1.1.2.4 7SR191 Capacitor Protection Relay

Description

The 7SR191 Capa devices are numeric protection relays designed for application on shunt connected distribution capacitor banks arranged in all common connection configurations, typically single star, double star, delta or in an H configuration. These relays provide all protection functions required in a single device. Relay versions which can be connected to primary voltage transformers provide additional voltage protection functions and metering.
The 7SR191 relays are developed from the proven 7SR11 & 7SR12 Argus family of products providing a familiar product using the latest generation of hardware technology.
Housed in a 4U high, size E4 or E6 (Optional IEC61850 model) case, these relays provide 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 electrical RS485 port for remote connection & optional IEC61850 communication through two rear Ethernet ports (Electrical or Optical).

Function Overview

Protection

37	Undercurrent/Loss of Supply
46MDT	Phase Unbalance
46	Negative Phase Sequence Overcurrent
49	Thermal Overload
50	Instantaneous Overcurrent
50N	Instantaneous Earth Fault
50BF	Circuit Breaker Fail
51	Time Delayed Overcurrent
51N	Time Delayed Derived Earth Fault
59C	Overvoltage by Current Integration
60C	Capacitor Unbalance Current
87REF	High Impedance REF
27/59	Under/Over Voltage
47	Negative Phase Sequence Voltage
59IT	Inverse Time Overvoltage
59N	Neutral Voltage Displacement
67/50	Directional Instantaneous Overcurrent
67/50N	Directional Instantaneous Earth Fault
67/51	Directional Time Delayed Overcurrent
67/51N	Directional Time Delayed Earth Fault
83	Under/Over Frequency

Supervision

60CTS CT Supervision
74T/CCS Trip & Close Circuit Supervision
60VTS VT Supervision

Control

CB Control
Reswitch Blocking

Features

Cold Load Settings
Four Settings Groups
Password Protection – 2 levels
User Programmable Logic
User specified voltage, current & thermal protection curves
Self Monitoring
Circuit Breaker Trip and Maintenance Counter
Trip Timers

User Interface

20 Character x 4 Line Backlit LCD
Menu Navigation Keys
9 User Programmable Tri-colour LEDs
User Language Configuration

Monitoring Functions

Primary/Secondary Current Phases and Earth Direction
Primary/Secondary Line and Phase Voltages
Capacitor Overvoltage
Capacitor Unbalance Current
Apparent Power and Power Factor
Real and Reactive Power
Import and Export, Real and Reactive Energy
Historical Demand Record
Positive Phase Sequence (PPS) Voltage & Current
Negative Phase Sequence (NPS) Voltage & Current
Zero Phase Sequence (ZPS) Voltage
Frequency
Harmonic currents up to 15^{th} and Total Harmonic Distortion
Binary Input/Output status
Trip circuit healthy/failure
Time and date
Starters
Fault records
Event records
Circuit breaker trip counters
I^2t summation for contact wear

Hardware

4 CT 3 Binary Inputs 5 Binary Outputs
4 CT 6 Binary Inputs 8 Binary Outputs
4 CT 3 VT 3 Binary Inputs 5 Binary Outputs
4 CT 3 VT 6 Binary Inputs 8 Binary Outputs

Application

The 7SR191 Capa is a numerical protection relay intended for use on shunt connected distribution capacitor banks. It provides a highly comprehensive functional software package with a range of integral application functions aimed at reducing installation, wiring and engineering time.
An extensive range of metered values can be viewed on the front LCD or at a remote point via the communication channel.
The integrated control feature allows local and remote operation of a single circuit breaker and monitoring of its trip and close circuits. Loss of supply to the capacitor is detected and can be used to disconnect from the network. Automatic blocking of subsequent reconnection until the capacitor has safely discharged is also provided.
Distribution capacitor banks are constructed from a large number of individual capacitor units. These units will periodically fail due to the electrical stress applied during normal service. Failure of a single unit is acceptable as the resulting short circuit will be cleared by either operation of fuses, in internally or externally fused arrangements, or simply be coped with by design in unfused and fuseless arrangements. However, the failure of one unit will impose increased stress on remaining units increasing the probability that these units will fail. This will further increase stresses and if not disconnected, could eventually lead to cascading failure of the whole bank. The bank is often split into similar sections, arranged such that the balanced nature can be used as a basis for early failure detection. Current transformers are typically fitted at suitable locations to allow unbalance current to be measured by protection devices.
In addition to this, measurement of the total bank current is measured to detect unbalance between phases caused by capacitor unit failure as well as overload protection and for detection of insulation failure faults such as phase to phase and phase to earth flashover.
The 7SR191 provides user configuration settings for operating mode to allow the current inputs to be allocated to the protection functions to cater for all common bank arrangements with a single ordering code. When set in 3 Pole Overcurrent + 1 Pole Unbalance mode, the four current inputs are allocated as three phase current inputs plus one unbalance input. In 1 Pole Overcurrent + 3 Pole Unbalance mode, the four inputs are allocated instead to provide three phase segregated inputs plus a single phase reference input.

Function Matrix

FUNCTIONAL REQUIREMENT	7SR1912/7SR1913 3P OC +1P UB mode *	7SR1912/7SR1913 1P OC +3P UB mode *	7SR1915/7SR1916 3P OC +1P UB mode *	7SR1915/7SR1916 1P OC +3P UB mode *
59C Overvoltage by current integration	■	■	■	■
60C Capacitor Unbalance	■	■	■	■
37 Undercurrent, Loss of Supply	■	■	■	■
Reswitch Blocking	■	■	■	■
46MDT Phase Unbalance	■		■	
46 Negative Phase Sequence Overcurrent	■		■	
47 Negative Phase Sequence Voltage			■	■
49 Thermal Overload	■	■	■	■
50 Instantaneous Overcurrent	■		■	
50N Derived Instantaneous Earth Fault	■		■	
50BF CB Failure	■	■	■	■
51 Time Delayed Overcurrent	■		■	
51N Derived Time Delayed Earth Fault	■		■	
27 Undervoltage			■	■
59 Overvoltage			■	■
59N Neutral Voltage Displacement			■	■
87REF High Impedance Restricted Earth Fault	■		■	
67 Directional Overcurrent			■	
67N Directional Derived Earth Fault			■	
81 Under/Over Frequency			■	■
CONTROL / MONITOR				
51c Cold Load	■	■	■	■
60CTS CT Supervision	■		■	■
60VTS VT Supervision			■	■
50BF Circuit breaker Fail	■	■	■	■

Key - ■ - Included as standard
* - Mode is selectable by user setting

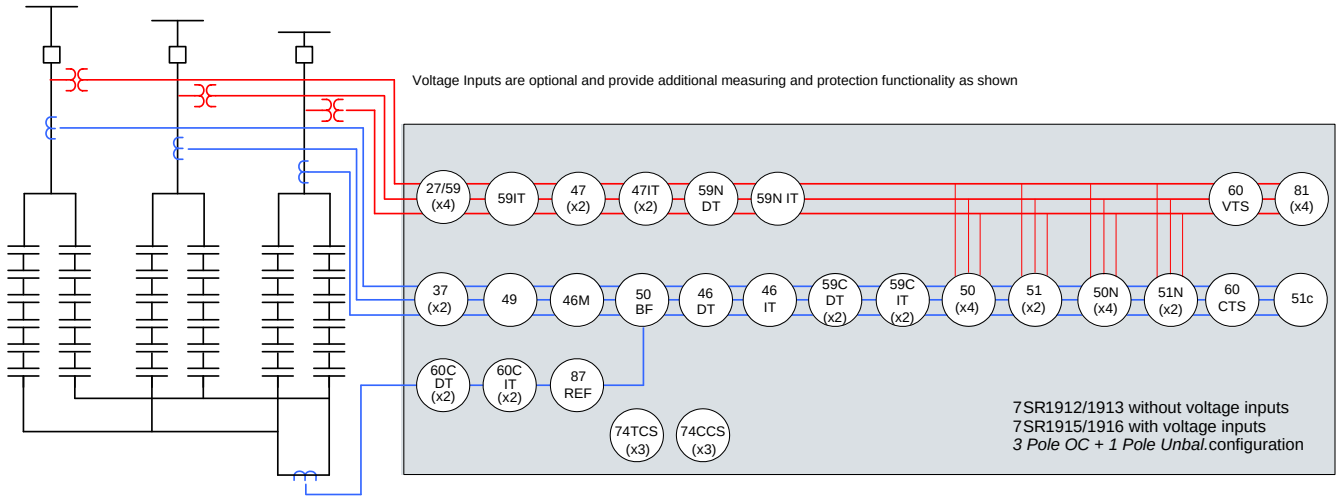

Fig1. Typical Unearthed Double Star (DY)

