PRS-7367

Protection and Control Unit

Instruction Manual

CYG SUNRI CO., LTD.

Preface

User's Guideline

This instruction manual contains full information of the equipment, including function descriptions, logic diagrams, input signals, output signals, setting parameters and technical parameters. It also lists the operations on safe handling, commissioning and maintaining of this equipment. The instruction manual can be can be used as a technical reference during the whole product life cycle.

Documentation and manufactured equipment purchased from CYG SUNRI CO., LTD. are dispatched separately due to the necessary manufacturing period. Therefore, they sometimes may not reach the recipients at the same time. Therefore, this manual is provided as a technical reference to commission the equipment.

The installation and commissioning personnel should read all relevant chapters carefully and get a thorough knowledge of the contents of this manual, before conducting any operation to the equipment. In this way, the personnel can get the required knowledge in handling electronic equipment.

This manual contains a security chapter which describes the safety precautions recommended when using the equipment. Before installing and using the equipment, this chapter is recommended to be thoroughly read and understood.

Personnel Security

The content in this chapter specifically describes to prevent and reduce the safety accidents in electric power production and construction processes, to ensure the personal safety and health of employees in production activities and to ensure the power grids stable operation and reliable power supply.

Any kind of directly touching with the metal parts of the electrical equipment should be avoided when electrical equipment is on operation, because of the potential electric shock risk. Neglecting warning notices should be preventing because the improperly operation may damage the device, even cause personnel injury.

The good operating condition of the equipment depends on proper shipping and handling, proper storage, installation, commissioning and maintenance. Therefore, only qualified personnel should be allowed to operate the equipment. Intended personnel are individuals who:

- Have a thorough knowledge of protection systems, protection equipment, protection functions and the configured functional logic in the IEDs;
- Have a basic knowledge in the installation, commissioning, and operation of the equipment;
- Are familiar with the working field where it is being installed;

- Are able to safely perform operations in accordance with accepted safety engineering steps;
- Are authorized to energize and de-energize equipment, and to isolate, ground, and label it;
- Are trained in the maintenance and use of safety apparatus in accordance with safety engineering regulations;
- Have been trained in first aid if any emergency situations happen.

Warning Indications

The following indicators and standard definitions are used:

⚠ **DANGER!** means that death, severe personal injury and considerable equipment damage will occur if safety precautions are disregarded.

⚠ **WARNING!** means that death, severe personal and considerable equipment damage could occur if safety precautions are disregarded.

⚠ **CAUTION!** means that light personal injury or equipment damage may occur if safety precautions are disregarded.

NOTICE! is particularly applies to damage to device and to resulting damage of the protected equipment.

⚠ **DANGER!**

NEVER allow the current transformer (CT) secondary circuit connected to this equipment to be opened while the primary system is live. Opening the CT circuit will produce a dangerously high voltage.

⚠ **WARNING!**

ONLY qualified personnel should work on or in the vicinity of this device. These personnel **MUST** be familiar with all safety regulations and service procedures described in this manual. During operating of electrical device, certain part of the device is under high voltage. Severe personal injury and significant device damage could result from improper behavior.

⚠ **WARNING!**

Do **NOT** touch the exposed terminals of this device while the power supply is on. The generated high voltage causes death, injury, and device damage.

⚠ **WARNING!**

Thirty seconds is **NECESSARY** for discharging the voltage. Hazardous voltage can be present in the DC circuit just after switching off the DC power supply.

CAUTION!

- **Earthing**

  Securely earthed the earthing terminal of the device.

- **Operating environment**

  ONLY use the device within the range of ambient environment and in an environment free of abnormal vibration.

- **Ratings**

  Check the input ratings **BEFORE** applying AC voltage/current and power supply to the device.

- **Printed circuit board**

  Do **NOT** attach or remove printed circuit board if the device is powered on.

- **External circuit**

  Check the supply voltage used when connecting the device output contacts to external circuits, in order to prevent overheating.

- **Connection cable**

  Carefully handle connection cables without applying excessive force.

NOTICE!

The firmware may be upgraded to add new features or enhance/modify existing features, please **MAKE SURE** that the version of this manual is compatible with the product in your hand.

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Documentation Outline

The manual provides a functional and technical description of this relay and a comprehensive set of instructions for the relay's use and application.

All contents provided by this manual are summarized as below:

1 Briefly Introduction

Briefly introduce the application scope, the selectable functions and product features about this equipment.

2 Technical Specifications

Introduce the technical specifications about this relay, including electrical specifications, mechanical specifications, ambient temperature and humidity range, communication interface parameters, type tests, setting ranges and accuracy limits etc.

3 Protection Functions

Provide a comprehensive and detailed protection function description of all protection modules.

4 Supervision Functions

Introduce the automatic self-supervision function of this equipment.

5 Monitoring & Control

Introduce the measurement, controlling, signaling, recording and other functions of this relay.

6 Hardware

Introduce the main module functions of this relay and describe the definition of all terminals of each module.

7 HUMAN MACHINE INTERFACE

Include all the menus of device.

8 Configuration Function

Introduce the configurable function (such as protection function configuration, LED configuration, binary input configuration and binary output configuration, analog quantities channels etc.) of this relay.

9 Communication Protocol

Introduce the communication interfaces and protocol that this relay contains. IEC60970-5-103 and IEC61850 protocols are introduced in details.

10 Commissioning

Introduce how to commission this relay, check the calibration and test all the function of this relay.

11 Installation

Recommend on unpacking, handling, inspection and storage of this relay. A guide to the mechanical installation and electrical wiring of this relay is also provided, including earthing recommendations. Some typical wiring connection is demonstrated in this manual as well.

12 Maintenance

A general maintenance steps for this device is outlined.

13 Decommissioning and Disposal

A general decommissioning and disposal steps for this relay is outlined.

14 Connection Diagrams

List the connection diagram examples including all types of modules.

15 Manual Version History

List the instruction manual versions and their corresponding modification history records.

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1 Briefly Introduction

1.1 Application Scope

The PRS-7367 is a numerical distributed protection intended for protecting and monitoring various primary apparatus including overhead line, underground cable, transformer, capacitor, etc. PRS-7367 can be used in various voltage level. PRS-7367 can detect and clear all types of internal phase-to-phase.

PRS-7367 provides fast and selective protection, monitoring and control for feeders and capacitors. The relay can operate correctly over a wide frequency range in order to accommodate power system frequency variations during disturbances.

This relay can sample the analog values from the traditional instrument transformers, or receive the sampled values from the electronic current and voltage transformers (via a merging unit). The binary inputs and outputs of this relay can be configured according to the demands of a practical engineering through the PRS IED Studio configuration tool auxiliary software, which can meet some special requirements of protection and control functions.

This relay can fully support the IEC61850 communication protocol and GOOSE function, and can completely meet the demands of a modern digitalized substation.

1.2 Product Function

Table 1.2-1 Functions included in the IEDs

Description	IEC 60617	ANSI	CYG Code
Non-directional overcurrent protection	3I>	50/51P	50/51P/51PVT
Directional overcurrent protection	3I> ->	67P	67P
Non-directional earth-fault protection	Io>	50/51N	50/51G/51GVT
Directional earth-fault protection	Io>->	67N	67G
Switch onto fault	SOTF	SOTF	SOTF
Circuit breaker failure protection	3I>/I0>BF	50BF	50BF
Three-phase thermal overload protection	3Ith>	49	49F
Phase discontinuity protection	I2/I1>	46PD	46BC
Negative sequence current protection	I2>	46N	46N
Three-phase overvoltage protection	3U>	59	59
Positive sequence overvoltage protection	U1>	47	59P
Residual overvoltage protection	Uo>	59G	59G

Description	IEC 60617	ANSI	CYG Code
Negative sequence overvoltage protection	U2>	47	59N
Three phase under voltage protection	3U<	27	27
Positive sequence undervoltage protection	U1<	47	27P
Overfrequency protection	f>	81	81O
Underfrequency protection	f<	81	81URS
Underfrequency restore protection	-	-	81URE
Frequency gradient protection	Df/dt<>	81	81R
Auto-recloser	O ->I	79	79
Synchrocheck	SYNC	25	25SYN
Current circuit supervision	MCS 3I	MCS 3I	CTS
Fuse failure supervision	FUSEF	60	PTS
Trip circuit supervision	TCS	TCM	TCS
Current unbalance protection	dI>C	51NC-1	51NA
Three phase current unbalance protection	3dI>C	51NC-2	51NT
Voltage unbalance protection	PQUUB	PQUUB	59NA
Three phase voltage unbalance protection	PQUUB	PQUUB	59NT
Fault locator	FLOC	21FL	21FL
Three phase under voltage protection of capacitor	3U<	27	CUB_27
Reverse power protection	P or Q>	32R/32O	32R
Power protection	P>	32R/32O/32U	32
Voltage Selection	/	/	/
Mechanical Protection			MP
Trip Logic	/	94	94T
Close Logic	/	/	Close Logic
Backup power automatic switch	/	/	BPAS
Wattmetric sensitive earth fault	/	/	SEF
Under current protection	/	37	37C
Block Busbar protection	/	/	Block Busbar
Gap current zero sequence voltage protection	/	/	Gap
Restricted Earth Fault Protection (64REF)	IdN/I	87NL	64REF
Transformer Current circuit supervision(CTS)	/	/	TF CTS
Transformer Fuse failure supervision(VTS)	/	/	TF VTS

Description	IEC 60617	ANSI	CYG Code
Faulty Phase Selection	/	/	FPS
Stabilized differential protection for machines	3dI>G/M	87M	87MPDIF
Flux-balance based differential protection for machines	3dIHi>G/M	/	87MFDIF
Machine Startup	/	/	MST
Long start protection	/	/	MQDS
The locked-rotor protection	/	/	MDZS
Synchronous Motor Loss of Step	/	/	78O
Synchronous Motor Loss of Excitation	/	/	40O

1.3 Product Features

- This device is based on a 32-bit high performance dual-core processor, internal high speed bus and intelligent I/O ports, and the hardware is in modularized design and can be configured flexibly, featuring interchangeability and easy extension and maintenance.
- Modularized hardware design makes this relay be easily upgraded or repaired by a qualified service person. Various function optional modules can satisfy various situations according to the different requirements of the users.
- The adoption of 16-bit A/D converter and the dual-channel sampling technology can ensure the accuracy and reliability of protection sampling and the correctness of protection operation. It also provides dedicated current transformers for metering, and ensures the high accuracy of telemetering with 40-point high speed sampling rate per cycle.
- This device can sample the analog values from the traditional instrument transformers, or receive the sampled values from the electronic transformers. It can support the protocol IEC60044-8, IEC61850-9-2 and GOOSE.
- Various algorithms for protection and measurement have been completed in this device for the feature of electronic transformer sampling, such as the error prevention method of multi-algorithms data anomaly for the digital channels, to realize high accuracy and reliability under various conditions of network faults or communication interruption.
- This device has powerful GOOSE functions, and the connection and cooperation between some devices can be realized without using electrical cables, to facilitate the realization of such functions as simple bus differential protection, overload interlock shedding function and backup automatic transfer function etc.
- This device has fully realized the technology to integrate six functions into one device: protection, measurement, control, remote signaling, merging unit function and remote module functions, to improve the reliability.
- Various methods of GPS time synchronization are supported in this relay, including SNTP, pulse per second (PPS) and IRIG-B synchronization.

- The protection modules are completely separated from other modules, and are independent in both hardware and software. The protection functions do not depend on the communication network, so the failure of communication network will not affect the normal operation of the protection functions.
- Mature protection configuration, fast speed and high security performance can meet the practical requirements. Each protective element is independent, so it is very convenient for whether adopting the selected protective element.
- This device constantly measures and calculates a large amount of analog quantities, such as phase voltage, phase-to-phase voltage, neutral voltage, phase current, neutral current, active power, reactive power, power factor and frequency etc.
- The human machine interface (HMI) with a small control module (a 320×240-dot LCD, a 9-key keypad and 19 LED indicators) on the front panel is very friendly and convenient to the user.
- This device can communicate with a SAS or RTU via different communication intermediates: Ethernet network, RS-485 serial ports. The communication protocol of this device is optional: IEC61850, IEC60870-5-103, DNP3.0.
- This device can detect the tripping circuit of the circuit breaker and monitor the operation (close or trip) time of a circuit breaker by checking the auxiliary contacts of the circuit breaker.
- Complete event recording function is provided: 64 latest protection operation reports, 1024 latest supervision records, 1024 latest control operation records, 1024 latest user operation records and 1024 latest records of time tagged sequence of event (SOE) can be recorded.
- Powerful fault and disturbance recording function is supported: 16 latest fault disturbance waves, 16 latest start disturbance waves and 4 manual disturbance waves, the duration of a wave recording is configurable.

2 Technical Specifications

2.1 Electrical Specifications

2.1.1 Current Transformer Ratings

Reference		IEC 60255-1, IEC 60255-27
Rated frequency (fn)		50Hz, 60Hz
Nominal range		fn ± 5Hz
Rated current (In)		1/5A
Thermal withstand capability	continuously	3×In
	for 10s	20×In
	for 1s	100×In
Burden		< 0.05VA/phase @1A, < 0.2VA/phase @5A,

2.1.2 Voltage Transformer Ratings

Reference		IEC 60255-1, IEC 60255-27
Rated frequency (fn)		50Hz, 60Hz
Nominal range		fn ± 5Hz
Rated voltage (Un)		100V - 120V (phase-to-phase voltage)
Thermal withstand capability	continuously	240V
	10s	360V
	1s	400V
Burden at rated voltage		< 0.03VA/phase @57.7V

2.1.3 Auxiliary Power Supply

Reference	IEC 60255-1, IEC 60255-26
Rated voltage	24VDC-250VDC, 48V-250VAC
Variation	80% - 120%
Frequency	50/60Hz, ± 5Hz
Maximum interruption time in the auxiliary DC voltage without resetting the IED	0%Un,100ms； 40%Un,200ms； 70%Un,500ms At the Un=DC220V
Gradual shut down / Start up	Class C (60s shut down ramp, 5 min power off, 60s start up ramp)
Ripple in the DC auxiliary voltage	Class A (15% of rated @200Hz, 220VDC)
Maximum load of auxiliary voltage supple	≤22W (normal state), ≤25W (maximum state)

2.1.4 Binary Input

Reference	IEC 60255-1, Clause:6.10.5
Binary input number	Up to 36
Rated voltage	24VDC-250VDC, 48V-250VAC

Pickup voltage	55% - 70% rated voltage
“ON” value voltage	70% - 120% rated voltage
“OFF” value voltage	< 55% rated voltage
Maximum permitted voltage	120% rated voltage
Resolution of binary input signal	≤ 1ms
Resolution of SOE	≤ 1ms

2.1.5 Binary Output

Reference	IEC 60255-1	
Item	Tripping output	Signal output
Binary output number	Up to 32	Up to 32
Output model	Potential-free contact	Potential-free contact
Max system voltage	380Vac, 250Vdc	380Vac, 250Vdc
Voltage across open contact	1000V RMS for 1min	1000V RMS for 1min
Continuous carry	10.0A @ 380Vac； 10.0A @ 250Vdc	5.0A @ 380Vac； 5.0A @ 250Vdc
Short duration current	30A, 3s 50A, 1s	30A, 1s
Breaking capacity	1.00A @ 48Vdc, L/R=40ms 0.35A @ 110Vdc, L/R=40ms 0.30A @ 125Vdc, L/R=40ms 0.20A @ 220Vdc, L/R=40ms 0.15A @ 250Vdc, L/R=40ms	0.60A @ 48Vdc, L/R=40ms 0.10A @ 110Vdc, L/R=40ms 0.05A @ 220Vdc, L/R=40ms
Pickup time	< 5ms	< 10ms
Dropout time	< 5ms	< 8ms

2.2 Mechanical Specifications

Mounting Way	Flush mounted	
Weight per device	Approx. 7.0kg (fully equipped)	
Mechanical size (width×high×deepth)	186.8mm*271 mm *209.7 mm	
Hole size (width×high)	154 mm *268 mm	
Display language	Optional: Chinese, English, Russian, French, Spanish	
Housing material	Metallic plates, parts and screws: Steel Plastic parts: Polycarbonate	
Housing color	Silver grey	
Location of terminal	Rear panel of the device	
Protection class	IEC60225-1: 2009	Front side: IP40 (IP52 with seal strip) Rear side, connection terminals: IP20 Other Sides: IP40

2.3 Ambient Temperature and Humidity Range

Standard	IEC 60255-1:2009
Operating temperature range	-25°C - +70°C
Transport and storage temperature range	-40°C - +70°C
Damp heat steady	+40℃ 93%humidity 16h
Damp-heat test, cyclic	6 cycles, +25℃ to +55℃, Humidity 97% to 93%

2.4 Communication Interfaces

2.4.1 Ethernet Port

Medium		Parameters	
Ethernet: Electrical or Optical	Electrical	Port number	3
		Connector type	RJ-45
		Transmission rate	100Mbits/s
		Transmission standard	100Base-TX
		Transmission distance	≤ 100m
		Protocol	IEC60870-5-103:1997, IEC61850 etc.
		Safety level	Isolation to ELV level
	Optical	Port number	3
		Connector type	LC
		Transmission rate	100Mbits/s
		Transmission standard	100Base-FX
		Optical fiber type	Multi-mode
		Wavelength	1310nm
		Transmission distance	≤ 2000m
		Protocol	IEC60870-5-103:1997, IEC61850 etc.

2.4.2 Serial Port

Medium	Parameters	
RS-485 (EIA)	Port number	2
	Baud rate	4800 - 115200bps
	Transmission distance	≤ 500m @ 4800bps
	Maximal capacity	32
	Protocol	IEC60870-5-103:1997, DNP3.0 etc.
	Safety level	Isolation to ELV level

2.4.3 Time Synchronization

Medium	Parameters	
RS-485 (EIA)	Port number	1
	Transmission distance	≤ 500m
	Maximal capacity	32
	Timing standard	IRIG-B

Medium	Parameters	
	Safety level	Isolation to ELV level
Optical Ethernet	Port number	1
	Transmission distance	≤ 2000m
	Timing standard	IRIG-B

2.4.4 Ethernet Port for Debugging

Medium	Parameters	
Electrical Ethernet (in front panel)	Port number	1
	Connector type	RJ-45
	Transmission rate	100Mbits/s
	Transmission standard	100Base-TX
	Transmission distance	≤ 100m
	Safety level	Isolation to ELV level

2.5 Type Tests

2.5.1 Environmental Tests

Dry heat operation test	IEC 60068-2-2, IEC 60255-27	16h, +70℃
Cold operation test	IEC 60068-2-1, IEC 60255-27	16h, -40℃
Dry heat storage test	IEC 60068-2-2, IEC 60255-27	16h , +70℃
Cold storage test	IEC 60068-2-1, IEC 60255-27	16h , -40℃
Damp heat steady state test +Verification of function	IEC 60255-1, IEC 60068-2-78	+40℃ 93%humidity
Damp-heat test, cyclic	IEC 60068-2-30, IEC 60255-27	6 cycles, +25℃ to +40℃, Humidity 97% to 93%
Change of temperature test	IEC 60068-2-14	5 Cycles , 1℃/min, -40℃ to +70℃

2.5.2 Mechanical Tests

Vibration response test	IEC 60255-21-1, IEC 60255-27	Class 1： Vibration Response: Class 1 (10-59Hz: 0.035mm, 59-150Hz: 0.5gn)
Vibration Endurance:	IEC 60255-21-1, IEC 60255-27	Class 1 (10-150Hz: 1gn)
Shock Response	IEC 60255-21-2, IEC 60255-27	Class 1 (5gn)
Shock Withstands	IEC 60255-21-2, IEC 60255-27	Class 1 (15gn)
Bump	IEC 60255-21-2, IEC 60255-27	Class 1(10gn)

Seismic +Verification of function	IEC 60255-21-3, IEC 60255-1	Class I

2.5.3 Electrical Tests

Impulse Voltage Tests.	IEC 60255-27	Impulse test: 5kV (rated insulation voltage ≤63V);Impulse test: 1kV (rated insulation voltage ＞63V);
AC or DC Dielectric Test	IEC 60255-27	dielectric 50,60Hz 5/60s DC 2.8KV AC 2KV
Insulation Resistance	IEC 60255-27	>100Mohm @500Vdc
Protective Bonding Resistance	IEC 60255-27	Test current DC20A, >12 Vac /Vdc, >60s,< 0.1 ohm

2.5.4 Electromagnetic Compatibility

Burst Disturbance Test / Damped Oscillatory Wave Immunity Test	IEC 60255-26, IEC 61000-4-18	For Power Supply, Binary Input / Output: Common Mode: 2.5kV, Differential Mode: 1kV;For Communication Port: Common Mode: 1kV
Electrostatic Discharge test	IEC 60255-26, IEC 61000-4-2	Contact Discharge: 8kV, Air Discharge: 15kV
Fast Transient test	IEC 60255-26, IEC 61000-4-4	(Power / Earth Port: 4kV, Signal / Control Port: 2kV)
Surge Immunity Test	IEC 60255-26, IEC 61000-4-5	For Power Supply, BI: L-E: 4kV, L-L: 2kV, voltage waveform: 1.2/50µs, current waveform: 8/20µs； Communication Port: L-E: 1kV, L-L: -, voltage waveform: 1.2/50µs, current waveform: 8/20µs)
Conducted radio interference test	IEC 60255-26, IEC 61000-4-6	150kHz-80MHz(Uo: 140dB µV or Uo: 10V)
Electromagnetic fields immunity	IEC 60255-26, IEC 61000-4-3	Test Field Strength:10V/m, Sweep frequency: 80MHz–1000MHz, Spot frequency: 80MHz, 160MHz,450MHz, 900MHz@80%Modulation&Pulse
immunity to conduct, common mode disturbance in frequency range 0 Hz to 150KHz	61000-4-16	Level 4：continuous 30V,short duration 300V at 50/3,50,60Hz; 15Hz-150Hz:30-3 decreases at 20dB/decade; 150Hz-1.5kHz:3 constant; 1.5kHz-15kHz:3-30 increases at 20dB/decade;
power frequency magnetic fields	IEC 61000-4-8, IEC 60255-26	Continuous: 100A/m, Short Duration 1s to 3s: 1000A/m)
Pulse magnetic field immunity test	IEC 61000-4-9	Class 5: Current 6.4/16µs, 1000A/m
Damped oscillatory magnetic field immunity test	IEC 61000-4-10	Class 5: 0.1MHz&1MHz, 100A/m
Power frequency immunity tests	IEC 60255-26	Input: Class A, Common Mode: 300V, Differential Mode: 150V
Ring wave immunity test	IEC 61000-4-12	Ring Wave Class 4,4kV
Conducted RF interference	IEC 60255-26,	Conducted Emission Limit for Auxiliary Power

on power supply terminals	CISPR 22	Supply Port：Frequency range: 0.15MHz-0.5MHz, Frequency range: 0.5MHz-30MHz；
Radiated interference	IEC 60255-26, CISPR 22	Radiated Emission Limit on Enclosure Port：Frequency range: 30MHz - 230MHz, Frequency range: 230MHz - 1000MHz;

2.6 Terminals

Connection Type	Wire Size
CT and VT circuit connections	Screw terminals, 4mm^2 lead
Binary I/O connection system	Screw terminals, 2.5mm^2 lead

2.7 Measurement Range and Accuracy

Metering Item	Range	Accuracy
Phase range	0° - 360°	≤ 0.5% or ±2°
Frequency	35.00Hz - 70.00Hz	≤ 0.01Hz
Current (three phase 3Ip)	0.05In<I<4In	±0.5%In, I≤In; ±0.5%I, I>In
Voltage (Phase 3Up, Phase-to-Phase 3Upp)	0.05 Un<U<1.50Un	±0.5%Un, U≤Un; ±0.5%U, U>Un
P, Q, S,	0.2In<I<4In 0.1 Un<U<1.5Un	±1% for power (S, P and Q)
power factor cos		±0.02 for power factor

2.8 Protection Function Features

2.8.1 Overcurrent Protection

Function	Accuracy
Operation current accuracy	±1.0% of the set value or ±0.005 × In
Blocking voltage accuracy	±1.0% of the set value or ±0.005 × Un
Reset time	≤45ms
Reset ratio	Typically 96%(±3%), or ($\frac{SetValue-0.005In}{SetValue}$)(±3%)
Operating time at instantaneous time mode without directional and voltage control element	≤25 ms at I=2xstart value
Operation time accuracy at definite time mode	±1.0% of the set value or ±40 ms
Operation time accuracy at inverse time mode	±5.0% of the theoretical value or ±40 ms, Start value multiples in range of 1.2...20 when I>In, Start value multiples in range of 2...20 when I≤In.
DIR criteria	≤±2°
Transient overreach accuracy (Only for Indonesia)	<10%
Transient accuracy overshoot (Only for Indonesia)	≤40ms

Note:

(1) Transient overreach accuracy: 10%

Variable testing

- Flow setting Is: 1.0 x In
- Setting time ts: 0 seconds (Instant)
- Test flow Itest: 0.98 x I s + DC offset

Calculation of transient overreach values:

*Transient Overreach[%]=(Is2/Is1-1)*100%*

Where:

Is1: The current settings when the relay does not work without conditions DC offset

Is2: The current setting when the relay does not work in situations where DC offset

(2) Transient accuracy overshoot: ≤ 40 ms

Variable testing

Flow setting Is : 1.0 x In

Setting time t s : 0.200 seconds (Instant)

Test flow I_{test} : 5 x Is

Test time t_{test} : Max t_{op}- 5 ms

Data retrieval: 5 repetitions in each case

Calculation of transient overreach values

$$Transient\ Overshoot[ms]=(T_{op}-T_{nop})*100$$

Where

Time Operate (T_{op}): Relay work time at 200 ms

Time Not Operate (T_{nop}): The duration of the disturbance (t_{test}) given during the relay not working

2.8.2 Residual Overcurrent Protection

Function	Accuracy
Operation current accuracy	±1.0% of the set value or ±0.005 × In
Blocking voltage accuracy	±1.0% of the set value or ±0.005 × Un
Reset time	≤45ms
Reset ratio	Typically 96%(±3%), Or ($\frac{SetValue - 0.005In}{SetValue}$)(±3%)
Operation time accuracy at instantaneous time mode without directional and voltage control element	≤25 ms at I=2xstart value
Operation time accuracy at definite time mode	±1.0% of the set value or ±40 ms
Operation time accuracy at inverse time mode	±5.0% of the theoretical value or ±40 ms, Start value multiples in range of 1.2...20 when I>In, Start value multiples in range of 2...20 when I≤In.
Transient overreach accuracy(Only for Indonesia)	<10%
Transient accuracy overshoot	≤40ms

2.8.3 Sequence Overcurrent Protection

Function	Accuracy
Operation current accuracy	±1.0% of the set value or ±0.005 × In
Reset time	≤45ms
Reset ratio	Typically 96%(±3%), Or ($\frac{SetValue - 0.005In}{SetValue}$)(±3%)

Function	Accuracy
Operation time accuracy at definite time mode	±1.0% of the set value or ±40 ms
Operation time accuracy at inverse time mode	±5.0% of the theoretical value or ±40 ms, Start value multiples in range of 1.2...20 when I>In, Start value multiples in range of 2...20 when I≤In.
Transient overreach accuracy (Only for Indonesia)	<10%
Transient accuracy overshoot (Only for Indonesia)	≤40ms

2.8.4 Broken Conductor Protection

Function	Accuracy
Tolerance of Ratio setting	±2% of the set value
Reset time	≤45ms
Current Reset ratio	Typically 96%(±3%), Or ($\frac{SetValue - 0.005In}{SetValue}$)(±3%)
Operation time accuracy at definite time mode	±1.0% of the set value or ±40 ms

2.8.5 Over/Under Frequency Protection

Function	Accuracy
Operation frequency accuracy	± 0.01Hz, 30.00-70.00 at Fn=50; 40.00-80.00 at Fn=60
Blocking voltage accuracy	±1.0% of the set value or ±0.005 × Un
Frequency gradient accuracy	± 0.1Hz/s at -10.00-10.00 Hz/s
Operation time, definite time function	±1.0% of the set value or ±60 ms
Reset time, definite time function	<190ms

2.8.6 Over/Under Voltage Protection

Function	Accuracy
Operation voltage accuracy	±1.0% of the set value or ±0.005 × Un
Blocking current accuracy	±1.0% of the set value or ±0.005 × In
Reset ratio	≤96%(±3%) for Over, ≥104%(±3%) for Under
Operation time accuracy at definite time mode	±1.0% of the set value or ±40 ms
Operation time accuracy at inverse time mode	±5.0% of the theoretical value or ±40 ms, the maximum Start value is 1.2Un, the Start value multiples in range of 1.10...2.00.

2.8.7 Power Protection

Function	Accuracy
Operation accuracy	At the frequency f = fn Power: ≤ 2.5% Setting or 0.5W
Reset ratio	≤96%(±3%)
Operation time accuracy	±1.0% of the set value or ±40 ms

2.8.8 50BF Protection

Function	Accuracy
Operation current accuracy	±1.0% of the set value or ±0.005 × In

Function	Accuracy
Operation residual current accuracy	±1.0% of the set value or ±0.005 × In
Current Reset ratio	Typically 96%(±3%), Or ($\frac{SetValue - 0.005In}{SetValue}$)(±3%)
Drop-off time	≤ 12.5ms
Operation time accuracy	±1.0% of the set value or ±40 ms

2.8.9 Thermal overload

Function	Accuracy
Operation current accuracy	±1.0% of the set value or ±0.005 × In at 0.04…3In
Operation time accuracy	IEC 60255-8, ±5% + 200ms

2.8.10 Auto-Reclose

Function	Accuracy
Operation time accuracy	±1.0% of the set value or ±40 ms

2.8.11 OCR_INR

Function	Accuracy
Operation accuracy	Current measurement: ±1.0% of the set value or ±0.005 × In Ratio I2Hp/Ip measurement: ±5.0% of the set value
Operation time accuracy	±1.0% of the set value or ±40 ms
Reset time	≤45ms
Reset ratio	(Ratio setting-0.005)/ Ratio setting(±3%)

2.8.12 Sensitive Earth Fault

Function	Accuracy
Operation accuracy	Current measurement: ±1.0% of the set value or ±0.005 × In Voltage measurement ±1.0% of the set value or ±0.005 × Un Power measurement: ±3.0% of the set value or ±0.002 × Sn
Operation time accuracy at definite time mode	±1.0% of the set value or ±40 ms
Operation time accuracy at inverse time mode	±5.0% of the theoretical value or ±40 ms
Reset time	≤45ms
Reset ratio	Typically 96%(±3%), Or ($\frac{SetValue - 0.005In}{SetValue}$)(±3%)

2.8.13 Gap overcurrent and zero sequence overvoltage

Function	Accuracy
Operation current accuracy	±1.0% of the set value or ±0.005 × In
Operation voltage accuracy	±1.0% of the set value or ±0.005 × Un

Function	Accuracy
Reset time	≤60ms
Current Reset ratio	Typically 96%(±3%), Or ($\frac{SetValue - 0.005In}{SetValue}$)(±3%)
Voltage Reset ratio	Typically 96%(±3%)
Operation time accuracy	±1.0% of the set value or ±40 ms

2.8.14 Restricted Earth Fault Protection 64REF

Function	Accuracy
Operation current accuracy	±1.0% of the set value or ±0.005 × In
Reset ratio	Typically 96%(±3%), Or ($\frac{SetValue - 0.005In}{SetValue}$)(±3%)
Operation time accuracy	±1.0% of the set value or ±40 ms

2.8.15 Differential Protection

Function	Accuracy
Operation current accuracy	±1.0% of the set value or ±0.005 × In
Reset time	≤45ms
Reset ratio	Typically 96%(±3%), Or ($\frac{SetValue - 0.005In}{SetValue}$)(±3%)
Operation time accuracy	±1.0% of the set value or ±40 ms
Transient accuracy overshoot (Only for Indonesia)	≤40ms

2.8.16 Fault Locator

Function	Accuracy
Accuracy for multi-phase faults with single end feed	3%
Accuracy will be higher in case of single-phase fault with high ground resistance.	

3 Protection Functions

3.1 Overview

The PRS-7367 relay is a microprocessor based relay which can provide mature protection for various primary equipment (generally all types of feeders, capacitors etc.). The following sections detail the individual protection functions of this relay.

3.1.1 Glossary

The glossary will be listed in the below form.

Category	Profession Vocabulary	Abbreviation
Electricity	Time	T
	Phase	Ph
	Direction	Dir
	Overcurrent	OC
	Curve	Curve
	Temperature	Temp
	Characteristic	Char
	Polarity	Pol
	Quantity	Qua
	Factor	Factor
	Current	Cur
	Residual Current	ResCur
	Negative Current	NegCur
	Positive Current	PosCur
	Voltage	Vol
	Residual Voltage	ResVol
	Negative Voltage	NegVol
	Positive Voltage	PosVol
	High Voltage	HigVol
	Low Voltage	LowVol
	thermal	Therm
	Overload	OL
	Negative	Neg
	Sequence	Seq
	Residual	Res
	Beta	Beta
	harmonic	Harm
	Power	Pow
	Earth-fault	EF

Category	Profession Vocabulary	Abbreviation
	Failure	Fail
	Impedance	Imp
	Reactance	React
	Induction	Induct
	Positive	Posi
Operation	Block	Blk
	Enable	Ena
	Operation	Op
	Trip	Tr
	Protection	Prot
	Mode	Mod
	Forward	Fwd
	Reverse	Rev
	Constant	Const
	External	Ex
	Internal	In
	Number	Num
	Selector	Sel
	Measurement	Meas
	Parameter	Para
	Multiplier	Mult
	Minimum	Min
	Alarm	Alm
	Reclose	Recls
	Counter	Counter
	Correction	Correction
	Available	Avai
	Initial	Init
	Reference	Ref
	Normal	Norm
	Restraint	Restr
	Slope	Slope
	Deblock	Deblk
	Winding	Wnd
	Elimination	Elim
	Nominal	Nom
	Connection	Connection
	Hysteresis	Hyst
	Compensation	Comp
	Check	Chk
	Synchronize	Syn
	Synchronization	Syn

Category	Profession Vocabulary	Abbreviation
	Energize	Energ
	Weigh	Weig
	Activation / Activate	Activ
	Error	Err
	Configuration	Cfg
	Parameter	Para
	Management	Mana
	Interrupt	Intr
	SelfCheck	SelfChk
	Start	Str
Apparatus	Generator	Gen
	Motor	Motor
	Rotor	Rotor
	Stator	Stator
	Busbar	Bus
	Transformer	TF
	Transmission Line	TL
	Line	Line
	Capacitor	Cap
	Reactor	Reac
	Resistor	Resis
	Switch	Sw
	Component	Comp

3.1.2 System parameter

Table 3.1-1 System parameters

No	Name	Range	Unit	Step	Default	Description
1	Prot_TA_Primary	1-9999	A	1	1000	The rated primary value of the No.1 protection phase CT
2	Prot_TA_Secondary	1-5	A	4	5	The rated secondary value of the No.1 protection phase CT
3	ZeroSeq_TA_Primary	1-9999	A	1	1000	The rated primary value of the No.1 zero sequence CT
4	ZeroSeq_TA_Secondary	1-5	A	4	5	The rated secondary value of the No.1 zero sequence CT
5	Prot_TV_Primary	0.01-1000	KV	0.01	110	The rated primary value of the No.1 protection VT
6	Prot_TV_Secondary	0.01-1000	V	0.01	115	The rated secondary value of the No.1 protection VT
7	Prot2_TA_Primary	1-9999	A	1	1000	The rated primary value of the No.2 protection phase CT
8	Prot2_TA_Secondary	1-5	A	4	5	The rated secondary value of the No.2 protection phase CT
9	Prot2_TV_Primary	0.01-1000	KV	0.01	110	The rated primary value of the No.2 protection VT
10	Prot2_TV_Secondary	0.01-1000	V	0.01	115	The rated secondary value of the No.2 protection VT
11	ZeroSeq2_TA_Primary	1-9999	A	1	100	The rated primary value of the No.2 zero sequence CT
12	ZeroSeq2_TA_Secondary	1-5	A	4	5	The rated secondary value of the No.2 zero sequence CT
13	ZeroSeq_TV_Primary	0.01-1000	KV	0.01	110	The rated primary value of the zero sequence VT
14	ZeroSeq_TV_Secondary	0.01-1000	V	0.01	115	The rated secondary value of the zero sequence VT
15	Ux_TV_Primary	0.01-1000	KV	0.01	110	The rated primary value of the synchronization VT
16	Ux_TV_Secondary	0.01-1000	V	0.01	115	The rated secondary value of the synchronization VT
17	Meas_TA_Primary	1-9999	A	1	1000	The rated primary value of the measurement CT
18	Meas_TA_Secondary	1-5	A	4	5	The rated secondary value of the measurement CT
19	Machine_Ie	0.01-20In	A	0.01In	5In	The machine rated current

3.2 Non-directional overcurrent protection 50/51P

3.2.1 50/51P Overview

This relay provides three types of non-directional phase overcurrent(OC) protection, including instantaneous stage (50P), time delay stage (51P) and Time delay stage with VTS (51PVT). The 50P is with dependent definite time (DT), the 51P and 51PVT contain dependent definite time (DT) and inverse definite minimum time (IDMT) characteristics. The stages of OC can be configured by application, the 50P is up to three stages (the default is one), the 51P is three stages, the 51PVT is one stage. Each stage can be enabled or disabled independently by the logic settings respectively. All overcurrent module, phase selection module, time characteristic settings apply to all three phases and are independent from each other.

Table 3.2-1 Function Description and ANSI

Function description	**ANSI**
Three-phase non-directional phase overcurrent protection - Instantaneous stage	50P
Three-phase non-directional phase overcurrent protection - Time delay stage	51P
Three-phase non-directional phase overcurrent protection - Time delay stage with VTS	51PVT

3.2.1.1 Function Block

The function block of the protection is as below.

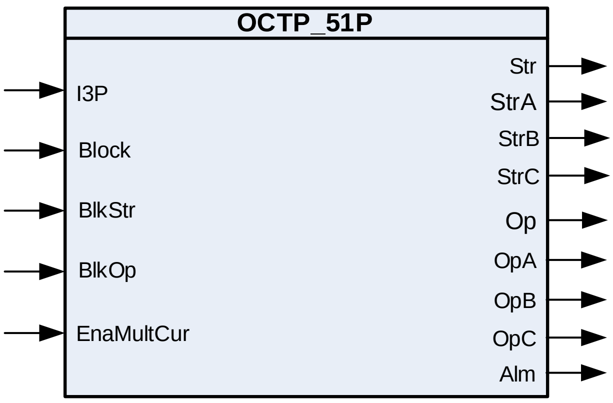


Figure 3.2-1 Function block

3.2.1.2 Signals

Table 3.2-2 Input Signals

Signal	Description
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.
EnaMultCur	This signal enables the current multiplier.

Table 3.2-3 Output Signals

Signal	Description
Str	This is the integrated start signal
StrA	This is the start signal of phase A
StrB	This is the start signal of phase B
StrC	This is the start signal of phase C.
Op	This is the integrated operation signal.
OpA	This is the operation signal of phase A
OpB	This is the operation signal of phase B
OpC	This is the operation signal of phase C
Alm	This is the integrated alarm signal

3.2.2 50/51P Protection Principle

3.2.2.1 51P

Each stage of the protection function can be enabled or disabled by setting the corresponding 51P_Ena parameter values as "1" or "0".

The operation of the overcurrent protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

- **Initiation logic**

The initiation logic diagram of the protection is as below:

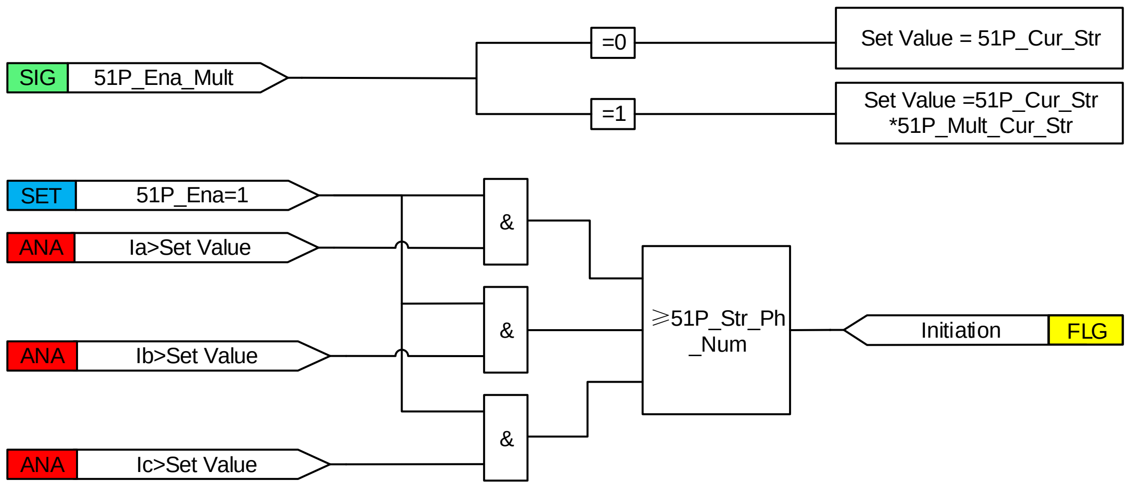


Figure 3.2-2 The initiation logic diagram for 51P

The measured phase currents are compared phase wise to the set 51P_Cur_Str. If the measured value exceeds the set 51P_Cur_Str, the level detector reports the exceeding of the value to the phase selection logic. If the 51P_EnaMultCur input is active, the 51P_Cur_Str value setting is multiplied by the 51P_Mul_Cur_Str setting.

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information is equal to or more than the 51P_Str_Ph_Num setting, the phase selection logic activates the “Initiation” signal.

Where:

51P_Cur_Str is the 51P start value.

51P_Mul_Cur_Str is the multiplier for scaling the start value.

51P_Op_Ph_Num is the Number of phases required for operate activation.

NOTICE!

Do not set the multiplier setting 51P_Mul_Cur_Str higher than necessary. If the value is too high, the function may not operate at all during an inrush followed by a fault, no matter how severe the fault is.

The start value multiplication is normally done when the inrush detection function (OCR_INR) is connected to the EnaMultCur input by <u>Three phase inrush function OCR_INR</u> or <u>Machine Startup MST</u>.

- **Timer element**

The functional module diagram is shown as below:

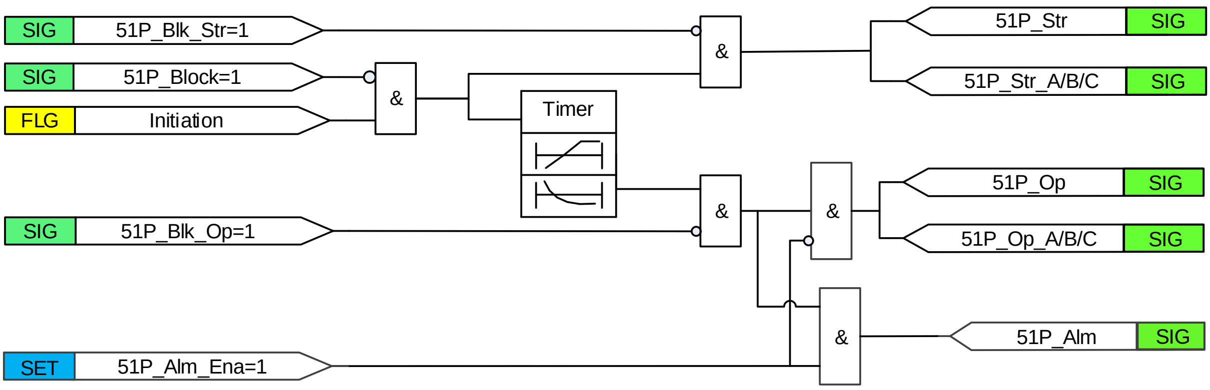


Figure 3.2-3 Functional module diagram for 51P

Once initiation logic is fulfilled and no blocking signal is activated, the 51P_Str signal is set. The 51P_StrA, 51P_StrB and 51P_StrC outputs are used to indicate which phases are started.

The timer model is determined by **IDMT curves for over quantity protection**

The operation is activated after the operation timer has reached the calculated value. However, 51P_Min_Op_T defines the minimum desired operate time for IDMT. If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the operation will reset after the set value 51P_Reset_T is exceeded.

NOTICE!

The 51P_Min_Op_T setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the 51P_Min_Op_T setting.

The binary input 51P_Block can be used to block the function. The activation of the 51P_Block input deactivates all outputs and resets internal timers. The binary input 51P_BlkStr can be used to block the start signals. The binary input 51P_BlkOp can be used to block the operation signals.

3.2.2.2 50P

The overcurrent protection in this relay provides instantaneous phase overcurrent protection. The overcurrent module, phase selection module, time characteristic settings apply to all three phases and are independent from each other. Configuring the relevant settings can enable or disable the corresponding protection.

The principle is same as the 51P except 50P time delay is instantaneous.

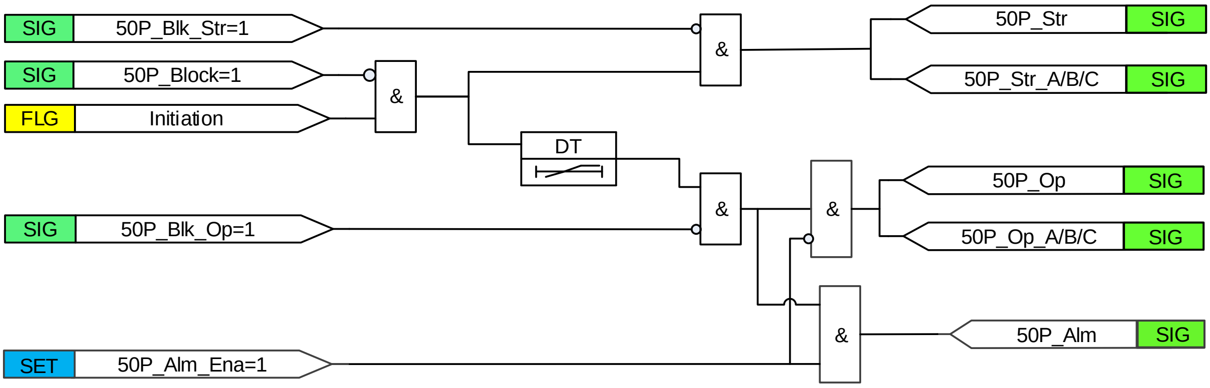


Figure 3.2-4 Functional module diagram for 50P

3.2.2.3 51PVT

The overcurrent protection in this relay provides phase overcurrent protection for VT Circuit Failure within dependent definite time (DT) and inverse definite minimum time (IDMT) characteristics. The overcurrent module, phase selection module, time characteristic settings apply to all three phases and are independent from each other. The operate time characteristics can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). Configuring the relevant settings can enable or disable the corresponding protection.

