Reyrolle
Protection
Devices

7SR23 DAD

High Impedance Protection Relay

Energy Management

SIEMENS

7SR23 DAD

High Impedance Relay

Fig 1. 7SR DAD fascia

Description

The 7SR23 DAD provides comprehensive, configurable high impedance protections with enhanced functionality and performance. Relay functionality is accessed via a familiar user friendly interface.
Housed in 4U high, size E6 or E8 cases, these relays provide protection, control, monitoring, instrumentation and metering with integrated input and output logic, data logging & fault reports.
Communication access to relay functionality is via a front USB port for local PC connection or rear electrical RS485 port for remote connection. Additional rear port options are available.

Function Overview

Protection

50G	Instantaneous/DTL Earth Fault
87REF	High Impedance REF
87/50	Phase Segregated Differential Protection

Supervision

CT50	CT Supervision
74TCS	Trip Circuit Supervision

Control

86	Lockout

Features

Password Protection – 2 levels
User Programmable Logic Equations, via HMI
Graphical Programmable Logic, via PC application
Self Monitoring

User Interface

20 character x 4 line backlit LCD
Menu navigation keys
3 fixed function LEDs
8 or 16 Programmable Tri-colour LEDs (Option)

Monitoring Functions

Standard Monitoring Functionality

Primary differential current phases and earth
Secondary differential current phases and earth
Binary Input/Output status
Trip circuit healthy/failure
Time and date
Starters
Fault records
Event records
Waveform records

Data Communications

Standard Communications Ports

Communication access to relay functionality is via a front USB port for local PC connection or rear electrical RS485 port for remote connection

Optional Communications Ports

2 rear ST fibre optic ports (2 x Tx/Rx) + IRIG-B port
1 rear RS485 + IRIG-B port
1 rear RS232 + IRIG-B port
2 rear electrical Ethernet RJ45 connectors
2 rear optical Ethernet duplex LC connectors

Protocols

IEC60870-5-103, Modbus RTU, and DNP 3.0 protocols. User selectable with programmable data points.
IEC61850 ethernet – optional.
Ethernet Redundancy: RSTP, HSR & PRP - standard on ethernet equipped models

Data

Up to 5000 event records
User configurable fault record duration
Waveform records
Measurands
Commands
Time synchronism
Viewing and changing settings

Description of Functionality

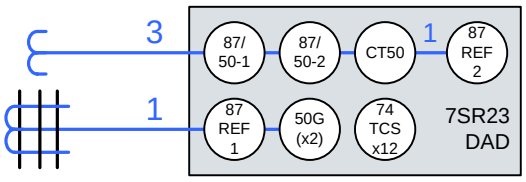


Fig 2. 7SR DAD Function Diagram

Figure 2 illustrates the functionality available within the 7SR23. The relay can be configured to provide the following modes of operation:

- 3 Pole Diff + REF
- 3 Pole Diff + EF
- REF1 + REF2

87/50 Differential Protection - scheme

Two sets of differential protection are provided, 87/50-1 and 87/50-2.
Current inputs can be connected to provide overall phase segregated high impedance differential protection.
External series stabilising resistors and non-linear, voltage limiting, shunt resistors are required for each phase.
To facilitate ordering, installation and commissioning these external components can be provided in a separate optional 'High Impedance Component Box'. See separate publication.
Output contacts of the relay are configured to trip the connected CBs and to short circuit the series stabilising resistors thereby ensuring that thermal ratings of the components are not exceeded.

CT50 CT Supervision

The CT Supervision feature measures the unbalance current in the CT circuits. Any unbalance current may indicate an open circuit in the CT secondary connections.
The phase segregated elements have user selectable operate current and time delay settings. This allows the faulted phase(s) to be short circuited and/or alarmed.

50G Earth Fault

Earth current is directly measured current from an independent CT or the residual connection of the 3 line CTs (Holmgreen connection).
Elements have independent settings for pickup current, and time-delay.

87REF Restricted Earth Fault - scheme

Analogue inputs can be connected and configured to provide one or two high impedance restricted earth fault protections (87 REF).
Each 87REF protection requires an external series stabilising resistor and non-linear shunt resistor.

In/Out Switching

When the protection is selected to 'Switched Out' the 87/50 functions are inhibited, trip contacts are disabled and contacts selected to the CT50 and 'Switched Out' functions are energized.