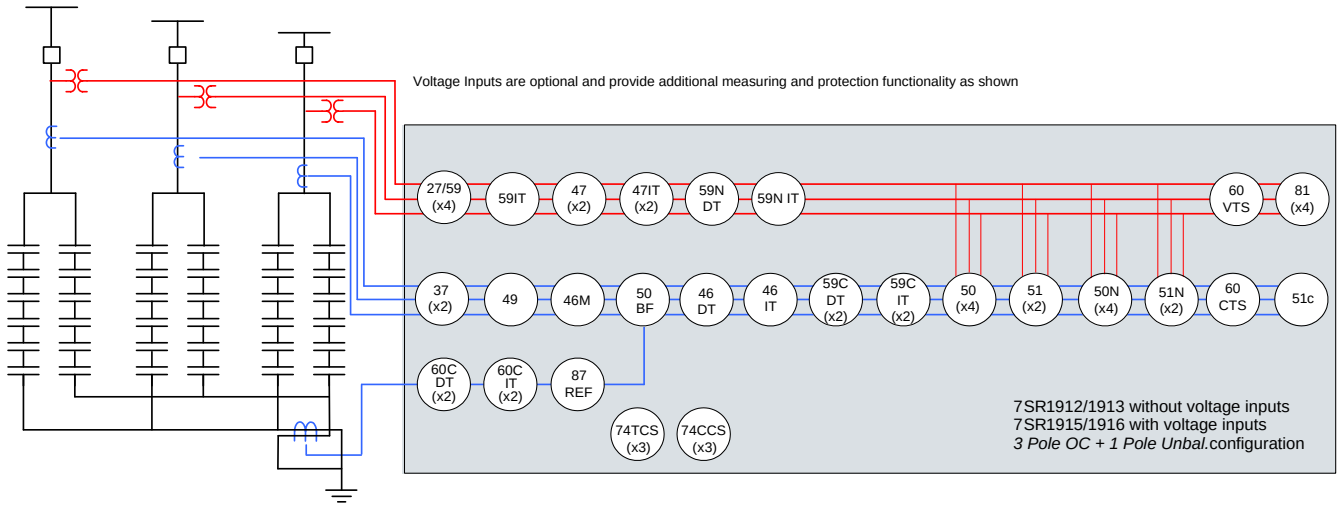

Fig2. Typical Earthed Double Star (DY)