The principle is same as the 51P except 51PTV is just only enabled when VTS alarm.

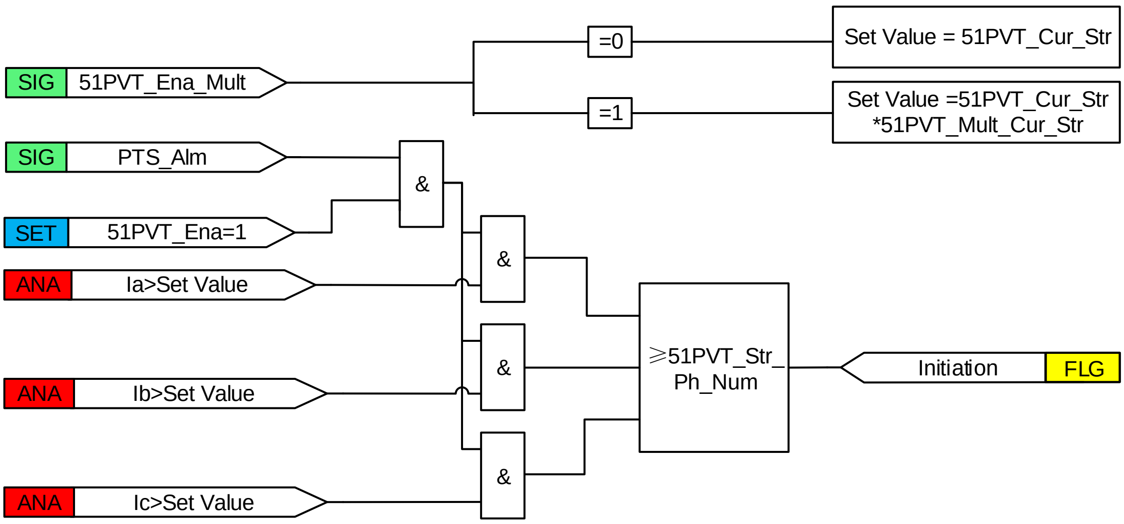


Figure 3.2-5 The initiation logic diagram for 51PVT

The function Functional module diagram is same as 51P.

3.2.3 50/51P Application Scope

50/51P is used for single-phase, two-phase and three-phase non-directional overcurrent and short-circuit protection. The applications of 51P include but are not limited to:

• Selective overcurrent and short-circuit protection of feeders

• Backup overcurrent and short-circuit protection of power transformers and generators

• Overcurrent and short-circuit protection of various devices connected to the power system

• General backup protection

• Overcurrent protection when VTS alarm

3.2.4 50/51P Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.2-4 50P settings

No	Name	Range	Unit	Step	Default	Description
1	50Pi_Cur_Str	0.04-20.00In	A	0.01In	0.04In	The Stage i instantaneous OC Start current value
2	50Pi_Mul_Cur	0.8-10.0	-	0.1	1	The Stage i instantaneous OC Multiplier current start value
3	50Pi _Op_T	0.000-120.000	s	0.001	0.000	The Stage i instantaneous OC operation time delay
4	50Pi_Ena	0-1	-	1	0	The Stage i instantaneous OC Operation Enable/Disable
5	50Pi_AlmEna	0-1	-	1	0	The Stage i instantaneous OC Alarm Enable/Disable
6	50Pi_Str_Ph_Num	1-3	-	1	1	The Stage i instantaneous OC Number of phases required for operate activation: 1: 1 out of 3; 2: 2 out of 3; 3: 3 out of 3

Table 3.2-5 51P settings

No	Name	Range	Unit	Step	Default	Description
1	51Pi_Cur_Str	0.04-20.00In	A	0.01In	0.04In	The Stage i OC Start current value
2	51Pi_Mul_Cur	0.8-10.0	-	0.1	1	The Stage i OC Multiplier current start value
3	51Pi_Mul_Cur2	20-40.0	-	0.1	30	It used to IDMT with I=Mul_Cur2*Ip, when I> Mul_Cur2*Ip, the IDMT time delay is calculated by Mul_Cur2. It is invalid if it is not configured or the Mul_Cur_Ena2 is disable.
4	51Pi_Mul_Cur_Ena2	0-1	-	1	0	The Mul_Cur2 Enable/Disable: Enable: Mul_Cur2 is effective Disable: Mul_Cur2 is ineffective.
5	51Pi_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite time, IEC and

No	Name	Range	Unit	Step	Default	Description
						ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
6	51Pi_Curve_ParaA	0.000-120.000	s	0.001	0	The Stage i OC Curve parameter A
7	51Pi_Curve_ParaB	0.000-9.000	s	0.001	0.2	The Stage i OC Curve parameter B
8	51Pi_Curve_ParaC	0.0-1.0	-	0.1	1.0	The Stage i OC Curve parameter C
9	51Pi_Curve_ParaP	0.02-2.00	-	0.01	2.00	The Stage i OC Curve parameter P
10	51Pi_Curve_ParaK	0.05-100	-	0.01	1.00	The Stage i OC Curve parameter k
11	51Pi_Min_Op_T	0.005-60.000	s	0.001	0.005	The Stage i OC minimum operation time delay
12	51Pi_Reset_T	0.000 -60.000	s	0.001	0.02	The Stage i OC Reset time delay
13	51Pi_Ena	0-1	-	1	0	The Stage i OC Operation Enable/Disable
14	51Pi_AlmEna	0-1	-	1	0	The Stage i OC Alarm Enable/Disable
15	51Pi_Str_Ph_Num	1-3	-	1	1	The Stage i OC Number of phases required for operate activation: 1: 1 out of 3; 2: 2 out of 3; 3: 3 out of 3

Table 3.2-6 51PVT settings

No	Name	Range	Unit	Step	Default	Description
1	51PVTi_Cur_Str	0.04-20.00In	A	0.01In	0.04In	The Stage i VTS OC Start current
2	51PVTi_Mul_Cur	0.8-10.0	-	0.1	1	The Stage i VTS OC Multiplier current start value
3	51PVTi_Mul_Cur2	20-40	-	0.1	30	It used to IDMT with I=Mul_Cur2*Ip, when I> Mul_Cur2*Ip, the IDMT time delay is calculated by Mul_Cur2. It is invalid if it is not configured or the Mul_Cur_Ena2 is disable.
4	51PVTi_Mul_Cur_Ena2	0-1	-	1	0	The Mul_Cur2 Enable/Disable: Enable: Mul_Cur2 is effective Disable: Mul_Cur2 is ineffective.
5	51PVTi_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
6	51PVTi_Curve_ParaA	0.000-120.000	s	0.001	0	The Stage i VTS OC Curve

No	Name	Range	Unit	Step	Default	Description
						parameter A
7	51PVTi_Curve_ParaB	0.000-9.000	s	0.001	0.2	The Stage i VTS OC Curve parameter B
8	51PVTi_Curve_ParaC	0.0-1.0	-	0.1	1.0	The Stage i VTS OC Curve parameter C
9	51PVTi_Curve_ParaP	0.02-2.00	-	0.01	2.00	The Stage i VTS OC Curve parameter P
10	51PVTi_Curve_ParaK	0.05-100	-	0.01	1.00	The Stage i VTS OC Curve parameter k
11	51PVTi_Min_Op_T	0.005-60.000	s	0.001	0.005	The Stage i VTS OC minimum operation time delay
12	51PVTi_Reset_T	0.000 -60.000	s	0.001	0.02	The Stage i VTS OC Reset time delay
13	51PVTi_Ena	0-1	-	1	0	The Stage i VTS OC Operation Enable/Disable
14	51PVTi_AlmEna	0-1	-	1	0	The Stage i VTS OC Alarm Enable/Disable
15	51PVTi_Str_Ph_Num	1-3	-	1	1	The Stage i VTS OC Number of phases required for operate activation: 1: 1 out of 3; 2: 2 out of 3; 3: 3 out of 3

3.3 Directional overcurrent protection 67P

3.3.1 67P Overview

The overcurrent protection in this relay provides four-stage directional phase overcurrent protection within dependent definite time (DT) and inverse definite minimum time (IDMT) characteristics. Each stage can be enabled or disabled independently by the logic settings respectively. All overcurrent module, phase selection module, time characteristic settings apply to all three phases and are independent from each other. The operate time characteristics for each stage can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). Configuring the relevant settings can enable or disable the corresponding protection.

3.3.1.1 Function Block

The function block of the protection is as below.

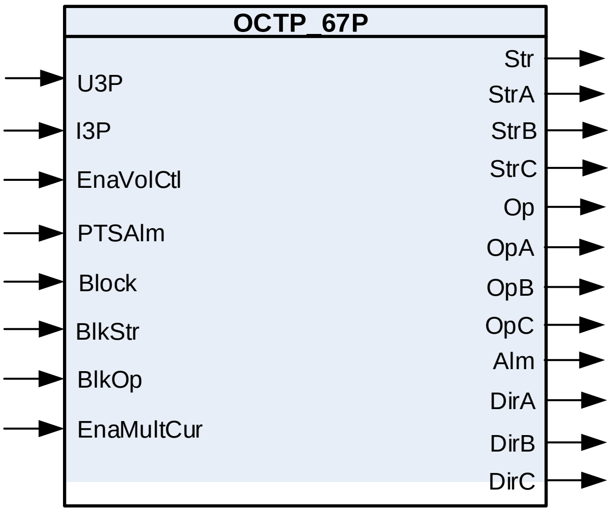


Figure 3.3-1 Function block

3.3.1.2 Signals

Table 3.3-1 Input signal

Signal	Description
U3P	The voltage in all the three phases
I3P	The current magnitude in all the three phases
EnaVolCtl	The voltage block control condition
PTSAlm	The PTS alarm block directional OC
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.
EnaMultCur	This signal enables the current multiplier.

Table 3.3-2 Output signal

Signal	Description
Str	This is the integrated start signal
StrA	This is the start signal of phase A
StrB	This is the start signal of phase B
StrC	This is the start signal of phase C.
Op	This is the integrated operation signal.
OpA	This is the operation signal of phase A
OpB	This is the operation signal of phase B
OpC	This is the operation signal of phase C
Alm	This is the integrated alarm signal

3.3.2 67P Protection Principle

Each stage of the protection function can be enabled or disabled by setting the corresponding 67P_Ena parameter values as "1" or "0".

The operation of directional overcurrent protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

- **PTS Alarm Blocking of 67P**

The PTS alarm can be set by PTS_Block setting, if PTS_Block=1 and the PTS Alm signal is 1, the 67P function will be blocked, including the startup, trip and the timer will be reset; when if PTS_Block=0 and the PTS Alm signal is 1, the VCE element and the Direction function will be invalid, the 67P function will become the non directional overcurrent.

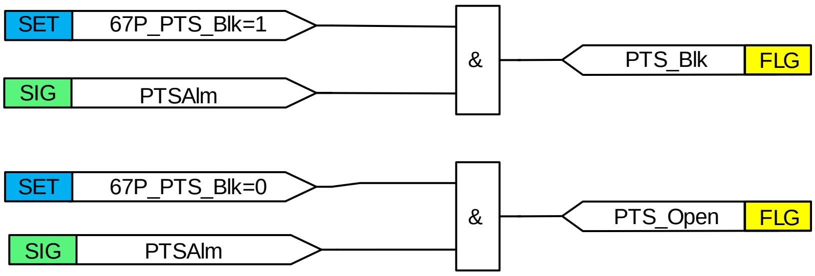


Figure 3.3-2 PTS Alarm Open and Block Condition

- **Voltage Control Element (VCE) of 67P**

In this part of 67P, the Voltage Control Element determines the phase-to-phase voltage or negative sequence voltage, when any phase phase-to-phase voltage is less than the setting value of low voltage or the negative sequence voltage is greater than the setting value of negative sequence voltage. Then the 67P VCE condition is fulfilled.

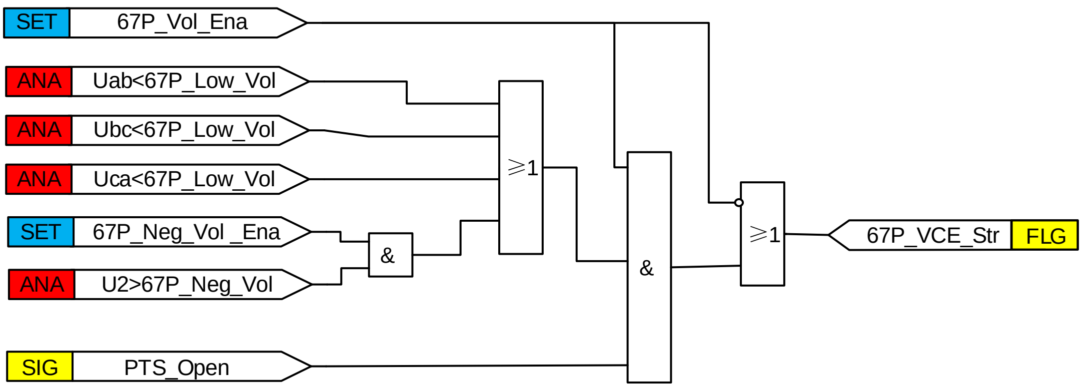


Figure 3.3-3 The Initiation Logic Diagram VCE Start

- **Directional element**

The directional logic diagram of the protection is as below.

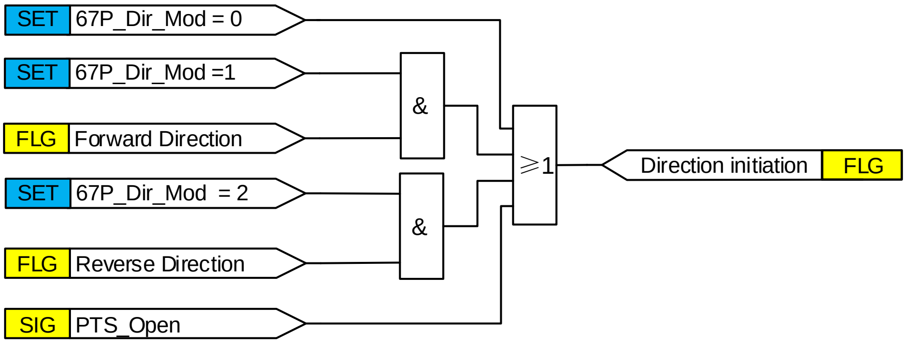


Figure 3.3-4 The directional logic diagram

The directional mode can be selected with the 67P_Dir_Mod setting. The user can select either "(Non-Dir)", "(Forward)" or "(Reverse)" mode. By setting the value of 67P_Dir_Mod to "0", the non-directional operation is allowed when the directional information is invalid.

Where:

67P_Dir_Mod is a direction mode setting for 67P.

The 67P_RCA setting is used to turn the directional characteristic. The value of 67P_RCA should be chosen in such a way that all the faults in the operating direction are seen in the operating zone and all the faults in the opposite direction are seen in the non-operating zone. The value of characteristic angle depends on the network configuration.

The cross-polarizing quantity is used to determine the fault direction(Ia→Ubc/Ib→Uca/Ic→Uab). The evaluation of the forward directionality is according to the equation:

$$-90^\circ(+5^\circ) < \arg\frac{\dot{I}_r}{\dot{U}_r}e^{j(RCA-90^\circ)} < 90^\circ(-5^\circ)$$

$$\text{or}\quad -90^\circ(+5^\circ) < \arg\frac{\dot{U}_r}{\dot{I}_r}e^{j(90^\circ-RCA)} < 90^\circ(-5^\circ)$$

Also, it can be calculated by following equation:

-90° (+5°)< angle(Ir) + RCA - 90° - angle(Ur)< 90° (-5°)

or -90° (+5°)< angle(Ur) +90° - RCA - angle(Ir)< 90° (-5°)

The evaluation of the backward directionality is according to the equation:

$$90^\circ(+5^\circ) < \arg\frac{\dot{I}_r}{\dot{U}_r}e^{j(RCA-90^\circ)} < 270^\circ(-5^\circ)$$

$$\text{or } 90^{o}(+5^{o}) < \arg\frac{\dot{U}_r}{\dot{I}_r}e^{j(90^{o}-RCA)} < 270^{o}(-5^{o})$$

Also, it can be calculated by following equation:

90°(+5°)< angle(Ir) + RCA - 90° - angle(Ur)< 270°(-5°)

or 90°(+5°)< angle(Ur) +90° - RCA - angle(Ir)< 270°(-5°)

$\pm 5^{o}$ is the max angle margin. I_r and U_r are the polarizing current and voltage. RCA is the relay characteristic angle.

The operating area and non-operating area can be described in the follow figure.

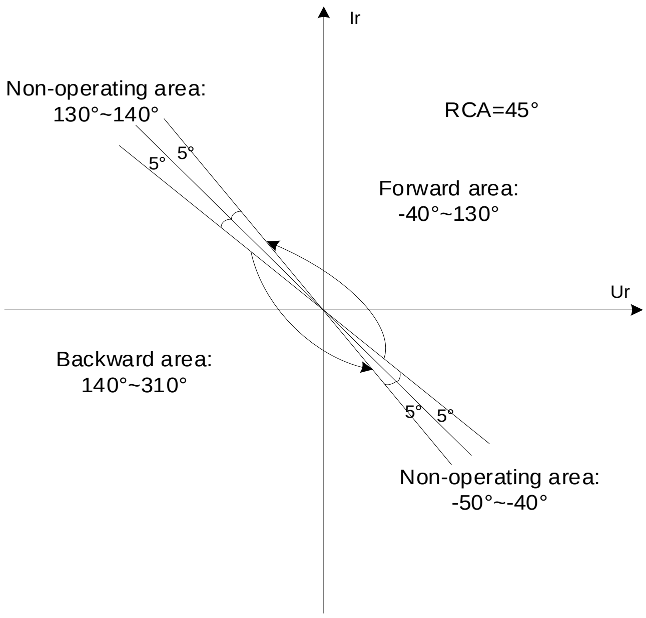


Figure 3.3-5 The operating area and non-operating area

- **Initiation logic**

The initiation logic diagram of the protection is as below:

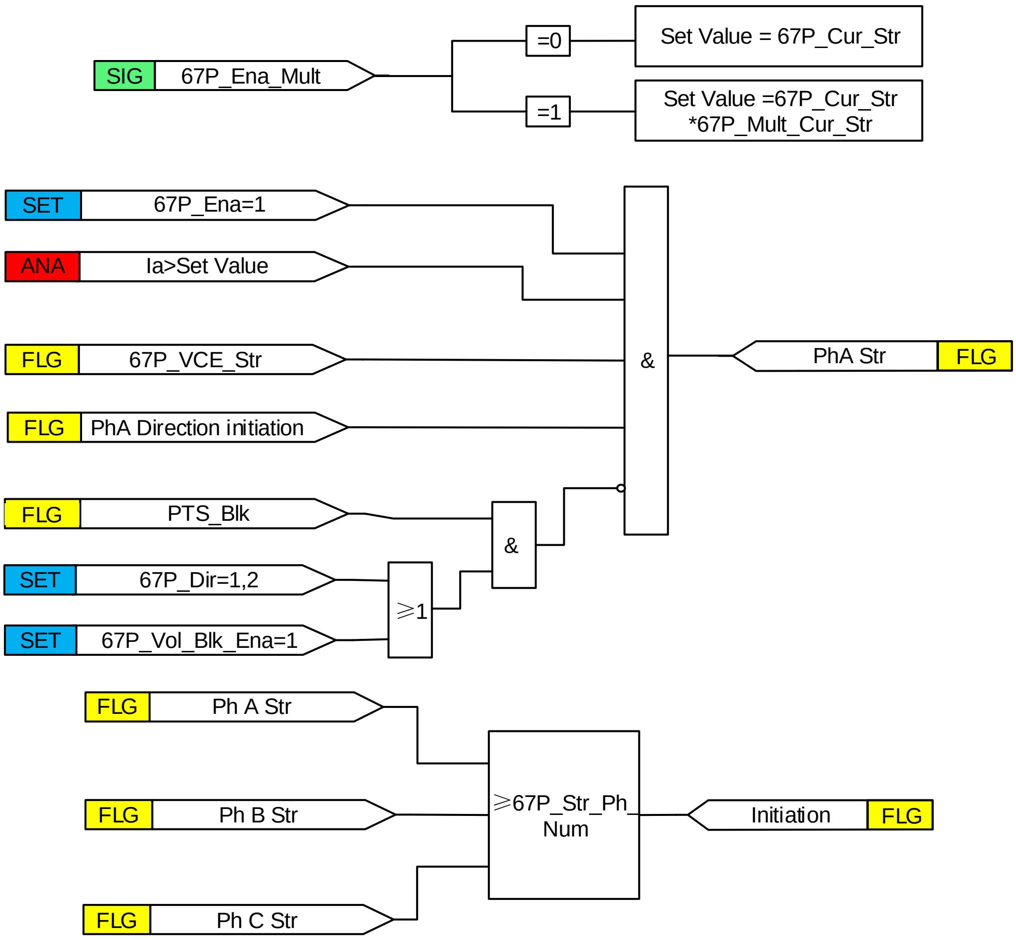


Figure 3.3-6 The initiation logic diagram

The measured phase currents are compared phase wise to the set 67P_Cur_Str. If the measured value exceeds the set 67P_Cur_Str the level detector reports the exceeding of the value to the phase selection logic. If the 67P_EnaMultCur input is active, the 67P_Cur_Str setting is multiplied by the 67P_Mul_Cur_Str setting.

The start value multiplication is normally used in case that the inrush situation happens.

NOTICE!

Do not set the multiplier setting 67P_Mul_Cur_Str higher than necessary. If the value is too high, the function may not operate at all during an inrush followed by a fault, no matter how severe the fault is.

The start value multiplication is normally done when the inrush detection function (OCR_INR) is connected to the EnaMultCur input by Three phase inrush function OCR_INR or Machine Startup MST.

If the fault criteria are fulfilled in the current level and the directional calculation, the phase selection detects the phase or phases in which the measured current exceeds the setting. If the phase information is equal to or more than the 67P_Str_Ph_Num setting, the initiation logic output signal is activated.

67P_Str_Ph_Num shows the number of phases required for operate activation.

➢ **Timer element**

The functional module diagram is shown as below:

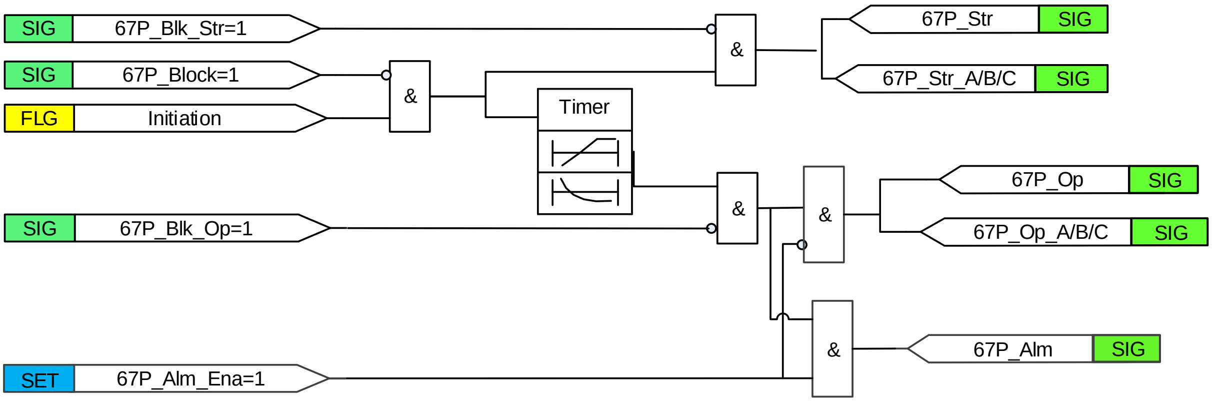


Figure 3.3-7 Functional module diagram

Once initiation logic is fulfilled and no 67P_Block signal is activated, the 67P_Str signal is set. The 67P_StrA, 67P_StrB and 67P_StrC outputs are used to indicate which phases are started.

The timer mode is determined by IDMT curves for over quantity protection.

The operation is activated after the operation timer has reached the calculated value. However, 67P_Min_Op_T defines the minimum desired operate time for IDMT. If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the operation will reset after the set value 67P_Reset_T is exceeded.

NOTICE!

The 67P_Min_Op_T setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the 67P_Min_Op_T setting.

67P can be blocked from 67P_Block. The activation of 67P_Block input deactivates all outputs and resets internal timers.

- The start signals from the function can be blocked from the binary input 67P_BlkStr.
- The operation signals from the function can be blocked from the binary input 67P_BlkOp.

3.3.3 67P Application Scope

67P is used as short-circuit protection in three-phase distribution or sub transmission networks operating at 50 or 60 Hz. In radial networks, phase overcurrent IEDs are often sufficient for the short circuit protection of lines, transformers and other equipment.

The phase overcurrent protection can also be used in closed ring systems as short circuit protection. This can be done in the closed ring networks and radial networks with the generation connected to the remote end in the system thus giving fault current infeed in reverse direction.

Directional overcurrent IEDs are also used to have a selective protection scheme. In ring connected supply feeders between substations or feeders with two feeding sources, 67P is also used.

3.3.4 67P Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.3-3 OC_VEC settings

No.	Name	Range	Unit	Step	Default	Description
1.	OC_Vol_Blk	10-120	V	0.01	100	Setting of blocking voltage
2.	OC_NegVol_Blk	2-70	V	0.01	57	Setting of Negative voltage
3.	OC_NegVol_Ena	0-1	-	1	0	Operation setting of Negative voltage Enable/Disable

Table 3.3-4 67P settings

No.	Name	Range	Unit	Step	Default	Description
1.	67Pi_Dir_Mod	0-2	-	1	0	Directional mode:0-2 for "Non-directional", "Forward" or "Reverse"
2.	67Pi_Cur_Str	0.04-20.00In	A	0.01In	0.04In	The Stage i Start current value
3.	67Pi_RCA	0-360	°	1	45	The Stage i Characteristic angle
4.	67Pi_Mul_Cur	0.8-10.0	-	0.1	1	The Stage i Multiplier for scaling the start current value
5.	67Pi_Mul_Cur2	20-40.0	-	0.1	30	It used to IDMT with I=Mul_Cur2*Ip, when I> Mul_Cur2*Ip, the IDMT time delay is calculated by Mul_Cur2. It is invalid if it is not configured or the Mul_Cur_Ena2 is disable.
6.	67Pi_Mul_Cur_Ena2	0-1	-	1	0	The Mul_Cur2 Enable/Disable: Enable: Mul_Cur2 is effective Disable: Mul_Cur2 is ineffective.
7.	67Pi_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
8.	67Pi_Curve_ParaA	0.000-120.000	s	0.001	0	The Stage i Curve parameter A
9.	67Pi_Curve_ParaB	0.000-9.000	s	0.001	0.2	The Stage i Curve parameter B
10.	67Pi_Curve_ParaC	0.0-1.0	-	0.1	1.0	The Stage i Curve parameter C
11.	67Pi_Curve_ParaP	0.02-2.00	-	0.01	2.00	The Stage i Curve parameter P
12.	67Pi_Curve_ParaK	0.05-100	-	0.01	1.00	The Stage i Curve parameter K
13.	67Pi_Min_Op_T	0.005-60.000	s	0.001	0.005	The Stage i minimum operating time
14.	67Pi_Reset_T	0.000 -60.000	s	0.001	0.02	The Stage i Reset time delay
15.	67Pi_Ena	0-1	-	1	0	The Stage i Protection enable/disable

No.	Name	Range	Unit	Step	Default	Description
16.	67Pi_Vol_Blk_Ena	0-1	-	1	0	The Stage i Voltage setting enable/disable
17.	67Pi_AlmEna	0-1	-	1	0	The Stage i Alarm Enable/Disable
18.	67Pi_Str_Ph_Num	1-3	-	1	1	The Stage i Number of phases required for operate activation: 1: 1 out of 3; 2: 2 out of 3; 3: 3 out of 3
19.	67Pi_PTBlkEna	0-1	-	1	0	The Stage i Protection PTS Alm Block enable/disable: 0: Open 67Pi VCE and Dir function, the Protection become 51Pi. 1: Block 67Pi, then the 51PVTi should be enabled

3.4 Non-directional earth-fault protection 50/51G

3.4.1 50/51G Overview

This relay provides three types of non-directional earth-fault overcurrent (EF) protection, including instantaneous stage (50G), time delay stage (51G) and Time delay stage with VTS (51GVT). The 50G is with dependent definite time (DT), the 51G and 51GVT contain dependent definite time (DT) and inverse definite minimum time (IDMT) characteristics. The stages of EF can be configured by application, the 50G is up to three stages (the default is one), the 51G is three stages, the 51GVT is one stage. Each stage can be enabled or disabled independently by the logic settings respectively. The zero sequence current for tripping can be calculated or directly derived from a zero sequence current transformer.

Table 3.4-1 Function Description and ANSI

Function description	ANSI
Non-directional earth-fault overcurrent protection - Instantaneous stage	50G
Non-directional earth-fault overcurrent protection - Time delay stage	51G
Non-directional earth-fault overcurrent protection - Time delay stage with VTS	51GVT

3.4.1.1 Function Block

The function block of the protection is as below.

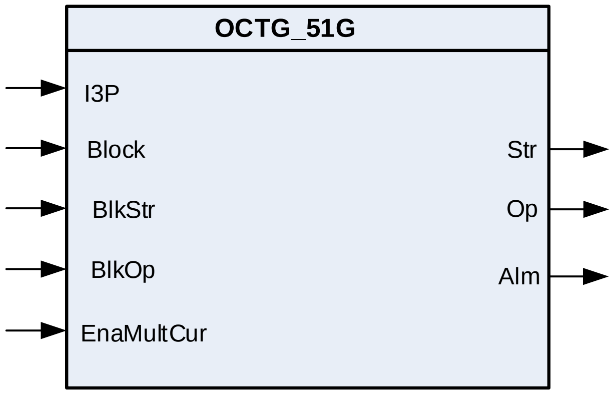


Figure 3.4-1 Function block

3.4.1.2 Signals

Table 3.4-2 Input Signals

Signal	Description
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.
EnaMultCur	This signal enables the current multiplier.

Table 3.4-3 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.
Alm	This is the integrated alarm signal

3.4.2 50/51G Protection Principle

3.4.2.1 51G

The earth-fault protection function can be enabled or disabled by setting the corresponding 51G_Ena parameter values as "1" or "0".

The residual current sample method is determined by 51G_3I0_Calc_Ena, if 51G1_3I0_Calc_Ena=0, the current is sample from external terminal, if 51G1_3I0_Calc_Ena=1, the current is calculated by three phases current.

The operation of non-directional earth-fault protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

➢ **Initiation element**

The initiation logic diagram is shown as below:

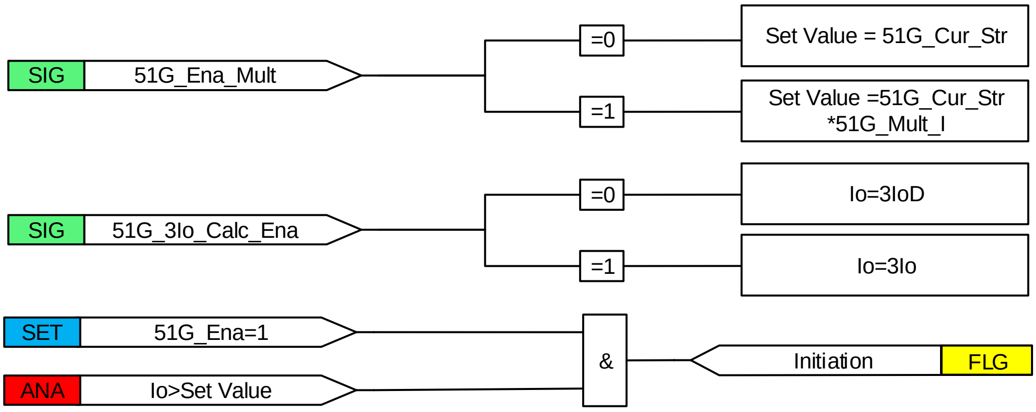


Figure 3.4-2 Initiation logic diagram for 51G

If the 51G_3Io_Calc_Ena input is active, the internally calculated residual current is configured to be available for the protection function it will be used as operating quantity. Otherwise the measured residual current is used. The operating quantity is compared to the set 51G_Cur_Str. If the measured value exceeds the set 51G_Cur_Str, the level detector sends an Initiation signal to the timer module.

The 51G_Cur_Str setting is multiplied by the 51G_Mul_Cur setting.

Where:

51G_Cur_Str is the start value of 51G.

51G_Mul_Cur is the multiplier for scaling the start value.

NOTICE!

Do not set the multiplier setting 51G_Mul_Cur higher than necessary. If the value is too high, the function may not operate at all during an inrush followed by a fault, no matter how severe the fault is.

The start value multiplication is normally done when the inrush detection function (OCR_INR) is connected to the EnaMultCur input by Three phase inrush function OCR_INR.

- **Timer element**

The functional module diagram is shown as below:

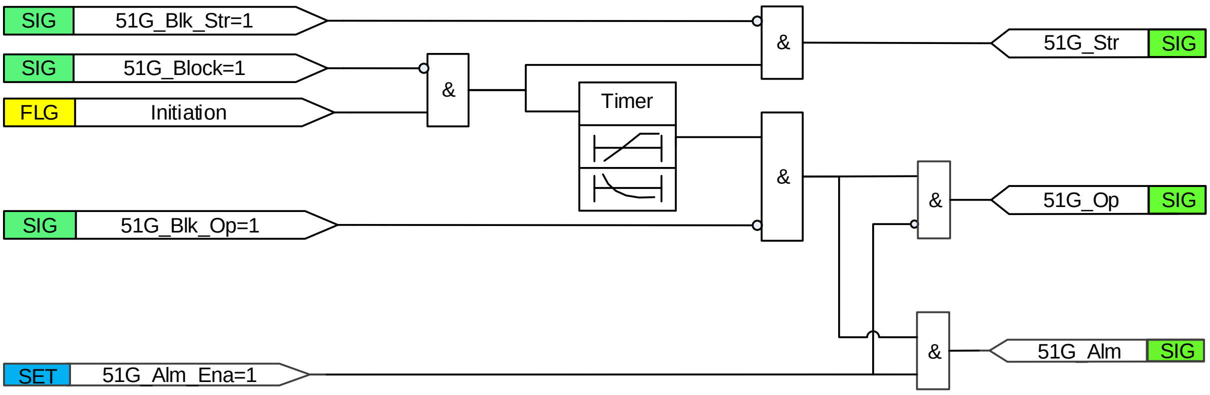


Figure 3.4-3 Functional module diagram for 51G.

Once initiation logic is fulfilled and no 51G_Block signal is activated, the 51G_Str signal is activated.

The timer model is determined by IDMT curves for over quantity protection.

The operation is activated after the operation timer has reached the calculated value. However, 51G_Min_Op_T defines the minimum desired operate time for IDMT. If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the operation will reset after the set value 51G_Reset_T is exceeded.

NOTICE!

The 51G_Min_Op_T setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the 51G_Min_Op_T setting.

The binary input 51G_Block can be used to block the function. The activation of the 51G_Block input deactivates all outputs and resets internal timers. The binary input 51G_BlkStr can be used to block the 51G_Str signals. The binary input 51G_BlkOp can be used to block the 51G_Op signals.

3.4.2.2 50G

The principle is same as the 51G except 50G time delay is instantaneous.

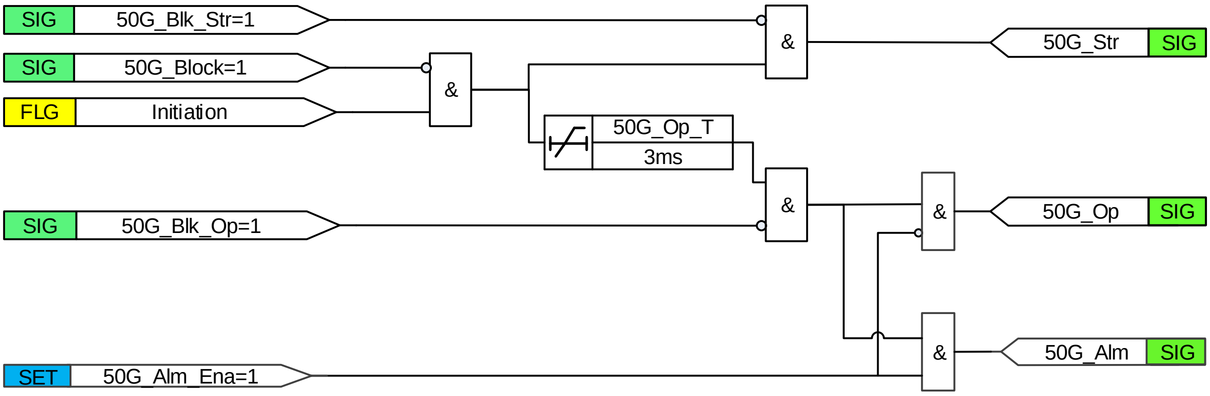


Figure 3.4-4 Functional module diagram for 50G

3.4.2.3 51GVT

The principle is same as the 51G except 51GTV is just only enabled when VTS alarm.

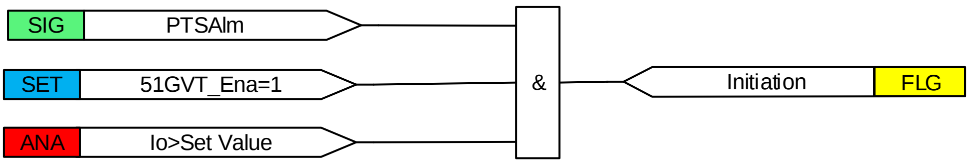


Figure 3.4-5 The Initiation logic diagram for 51GVT

3.4.3 50/51G Application Scope

50/51G is designed for protection and clearance of earth faults in distribution and sub-transmission networks, especially when the neutral point is isolated or earthed via a resonance coil or through low resistance. It also applies to solidly earthed networks and earth-fault protection of different equipment connected to the power systems, such as shunt capacitor bank or shunt reactors and for backup earth-fault protection of power transformers.

3.4.4 50/51G Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.4-4 50G settings

No.	Name	Range	Unit	Step	Default	Description
1	50Gi_Cur_Str	0.04-20.00In	A	0.01In	0.04In	The Stage i Start value
2	50Gi_Mul_Cur	0.8-10.0	-	0.1	1	The Stage i Multiplier for scaling the start value
3	50Gi_Op_T	0.0-120.000	s	0.001	0.000	The Stage i Operating time
4	50Gi_Ena	0-1	-	1	0	The Stage i Operation Enable/Disable
5	50Gi_AlmEna	0-1	-	1	0	The Stage i Alarm Enable/Disable
6	50Gi_3Io_Calc_Ena	0-1	-	1	0	The Stage i measured residual current/calculated residual current

Table 3.4-5 51G settings

No.	Name	Range	Unit	Step	Default	Description
1.	51Gi_Cur_Str	0.04-20.00In	A	0.01In	0.04In	The Stage i Start value
2.	51Gi_Mul_Cur	0.8-10.0	-	0.1	1	The Stage i Multiplier for scaling the start value
3.	51Gi_Mul_Cur2	20-40.0	-	0.1	30	It used to IDMT with I=Mul_Cur2*Ip, when I> Mul_Cur2*Ip, the IDMT time delay is calculated by Mul_Cur2. It is invalid if it is not configured or the Mul_Cur_Ena2 is disable.
4.	51Gi_Mul_Cur_Ena2	0-1	-	1	0	The Mul_Cur2 Enable/Disable: Enable: Mul_Cur2 is effective Disable: Mul_Cur2 is ineffective.
5.	51Gi_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
6.	51Gi_Curve_ParaA	0.000-120.000	s	0.001	0	The Stage i Curve parameter A
7.	51Gi_Curve_ParaB	0.000-9.000	s	0.001	0.2	The Stage i Curve parameter B
8.	51Gi_Curve_ParaC	0.0-1.0	-	0.1	1.0	The Stage i Curve parameter C
9.	51Gi_Curve_ParaP	0.02-2.00	-	0.01	2.00	The Stage i Curve parameter P
10.	51Gi_Curve_ParaK	0.05-100	-	0.01	1.00	The Stage i Curve parameter K
11.	51Gi_Min_Op_T	0.005-60.000	s	0.001	0.005	The Stage i Minimum Operating time for IDMT
12.	51Gi_Reset_T	0.000 -60.000	s	0.001	0.02	The Stage i Reset delay time
13.	51Gi_Ena	0-1	-	1	0	The Stage i Operation Enable/Disable
14.	51Gi_AlmEna	0-1	-	1	0	The Stage i Alarm Enable/Disable
15.	51Gi_3I0_Calc_Ena	0-1	-	1	0	The Stage i measured residual current/calculated residual current

Table 3.4-6 51GVT settings

No.	Name	Range	Unit	Step	Default	Description
1.	51GVTi_Cur_Str	0.04-20.00In	A	0.01In	0.04In	The Stage i Start value
2.	51GVTi_Mul_Cur	0.8-10.0	-	0.1	1	The Stage i Multiplier for scaling the start value
3.	51GVTi_Mul_Cur2	20-40.0	-	0.1	30	It used to IDMT with I=Mul_Cur2*Ip, when I> Mul_Cur2*Ip, the IDMT time delay is calculated by Mul_Cur2. It is invalid if it is not configured or the Mul_Cur_Ena2 is disable.
4.	51GVTi_Mul_Cur_Ena2	0-1	-	1	0	The Mul_Cur2 Enable/Disable: Enable: Mul_Cur2 is effective Disable: Mul_Cur2 is ineffective.
5.	51GVTi_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
6.	51GVTi_Curve_ParaA	0.000-120.000	s	0.001	0	The Stage i Curve parameter A
7.	51GVTi_Curve_ParaB	0.000-9.000	s	0.001	0.2	The Stage i Curve parameter B
8.	51GVTi_Curve_ParaC	0.0-1.0	-	0.1	1.0	The Stage i Curve parameter C
9.	51GVTi_Curve_ParaP	0.02-2.00	-	0.01	2.00	The Stage i Curve parameter P
10.	51GVTi_Curve_ParaK	0.05-100	-	0.01	1.00	The Stage i Curve parameter K
11.	51GVTi_Min_Op_T	0.005-60.000	s	0.001	0.005	The Stage i Minimum Operating time for IDMT
12.	51GVTi_Reset_T	0.000 -60.000	s	0.001	0.02	The Stage i Reset delay time
13.	51GVTi_Ena	0-1	-	1	0	The Stage i Operation Enable/Disable
14.	51GVTi_AlmEna	0-1	-	1	0	The Stage i Alarm Enable/Disable
15.	51GVTi_3I0_Calc_Ena	0-1	-	1	0	The Stage i measured residual current/calculated residual current

3.5 Directional earth-fault protection 67G

3.5.1 67G Overview

This relay provides four stages of directional earth-fault overcurrent protections with independent definite time and inverse definite minimum time characteristics. Each stage can be enabled or disabled independently by the corresponding logic setting respectively.

When this relay is used in small resistance grounding system, the grounding zero sequence current during earth fault is larger and can be used for tripping directly. All stages are equipped for the zero sequence overcurrent protection. In this case, the zero sequence current for tripping can be calculated or directly derived from a zero sequence current transformer.

3.5.1.1 Function Block

The function block of the protection is as below.

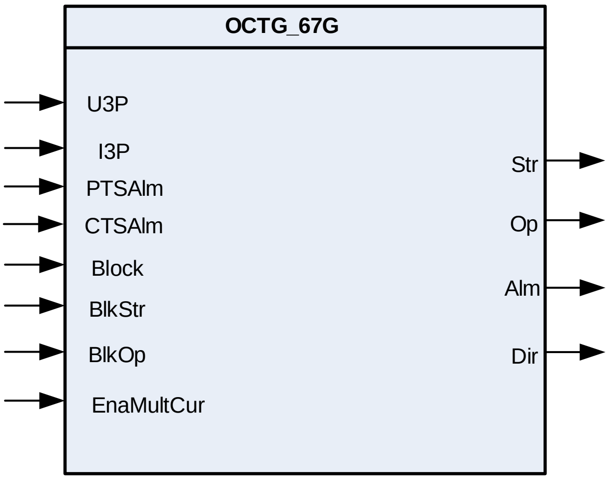


Figure 3.5-1 Function block

3.5.1.2 Signals

Table 3.5-1 Input Signals

Signal	Description
U3P	The voltage in all the three phases
I3P	The current magnitude in all the three phases
PTSAlm	The PTS alarm block directional OC
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.
EnaMultCur	This signal enables the current multiplier.

Table 3.5-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.
Alm	This is the integrated alarm signal

3.5.2 67G Protection Principle

The directional earth-fault protection function can be enabled or disabled by setting the corresponding 67G_Ena parameter values as "1" or "0".

The operation of directional earth-fault protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

➢ **PTS Alarm Blocking of 67G**

The PTS alarm can be set by PTS_Block setting, if PTS_Blk=1 and the PTS Alm signal is 1, the 67G function will be blocked, including the startup, trip and the timer will be reset; when if PTS_Blk=0 and the PTS Alm signal is 1, the VCE element and the Direction function will be invalid, the 67G function will become the non directional earth fault.