74TCS Trip Circuit Supervision

The trip circuits can be monitored via binary inputs connected in H4/H5/H6 or H7 schemes. Trip circuit failure raises an HMI alarm and output(s).

Programmable User Logic

The user can map Binary Inputs and Protection operated outputs to Function Inhibits, Logic Inputs, LEDs and/or Binary Outputs.
The user can also enter up to 16 equations defining scheme logic using standard functions e.g. Timers, AND/OR gates, Inverters and Counters.
Each Protection element output can be used for Alarm/Indication and/or tripping.
In addition, the Reydisp Manager PC application provides graphical programming of user logic within the device.

Function LED's

Eight or sixteen user programmable tri-colour LED's are provided eliminating the need for separate panel mounted indicators and associated wiring. Each LED can be user set to red, green or yellow allowing for indication of the associated function's status.
A slip-in pocket adjacent to the LEDs enables the user to insert customised labels. A printer compatible template is available.

Application

3 phase high impedance differential protection is typically applied to busbars, connections, auto-transformers, reactors and motors. Restricted earth fault protection is typically applied to provide protection of transformer windings. See figure 6.

High impedance protection is recommended for all applications where faults must be cleared in the shortest possible time and where discrimination must be ensured. High impedance schemes can provide lower fault settings and better through fault stability than is possible with most other schemes.

The stability of the high impedance scheme is ensured because the applied operate voltage setting is greater than the maximum voltage that can appear across the relay circuit under through fault conditions. An external series stabilising resistor (R_{STAB}) is installed to provide a relay circuit operate voltage is above that required to guarantee stability.
External non-linear resistors (Metrosils) are connected in parallel with the relay circuit to limit circuit over-voltages.

The relay current setting and the operating voltage of the relay/stabilising resistor combination is calculated taking into account:-

- Transient stability under through fault conditions as verified by calculation assuming worst case conditions.
- The required operate level for internal fault conditions.

It is recommended that low reactance CTs to IEC 61869-2 Class PX are used.

The CT supervision function (CT50) provides monitoring of CT secondary wiring connections.
CT supervision commonly supplements 3-phase differential protection as a fault in the CT secondary circuit wiring will cause unbalance current to flow during normal load conditions. Where the unbalance current is above the protection operate level this will cause unnecessary tripping of the protected zone. This is particularly relevant where current transformer wiring is switched as in some busbar protection arrangements.
Detection of a CT secondary wiring fault is arranged to provide an alarm and/or inhibit the differential protection (87/50) after a time delay. The time delay is required such that the CT supervision function does not operate during internal fault conditions.

Theory of High Impedance Current Balance Protective Schemes and their Application

Determination of Stability

The stability of a current balance scheme using a high impedance relay circuit depends upon the relay voltage setting being greater than the maximum voltage which can appear across the relay during a through fault condition. This maximum voltage can be determined by means of a simple calculation which makes the following assumptions:
One current transformer is fully saturated making its excitation impedance negligible.
The resistance of the secondary winding of the saturated current transformer together with the leads connecting it to the relay circuit terminals constitute the only burden in parallel with the relay.
The remaining current transformers maintain their ratio.

Thus the maximum voltage is given by:

(1) $$V = I_F\left(R_{CT} + R_L\right) \times T$$

Where:

V = Maximum voltage across relay circuit during through fault conditions.

R_L = Resistance current transformer connection leads.

R_{CT} = Current transformer secondary winding resistance

I_F = Maximum steady state through fault current.

T = Turns ratio of all current transformers (Primary turns / secondary turns)

For stability, the voltage setting of the relay V_S must be made equal to or exceed, the highest value of V calculated above. Experience and extensive laboratory tests have proved that if this method of estimating the relay setting voltage is adopted, the stability of the protection will be very much greater than the value of I used in the calculation. This is because a current transformer is normally not continuously saturated and consequently any voltage generated by this current transformer will reduce the voltage appearing across the relay circuit.

Method of Establishing Relay Setting Current

Relay setting current is given by:

(2) $$I_S = P.O.C - \left(\sum I_{mag} + I_{NLR}\right) / T$$

Where:

I_S = Relay setting current

P.O.C. = Primary operate current (fault setting).

I_{mag} = Current transformer magnetising currents at the value of V_S.

I_{NLR} = Current taken by the non-linear resistor/voltage limiting device at V_S (this value is usually small and often may be neglected).

Equation (2) should properly be the vector sum, however arithmetic addition is normally used.