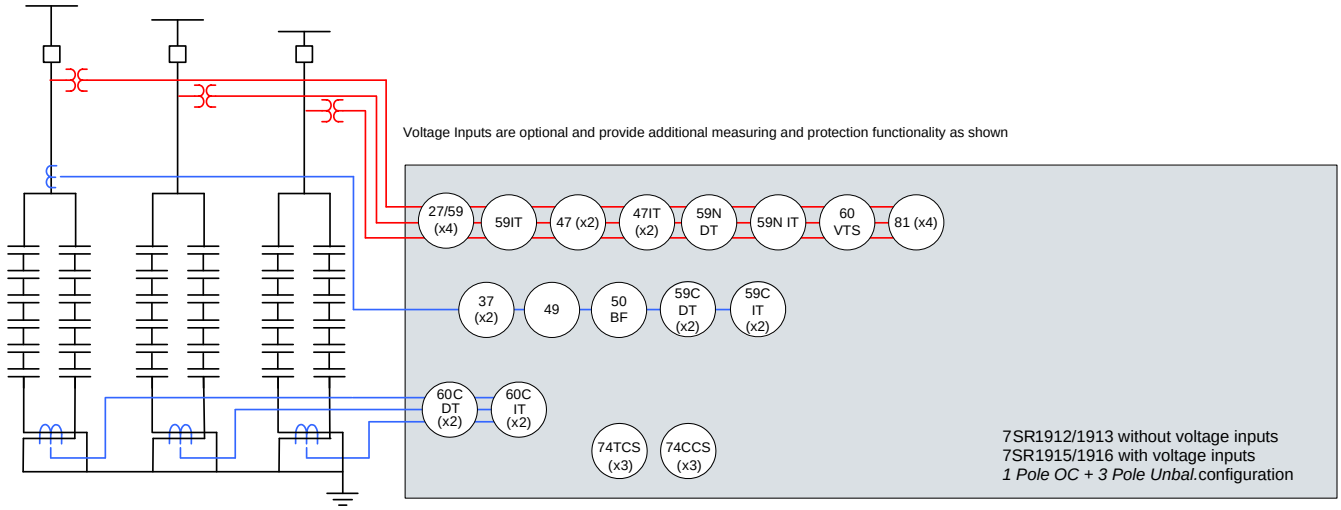

Fig3. Typical Earthed Double Star (DY) with segregated unbalance

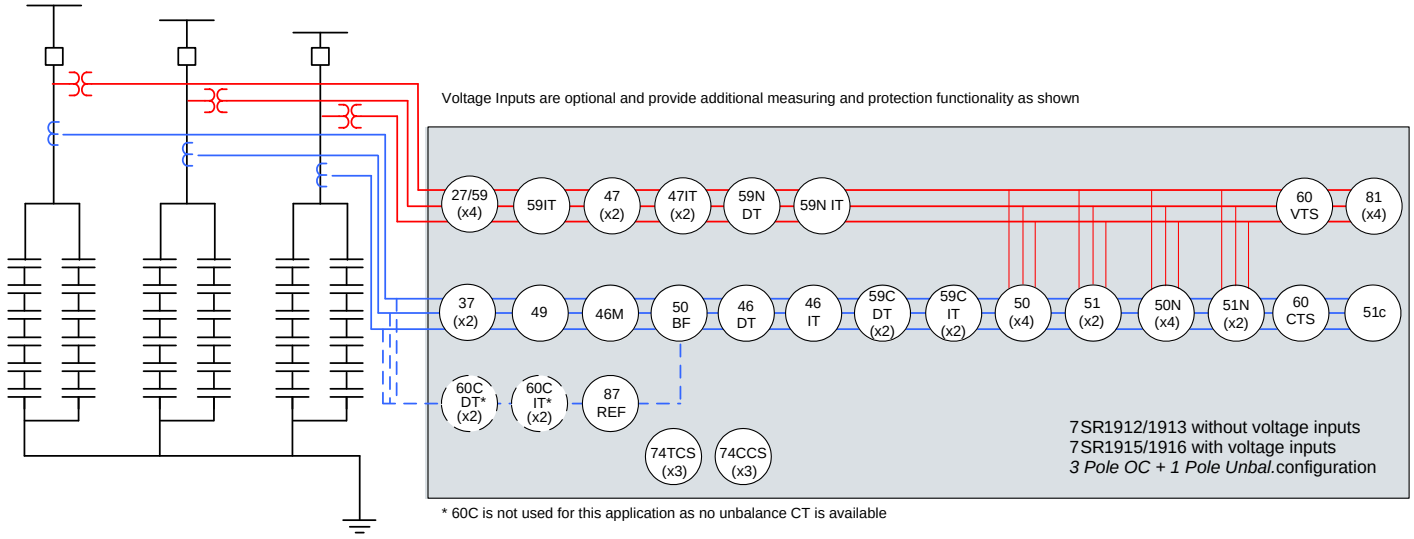

Fig4. Typical Single Star

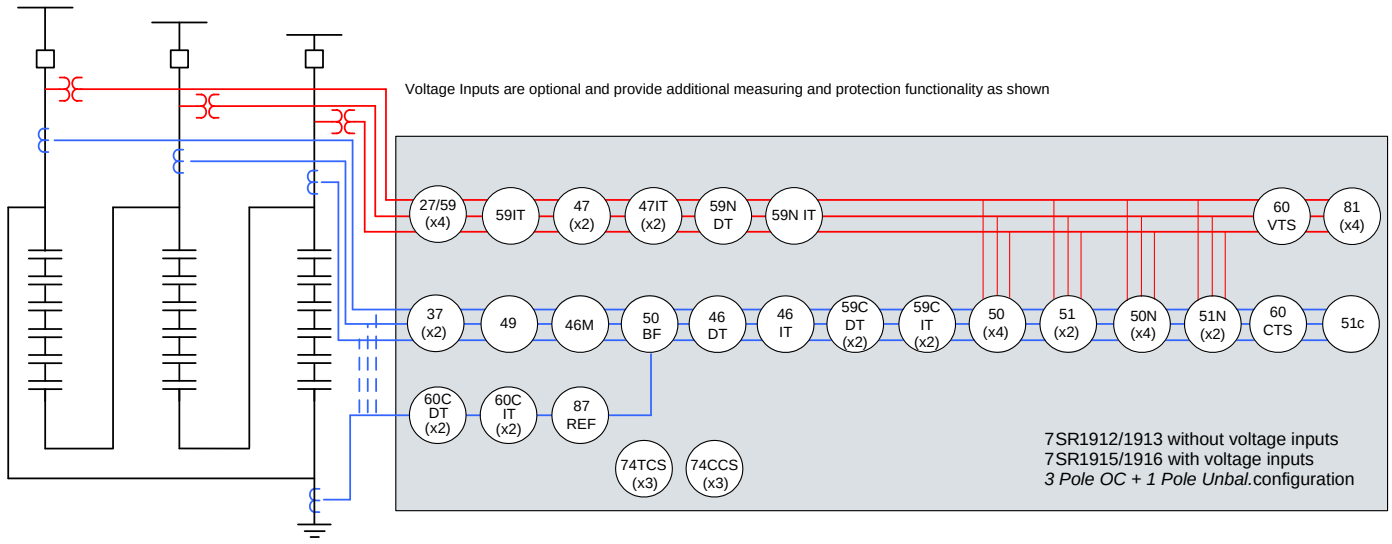

Fig5. Typical Delta

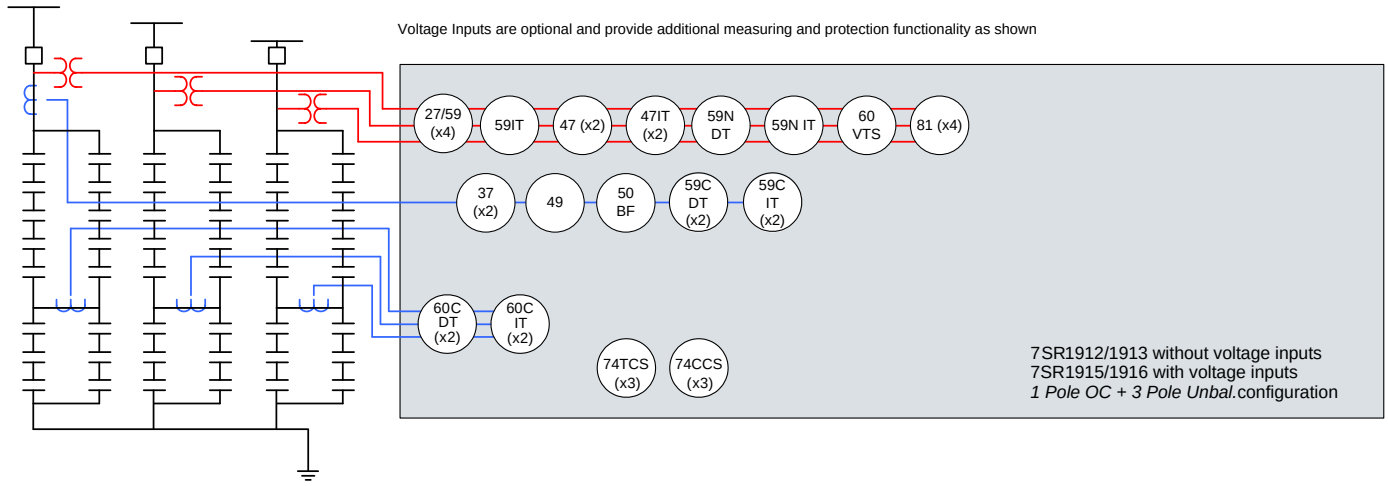

Fig6. Typical H Bridge (Split H)

7SR1912/3 Functional Diagrams

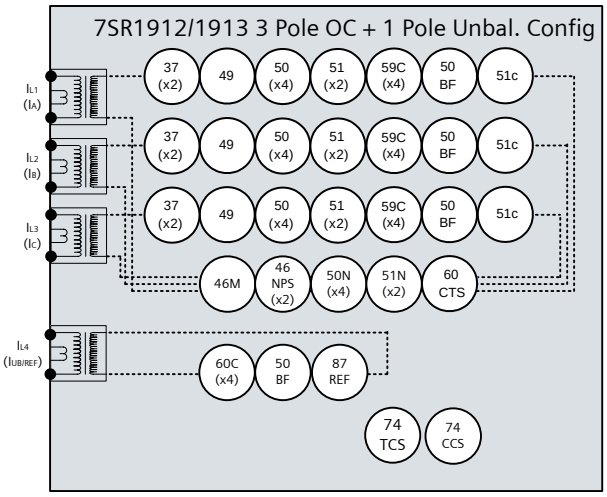

Fig7. 7SR1912/1913 3 Pole OC + 1 Pole Unbal. Configuration

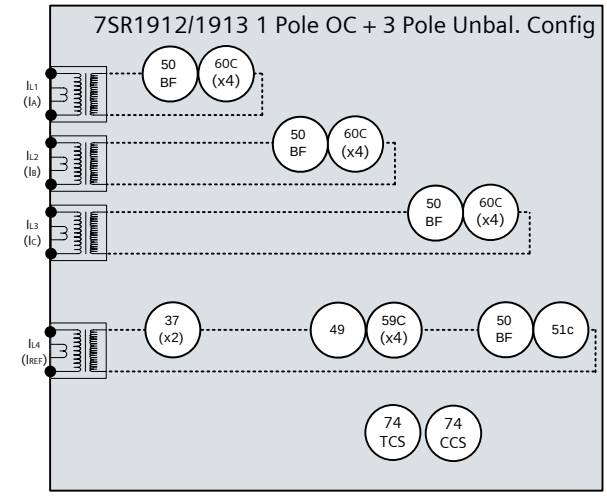

Fig8. 7SR1912/1913 1 Pole OC + 3 Pole Unbal. Configuration

7SR1915/6 Functional Diagrams

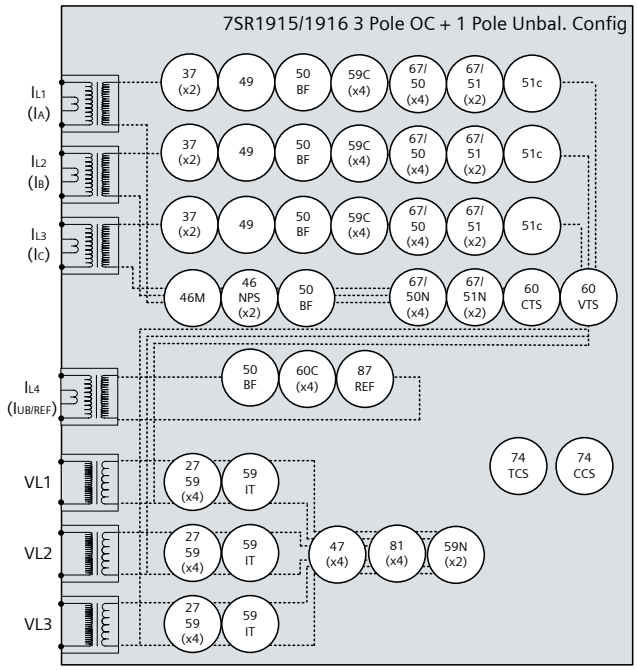

Fig9. 7SR1915/1916 3 Pole OC + 1 Pole Unbal. Configuration

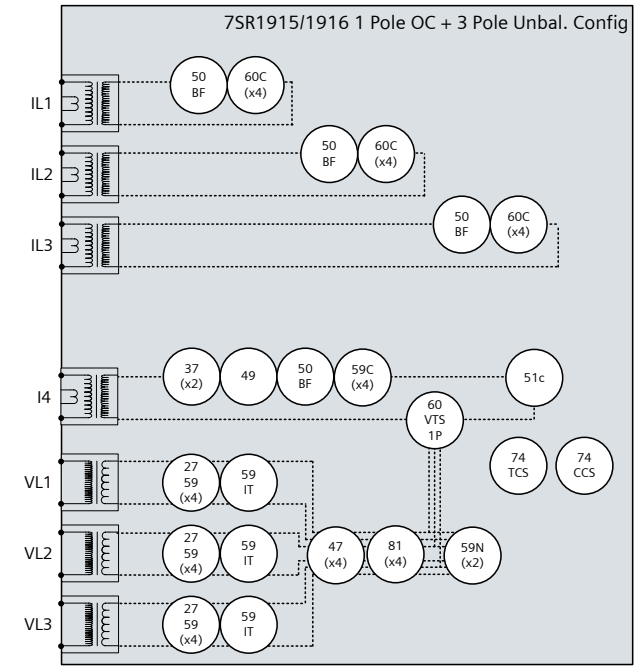

Fig10. 7SR1915/1916 1 Pole OC + 3 Pole Unbal. Configuration

Notes

1. The use of some functions are mutually exclusive. e.g. 60C/87REF
2. Some functions are dependent on the operating mode selection.

Description of Functionality

27/59 Under/Over Voltage

Each element has settings for pickup level, drop-off level and Definite Time Lag (DTL) delays. Operates if voltage exceeds setting for duration of delay.

