Reyrolle
Protection
Devices

7SR18 Solkor
Line Differential Protection

Energy Management

SIEMENS

7SR18 Solkor

Fig. 1. Typical Fascia showing additional LED variant

Description

The Solkor, two-ended, line differential relay has been developed to enhance the Reyrolle family of products. Designed using state-of-the-art hardware technology, it provides differential protection and control for overhead lines and cable feeders. Housed in a 4U high, size E6 case, it provides protection, monitoring, instrumentation and metering with integrated input and output logic, data logging & fault reports. Communication access to the relay functionality is via a front USB port for local PC connection or rear RS485 communications port for remote connection.

Function Overview

87L	Three-phase differential (two elements)
85	Inter-trip Feature
50	Instantaneous Overcurrent
50G/50N	Instantaneous Earth Fault
51	Time Delayed Overcurrent
51G/51N	Time Delayed Measured/Derived/Earth Fault
60CTS-I	CT Supervision

Two, three-pole differential elements, each with two stage bias characteristics, are provided for differential protection. Inter-tripping comes from internal or six independent external initiation channels. Overcurrent protection can operate as a stand-alone feature, it can also be configured to operate as 'guard' feature and/or back-up in case of protection signalling communications failure. Connection to CTs is via selectable 1 A or 5 A inputs. Ratio correction for miss-matched line current transformer ratios is available. The ability to invert CT inputs is provided to facilitate commissioning. There are

five or eight user-programmable binary output contacts and three or six user programmable status inputs with pick-up and drop-off timers.

Monitoring Functions

Local end and remote end ammeters,
Differential starters,
Protection signalling link status,
General alarms,
Binary Input / Output status,
Trip circuit supervision
Time and date
Starters
Fault records
Event records
Circuit breaker trip counters
I^2t summation for contact wear
Communication loop-back test modes.
Communication link supervision.
Time and Date
Starters
Power on counter

Data Acquisition - Via Communication Interface

Sequence of event records

Up to 1000 events are stored and time tagged to 1 ms resolution.

Fault Records

The last 10 fault records are displayed on the relay fascia and are also available through the communication interface, with time and date of trip, measured quantities and type of fault.

Waveform recorder

The waveform recorder stores analogue data for all poles and the states of protection functions, binary inputs, LEDs and binary outputs with user settable pre & post trigger data. A record can be triggered from protection function, binary input or via data communications. The 8 most recent records are stored and made available for convenient retrieval using Reydisp Evolution.

Demand Metering

A record of demand is available. The demand minimum, maximum and average values for currents, voltages, power and frequency, over a user selectable period of time, is displayed and can be downloaded. Typically this is set as a rolling value for the last 24 hours.

Real Time Clock

The time and date can be set and are maintained while the relay is de-energised by a back up storage capacitor. The time can be synchronized from a binary input pulse or the data communication channel.

Description of Functionality

Current Differential Protection

The relay compares magnitude of measured currents at either end of the protected feeder, it operates for faults detected within the protected zone. The three-pole, phase-fault differential comparators each provide two bias-slopes. The first stage of bias accommodates proportional measuring errors in the system. The second stage accommodates additional spill current caused by CT saturation at high fault levels.
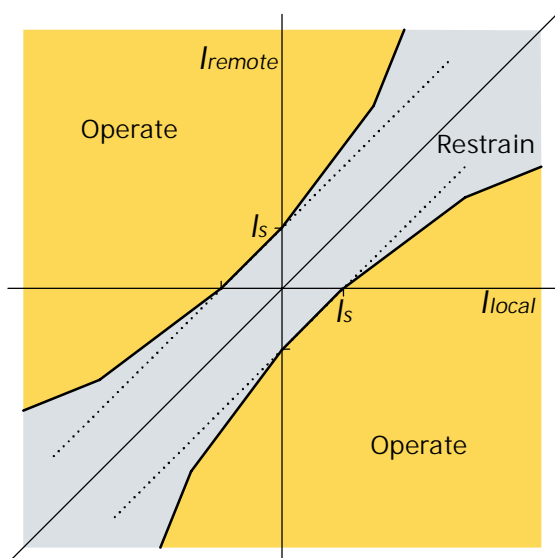
It is not necessary to have the same CT ratios at either end of a protected feeder, since ratio compensation is settable. It is also possible to invert the current inputs to aid in commissioning.

Backup Overcurrent Protection

In addition to the differential protection, comprehensive overcurrent protection for phase and earth faults provides back-up IDMTL and DTL characteristics in the event of a communications link failure.

Guard Relays

If it is necessary to add security to the differential scheme it is possible to configure an overcurrent element as a 'guard' feature. The appropriate overcurrent element must operate at the same instance as the differential element to allow a trip command to be issued.

Inter-tripping

Auxiliary signalling channels are provided for inter-tripping. Internal inter-trip dedicated to the differential protection and independent inter-trips which can be used for either direct or permissive inter-tripping from an internal or external source. Where an internal fault is fed largely from one end, the differential comparators at both ends operate identically, but the guard at the low current end may not pick up and so block the trip. To overcome

this, an internal inter-trip signal is sent which can be used at the receive end to either override the guard so allowing the differential to trip or operate the trip contacts directly.