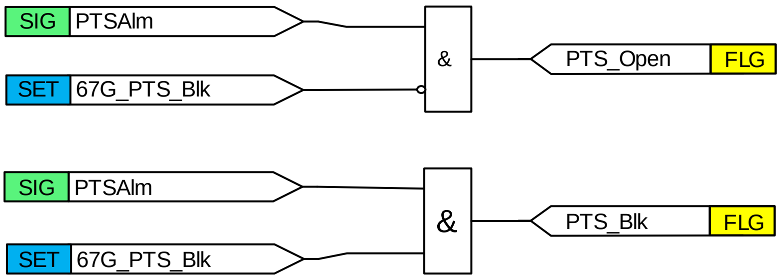


Figure 3.5-2 PTS Alarm Open and Block Condition

➢ **Directional element**

The directional logic diagram of the protection is as below.

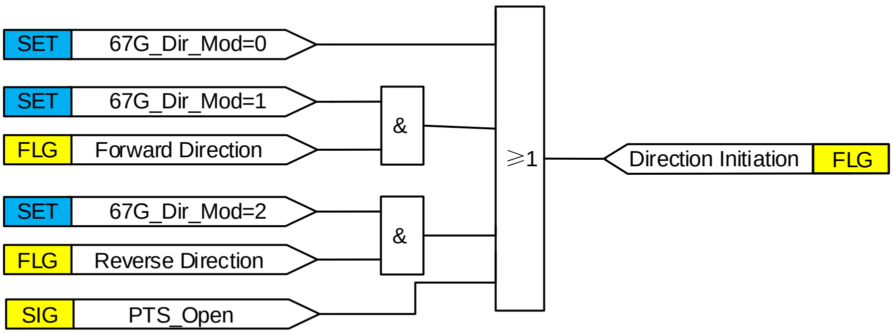


Figure 3.5-3 The directional logic diagram

Self-polarizing is used (I_0-(-U_0)) to determine the fault direction.

The evaluation of the forward directionality is according to the equation:

$$-90^{\circ}(+5^{\circ}) < \arg\frac{\dot{I}_o e^{jRCA}}{-\dot{U}_o} < 90^{\circ}(-5^{\circ})$$

Also, it can be calculated by following equation:

-90° (+5°)< angle(Io) + RCA - angle(Uo) -180° < 90° (-5°)

The evaluation of the backward directionality is according to the equation:

$$90^{\circ}(+5^{\circ}) < \arg\frac{\dot{I}_o e^{jRCA}}{-\dot{U}_o} < 270^{\circ}(-5^{\circ})$$

Also, it can be calculated by following equation:

90° (+5°)< angle(Io) + RCA - angle(Uo) -180° < 270° (-5°)

$\pm 5^{o}$ is the max angle margin, I_0 and U_0 are the current and voltage of the Self-polarizing. RCA is the Relay characteristic angle, which is used to turn the direction element to best comply with the fault situation.

The operating area and non-operating area can be described in following figure.

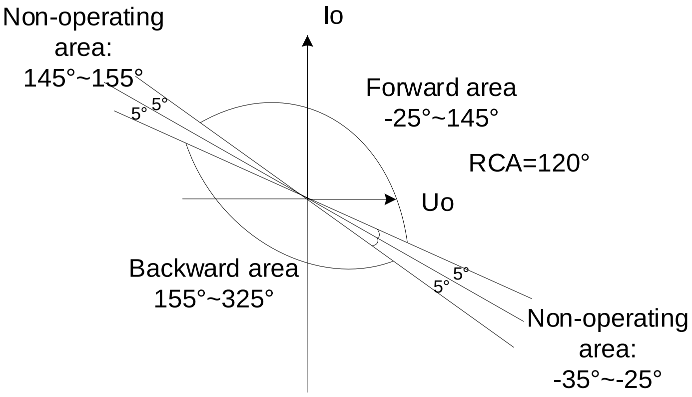


Figure 3.5-4 The operating area and non-operating area

The directionality of the operation can be selected with the 67G_Dir_Mod setting. The user can select either "Non-directional", "Forward" or "Reverse" operation.

The directionality also can be use in double circuit line by negative current and voltage, it can be enable or disable by setting 67G1_PolU, when 67G1_PolU=1, the condition is following:

Self-polarizing is used (I_2- (-U_2)) to determine the fault direction.

The evaluation of the forward directionality is according to the equation:

$$-90^{\circ}(+5^{\circ}) < \arg\frac{\dot{I}_2 e^{jRCA}}{-\dot{U}_2} < 90^{\circ}(-5^{\circ})$$

Also, it can be calculated by following equation:

-90° (+5°)< angle(I2) + RCA - angle(U2) -180° < 90° (-5°)

The evaluation of the backward directionality is according to the equation:

$$90^{\circ}(+5^{\circ}) < \arg\frac{\dot{I}_2 e^{jRCA}}{-\dot{U}_2} < 270^{\circ}(-5^{\circ})$$

Also, it can be calculated by following equation:

90° (+5°)< angle(I2) + RCA - angle(U2) -180° < 270° (-5°)

The operating area and non-operating area can be described in following figure.

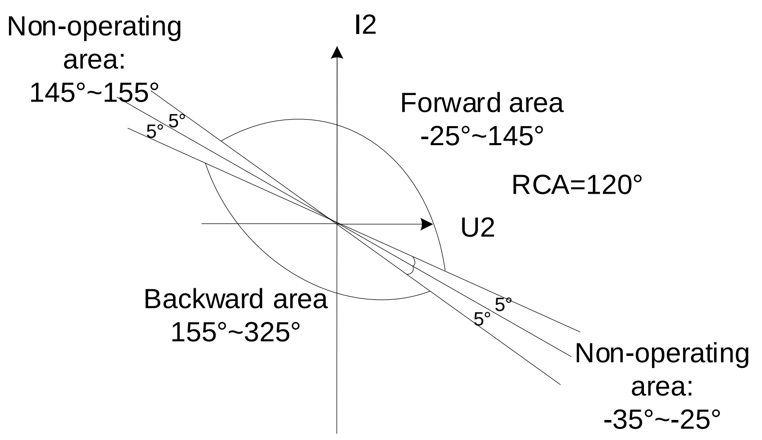


Figure 3.5-5 The operating area and non-operating area

- **Voltage control element**

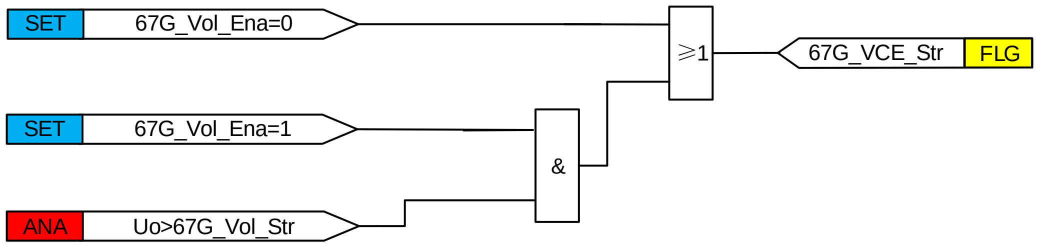
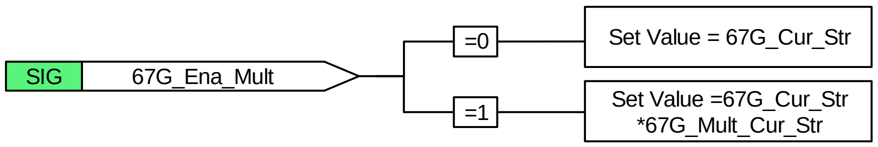


Figure 3.5-6 The voltage control logic diagram

- **Initiation element**

The initiation logic diagram is shown as below:



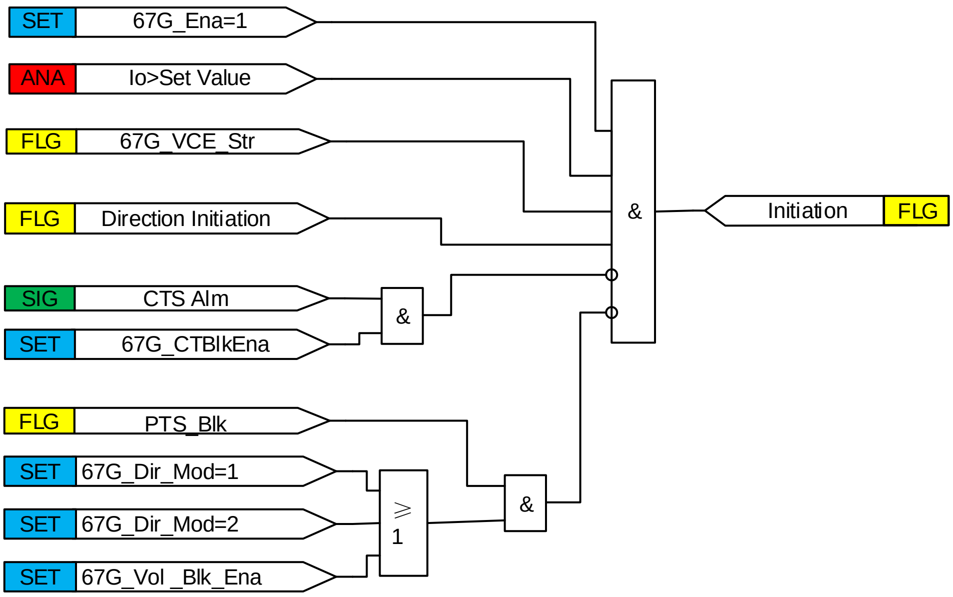


Figure 3.5-7 Initiation logic diagram

The measured zero sequence current is compared phase wise to the set 67G_Cur_Str. If the measured value exceeds the set 67G_Cur_Str, the VCE and directional condition are met, 67G is initiation. If the 67G_EnaMultCur input is active, the 67G_Cur_Str setting is multiplied by the 67G_Mul_Cur_Str setting.

The start value multiplication is normally used in case that the inrush situation happens.

NOTICE!

Do not set the multiplier setting 67G_Mul_Cur_Str higher than necessary. If the value is too high, the function may not operate at all during an inrush followed by a fault, no matter how severe the fault is.

The start value multiplication is normally done when the inrush detection function (OCR_INR) is connected to the EnaMultCur input by Three phase inrush function OCR_INR.

Where：

67G_Cur_Str is the start value of 67G.
67G_VCE_Str is the voltage start value of 67G.
67G_Vol_Blk_Ena can enable voltage limit.
67G_Mul_Cur_Str is the multiplier for scaling the start value.

➢ **Timer element**

The functional module diagram is shown as below:

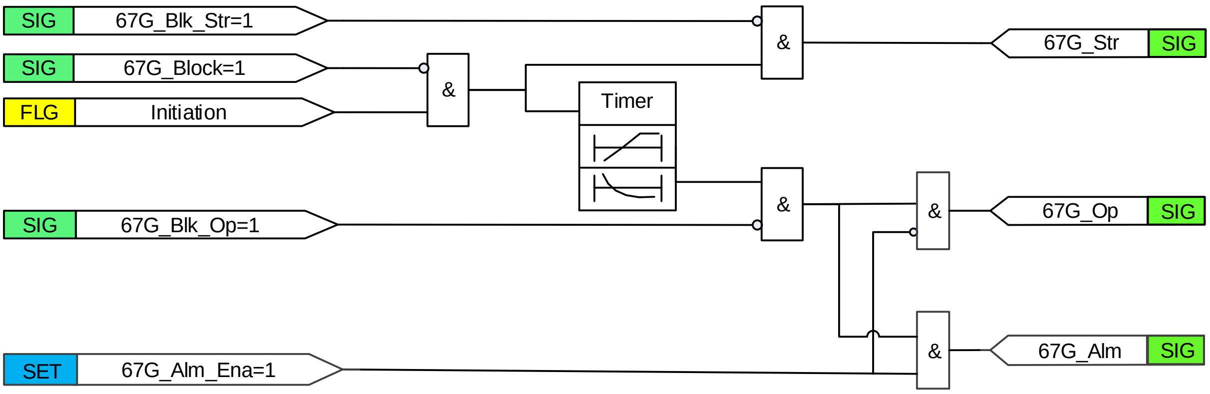


Figure 3.5-8 Functional module diagram

Once initiation logic is fulfilled and no 67G_Block signal is activated, the 67G_Str signal is set.

The timer model is determined by IDMT curves for over quantity protection.

The operation signal is activated after the operation timer has reached the calculated value. However, 67G_Min_Op_T defines the minimum desired operate time for IDMT. If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the operation will reset after the set value 67G_Reset_T is exceeded.

NOTICE!

The 67G_Min_Op_T setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the 67G_Min_Op_T setting.

67G can be blocked from the binary input 67G_Block. Activation of 67G_Block input deactivates all outputs and resets internal timers.

The start signals from the function can be blocked from the binary input 67G_BlkStr.

The operate signals from the function can be blocked from the binary input 67G_BlkOp.

67G_Min_Op_T is the minimum operate time for IDMT curves.

3.5.3 67G Application Scope

The directional earth-fault protection is designed for protection and clearance of earth faults and for earth-fault protection of different equipment connected to the power systems, such as shunt capacitor banks or shunt reactors, and for backup earth-fault protection of power transformers.

3.5.4 67G Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.5-3 67G settings

No.	Name	Range	Unit	Step	Default	Description
1.	67Gi_Dir_Mod	0-2:	-	1	0	The Stage i Directional mode:0-2 for "Non-directional", "Forward" or "Reverse"
2.	67Gi_Cur_Str	0.04-20.00In	A	0.01In	0.04In	The Stage i Current Start value
3.	67Gi_ResVol_Blk	10-100	V	0.01	10	The Stage i Voltage start value
4.	67Gi_RCA	0-360	°	1	120	The Stage i Characteristic angle
5.	67Gi_Mul_Cur	0.8-10.0	-	0.1	1	The Stage i Multiplier current start value
6.	67Gi_Mul_Cur2	20-40.0	-	0.1	30	It used to IDMT with I=Mul_Cur2*Ip, when I> Mul_Cur2*Ip, the IDMT time delay is calculated by Mul_Cur2. It is invalid if it is not configured or the Mul_Cur_Ena2 is disable.
7.	67Gi_Mul_Cur_Ena2	0-1	-	1	0	The Mul_Cur2 Enable/Disable: Enable: Mul_Cur2 is effective Disable: Mul_Cur2 is ineffective.
8.	67Gi_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
9.	67Gi_Curve_ParaA	0.000-120.000	s	0.001	0	The Stage i Curve parameter A
10.	67Gi_Curve_ParaB	0.000-9.000	s	0.001	0.2	The Stage i Curve parameter B
11.	67Gi_Curve_ParaC	0.0-1.0	-	0.1	1.0	The Stage i Curve parameter C
12.	67Gi_Curve_ParaP	0.02-2.00	-	0.01	2.00	The Stage i Curve parameter P
13.	67Gi_Curve_ParaK	0.05-100	-	0.01	1.00	The Stage i Curve parameter K
14.	67Gi_Min_Op_T	0.005-60.000	s	0.001	0.005	The Stage i minimum operation time delay for IDMT
15.	67Gi_Vol _Blk_Ena	0-1	-	1	0	The Stage i Voltage blocking element Enable/Disable
16.	67Gi_Ena	0-1	-	1	0	The Stage i Operation Enable/Disable
17.	67Gi_AlmEna	0-1	-	1	0	The Stage i Alarm Enable/Disable
18.	67Gi_Reset_T	0.000 -60.000	s	0.001	0.02	The Stage i Reset time delay
19.	67Gi_3Io_Calc_Ena	0-1	-	1	0	The Stage i Zero sequence Self Extraction Enable/Disable
20.	67Gi_PTBlkEna	0-1	-	1	0	The Stage i Protection PTS Alm Block enable/disable: 0: Open 67Gi VCE and Dir function, the Protection become 51Gi. 1: Block 67Gi, then the 51GVTi should

No.	Name	Range	Unit	Step	Default	Description
						be enabled
21.	67Gi_CTBlkEna	0-1	-	1	0	The Stage i Protection CTS Alm Block enable/disable
22.	67Gi_PolU	0-1	-	1	0	The Stage i Protection Negative Current Direction Element enable/disable: 0: zero sequence current direction; 1: Negative Current Direction Element

3.6 Switch onto fault SOTF

3.6.1 SOTF Overview

This relay provides one stage of switch onto fault function with a definite time characteristic. It can be enabled or disabled independently by the logic settings respectively.

In some feeder applications, three-pole fast tripping may be required if a fault is present on the feeder when it is energized. Such faults may be due to a fault condition not having been removed from the feeder, or due to earthing clamps having been left on the following maintenance. In either case, it may be desirable to clear the fault condition in an accelerated time, rather than waiting for the time delay associated with overcurrent protection.

Switch onto fault overcurrent protection is equipped in this equipment. Acceleration after tripping includes accelerated tripping for manual switching-onto-fault or automatic reclosing-onto-fault. Current settings and delays of the accelerated tripping protection can be configured independently.

3.6.1.1 Function Block

The function block of the protection is as below.

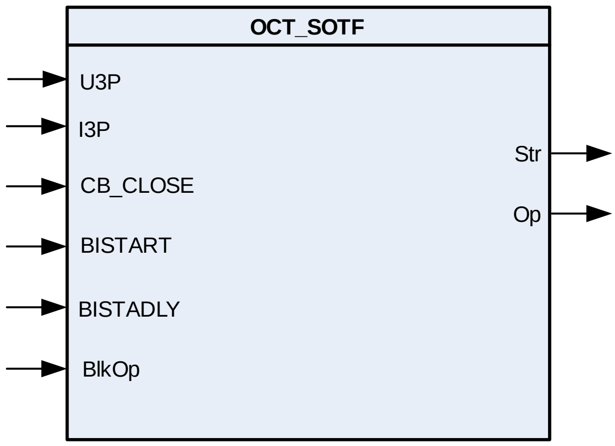


Figure 3.6-1 Function block

3.6.1.2 Signals

Table 3.6-1 Input Signals

Signal	Description
U3P	The voltage in all the three phases
I3P	The current magnitude in all the three phases
BlkOp	This signal blocks all the trip signals of the function.
CB_CLOSE	The CB close signal
BISTART	The BI startup signal to trigger the SOTF
BISTADLY	The BI startup signal with delay to trigger the SOTF

Table 3.6-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.
Alm	This is the integrated alarm signal

3.6.2 SOTF Protection Principle

The automatic switch-onto-fault protection function can be enabled or disabled by setting the corresponding SOTF_Ena parameter values as "1" or "0".

The operation of automatic switch-onto-fault logic can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

➢ **External Start**

This module is used for detecting a possible fault immediately after circuit breaker closing. The use of external protection function (typically the start-signal from a non-directional distance zone or overcurrent stage) is required for fault indication. The SOTF_Str and SOTF_Str_Dly inputs are available for the purpose.

- The SOTF_Str input has no delay. Thus, a switch-onto-fault situation is immediately triggered to SOTF control.
- SOTF_Str_Dly is used when an additional delay is required to start the signal. The switch-onto-fault situation is triggered to the SOTF control after the set SOTF_Str_Dly_T.

The external start logic diagram is shown as below.

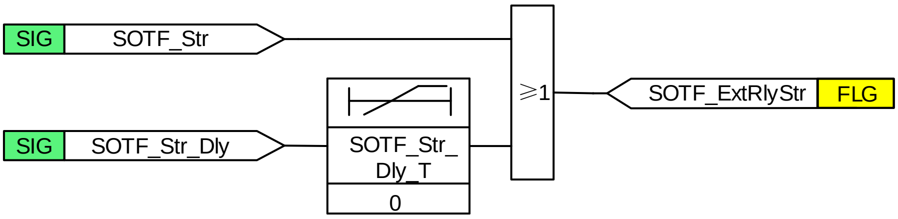


Figure 3.6-2 External start logic diagram

➢ SOTF Initial

The SOTF initial logic diagram is shown as below.

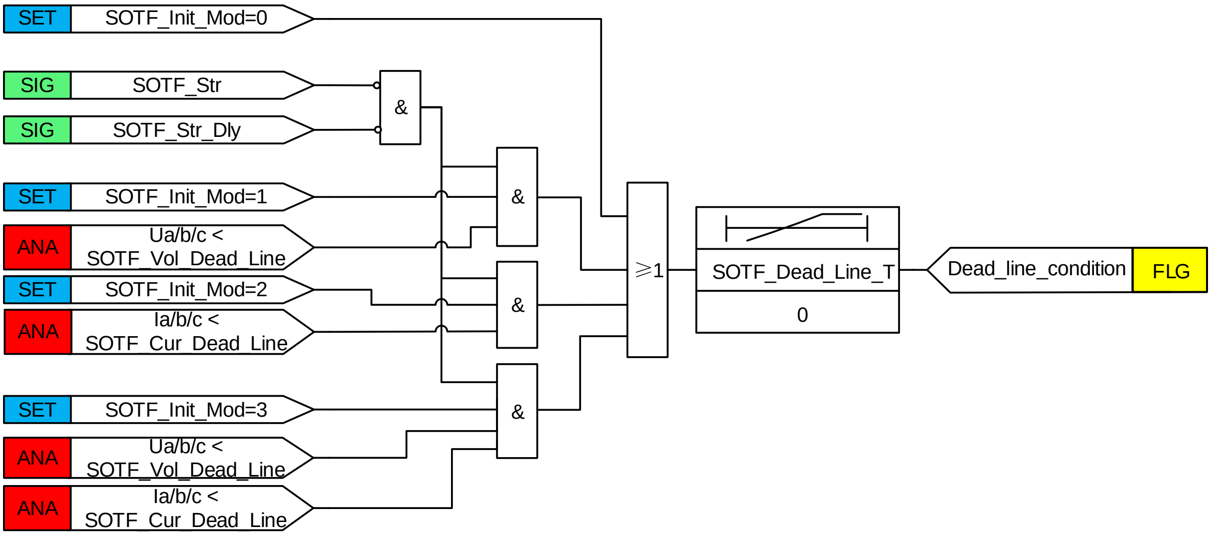


Figure 3.6-3 Dead-line detection logic diagram

The dead-line detection should be used only when the voltage transformers are located on the line side of the circuit breaker.

Where:

The SOTF_Init_Mod setting is used to configure the internal dead-line detection function.

Table 3.6-3 Options for dead-line detection

Value of SOTF_Init_Mod	Description
"0"	The dead-line detection function is disabled. This operation mode must be applied when voltage transformers are located on the bus side of the circuit breaker.
"1"	The dead-line detection function is enabled and based solely on the under voltage condition. A dead-line condition is declared, if all the phase voltages are below the SOTF_Vol_Dead_Line setting. The dead line is detected if the dead-line condition is declared and simultaneously no fault is detected by the SOTF_Str and SOTF_Str_Dly inputs. The dead-line condition is signaled to the SOTF control after the delay defined with the SOTF_Dead_Line_T setting.

Value of SOTF_Init_Mod	Description
“2”	The dead-line detection function is enabled and based solely on the undercurrent condition. A dead-line condition is declared, if all the phase currents are below the SOTF_Cur_Dead_Line setting. The dead line is detected if the dead-line condition is declared and simultaneously no fault is detected by the SOTF_Str and SOTF_Str_Dly inputs. The dead-line condition is signaled to the SOTF control after delay defined with the SOTF_Dead_Line_T setting.
“3”	The dead-line detection function is enabled and based on undercurrent and under voltage condition. A dead line condition is declared, if all the phase currents are below the Current dead Lin Val setting and simultaneously all phase voltages are below the Voltage dead Lin Val setting. The dead line is detected if the dead-line condition is declared and simultaneously no fault is detected by the SOTF_Str and SOTF_Str_Dly inputs. The dead-line condition is signaled to the SOTF control after delay defined with the SOTF_Dead_Line_T setting.

- **SOTF detection**

The SOTF detection logic diagram is shown as below:

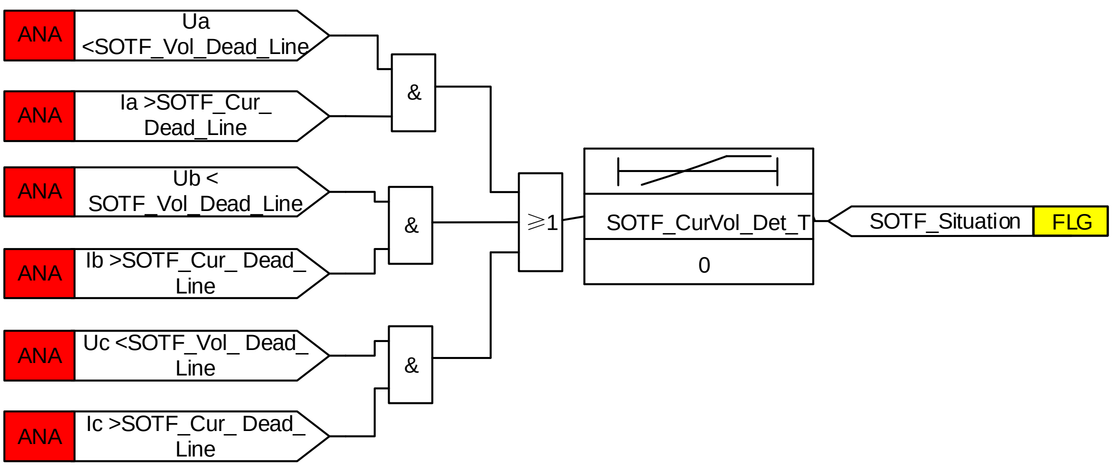


Figure 3.6-4 SOTF detection logic diagram

The purpose of this module is to detect the switch onto fault situation based on the current and voltage measurements. If the voltage, in any of the phases, is below the SOTF_Vol_Dead_Line setting and simultaneously the current in the same phase exceeds the SOTF_Cur_Dead_Line setting, the SOTF situation is signaled to SOTF control module after the set SOTF_CurVol_Det_T.

- **SOTF control**

The SOTF control activated and reset diagram is shown below:

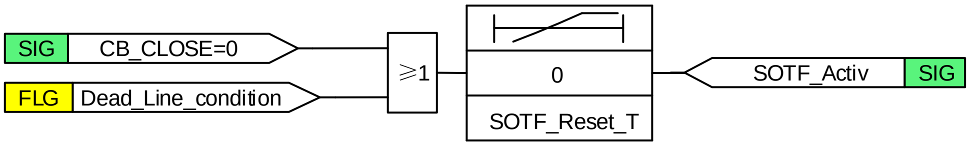


Figure 3.6-5 SOTF control activated and reset

The SOTF control module needs to be activated before the operation is possible in the switch-onto-fault situation. There are two ways to activate the SOTF control module.

• By CB position (circuit breaker is open position, CB_CLOSE=0)

• By the dead-line condition received from the dead-line detection

The dead-line detection should be used only when the voltage transformers are located on the line side of the circuit breaker.

When the CB position is open or the dead-line condition is detected, the SOTF control module becomes active. The reset timer is started when CB position is closed or the dead-line condition disappears. Thus the module becomes inactive after the set SOTF_Reset_T is exceeded.

The functional module diagram is shown as below:

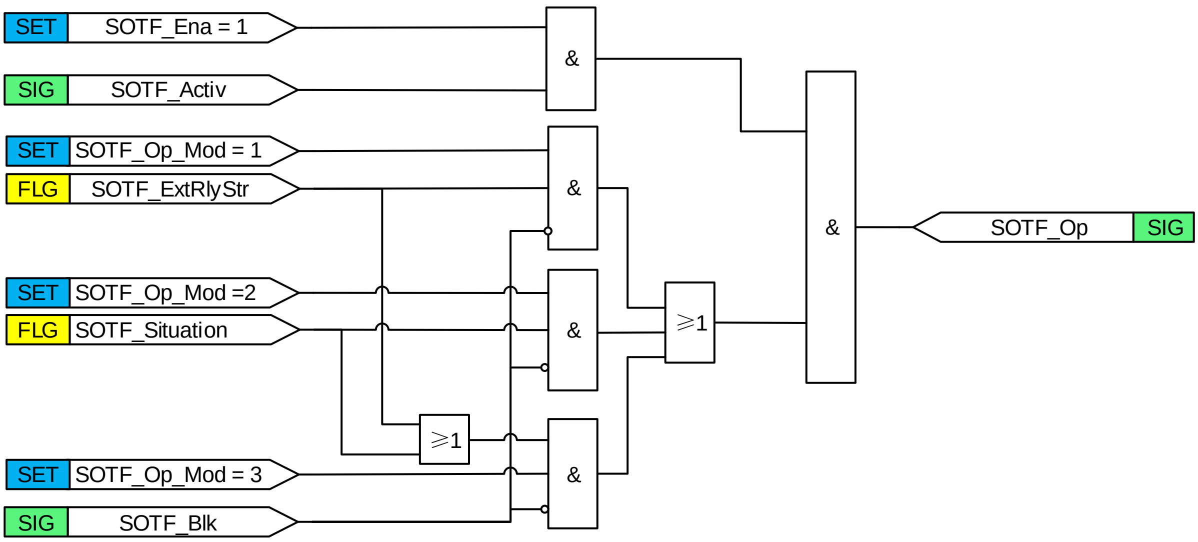


Figure 3.6-6 Functional module diagram

When the SOTF control module is active, the SOTF_Op_Mod setting defines the operation criteria for the detection of a switch-onto-fault condition. The detection can be based on the external start signals from the other protection functions such as distance or overcurrent functions, or on the measured internal voltage and current levels or on both.

The SOTF_Op output can be blocked by activating the SOTF_BlkOp input.

Table 3.6-4 Options for SOTF control

Value of SOTF_Op_Mod	Description
"1"	The operate output is activated immediately after a signal from the trigger module. This indicates that the breaker is closed onto fault.
"2"	The operate output is activated immediately after a signal from the SOTF detection module. This indicates that the breaker is closed onto fault. This operation mode can be used, for example, if the non-directional distance zone is not available.
"3"	The operate output is activated immediately after a signal from the trigger or SOTF detection modules. This indicates that the breaker is closed onto fault.

3.6.3 SOTF Application Scope

The operation of SOTF is generally based on the non-directional distance zone or the non-directional overcurrent stage. Other protection functions, like time delayed zero sequence overcurrent functions, can be connected to SOTF to increase the dependability of the scheme. The other main advantage of using SOTF is that it typically accelerates the tripping in case of energizing a feeder onto a fault. Without SOTF, this tripping is normally performed by the normal time-graded protection or alternatively by the time-delayed local backup protection, for which operate times are considerably longer than with SOTF tripping.

An internal dead-line detection check is provided to activate the function when the voltage transformers are located on the feeder side. An initiation by the dead-line detection is highly recommended for the busbar configurations where more than one circuit breaker at one feeder end can energize the protected feeder or the feeder can also be energized from the other end.

3.6.4 SOTF Settings

Table 3.6-5 SOTF settings

No.	Name	Range	Unit	Step	Default	Description
1	SOTF_Ena	0-1	-	1	0	Operation Enable/Disable
2	SOTF_Op_Mod	1-3: Start Current&Voltage Both	-	1	1	Mode of operation of SOTF Function: 1-3 for External Start Signal Mode, Current&Voltage Mode, and Both
3	SOTF_ Init _Mod	0-3 DLD disabled Voltage Current Current&Voltage	-	1	1	Automatic switch onto fault initialization mode:0-3 for disabled , Voltage, Current, Current&Voltage
4	SOTF_Cur_Dead_Line	0.02In-20In	A	0.01In	0.2In	Dead line Current setting value
5	SOTF_Vol_Dead_Line	30-100	V	1	30	Dead line Voltage setting value
6	SOTF_Dead_Line_T	0.03-60.00s	s	0.01	0.2	time delay for dead line
7	SOTF_CurVol_Det_T	0.03-60.00	s	0.01	0.20	Time delay for voltage and current based detection

No.	Name	Range	Unit	Step	Default	Description
8	SOTF_Ext_Dly_T	0.03-120.00	s	0.01	0.03	SOTF start time delay
9	SOTF_Reset_T	0.00-60.00	s	0.01	0.02	SOTF reset time delay

3.7 Circuit breaker failure protection 50BF

3.7.1 50BF Overview

This relay provides a circuit breaker failure function with a definite time characteristic. The circuit breaker failure protection is specially applied for re-tripping the circuit breaker, when the relay has transmitted the tripping command to the circuit breaker, but the fault is still existed in the system or the circuit breaker is still closed after an appointed time delay.

The breaker failure protection in this relay has four independent definite time delay characteristics, including two stages of its own breaker through both of the tripping coils: one is for repeating tripping, and another is breaker failure tripping; and two stages for tripping logic operation of the electrically-adjacent breakers: one is breaker failure tripping, and another is dead zone tripping.

For some special faults (for example, overvoltage protection operating), maybe the faulty current is very small and the current criterion of the breaker failure protection cannot be satisfied, in order to ensure the breaker failure protection can operate in such a situation, the auxiliary contact of the circuit breaker can be taken into account.

3.7.1.1 Function Block

The function block of the protection is as below.

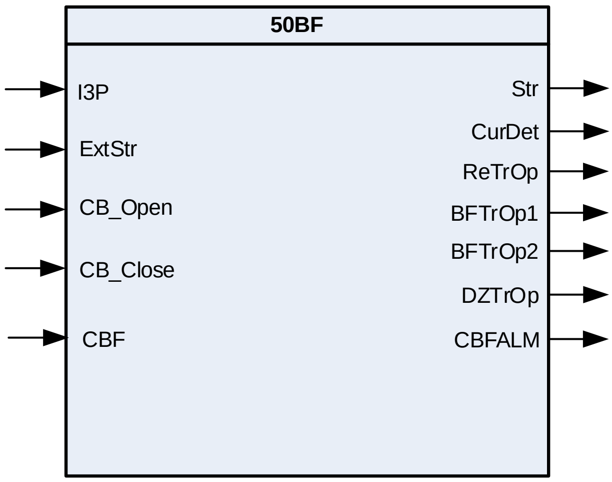


Figure 3.7-1 Function block

3.7.1.2 Signals

Table 3.7-1 Input Signals

Signal	Description
I3P	The current magnitude in all the three phases
ExtStr	The external 50BF start command
Block	The block signal of function
CB_Open	The CB open signal
CB_Close	The CB close signal
CBF	The BI signal that CB is faulty and unable to trip by external checked

Table 3.7-2 Output Signals

Signal	Description
Str	This is the integrated start signal
CurDet	The current detector condition
ReTrOp	The retrip command of the CB.
BFTrOp1	The BF trip command of the CB
BFTrOp2	The BF trip command of the backup CB
DZTrOp	The Dead zone trip command of the backup CB
CBF ALM	The CB FAULT ALM output

3.7.2 50BF Protection Principle

The breaker failure protection function can be enabled or disabled by setting the corresponding 50BF_Ena parameter values as "1" or "0".

The operation of the breaker failure protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

3.7.2.1 Enable element

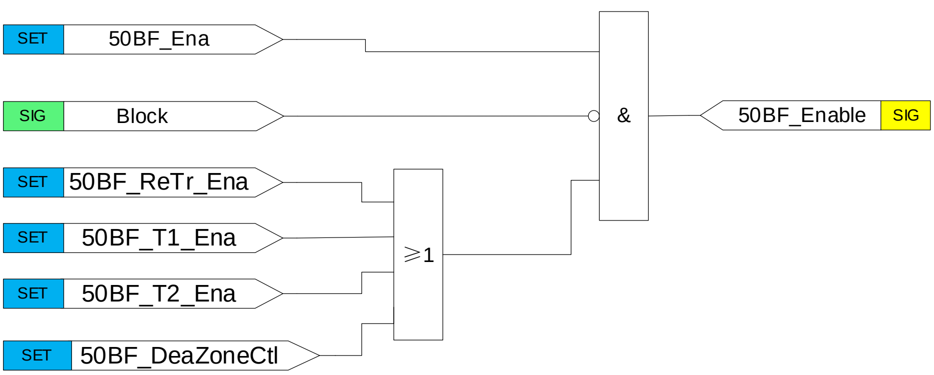


Figure 3.7-2 50BF Enable logic

3.7.2.2 Start element

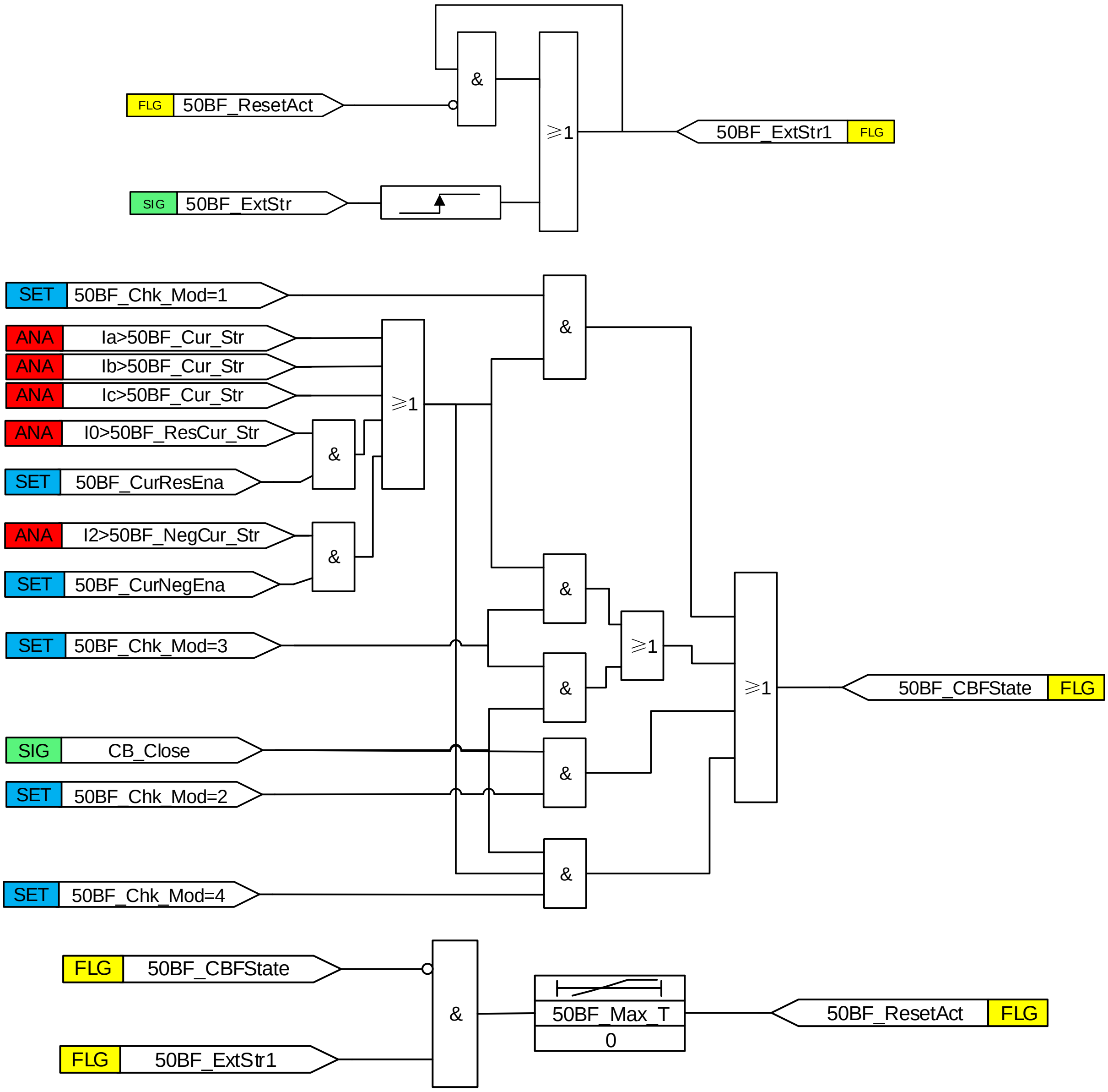


Figure 3.7-3 50BF Startup Logic

There are 4 check modes for circuit breaker failure protection, as shown in the following table.

Table 3.7-3 Options for check mode

Value of 50BF_Chk_Mod	Description
1	Current check
2	CB status check
3	Current or CB status check
4	Current and CB status check

If the 50BF_Chk_Mod value is 1, the Start logic is activated when the current criteria are fulfilled and the start input signal is set. If the measured phase current or the measured residual current or negative current exceeds the 50BF_Cur_Str and 50BF_ResCur_Str settings and

50BF_NegCur_Str, the level detector reports the exceeding of the value to the Start logic. The residual current or negative current check can be enabled separately.

If the 50BF_Chk_Mod value is 2, the Start logic is activated when the CB position is closed and the start input signal is set.

If the 50BF_Chk_Mod value is 3, the Start logic is activated when the current criteria or CB position are fulfilled and the start input signal is set.

If the 50BF_Chk_Mod value is 4, the Start logic is activated when the current criteria and CB position are fulfilled and the start input signal is set.

Once the start logic is activated(50BF_ExtStr1=1), 50BF can be reset only after the 50BF_CBF State return and last for 50BF_Max_T, the 50BF_Max_T is the max value of the duration of the 50BF_ReTr_T, 50BF_Op_T1, 50BF_BFTrBu_T and 50BF_Max_T settings, the default value of 50BF_Max_T is 150ms.

3.7.2.3 Retrip CB Logic (Own Breaker)

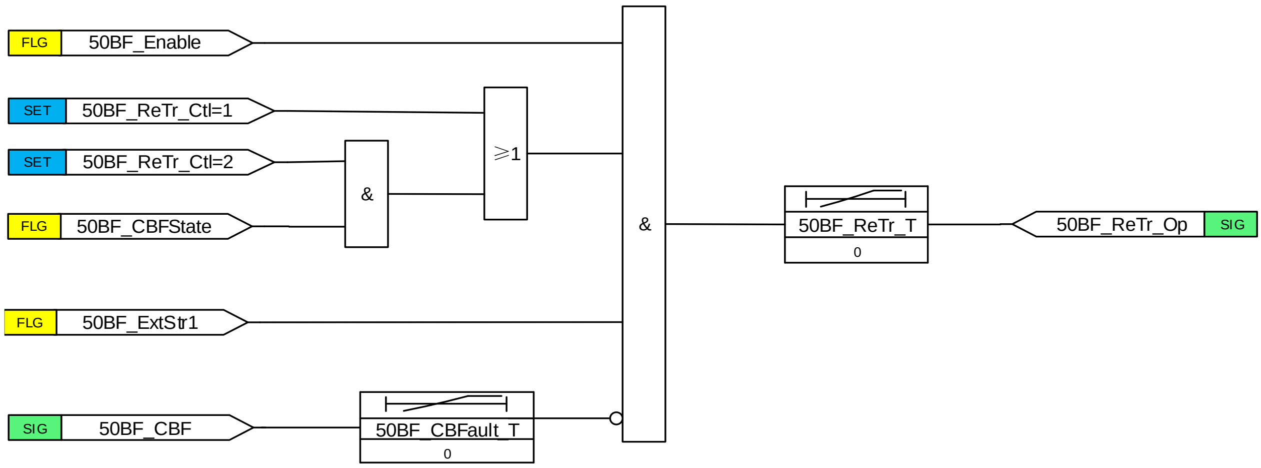


Figure 3.7-4 Own Breaker Retrip Logic

When 50BF_Enable=1, the retrip status will up to the 50BF_ReTr_Ctl setting:

Value of 50BF_ReTr_Ctl	Description
“0”	Disable
“1”	Without Check
“2”	Check

If 50BF_Retr_Ctl=0, the retrip function is disable;

If 50BF_Retr_Ctl=1 ("Without check" mode), the Retrip Logic is activated without checking the current level or CB position.

If 50BF_Retr_Ctl=2 ("Check" mode), the activation of the Retrip Logic output TRRET depends on the CB failure mode setting 50BF_Chk_Mod.

Besides above conditions, if the 50BF_ExtStr1 =1 and last for time delay 50BF_Retrip_T, the retrip logic is met and the relay will send 50BF_Retrp signal. The retrip logic only be used before the external mechanical equipment has checked the CB is failure, it means that if the status is happened after the 50BF_CBF=1 and last for 50BF_Fault_T, the retrip logic will be blocked. A typical setting of 50BF_Retrip_T is 0...50 ms.

3.7.2.4 BF trip CB Logic (Own Breaker Failure)

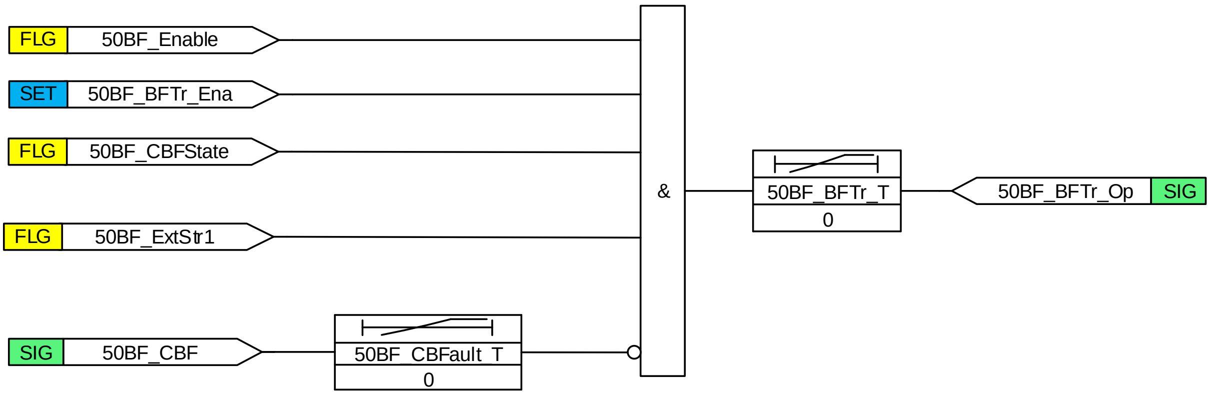


Figure 3.7-5 Own Breaker BF trip1 (Failure trip) Logic

When 50BF_Enable=1 and 50BF_BFTr_Ena=1, if the 50BF_CBFState =1, also the 50BF_ExtStr1 and last for time delay 50BF_BFTr_T, the BF trip1 logic is met and the relay will send 50BF_BFTrOp signal. The BF trip1 logic only be used before the external mechanical equipment has checked the CB is failure, it means that if the status is happened after the 50BF_CBF=1 and last for 50BF_Fault_T, the BF trip1 logic will be blocked. A typical setting of 50BF_BFTr_T is 90...150 ms.