37 Loss of Supply/Undercurrent

Each element has settings for pickup level and Definite Time Lag (DTL) delays. Operates if current falls below setting for duration of delay.

Re-switch Blocking

If the capacitor is disconnected or otherwise de-energised, automatic blocking of re-energisation can be applied utilising a user selectable timer to allow the capacitor voltage to discharge before re-energisation. Detection of de-energisation can be selected from current level or CB status signals or combinations of both.

46M Phase Unbalance

The element has settings for pickup level and DTL delay. The difference in magnitude of the highest and lowest phase current is compared to the average phase current. This can be used to detect that a number of capacitor units have failed in such a pattern that measured unbalance spill current is negligible.

46NPS Negative Phase Sequence Overcurrent

Each element has user settings for pickup level and IDMTL or DTL delay, operates if NPS current exceeds setting and delay. NPS current elements can be used to detect that a number of capacitor units have failed in such a pattern that measured unbalance spill current is negligible.

47 Negative Phase Sequence Voltage

Each element has settings for pickup level and Definite Time Lag (DTL) delays. Operates if NPS voltage exceeds setting for duration of delay.

49 Thermal Overload

The thermal algorithm continuously calculates the present thermal state of the capacitor bank from the measured currents and the previous thermal state thus including long term overload conditions. Alarm outputs are given for thermal overload and thermal capacity.

50BF Circuit Breaker Fail

The circuit breaker fail function may be triggered from an internal trip signal or from a binary input. Line currents and earth currents are monitored following a trip signal and an output is issued if any current is still detected, above setting, after a specified time interval. Alternatively, if the trip is from an external protection the circuit breaker position can be used to determine a failure. A second time delay is available to enable another stage to be utilized if required. An input is also available to bypass the time delays when the circuit breaker is known to be faulty.

51c Cold Load Pickup

When a capacitor bank is initially energized the connected system may create transient effects which could appear as operating currents at the relay. These conditions can exist for an extended period and must not be interpreted as a fault. To allow optimum setting levels to be applied for normal operation, the cold load pickup feature will apply alternative current settings or protection element inhibits for a limited period. The feature resets when either the circuit breaker has been closed for a settable period, or if the current has reduced beneath a set level for a user set period.

50/51 Phase Fault

50 INST/DTL and 51 IDMTL/DTL elements provide 3 phase overcurrent protection in 3P OC + 1P UB mode, each with independent settings for pickup current, time-multiplier (51) and time-delays. User can select IEC or ANSI time current characteristics. The IDMT stage has a user programmable reset characteristic, either DTL or shaped current ~ time reset characteristic, to improve grading with electromechanical protection.

50N/51N Earth Fault

The earth fault current is internally derived from the 3 phase CT inputs in normal operating mode. 50N INST/DTL and 51N IDMTL/DTL elements provide overcurrent protection, each with independent settings for pickup current, time-multiplier (51) and time-delays. User can select IEC or ANSI time current characteristics. The IDMT stage has a user programmable reset characteristic either DTL or shaped current ~ time reset characteristic to improve grading with electromechanical protection.

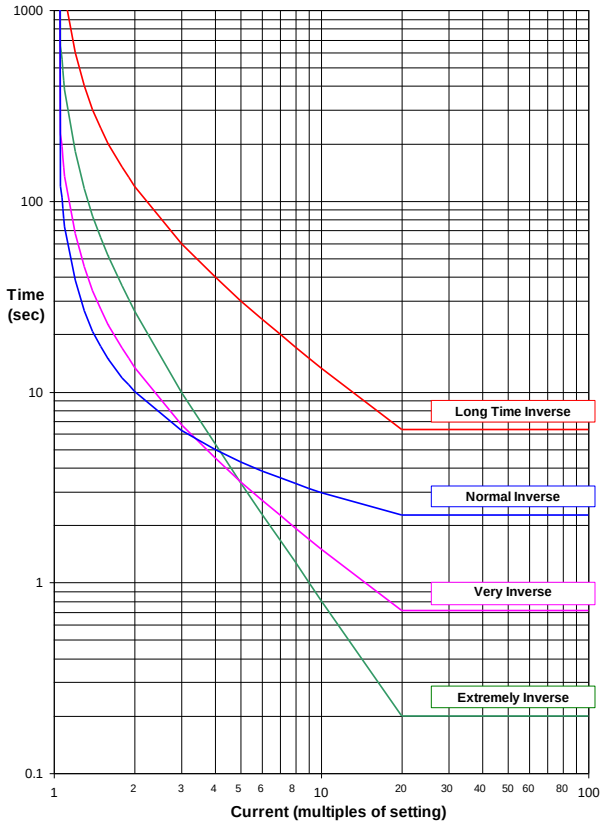

Fig 11. IEC Overcurrent Curves

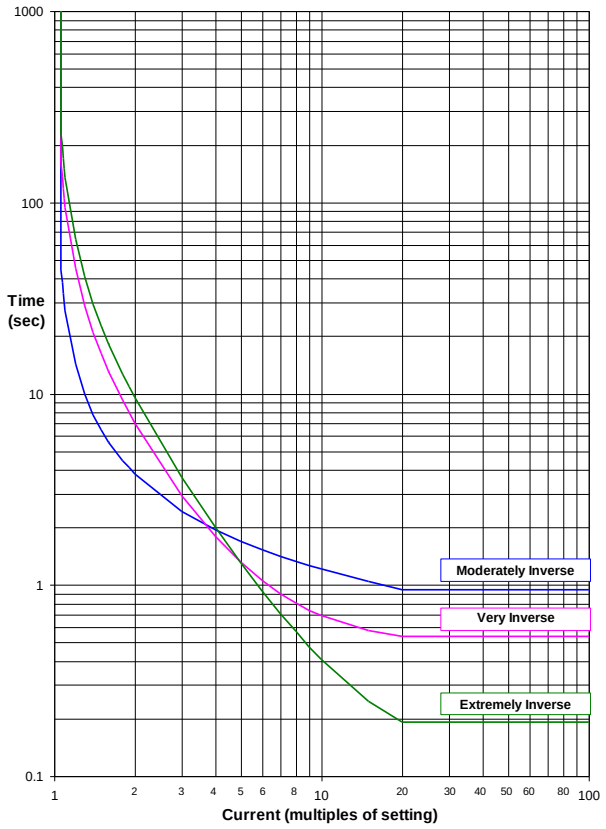

Fig 12. ANSI Overcurrent Curves

59C Overvoltage

The effective applied voltage is calculated from the measured capacitor current by numeric integration techniques such that all harmonic frequency components of the current are correctly incorporated.
The capacitor units are rated to withstand 110% of rated voltage continuously. IEC and ANSI standards specify withstand times for higher voltage levels. These requirements are used to construct an overvoltage withstand curve. Time Multiplier set to default setting = 0.9 is recommended to provide safety margin.

i> (vc>)	Standard duration (s)	
1.1	infinite	
1.15	1,800	IEC 871-1
1.20	300	IEC 871-1
1.30	60	ANSI 18-1980, IEC 871-1
1.40	15	ANSI 18-1980
1.7	1	ANSI 18-1980
2.00	0.3	ANSI 18-1980
2.20	0.12	ANSI 18-1980

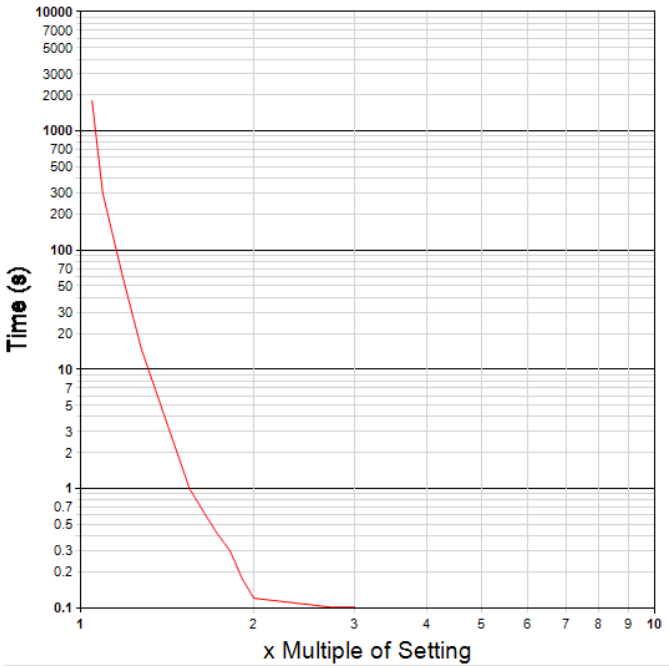

Fig 13. Capacitor Curve (Time Multiplier = 1)

59N Neutral Overvoltage

Neutral overvoltage can be used to detect unbalance in the capacitor bank in ungrounded arrangements.
Operates if the calculated neutral voltage exceeds setting for duration of delay.