Establishing the Value of Setting Resistors

Stabilising resistor value R_{STAB} is given by:

(3) $$R_{STAB} = \frac{V_S}{I_S}$$

Where:

V_S = Relay circuit operate voltage

Exact resistor values are not necessary, a higher standard resistance value may be chosen. A check is made to confirm that the finalized value of Vs provides stability and is compatible with the installed CTs ie:

(4) V < **Vs** < 0.5V x CT knee point voltage

The required watt-second rating of the resistor is established at setting and at the maximum fault rating – short time rating. The power dissipation of the resistors should be considered, they should be mounted vertically in a well ventilated location and clear of all other wiring and equipment.

Data Acquisition - Via Communication Interface

Sequence of event records

Up to 5000 events are stored and time tagged to 1ms 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.
20 seconds of waveform storage is available.
The waveform storage duration period is user configurable.
Different storage periods can be selected for triggering from protection function, binary input or data comms.

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, via the data communication channel(s) or from the optional IRIG-B port.

Reydisp Evolution

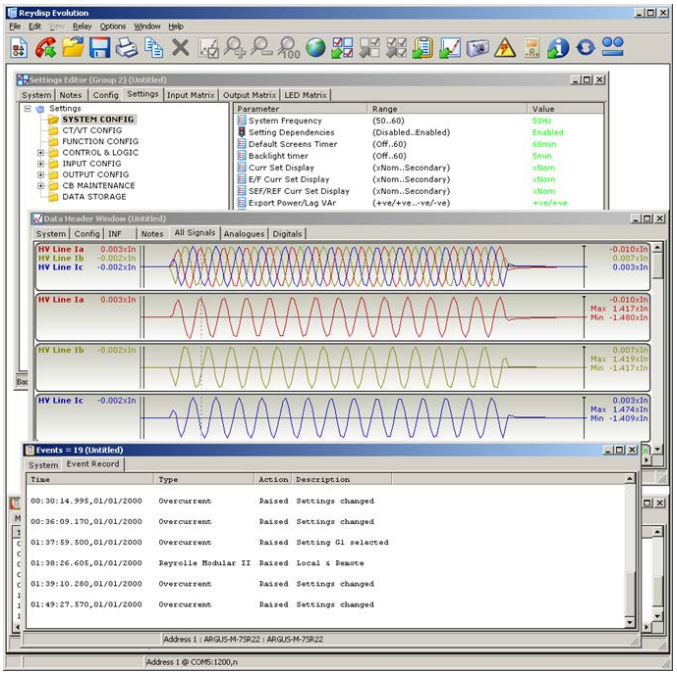


Fig 3. Typical Reydisp Evolution screenshot

Reydisp Evolution is common to the entire range of Reyrolle numeric products. It provides a means for the user to apply settings, interrogate settings and also to retrieve events & disturbance waveforms from the relay.

Reydisp Evolution installation includes a Communications Editor to allow configuration of the serial protocol data points and a Language Editor to allow relay display text to be edited. This can be used to provide non-English language support using the European character set.

Reydisp Manager

Reydisp Manager provides the functionality of Reydisp Evolution and also provides project management of multiple devices to allow engineering of IEC61850 projects. It also provides access to user logic within the devices via an easy to use graphical interface.