3.7.2.5 BF trip Backup CB Logic (Electrically-adjacent Breaker Failure)

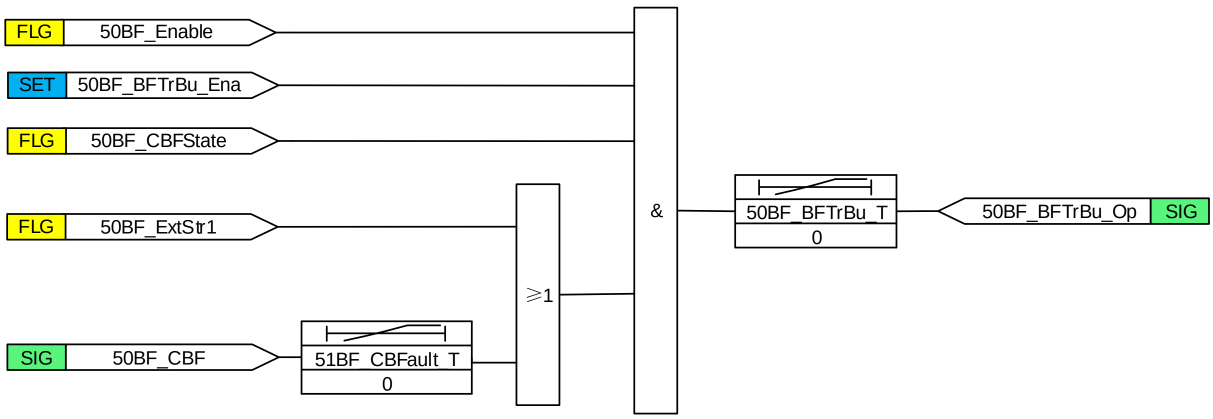


Figure 3.7-6 Adjacent Breaker BF trip2 (Failure trip) Logic

The BF trip2 logic provides the 50BF_BFTrBu_Op output which can be used to trip the upstream backup circuit breaker when the main circuit breaker fails to clear the fault. When 50BF_Enable=1 and 50BF_BFTrBu_Ena=1, if the 50BF_CBFState =1, also the 50BF_ExtStr1 and last for time delay 50BF_BFTrBu_T; or the 50BF_ExtStr1=1, the 50BF_CBF signal is 1 and last for 50BF_Fault_T, the BF trip2 logic is met. A typical setting of 50BF_BFTrBu_T is 90...150 ms.

3.7.2.6 Dead Zone Trip Backup CB Logic (Electrically-adjacent Dead Zone Trip)

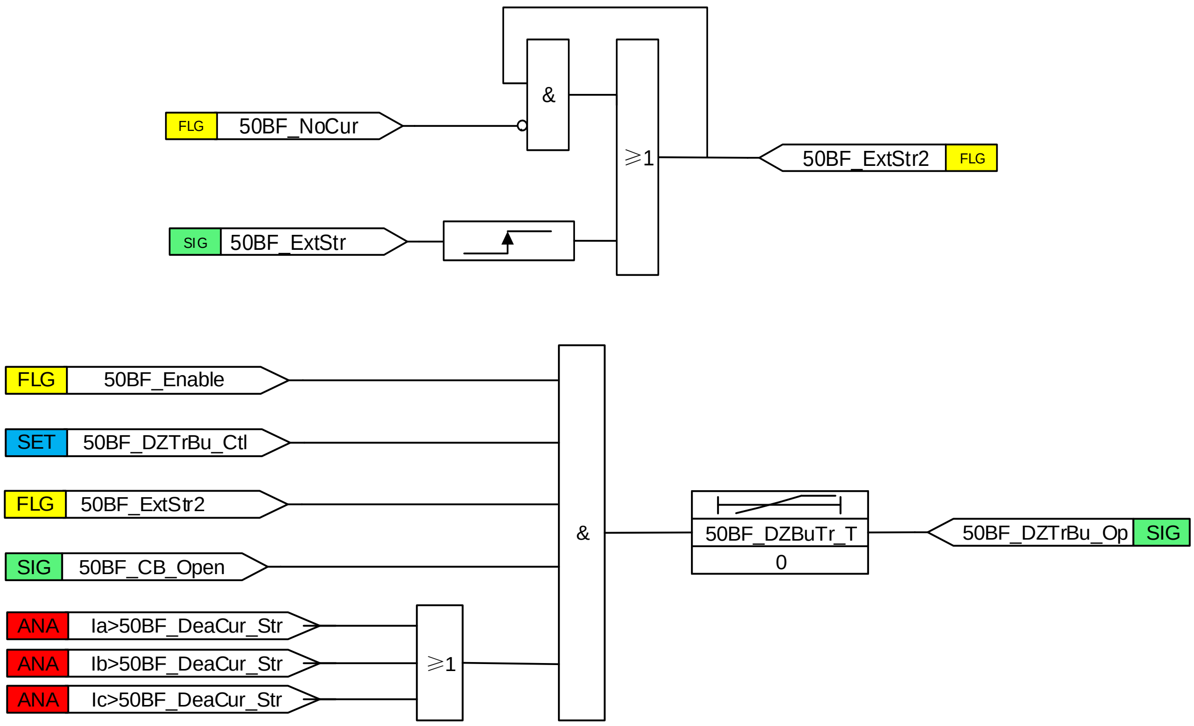


Figure 3.7-7 Adjacent Breaker Dead Zone trip (Dead Zone trip) Logic

For some wiring arrangement (for example, circuit breaker is located between CT and the line), if fault occurs between CT and circuit breaker, line protection can operate to trip circuit breaker quickly, but the fault have not been cleared since local circuit breaker is tripped. Here dead zone protection is needed in order to trip relevant circuit breaker.

The criterion for dead zone protection is: When the 50BF_ExtStr=1 or the fault current is not clear (50BF_NoCur=0), the dead zone startup (50BF_ExtStr2=1).

When 50BF_Enable=1 and 50BF_DeadEna=1, if the 50BF_ExtStr2=1 and CB is Open (50BF_CB_Open=1), also any phase of current is larger than dead zone current setting. All conditions are met and last for time delay 50BF_DeaOp_T, the 50BF_DZTrOp signal will be sent. A typical setting of 50BF_DeaOp_T is 90...150 ms.

3.7.2.7 Breaker Failure Alarm Logic

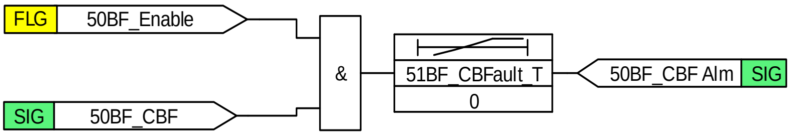


Figure 3.7-8 CBF Alarm logic

When the external mechanical equipment has checked the CB is failure, it means that when the 50BF_CBF=1 and last for 50BF_Fault_T, the 50BF_Alm signal will be sent. A typical value of 50BF_Fault_T is 5 s.

3.7.2.8 Current Detector Logic

The current detector function is used to check the non-directional instantaneous overcurrent relay pickup and resetting condition. The setting 50BF_QuickRet_Ena can be used and enabled to test fast-resetting function.

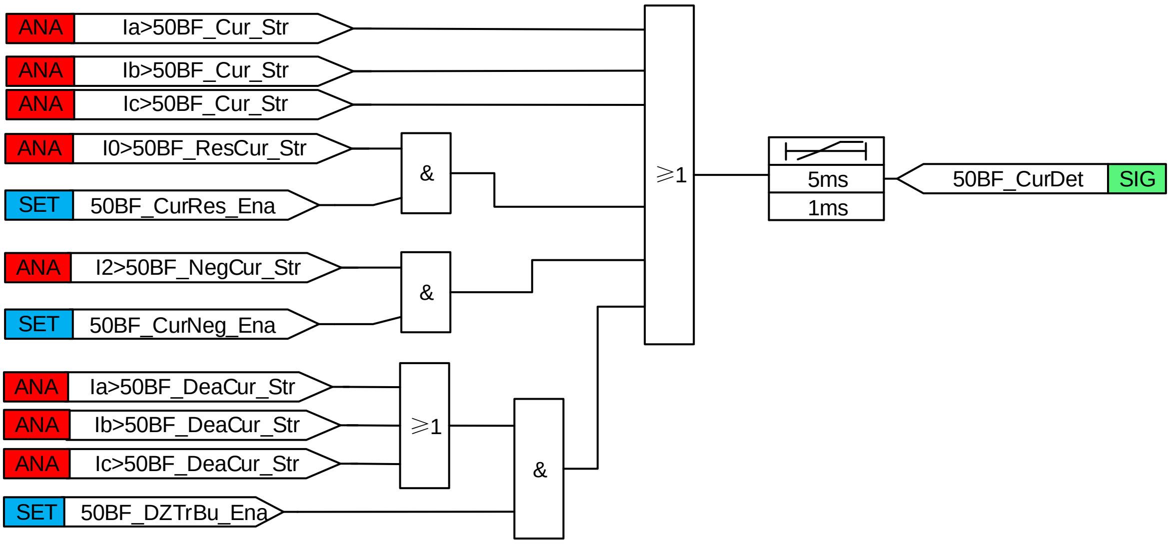


Figure 3.7-9 Current detection logic

3.7.2.9 Time delay setting note

The 50BF time delay should consider the CB physical condition, the characteristic should be DT. The minimum time delay for the all trip can be estimated as:

$$50BF\_ReTr\_T \geq t_{CBOpen} + t_{BF\_Reset} + t_{Margin}$$

$$50BF\_BFTr\_T \geq t_{CBOpen} + t_{BF\_Reset} + t_{Margin}$$

$$50BF\_BFTrBu\_T \geq t_{ReTr} + t_{CBOpen} + t_{BF\_Reset} + t_{Margin}$$

$$51BF\_DZTrBu\_T \geq t_{CBOpen} + t_{BF\_Reset} + t_{Margin}$$

Circuit breaker operating time (t_{CBOpen}), which is the time between activating the trip command for the circuit breaker trip coil and CB reaching the open position

• Reset time (t_{BF_Reset}) of current detection, which is the time between the moment when the circuit breaker is opened and the moment when the measured current is detected to be under the set value

• Additional safety margin (t_{Margin}), which is to avoid unintentional operation of circuit breaker failure protection.

The time delay for the backup trip(50BF_BFTrBu_T) must be longer compared to the retrip time so that the unwanted backup tripping can be avoided.

3.7.3 50BF Application Scope

50BF can retrip and breaker failure trip. This means that a second trip signal is sent to the protected circuit breaker. These functions are used to increase the operational reliability of the breaker. The function can also be used to avoid backup tripping of several breakers in case mistakes occur during IED maintenance and tests.

The breaker failure protection and dead zone protection issue a backup trip command to upstream circuit breakers in case the original circuit breaker fails to trip for the protected component. The detection of a failure to break the current through the breaker is made by measuring the current or by detecting the remaining trip signal.

Dead zone protection application:

When a fault occurs between the circuit breaker and current transformer(CT), in many cases, the fault cannot be cut off after the protection operation.

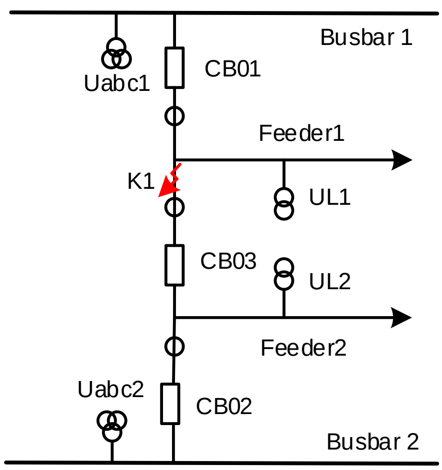


Figure 3.7-10 The diagram of dead zone fault

For example, as shown in Figure 3.7-10 if there is a fault at K1, within the protection zone of bus I, when the protection operation trips the circuit breaker CB01, and the fault is still in the system, this type of fault is called a dead zone fault. Then the dead zone protection operates and trips the adjacent circuit breaker CB03.

Considering the occurrence of dead zone faults in the station, the current is generally large and has a significant impact on the system. Although it can be cut off by circuit breaker failure (BF) protection, the BF protection time delay is generally longer, a dead zone protection that is faster than the BF protection is specially designed. The circuit breaker of dead zone protection is consistent with the circuit breaker failure protection, that is, when the BF protection operate and trip the upstream backup or adjacent circuit breaker, the dead zone protection will trip the same circuit breaker. Dead zone protection can also be understood as an alternative type of failure protection (with different criteria and time delays).

3.7.4 50BF Settings

Table 3.7-4 50BF settings

No.	Name	Range	Unit	Step	Default	Description
1	50BF_Ena	0-1	-	1	0	Operation Enable/Disable
2	50BF_ReTr_Ctl	0-2	-	1	0	Retrip Control Logic Setting: =0: Disable =1: Without Check =2: Check
3	50BF_BFTr_Ena	0-1	-	1	0	Enable signal of BF trip CB logic
4	50BF_BFTrBu_Ena	0-1	-	1	0	Enable signal of BF trip backup CB logic
5	50BF_DZTrBu_Ctl	0-1	-	1	0	Enable signal of Dead zone trip backup CB logic
6	50BF_ResCur_Ena	0-1	-	1	0	Enable signal of zero sequence current logic
7	50BF_NegCur_Ena	0-1	-	1	0	Enable signal of negative current logic
8	50BF_QuickRet_Ena	0-1	-	1	0	Enable quick return the operation
9	50BF_Cur_Str	0.04-20.00In	A	0.01In	0.04In	Operating phase current
10	50BF_ResCur_Str	0.04-20.00In	A	0.01In	0.04In	Operating residual current
11	50BF_NegCur_Str	0.04-20.00In	A	0.01In	0.04In	Operating negative current
12	50BF_DeaCur_Str	0.04-20.00In	A	0.01In	0.04In	Operating Dead zone current
13	50BF_CBFault_T	0.00-60.00	s	0.01	5	Delay of circuit breaker fault
14	50BF_ReTr_T	0.00-60.00	s	0.01	0.05	Delay for retrip
15	50BF_BF_T	0.00-60.00	s	0.01	0.15	Delay for BF trip CB
16	50BF_BFBuTr_T	0.00-60.00	s	0.01	0.15	Delay for BF trip backup CB
17	50BF_DeaBuTr_T	0.00-60.00	s	0.01	0.15	Delay for Dead Zone trip backup CB
18	50BF_Chk_Mod	1-4	-	1	3	=1: Current check; =2: CB status check; =3: Current check or CB status check =4: Current check and CB status check

3.8 Three-phase thermal overload protection 49F

3.8.1 49F Overview

The relay incorporates a one-stage current based thermal calculation. The heat generated within an item of the plant, such as a cable or a transformer, is the resistive loss. Thus, heating is directly proportional to current squared. The thermal time characteristic used in the relay is therefore based on current squared, integrated over time. The relay automatically uses the largest phase current for input to the thermal calculation.

If the temperature of the protected object reaches the warning level, the alarm signal is given out. If the temperature continues to increase to the maximum allowed temperature value, the protection issues a trip signal to the protected line.

3.8.1.1 Function Block

The function block of the protection is as below.

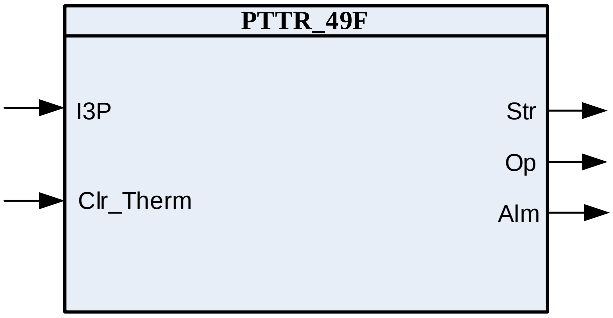


Figure 3.8-1 Function block

3.8.1.2 Signals

Table 3.8-1 Input Signals

Signal	Description
I3P	The current magnitude in all the three phases
Clr_Therm	The input signal of clearing thermal

Table 3.8-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.
Alm	This is the integrated alarm signal

3.8.2 49F Protection Principle

The thermal overload protection function has two operation types: one for alarm and one for tripping, which can be enabled or disabled by respectively setting the corresponding 49F_Alm_Ena and 49F_Trp_Ena parameter values as "1" or "0".

The operation of three-phase thermal protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

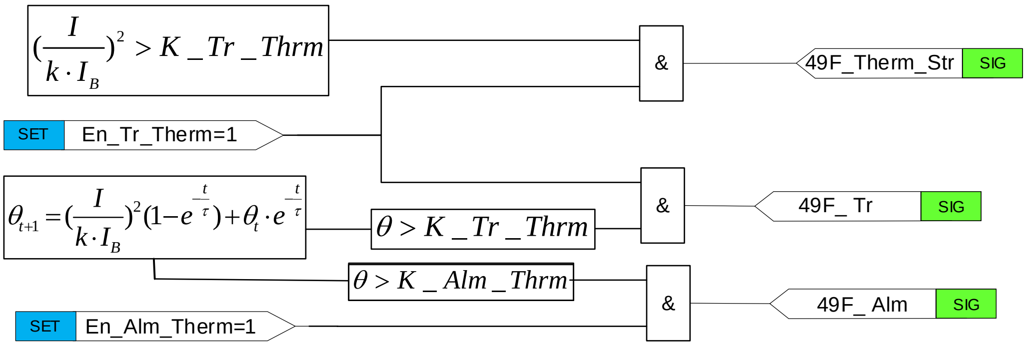


Figure 3.8-2 Functional module diagram

The function continuously checks the highest measured phase current value and reports the highest value to the temperature calculator.

If $(I/(k*I_B))^2$ is more than the set value of 49F_K_Tr, the 49F_Str output is activated. Whereas, if $(I/(k*I_B))^2$ is smaller than the set value of 49F_K_Tr, the 49F_Str output is deactivated.

The final temperature rise is calculated from the highest of the three-phase currents according to the expression, one of the three phase meet the formula, the protection startup.

$$\theta_{t+1}=(\frac{I}{k\cdot I_B})^2(1-e^{-\frac{t}{\tau}})+\theta_t\cdot e^{-\frac{t}{\tau}}$$

Where:

I RMS value of the max fault phase current.

K set value of 49F_K_Factor.

IB the rated current 49F_Rated_Cur

τ the set value of 49F_T_Mult

θ_t is the initial thermal state, if the initial thermal state is 30%, the θ_t is 0.3. θ_t is calculated from the following equation: $I_p^2=\theta_t\cdot(k\cdot I_B)^2$. For the heat rising process, Ip is the previous current 100ms before the heat first rises; for the cooling process, the Ip is the trip current.

θ_{t+1} is the trip or alarm thermal state: θ_{Trip} (the setting value 49F_K_Tr) or θ_{Alarm} (the setting 49F_K_Alm). For cooling process, the θ_{t+1} is the return value.

When the component temperature reaches the set alarm level 49F_K_Alm, the output signal 49F_Alm is issued. When the component temperature reaches the set trip level 49F_K_Tr, the 49F_Tr output is activated.

There is also a calculation of the present time to operation with the present current. This is only calculated if the final temperature is calculated to be above the operation temperature.

The time to operate can be calculated as:

$$t = \tau \times \ln \frac{I^2 - \theta_t (k \cdot I_B)^2}{I^2 - \theta_{t+1} (k \cdot I_B)^2}$$

The cooling time is also calculated based on the listed equation.

The temperature calculation is initiated from the value defined with the initial temperature. This is done in case the IED is powered up, the function is turned off and back on or reset through the 49F_Clr_Therm input.

The temperature is also stored in the nonvolatile memory and restored in case the IED is restarted.

3.8.3 49F Application Scope

If any sudden change in electrical power system, its directly impact to the operating factors of value likes current and voltage. In such a case, if the current level of transmission line increases to maximum capacity of the transmission line then according to the basic principle joule’s law the dissipation of heat is greater and greater. In simple words the temperature of transmission lines conductor is increased and it’s a possible chance of enormous damage in power system.

Therefore, the thermal overload protection (49F) initially completely underneath the protection of all above mentioned cases. If the thermal level of transmission line is increased due to any reason, three-phase thermal overload protection (49F) will protect.

3.8.4 49F Settings

Table 3.8-3 49F settings

No.	Name	Range	Unit	Step	Default	Description
1	49F_Alm_Ena	0-1	-	1	0	Alarm function disable/enable
2	49F_Trp_Ena	0-1	-	1	0	Trip function disable/enable
3	49F_Rated_Cur	0.05In-20In	A	0.01In	In	Rated current
4	49F_T_Mult	1-6000	s	1	600	Time multiplier
5	49F_K_Factor	1-5	-	0.01	1.05	Temperature factor
6	49F_K_Tr	50-200	%	1	100	Temperature level for tripping
7	49F_K_Alm	0-100	%	1	90	Temperature level for alarm

3.9 Broken Conductor(46BC)

3.9.1 46BC Overview

This relay provides a one-stage phase discontinuity protection with definite time delay characteristics to detect the unbalance current fault.

The relay incorporates an element which measures the ratio of negative to positive sequence current (I_2/I_1). This will be affected to a lesser extent than the measurement of negative sequence current alone, since the ratio is approximately constant with variations in load current. Hence, a more sensitive setting may be achieved.

At the moment when the circuit breaker is closed, because the three poles of the circuit breaker are discrepant for a very short time, and if the broken conductor protection is enabled, it is easy to make the broken conductor protection pick up, and it will restore after the load current is stable.

3.9.1.1 Function Block

The function block of the protection is as below.

Figure 3.9-1 Function block

3.9.1.2 Signals

Table 3.9-1 Input Signals

Signal	Description
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Table 3.9-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.

3.9.2 46BC Protection Principle

The phase discontinuity protection function can be enabled or disabled by setting the corresponding 46BC_Ena parameter values as "1" or "0".

The phase discontinuity protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The initiation logic diagram is shown as below:

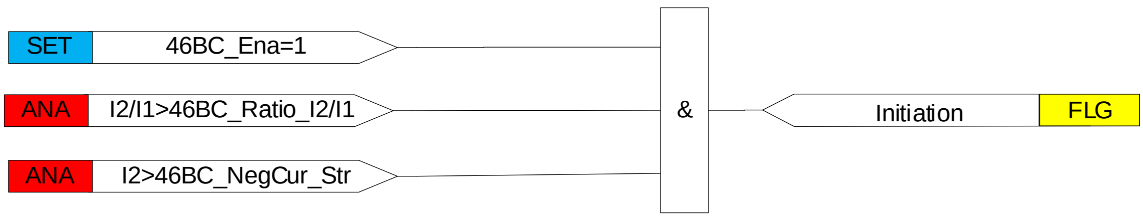


Figure 3.9-2 The initiation logic diagram

Note: I1>0.02IN

The 46BC calculates the ratio of the negative and positive sequence current (I2/I1).

Then it compares the calculated ratio to the set 46BC_Ratio_I2/I1. If the calculated value exceeds the set 46BC_Ratio_I2/I1 and I2 is larger than the setting 46BC_NegCur_Str, the initiation element is activated.

The functional module diagram is shown as below:

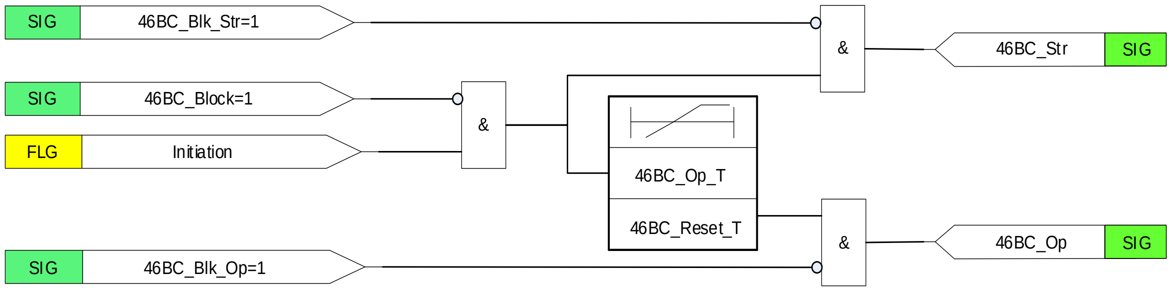


Figure 3.9.3 Functional module diagram

Once initiation elements activated and no blocking signal is fulfilled, the timer and 46BC_Str signal are activated.

The time characteristic is according to DT. When the operation timer has reached the value set by 46BC_Op_T, the 46BC_Op output is activated. If the fault disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by 46BC_Rest_T, the operate timer resets and the 46BC_Str output is deactivated.

The binary input 46BC_Block can be used to block the function. The activation of the 46BC_Block input deactivates all outputs and resets internal timers. The binary input 46BC_BlkStr can be used to block the start signals. The binary input 46BC_BlkOp can be used to block the operation signals.

3.9.3 46BC Application Scope

In three-phase distribution and sub transmission network applications the phase discontinuity in one phase can cause increase of zero sequence voltage and short overvoltage peaks and also oscillation in the corresponding phase.

46BC is a three-phase protection with DT characteristic, designed for detecting broken conductors in distribution and sub transmission networks. The function is applicable for both overhead lines and underground cables.

The operation of 46BC is based on the ratio of positive and negative sequence currents. This gives better sensitivity and stability compared to plain negative sequence current protection since the calculated ratio of positive and negative sequence currents is relatively constant during load variations.

3.9.4 46BC Settings

Table 3.9-3 46BC settings

No.	Name	Range	Unit	Step	Default	Description
1	46BC_Ratio_I2/I1	20-100	%	1	20	Current ratio setting I2/I1
2	46BC_Op_T	0.1-120.00	s	0.01	0.1	Operate time delay
3	46BC_Ena	0-1	-	1	0	Operation Disable/Enable
4	46BC_Reset_T	0.0-60.000	s	0.001	0.02	Reset time delay
5	46BC_NegCur_Str	0.04In-20In	A	0.01In	0.04In	Negative current start setting

3.10 Negative sequence current protection 46N

3.10.1 46N Overview

This relay provides one stage of negative sequence overcurrent protection.

The application of negative sequence overcurrent protection has a special significance to motors. Unbalanced loads create counter-rotating fields in three-phase induction motors, which act on the rotor at double frequency. Eddy currents are induced on the rotor surface, which causes local overheating in rotor end zones and the slot wedges. This especially goes for motors which are tripped via vacuum contactors with fuses connected in series. With single phasing due to operation of a fuse, the motor only generates small and pulsing torques such that it soon is the normally strained assuming that the torque required by the machine remains unchanged. In addition, the unbalanced supply voltage introduces the risk of thermal overload. Due to the small negative sequence reactance even small voltage asymmetries lead to large negative sequence currents.

3.10.1.1 Function Block

The function block of the protection is as below.

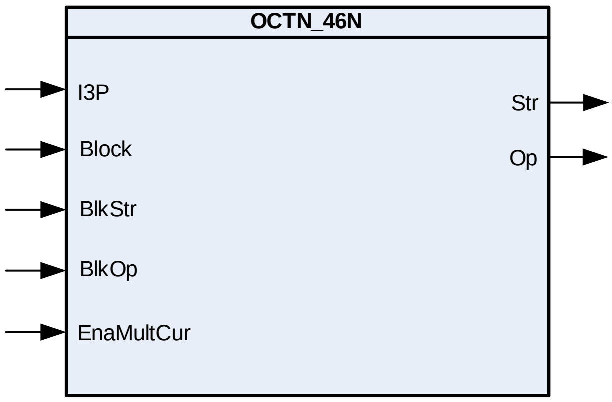


Figure 3.10-1 Function block

3.10.1.2 Signals

Table 3.10-1 Input Signals

Signal	Description
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.
EnaMultCur	This signal enables the current multiplier.

Table 3.10-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.

3.10.2 46N Protection Principle

The negative sequence current protection function can be enabled or disabled by setting the corresponding 46N_Ena parameter values as "1" or "0".

The operation of the negative sequence current protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

➢ **Initiation element**

The measured negative-sequence current is compared to the set 46N_Cur_Str value. If the measured value exceeds the set 46N_Cur_Str, the level detector activates the timer module.

If the 46N_EnaMultCur input is active, the set 46N_Cur_Str, is multiplied by the set 46N_Mul_Cur_Str.

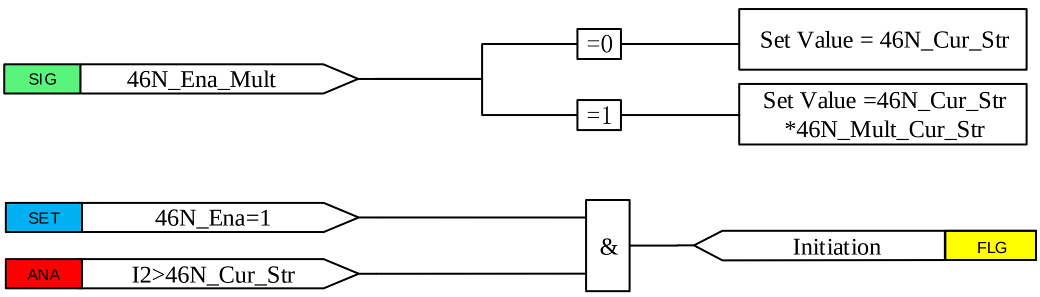


Figure 3.10-2 The initiation logic diagram

NOTICE!

Do not set the multiplier setting 46N_Mul_Cur_Str higher than necessary. If the value is too high, the function may not operate at all during an inrush followed by a fault, no matter how severe the fault is.

The start value multiplication is normally done when the inrush detection function (OCR_INR) is connected to the EnaMultCur input by Three phase inrush function OCR_INR.

➢ **Timer element**

The functional module diagram is shown as below:

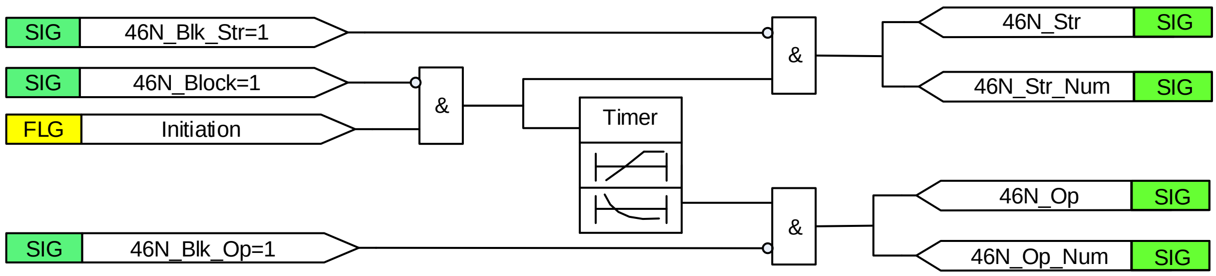


Figure 3.10-3 Functional module diagram

Once initiation logic is fulfilled and no 46N_Block signal is activated, the 46N_Str signal is activated.

The timer model is determined by IDMT curves for over quantity protection.

The operation is activated after the operation timer has reached the calculated value. However, 46N_Min_Op_T defines the minimum desired operate time for IDMT. If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the operation will reset after the set value 46N_Reset_T is exceeded.

NOTICE!

The 46N_Min_Op_T setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the 46N_Min_Op_T setting.

The binary input 46N_Block can be used to block the function. The activation of the 46N_Block input deactivates all outputs and resets internal timers. The binary input 46N_BlkStr can be used to block the 46N_Str signals. The binary input 46N_BlkOp can be used to block the 46N_Op signals.

3.10.3 46N Application Scope

The negative sequence current quantities are not present during normal condition. The negative sequence overcurrent protection elements can be set for faster and more sensitive operation than the normal phase overcurrent protection for fault conditions occurring between two phases. The negative sequence overcurrent protection also provides a back-up protection functionality for the feeder earth-fault protection in solid and low resistance earthed networks.

3.10.4 46N Settings

Table 3.10-3 46N settings

No.	Name	Range	Unit	Step	Default	Description
1	46N_Cur_Str	0.04-20.00In	A	0.01In	0.04In	Current start value
2	46N_Mul_Cur_Str	0.8-10.0		0.1	1	Multiplier Current start value
3	46N_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite

No.	Name	Range	Unit	Step	Default	Description
						time, IEC and ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
4	46N_Curve_ParaA	0.000-120.000	s	0.001	0	Curve parameter A
5	46N_Curve_ParaB	0.000-9.000	s	0.001	0.2	Curve parameter B
6	46N_Curve_ParaC	0.0-1.0	-	0.1	1.0	Curve parameter C
7	46N_Curve_ParaP	0.02-2.00	-	0.01	2.00	Curve parameter P
8	46N_Curve_ParaK	0.05-100	-	0.01	1.00	Curve parameter k
9	46N_Min_Op_T	0.005 -60.000	s	0.001	0.005	Minimum operate time for IDMT curves
10	46N_Reset_T	0.000 -60.000	s	0.001	0.02	reset time for IDMT curves
11	46N_Ena	0-1		1	0	Selection of reset curve type

3.11 Three-phase overvoltage protection 59

3.11.1 59 Overview

This relay provides a two-stage of overvoltage protection with definite time (DT) or inverse definite minimum time (IDMT) characteristics. Each stage has same protection logics. Each stage can be used for tripping or alarming through the related logic settings.

This protection can support all kinds of VT connection: three phase voltage (Ua, Ub, Uc), three phase-to-phase voltages (Uab, Ubc, Uca), two phase-to-phase voltages (Uab, Ubc), anyone of three phase voltages or anyone of three phase-to-phase voltages.

3.11.1.1 Function Block

The function block of the protection is as below.

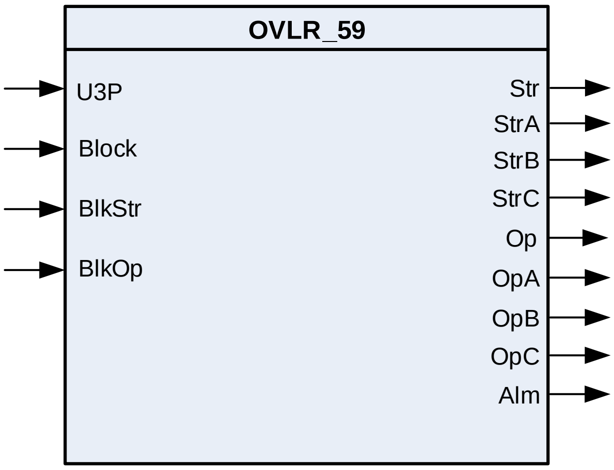


Figure 3.11-1 Function block

3.11.1.2 Signals

Table 3.11-1 Input Signals

Signal	Description
U3P	The voltage in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Table 3.11-2 Output Signals

Signal	Description
Str	This is the integrated start signal
StrA	This is the start signal of phase A
StrB	This is the start signal of phase B
StrC	This is the start signal of phase C.
Op	This is the integrated operation signal.
OpA	This is the operation signal of phase A
OpB	This is the operation signal of phase B
OpC	This is the operation signal of phase C
Alm	This is the integrated alarm signal

3.11.2 59 Protection Principle

The three-phase overvoltage protection function can be enabled or disabled by setting the corresponding 59_Ena parameter values as "1" or "0".

The operation of the three-phase overvoltage protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

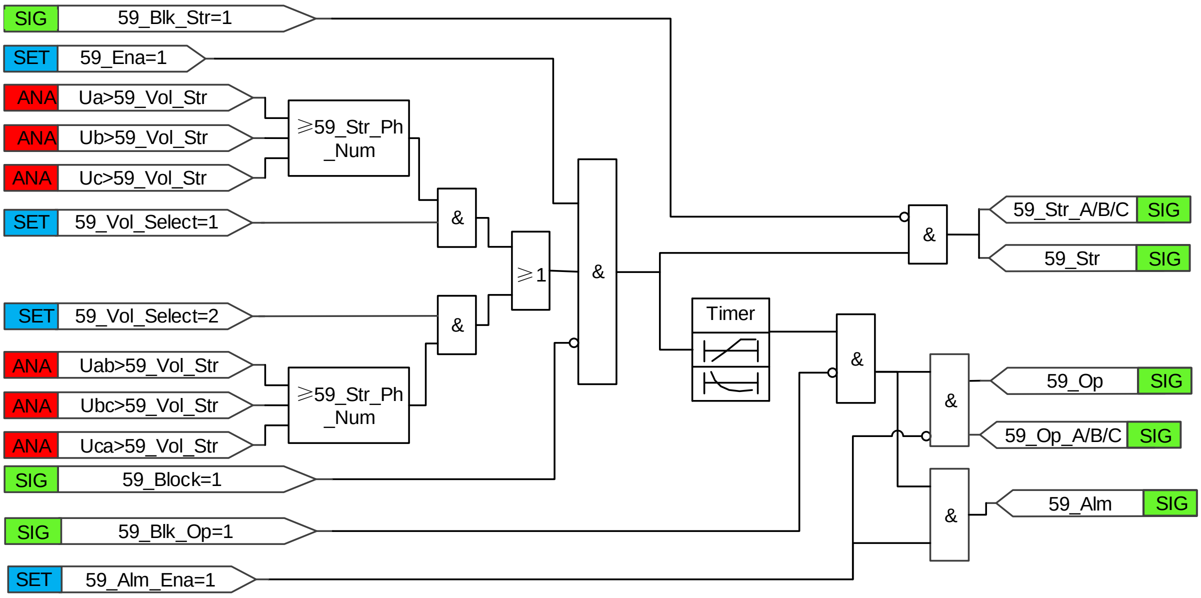


Figure 3.11-2 Functional module diagram

The fundamental frequency component of the measured three phase voltages is compared phase-wise to the set value of the 59_Vol_Str setting. If the measured value is higher than the set value of the 59_Vol_Str setting, the phase selection logic detects the phase or phases in which the fault level is detected. If the number of faulty phases is equal to or more than the set 59_Str_Ph_Num and no blocking signal input is activated, the phase selection logic activates the timer and the 59_Str output and the corresponding output of the respective phases (59_StrA/B/C).

Where:

The 59_Vol_Select setting is used for selecting phase-to-earth (59_Vol_Select=1) or phase-to-phase(59_Vol_Select=2) voltages for protection.

59_Vol_Str is the preset value to check for the voltage

59_Str_Ph_Num shows the number of phases required for operate activation.

➢ **Timer element**

The timer mode is determined by IDMT curves for over quantity protection.

The operation is activated after the operation timer has reached the calculated value. If 59_Alm_Ena = 0, the 59_Op output is activated, the corresponding output for the respective phases (59_OpA/B/C) is also activated, when 59_Alm_Ena = 1, the 59_Alm output is activated. However, 59_Min_Op_T defines the minimum desired operate time for IDMT. If a drop-off situation occurs, that is, a fault suddenly disappears before the operation delay is exceeded, the reset state is activated. If the drop-off situation exceeds the set 59_Reset_T, the timer is reset and the 59_Str output is deactivated.

NOTICE!

The 59_Min_Op_T setting should be used with care because the operation time is according to the IDMT curve but always at least the value of the 59_Min_Op_T setting.

The binary input 59_Block can be used to block the function. The activation of the 59_Block input deactivates all outputs and resets the internal timers. The binary input 59_BlkStr can be used to block the start signals. The binary input 59_BlkOp can be used to block the operating signals.

3.11.3 59 Application Scope

Overvoltage in a network occurs either due to the transient surges on the network or due to prolonged power frequency overvoltage. Surge arresters are used to protect the network against the transient overvoltage, but the IED protection function is used to protect against power frequency overvoltage.

The power frequency overvoltage may occur in the network due to contingencies such as:

- Defective operation of the automatic voltage regulator when the generator is in isolated operation.

- Operation under manual control with the voltage regulator out of service. A sudden variation of load, in particular the reactive power component, gives rise to a substantial change in voltage because of the large voltage regulation inherent in a typical alternator.

- Sudden loss of load due to the tripping of outgoing feeders, leaving the generator isolated or feeding a very small load, can cause a sudden rise in the terminal voltage due to the trapped field flux and over speed.

59 is not usually applied to the attended generators but can be required for the unattended automatic hydro-stations. If a load sensitive to overvoltage remains connected, it leads to equipment damage.

Therefore, it is essential to provide power frequency overvoltage protection in the form of time delayed element, either IDMT or DT.

3.11.4 59 Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.11-3 59 settings

No.	Name	Range	Unit	Step	Default	Description
1	59_i_Vol_Str	0.00-160.00V	V	0.01	110.00	Stage i Start value of overvoltage
2	59_i_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
3	59_i_Curve_ParaA	0.000-120.000	s	0.001	0	The Stage i Curve parameter A
4	59_i_Curve_ParaB	0.000-9.000	s	0.001	0.2	The Stage i Curve parameter B
5	59_i_Curve_ParaC	0.0-1.0	-	0.1	1.0	The Stage i Curve parameter C
6	59_i_Curve_ParaP	0.02-2.00	-	0.01	2.00	The Stage i Curve parameter P
7	59_i_Curve_ParaK	0.05-100	-	0.01	1.00	The Stage i Curve parameter K
8	59_i_Min_Op_T	0.005-60.000	s	0.001	0.005	The Stage i minimum operating time
9	59_i_Reset_T	0.000 -60.000	s	0.001	0.02	The Stage i Reset time delay
10	59_i_Str_Ph_Num	1-3	-	1	1	The Stage i Number of phases required for operate activation: 1: 1 out of 3; 2: 2 out of 3; 3: 3 out of 3
11	59_i_Vol_Select	1-2	-	1	2	The Stage i voltage parameter selection criteria: 1 for phase voltages; 2 for phase-to-phase voltages
12	59_i_Ena	0-1	-	1	0	The Stage i Protection enable/disable
13	59_i_Alm_Ena	0-1	-	1	0	The Stage i 59 alarm/ 59 operate

3.12 Positive sequence overvoltage protection 59P

3.12.1 59P Overview

This relay provides a one-stage positive sequence overvoltage protection with definite time delay characteristics.

3.12.1.1 Function Block

The function block of the protection is as below.

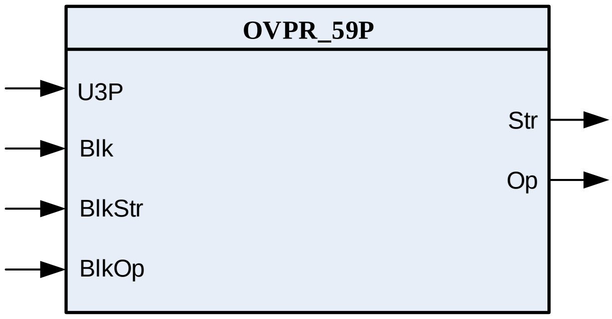


Figure 3.12-1 Function block

3.12.1.2 Signals

Table 3.12-1 Input Signals

Signal	Description
U3P	The voltage in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Table 3.12-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.

3.12.2 59P Protection Principle

The positive-sequence overvoltage protection function can be enabled or disabled by setting the corresponding 59P_Ena value as "1" or "0".

The operation of the positive-sequence overvoltage protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

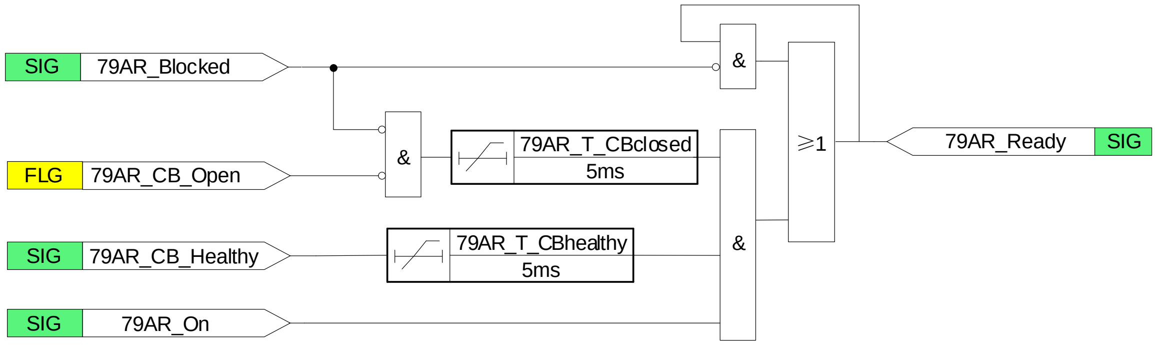


Figure 3.12-2 Functional module diagram

The calculated positive-sequence voltage is compared to the set 59P_Vol_Str setting. If the value exceeds the set 59P_Vol_Str and no block signal is activated, the timer and 59P_Str signal are activated.

59P_Vol_Str is the start value for the voltage.

The time characteristic is according to DT. When the operation timer has reached the value set by 59P_Op_T, the 59P_Op output is activated. If the positive sequence voltage normalizes before the module operates, the reset timer is activated. If the reset timer reaches 30ms, the 59P_Op output is deactivated.

The binary input 59P_Block can be used to block the function. The activation of the 59P_Block input deactivates all outputs and resets internal timers. The binary input 59P_BlkStr can be used to block the start signals. The binary input 59P_BlkOp can be used to block the operation signals.

3.12.3 59P Application Scope

59P is applied to power system elements, such as generators, transformers, motors and power lines, to detect overvoltage conditions.

59P can be used in combination with low-current signals or a directional reactive overpower function to identify the distribution line with an open remote end. 59P can also be used to initiate voltage correction measures like insertion of shunt reactors or switching out capacitor banks to control the voltage.

59P prevents sensitive equipment from running overvoltage conditions causing the equipment to overheat or stress on insulation material.

3.12.4 59P Settings

Table 3.12-3 59P settings

No.	Name	Range	Unit	Step	Default	Description
1	59P_Vol_Str	40.00 -100.00	V	0.01	70.00	Positive Sequence overvoltage start value
2	59P_Op_T	0.04-120.00	s	0.01	0.04	Operate delay time
3	59P_Ena	0-1	-	1	0	Operation Enable/Disable

3.13 Residual overvoltage protection 59G

3.13.1 59G Overview

This relay provides a zero sequence overvoltage protection with definite time delay characteristics.