60C Capacitor Unbalance

In 3P OC + 1P UB mode, 60C is applied at the 4th current input, typically connected to an unbalance CT. In 1P OC + 3P UB mode, 60C is applied at each of the 3 phase segregated current inputs, typically connected to an unbalance CT. Each element has user settings for pickup level and IDMTL or DTL delay, operates if measured current exceeds setting and delay. The element can be trimmed for phase and magnitude to suit the natural unbalance current and also can be zeroed manually. This calibration is compensated to allows for the switch-off condition

60CTS CT Supervision

The relay has two methods of CT supervision. The 7SR1912/3 monitors each phase current input and operates if any one or two inputs fall below the setting. The 7SR1915/6 has the above method and an addition method that considers the presence of negative phase sequence current, without an equivalent level of negative phase sequence voltage, for a user set time as a CT failure.
This function is not used in 1 Pole OC + 3 Pole UB mode.
Both element types have user operate and delay settings.

60VTS VT Supervision

The VT supervision uses a combination of negative phase sequence voltage and negative phase sequence current to detect a VT fuse failure in 3 Pole OC + 1 Pole UB mode. This condition may be alarmed or used to inhibit voltage dependent functions. Element has user operate and delay settings.
In1 Pole OC + 3 Pole UB mode, a simpler element using current and voltage magnitudes is provided.

87REF Restricted Earth Fault

The measured earth fault input may be used in a 87REF high impedance restricted earth fault scheme to provide sensitive high speed unit protection. A calculation is required to determine the values of the external series stabilising resistor and non-linear shunt resistor which can be ordered separately. This function is used on single-star arrangements where no unbalance CT is available and is connected to the unused 4th current input.

67/67N Directional Control

Phase, earth and sensitive earth fault elements can be directionalised. Each element can be user set to Forward, Reverse, or Non-directional.
Directional Phase Fault elements are polarised from quadrature voltage.
Derived earth fault elements can be user set to be polarised from residual voltage or negative phase sequence voltage.
Measured earth fault elements are polarized from Vo.

74T/CCS Trip & Close Circuit Supervision

The trip or close circuit(s) can be monitored via binary inputs. Trip circuit failure raises an HMI alarm and output(s).

81 Under/Overfrequency

Each element has settings for pickup level, drop-off level and Definite Time Lag (DTL) delays. Operates if frequency exceeds setting for duration of delay.

Programmable Logic

The user can map binary inputs, protection elements, LEDs and binary outputs together in a logical scheme.
Up to 8 logic equations can be defined using standard logic functions e.g. Timers, AND/OR gates, Inverters and Counters to provide the user required functionality.
Each logic equation output can be used for alarm & indication and/or tripping.

Virtual Inputs/Outputs

There are 8 virtual inputs/outputs to provide internal logical states to assist in the application of the functions. Each virtual I/O can be assigned in the same way as a physical I/O.

Circuit Breaker Maintenance

Two circuit breaker operations counters are provided to assist with maintenance scheduling. The maintenance counter records the overall number of operations and the delta counter records the number of operations since the last reset.
An I^2t summation counter provides a measure of the contact wear indicating the total energy interrupted by the circuit breaker contacts.
Each counter has a user set target operations count which, when reached, can be mapped to raise alarms/ binary outputs. A CB Trip Time meter is also available, which measures the time between the trip or open command being issued and the auxiliary contacts changing state.

Control Mode

The relay has a control menu with access to commonly used command operations. Access to the control commands is restricted by a 4 character control function password. Each command requires a select then execute operation, if the execute operation is not performed within a time window the command is aborted. The following control functions are available: CB Operation

Fig14. Example of Control Function View

Construction

The relay is housed in a 4U high size E4 or E6 case with a removable clear plastic fascia cover. The plastic fascia cover can be ordered with or without two push buttons to allow the user to view the settings and instruments without removing the cover.
Two plastic handles are provided to allow the relay to be withdrawn from its case, contacts in the case ensure that the CT circuits and normally closed contacts remain short circuited when the relay is withdrawn.
The rear terminal blocks comprise M4 female terminals for ring crimp wire connections, to provide a secure and reliable termination.

Fig15. Rear view of E4 relay

Fig16. Rear view of relay with 2x LC Fibre Optic ports (E6 Case with IEC61850)

User Interface

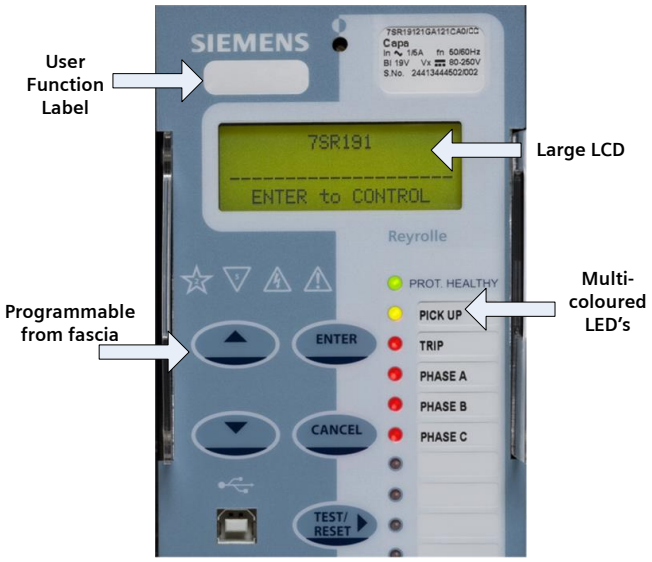

Fig17. User Interface

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 with power save operation indicates the relay identifier, settings, instrumentation, fault data and control commands.
Up to 6 user programmable general alarms can be configured to display your own indications on the LCD.

LEDs

A green steadily illuminated LED indicates the 'Protection Healthy' condition.
9 user programmable LEDs are available eliminating the need for expensive panel mounted pilot lights and associated wiring. Each LED is tri-colour (red, green, yellow) allowing for clear indication of the associated function's state and has a label insert for identification.

Relay Information

The device is identified by the rating label on the fascia. The user can also give the device its own identity by editing the 'Relay Identifier' displayed on the LCD or space is provided to place a slip in label giving the relays function.

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	80 x In
Instrumentation ≥ 0.1xIn	±1% In
Frequency	50/60Hz
Thermal Withstand: Continuous 1 Second 1 Cycle	 4 x In 100A (1A) 350A (5A) 700A (1A) 2500A (5A)
Burden @ In	≤0.02VA (1A phase and Earth element) ≤0.2VA (5A phase and earth element)

Voltage Inputs (optional)

Quantity	3, ph-ph or ph-n
Nominal	40...160 Vrms
Operating Range	0... 200 Vrms
Instrumentation ≥ 0.8xVn	±1% Vn
Burden @ 110V	≤ 0.06 VA
Overvoltage Withstand	300 Vrms

Auxiliary Supply

Rated DC Voltage	110/125/220/250V Operating range 64 to 300V 24/48/60V Operating range 18 to 72V	
Allowable superimposed ac component	12% of DC voltage	
Rated AC Voltage	115 V rms 50/60Hz Range 92 to 138 V rms AC 50/60Hz ±5%	
Power Consumption:	E4 Min (DC) E4 Max (DC)	3.9W 8W
	E4 Min (AC) E4 Max (AC)	9VA 0.5PF 16VA 0.5PF
	E6 Min (DC) E6 Max (DC)	6.4W 10.5W
	E6 Min (AC) E6 Max (AC)	14.5VA 0.5PF 21.5VA 0.5PF
Allowable breaks/dips in supply (collapse to zero)	DC	50ms
	AC	2.5/3 cycles @50/60Hz

Binary Inputs

Number	3 or 6	
Operating Voltage	19V dc	DC Range 17 to 320V dc AC Range 92 to 138 V_{RMS}AC
	88V dc	Range 70 to 320V dc

Maximum dc current for operation	1.5mA
Maximum peak ac current for operation	1.5mA
Pick Up Delay	User Selectable 0 to 14,400,000ms (up to 4 hours)
Drop Off Delay	User Selectable 0 to 14,400,000ms (up to 4 hours)

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

Binary Outputs

Number	5 or 8 (3 change over contacts)
Operating Voltage	Voltage Free
Operating Mode	User selectable - Self or Hand/Electrical Reset or pulsed.
Operating Time from Energizing Binary Input	<20ms
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	 1250 VA 250 VA at p.f. ≤ 0.4 75 W 30 W at L/R ≤ 40ms 50 W at L/R ≤ 10ms

