blocked indication red	1
	Marshallable LEDs red	6
Serial interfaces	Operator interface	non–isolated, 25–pole D–type sub– miniature 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 connectors for connection to fibre optic cables
	Optical wavelength	820 nm
	Permissible attenuation	max. 8 db with glass fibre 62.5/125 µm
	Distance	max. 1.5 km
Construction of unit	Case, dimensions	7XP20, see dimension drawings
	Weight : flush mounting/cubicle mounting	approx. 9.5 kg
	surface mounting	approx. 11.5 kg
	Degree of protection according to DIN 40 050	IP51
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 DC 2.8 kV; 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
Disturbance tests	High frequency test (1 MHz test) IEC255–22–1, Class III	2.5 kV (peak); τ = 15 µs; 400 shots per second, duration 2 s
	Electrostatic discharge test (ESD test) IEC255–22–2, Class III	8 kV (peak); 5 ns/30 ns; 10 positive discharges
	Electromagnetic field test (Radiated electr. magn. field test) IEC255–22–3, Class III	frequency 27 MHz to 500 MHz; 10 V/m
	Fast transient test IEC41B(CO)53, 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 according to IEC255 and IEC870	
	in service	5° to +55 °C
	during storage	–25° to +55 °C
	during transport	–25° to +70 °C
	Humidity rating	Code letter F to DIN 40 040, condensation not permissible
Mechanical stress tests according to IEC68	Permissible mechanical stress according to IEC255–21	
	in service	10 Hz to 60 Hz: 0.035 mm amplitude 60 Hz 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

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Technical data

Setting ranges				
Circuit breaker failure protection	Initiation conditions			With or without current, 1 or 3 pole
	Current detection	Step	0.01 I_n	0.05 I_n to 4 I_n
	Reset ratio			0.9
	Delay times	all delay stages	0.01 s	0 to 32 s, or ∞ (off)
	Pick–up time			±5 ms
	Reset time	sinusoidal current maximum		≤10 ms (typical 5 ms) ≤20 ms (typical 15 ms)
	Tolerances			
	Current pick–up value (0.1 I_n – 4 I_n)			±5 % of set value
	Current pick–up value (0.05 I_n – 0.1 I_n)			±10 % of set value
	Time			±1 % or a minimum of 10 ms
End fault protection	Delay time	Step	0.01 s	0 to 32 s, or ∞ (off)
	Tolerances	Time		±1 % or a minimum of 10 ms
Pole discrepancy protection	Start criterion			any one or two poles open
	Delay time	Step	0.01 s	0 to 32 s, or ∞ (off)
	Tolerances	Time		±1 % or a minimum of 10 ms
Disturbance recording	Measured values			I_{L1}, I_{L2}, I_{L3}, I_E
	Trigger			Trip, or fault detection, or 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	Values for operating/on–line measurements			
	Current			I_{L1}, I_{L2}, I_{L3}, I_E (in primary amps or % of I_n)
	Effective range			10 % I_n to 240 % I_n
	Tolerance			<2 % of respective rated value

Selection and ordering data

Selection and ordering data	Ordering–No. **7SV512** □ – □ □ **A 0** □ – **0** □ **A 0**
Rated current at 50/60 Hz AC	
1 A	**1**
5 A	**5**
Rated auxiliary voltage	
DC 24, 48 V	**2**
DC 60, 110, 125 V	**4**
DC 220, 250 V	**5**
Construction	
for panel surface mounting	**B**
for flush mounting/cubicle mounting	**C**
Real–time clock and non–volatile annunciation memory	
without	**0**
with	**1**
Serial interface	
without interface	
with integrated fibre optic serial interface (820 nm)	**A** **C**