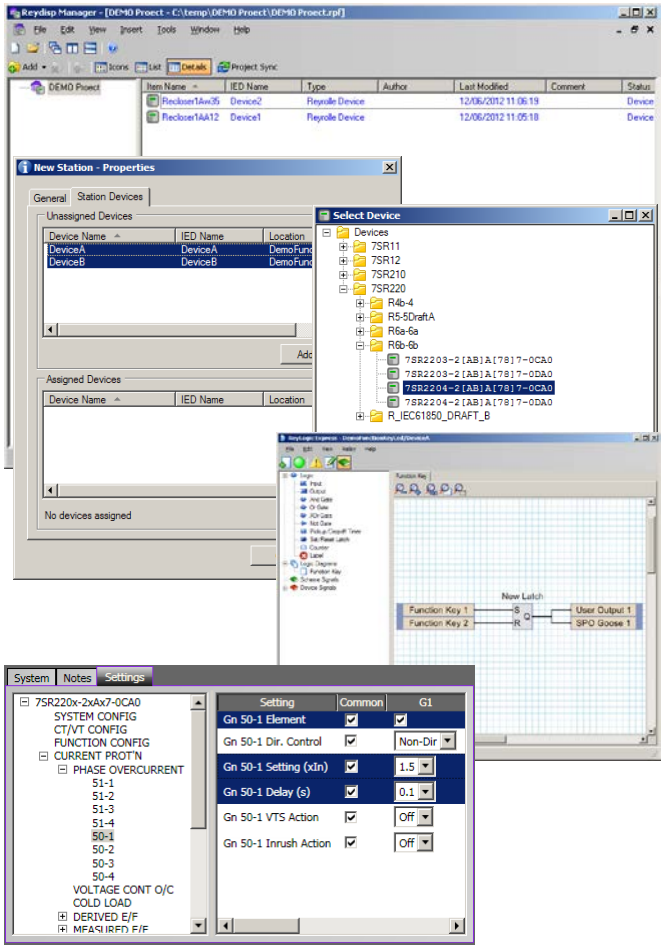


Fig 3. Typical Reydisp Manager screenshots

Technical Data

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

Inputs and Outputs

Current Inputs

Quantity	4
Rated Current IN	1/5A
Measuring Range	8 x In max
Instrumentation	±1% In or ±10mA
Frequency	50/60Hz
Thermal Withstand: Continuous 1 Second	 4.0 xIn 100A (1A) 350A (5A)
Burden @ In	≤0.1VA (1A input) ≤0.3VA (5A input)

Auxiliary supply

Rated DC Voltage	24-250V DC Operating Range 19.2 to 275V	
Allowable superimposed ac component	12% of DC voltage	
Rated AC Voltage	100-230 VAC 50/60Hz Range 80 to 253 V rms AC 50/60Hz ±5%	
Power Consumption:	Quiescent State (DC) Maximum Load (DC)	24V: 8W 110V: 7W 250V: 7W 24V: 12W 110V: 11W 250V: 11W
	Quiescent State (AC) Maximum Load (AC)	100V: 16VA 230V: 21VA 100V: 23VA 230V: 30VA
Allowable breaks/dips in supply (collapse to zero)	DC	50ms
	AC	2.5/3 cycles @50/60Hz

Binary Inputs

Operating Voltage	19V dc: Range 17 to 290V dc 88V: Range 74 to 290V dc
Maximum dc current for operation	1.5mA

Binary Outputs

Operating Voltage	Voltage Free	
Operating Mode	User selectable - Self or Hand Reset	
Contact Operate / Release Time.	7ms / 3ms	
Making Capacity: Carry continuously Make and carry (L/R ≤ 40 ms and V ≤ 300 V)	 5A ac or dc 20A ac or dc for 0.5s 30A ac or dc for 0.2s	
Breaking Capacity (≤ 5 A and ≤ 300 V): AC Resistive AC Inductive DC Resistive DC Inductive	 1250VA 250VA 75W 30W 50W	 at p.f. ≤ 0.4 at L/R ≤ 40ms at L/R ≤ 10ms

Mechanical Tests

Vibration (Sinusoidal)

IEC 60255-21-1 Class I

Type	Level	Variation
Vibration response	0.5gn	≤ 5 %
Vibration endurance	1.0gn	≤ 5 %

Shock and Bump

IEC 60255-21-2 Class I

Type	Level	Variation
Shock response	5gn, 11ms	≤ 5 %
Shock withstand	15gn, 11ms	≤ 5 %
Bump test	10gn, 16ms	≤ 5 %

Seismic

IEC 60255-21-3 Class I

Type	Level	Variation
Seismic response	1gn	≤ 5 %

Mechanical Classification

Durability	>10^6 operations

Electrical Tests

Insulation

IEC 60255-5

Type	Level
Between any terminal and earth	2.0kV AC RMS for 1min
Between independent circuits	
Across normally open contacts	1.0kV AC RMS for 1min

High Frequency Disturbance

IEC 60255-22-1 Class III

Type	Level	Variation
Case, Aux Power & I/O. Common mode	2.5kV	≤ 10%
Case, Aux Power & I/O. Transverse mode	1.0kV	≤ 10%
RS485 Comms	1.0kV	No data loss

Electrostatic Discharge

IEC 60255-22-2 Class IV

Type	Level	Variation
Contact discharge	8.0kV	≤ 5%

Electrical Fast Transient / Burst Immunity

IEC 60255-22-4 Class A (2002)

Type	Level	Variation
Case, Aux Power & I/O	4.0kV	≤ 10%
RS485 Comms	2.0kV	No data loss