Protection Signalling

The end-to-end protection signalling channel is via a direct optical link for distances up to 2 km* using multi-mode fibres (ST®) bayonet style connectors or up to 40 km using single-mode fibres Duplex LC connectors. Continuous protection signalling link supervision is provided. Two test modes, loop test & line test, are included to assist with commissioning the signalling link. In loop test mode the local transmit and receive terminals can be connected together, allowing relays at each end to be tested in isolation. Line test mode allows the integrity of the whole signalling channel to be checked. The relay commands the remote end to 'echo' all received data back to the local end. In line test mode, the remote differential protection is suspended.

* For distances greater than 2 km consider using the additional 7XV5461-xxxxx devices

Circuit Breaker Maintenance

A circuit-breaker operations counter is provided. A summation of I^2 broken by the circuit-breaker provides a measure of the contact erosion. Operations count and I^2 alarm levels can be set which, when reached, can be used as an input to a condition-based maintenance regime.

Communications

The relay offers a front USB serial port as standard. All of the relays functions can be set on a PC using Reydisp Evolution via the USB port. The connection is made via a USB cable and operates with a 'plug and play' connection. In addition a rear RS485 electrical connection is available as standard on all units for system interface connections. An internal terminating resistor is provided, which can be connected into the circuit by adding a wire loop between the relevant terminals. Both ports can be switched to OFF or set to use either the DNP3.0, MODBUS-RTU, IEC60870-5-103 and ASCII protocols. IEC61850 is provided as an ordering option for either Electrical or Optical connectivity.

Ethernet Redundancy Protocols:

PRP (Parallel Redundancy Protocol)
RSTP (Rapid Spanning Tree Protocol)
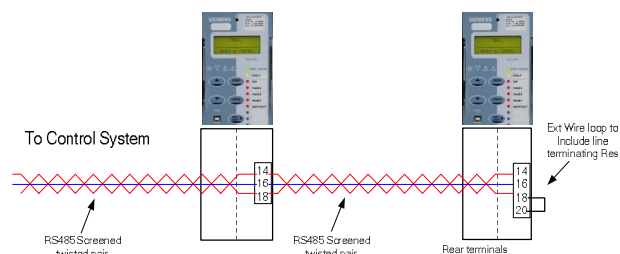HSR (High availability Seamless Redundancy)

Reydisp Evolution

Reydisp Evolution is a Windows based software tool, providing the means for the user to apply settings, interrogate settings and retrieve events and disturbance waveforms from the device and is common to the entire range of Reyrolle protection relays.
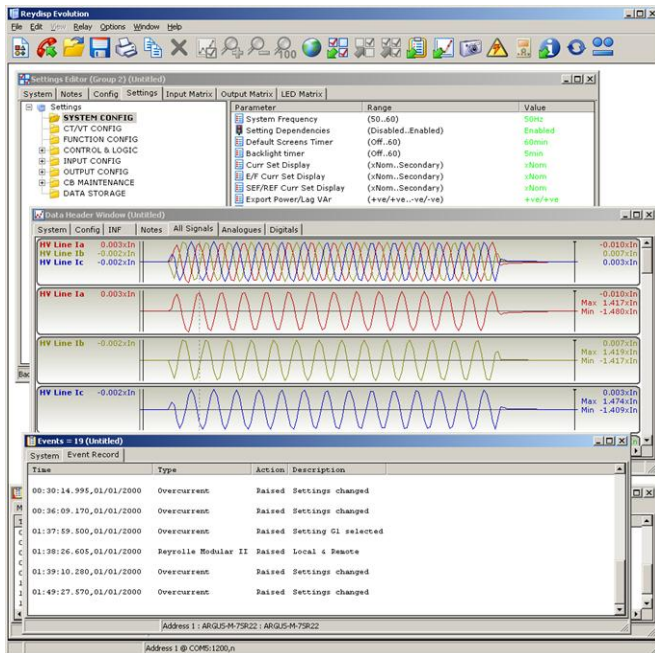

Fig. 4. Typical Reydisp Evolution Screenshot

Language Editor

The Language editor software gives the user the ability to customize the text displayed in the relays, Menu structure and instrumentation views. The tool allows a language file to be created and transferred to the relay also containing Western European characters.
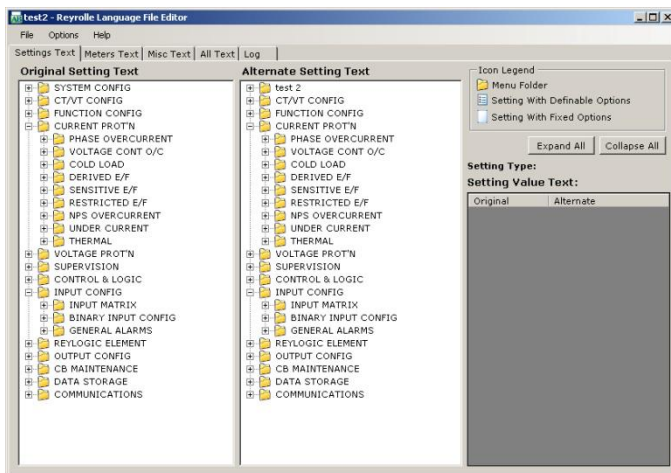

Fig. 5. Typical Language Editor Screenshot

Communications Editor

To facilitate easier interfacing to a substation the relays default Protocol configuration may be modified using the communication editor software tool.