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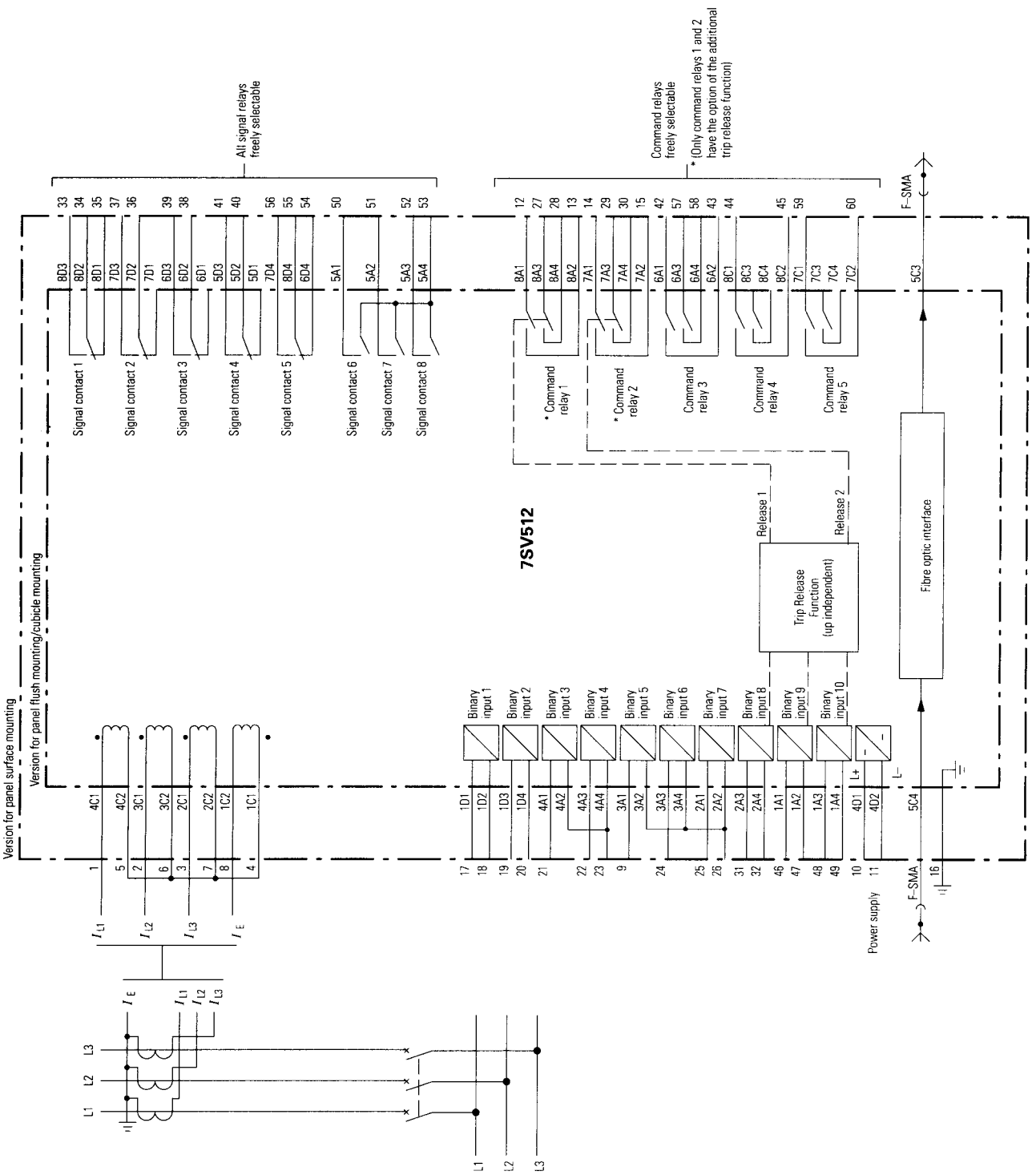