Surge Immunity

IEC 60255-22-5

Type	Level	Variation
Analog Inputs. Line to Earth	4.0kV	≤ 10%
Case, Aux Power & I/O. Line to Earth	2.0kV	
Analog Inputs. Line to Line	1.0kV	
Case, Aux Power & I/O. Line to Line	1.0kV*	
RS485 Comms port. Line to Earth	1.0kV	No data loss

*Note 45ms pick up delay applied to binary inputs

Conducted Radio Frequency Interference

IEC 60255-22-6

Type	Level	Variation
0.15 to 80MHz	10V	≤ 5%

Radiated Radio Frequency

IEC 60255-25

Type	Limits at 10m, Quasi-peak
30 to 230MHz	40dB(μV/m)
230 to 10000MHz	47dB(μV/m)

Conducted Radio Frequency

IEC 60255-25

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

Radiated Immunity

IEC 60255-22-3 Class III

Type	Level	Variation
80MHz to 1000MHz	10V/m	≤ 5%

Magnetic Field with Power Frequency

IEC 61000-4-8, Class V

Type	Level
100A/m (0.126mT) continuous	50Hz
1000A/m (1.26mT) for 3s	

Environmental Tests

Temperature

IEC 60068-2-1/2

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 95% relative humidity

IP Ratings

IEC 60529

Type	Level
Installed with cover	IP 51 from front of relay
Installed with cover re-moved	IP 20 from front of relay

Performance

87/50 Differential Protection

Setting Range	0.01…2.00 xI_n
Operate Level	100% Is, ±5% or ±1% xIn
Time Delay	0.00… 60s
Basic Operate Time	2 x Is: 22ms ±5ms, 50Hz 2 x Is: 20ms ±5ms, 60Hz 3 x Is: 1 cycle ±5ms 5 x Is: < 1 cycle
Reset Time	< 50ms
Harmonic Rejection	40:1 minimum (2nd to 15th harmonic)
Inhibited by	CT50, Binary or Virtual Input

CT50 CT Supervision

Setting Range	0.005…2.00 xI_n
Operate Level	100% Is, ±5% or ±1% xIn
Time Delay	0.00… 60s
Basic Operate Time	2 x Is: 22ms ±5ms, 50Hz 2 x Is: 20ms ±5ms, 60Hz 3 x Is: 1 cycle ±5ms 5 x Is: < 1 cycle
Inhibited by	Binary or Virtual Input