The communication editor is a PC based software package provided within the Reydisp software suite which allows modification of the IEC60870-5-103, DNP 3.0 and MODBUS Protocols.
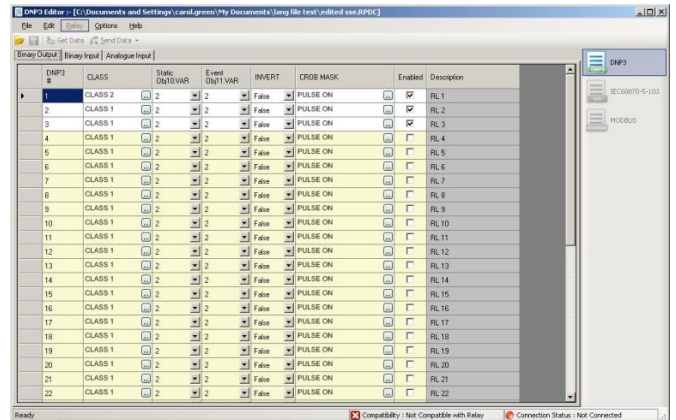

Fig. 6. Typical Communications Editor Screenshot

Construction

The relay is housed in a 4U high size E6 case with a removable clear plastic fascia cover. Two handles are provided to facilitate the withdrawal of the relay element from its case. Internal contacts within the case ensure the CT circuits and normally closed contacts remain short-circuit when the relay is withdrawn. The rear connection blocks are comprised of screw terminals facilitating M4 ring-crimp connections, providing a secure and reliable termination.

Fig. 7. Typical Rear view of relay
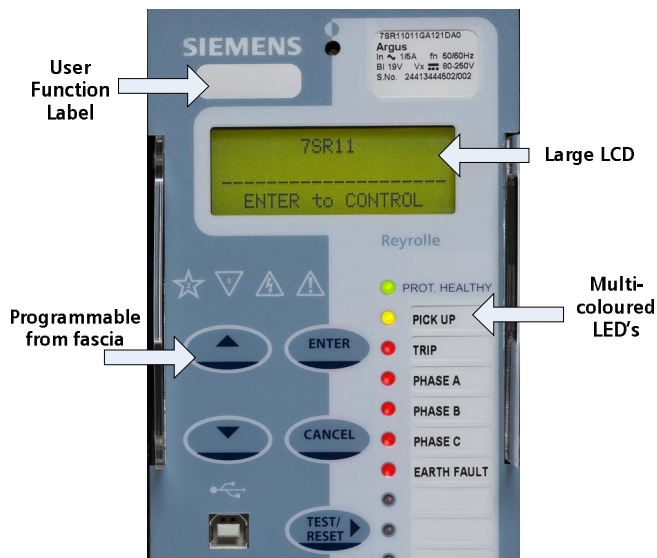
User Interface

Fig. 8. Typical User Interface

The operator interface is designed to provide a user friendly method of controlling, viewing menus, entering settings and retrieving data from the relay. Five buttons are provided for navigation around the menu structure.

LCD

A 4 line by 20 character liquid crystal display (LCD) with power save operation permits viewing of the relay identifier, settings, instrumentation, fault data and control commands. Up to 6 user programmable general alarms can be configured for status indication.

LEDs

A steadily illuminated LED indicates the 'Protection Healthy' condition. There are 9 or 17 user programmable LEDs available eliminating the need for additional expensive panel mounted indication and associated wiring. Each is tri-coloured (red, green, yellow) allowing for indication severity classification of the associated function's state and has a label insert for text identification.

Relay Information

The device type and rating information is shown as standard on the fascia slip-in label. There is also provision for relay designation to be displayed on the LCD showing 'Relay Identifier' & 'Circuit Identifier' information. In addition space is provided on the fascia via a slip-in label repeating such information.

Technical Data

For full technical data refer to the Performance Specification Section of the Technical Manual.

Inputs and Outputs

Current Inputs

Quantity	3 x Phase & 1 x Earth
Rated Current In	1 A or 5 A
Measuring Range	80 x In
Instrumentation ≥ 0.1xIn	±1% In
Frequency	50 Hz or 60 Hz
Thermal Withstand: Continuous 10 Minutes 2 Minutes 1 Second 1 Cycle	3 x In 3.5 x In 6 x In 100 A (1 A) 350 A (5 A) 700 A (1 A) 2500 A (5 A)
Burden @ In	≤0.02 VA (1 A phase and Earth element) ≤0.2 VA (5 A phase and earth element)

Auxiliary Supply

Rated DC Voltage	Nominal Range 24 V to 250V Absolute Range 19.2 V to 275 V	
Allowable superimposed ac component	12% of DC voltage	
Rated AC Voltage	Nominal Range 100 V to 230 V AC 50 Hz or 60 Hz Absolute Range 88 V to 253 V rms AC	
Power Consumption:	Min (DC) Max (DC)	3.9 W 8 W
	Min (AC) Max (AC)	9 VA 0.5 PF 15 VA 0.5 PF
Allowable breaks/dips in supply (collapse to zero)	DC	50 ms
	AC	2.5 cycles or 3 cycles @50 Hz or 60 Hz