Unit Design

Housing	E4 or E6 (see dimension drawing)
Indication	20 Character 4 line Display Relay Healthy LED 9 Tri Coloured User Programmable Self or Hand Reset LED's
With-drawable Element	Yes
User Interface	5 Navigation Keys
Weight	Typical 3.2kg E4 case, 4.15 kg E6 case. Additional Transport packaging: add 0.4kg

Data Communication Interface

Communication Port	Front USB Type B Rear RS485 2 wire electrical IEC61850 optional ports: 2x Electrical RJ45 Ethernet 2x LC Fibre Optic Ethernet
Protocols	IEC60870-5-103 MODBUS RTU (Serial) DNP3.0 O (Serial) IEC61850 - optional
Fibre Optic Ethernet Data Communication Interface (IEC 61850 Option)	

EN100 Fibre Optic Data Communication Interface (IEC 61850 Option)

Physical	Fibre-optic
Connectors	Duplex LC 100BaseF in acc. With IEEE802.3
Recommended fibre	62.5/125 µm glass fibre with Duplex-LC connector
Transmission Speed	100 MBits/s
Optical Wavelength	1300 nm
Bridgeable distance	2 km

EN100 Electrical Ethernet Data Communication Interface (IEC 61850 Option)

Physical	Electrical
Connectors	RJ45 100BaseT in acc. With IEEE802.3
Transmission Speed	100 MBits/s
Test Voltage (with regard to socket)	500 VAC 50 Hz
Bridgeable distance	20m

Data Storage

Fault Record	10
Waveform Record	10 x 1sec 2 x 5sec 5 x 2sec 1 x 10sec Pre trigger 10...90%
Events	1000 1ms Resolution

Mechanical Tests

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

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

Shock and Bump IEC 60255-21-2 Class I

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

Seismic IEC 60255-21-3 Class I

Type	Level	Variation
Seismic response	X-plane - 3.5mm displacement	≤ 5 %

	below crossover freq (8-9Hz) 1gn above. Y-plane – 1.5mm displacement below crossover freq (8-9Hz) 0.5gn above.	

Mechanical Classification

Durability	>10^6 operations

Electrical Tests

Insulation
IEC 60255-5

Type	Level
Between any terminal and earth	2.5 kV AC RMS for 1 min
Between independent circuits	2.5 kV AC RMS for 1 min
Across normally open contacts	1.0 kV AC RMS for 1 min

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	8.0 kV	≤ 5 %

Electrical Fast Transient / Burst Immunity
IEC 60255-22-4 Class A (2002)

Type	Level	Variation
Case, Aux Power & I/O	4kV	≤ 10 %
RS485 Comms	2.0kV	No data loss

Surge Immunity
IEC 60255-22-5; IEC 61000-4-5

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

*Note 50ms DTL pick up delay applied to binary inputs

Conducted Radio Frequency Interference
IEC 60255-22-6

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

Radiated Radio Frequency
IEC 60255-25

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

Conducted Radio Frequency

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

Radiated Immunity
IEC 60255-22-3 Class III

Type	Level
80 MHz to 1000 MHz Sweep	10 V/m
1.4GHz to 2.7GHz Sweep	10V/m
80,160,380,450,900,1850, 2150 MHz Spot	10V/m

Magnetic Field with Power Frequency
IEC 61000-4-8, Class V

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

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 93 % relative humidity

Cyclic Temperature and Humidity
IEC 60068-2-30

Operational test	25 °C to 55 °C (outdoor equipment) and 97/93 % relative humidity. 6 x 24h (12h+12h) cycles.

IP Ratings
IEC 60529

Type	Level
Installed with cover	IP 51 from front of relay
Installed with cover removed	IP 20 from front of relay

Performance

27/59 Under/Over Voltage

Number of Elements	4 Under or Over
Operate	Any phase or All phases
Voltage Guard	1 to 200V
Setting Range Vs	5 to 200V
Hysteresis Setting	0 to 80%
Vs Operate Level	100% Vs, ±1% or ±0.25V
Reset Level:	

Overvoltage Undervoltage	=(100%-hyst)xVop, ±1% or ±0.25V =(100%+hyst)xVop, ±1% or±0.25V
Delay Setting td	0.00 to 14400s
Basic Operate Time : 0 to 1.1xVs 0 to 2.0xVs 1.1 to 0.5xVs	 73ms ±10ms 63ms ±10ms 58ms ±10ms
Operate time following delay.	Tbasic +td , ±1% or ±10ms
Inhibited by	Binary or Virtual Input VT Supervision, Voltage Guard

37 Undercurrent

Number of Elements	2
Operate	Any phase or ALL
Setting Range Is	0.05 to 5.0 x In
Operate Level	100% Is, ±5% or ±1%xIn
Current Guard	0.05 to 5.0 x In
Delay Setting td	0.00 to 14400s
Basic Operate Time: 1.1 to 0.5xIn	 35ms ±10ms
Operate time following delay.	Tbasic +td , ±1% or ±10ms
Overshoot Time	< 40ms
Inhibited by	Binary or Virtual Input, Guard

46MDT Phase Unbalance

Number of Elements	1
Setting Range Ss	0.01 to 1.0
Operate Level	100% Ss, ±5% for Imean ≥0.1xIn
Delay Setting td	0.00 to 14400s
Basic Operate Time 0.01 to 1	 95ms ±10ms
Operate time following delay.	Tbasic +td , ±1% or ±10ms
Inhibited by	Binary or Virtual Input

46 Negative Phase Sequence Overcurrent

Number of Elements	DT & IT
DT Setting Range Is	0.05,0.10...4.0 x In
DT Operate Level	100% Is, ±5% or ±1%xIn
DT Delay Setting td	0.00 to 14400s
DT Basic Operate Time 0 to 2 xIs 0 to 5 xIs	 40ms ±10ms 30ms ±10ms
DT Operate time following delay.	Tbasic +td , ±1% or ±10ms
IT Char Setting	IEC NI,VI,EI,LTI ANSI MI,VI,EI & DTL
IT Setting Range	0.05 to 2.5
Tm Time Multiplier	0.025 to 100
Char Operate Level	105% Is, ±4% or ±1%In
Overshoot Time	< 40ms
Inhibited by	Binary or Virtual Input

47 Negative Phase Sequence Overvoltage

Number of Elements	2xDT & 2xIT
Setting Range Vs	1 to 90V
DT Hysteresis Setting	0 to 80%
Operate Level	100% Vs, ±2% or ±0.5V
DT Delay Setting td	0.00 to14400s
Basic Operate Time 0V to 1.5xVs 0V to 10xVs	 80ms ±20ms 55ms ±20ms
DT Operate time following delay.	Tbasic +td , ±2% or ±20ms
IT Char Setting	IDMTL, DTL
IT Tm Time Multiplier	0.025 to 100
IT Char Operate Level	100% Is, ±2% or ±0.5V
Overshoot Time	< 40ms
Inhibited by	Binary or Virtual Input

49 Thermal Overload

Operate levels	Operate and Alarm
Setting Range Is	0.10 to 3.0 x In
Operate Level	100% Is, ±5% or ±1%xIn
Time Constant Setting	1 to 1000min
Operate time	$t = \tau \times In\left\{\frac{I^2 \cdot I_P^2}{I^2 \cdot (k \times I_B)^2}\right\}$ ±5% absolute or ±100ms where Ip = prior current
Alarm Level	Disabled, 50,51...100%
Inhibited by	Binary or Virtual Input

50 (67) Instantaneous & DTL OC&EF (Directional)

Operation 7SR1915/6 only	Non directional, Forward or reverse
Elements	Phase (50)& Derived Earth (50N)
Number of Elements	4 x OC 4 x Derived EF
Operating Current	RMS or Fundamental frequency
Setting Range Is	0.05 to 50 x In
Time Delay	0.00 to 14400s
Operate Level	100% Is, ±5% or ±1%xIn
Operate time: 50 50N	 0 to 2xIs – 35ms, ±10ms, 0 to 5xIs – 25ms, ±10ms 0 to 2xIs – 40ms, ±10ms, 0 to 5xIs – 30ms, ±10ms
Operate time following delay	Tbasic +td , ±1% or ±10ms
Inhibited by	Binary or Virtual Input VT Supervision

51(67) Time Delayed OC&EF (Directional)

Operation – 7SR1915/6 only	Non directional, Forward or reverse
Elements	Phase & Derived Earth
Number of Elements	2 x OC 2 x Derived EF
Operating Current	RMS or Fundamental frequency
Characteristic	IEC NI,VI,EI,LTI ANSI MI,VI,EI & DTL
Setting Range Is	0.05 to 2.5 x In
Time Multiplier	0.025 to 100
Time Delay	0,0.01... 20s
Operate Level	105% Is, ±4% or ±1%xIn
Minimum Operate time IEC ANSI	 $t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$ $t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{p} - 1} + B\right] \times Tm$ ± 5 % absolute or ± 30 ms
Follower Delay	0 - 20s
Reset	ANSI decaying, 0 – 60s
Inhibited by	Binary or Virtual Input VT Supervision