The residual voltage can be calculated internally based on the measurement of the three-phase voltage. This voltage can also be measured by a single-phase voltage transformer, located between a transformer star point and earth, or by using an open-delta connection of three single-phase voltage transformers.

On a healthy three-phase power system, the addition of each of the three-phase to earth voltages is nominally zero. However, when an earth fault occurs on the primary system, the balance is upset and a residual voltage is produced. Hence, a zero sequence overvoltage protection can be used to offer earth fault protection on such a system.

3.13.1.1 Function Block

The function block of the protection is as below.

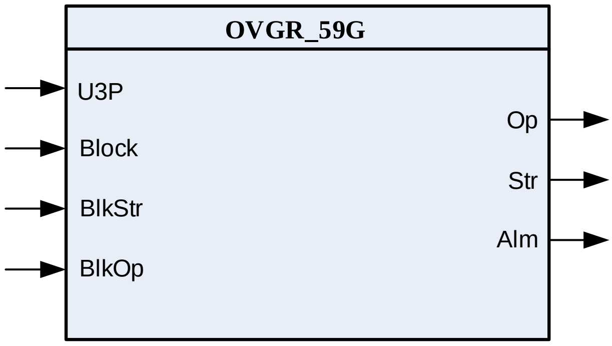


Figure 3.13-1 Function block

3.13.1.2 Signals

Table 3.13-1 Input Signals

Signal	Description
U3P	The voltage in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Table 3.13-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.

Signal	Description
Alm	This is the integrated alarm signal

3.13.2 59G Protection Principle

The residual overvoltage protection function can be enabled or disabled by setting the corresponding 59G_Ena parameter values as "1" or "0".

The residual voltage sample method is determined by 59G_U0_Calc, if 59G_U0_Calc =0, the voltage is sample from external terminal, if 59G_U0_Calc = 1, the voltage is calculated by three phases voltage.

The operation of residual overvoltage protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

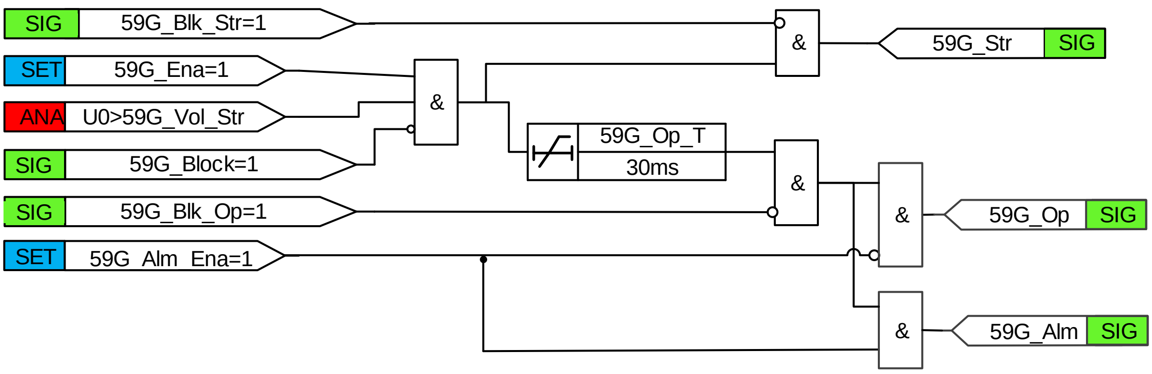


Figure 3.13-2 Functional module diagram

The measured or calculated residual voltage U0 is compared with the set 59G_Vol_Str. If the value exceeds the set start value and no block signal is activated, the timer and 59G_Str signal are activated.

Where:

59G_Vol_Str is the residual overvoltage start value.
59G_Op_T is operating delay time for 59G.

The time characteristic is according to DT. When the operation timer has reached the value set by 59G_Op_T and 59G_Alm_Ena=0, the 59G_Op output is activated; When the operation timer has reached the value set by 59G_Op_T and 59G_Alm_Ena=1, the 59G_Alm output is activated. If the fault disappears before the module operates, the operation will reset with a time delay of 30ms.

The binary input 59G_Block can be used to block the function. The activation of the 59G_Block input deactivates all outputs and resets internal timers. The binary input 59G_BlkStr can be used to block the start signals. The binary input 59G_BlkOp can be used to block the operation signals.

3.13.3 59G Application Scope

59G is designed to be used for earth-fault protection in isolated neutral, resistance earthed or reactance earthed systems. In compensated and isolated neutral systems, the system neutral voltage, that is, the residual voltage, increases in case of any fault connected to earth. In compensated networks, starting of the function can be used to control the switching device of the neutral resistor.

Therefore, this function is often used as a backup protection or as a release signal for the feeder earth-fault protection.

The protection can also be used for the earth-fault protection of generators and motors and for the unbalance protection of capacitor banks.

3.13.4 59G Settings

Table 3.13-3 59G settings

No.	Name	Range	Unit	Step	Default	Description
1	59G_Vol_Str	0.00 -100.00	V	0.01	3.00	Residual overvoltage start value
2	59G_Op_T	0.04-300.00	s	0.01	0.04	Operate delay time
3	59G_Ena	0-1	-	1	0	Operation Enable/Disable
4	59G_3U0_Cal_Ena	0-1	-	1	0	Measured residual Voltage/calculated residual Voltage
5	59G_Alm_Ena	0-1	-	1	0	59G alarm /59G Operation

3.14 Negative sequence overvoltage protection 59N

3.14.1 59N Overview

This relay provides a one-stage negative sequence overvoltage protection with definite time delay characteristics.

On a healthy three-phase power system, the negative sequence voltage is nominally zero. However, when an unbalance situation occurs on the primary system, the negative sequence voltage is produced.

3.14.1.1 Function Block

The function block of the protection is as below.

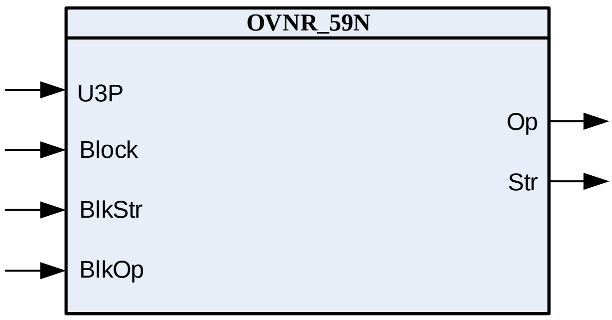


Figure 3.14-1 Function block

3.14.1.2 Signals

Table 3.14-1 Input Signals

Signal	Description
U3P	The voltage in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Table 3.14-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.

3.14.2 59N Protection Principle

The negative-sequence overvoltage protection function can be enabled or disabled by setting the corresponding 59N_Ena parameter values as "1" or "0".

The operation of the negative-sequence overvoltage protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

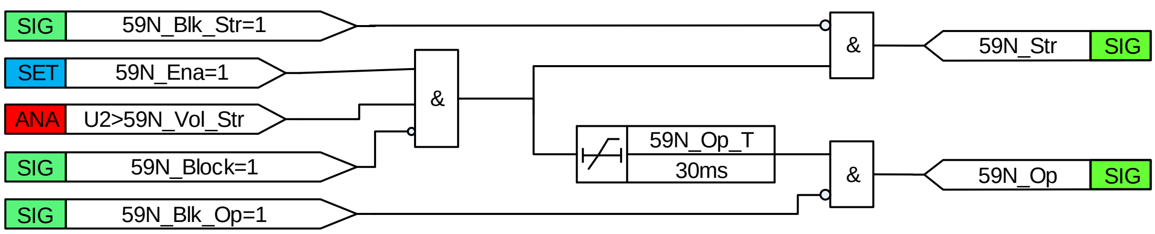


Figure 3.14-2 Functional module diagram

The calculated negative-sequence voltage is compared to the set 59N_Vol_Str setting. If the value exceeds the set 59N_Vol_Str and no block signal is activated, the timer and 59N_Str signal are activated.

Where:

59N_Vol_Str is the start value for the voltage.
59N_Op_T is operating delay time for 59N.

The time characteristic is according to DT. When the operation timer has reached the value set by 59N_Op_T, the OPERATE output is activated if the overvoltage condition persists. If the negative-sequence voltage normalizes before the module operates, the operation will reset with a time delay of 30ms.

The binary input 59N_Block can be used to block the function. The activation of the BLOCK input deactivates all outputs and resets internal timers. The binary input 59N_BlkStr can be used to block the start signals. The binary input 59N_BlkOp can be used to block the operation signals.

3.14.3 59N Application Scope

The 59N are used to accomplish a selective protection against the voltage and current unbalance for each machine separately. The protection can be used to monitor the voltage unbalance of the busbar.

The 59N can be applied as a backup protection or it can be used as an alarm. The latter can be applied when it is not required to trip loads tolerating voltage unbalance better than the rotating machines.

If there is a considerable degree of voltage unbalance in the network, the rotating machines should not be connected to the network at all. This logic can be implemented by inhibiting the closure of the circuit breaker if the 59N operation has started. This scheme also prevents connecting the machine to the network if the phase sequence of the network is not correct.

3.14.4 59N Settings

Table 3.14-3 59N settings

No.	Name	Range	Unit	Step	Default	Description
1	59N_Vol_Str	0.00 -100.00	V	0.01	3	Negative sequence overvoltage start value
2	59N_Op_T	0.04-120.00	s	0.01	0.04	Operate delay time
3	59N_Ena	0-1	-	1	0	Operation Enable/Disable

3.15 Under Voltage Load Shedding Protection 27

3.15.1 27 Overview

The three-phase under voltage protection function is used to disconnect from the network devices, for example electric motors, which are damaged when subjected to service under low voltage conditions. It includes a settable value for the detection of under voltage either in a single phase, two phases or three phases.

3.15.1.1 Function Block

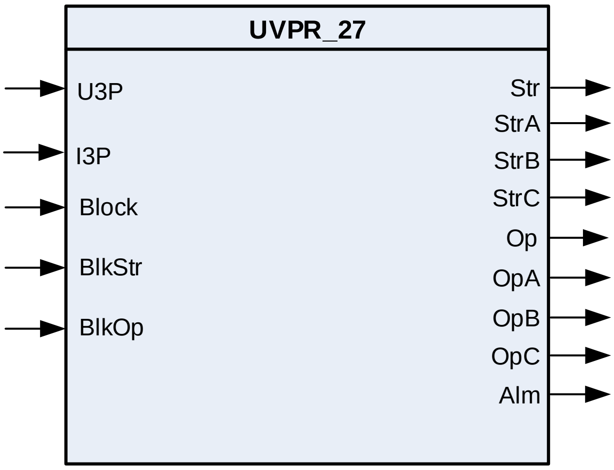


Figure 3.15-1 Function block

3.15.1.2 Signals

Table 3.15-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Table 3.15-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.
Alm	This is the integrated alarm signal

3.15.2 27 Protection Principle

The function can be enabled and disabled with the Operation setting. The corresponding parameter values are "On" and "Off".

The operation of 27 can be described using a module diagram. All the modules in the diagram are explained in the next sections.

3.15.2.1 Initiation logic

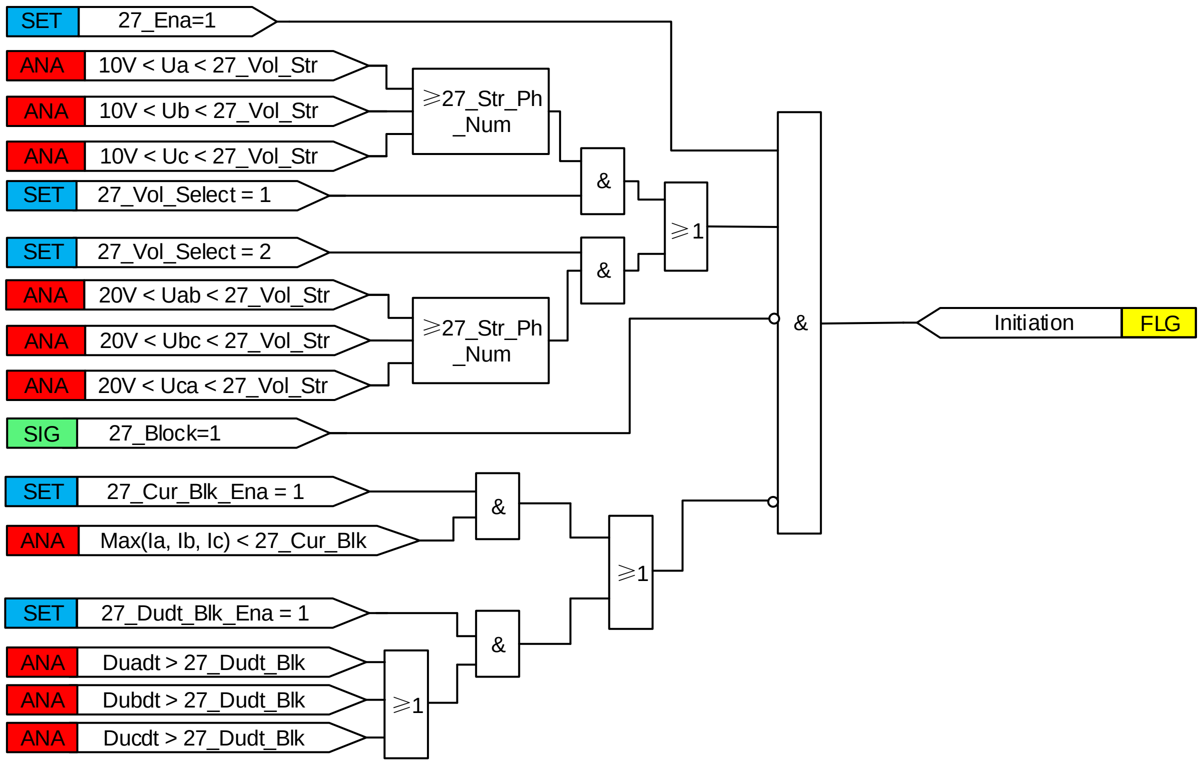


Figure 3.15-2 The initial diagram

The protection can be blocked by low current, it can be enabled or disabled by setting 27_i_Cur_Blk_Ena, when 27_i_Cur_Blk_Ena=1 and the maximum phase current is less than the setting 27_i_Cur_Blk, the relay is blocked.

The protection can be blocked by the rate of voltage change, it can be enabled or disabled by setting 27_i_Dudt_Blk_Ena, when the 27_i_Dudt_Blk_Ena=1 and the du/dt is larger than setting 27_i_Dudt_Blk.

When the relay is enabled, the fundamental frequency component of the measured three phase voltages and currents are compared phase-wise to the set Start value. If the three phase voltages are lower than the set value of the voltage, the relay will initial.

3.15.2.2 Timer element

The functional module diagram is shown as below:

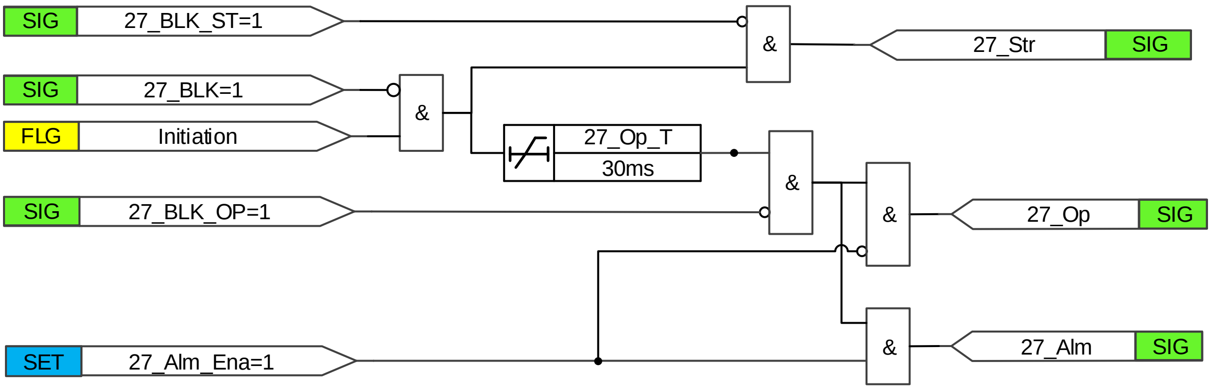


Figure 3.15-3 Timer element

The time characteristic is according to DT. When the operation timer has reached the value set by 27_Op_T and 27_Alm_Ena=0, the 27_Op output is activated if the under voltage condition persists. The time characteristic is according to DT. When the operation timer has reached the value set by 27_Op_T and 27_Alm_Ena=1, the 27_Alm output is activated If the three phase voltages normalize before the module operates, the operation resets with a time delay of 30ms.

Note: when the 27 relay is used as capacitor under voltage protection, the CB open position will block 27 relay by connecting the CB open position to the 27_BLK input.

3.15.3 27 Application Scope

27 relay is applied to power system elements, such as generators, transformers, motors and power lines, to detect low voltage conditions. Low voltage conditions are caused by abnormal operation or a fault in the power system. Another application is the detection of a no-voltage condition, for example before the energization of a high voltage line, or an automatic breaker trip in case of a blackout.

3.15.4 27 Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.15-3 27 27 settings

No.	Name	Range	Unit	Step	Default	Description
1.	27_i_Ena	0-1	-	1	0	Operation Enable/Disable
2.	27_i_Alm_Ena	0-1	-	1	0	27 alarm / 27 operate
3.	27_i_Vol_Str	1.00 -120.00	V	0.01	50	The voltage start value
4.	27_i_Op_T	0.04-120.00	s	0.01	0.04	The delay of definite time
5.	27_i_Cur_Blk_Ena	0-1	-	1	0	The current block criterion disable/enable
6.	27_i_Cur_Blk	0.04-20.00In	A	0.01In	0.04In	The current blocking value
7.	27_i_Str_Ph_Num	1-3	-	1	1	The Stage i Number of phases required for operate activation: 1: 1 out of 3; 2: 2 out of 3; 3: 3 out of 3

No.	Name	Range	Unit	Step	Default	Description
8.	27_i_Vol_Select	1-2	-	1	2	The Stage i voltage parameter selection criteria: 1 for phase voltages; 2 for phase-to-phase voltages
9.	27_i_Dudt_Blk_Ena	0-1	-	1	0	The voltage-slip block criterion disable/enable
10.	27_i_Dudt_Blk	0-20	V/s	0.01	20	The voltage-slip block setting value

3.16 Positive sequence under voltage protection 27P

3.16.1 27P Overview

This relay provides a one-stage positive sequence under voltage protection with definite time delay characteristics.

3.16.1.1 Function Block

The function block of the protection is as below.

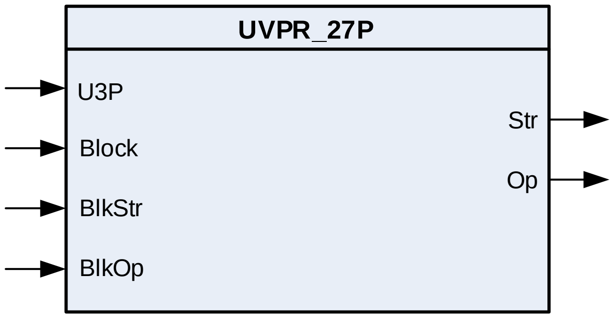


Figure 3.16-1 Function block

3.16.1.2 Signals

Table 3.16-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Table 3.16-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.

3.16.2 27P Protection Principle

The positive-sequence under voltage protection function can be enabled or disabled by setting the corresponding 27P_Ena parameter values as "1" or "0".

The operation of the positive-sequence under voltage protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

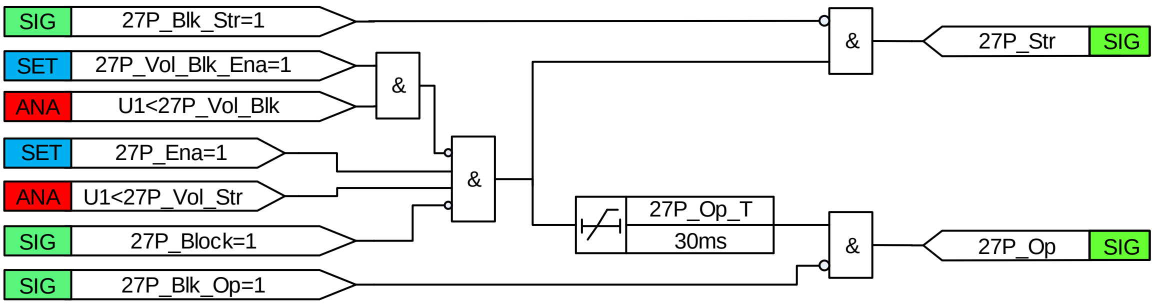


Figure 3.16-2 Functional module diagram

The calculated positive-sequence voltage is compared to the set 27P_Vol_Str setting. If the value drops below the set 27P_Vol_Str and no block signal is activated, the timer and 227P_Str signal are activated.

A low-level blocking functionality for cases where the positive-sequence voltage is below the desired level is applied. This feature is useful when unnecessary starts and operates are wanted to avoid during, for example, an auto reclose sequence. The low-level blocking is activated by default (27P_Vol_Blk_Ena is set to “1”) and the blocking level can be set with the 27P_Vol_Blk setting.

Where:

27P_Vol_Str is the preset value to check for the voltage violation.
27P_Vol_Blk_Ena can enable internal blocking.
27P_Vol_Blk is the internal blocking voltage level.
27P_Op_T is operating delay time for 59P.

The time characteristic is according to DT. When the operation timer has reached the value set by 27P_Op_T, the 27P_Op output is activated if the under voltage condition persists. If the positive-sequence voltage normalizes before the module operates, the operation resets with a time delay of 30ms.

The binary input 27P_Block can be used to block the function. The activation of the 27P_Block input deactivates all outputs and resets internal timers. The binary input 27P_BlkStr can be used to block the start signals. The binary input 27P_BlkOp can be used to block the operation signals.

3.16.3 27P Application Scope

27P can be applied for protecting a power station used for embedded generation when network faults like short circuits or phase-to-earth faults in a transmission or a distribution line cause potentially dangerous situations for the power station.

27P complements other loss-of-grid protection principles based on the frequency and voltage operation.

Motor stalling and failure to start can lead to a continuous under voltage. The positive- sequence under voltage is used as a backup protection against the motor stall condition.

3.16.4 27P Settings

Table 3.16-3 27P settings

No.	Name	Range	Unit	Step	Default	Description
1	27P_Vol_Str	1.00 -120.00	V	0.01	110	Positive sequence under voltage start value
2	27P_Op_T	0.04-120.00	s	0.01	0.04	Operate delay time
3	27P_Vol_Blk	0.00-100.00	V	0.01	30	Internal blocking voltage level
4	27P_Vol_Blk_Ena	0-1	-	1	0	Enable Internal Blocking
5	27P_Ena	0-1	-	1	0	Operation Enable/Disable

3.17 Under voltage protection CUB_27

3.17.1 CUB_27 Overview

The under voltage protection function CUB_27 is used to disconnect capacitor from the system when the voltage of capacitor is less than setting value.

3.17.1.1 Function Block

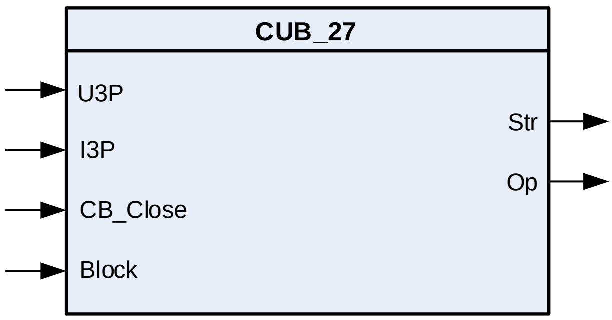


Figure 3.17-1 Function block

3.17.1.2 Signals

Table 3.17-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
CB_Close	The close position of CB
Block	This signal blocks all the binary output signals of the function

Table 3.17-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.

3.17.2 CUB_27 Protection Principle

The function can be enabled and disabled with the Operation setting. The corresponding parameter values are "On" and "Off".

The operation of CUB_27 can be described using a module diagram. All the modules in the diagram are explained in the next sections.

3.17.2.1 Initiation logic

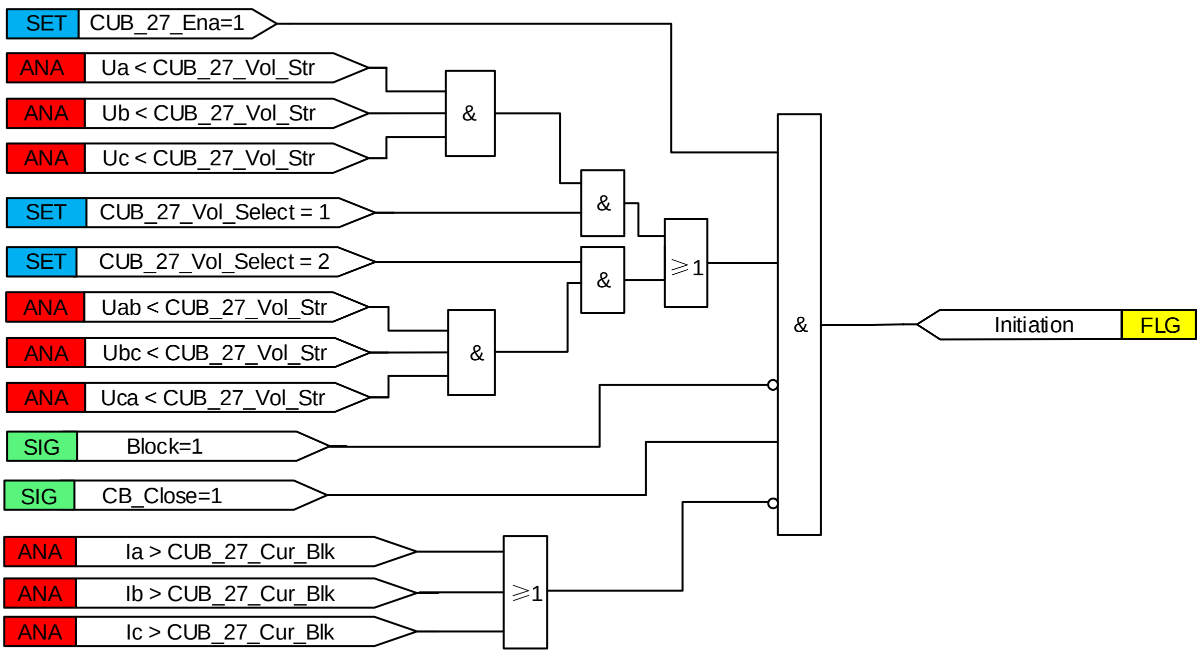


Figure 3.17-2 The initial diagram

When the relay is enabled, the fundamental frequency component of the measured three phase voltages and currents are compared phase-wise to the set Start value. If the three phase voltages are lower than the set value of the voltage, the relay will initial.

3.17.2.2 Timer element

The functional module diagram is shown as below:

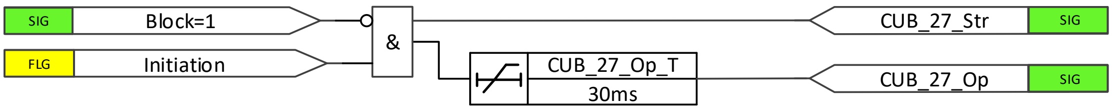


Figure 3.17-3 Timer element

If the initiation condition is satisfied and no block signal is activated, the CUB_27_Str signal is activated.
The time characteristic is according to DT. When the operation timer has reached the value set by CUB_27_Op_T, the CUB_27_Op is activated. Alm output is activated If the three phase voltages normalize before the module operates, the operation resets with a time delay of 30ms.

3.17.3 CUB_27 Application Scope

CUB_27 relay is applied to capacitors. The capacitor may have residual voltage after cutting off power. During restoring period, the capacitor may withstand overvoltage due to residual voltage, which will damage the capacitor.

3.17.4 CUB_27 Settings

Table 3.17-3 Capacitor 27 settings

No.	Name	Range	Unit	Step	Default	Description
1	CUB_27_Cur_Blk	0.04-20.00In	A	0.01In	0.04In	The current blocking value
2	CUB_27_Vol_Str	1.00 -120.00	V	0.01	50.00	The voltage start value
3	CUB_27_Op_T	0.04 –120.00	s	0.01	120.0	The time delay of definite time
4	CUB_27_Ena	0-1	-	1	0	Relay Enable/Disable
5	CUB_27_Vol_Select	1-2	-	1	2	The Stage i voltage parameter selection criteria: 1 for phase voltages; 2 for phase-to-phase voltages

3.18 Over frequency protection 81O

3.18.1 81O Overview

The feeder relay provides a two-stage over frequency protection with independent definite time delay characteristics, and each stage has the same protection logics.

An increase in system frequency occurs, e.g. when large blocks of load (island network) are removed from the system, or again when a malfunction occurs with a generator governor. This entails risk of self-excitation for generators feeding long lines under no-load conditions.

The calculation of the frequency is based on the voltage sampled values.

3.18.1.1 Function Block

The function block of the protection is as below.

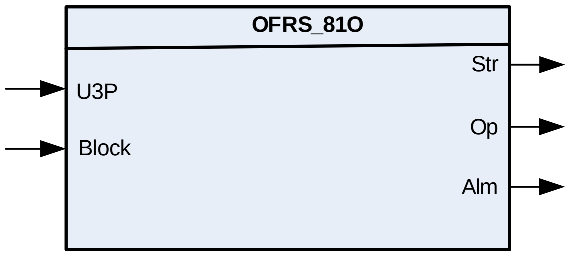


Figure 3.18-1 Function block

3.18.1.2 Signals

Table 3.18-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function

Table 3.18-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.

3.18.2 81O Protection Principle

The over frequency protection function can be enabled or disabled by setting the corresponding 81O_Ena parameter values as "1" or "0".

The operation of the over frequency protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The two-step protection logic is almost the same except for the individual settings, the functional module diagram of step 1 is shown as below:

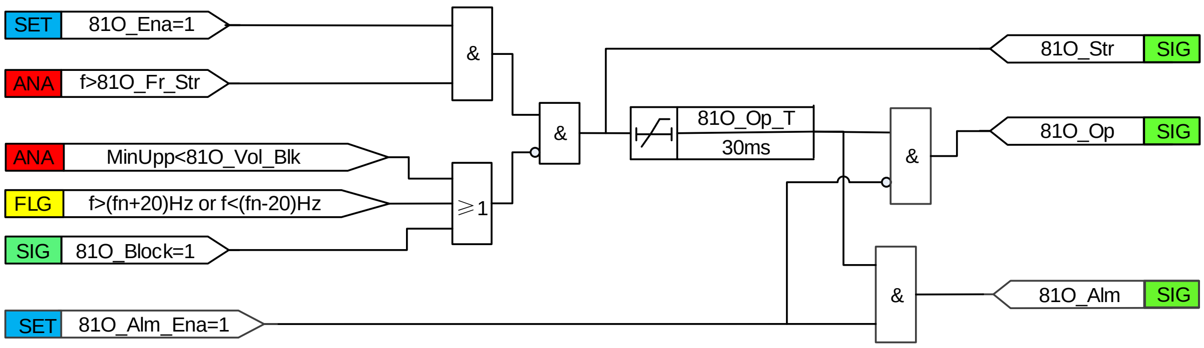


Figure 3.18-2 Functional module diagram

The fundamental frequency of the voltage is compared to the start value setting. If the frequency exceeds the set 81O_Fr_Str and no block signal is activated, the timer and 81O_Str signal are activated. However, if the voltage magnitude is below the 81O_Vol_Blk set value or the difference between the measured frequency and the rated frequency exceeds 20 Hz, the timer and 81O_Str signal are deactivated.

Where:

81O_Fr_Str is the Frequency setting of the 81O.

81O_Op_T is the operate time setting of the 81O.

The time characteristic is according to DT. When the operation timer has reached the value set by 81O_Op_T, the OPERATE output is activated. If the frequency becomes normal before the module operates, the operation resets after 30ms.

The activation of the BLOCK input resets the timer and deactivates the OPERATE and START outputs.

Note:

The reset value is the startup setting -0.02Hz

3.18.3 81O Application Scope

81O is applicable in all situations where high levels of the fundamental frequency of power system voltage must be reliably detected. A high fundamental frequency in a power system indicates that there is an unbalance between production and consumption. In this case, the available generation is too large compared to the power demanded by the load connected to the power grid. If the situation continues and escalates, the power system loses its stability.

The over frequency function detects such situations and provides an output signal suitable for example for generator shedding. The function can also be used as a sub-nominal frequency stage initiating load restoring. The over frequency function is very sensitive and accurate and can also be used to alert operators that frequency has slightly deviated from the set-point and that manual actions can suffice.

3.18.4 81O Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.18-3 81O settings

No.	Name	Range	Unit	Step	Default	Description
1	81Oi_Ena	0-1	-	1	0	The Stage i Operation Enable/Disable
2	81Oi_Alm_Ena	0-1	-	1	0	The Stage i Alarm Enable/Disable
3	81Oi_Fr_Sta	40.00-80.00	Hz	0.01	51.20	The Stage i Frequency start value: 50-70 at Fn=50; 60-80 at Fn=60
4	81Oi_Op_T	0.04-200.00	s	0.01	0.04	The Stage i Operate time delay
5	81Oi_Vol_Blk	18.00-120.00	V	0.01	30	The Stage i Block value of low voltage

3.19 Under frequency protection 81URS

3.19.1 81URS Overview

The feeder relay provides a five-stage under frequency protection with independent definite time delay characteristics, and each stage has the same protection logics.

The calculation of the frequency is based on the voltage sampled values. Four cycles of the voltage sampled values are fixedly adopted for the frequency calculation.

3.19.1.1 Function Block

The function block of the protection is as below.

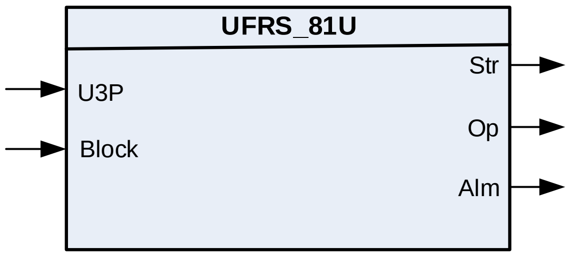


Figure 3.19-1 Function block

3.19.1.2 Signals

Table 3.19-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function

Table 3.19-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.

3.19.2 81URS Protection Principle

The under frequency protection function can be enabled or disabled by setting the corresponding 81URS_Ena parameter values as "1" or "0".

The operation of under frequency protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

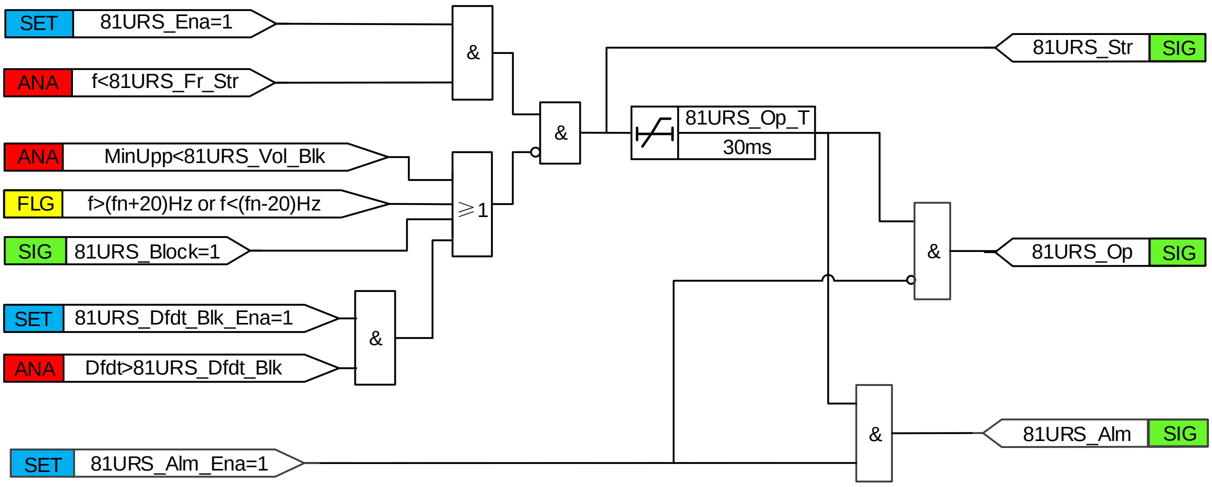


Figure 3.19-2 Functional module diagram

The fundamental frequency is compared to the 81URS_Fr_Str setting. If the frequency is lower than the set 81URS_Fr_Str and no block signal is activated, the operate timer and 81URS_Str signal are activated. However, if the voltage magnitude is below the 81URS_Vol_Blk set value, the difference between the measured frequency and the rated frequency exceeds 20 Hz or slip-frequency exceeds 81URS_Dfdt_Blk when 81URS_Dfdt_Blk_Ena = 1, the operate timer and 81URS_Str signal are deactivated.

Where:

81URS_Fr_Str is the frequency setting of the 81URS.

The measured frequency is available in the monitored data view.

The time characteristic is according to DT. When the operation timer reaches the value set by 81URS_Op_T, the 81URS_Op output is activated. If the fault disappears before the module operates, the operation reset delay time is 30ms.

The activation of the 81URS_Block input resets the timer and deactivates the 81URS_Op and

81URS_Str outputs.

Note:

The reset value is the startup setting +0.02Hz

3.19.3 81URS Application Scope

81URS is applicable in all situations where a reliable detection of a low fundamental power system voltage frequency is needed. A low fundamental frequency in a power system indicates that the power generated is too low to meet the power demanded by the load connected to the power grid.

The frequency dips rapidly, resulting in load shedding either by the load shedding relays or by the operator action. 81URS detects such situations and provides an output signal suitable for load shedding, generator boosting, set point change in sub-transmission DC systems, gas turbine startup and so on.

The 81URS function is very sensitive and accurate and can also be used to alert the operators that the frequency deviates slightly from the set-point and that manual actions can be sufficient enough to ensure the stability of the system. The under frequency signal is also used for over-excitation detection. If the generator is still energized, the system experiences over-excitation due to the low frequency.

3.19.4 81URS Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.19-3 81URS settings

No.	Name	Range	Unit	Step	Default	Description
1	81URSi_Fr_Str	40.00-80.00	Hz	0.01	48.8	The Stage i Frequency start value: 40-50 at Fn=50; 50-60 at Fn=60
2	81URSi_Op_T	0.04-200.00	s	0.01	0.04	The Stage i Operate time delay
3	81URSi_Vol_Blk	18.00-120.00	V	0.01	30.00	The Stage i Block signal of the function
4	81URSi_Ena	0-1	-	1	0	The Stage i Operation disable / enable
5	81URSi_Alm_Ena	0-1	-	1	0	The Stage i Alarm Enable/Disable
6	81URSi_Dfdt_Blk_Ena	0-1	-	1	0	The Stage i slip-frequency criterion disable/enable
7	81URSi_Dfdt_Blk	0-10.00	Hz/s	0.01	10.00	The Stage i slip-frequency setting value

3.20 Under frequency restore protection 81URE

3.20.1 81URE Overview

The feeder relay provides a one-stage under frequency restore protection with independent definite time delay characteristics.

A decrease in system frequency occurs when the system experiences an increase in the real power demand, or when a malfunction occurs within a generator governor or automatic generation control system. The under frequency protection will operate and disconnect load from the power system. After the frequency recovers to normal level, the disconnected load will be restored by using the under frequency restore protection.

The calculation of the frequency is based on the voltage sampled values.

3.20.1.1 Function Block

The function block of the protection is as below.

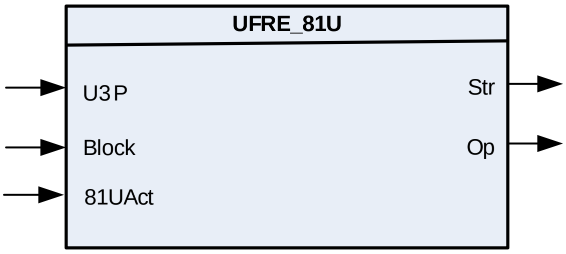


Figure 3.20-1 Function block

3.20.1.2 Signals

Table 3.20-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
81U_Act	This 81U operation signal.

Table 3.20-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.

3.20.2 81URE Protection Principle

The under frequency restore protection function can be enabled or disabled by setting the corresponding 81URE_Ena parameter values as "1" or "0".

The operation of under frequency restore protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

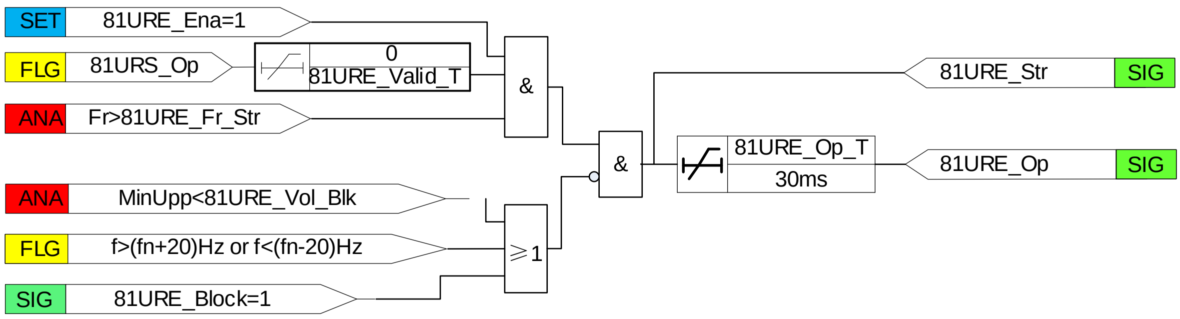


Figure 3.20-2 Functional module diagram

- **Restoring frequency element**

After the 81URE_Op output is activated with a duration time of 81URE_Valid_T and the frequency has returned to a value higher than the set value of 81URE_Fr_Str, the timer and 81URE_Str signal are activated. However, if the minimum voltage magnitude is below the 81URE_Vol_Blk set value or the difference between the measured frequency and the rated frequency exceeds 20 Hz, the operate timer and 81URE_Str signal are deactivated.

Where:

81URE_Fr_Str is the restore frequency setting value of the 81URE.

- **Restore timer element**

Once activated, the 81URE_Op output is activated after the set 81URE_T. The time characteristic is according to DT. If the frequency drops below the set value of 81URE_Fr_Rstore before 81URE_Op is activated, the 81URE_Op will reset with a time delay of 30 ms.

Where:

81URE_T is the restore time setting of the 81URE.

The 81URE_Op output remains active for 100 ms.

Activating the 81URE_Block input deactivated the restoring operation. If the restoring command is cancelled, the 81URE_Op output can be activated only when the next load-shedding operation is detected, that is, when the 81URE_Op output is activated.

The activation of the 81URE_Block deactivates the 81URE_Op output.

3.20.3 81URE Application Scope

81URS is applicable in all situations where a reliable detection of a low fundamental power system voltage frequency is needed. A low fundamental frequency in a power system indicates that the power generated is too low to meet the power demanded by the load connected to the power grid.

The frequency dips rapidly, resulting in load shedding either by the load shedding relays or by the operator action. 81URE detects such situations and provides an output signal suitable for load shedding. When the system recovers from the disturbance after the action of the under frequency protection, the operating frequency recovers to nominal frequency. The load that was shed during the disturbance can be restored.

3.20.4 81URE Settings

Table 3.20-3 81URE settings

No.	Name	Range	Unit	Step	Default	Description
1	81URE_Fr_Str	40.00-80.00	Hz	0.01	48.8	The Stage i Frequency start value: 40-50 at Fn=50; 50-60 at Fn=60
2	81URE_Op_T	0.04-200.00	s	0.01	0.04	Operate time delay
3	81URE_Valid_T	0.04-200.00	s	0.01	0.04	Valid duration time of operation for under frequency protection
4	81URE_Vol_Blk	18.00-120.00	V	0.01	30.00	Block signal of the function
5	81URE_Ena	0-1	-	1	0	Operation disable/enable

3.21 Frequency gradient protection 81R

3.21.1 81R Overview

This relay provides one-stage frequency gradient protection with independent definite time delay characteristic.

The calculation of the frequency and frequency rate are based on the voltage sampled values.

3.21.1.1 Function Block

The function block of the protection is as below.

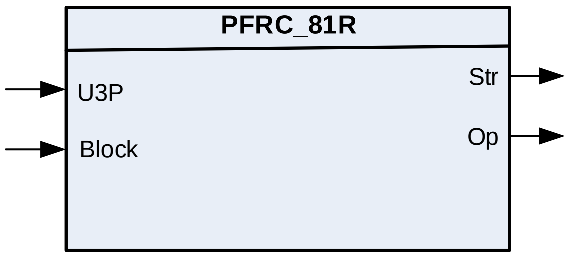


Figure 3.21-1 Function block

3.21.1.2 Signals

Table 3.21-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function

Table 3.21-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.

3.21.2 81R Protection Principle

The frequency gradient protection function can be enabled or disabled by setting the corresponding 81R_Ena parameter values as "1" or "0".

The operation of frequency gradient protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

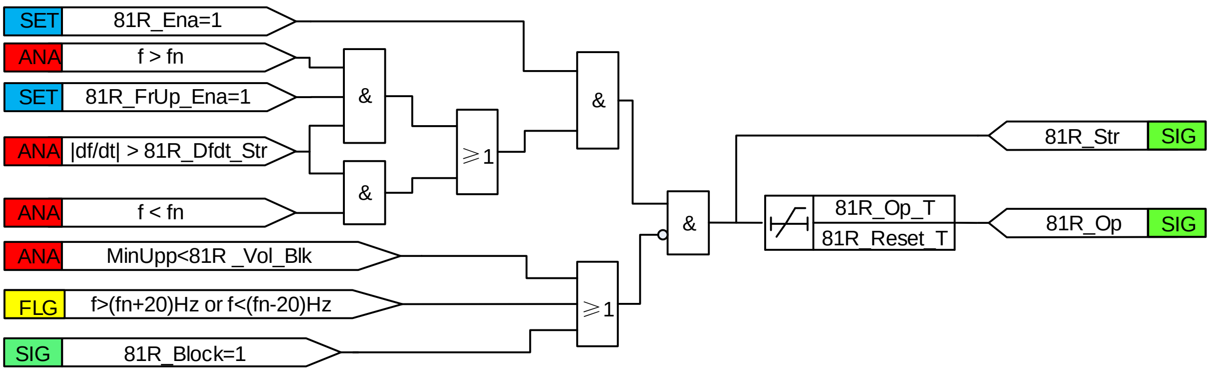


Figure 3.21-2 Functional module diagram

The changing rate of the frequency of the positive sequence voltage is calculated from phase-to-phase or phase-to-earth voltages and compared to the set 81R_Dfdt_Str. If the measured frequency changing rate is higher than the set 81R_Dfdt_Str and no block signal is activated, the operate timer and 81R_Str signal are activated. However, if the voltage magnitude is below the 81R_Vol_Blk set value or the difference between the measured frequency and the rated frequency exceeds 20 Hz, the operate timer and 81R_Str signal are deactivated.