Binary Inputs

Number	3 or 6	
Operating Voltage	19 V dc	DC Range 17 V to 320 V dc AC Range 92 V to 138 V$_{RMS}$AC
	88 V dc	Range 70 V to 320V dc
Maximum dc current for operation	1.5 mA	
Maximum peak ac current for operation	1.5 mA	
Pick Up Delay	User Selectable 0 s to 14400 s (up to 4 hours)	
Drop Off Delay	User Selectable 0 s to 14400 s (up to 4 hours)	

For AC operation the BI pick-up delay should be set to 0 ms and the drop-off delay to 20 ms.

Binary Outputs

Number	5 or 8 (2 are change-over contacts)
Operating Voltage	Voltage Free
Operating Mode	User selectable - Self or Hand/Electrical Reset or pulsed.
Operating Time from Energizing Binary Input	<20 ms
Making Capacity: Carry continuously Make and carry (L/R ≤ 40 ms and V ≤ 300 V)	5 A ac or dc 20 A ac or dc for 0.5 s 30 A ac or dc for 0.2 s
Breaking Capacity (≤ 5 A and ≤ 300 V): AC Resistive AC Inductive DC Resistive DC Inductive	1250 VA 250 VA at p.f. ≤ 0.4 75 W 30 W at L/R ≤ 40 ms 50 W at L/R ≤ 10 ms

Unit Design

Housing	E6 (see dimension drawing)
Indication	20 Character 4 line Display Relay Healthy LED Tri-Coloured User Programmable Self or Hand Reset LED's
With-drawable Element.	Yes
User Interface.	5 Navigation Keys
Weight.	Typical 4.26 Kg
IP Rating installed with cover fitted.	IP 51 from front
IP Rating installed with cover removed.	IP 20 from front

Phase/Earth Current Inputs: Thermal Withstand

Continuous	3.0 x In	
10 minutes	3.5 x In	
5 minutes	4.0 x In	
3 minutes	5.0 x In	
2 minutes	6.0 x In	
	1 A Input	5 A Input
3 Second	57.7 A	230 A
2 Second	70.7 A	282 A
1 Second	100 A	400 A
I Cycle	700 A	2500 A

Operate State	Burden
Quiescent (Typical)	3 W
Maximum	10 W

Allowable superimposed ac component	≤ 12% of dc voltage
Allowable breaks/dips in supply (collapse to zero from nominal voltage)	≤ 20 ms

Serial Interface

Communication Port	Front USB Type standard B Rear RS485 2 wire electrical Rear EN100+ IEC 61850 Electrical or Optical (Optional)
Protocol	IEC60870-5-103 MODBUS RTU IEC61850 DNP3.0

Mechanical

Vibration (Sinusoidal)
IEC 60255-21-1:1988 Class I

Vibration response	0.5 gn
Vibration endurance	1.0 gn

Shock and Bump
IEC 60255-21-2:1988 Class I

Shock response	5 gn, 11 ms	
Shock withstand	15 gn, 11 ms	
10 gn, Bump test, 16 ms	10 gn, 16 ms	

Seismic
IEC 60255-21-3 Class I

Seismic Response	1 gn

Mechanical Classification

Durability	In excess of 10^6 operations

Electrical Tests

Insulation
IEC 60255-27

Between all terminals and earth for 1 minute	2.5 kV rms
Between independent circuits for 1 minute	2.5 kV rms
Across normally open contacts for 1 minute	1.0 kV rms

Transient overvoltage
IEC 60255-27

Between all the terminals and earth or between any two independent circuits without damage or flashover	5 kV 1.2/50 µs 0.5 J

Slow Damped Oscillatory Wave
IEC 60255-26

2.5 kV Common mode	< 3 % deviation
1.0 kV Differential mode	

Electrostatic Discharge
IEC 60255-26

8 kV, Contact discharge	≤ 5 % variation

Radiated Radio Frequency Electromagnetic Field Immunity
IEC60255-26

10 V/m, 80 MHz to 1000 MHz (Sweep)	≤ 5 % variation
10 V/m, 1.4 GHz to 2.7 GHz (Sweep)	≤ 5 % variation
10 V/m, 80 MHz, 160 MHz, 380 MHz, 450 MHz, 900 MHz, 1850 MHz, 2150 MHz (Spot)	≤ 5 % variation

Fast Transient
IEC 60255-26

4 kV, 5/50 ns, 5 kHz, repetitive	≤ 3 % variation

* Note 20 ms drop-off delay applied to binary inputs

Conducted Disturbance Induced by Radio Frequency Interference
IEC 60255-26

10 V, 0.15 MHz to 80 MHz	≤ 5 % variation

Conducted Disturbance Induced by Radio Frequency Interference Limits
IEC 60255-26

Frequency Range	Limits dB(µV)	
	Quasi-peak	Average
0.15 MHz to 0.5 MHz	79	66
0.5 MHz to 30 MHz	73	60