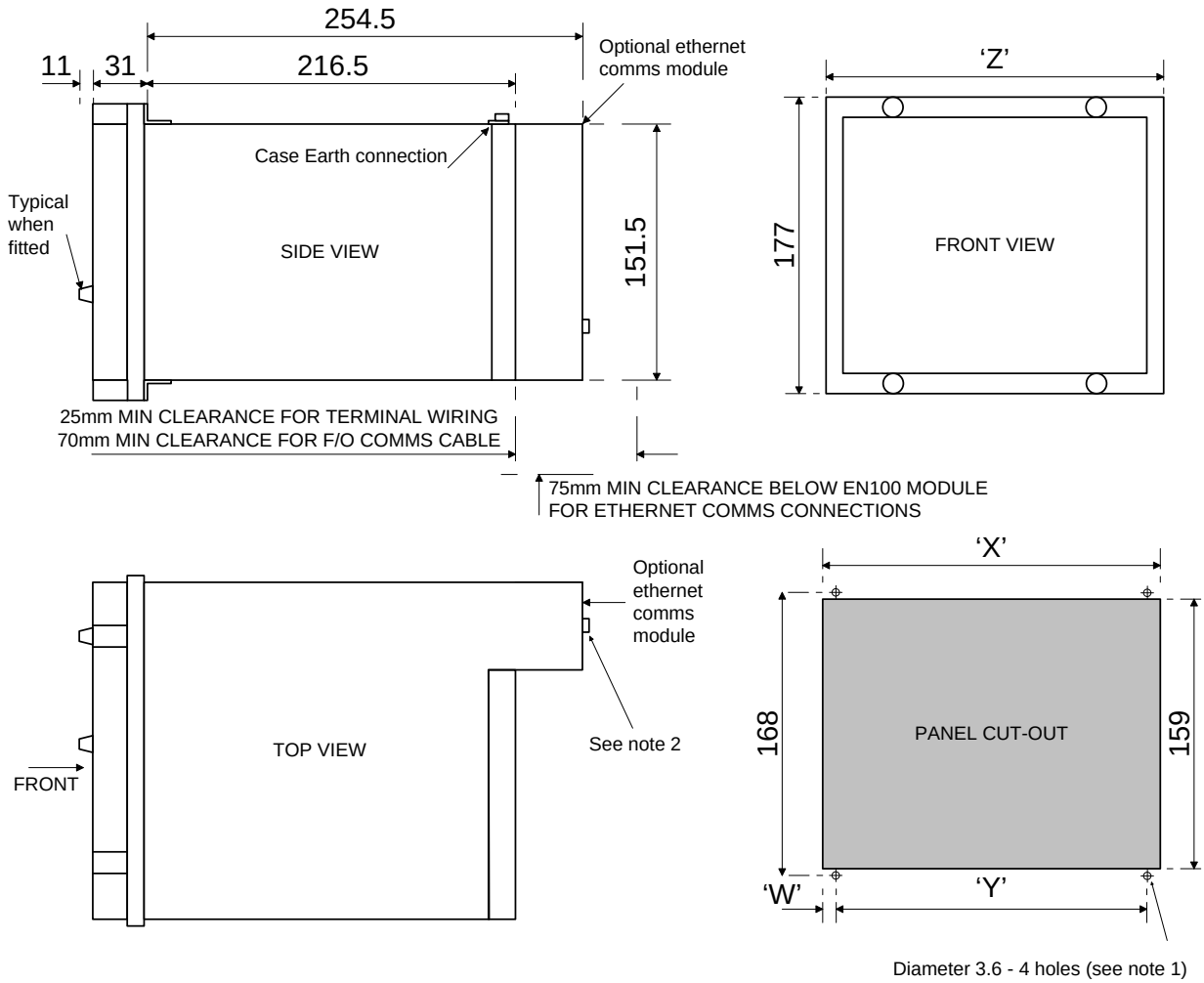
87REF Restricted Earth Fault

Setting Range	0.01…2.00 xI_n
Operate Level	100% Is, ±5% or ±1% xIn
Time Delay	0.00… 60s
Basic Operate Time	2 x Is: 22ms ±5ms, 50Hz 2 x Is: 20ms ±5ms, 60Hz 3 x Is: 1 cycle ±5ms 5 x Is: < 1 cycle
Reset Time	< 50ms
Harmonic Rejection	40:1 minimum (2nd to 15th harmonic)
Inhibited by	Binary or Virtual Input

50G Instantaneous & DTL Measured EF

Elements	Measured Earth
Number of Elements	2
Setting Range Is: - Measured E/F 'G'	0.01…2 xIn
Time Delay	0.00…60s
Operate Level	100% Is, ±5% or ±1% xIn
Operate time	2 x Is: 22ms ±5ms, 50Hz 2 x Is: 20ms ±5ms, 60Hz 3 x Is: 1 cycle ±5ms 5 x Is: < 1 cycle
Operate time following delay	t_{basic} +t_d , ±1% or ±10ms
Inhibited by	Binary or Virtual Input