50BF Circuit Breaker Fail

Operation	Current check - Phase and Measured I4 with independent settings, Mechanical Trip,

	CB Faulty Monitor
Setting Range Is	0.05 to 2.0 x In
2 Stage Time Delays	Timer 1 - 20 to 60000ms Timer 2 - 20 to 60000ms
Operate Level	100% Is, ±5% or ±1%xIn
Disengaging time	< 20ms
Operate time following delay	Tcbf ±1% or ±2ms
Triggered by	Any function mapped as trip contact.
Inhibited by	Binary/Virtual Input
Timer By pass	Yes, 50BF CB Faulty Input

59IT Time Delayed Phase Overvoltage

Number of Elements	1
IT Char Setting	IDMTL, Capacitor & DTL
IT Setting Range	1 to 100V
Tm Time Multiplier(IDMT)	0.1 to 140
Delay (DTL)	0 to 20s
Operate time IDMTL	$t_{op} = \frac{M}{\left[\frac{V}{Vs}\right]-1}$, ± 5 % or ± 65 ms.
Capacitor	See Fig. 13 above, ± 5 % or ± 65 ms.
DTL	t_d, ± 1 % or ± 40ms
Reset	0 to 60s
Char Operate Level	105% Vs, ±2% or ±0.5V
Inhibited by	Binary or Virtual Input

59C Capacitor Overvoltage

Number of Elements	2xDT & 2xIT
Capacitor Rated Current, equivalent to Vcr	0.1 to 5 xIn
Setting Range Is	80 to 150% Vcr
DT Operate Level	100% Vs, ±2% or ±0.5V
DT Delay Setting td	0.00 to 14400s
DT Basic Operate Time 0 to 2 xVs 0 to 5 xVs	 50ms ±10ms 45ms ±10ms
DT Operate time following delay.	Tbasic +td , ±1% or ±20ms
IT Char Setting	Capacitor, IDMTL, DTL
IT Setting Range	80 to 150% Vcr
IT Tm Time Multiplier	0.025 to 1.6
IT Char Operate Level	100% Is, ±2% or ±0.5V
Operate time IDMTL	$t_{op} = \frac{M}{\left[\frac{V}{Vs}\right]-1}$, ± 5 % or ± 65 ms.
Capacitor	See Fig. 13 above, ± 5 % or ± 65 ms.
DTL	t_d, ± 1 % or ± 50ms
Overshoot Time	< 40ms
Inhibited by	Binary or Virtual Input

59N Neutral Voltage Displacement

Number of Elements	DT & IT
DT Setting Range Is	1 to 100V
DT Operate Level	100% Vs, ±2% or ±0.5V
DT Delay Setting td	0 to 14400s
DT Basic Operate Time 0V to 1.5 x Vs 0V to 10 x Vs	 76ms ±20ms 63ms ±20ms
DT Operate time following delay.	Tbasic +td , ±1% or ±20ms
IT Char Setting	IDMTL & DTL
IT Setting Range	1 to 100V
Tm Time Multiplier(IDMT)	0.1 to 140
Delay (DTL)	0 to 20s
Operate time IDMTL	$t_{op} = \frac{M}{\left[\frac{V}{Vs}\right]-1}$, ± 5 % or ± 65 ms.
Reset	IEC/ANSI Decaying, 0 to 60s
Char Operate Level	105% Vs, ±2% or ±0.5V
Inhibited by	Binary or Virtual Input

60C Capacitor Unbalance

Number of Elements	DT & IT
DT Setting Range Is	0.01 to 2.0 x In
DT Operate Level	100% Is, ±5% or ±1%xIn
DT Delay Setting td	0.00 to 14400s
DT Basic Operate Time 0 to 2 xIs 0 to 5 xIs	 50ms ±10ms 40ms ±10ms
DT Operate time following delay.	Tbasic +td , ±1% or ±10ms
IT Char Setting	DTL & User Specified
IT Setting Range	0.01 to 2
Tm Time Multiplier	0.025 to 100
Char Operate Level	105% Is, ±4% or ±1%In
Overshoot Time	< 40ms
Inhibited by	Binary or Virtual Input

60 Supervision

CT	7SR1912/3 Current 7SR1915/6 Current or Vnps & Inps
VT	7SR1915/6 nps/zps

87REF Restricted Earth Fault

Setting Range	0.05 to 0.95 x*In*
Operate Level	100% Is, ±5% or ±1%xIn
Time Delay	0 to 60s
Basic Operate Time	0 to 2 xIs 40ms ±10ms 0 to 5 xIs 30ms ±10ms
Inhibited by	Binary or Virtual Input

74T/CC Trip/Close Circuit Supervision

Number of supervisable circuits	3 x Trip and 3 x Close
Number of BI's Required	1 or 2 per function

81 Under/Over Frequency

Number of Elements	4 Under or Over
Under Voltage Guard	Yes/No
Setting Range Hz	43 to 57Hz (50Hz) 53 to 68Hz (60Hz)
Hysteresis Setting	0 to 2%
Operate Level	100% Fs ±10mHz
Operate Time	Typical <150ms
Vs Operate Delay	0 to 14400s

Reswitch Blocking

Operation	UC, CB position, UC&CB, UC or CB
Blocking time	0 to 60000s
Setting Range Is	0.05 to 5.0 x In
Operate Level	100% Is, ±5% or ±1%xIn
Delay Setting td	0.00 to 14400s

Basic Operate Time: 1.1 to 0.5xIn	50ms ±10ms
Operate time following delay.	Tbasic +td , ±1% or ±10ms

CB Maintenance

Trip Counter	Total & Delta 0...10000
I^2t Alarm	10...100000

Control Functions

CB	Open/Close
EF	IN/OUT
Relay Mode	Local/Remote/Local or Remote
Reset	LED's & O/P's