Radiated Radio Frequency Electromagnetic Field Immunity Limits
IEC 60255-26

Frequency Range	Limits at 10 m Quasi-peak, dB(µV/m)
30 to 230 MHz	40
230 to 1000 MHz	47

Surge
IEC 60255-26

Type	Level	Variation
Analogue Inputs, Auxiliary Power: Line to Earth	4.0 kV	≤ 10%
I/O: Line to Earth	2.0 kV *	≤ 10%
RS485 Comms port: Line to Earth	1.0 kV	No Data Loss
Analogue Inputs, Auxiliary Power: Line to Line	2.0 kV	≤ 10%
I/O: Line to Line	1.0 kV *	≤ 10%

* Note 50 ms pick-up delay and 20 ms drop-off delay applied to binary inputs

Environmental

Temperature
IEC 60068-2-1

Operating range	-10 °C to +55 °C
Storage range	-25 °C to +70 °C

Humidity
IEC 60068-2-78

Operational test	56 days at +40 °C and 93 % RH

Protection Elements

General Accuracy

Reference Conditions	
General	IEC 60255-151
Current settings	100% of In
Current input	IDMTL – 0.05 to 2.5 xIs
	DTL – 0.05 to 50 xIs
Auxiliary supply	Nominal
Frequency	50 Hz or 60 Hz
Ambient temperature	20 °C

General Settings	
Transient overreach of highset/lowset (X/R = 100)	≤ 5 %
Disengaging time (see note)	< 42 ms
Overshoot time	< 40 ms

Note. Output contacts have a programmable minimum dwell time, after which the disengaging time is as above.

Accuracy Influencing Factors

Temperature		
-10 °C to +55 °C	≤ 5 % variation	
Frequency		
47 Hz to 52 Hz 57 Hz to 62 Hz	Level:	≤ 5 % variation
	Operating time:	≤ 5 % variation
Harmonic content		
Frequencies to 550 Hz	≤ 5 % variation	

Current differential

Level	
No. of elements	2
Initial Setting	0.1 to 2.5
1st Bias Slope	0.1 to 0.7
2nd Bias Slope	0.5 to 2

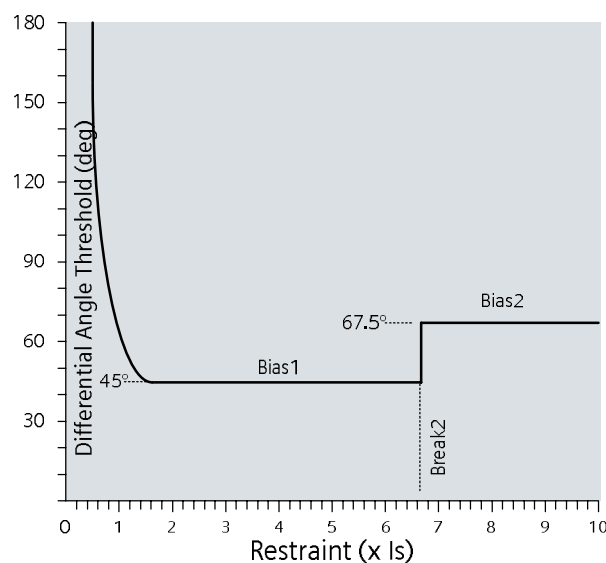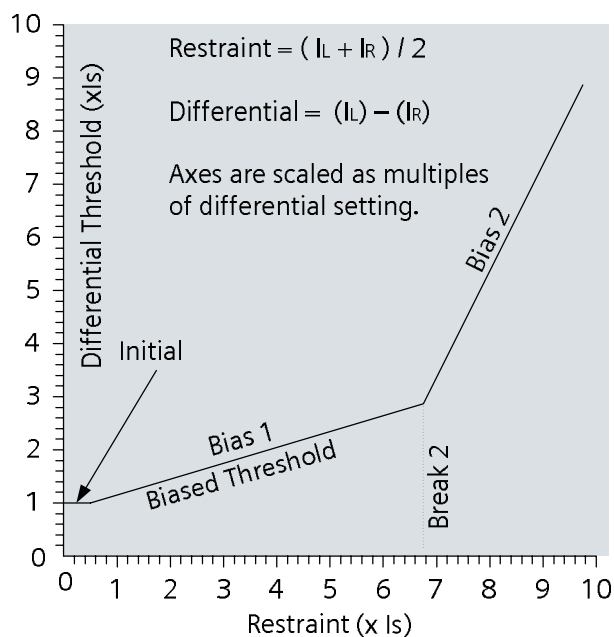Typical operating threshold characteristics are shown below: -

$$\text{Restraint} = (I_L + I_R) / 2$$

$$\text{Differential} = (I_L) - (I_R)$$

Axes are scaled as multiples of differential setting.