Case Dimensions



EPSILON CASE SIZE		
	E6	E8
W	10	9.75
X	150	201.5
Y	130	182
Z	155.5	207.5

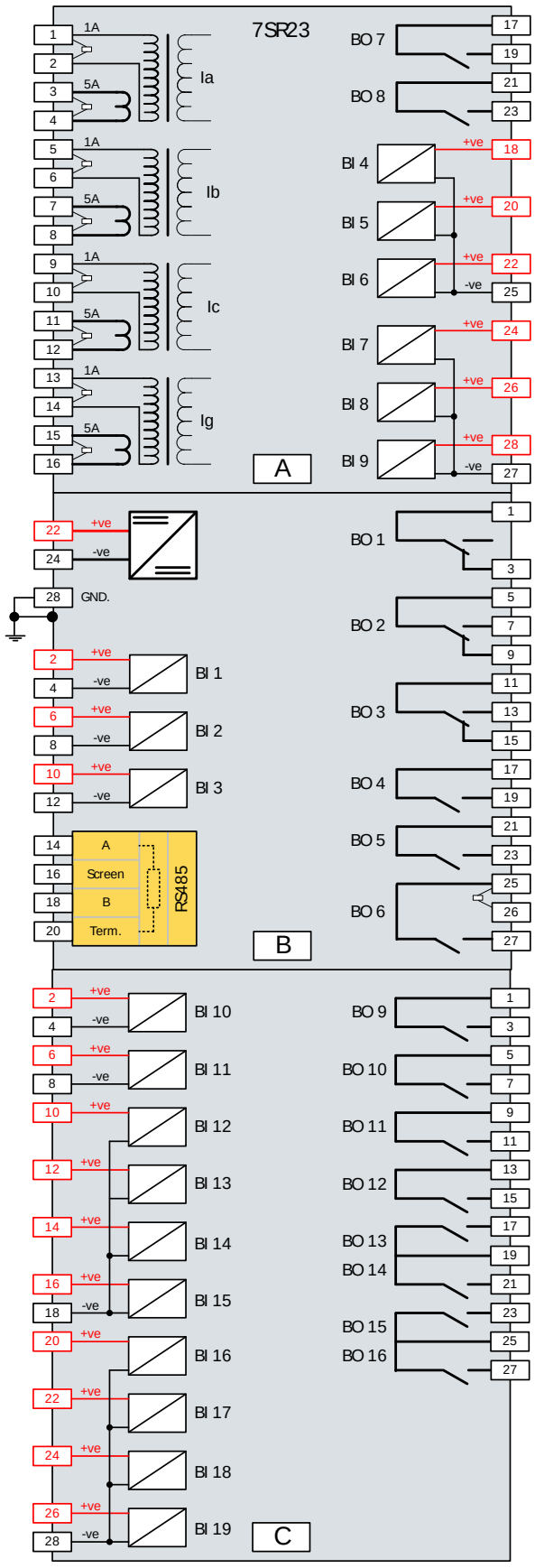
NOTES:

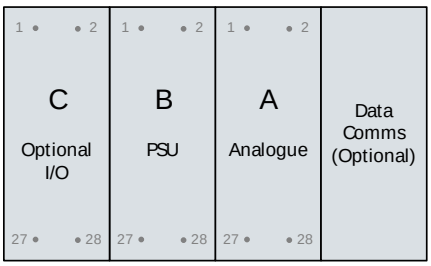
1) THE 3.6 HOLES ARE FOR M4 THREAD FORMING (TRILOBULAR) SCREWS. THESE ARE SUPPLIED AS STANDARD AND ARE SUITABLE FOR USE IN FERROUS / ALUMINIUM PANELS 1.6mm THICK AND ABOVE. FOR OTHER PANELS, HOLES TO BE M4 CLEARANCE (TYPICALLY 4.5 DIAMETER) AND RELAYS MOUNTED USING M4 MACHINE SCREWS, NUTS AND LOCKWASHERS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

2) ACCESS CLEARANCE REQUIRED FOR OPTIONAL ETHERNET COMMS MODULE RETAINING SCREW

Fig 4. Case overall dimensions and panel drilling details (All dimensions in are mm)

7SR DAD Connection Diagram

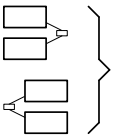




Rear View
Arrangement of terminals and modules

NOTES

BI = Binary Input
BO = Binary Output



Shows contacts internal to relay case assembly.
Contacts close when the relay chassis is withdrawn from case