81R_Dfdt_Str is the frequency gradient start value. When the setting 81R_FrUp_Ena equals 1, it means a positive change in frequency. Otherwise, it means a negative change in frequency.

Once activated, the 81R_Str output activates. The time characteristic is according to DT. When the operation timer has reached the value set by 81R_Op_T, the 81R_Op output is activated. If the frequency gradient condition disappears before the module operates, the operation resets with a set time delay of 81R_Reset_T.

The activation of the 81R_Block input resets the timer and deactivates the 81R_Op and 81R_Str outputs.

Where:

81R_Op_T is the operation delay time setting of the 81R.

81R_Reset_T is the reset delay time setting of the 81R.

3.21.3 81R Application Scope

81R is applicable in all the situations where the change of the fundamental power system voltage frequency should be detected reliably. 81R can be used for both increasing and decreasing of the frequencies.

This function provides a trip signal suitable for load shedding, generator shedding, generator boosting and gas turbine startup. The frequency gradient is often used in combination with a low frequency signal, especially in smaller power systems where the loss of a fairly large generator requires quick remedial actions to secure the power system's integrity.

3.21.4 81R Settings

Table 3.21-3 81R settings

No.	Name	Range	Unit	Step	Default	Description
1	81R_Dfdt_Str	0.00- 10.00	Hz/s	0.01	0.50	Frequency gradient start value
2	81R_Op_T	0.12-60.00	s	0.01	0.20	Operate time delay
3	81R_Vol_Blk	18.00-120.00	V	0.01	30.00	Block signal of the function
4	81R_Reset_T	0.00-60.00	s	0.01	0.02	Time delay for reset
5	81R_FrUp_Ena	0-1	-	1	0	Negative/positive change in frequency:0 for negative, 1 for positive
6	81R_Ena	0-1	-	1	0	Operation Disable/Enable

3.22 Automatic Reclose 79AR

3.22.1 Overview

To maintain the integrity of the overall electrical transmission system, the device is installed on the transmission system to isolate faulted segments during system disturbances. Faults caused by lightning, wind, or tree branches could be transient in nature and may disappear once the circuit is de-energized. According to statistics, 80%-90% of the faults on overhead lines are the transient faults. Auto-reclosing systems are installed to restore the faulted section of the transmission system once the fault is extinguished (providing it is a transient fault). For certain transmission systems, auto-recloser is used to improve system stability by restoring critical transmission paths as soon as possible.

When the auto-reclosing command is issued, the reclaim timer starts. If the circuit breaker does not trip again, the auto-recloser resets at the end of the reclaim time. If another protection operates during the reclaim time delay, this relay either proceeds to the next shot in the programmed auto-reclosing cycle, or it lockouts if all programmed reclose attempts have been made. The reclaim time should be set long enough to allow this relay to operate when the circuit breaker is automatically closed onto a fault.

3.22.1.1 Function Block

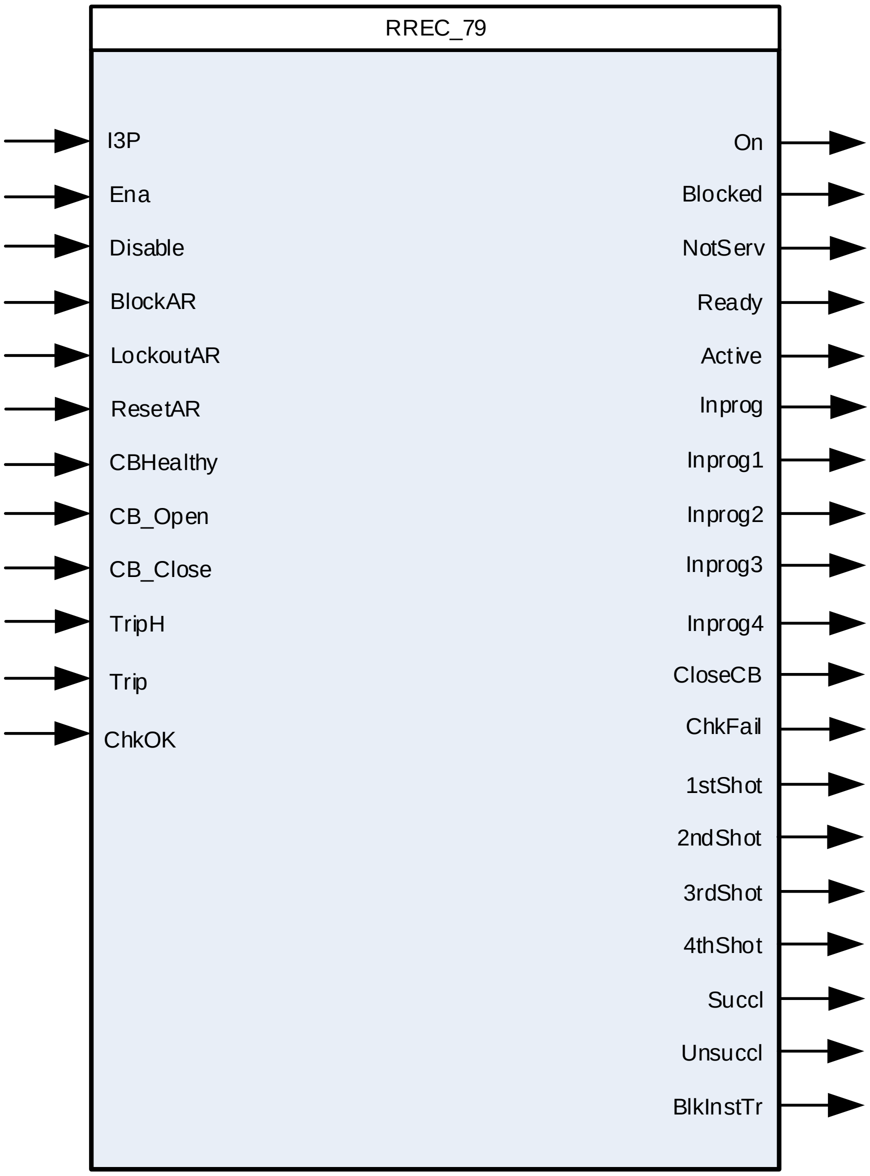


Figure 3.22-1 Autorecloser block

3.22.1.2 Signals

Table 3.22-1 Input Signals

NO.	Signal	Description
1	I3P	The current magnitude in all the three phases
2	Ena	Binary input for enabling AR. If the logic setting ExtCtrl =1,enabling AR will be controlled by the external input and Enable Setting
3	Disable	Binary input for disabling AR. If the logic setting ExtCtrl =1, disabling AR will be controlled by the external input. Enabling AR will be controlled by the external input and Enable Setting.

NO.	Signal	Description
4	BlockAR	Binary input signal to block, if AR is blocked, the ready status will be clear and AR out of serve will be active.
5	LockoutAR	Binary input signal to lockout, if AR is lockout, it need to be reset automatically or manually ,and also the ready status will be clear and AR NotServ BO will be active.
6	ResetAR	Binary input signal to reset auto-recloser. If the logic setting 79AR_AutoRst =0, the lockout AR only can be reset by this input.
7	CB_Healthy	Binary input of circuit breaker in healthy condition
8	CB_Open	The position indication of the circuit breaker, normally closed.
9	CB_Close	The position indication of the circuit breaker, normally open.
10	TripH	Tripping circuit breaker by instantaneous tripping protection
11	Trip	Tripping circuit breaker by delay time tripping protection
12	ChkOK	Synchronizing OK signal from 25SYN

Table 3.22-2 Output Signals

NO.	Signal	Description
1	On	Automatic reclose is enabled
2	Blocked	Automatic reclose is blocked
3	NotServ	Automatic reclose is out of service
4	Ready	Automatic reclose is ready for reclosing cycle
5	Active	Automatic reclosing is active
6	Inprog	AR is in progress
7	Inprog1	AR is in progress for first shot
8	Inprog2	AR is in progress for second shot
9	Inprog3	AR is in progress for third shot
10	Inprog4	AR is in progress for forth shot
11	CloseCB	Close command for circuit breaker
12	ChkFail	Re-closing condition checking fail signal
13	1stShot	The first shot reclosing attempts
14	2ndShot	The second shot reclosing attempts
15	3rdShot	The third shot reclosing attempts
16	4thShot	The forth shot reclosing attempts
17	Succl	Automatic reclosing is successful
18	Unsuccl	Automatic reclosing is unsuccessful
19	BlkInstTr	Block Instantaneous Protection trip

3.22.2 Operation Principle

This auto-reclosing logic can be used with either integrated device or external device. When the auto-reclose is used with integrated device, the internal protection logic can initiate AR, moreover, a tripping contact from external device can be connected to the device via opto-coupler input to initiate integrated AR function.

3.22.2.1 Enable AR (AR ON)

AR function can be enabled by internal logic settings of AR mode or external signal via binary inputs in addition to internal logic setting 79AR_Enable. When the setting 79AR_ExtCtrl is set as “1”, AR enable are determined by external signal via binary inputs and logic settings. When logic setting 79AR_ExtCtrl set as “0”, AR enable are determined only by logic settings. When AR is enabled, the device will output contact 79AR_On.

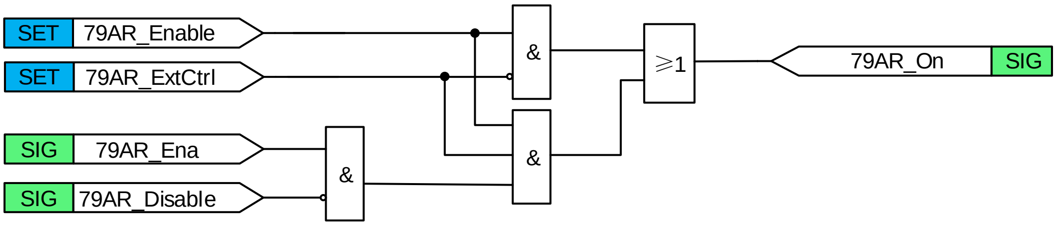


Figure 3.22-2 AR On

3.22.2.2 AR Ready

An auto-recloser must be ready to operate before performing reclosing. The output signal 79AR_Ready means that the auto-recloser can perform at least one shot of reclosing function, i.e., breaker open-close-open. When the device is energized or after the settings are modified, 79AR cannot be ready unless the following conditions are met:

- AR is enabled (79AR_On=1).
- The CB_Open flag is 0 (when the CB close position is 1 or the CB_Open position is 0) and last for 79_CBClose_T.
- The CB healthy is 1 and last for 79_CBHealthy_T, such as, normal storage energy and no low pressure signal
- There is no blocked signal.

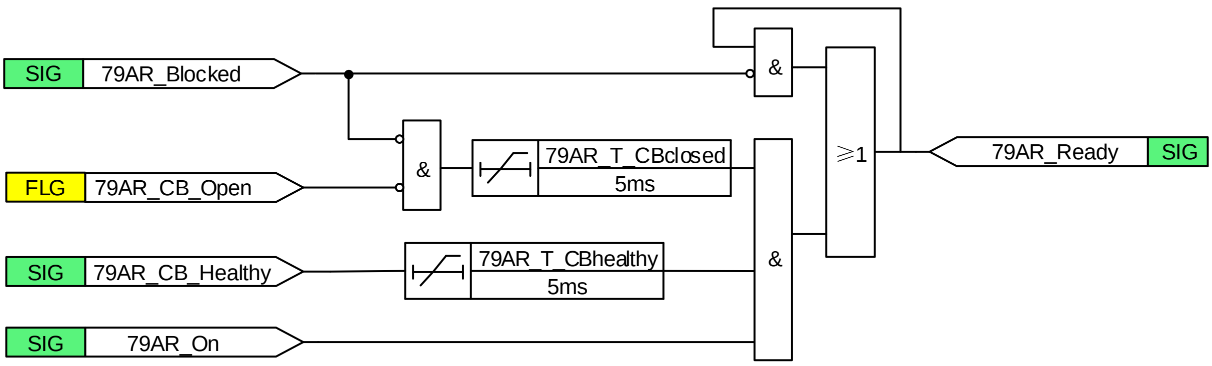


Figure 3.22-3 AR Ready

The input signal 79AR_CB_Healthy must be energized before AR gets ready. Because most circuit breakers can finish one complete process: open-closed-open, it is necessary that circuit breaker has enough energy before reclosing. When AR is ready, if CB_Close become 0 from 1 and last for 400ms or CB_Healthy become 0 from 1 and last for 200ms, AR_Ready will drop off and AR_NotServ BO will be initialized.

When auto-reclose is blocked, AR ready will be drop off immediately and next auto-reclosing will be disabled.

3.22.2.3 AR Initiation

When 79AR is initiated, the device will initialize a new shot and output 79AR_Active signal until AR drop off after Reclaim time. When AR is active, the 79AR_BlkInstTr BO is active until 79AR_Active is returned. There are two methods to initialize the AR:

- AR initiated by tripping signal

79AR can be initiated by tripping signal, and the tripping signal may be from internal trip signal or external trip signal.

When 79AR is ready to reclose and the tripping command is received, this tripping command will be kept in the device, 79AR will be initiated after the tripping command drops off (Drop off condition: corresponding phase current is nil: IA/B/C/3I0D≤0.05In).

The 79AR_TripH can be used to initial the 79AR is some projects, but it is also used to block the 79AR in another project, which can be configured by setting 79AR_TripHBlkEna. When the setting 79AR_TripHBlkEna is not used, the logic is 79AR Initiated by Tripping Signal. When the setting 79AR_TripHBlkEna is used, the logic is 79AR Lockout conditions, if 79AR_TripHBlkEna=0, the 79AR will be initial but not lockout when 79AR_TripH=1.

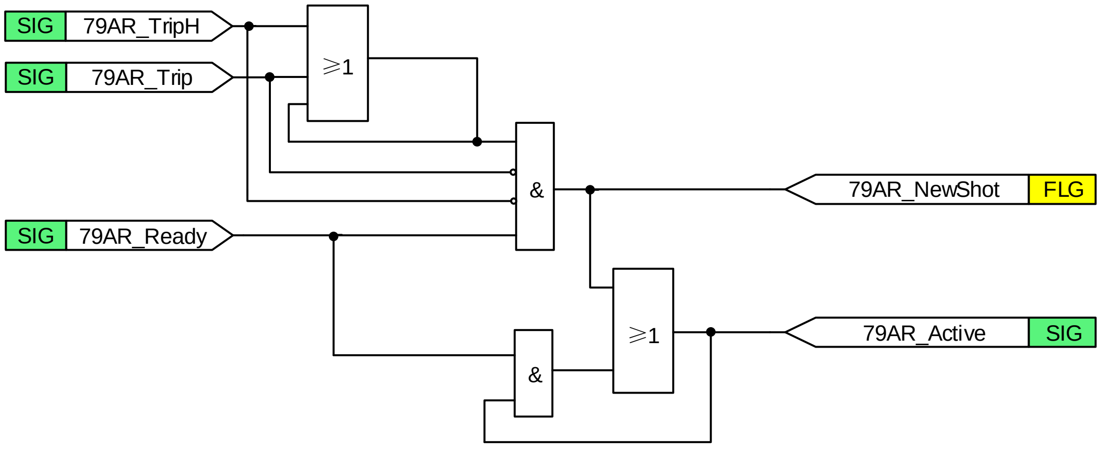


Figure 3.22-4 79AR Initiated by Tripping Signal

- AR initiated by CB State

The setting 79AR_CBStr is available for selection that 79AR is initiated by CB state. When 79AR is ready to reclose, 79AR will be initiated if circuit breaker is open and corresponding phase current is nil (IA/B/C/3I0D≤0.05In).

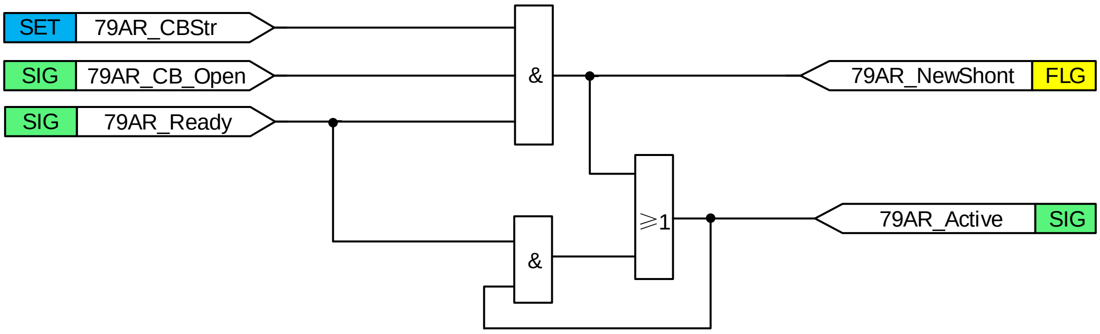


Figure 3.22-5 79AR Initiated by CB State

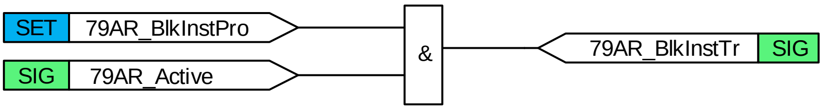


Figure 3.22-6 79AR block instantaneous protection

3.22.2.4 AR Reclosing

When a new shot is initialized, the AR is in process. The AR contains two types of start commands at the first shot: high speed or time delayed startup signal (such as: By instantaneous or time delay units of overcurrent relay startup). The starting signal determines whether a high speed or delay recloses and time delay required for each reclose, until the final tripping is made.

For the first shot, if AR is activated by input 79AR_TripH, the dead time is 79AR_T_DeadTimeH without synchro check, if AR is activated by input 79AR_Trip, the dead time is 79AR_T_DeadTime1, another shots dead time are 79AR_T_DeadTime2, 79AR_T_DeadTime3 and 79AR_T_DeadTime4 separately. This function can be enabled or disabled by setting 79AR_TripHBlkEna, if 79AR_TripHBlkEna=1, the input 79AR_TripH will block the AR function.

Except the high speed startup, the synchro check condition is judged by settings 79_Sync_Ena. When the dead time delay of AR expires after AR is initiated, if the setting 79_Sync_Ena=1, the release of reclosing command shall be subject to the result of synchronism check. After the dead time delay of AR expires, if the synchronism check is still unsuccessful within the time delay 79AR_T_WaitSyn, the signal of synchronism checks failure 79AR_ChkFail will be output and the AR will be blocked. If the setting 79_Sync_Ena=0, the condition of synchronism checks success 25SYN_Chk_OK will always be established. And the signal of synchronism checks success 25SYN_Chk_OK from the synchronism check logic can be applied by auto-reclosing function inside the device or external synchronism device.

If a circuit breaker close command is given successfully at the end of the dead time, a reclaim time starts. The reclosing pulse length may be set through the setting 79AR_T_Pluse. If the circuit breaker does not trip again within reclaim time setting 79AR_T_Reclaim, the AR indicates a successful reclosing and resets into "ready" status. If the protection trips again during the setting 79AR_T_Reclaim, the sequence advances to the next shot. If all reclosing attempts have been made and the circuit breaker does not remain closed, the AR indicates an unsuccessful reclosing.

The 79AR_RUN_Circle_N is counted from 1 (the first shot) in a reclosing cycle, the 79AR_RUN_Circle_N plus 1 when AR reclose command issues, and also the reclaim timer will start, if there is no trip startup signal, it means AR reclose successfully, the AR will return to ready status and wait for next reclose reclosing cycle. If there is a new trip startup signal in the reclaim time, and also 79AR_RUN_Circle_N is less than the setting 79AR_Circle_N, AR will go to next shot.

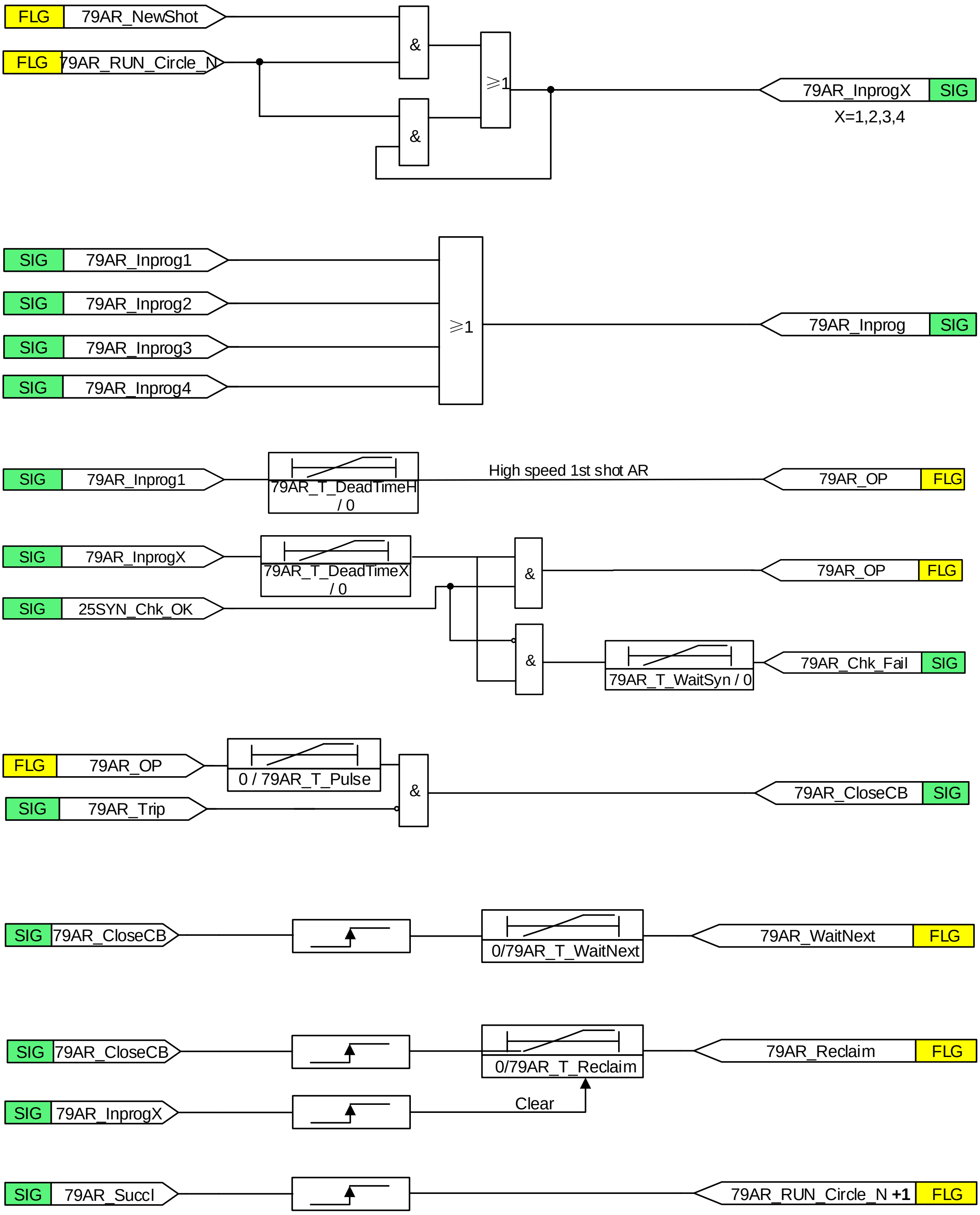


Figure 3.22-7 79AR Pulse and Reset

3.22.2.5 Reclosing Success and Unsuccess

For transient fault, the fault will be cleared after the device operates to trip. After the reclosing command is issued, AR will drop off after time delay 79AR_T_Pluse, and can carry out next reclosing. When the reclosing is unsuccessful or the reclosing condition is not met after AR initiated, the reclosing will be considered as unsuccessful, it means that when AR is on, there is a tripping signal cause the CB to be Open status finally in one reclose cycle, there are several cases.

1) If any protection element operates to trip when AR is enabled (79AR_On=1) and AR is not ready (79AR_Ready=0), the device will output the signal 79AR_Unsuccl.
2) For one-shot AR, if the tripping command is received again within reclaim time after the reclosing pulse is issued, the reclosing shall be considered as unsuccessful.
3) For multi-shot AR, if the reclosing times are equal to the setting value of AR number and the tripping command is received again after the last reclosing pulse is issued, the reclosing shall be considered as unsuccessful (79AR_RUN_Circle_N > 79AR_Circle_N).
4) There is a block or lockout BI signal after the AR is initialized.
5) After the dead time is escaped, the automatic sequence initiation is not allowed because of a synchronization failure when the time setting 79AR_T_WaitSyn expires.
6) A new shot is initiated during the 79AR_T_WaitNext after AR reclose.
7) The protection trip signal has been active longer than the time set 79AR_T_TrFail since the shot initiation and AR is ready.
8) The circuit breaker is still open after the setting 79AR_T_Unsuc escapes since AR reclose.

After unsuccessful AR is confirmed, if 79AR_UnsucBlk=1, AR will be lockout and AR ready will reset when AR is failure, so AR can be ready only after releasing lockout and the ready conditions are met again. If 79AR_UnsucBlk=0, AR ready will reset but not lockout when AR is failure, so AR will be ready without releasing lockout after the ready conditions are met.

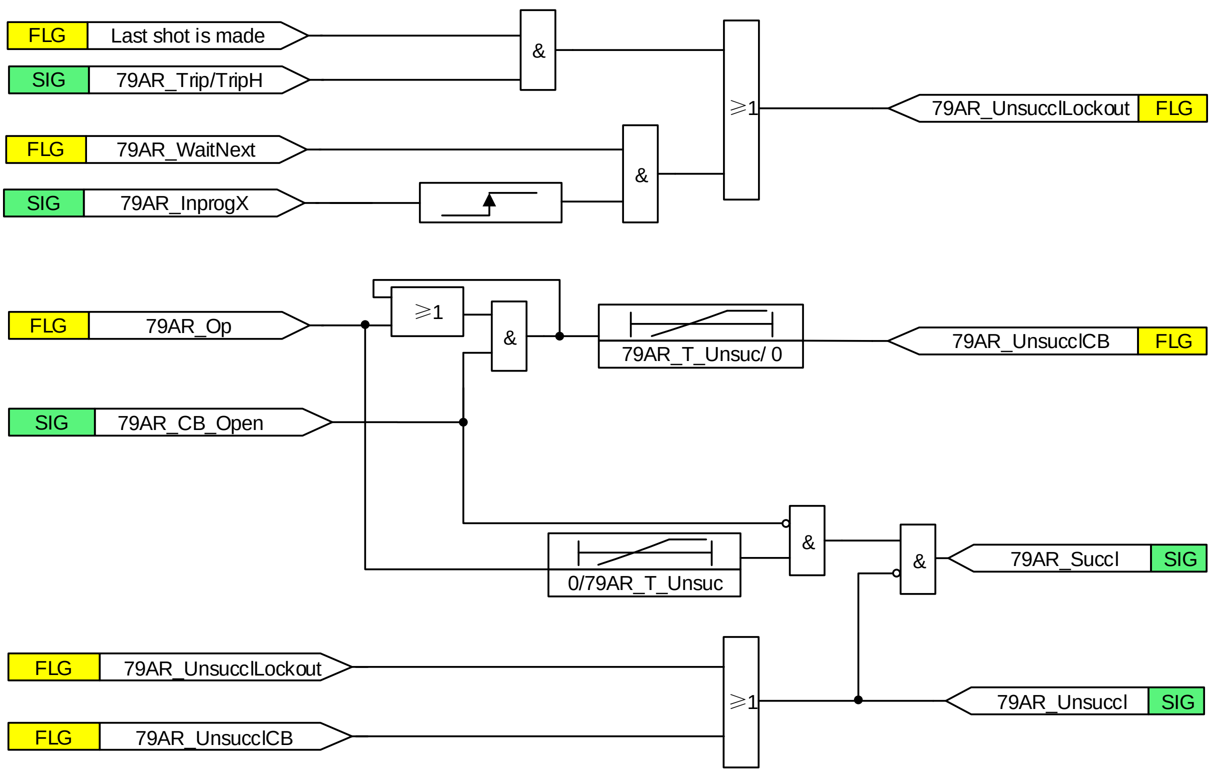


Figure 3.22-8 79AR Success and Unsuccess

3.22.2.6 AR Block and lockout

Beside the above unsuccessful conditions, there are some other block and lockout conditions.

Lockout: 79AR_LockoutAR=1, or the signal 79AR_Unsuccl = 1 and the setting 79AR_UnsucBlk = 1.

When the setting 79AR_TripHBlkEna is used, the logic is 79AR Lockout conditions, if 79AR_TripHBlkEna=1, the 79AR will be lockout when 79AR_TripH=1.

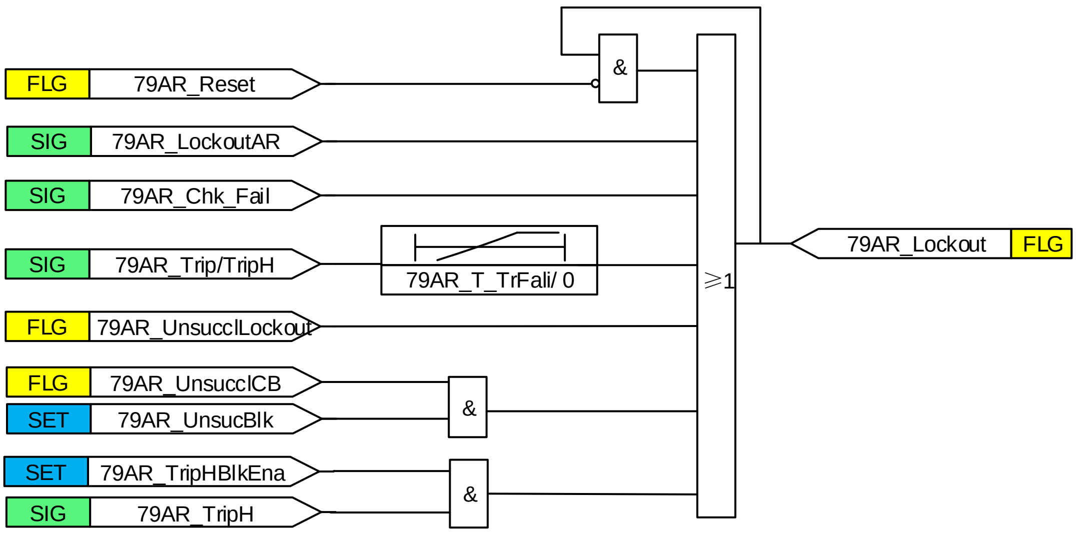


Figure 3.22-9 79AR Lockout conditions

When BI 79AR_BlockAR=1, or AR is in lockout, the 79AR_Blocked BO is active.

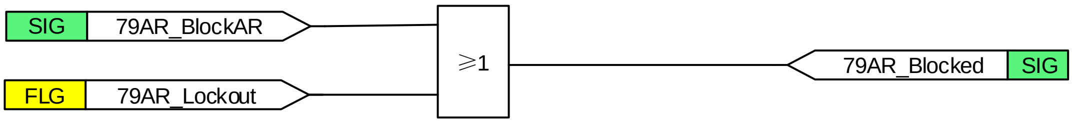


Figure 3.22-10 79AR Blocked BO active

The 79_AR_Ready state will be reset when the 79AR_Blocked BO is active, beside this condition, there are some other reset conditions:

If the CB Close become 0 when AR is not initialized, the 79_AR_Ready state will be reset after 400ms

If the CB Healthy become 0 when AR is not initialized, the 79_AR_Ready state will be reset after 200ms.

When Synchronism check or voltage check is enabled but there are any conditions: PT supervision alarm, line PT supervision alarm or synchronism voltage error.

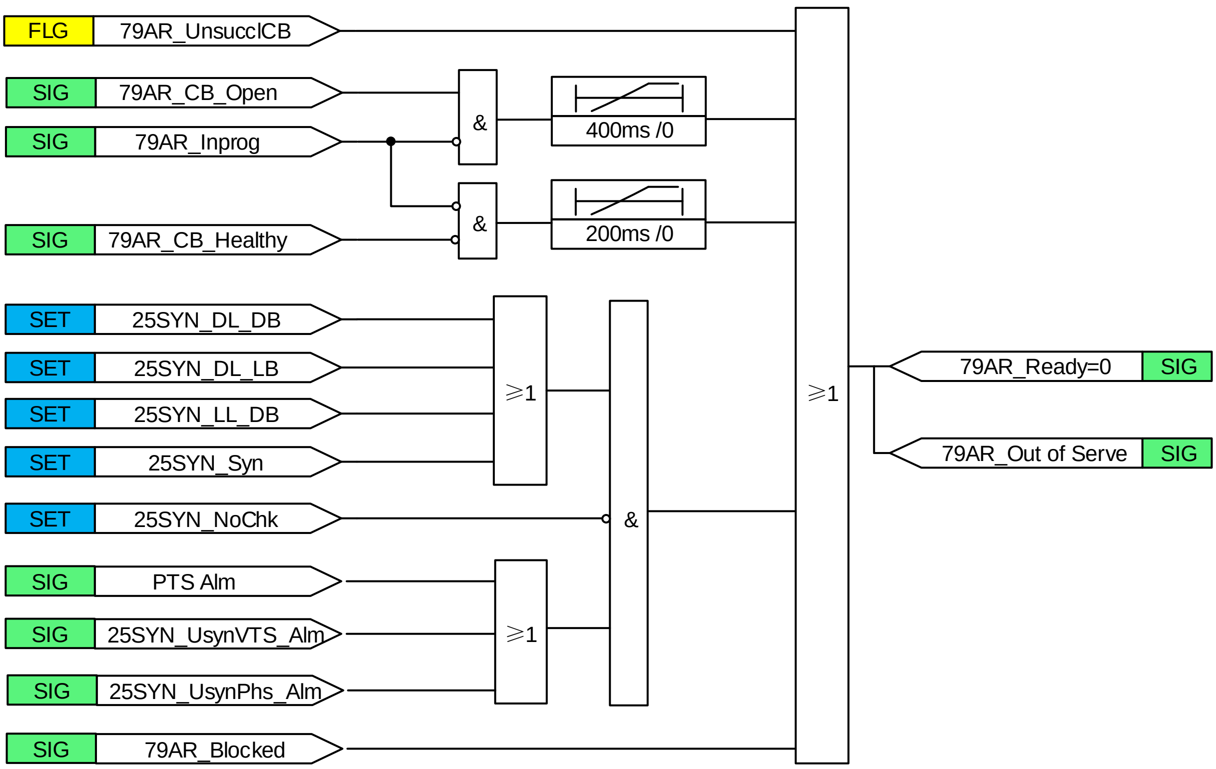


Figure 3.22-11 79AR_Reday reset and Out of Service

3.22.2.7 Reset AR lockout

When the AR function is in lockout status, it means that new sequences cannot be initialized, because AR is insensitive to initiation commands. it can be released from the lockout state if all blocked signals disappear (such as 79AR_LockoutAR BI=0) in the following ways:

• The function is reset through by 79AR_ResetAR BI manually or locally control.

• If the setting 79AR_AutoRst=1, the lockout is automatically reset after the reclaim time.

Note: If the setting 79AR_AutoRst=0, the lockout can be reset only by 79AR_ResetAR BI.

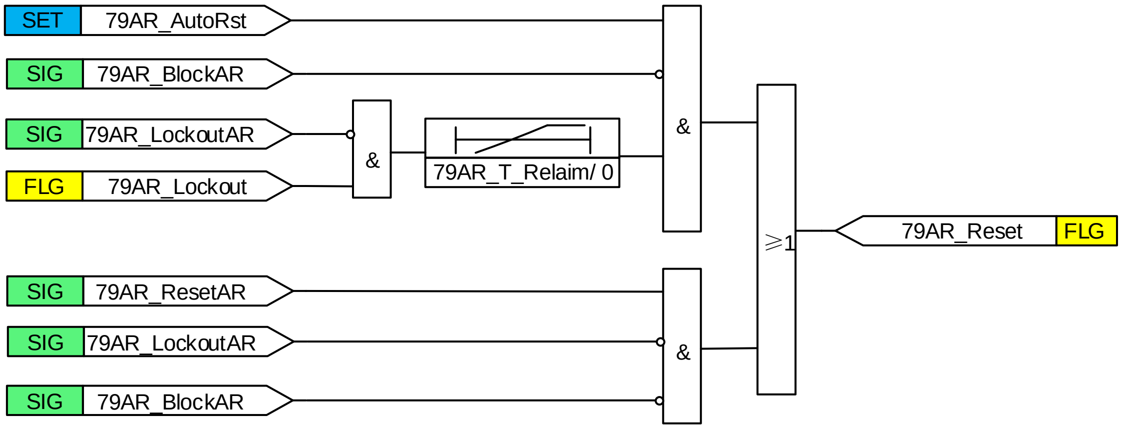


Figure 3.22-12 Reset AR Lockout

3.22.2.8 Reclosing shots count

The reclose shall be provided with counters to count the number of each reclosing attempts and total number of unsuccessful shots, each counter will plus 1 when the reclosing attempt is sent and it can be cleared by submenu [Clr BOCnt], The number will be display in device MENU [Monitor] -> [BO Count].

Table 3.22-3 The number of each reclosing attempts and total unsuccessful shots

NO.	Signal	Description
1	1stShot	Number of the first shot reclosing attempts
2	2ndShot	Number of the second shot reclosing attempts
3	3ndShot	Number of the third shot reclosing attempts
4	4thShot	Number of the forth shot reclosing attempts
5	Unsuc_Shot	Number of total unsuccessful reclosing attempts

3.22.2.9 Typical auto-reclose situation

For the first shot, if AR is activated by input 79AR_TripH, the dead time is 79AR_T_DeadTimeH without synchro check. If the AR cannot reclose during the 79AR_T_Unsuc, the AR Unsuccl BO will be active, the inprog1 BO will be returned. The Reclaim and Unsuccl BO are active until after the 79AR_T_Reclaim is issued.

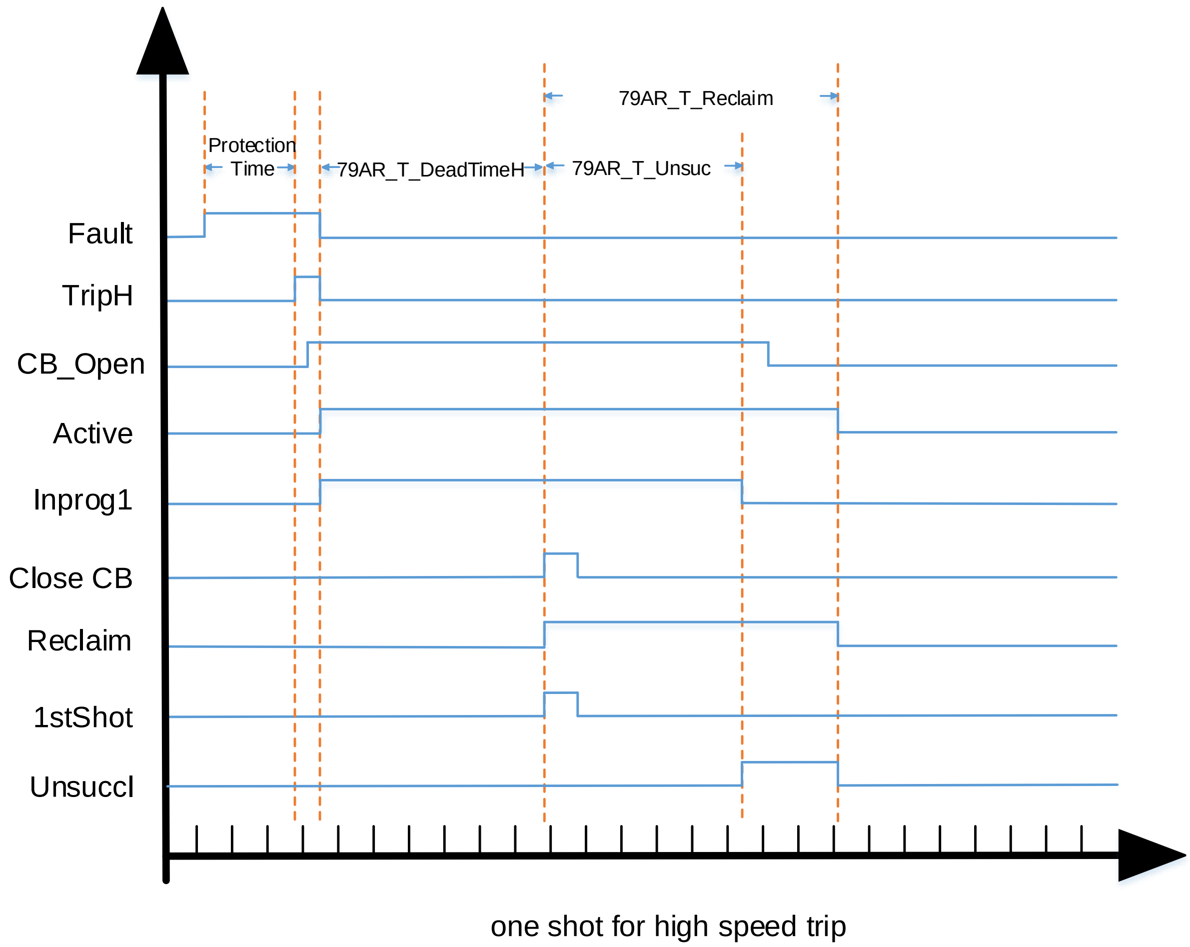


Figure 3.22-13 One shot for high speed trip

If AR is activated by input 79AR_Trip, the dead time is 79AR_T_DeadTime1 with synchro check. After the dead time, the synchronism check will be judge, the AR will send reclose command if the synchronism check is ok during 79AR_T_WaitSyn, otherwise the AR will be unsuccessful. If the AR reclose during the 79AR_T_Unsuc, the AR Succl BO will be active and Inprog1 will be returned.

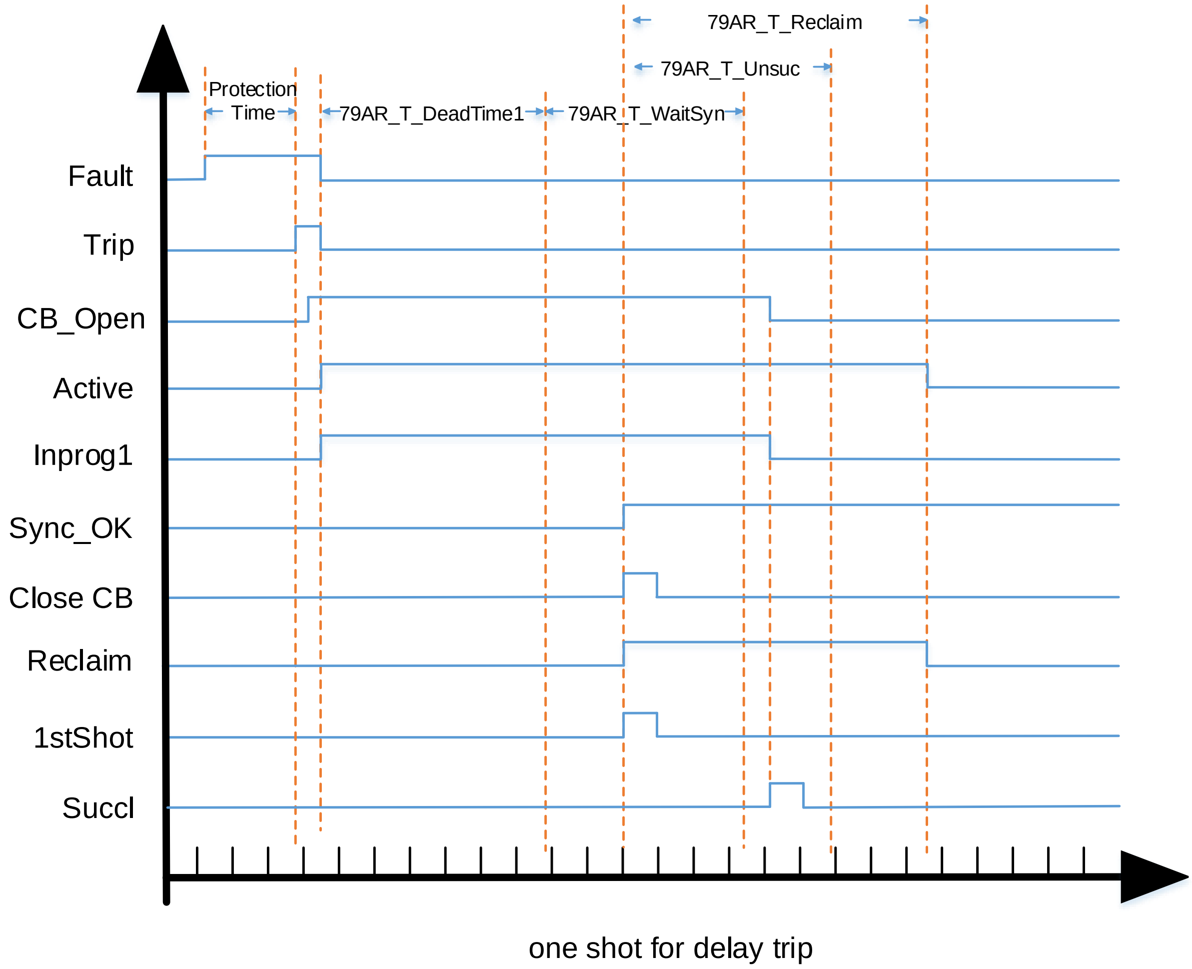


Figure 3.22-14 one shot for delay trip

For two-shot AR, the tripping command is received again after the second reclosing pulse is issued, the reclosing shall be considered as unsuccessful and the blocked BO will be active. When the next reclose command is issued, the last reclaim time will be end, the next progress will begin. When AR is active, the 79AR_BlkInstTr BO is active until 79AR_Active is returned.