Fig. 9 Differential Protection Operating Characteristic

The error limits on these diagrams are as follows: -

Operate Levels	
Initial Setting	± 10% of I$_{OP}$ or ± 0.1In
Biased slope	±(10 % of Restraint) or ± 10 mA

Differential and Inter-trip operate times are given by: -

$$t = t0 + td$$

Where
t0 is the base operating time
td is the Differential Delay time

Operate Times (Typical)	
Differential base operate time (Idiff > 10 Is)	30 ms ± 5 ms (Fault Line) 50 ms ± 5 ms (below fault line)
Differential Delay Time	± 1 % or ± 10 ms

DTL	
No. of elements	4
Level	
Setting Range Is	0.05 xIn to 50 xIn
Accuracy	Operate: 100 % Is, ±5 % or, ±10 mA Reset ≥ 95 % of operate current
Repeatability	± 1 %
DTL Delay	
Setting	0.0 s to 14400 s
Accuracy	± 5 ms
Repeatability	± 1 % or ± 5 ms

Overcurrent protection

| Characteristic	
Setting	IEC Normal Inverse (NI) IEC Very Inverse (VI) IEC Extremely Inverse (EI) IEC Long Time Inverse, (LTI) DTL ANSI Moderatly Inverse (MI) ANSI Very Inverse (VI) ANSI Extremely Inverse (EI)
No. of elements	4
Level	
Setting Range Is	0.05, 0.01…2.5 x In
Accuracy	Operate: 105 % Is, ±4 % or ±1 % xIn Reset ≥ 95% of operate current
Repeatability	± 1%
IDMTL Time Multiplier	
Setting	0.025, 0.05…100
Accuracy	± 5 % or ± 30 ms
Repeatability	± 1 % or ± 5 ms
DTL Delay	
Setting	0.00 s to 14400 s
Accuracy	± 10 ms
Repeatability	± 5 ms
Reset	
Setting	0 s to 60 s
Accuracy	± 1 % or ± 10 ms
Repeatability	± 1 % or ± 5 ms
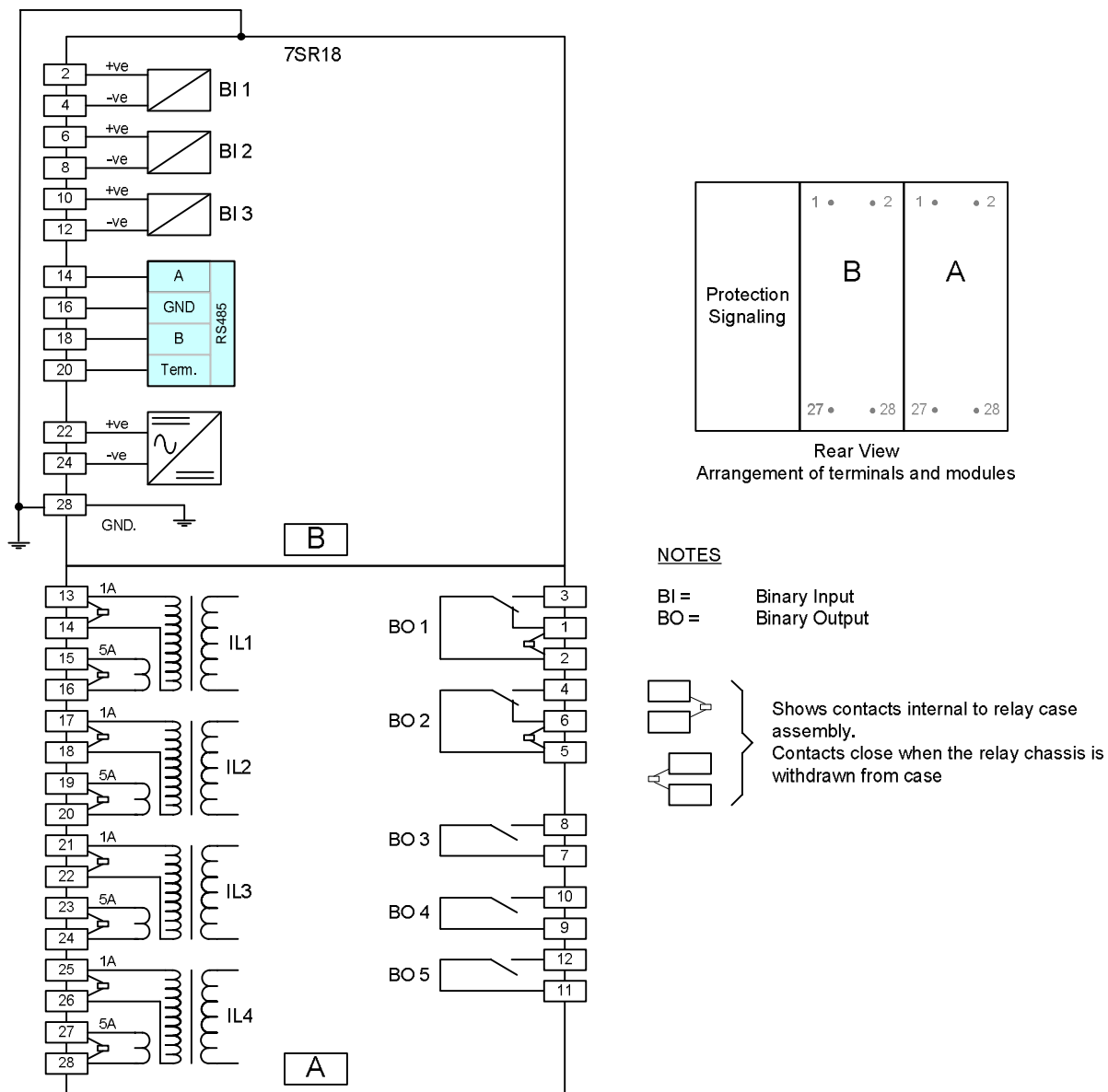
Fig. 10. Connections Diagram for 7SR18 Non-Directional Relay (3BI and 5BO)
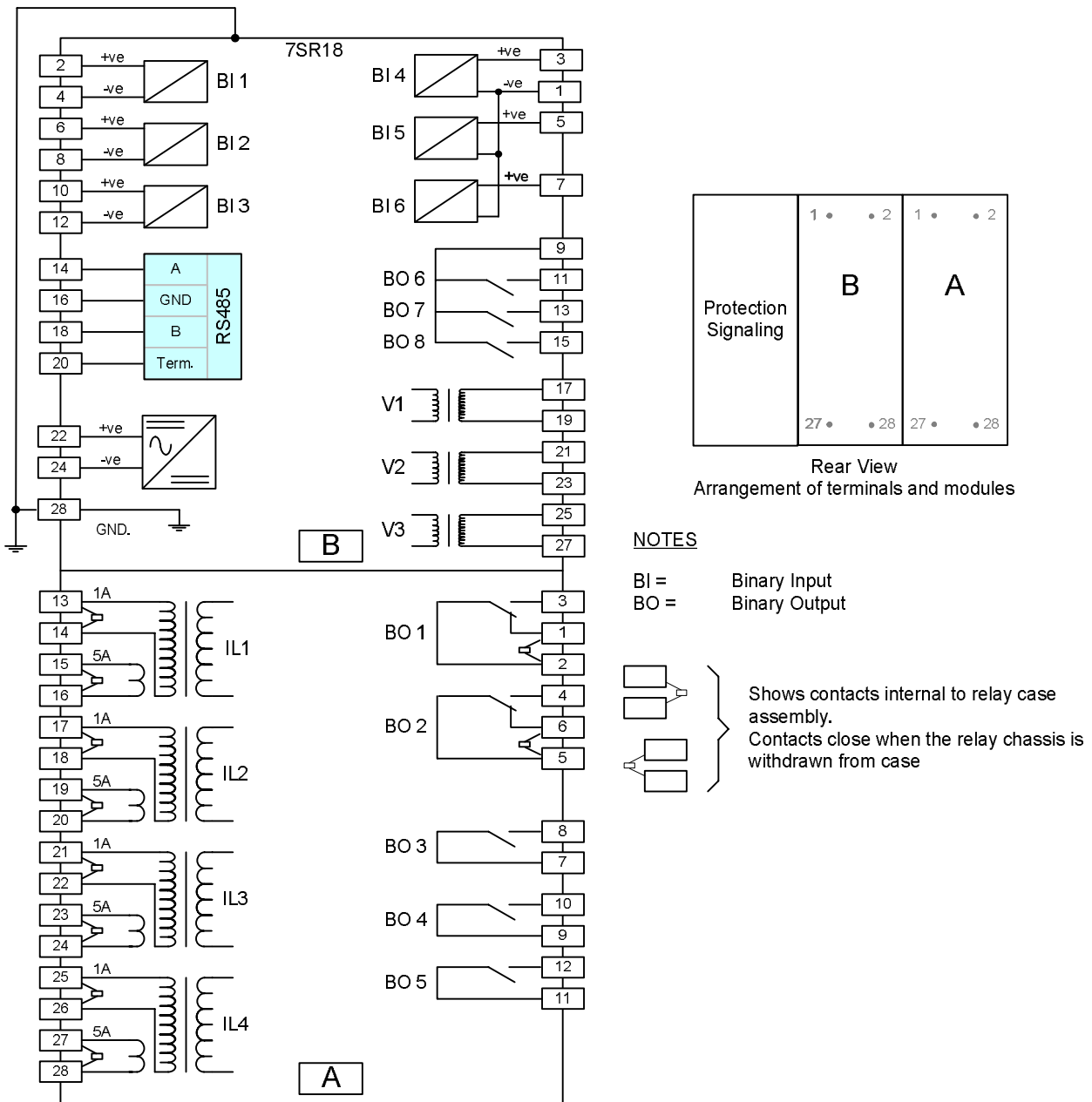
Fig. 11. Connections Diagram for 7SR18 Directional Relay (6BI and 8BO)