7SR1912/1913 Connection Diagram

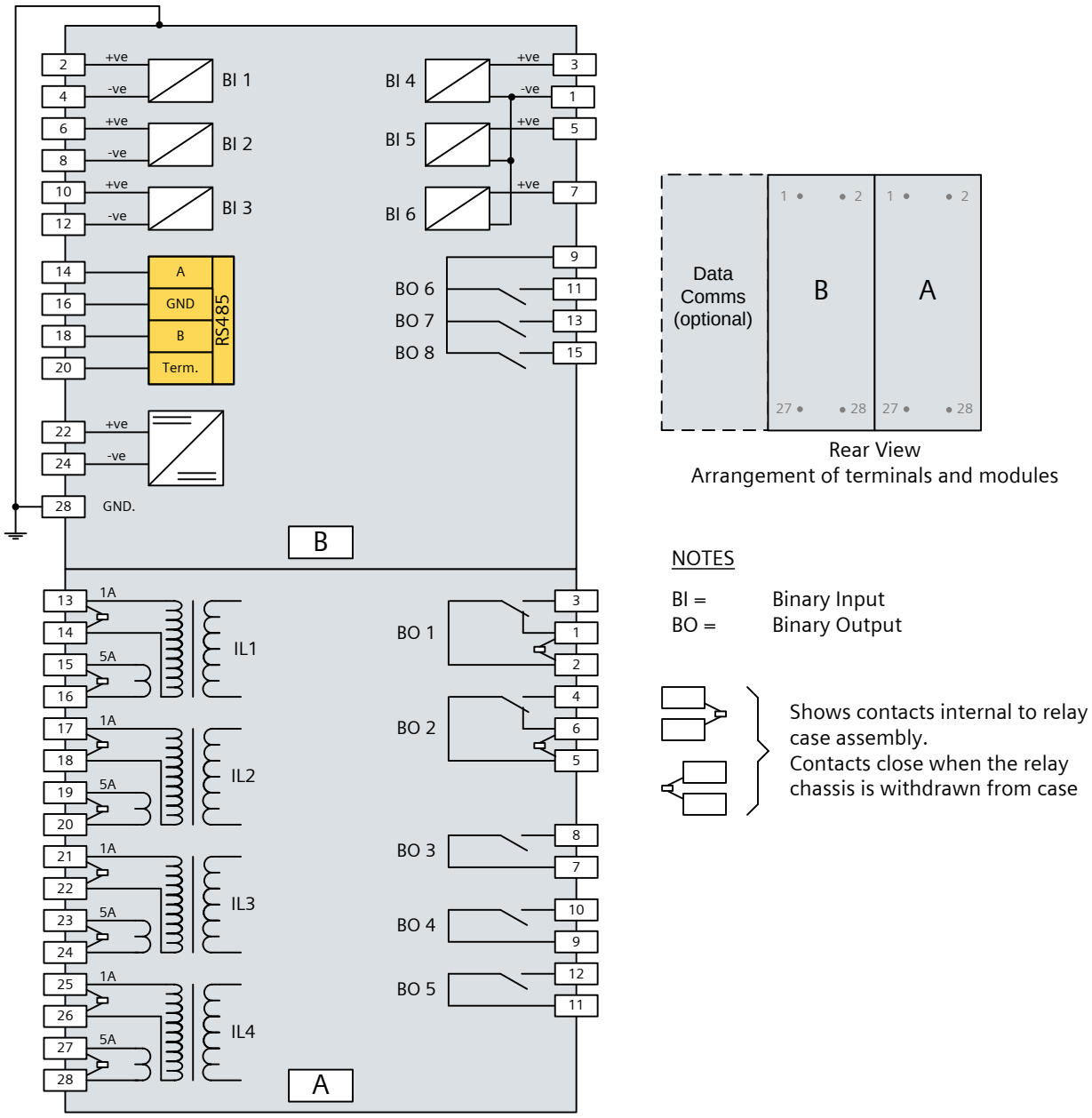

Fig18. Diagram showing 7SR1913 relay with 4 CT inputs, 6 binary inputs and 8 binary outputs.

7SR1915/1916 Connection Diagram

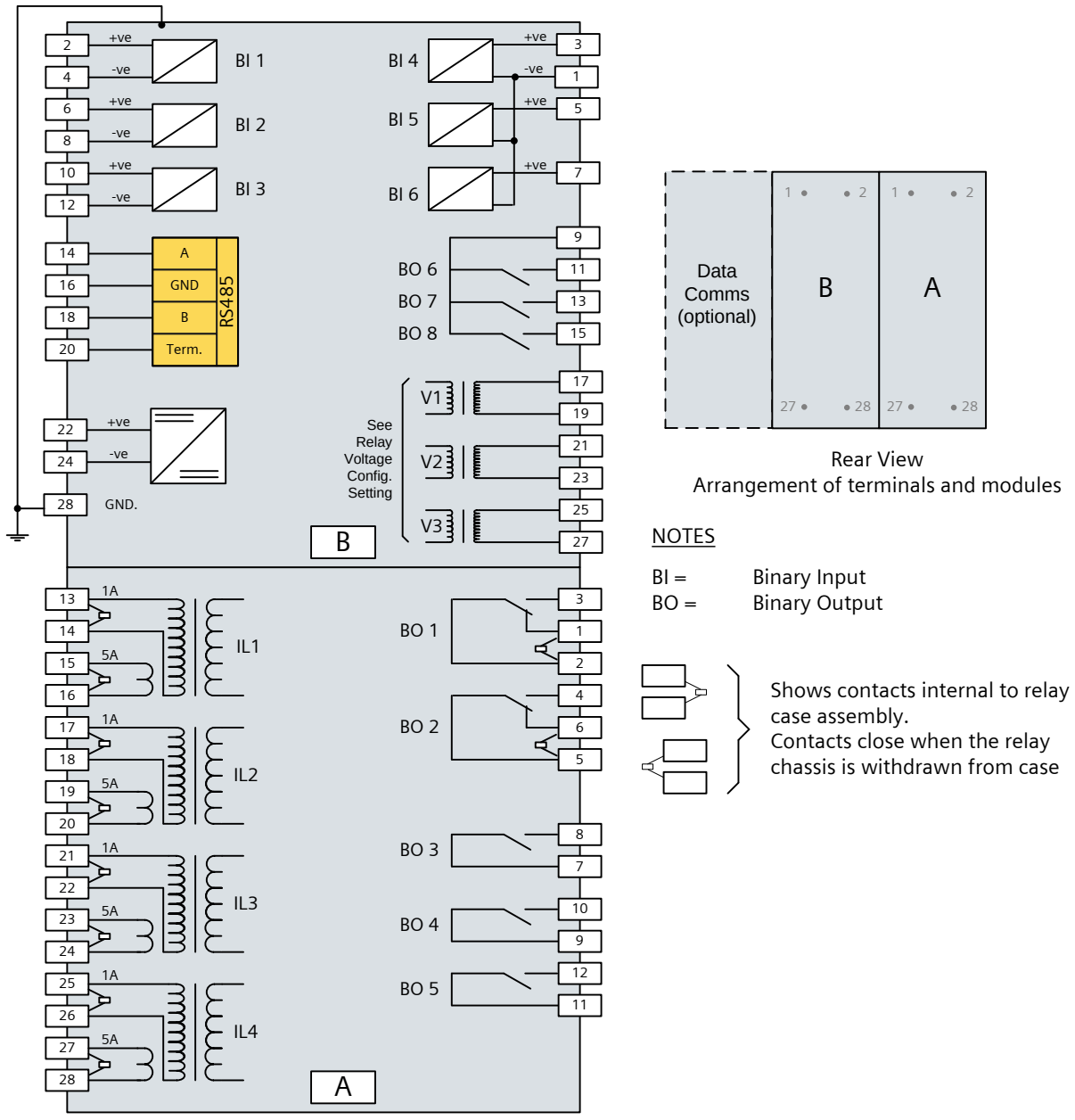

Fig19. Diagram showing 7SR1916 relay with 4 CT inputs, 3 VT inputs, 6 binary inputs and 8 binary outputs.

Ordering Information – 7SR191 Capa Capacitor Bank Protection

Product description	Variants	Order No.
Capacitor Protection		**7 S R 1 9 1 ☐- 1 ☐A ☐ ☐- ☐C A 0**
Capacitor Bank protection relay		
	Protection Product	
	Miscellaneous Protection	**9**
	Capacitor Protection	**1**
	Case I/O and Fascia	
	4 CT, 3 Binary Inputs / 5 Binary Outputs, 10 LEDs	**2**
	4 CT, 6 Binary Inputs / 8 Binary Outputs, 10 LEDs	**3**
	4 CT, 3VT, 3 Binary Inputs / 5 Binary Outputs, 10 LEDs	**5**
	4 CT, 3VT, 6 Binary Inputs / 8 Binary Outputs, 10 LEDs	**6**
	Measuring Input	
	1/5 A, 50/60Hz[1], 40-160V[2]	**1**
	Auxiliary voltage	
	80 to 250V DC / 115V AC, binary input threshold 19V DC	**G**
	80 to 250V DC, binary input threshold 88V DC	**H**
	24 to 60V DC, binary input threshold 19V DC	**J**
	Communication Interface	
	Standard version – included in all models, USB front port, RS485 rear port (E4 case) [3]	**1** 2
	Standard version - plus additional rear electrical Ethernet RJ45 (x2) (E6 Case) [3]	**7** 7
	Standard version - plus additional rear optical Ethernet duplex (x2) (E6 Case) [3]	**8** 7
	Protocol	
	IEC 60870-5-103, Modbus RTU and DNP3 (user selectable)	**2**
	IEC 60870-5-103, Modbus RTU, DNP3 and IEC 61850. (user selectable settings)	**7**
	Relay Cover	
	Standard Version – No Push Buttons	**1**
	Push Buttons – Down and Right Arrows	**2**
	Protection Function Packages	
	Standard version	**C**
	37 Undercurrent	
	46M Phase unbalance	
	46 Negative phase sequence overcurrent	
	49 Thermal overload	
	50 Instantaneous phase fault overcurrent	
	50BF Circuit breaker fail	
	50N Instantaneous earth fault	
	51 Time delayed phase fault overcurrent	
	51c Cold load pickup	
	51N Time delayed earth fault	
	59C Overvoltage by current integration	
	60C Unbalance Overcurrent	
	60CTS CT supervision	
	87REF High Impedance REF	
	74T/CCS Trip & Close circuit supervision	
	Re-energisation Blocking	
	Programmable Logic	
	For variants with 3 x VT inputs, as above plus:	
	27/59 Under/overvoltage	
	47 Negative phase sequence voltage	
	59N Neutral voltage displacement	
	60VTS VT Supervision	
	67/50 Directional instantaneous phase fault overcurrent	
	67/50N Directional instantaneous earth fault	
	67/51 Directional time delayed phase fault overcurrent	
	67/51N Directional time delayed earth fault	
	81U/0 Under/Over Frequency	
	Additional Functionality	
	No Additional Functionality	**A**

1) 4CT is configured by user setting as: 3PF + 1 Unbalance OR 1PF +3 Unbalance

2) Voltage rating applies to models with optional VT inputs only.

3) E4 case is standard, E6 case is required if IEC61850 option fitted