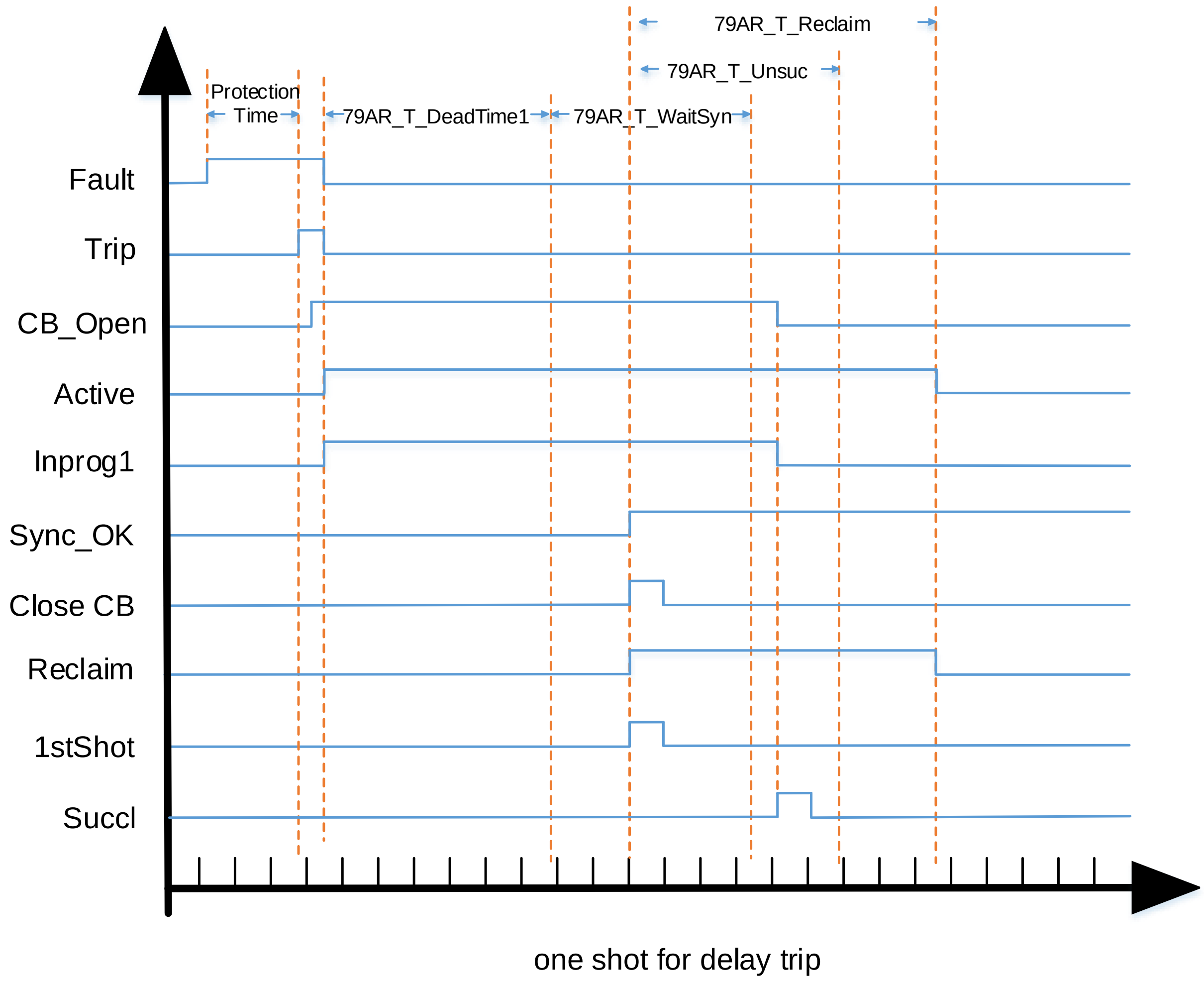


Figure 3.22-15 three times fault happen in two shot AR

3.22.3 Settings

Table 3.22-4 79AR Settings

No.	Name	Range	Unit	Step	Default	Description
1	79AR_Enable	0 -1	-	1	0	Enabling/disabling auto-reclosing 0: disable 1: enable
2	79AR_ExtCtrl	0 -1	-	1	0	Enabling/disabling AR by external input signal besides logic setting 79AR_Enable 0: only logic setting 1: logic setting and external input signal
3	79AR_CBStr	0 -1	-	1	0	Enabling/disabling 79AR be initiated by open state of circuit breaker (three phase) 0: disable 1: enable
4	79AR_BlkInstPro	0 -1	-	1	0	Enabling/disabling 79AR Block instantaneous protection 0: disable

No.	Name	Range	Unit	Step	Default	Description
						1: enable
5	79AR_UnsucBlk	0 -1	-	1	0	Enabling/disabling block AR at unsuccessful reclosing 0: disable 1: enable
6	79AR_AutoRst	0 -1	-	1	1	Enabling/disabling auto reset the blocked status 0: disable 1: enable
7	79AR_TripHBlkEna	0 -1	-	1	0	Enabling/disabling TripH blocked AR 0: disable 1: enable
8	79AR_Circle_N	1-4		1	4	Maximum number of reclosing attempts
9	79AR_T_CBclosed	0.00-600.00	s	0.01	5	Time delay of circuit breaker in closed position before reclosing
10	79AR_T_CBhealthy	0.00-600.00	s	0.01	5	Time delay to wait for CB healthy.
11	79AR_T_TrFail	0.10-5.00	s	0.01	0.5	Time delay that protection trip signal can last for
12	79AR_T_DeadTimeH	0.10-10.00	s	0.01	0.1	Dead time of high speed startup (first instantaneous time shot 3-pole reclosing) at first shot
13	79AR_T_DeadTime1	0.10-600.00	s	0.01	1	Dead time of time delayed startup at first shot 3-pole reclosing
14	79AR_T_DeadTime2	0.10-600.00	s	0.01	1	Dead time of time delayed startup at second shot 3-pole reclosing
15	79AR_T_DeadTime3	0.10-600.00	s	0.01	1	Dead time of time delayed startup at third shot 3-pole reclosing
16	79AR_T_DeadTime4	0.10-600.00	s	0.01	1	Dead time of time delayed startup at fourth shot 3-pole reclosing
17	79AR_T_Pluse	0.10-5.00	s	0.01	0.2	Pulse width of 79AR closing signal
18	79AR_T_WaitSyn	0.05-60.00	s	0.01	10	Maximum wait time for synchronism check
19	79AR_T_WaitNext	0.00-10.00	s	0.01	0	Wait time of next reclosing
20	79AR_T_Reclaim	0.10-900.00	s	0.01	10	Reclaim time
21	79AR_T_Unsuc	0.05-10.00	s	0.01	2	Maximum wait time for circuit breaker closing before indicating unsuccessful

3.23 Synchronism check 25SYN

3.23.1 Overview

The synchronization checking function 25SYN ensures that the grid can be merged at the right time and improve the stability of the auto-reclose. 25SYN checks whether the activation is permissible without a risk to the stability of the system when interconnecting 2 parts of an electrical power system. Typical applications are the synchronization of a line and a bus bar.

3.23.1.1 Function Block

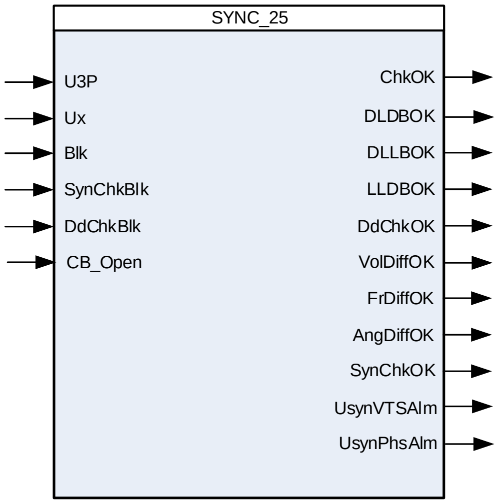


Figure 3.23-1 Function block

3.23.1.2 Signals

Table 3.23-1 25SYN Input Signals

NO.	Signal	Description
1	U3P	Three-phase voltage input
2	Ux	Synchronism voltage input
3	Blk	Block signal of synchro check function for AR
4	SynChkBlk	Block signal of synchronism check for AR
5	DdChkBlk	Block signal of dead charge check for AR
6	CB_Open	Normally closed contact of circuit breaker

Table 3.23-2 25SYN Output Signals

NO.	Signal	Description
1	ChkOK	Synchronizing OK or dead charge check OK output
2	DBDLOK	Dead line and dead bus condition is met

NO.	Signal	Description
3	LBDLOK	Dead line and live bus condition is met
4	DBLLOK	Live line and dead bus condition is met
5	DdChkOK	Dead charge check is OK
6	VolDiffOK	To indicate that voltage difference condition for synchronism check of AR is met, voltage difference between reference voltage and synchronism voltage is smaller than 25SYN_Vol_Diff.
7	FrDiffOK	To indicate that frequency difference condition for synchronism check of AR is met, frequency difference between reference voltage and synchronism voltage is smaller than 25SYN_Fr_Diff.
8	AngDiffOK	To indicate that phase angle difference condition for synchronism check of AR is met, phase angle difference between reference voltage and synchronism voltage is smaller than 25SYN_Ang_Diff.
9	SynChkOK	Synchronism is OK
10	UsynVTSAlm	Synchronism circuit failure alarm signal
11	UsynPhsAlm	Synchronism phase error alarm signal

3.23.2 Operation Principle

The synchronism check function is mainly to measure the electrical quantities between both sides of the circuit breaker and compares them with the corresponding settings. The output is only given if all measured quantities are simultaneously within their set limits.

3.23.2.1 Synchronization Voltage Selection

3.23.2.2 Dead Charge Check Logic

The bus/line dead criterion is:

$$U<25SYN\_Vol\_Dd$$

Where:

U is the voltage $\dot{U}_{syn}$ or $\dot{U}_{ref}$.

25SYN_Vol_Dd is the setting of Voltage threshold of dead check.

the bus/line live criterion is:

$$U>25SYN\_Vol\_Lv$$

Where:

U is the voltage $\dot{U}_{syn}$ or $\dot{U}_{ref}$.

25SYN_Vol_Lv is the setting of voltage threshold of live check.

3.23.2.3 Synchronism Check Logic

The voltage difference criterion is:

$$\left|\dot{U}_{syn}-\dot{U}_{ref}\right| \leq 25SYN\_Vol\_Diff$$

The phase difference criterion is:

$$\left|\arg\frac{\dot{U}_{syn}}{\dot{U}_{ref}}\right| \leq 25SYN\_Ang\_Diff$$

The frequency difference criterion is:

$$\left|f\left(\dot{U}_{syn}\right)\text{-}f\left(\dot{U}_{ref}\right)\right| \leq 25SYN\_Fr\_Diff$$

Where:

25SYN_Vol_Diff is the setting of voltage difference limit.

25SYN_Ang_Diff is the setting of phase difference limit.

25SYN_Fr_Diff is the setting of frequency difference limit.

3.23.3 Logic

The dead charge check conditions have three types, namely, live-bus and dead-line check, dead-bus and live-line check and dead-bus and dead-line check. The above three modes can be enabled and disabled by the corresponding logic settings. The device can calculate the measured bus voltage and line voltage at both sides of the circuit breaker and compare them with the settings. When the voltage is higher than 25SYN_Vol_Lv, the bus/line is regarded as live. When the voltage is lower than 25SYN_Vol_Dd, the bus/line is regarded as dead.

When inject 3 phase bus voltages and 1 phase line voltage, the $\dot{U}_{ref}$ .is the bus voltage, the $\dot{U}_{syn}$ is the line voltage. The logic is as following:

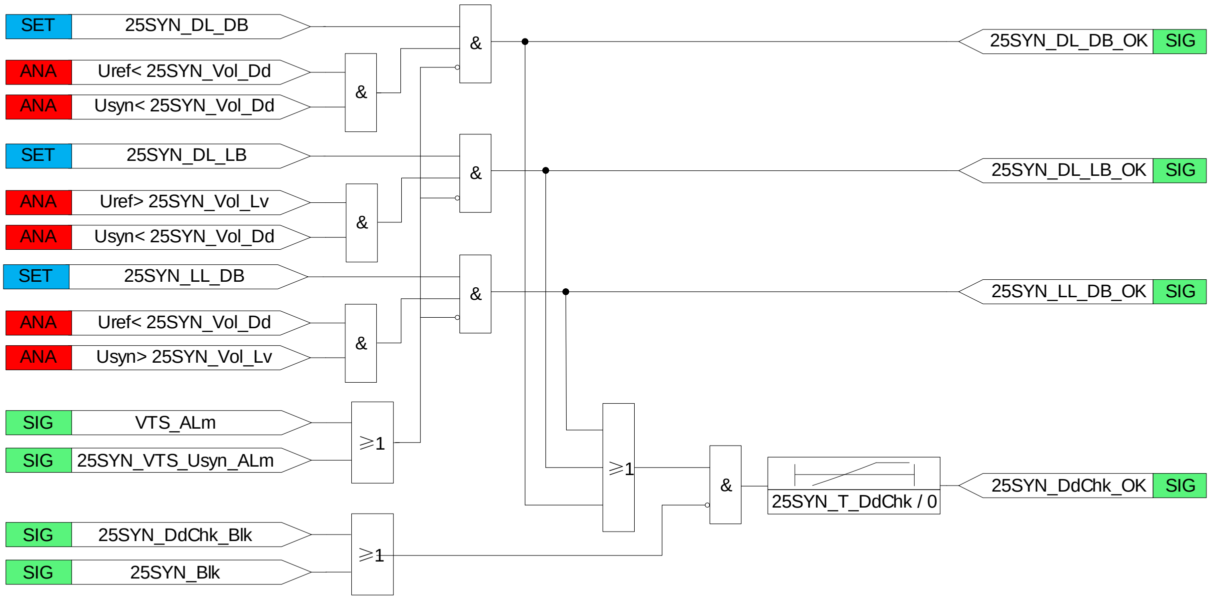


Figure 3.23-2 Logic Diagram of Dead charge check logic of 3 phases bus voltages and 1 phase line voltage

When inject 3 phase line voltages and 1 phase bus voltage, the $\dot{U}_{ref}$ .is the line voltage, the $\dot{U}_{syn}$ is the bus voltage. The logic is as following:

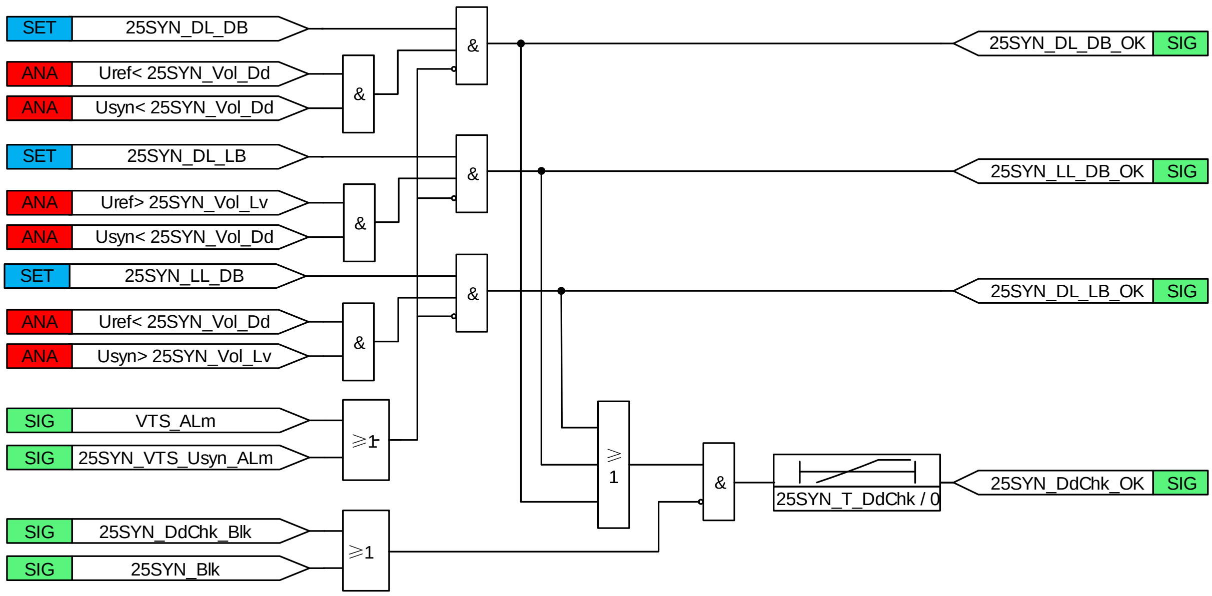


Figure 3.23-3 Logic Diagram of Dead charge check logic of 3 phases line voltages and 1 phase bus voltage

The frequency difference, voltage difference, and phase difference of voltages from both sides of the circuit breaker are calculated in the device, they are used as input conditions of the synchronism check. When the synchronism check function is enabled and the voltages of both ends meet the requirements of the voltage difference, phase difference, and frequency difference, and there is no synchronism check blocking signal, and the measured bus voltage and line voltage for synchro-check should not exceed the overvoltage threshold 25SYN_OV or lag the under voltage threshold 25SYN_UV, it is regarded that the synchronism check conditions are met.

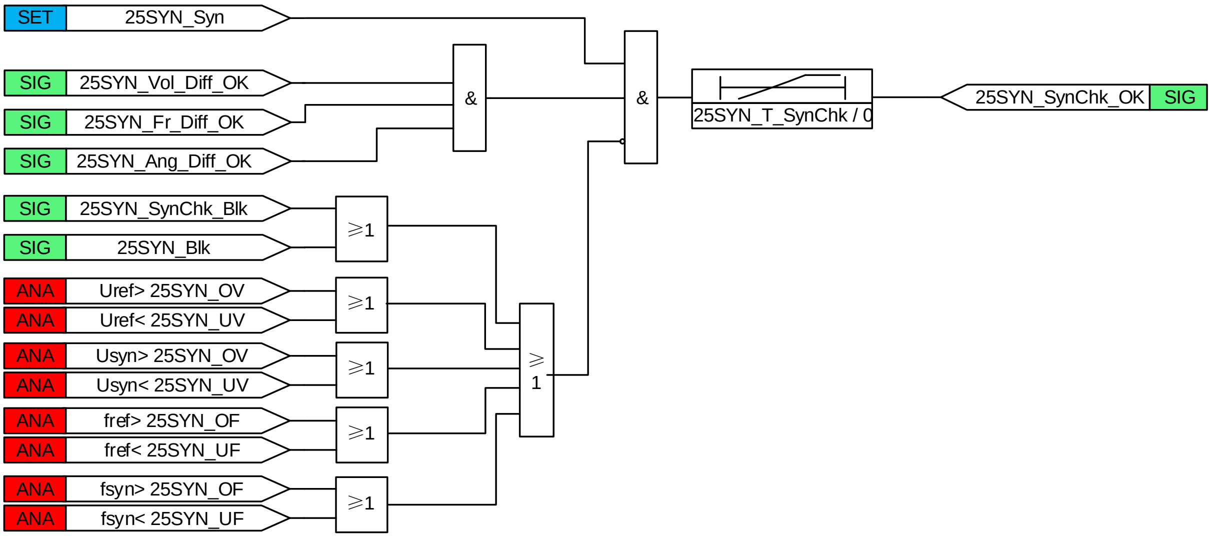


Figure 3.23-4 Logic Diagram of Synchronism check

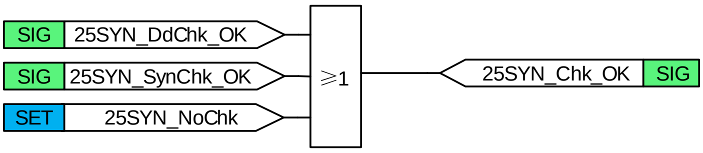


Figure 3.23-5 Logic diagram of Synchronism Output

3.23.4 Settings

Table 3.23-3 25SYN Settings

NO	Name	Range	Unit	Step	Default	Description
1	25SYN_NoChk	0 -1	-	1	0	Enabling/disabling without any check 0: disable 1: enable
2	25SYN_DL_DB	0 -1	-	1	0	Enabling/disabling dead line and dead bus (DBDL) check 0: disable 1: enable
3	25SYN_DL_LB	0 -1	-	1	0	Enabling/disabling dead line and live bus (LBDL) check 0: disable 1: enable
4	25SYN_LL_DB	0 -1	-	1	0	Enabling/disabling live line and dead bus (DBLL) check 0: disable 1: enable
5	25SYN_Syn	0 -1	-	1	0	Enabling/disabling synchronism check

NO	Name	Range	Unit	Step	Default	Description
						0: disable 1: enable
6	25SYN_3PLinePT	0 -1	-	1	0	Enabling/disabling line three phase voltage. 0: disable, the Uref is bus three phase voltage; 1: enable, the Uref is line three phase voltage.
7	25SYN_OV	57.7-110.00	V	0.01	110	Threshold of over voltage for synchronism blocking
8	25SYN_UV	0.01-66.4	V	0.01	40	Threshold of under voltage for synchronism blocking
9	25SYN_OF	0-65	Hz	0.01	65	Threshold of over frequency for synchronism blocking
10	25SYN_UF	0-65	Hz	0.01	45	Threshold of under frequency for synchronism blocking
11	25SYN_Vol_Dd	0.01-110.00	V	0.01	30	Voltage threshold of dead check
12	25SYN_Vol_Lv	0.01-110.00	V	0.01	40	Voltage threshold of live check
13	25SYN_Ang_Diff	2- 89	deg	1	25	Phase difference limit of synchronism check
14	25SYN_Vol_Diff	0.01-110.00	V	0.01	10	Voltage difference limit of synchronism check
15	25SYN_Fr_Diff	0.01-5.00	Hz	0.01	0.20	Frequency difference limit of synchronism check
16	25SYN_T_DdChk	0.01-20.00	s	0.01	1	Time delay to confirm dead check condition
17	25SYN_T_SynChk	0.01-20.00	s	0.01	1	Time delay to confirm synchronism check condition
18	25SYN_SynPhs	0-5	-	1	0	0:Ua: A-phase voltage 1:Ub: B-phase voltage 2:Uc: C-phase voltage 3:Uab: AB-phase voltage 4:Ubc: BC-phase voltage 5:Uca: CA-phase voltage

3.24 Current unbalance protection 51NA

3.24.1 51NA Overview

The current unbalance protection for shunt capacitor banks function 51NA is used to protect the Double-Y-connected capacitor banks from internal faults. 51NA is suitable for the protection of internally fused, externally fused and fuse less applications. 51NA can be enabled or disabled and it starts when the measured unbalance current exceeds the current startup setting. The operation time characteristics can be selected to be either definite time (DT) or inverse definite minimum time (IDMT).

3.24.1.1 Function Block

The function block of the protection is as below.

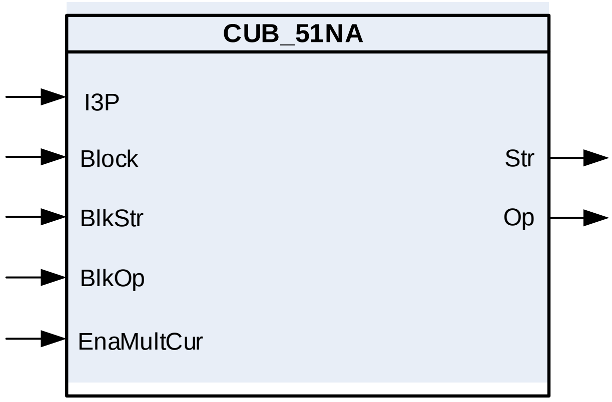


Figure 3.24-1 Function block

3.24.1.2 Signals

Table 3.24-1 Input Signals

Signal	Description
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.
EnaMultCur	This signal enables the current multiplier.

Table 3.24-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.

3.24.2 51NA Protection Principle

A standard Double-Y-connected shunt capacitor bank configuration is shown in following diagram. The fundamental frequency component of an unbalance current is measured on the common neutral connecting the two balanced parts of a shunt capacitor bank.

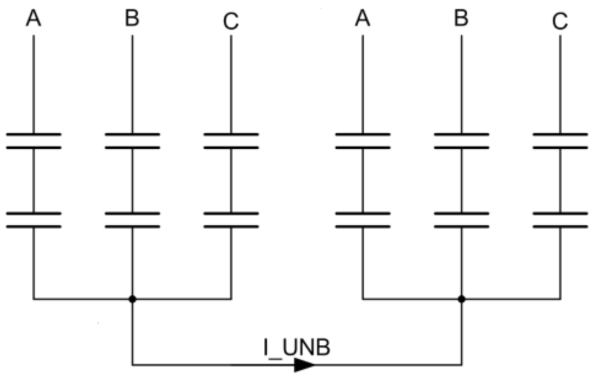


Figure 3.24-2 The neutral balance current of Double-Y-connected capacitor bank

The function can be enabled and disabled with the Operation setting. The corresponding parameter values are “On” and “Off”. The operation of 51NA can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

3.24.2.1 Initiation logic

The initiation of neutral current unbalance protection can be described by using a module diagram. The functional module diagram is shown as below: the unbalance current I_UNB is sampled in device by Ia2 current.

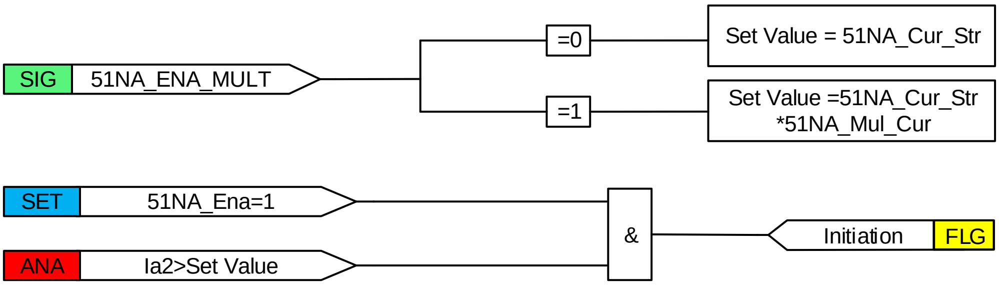


Figure 3.24-3 Initiation module diagram

The measured neutral unbalance current is compared to the set 51NA_Cur_Str. If the measured value exceeds the set 51NA_Cur_Str and no block signal is activated, the timer and 51NA_Str signal are activated. If the 51NA_EnaMultCur input is active, the 51NA_Cur_Str value setting is multiplied by the 51NA_Mul_Cur setting.

Where:

51NA_EnaMultCur is a binary input to enable or disable the start multiplier.

51NA_Ena is used to enable or disable the protection.

51NA_Cur_Str is the start value.

51NA_Mul_Cur is the multiplier for scaling the start value.

NOTICE!

Do not set the multiplier setting 51NA_Mul_Cur higher than necessary. If the value is too high, the function may not operate at all during an inrush followed by a fault, no matter how severe the fault is.

The start value multiplication is normally done when the inrush detection function (OCR_INR) is connected to the EnaMultCur input by Three phase inrush function OCR_INR.

3.24.2.2 Timer element

The functional module diagram is shown as below:

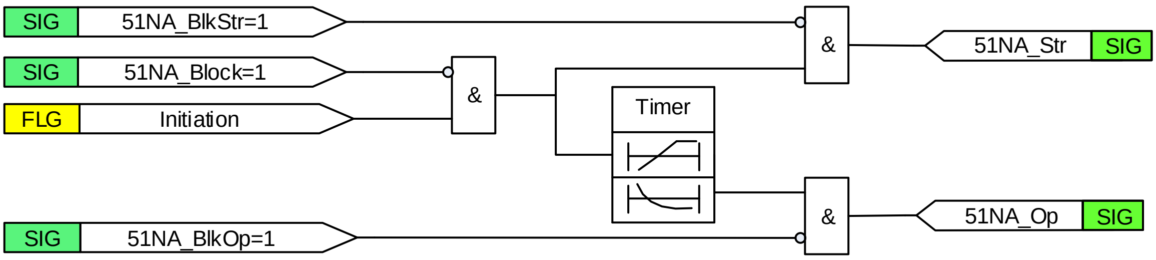


Figure 3.24-4 Functional module diagram

Once initiation logic is fulfilled and no blocking signal is activated, the 51NA_Str signal is set.

The timer model is determined by **IDMT curves for over quantity protection.**

The operation is activated after the operation timer has reached the calculated value. However, 51NA_Min_Op_T defines the minimum desired operate time for IDMT. If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the operation will reset after the set value 51NA_Reset_T is exceeded.

NOTICE!

The 51NA_Min_Op_T setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the 51NA_Min_Op_T setting.

The binary input 51NA_Block can be used to block the function. The activation of the 51NA_Block input deactivates all outputs and resets internal timers. The binary input 51NA_BlkStr can be used to block the start signals. The binary input 51NA_BlkOp can be used to block the operation signals.

3.24.3 51NA Application Scope

51NA is designed for the protection against internal faults in Double-Y-connected capacitor banks. This unbalance protection detects an asymmetry in the capacitor bank caused by blown fuses or short circuits across bushings or between capacitor units and the racks in which they are mounted. Normally, the capacitor units are designed to withstand 110 percent of the nominal voltage continuously. When an element inside a capacitor bank fails, the remaining healthier elements experience an increase in voltage across them. If the voltage exceeds the 110 percent value of the nominal voltage, it can lead to a failure of the healthier elements of the bank and in turn fail the entire capacitor bank.

3.24.4 51NA Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.24-3 51NA settings

No.	Name	Range	Unit	Step	Default	Description
1	51NA_i_Cur_Str	0.04-20.00In	A	0.01In	0.04In	Start current value
2	51NA_i_Mul_Cur	0.8-10.0		0.1	1	Multiplier current start value
3	51NA_i_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
4	51NA_i_Curve_ParaA	0.000-120.000	s	0.001	0	Curve parameter A
5	51NA_i_Curve_ParaB	0.000-9.000	s	0.001	0.2	Curve parameter B
6	51NA_i_Curve_ParaC	0.0-1.0	-	0.1	1.0	Curve parameter C
7	51NA_i_Curve_ParaP	0.02-2.00	-	0.01	2.00	Curve parameter P
8	51NA_i_Curve_ParaK	0.05-100	-	0.01	1	Curve parameter k
9	51NA_i_Min_Op_T	0.005-60.000	s	0.001	0.005	Minimum operation time delay
10	51NA_i_Reset_T	0.000 -60.000	s	0.001	0.02	Reset time delay
11	51NA_i_Ena	0-1	-	1	0	Operation Enable/Disable

3.25 Three phase current unbalance protection 51NT

3.25.1 51NT Overview

The current unbalance protection for shunt capacitor banks function 51NT is used to protect the Double-Y-connected capacitor banks from internal faults. 51NT is suitable for the protection of internally fused, externally fused and fuse less applications. 51NT can be enabled or disabled and it starts when the measured unbalance current exceeds the current startup setting. The operation time characteristics can be selected to be either definite time (DT) or inverse definite minimum time (IDMT).

3.25.1.1 Function Block

The function block of the protection is as below.

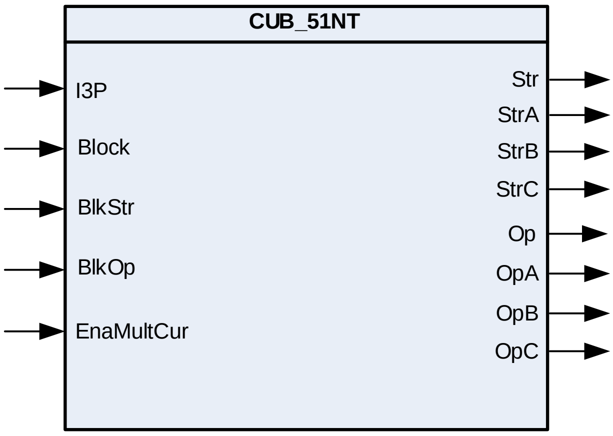


Figure 3.25-1 Function block

3.25.1.2 Signals

Table 3.25-1 Input Signals

Signal	Description
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.
EnaMultCur	This signal enables the current multiplier.

Table 3.25-2 Output signal

Signal	Description
Str	This is the integrated start signal
StrA	This is the start signal of phase A
StrB	This is the start signal of phase B
StrC	This is the start signal of phase C.
Op	This is the integrated operation signal.
OpA	This is the operation signal of phase A
OpB	This is the operation signal of phase B
OpC	This is the operation signal of phase C

3.25.2 51NT Protection Principle

In the three-phase H-bridge-connected shunt capacitor bank configuration, the unbalance currents I_UNB_A, I_UNB_B and I_UNB_C are measured at the common points of the H-bridge.

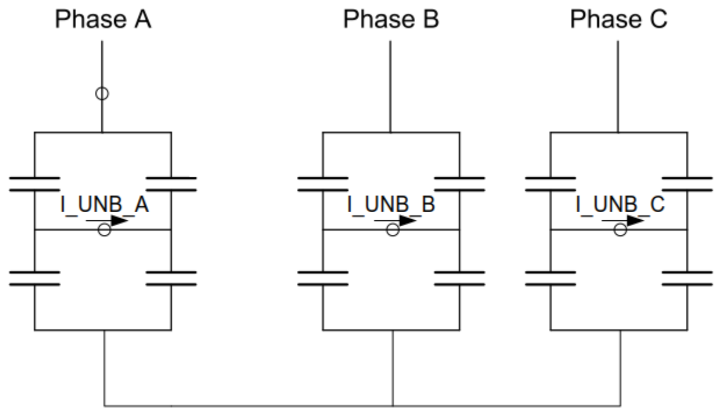


Figure 3.25-2 H-Bridge-connected capacitor bank

The protection function can be enabled or disabled by setting the corresponding 51NT_Ena as "1" or "0".

The operation of the three phase unbalance protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

3.25.2.1 Initiation logic

The initiation of three-phase current unbalance protection can be described by using a module diagram. The functional module diagram is shown as below: the unbalance currents I_UNB_A, I_UNB_B, I_UNB_C are sampled in device by Ia2, Ib2, Ic2.

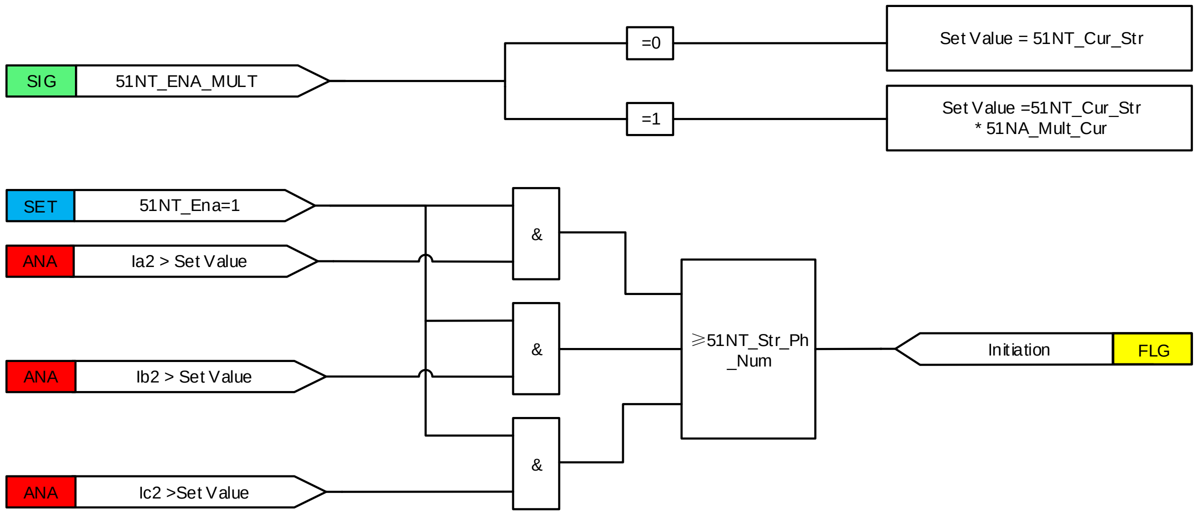


Figure 3.25-3 Initiation module diagram

The measured three phase unbalance currents are compared to the set 51NT_Cur_Str. If the measured value exceeds the set 51NT_Cur_Str, the level detector reports the exceeding of the value to the phase selection logic. If the 51NT_EnaMultCur input is active, the 51NT_Cur_Str value setting is multiplied by the 51NT_Mul_Cur setting.

If the fault criteria are fulfilled in the level detector, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information is equal to or more than the 51NT_Str_Ph_Num setting, the phase selection logic activates the "Initiation" signal.

Where:

51NT_EnaMultCur is a binary input to enable or disable the start multiplier.

51NT_Ena is used to enable or disable the protection.

51NT_Cur_Str is the 51NT start value.

51NT_Mul_Cur is the multiplier for scaling the start value.

51NT_Str_Ph_Num is the Number of phases required for activation.

NOTICE!

Do not set the multiplier setting 51NT_Mul_Cur higher than necessary. If the value is too high, the function may not operate at all during an inrush followed by a fault, no matter how severe the fault is.

The start value multiplication is normally done when the inrush detection function (OCR_INR) is connected to the EnaMultCur input by Three phase inrush function OCR_INR.

3.25.2.2 Timer element

The functional module diagram is shown as below:

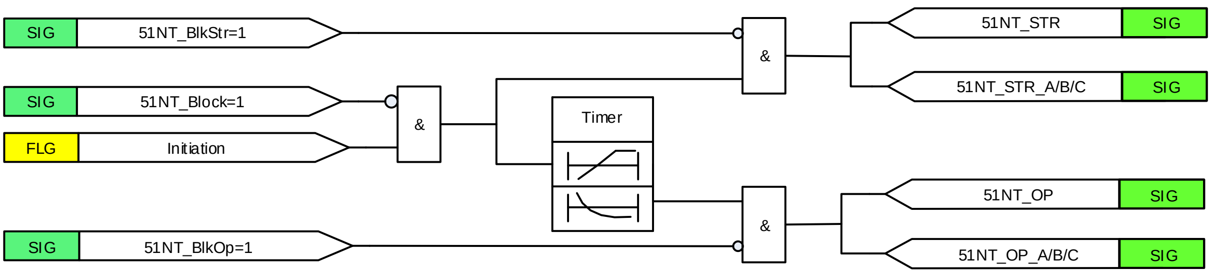


Figure 3.25-4 Functional module diagram

Once initiation logic is fulfilled and no blocking signal is activated, the 51NT_Str signal is set. The 51NT_StrA, 51NT_StrB and 51NT_StrC outputs are used to indicate which phases are started.

The timer model is determined by **IDMT curves for over quantity protection**

The operation is activated after the operation timer has reached the calculated value. However, 51NT_Min_Op_T defines the minimum desired operate time for IDMT. If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the operation will reset after the set value 51NT_Reset_T is exceeded.

NOTICE!

The 51NT_Min_Op_T setting should be used with great care because the operation time is according to the IDMT curve, but always at least the value of the

51NT_Min_Op_T setting.

The binary input 51NT_Block can be used to block the function. The activation of the 51NT_Block input deactivates all outputs and resets internal timers. The binary input 51NT_BlkStr can be used to block the start signals. The binary input 51NT_BlkOp can be used to block the operation signals.

3.25.3 51NT Application Scope

Shunt capacitor banks are widely used in transmission and distribution networks to produce reactive power support. 51NT is designed for the protection against internal faults in H-bridge-connected capacitor banks. This 51NT detects an asymmetry in the capacitor bank, caused by blown fuses or short-circuits across bushings, or between capacitor units and the racks in which they are mounted.

Normally, the capacitor units are designed to withstand 110% of the nominal voltage continuously. When an element inside a capacitor bank fails, the remaining healthy elements experience an increase in voltage across them. If the voltage exceeds 110% of the nominal voltage, it can lead to a failure of the healthy elements of the bank and in turn fail the entire capacitor bank.

3.25.4 51NT Settings

Table 3.25-3 51NT settings

No.	Name	Range	Unit	Step	Default	Description
1	51NT_Cur_Str	0.04-20.00In	A	0.01In	0.04In	Start current value
2	51NT_Mul_Cur	0.8-10.0	-	0.1	1	Multiplier current start value
3	51NT_i_Op_Curve_Type	0-13	-	1	0	The operation curve type setting: including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in Table 3.33-1 Curve parameters for IDMT curves.
4	51NT_Curve_ParaA	0.000-120.000	s	0.001	0	Curve parameter A
5	51NT_Curve_ParaB	0.000-90.000	s	0.001	0.2	Curve parameter B
6	51NT_Curve_ParaC	0.0-1.0	-	0.1	1.0	Curve parameter C
7	51NT_Curve_ParaP	0.02-2.00	-	0.01	2.00	Curve parameter P
8	51NT_Curve_ParaK	0.05-100	-	0.01	1.00	Curve parameter k
9	51NT_Min_Op_T	0.005-60.000	s	0.001	0.005	Minimum operation time delay
10	51NT_Reset_T	0.000-60.000	s	0.001	0.02	Reset time delay
11	51NT_Ena	0-1	-	1	0	Operation Enable/Disable
12	51NT_Str_Ph_Num	1-3	-	1	1	Start current value

3.26 Voltage unbalance protection 59NA

3.26.1 59NA Overview

The voltage unbalance function 59NA monitors voltage unbalance conditions in power transmission and distribution networks. It can be applied to identify a network and load unbalance that can cause sustained voltage unbalance.

3.26.1.1 Function Block

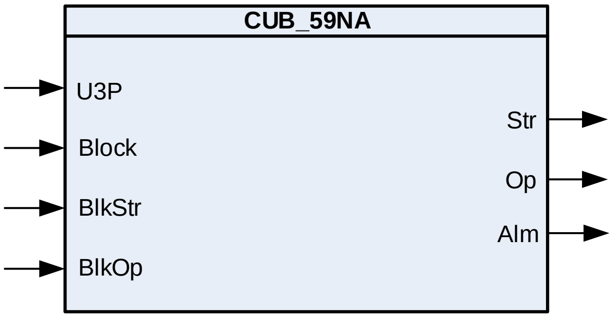


Figure 3.26-1 Function block

3.26.1.2 Signals

Table 3.26-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Table 3.26-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.
Alm	This is the integrated alarm signal.

3.26.2 59NA Protection Principle

A standard Double-Y-connected shunt capacitor bank configuration is shown in following diagram. The fundamental frequency component of an unbalance voltage is measured on the common neutral connecting the two balanced parts of a shunt capacitor bank.

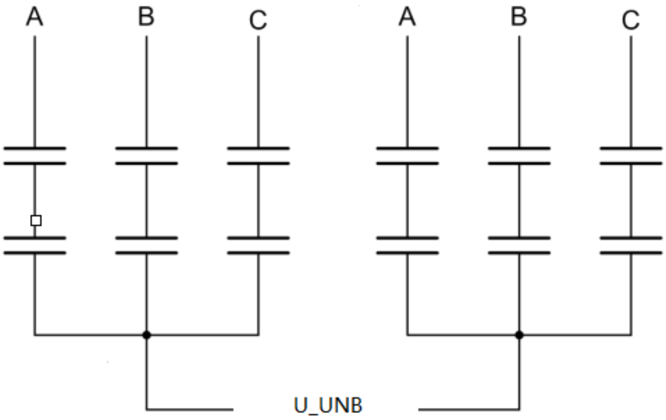


Figure 3.26-2 The neutral balance voltage of Double-Y-connected capacitor bank

3.26.2.1 Initiation logic

The initiation of neutral voltage unbalance protection can be described by using a module diagram. The functional module diagram is shown as below: the unbalance voltage U_UNB is sampled in device by Ua2.

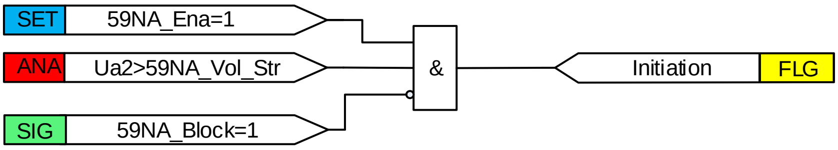


Figure 3.26-3 The initiation diagram

The measured neutral unbalance voltage is compared to the set 59NA_Vol_Str. If the measured value exceeds the set 59NA_Vol_Str and no block signal is activated, the timer and 59NA_Str signal are activated.

Where:

59NA_Ena is used to enable or disable the protection.

59NA_Vol_Str is the start value.

3.26.2.2 Timer element

The functional module diagram is shown as below:

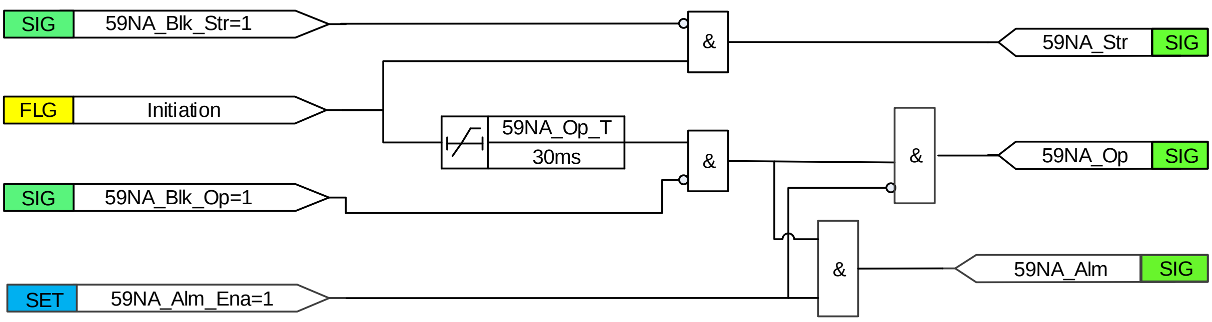


Figure 3.26-4 The function diagram

The time characteristic is according to DT. When the operation timer has reached the value set by 59NA_Op_T, the 59NA_Op output is activated. If the fault disappears before the module operates, the operation will reset with a time delay of 30ms.