Case Dimensions

PANEL CUT-OUT — 150, 168, 159, 10, 130

SIDE VIEW — 11, 31, 216.5, 151.5

Case Earth connection

Typical when fitted

MINIMUM CLEARANCES:
25mm FOR TERMINAL WIRING
45mm FOR ETHERNET COMMS MODULE
70mm FOR F/O COMMS CABLE

Diameter 3.6 – 4 holes (see note)

75mm MIN CLEARANCE FOR ETHERNET COMMS WIRING

FRONT VIEW — 155.5, 177
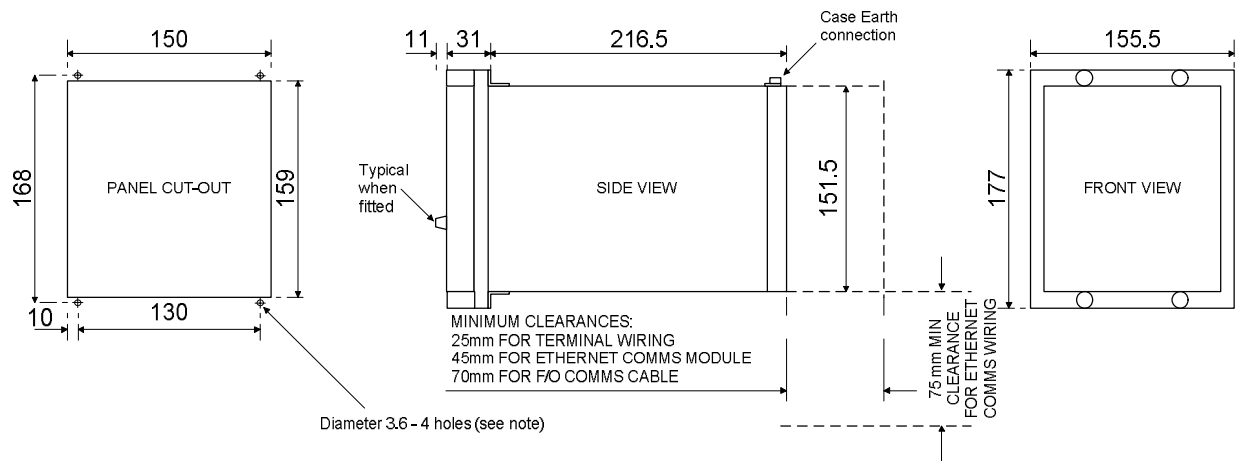
NOTE:
THE 3.6 HOLES ARE FOR M4 THREAD FORMING (TRILOBULAR) SCREWS. THESE ARE SUPPLIED AS STANDARD AND ARE SUITABLE FOR USE IN FERROUS / ALUMINIUM PANELS 1.6mm THICK AND ABOVE. FOR OTHER PANELS, HOLES TO BE M4 CLEARANCE (TYPICALLY 4.5 DIAMETER) AND RELAYS MOUNTED USING M4 MACHINE SCREWS, NUTS AND LOCKWASHERS (SUPPLIED IN PANEL FIXING KIT).

Fig. 12. E6 Case overall dimensions and panel drilling details (All dimensions in are mm)

Product description	Variants	Order No.

Order No.: `7 S R 1 8 1` `-` `☐ ☐ ☐ ☐ ☐` `-` `0` `A` `0`

Protection Product Family

Differential Protection	8

Case size

E6 [2]	1

I/O and Fascia

3 Binary Inputs, 5 Binary Outputs, 18 LEDs	1
3 Binary Inputs, 5 Binary Outputs, 10 LEDs + (6 keys each with LED)	2
6 Binary Inputs, 8 Binary Outputs, 18 LEDs	3
6 Binary Inputs, 8 Binary Outputs, 10 LEDs + (6 keys each with LED)	4

Measuring input

4 CTs (1 A or 5 A)	1
4 CTs (1 A or 5 A), 3 VTs (40 V to 160 V)	2

Auxiliary voltage

24 V DC to 250 V DC, 100 V AC to 230 V AC, binary input threshold 19 V DC	M
24 V DC to 250 V DC, 100 V AC to 230 V AC, binary input threshold 88 V DC	N

Protection Signalling Channel

Optical fibre link (820 nm) (ST connection) 2 km [1]	B	1
Optical fibre link (1300 nm) (LC connection) 40 km [1]	C	

Data Communication Interface

USB front port, RS485 (Terminal block) rear port	1	2
USB front port, RS485 (Terminal block) rear port, Electrical Ethernet RJ45 (x2) rear port	7	7
USB front port, RS485 (Terminal block) rear port, Optical Ethernet Duplex (x2) rear port	8	7

Protocol

IEC 60870-5-103 and Modbus RTU and DNP 3.0 (user selectable)	2
IEC 60870-5-103 and Modbus RTU and DNP 3.0 (user selectable) and IEC61850	7

Spare

	0

Protection Function Packages

Standard version — **C**

87L	3-Phase differential (with variable settings)
87HS	3-Phase Differential High Set
85	Inter-Trip
50	Instantaneous phase fault overcurrent
50G/50N	Instantaneous earth fault
51	Time delayed phase fault overcurrent
51G/51N	Time delayed earth fault
50LC	Line Check
37	Undercurrent
46NPS	Negative phase sequence overcurrent
49	Thermal overload
50BF	Circuit breaker fail
46BC	Broken conductor/load unbalance
60CTS-I	CT Supervision
74T&C	Trip & Close circuit supervision
51c	Cold load pickup
81HBL2	Inrush Detector
	Programmable Logic

For variants with 3 x VT inputs as above plus

51V	Voltage Controlled Overcurrent
60CTS	CT Supervision
60 VTS	VT supervision
67/50, 67/51	Directional Overcurrent
67 G/N	Directional Earth Fault

Version C - plus — **D**

79	Autoreclose

Additional Functionality

No additional functionality	A

Spare

	0

[1] Refer to Technical Manual
[2] Standard Version Cover - No Push Buttons

www. siemens.com/Reyrolle