Fig.3
Connection diagram for the circuit breaker fail protection relay 7SV512

Dimension drawing in mm

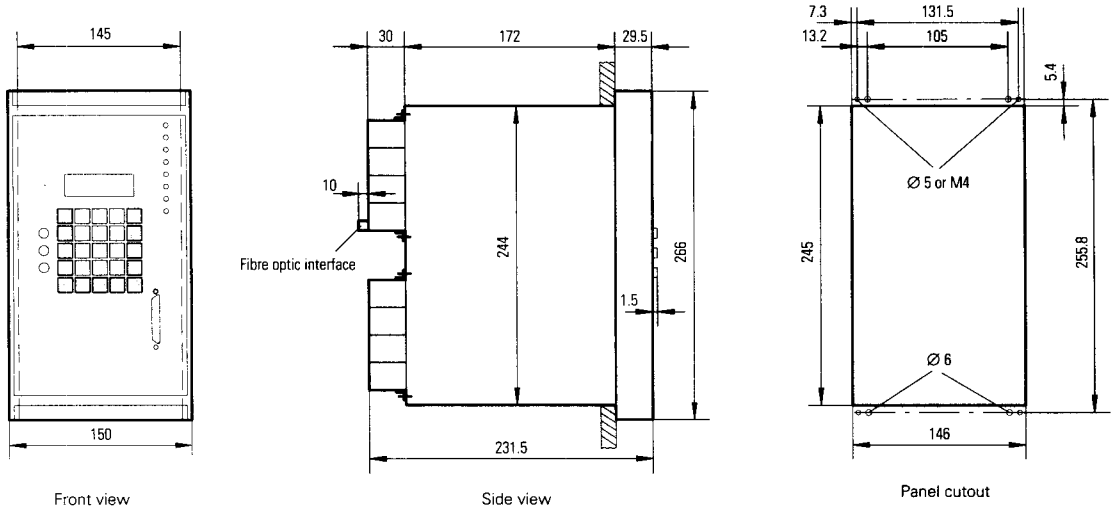

Fig.4
Housing 7XP2030–2 (for panel flush mounting and cubicle mounting)

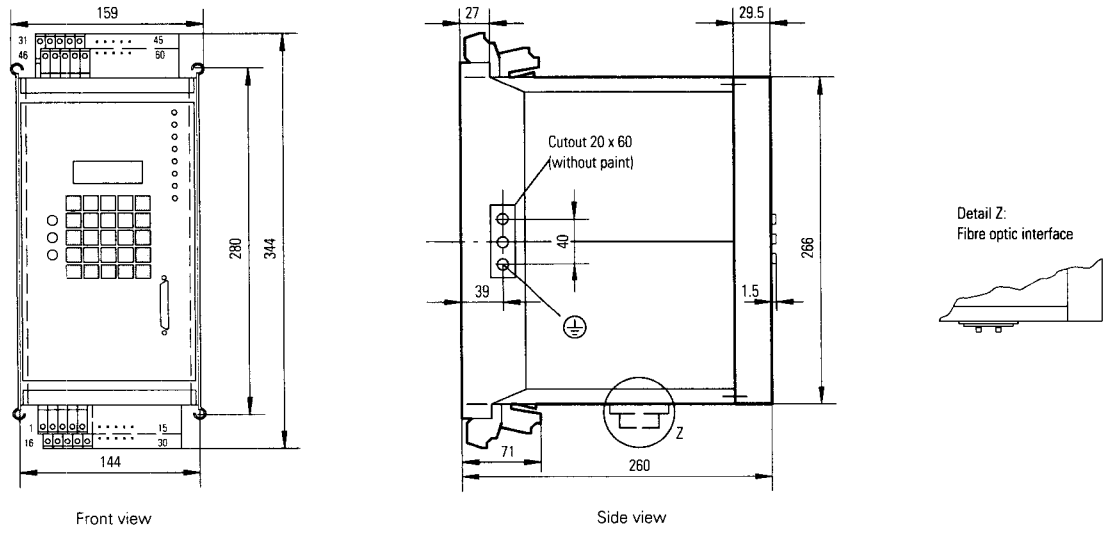

Fig.5
Housing 7XP2030–1 (for panel surface mouting)

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