Fig 5. 7SR DAD Wiring Diagram

Typical Applications

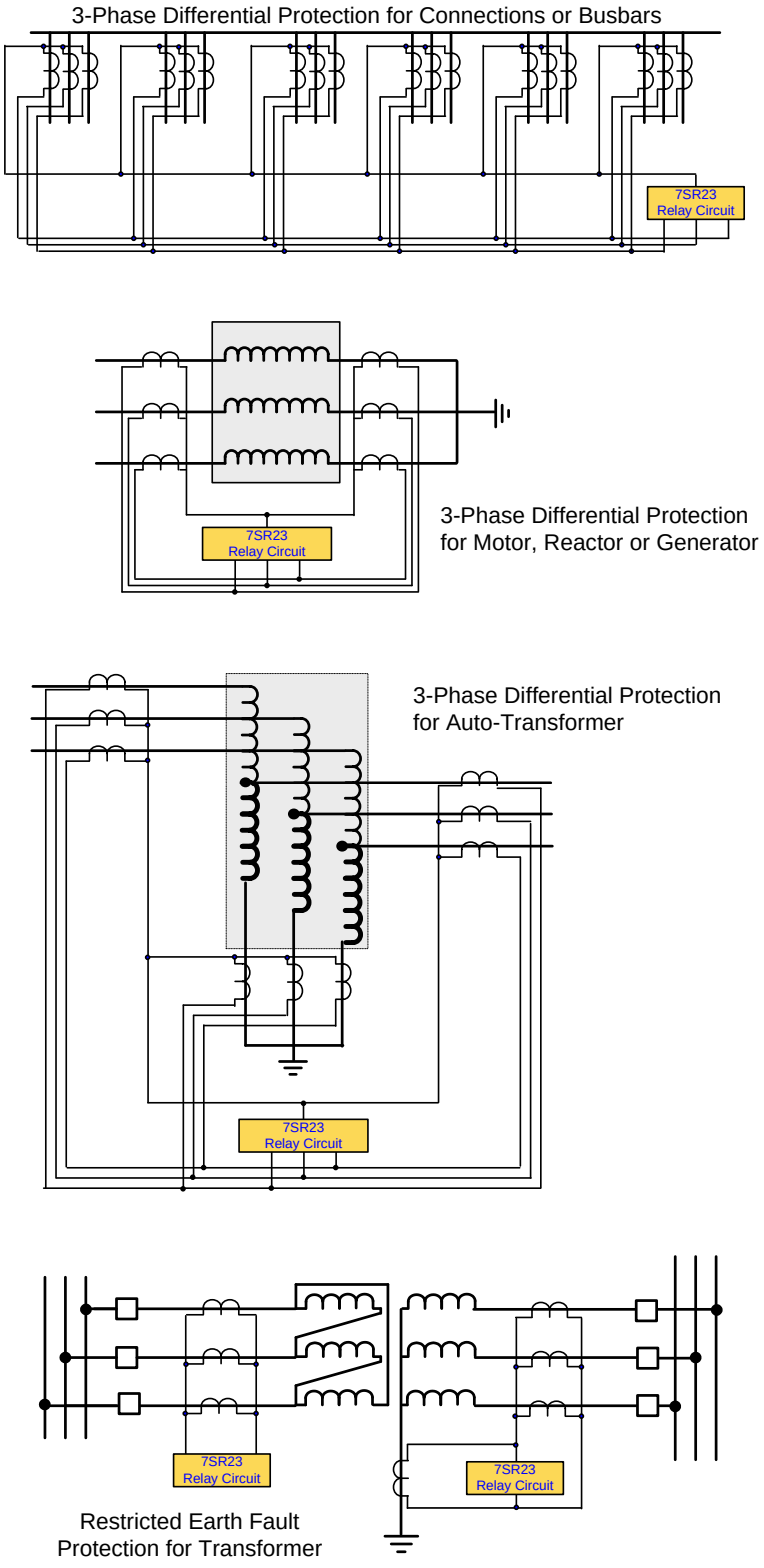


Fig 6. Typical Applications for the 7SR23 DAD

Ordering Information – 7SR23 DAD High Impedance Relay

DAD

High Impedance Protection

7 S R 2 3 0 □ - 1 □ A □ □ - 0 C A 0

Protection Product
Circulating Current — 3 0

Case I/O and Fascia [1)]
4 CT, 9 BI, 8 BO, 8 LEDs E6 Case (1 — 2
4 CT, 19 BI, 16 BO, 16 LEDs E8 Case (1 — 3

Measuring Input
1/5 A, 50/60Hz — 1

Auxiliary voltage
PSU Rated: 24-250V DC / 100-230V AC, binary input threshold 19V DC (Rated: 24-250V DC) — M
PSU Rated: 24-250V DC / 100-230V AC, binary input threshold 88V DC (Rated: 110-250V DC) — N

Communication Interface
Standard version – included in all models, USB front port, RS485 rear port — 1 2
Standard version – plus additional rear F/O ST connectors (x2) and IRIG-B — 2 2
Standard version – plus additional rear RS485 and IRIG-B — 3 2
Standard version – plus additional rear RS232 and IRIG-B — 4 2
Standard version – plus additional rear Electrical Ethernet RJ45 (x2) — 7 7
Standard version – plus additional rear Optical Ethernet Duplex LC (x2) — 8 7

Protocol
IEC 60870-5-103, Modbus RTU and DNP3.0 (user selectable setting) — 2
IEC 60870-5-103, Modbus RTU and DNP 3.0 (user selectable) and IEC 61850 — 7

Protection Function Packages

50G	Measured Earth Fault Protection
87/50	Phase Segregated High Impedance Differential Protection
87REF	High Impedance Restricted Earth Fault Protection
CT50	CT Supervision
74TCS	
	Programmable logic

C

1) BI = Binary Input, BO = Binary Output,

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