The binary input 59NA_Blk can be used to block the function. The activation of the 59NA_Block input deactivates all outputs and resets internal timers. The binary input 59NA_BlkStr can be used to block the start signals. The binary input 59NA_BlkOp can be used to block the operation signals.

3.26.3 59NA Application Scope

59NA check voltage unbalance conditions in power transmission and distribution networks. Normally, the capacitor units are designed to withstand 110 percent of the nominal voltage continuously. When an element inside a capacitor bank fails, the remaining healthier elements experience an increase in voltage across them. If the voltage exceeds the 110 percent value of the nominal voltage, it can lead to a failure of the healthier elements of the bank and in turn fail the entire capacitor bank.

3.26.4 59NA Settings

Table 3.26-3 59NA settings

No.	Name	Range	Unit	Step	Default	Description
1	59NA_Vol_Str	0.00 -100.00	V	0.01	60	Residual voltage start value
2	59NA_Op_T	0.04-300.00	s	0.01	0.04	Operate delay time
3	59NA_Ena	0-1	-	1	0	Operation Enable/Disable
4	59NA_AlmEna	0-1	-	1	0	Alarm Enable/Disable

3.27 Three phase voltage unbalance protection 59NT

3.27.1 59NT Overview

The three phase voltage unbalance protection for shunt capacitor banks function 59NT is used to protect the Y-connected capacitor banks from internal faults. 59NT is suitable for the protection of internally fused, externally fused and fuse less applications. 59NT can be enabled or disabled and it starts when the measured unbalance current exceeds the current startup setting. The operation time characteristics is definite time (DT).

3.27.1.1 Function Block

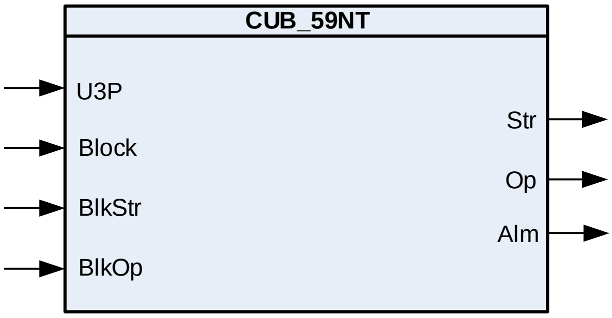


Figure 3.27-1 Function block

3.27.1.2 Signals

Table 3.27-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Table 3.27-2 Output Signals

Signal	Description
Str	This is the integrated start signal.
Op	This is the integrated operation signal.
Alm	This is the integrated alarm signal.

3.27.2 59NT Protection Principle

A standard Y-connected shunt capacitor bank configuration is shown in following diagram. The three-phase unbalance voltage is measured.

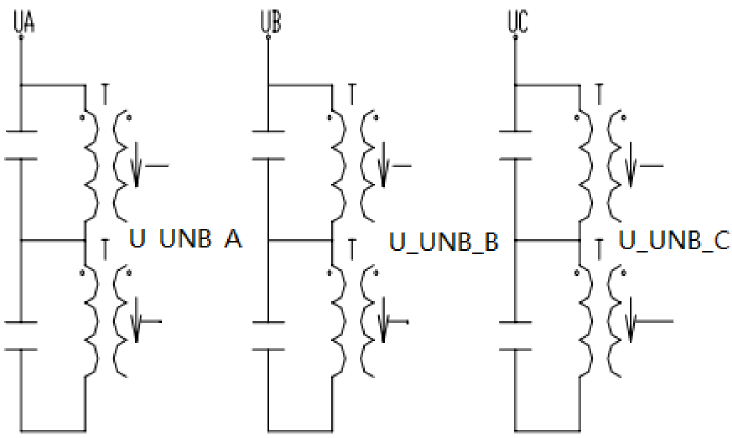


Figure 3.27-2 The three phase balance voltage of Y-connected capacitor bank

3.27.2.1 Initiation logic

The initiation of three phase voltage unbalance protection can be described by using a module diagram. The functional module diagram is shown as below: the unbalance voltages U_UNB_A, U_UNB_B and U_UNB_C are sampled in device by Ua2, Ub2, Uc2.

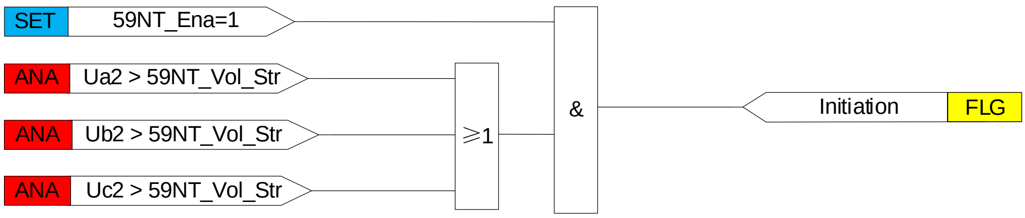


Figure 3.27-3 The initial diagram

3.27.2.2 Timer element

The functional module diagram is shown as below:

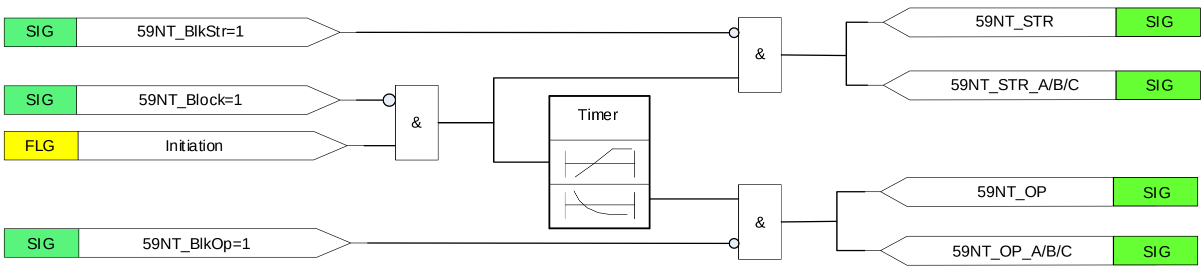


Figure 3.27-4 Timer element

The time characteristic is according to DT. When the operation timer has reached the value set by 59NT_Op_T, the 59NT_Op output is activated. If the fault disappears before the module operates, the operation will reset with a time delay of 30 ms.

The binary input 59NT_Block can be used to block the function. The activation of the 59NT_Block input deactivates all outputs and resets internal timers. The binary input 59NT_BlkStr can be used to block the start signals. The binary input 59NT_BlkOp can be used to block the operation signals.

3.27.3 59NT Application Scope

59NT check voltage unbalance conditions in power transmission and distribution networks. Normally, the capacitor units are designed to withstand 110 percent of the nominal voltage continuously. When an element inside a capacitor bank fails, the remaining healthier elements experience an increase in voltage across them. If the voltage exceeds the 110 percent value of the nominal voltage, it can lead to a failure of the healthier elements of the bank and in turn fail the entire capacitor bank.

3.27.4 59NT Settings

Table 3.27-3 59NT Settings

No.	Name	Range	Unit	Step	Default	Description
1	59NT_Vol_Str	0.00 -100.00	V	0.01	60	Voltage start value
2	59NT_Op_T	0.04-300.00	s	0.01	0.04	Operate delay time
3	59NT_Ena	0-1	-	1	0	Operation Enable/Disable
4	59NT_AlmEna	0-1	-	1	0	Alarm Enable/Disable

3.28 Fault locator 21FL

3.28.1 21FL Overview

3.28.1.1 Function Block

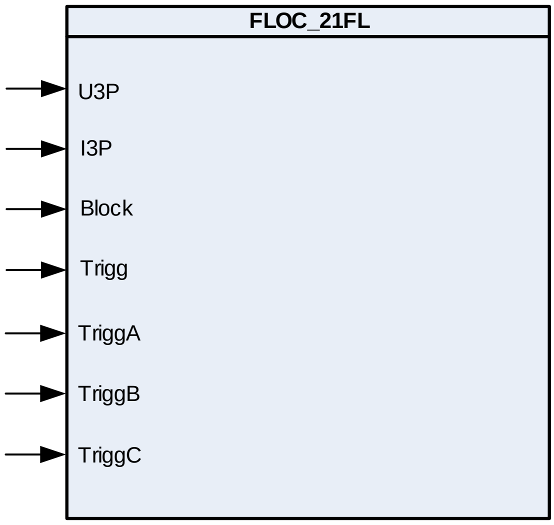


Figure 3.28-1 Function block

3.28.1.2 Signals

Table 3.28-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
Trigg	This signal trigger the relay
TriggA	This signal is to select that the phase A is fault phase
TriggB	This signal is to select that the phase B is fault phase
TriggC	This signal is to select that the phase C is fault phase

Note: The TriggA/B/C can be configured to null, if null, the default Fault phases are up to the FPS element.

3.28.2 21FL Protection Principle

The function can be enabled and disabled with the Operation setting. The corresponding parameter values are "On" and "Off".

The actual fault distance calculation consists of two steps. The fault type is determined first by using the trigger information. After this, the fault distance is calculated. As a fundamental operation criterion, the maximum of the phase current magnitudes must exceed a threshold value of 0.1In, In is the CT secondary current. When this condition is not met, all the outputs of the function are blocked.

3.28.2.1 Fault type selection

The identification of the faulty phases is compulsory for the correct operation of the fault locator function. This is because only one of the impedance measuring elements, that is, the fault type, provides the correct result. A three-phase fault is an exception and it could, in theory, be calculated with any of the fault loops, in this relay, the phase BC is used. The fault type is determined by the input of trigger information, as shown in table.

Table 3.28-2 The fault type is determined by trigger information

Trigger information	Fault type	Calculation formula
21FL_SELA=1, 21FL_SELB=0, 21FL_SELC=0	Phase A to Ground	UA/(IA+K*3I0),K=(Z0-Z1)/(3*Z1)
21FL_SELA=0, 21FL_SELB=1, 21FL_SELC=0	Phase B to Ground	UB/(IB+K*3I0) ,K=(Z0-Z1)/(3*Z1)
21FL_SELA=0, 21FL_SELB=0, 21FL_SELC=1	Phase C to Ground	UC/(IC+K*3I0) ,K=(Z0-Z1)/(3*Z1)
21FL_SELA=1, 21FL_SELB=1, 21FL_SELC=0	Phase A to B	UAB/(IA-IB)
21FL_SELA=0, 21FL_SELB=1, 21FL_SELC=1	Phase B to C	UBC/(IB-IC)
21FL_SELA=1, 21FL_SELB=0, 21FL_SELC=1	Phase C to A	UCA/(IC-IA)
21FL_SELA=1, 21FL_SELB=1, 21FL_SELC=1	Three phase	UBC/(IB-IC)

For phase overcurrent protection, if the TriggA/B/C are invalid, the 21FL protection can be triggered by phase overcurrent protection operation phase judged by 94Trip protection; For earth protection, the fault distance can be calculated only when both of the Phase N and FPS are valid.

3.28.2.2 Fault distance calculation

As soon as a fault condition is recognized, the fault distance calculation is started using one of the seven impedance measuring elements. 21FL employs independent algorithms for each fault type in order to achieve optimal performance.

- **Single-phase earth faults**

When the individual earth faults are located at different feeders, the voltage and current of fault phase will be changed, also, the zero CT will affect the result of normal phases, this is up to the ratio of zero impendence to positive impendence in fault position. So in the single-phase earth faults, the zero impendence will be considered. The calculation formula is as following:

Up/ (Ip + K*3I0), K=(Z0-Z1)/(3*Z1) (p=A, B, C)

The detail is shown in Table 3.28-2.

- **Two-phase earth faults**

It is used for the phase-to-phase short circuit faults and also for the phase-to-phase-to-earth faults if the individual earth-faults are located in the same feeder. The calculation formula is as following:

Upp/(Ipp) (pp=AB, BC, CA)

The detail is shown in Table 3.28-2.

- **Three-phase earth faults**

It is used only for the three-phase short circuit the impedances, the three phases are symmetrical, user can use only two phases to calculate the impendence. In 21FL, the phase BC is chosen. The calculation formula is as following:

UBC/(IBC)

The detail is shown in Table 3.28-2.

- **Calculation formula**

The fault distance is calculated by a calculation formula, as shown in following:

L = Line Length*Im(Zx)/(PosZ*sin(PosAng))

Where, the Im(Zx) is the imaginary part of Zx, $\mathrm{Im(Zx)=|Zx|*sin}\theta$, θ is the angle of voltage U and current I.

3.28.3 21FL Application Scope

The main objective of line protection and monitoring terminals is fast, selective and reliable operation for faults on a protected line section. Besides this, information on the distance to fault is very important for those involved in operation and maintenance. Reliable information on the fault location greatly decreases the downtime of the protected lines and increases the total availability of a power system. 21FL provides the distance to the fault together with the information about the measuring loop that has been used in the calculation. Also, an estimate for the fault resistance at the fault point is calculated.

3.28.4 21FL Settings

Table 3.28-3 21FL Settings

No.	Name	Range	Unit	Step	Default	Description
1	21FL_LineLen	0-655	KM	0.01	100	The whole line length
2	21FL_PosZ	(0.05-655)/In	OHM	0.01/In	10/In	The positive sequence impendence amplitude
3	21FL_PosAng	30-89	°	1	30	The positive sequence impendence angle
4	21FL_ZeroCoe	0-2	-	0.01	0.67	The zero sequence impendence coefficient k
5	21FL_Ena	0-1	-	1	0	Operation Enable/Disable

3.29 Reverse power protection 32R

3.29.1 32R Overview

The feeder relay provides a two-stage power protection with independent definite time delay characteristics, and each stage has the same protection logics.

This function contains a blocking functionality. It is possible to block the function outputs, timer or the function itself, if desired.

3.29.1.1 Function Block

The function block of the protection is as below.

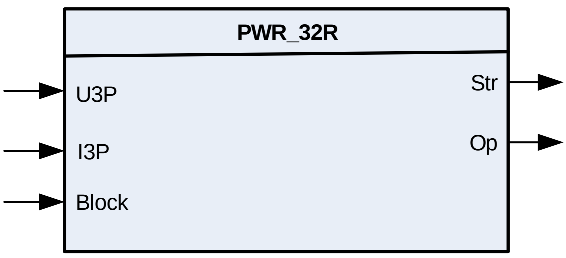


Figure 3.29-1 Function block

3.29.1.2 Signals

Table 3.29-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function

Table 3.29-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.

3.29.2 32R Protection Principle

The reverse power protection function can be enabled or disabled by setting the corresponding 32R_Ena parameter values as "1" or "0".

The operation of the reverse power protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The two-step protection logic is almost the same except for the individual settings, the functional module diagram of step 1 is shown as below:

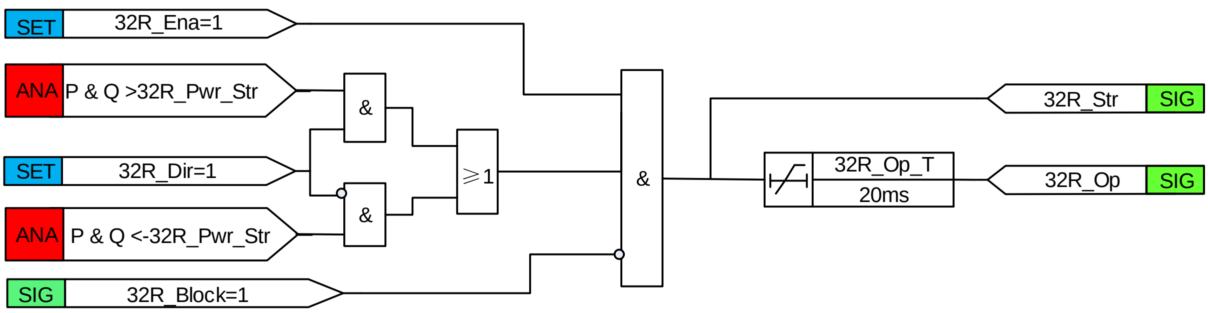


Figure 3.29-2 Functional module diagram

The power value is compared to the startup value setting. If the 32R_Dir is 1, the power value exceeds the setting 32R_Pwr_Str, and if the 32R_Dir is 0, and the power value is less than the negative setting; And then if there is no block signal is activated, the timer and 32R_Str signal are activated.

Where:

32R_Ena can enable PWR 32R protection;
32R_StrVal is the power startup setting;
32R_StrAng is the power startup angle setting;

32R_Op_T is the operate time setting;

32R_Dir can switch the operation mode. 32R_Dir = 1 is recommended, which means the system is operating in forward mode. On the contrary, 32R_Dir = 0 means the system is operating in reverse mode.

The operation area is shown in Fig. 3-29-3, and the operation conditions are depended on the 32R_StrAng & 32R_StrVal.

If the 32R_Dir is 1, the operation conditions are shown as followed:

I. When 32R_StrAng = 0°/360°, the operation condition is: P > 32R_StrVal;

II. When 32R_StrAng = 90°, the operation condition is: Q > 32R_StrVal;

III. When 32R_StrAng = 180°, the operation condition is: P < -32R_StrVal;

IV. When 32R_StrAng = 270°, the operation condition is: Q < -32R_StrVal;

V. When 0°<32R_StrAng<90° OR 90°<32R_StrAng<180°, the operation condition is: Q > K*P-K*P0;

VI. When 180°<32R_StrAng<270° OR 270°<32R_StrAng<360°, the operation condition is: Q < K*P-K*P0;

Where: $K=-\frac{1}{\tan(32R\_StrAng)}$; $P_0=\frac{32R\_StrVal}{\cos(32R\_StrAng)}$

If the 32R_Dir is 0, the operation conditions are shown as followed:

I. When 32R_StrAng = 0°/360°, the operation condition is: P < -32R_StrVal;

II. When 32R_StrAng = 90°, the operation condition is: Q < -32R_StrVal;

III. When 32R_StrAng = 180°, the operation condition is: P > 32R_StrVal;

IV. When 32R_StrAng = 270°, the operation condition is: Q > 32R_StrVal;

V. When 0°<32R_StrAng<90° OR 90°<32R_StrAng<180°, the operation condition is: Q < K*P-K*P0;

VI. When 180°<32R_StrAng<270° OR 270°<32R_StrAng<360°, the operation condition is: Q > K*P-K*P0;

Where: $K=-\frac{1}{\tan(32R\_StrAng)}$; $P_0=\frac{32R\_StrVal}{\cos(32R\_StrAng)}$

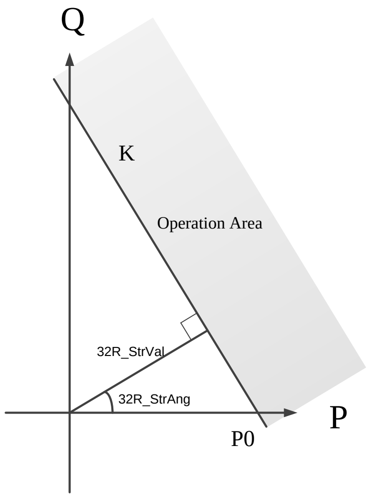
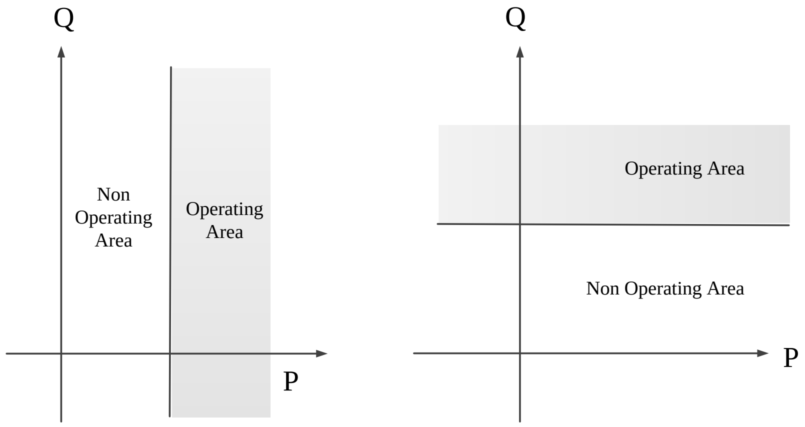
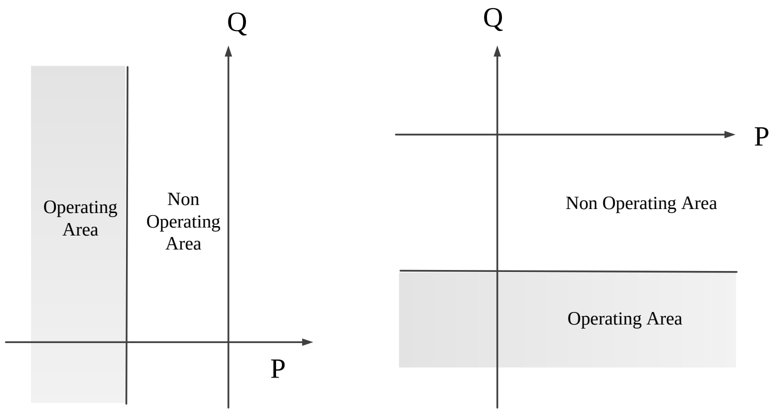


Figure 3.29-3 Functional module diagram



(a) (b)

Figure 3.29-4 Forward active overpower characteristics and forward reactive overpower characteristics



(a) (b)

Figure 3.29-5 Reverse active overpower characteristics and reverse reactive overpower characteristics

If there is no block signal is activated, the timer and 32R_Str signal are activated.

The time characteristic is according to DT. When the operation timer has reached the value set by 32R_Op_T, the 32R_Op output is activated. If the power becomes normal before the module operates, the operation resets after 30 ms.

The activation of the 32R_Blk input resets the timer and deactivates the 32R_Str and 32R_Op outputs.

3.29.3 32R Application Scope

The reverse power protection can be used for generator protection against delivering an excessive power beyond the generator's capacity to the grid, against the generator running like a motor, against the motor running like a generator and protecting a motor which consumes more reactive power due to loss of field. It also can be used in feeder protection for indicating overload on the distribution system to indicate that a customer is supplying power into the grid and for protecting the transformer from delivering an excessive load.

3.29.4 32R Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.29-3 32Ri settings

No.	Name	Range	Unit	Step	Default	Description
1	PWR_32Ri_Enable	0-1	-	1	0	The Stage i Operation Enable/Disable
2	PWR_32Ri_PosDir	0-1	-	1	1	1:Forward,0:Reverse
3	PWR_32Ri_StrVal	0.01-1999.99In	W	0.01In	200In	The Stage i power start value
4	PWR_32Ri_StrAng	0-360	W	1	0	The Stage i power factor angle
5	PWR_32Ri_Op_T	0.08-200.00	s	0.01	200	The Stage i Operate time delay

3.30 Power protection 32

3.30.1 32 Overview

The relay provides power protection with independent definite time delay characteristics, it can be used to over power, under power and reverse power.
This function contains a blocking functionality. It is possible to block the function outputs, timer or the function itself, if desired.

3.30.1.1 Function Block

The function block of the protection is as below.

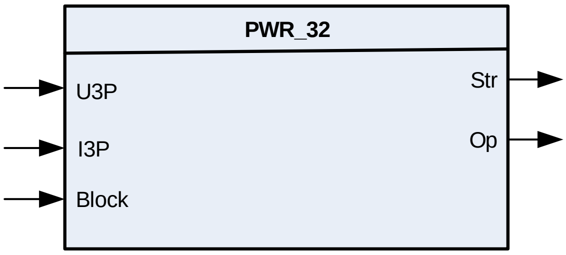


Figure 3.30-1 Function block

3.30.1.2 Signals

Table 3.30-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function

Table 3.30-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.

3.30.2 32 Protection Principle

The power protection function can be enabled or disabled by setting the corresponding 32_Ena parameter values as "1" or "0".

The operation of the power protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The functional module diagram is shown as below:

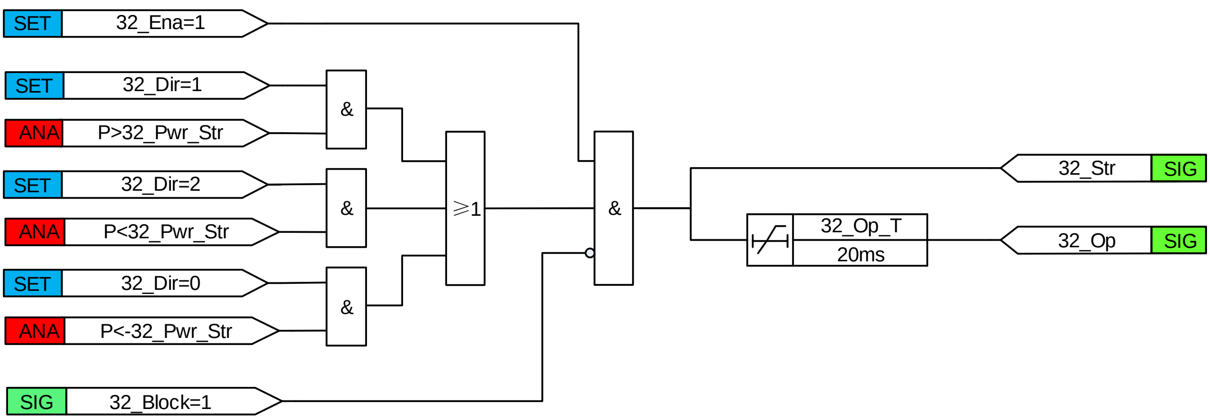


Figure 3.30-2 Functional module diagram

The power value is compared to the startup value setting. If the 32_Dir=1, it is over power, the power value exceeds the setting 32_Pwr_Str; and if the 32_Dir =2, it is under power, and the power value is less than the setting 32_Pwr_Str; and if the 32_Dir =0, it is reverse power, and the power value is less than the negative setting -32_Pwr_Str; And then if there is no block signal is activated, the timer and 32_Str signal are activated.

Where:

32_Ena can enable or disable the 32 protection;
32_StrVal is the power startup setting;
32_Op_T is the operate time setting;
32_Dir can switch the operation mode.

3.30.3 32 Application Scope

The power protection can be used for generator protection against delivering an excessive power beyond the generator's capacity to the grid, against the generator running like a motor, against the motor running like a generator and protecting a motor which consumes more reactive power due to loss of field, or protecting the generator from very low power output conditions. It also can be used in feeder protection for indicating overload on the distribution system to indicate that a customer is supplying power into the grid and for protecting the transformer from delivering an excessive load.

3.30.4 32 Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.30-3 32 settings

No.	Name	Range	Unit	Step	Default	Description
1	PWR_32_Enable	0-1	-	1	0	The Stage i Operation Enable / Disable
2	PWR_32_PosDir	0-2	-	1	1	0: Reverse Power 1: OverPower 2: UnderPower
3	PWR_32_StrVal	0.01-1999.99In	W	0.01In	200In	The Stage i power start value
4	PWR_32_Op_T	0.08-200.00	s	0.01	200	The Stage i Operate time delay

3.31 Voltage Selection

3.31.1 Overview

The function is used to select one voltage between two bus voltages or two line voltages when there is no external selection. The selection result depends on the type of system configuration.

3.31.1.1 Function Block

The function block of the protection is as below.

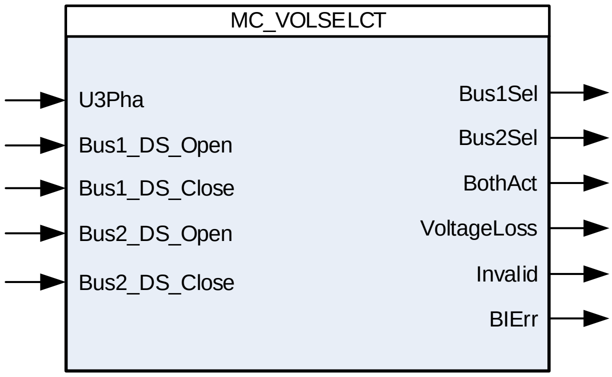


Figure 3.31-1 Function block

3.31.1.2 Signals

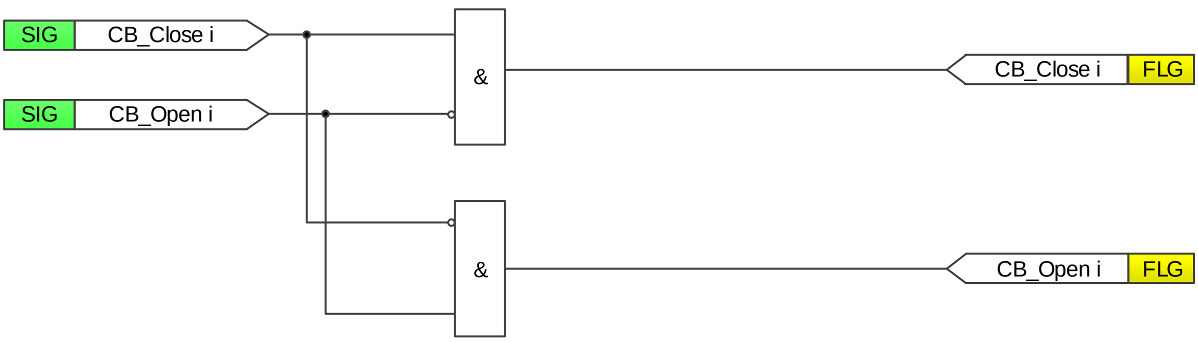
Table 3.31-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
"Busi_DS_Open" (i=1,2)	The open position of Bus1 and Bus2 or Line1 and Line2 disconnections.
"Busi_DS_Close" (i=1,2)	The close position of Bus1 and Bus2 or Line1 and Line2 disconnectors.

Table 3.31-2 Output Signals

Signal	Description
Bus1Sel	It means the Bus1 or Line1 voltage is valid
Bus2Sel	It means the Bus2 or Line2 voltage is valid.
BothAct	It means both Bus1 and Bus2 voltage, or both Line1 and Line2 voltage are valid, and Bus1 or Line1 voltage will be selected.
VoltageLoss	It means neither Bus1 nor Bus2 voltage, or neither Line1 nor Line2 voltage transformer fuse failed.
Invalid	It means the position is invalid.
BIErr	It means the position of CBs are error.

3.31.2 Protection Principle



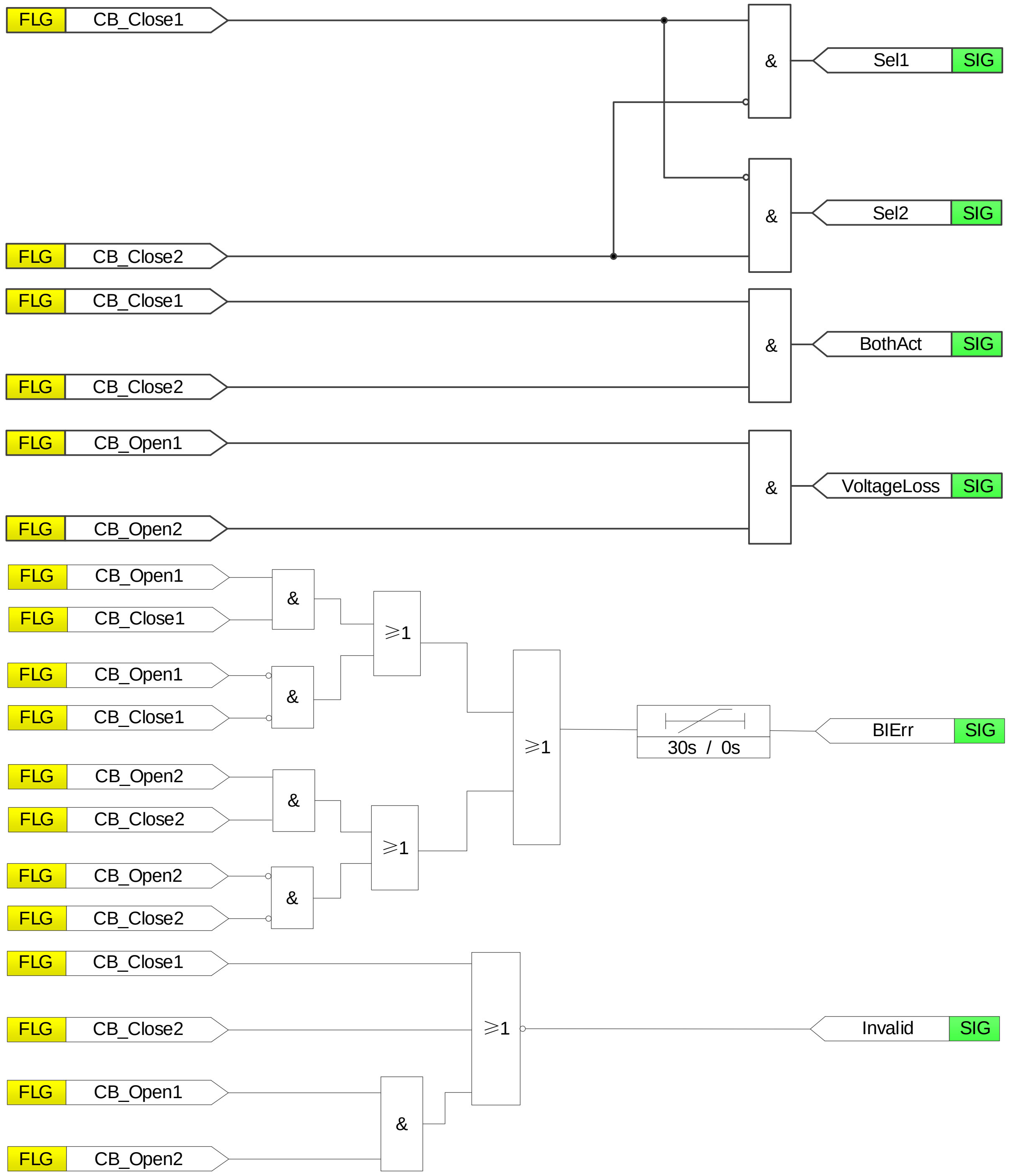


Figure 3.31-2 Voltage sample

The function uses a double point position input to verify the validity of the disconnectors, if any CB position is invalid, then the binary input error alarm will set to true after 30s time delay.

If CB1 is closed or CB1 and CB2 are both closed, then the voltage from bus 1 or line 1 is used by the protection function; If only CB2 is closed, then the voltage from bus or line 2 is used; If both CB are in open position, then the voltage output is 0.

Beyond the above three conditions, the voltage selection is considered invalid, and should use the latest valid voltage selection result as input.

3.31.3 Application Scope

The function is used to select one voltage between two bus voltages or two line voltages. The selection result depends on the type of system configuration.

3.32 Mechanical Protection MP

3.32.1 Overview

This relay provides a one-stage mechanical protection with definite time delay characteristics.

3.32.1.1 Function Block

The function block of the protection is as below.

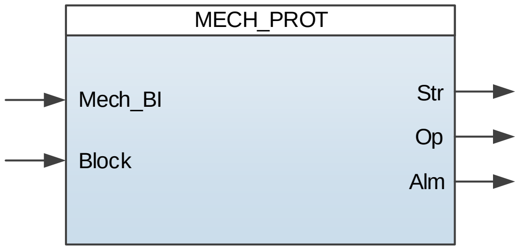


Figure 3.32-1 Function block

3.32.1.2 Signals

Table 3.32-1 Input Signals

Signal	Description
Mech_BI	The mechanical binary input signal
Block	This signal blocks all the binary output signals of the function

Table 3.32-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.
Alm	This is the integrated alarm signal.

3.32.2 Protection Principle

The operation of the protection can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

The two-step protection logic is almost the same except for the individual settings, the functional module diagram of step 1 is shown as below:

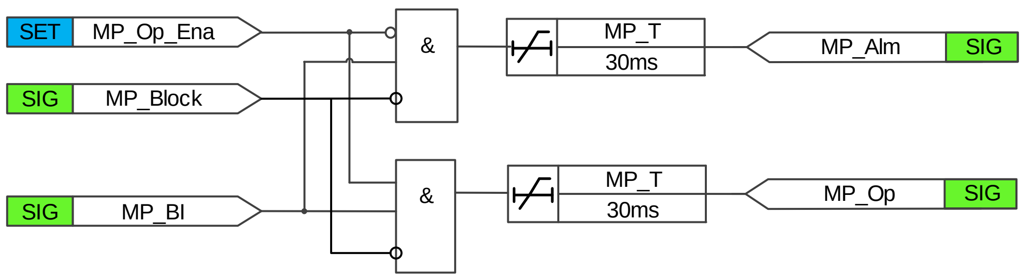


Figure 3-31 Functional module diagram

If there exists binary input signal "MP_BI" and no block signal is activated, the timer and MP_Str signal are activated.

The time characteristic is according to DT. When the operation timer has reached the value set by MP_T, the output of mechanical protection is activated. If the fault disappears before the module operates, the output will reset with a time delay of 30 ms.

The output of mechanical protection depends on setting MP_Op_Ena (The default value is Disable):

- When MP_Op_Ena = Enable, the output MP_Op is activated;
- When MP_Op_Ena = Disable, the output MP_Alm is activated;

The binary input MP_Block can be used to block the function. The activation of the MP_Block input deactivates all outputs and resets internal timers.

Where:

MP_Op_Ena is used to control the output of mechanical protection.

Mp_T is the time delay of mechanical protection.

3.32.3 Application Scope

Mechanical protection is based on fault information characterized by mechanical binary inputs, such as temperature, oil speed, pressure and so on. The mechanical protection includes gas protection, pressure protection, temperature protection, oil level protection and so on.

3.32.4 Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.32-3 MP settings

No.	Name	Range	Unit	Step	Default	Description
1	MP_i_Op_Ena	0-1	-	1	0	Enable: The output of MP is MP_Op; Disable: The output of MP is MP_Alm
2	MP_i_T	0.08-200.00	s	0.01	200.00	Operate time delay

3.33 General function block

3.33.1 IDMT curves for over quantity protection

The inverse-time modes, the operation time depends on the momentary value of the quantity (such as fault current or voltage): the higher the quantity, the faster the operation time. The operation time calculation starts immediately when the quantity exceeds the set Start value.

The time duration can be calculated according to the formula:

$$t = (\frac{A}{(G/G_s)^p - C} + B) \times k$$

Where:

t The operate time (in seconds)

A The Curve Parameter A

B The Curve Parameter B

C The Curve Parameter C

p The Curve Parameter p

G The value of the characterizing quantity

Gs The Start setting value of the characterizing quantity

k The Constant characterizing the relay

User can select the operating characteristic from various inverse-time characteristic curves by setting Curve_Type.

If the Curve_Type= ANSIDefTime or IECDefTime or Resv **,** the operate time is Definite Time mode and the time duration can be calculated according to the formula:

$$t = B \times k$$

If the Curve_Type= UserDefine, the operate time is user Programmable. The timer model is determined by the parameter A, B, C, p, k setting value.

Both IEC and ANSI standardized inverse-time characteristics are supported. when it is IEC or ANSI curve, the parameter C=1, The time duration can be calculated according to the formula:

$$t = (\frac{A}{(G/G_s)^p - 1} + B) \times k$$

Where:

t Operate time in seconds

A Curve Parameter A

B The Curve Parameter B

p Curve Parameter p

G The measured value

Gs The Start value

k The Time Multiplier

The parameters of available characteristics for selection of different Curve_Type setting value are listed in the following table.

Table 3.33-1 Curve parameters for IDMT curves

Curve Value	Curve Type	Curve Characteristic	A	P	B
1	ANSIE	ANSI Extremely Inverse	28.2	2	0.1217
2	ANSIV	ANSI Very Inverse	19.61	2	0.491
3	ANSIN	ANSI Normal Inverse	0.0086	0.02	0.0185
4	ANSIM	ANSI Moderately Inverse	0.0515	0.02	0.114
5	ANSIDefTime	ANSI Definite Time	×	×	×
6	ANSILTE	ANSI Long Time Extremely Inverse	64.07	2	0.25
7	ANSILTV	ANSI Long Time Very Inverse	28.55	2	0.712
8	ANSILT	ANSI Long Time Inverse	0.086	0.02	0.185
9	IECN	IEC Normal Inverse	0.14	0.02	0
10	IECV	IEC Very Inverse	13.5	1	0
11	IEC	IEC Inverse	0.14	0.02	0
12	IECE	IEC Extremely Inverse	80	2	0
13	IECST	IEC Short Time Inverse	0.05	0.04	0
14	IECLT	IEC Long Time Inverse	120	1	0
15	IECDefTime	IEC Definite Time	×	×	×
16	Resv	Reserve	×	×	×
17	UserDefine	User Programmable	-	-	-

Note: when using the IDMT curves in OC or EF protection, such as 51P, 67P, 51G, 67G, etc., it is necessary to consider coordination of the Mul_Cur2 and Min _Op_T settings. The Min _Op_T should be less than the time delay calculated by the fault current I=Mul_Cur2*Ip.

The operation is activated after the operation timer has reached the calculated time value. If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the operation will reset after the reset time is exceeded.

3.33.2 CB Position

Table 3.33-2 Input Signals

NO.	Signal
CB_Opn	CB Close input
CB_Cls	CB Open input

Table 3.33-3 Output signal

NO.	Signal
Err	CB positon is error, when CB Open input and CB Close input are 1 or 0.
Opn	CB Open
Cls	CB Close

Table 3.33-4 Settings

No	Name	Range	Unit	Step	Default	Description
1	CB_DPS_Set	0-3	-	1	0	Double signal setting: Only for CB connected in the configuration at the same time CB_Opn and CB_Cls terminal, when CB_Opn and CB_Cls are both 1 or 0, Err=1，Opn=0，Cls=0. =0，Opn= CB_Opn，Cls = CB_Cls， =1，Opn= CB_Opn，Cls =Not(CB_Opn)； =2，Cls = CB_Cls，Opn =Not(CB_Cls); =3，Opn= CB_Opn 且 Not(CB_ Cls)，Cls = CB_ Cls and Not(CB_Opn) Notes: 1) If only configuring CB_Opn，Opn= CB_Opn，Cls =Not(CB_Opn)； 2) If only configuring CB_ Cls，Cls = CB_ Cls，Opn =Not(CB_ Opn);

3.33.3 Timer

The relay provide 5 types of user defined timer. The function block is as following:

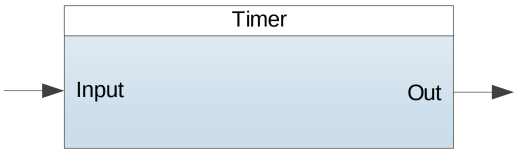


Figure 3.33-1 Function block

The setting attribute is shown in Table 3.33-5.

Table 3.33-5 Timer attribute setting

Name	Description
ActT1	The action time delay T1, the unit is ms
RetT2	The return time delay T2, the unit is ms
TimeMod	The time mode

The timer can be used according to different TimeMod, the details are shown in Table 3.33-6.

Table 3.33-6 Timer condition in different time mode

TimeMod	Input	Time delay(ms)	Out	Description of different time mode
0	0->1	ActT1	1	If the input is 0->1->0, the time delay ActT1 will be reset, only the input is 1 and last for ActT1, the out is 1.
	1->0	RetT2	0	If the out is 0->1->0, the time delay ActT2 will be reset, only the input is 0 and last for ActT2, the out is 0.
1	0->1	ActT1	1	If the input is 0->1->0, the time delay ActT1 will be reset, only the input is 1 and last for ActT1, the out is 1.
	1->0	RetT2	0	If the input is 0->1->0, the time delay ActT2 will not be reset.
2	0->1	ActT1	1	If the input is 0->1->0, the time delay ActT1 will be reset, only the input is 1 and last for ActT1, the out is 1.
	1->0	RetT2	0	If the out is 1, whether the input is 0 or 1, the return time delay will be calculated, when the return time delay last for ActT2, the out is 0. If the input is 0->1-0 during the return time delay, the return time delay ActT2 will not be reset.
3	0->1	ActT1	1	If the input is 0->1->0, the time delay ActT1 will be reset, only the input is 1 and last for ActT1, the out is 1.
	1->0	RetT2	0	If the out is 1, the return time delay will be calculated, If the input is 0->1-0 during the return time delay, the return time delay ActT2 will be reset, only the out is 1 and there is no 0->1 or 1->0 status disturbance, and the time delay last for ActT2, the out is 0.
4	0->1	ActT1	1	If the input is 0->1 for one time and the out is 1 after the time delay ActT1.
	1->0	RetT2	0	If the out is 1, the return time delay will be calculated, after the time delay last for ActT2, the out is 0.

3.34 Backup power automatic switch BPAS

3.34.1 Overview

Backup power automatic switching mainly applies to circumstances where single-busbar stage of single-ended substation, for example, stage backup power automatic switching at load side of main transformer and bridge backup power automatic switching at power supply side.

The main wiring diagram of backup power automatic switch is shown in Figure 3.34-1.

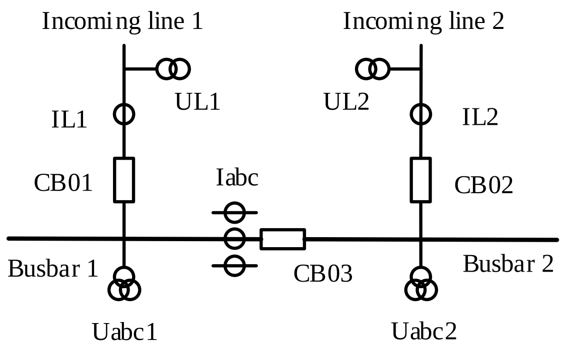


Figure 3.34-1 Main wiring diagram of backup power automatic switch

The charge conditions of backup power automatic switching including:

1) No blocking condition, discharge condition;
2) Backup power automatic switching device is enabled;
3) Operating and backup breakers are in normal position;
4) Operating and backup power supply are in good condition.

Backup power automatic switching does not operate unless the device is charged for 15s after all charge conditions are satisfied.

After backup power automatic switching is completed charged, in case of busbar voltage failure, no current at operating incoming line and backup power supply live voltage, backup power automatic switching device activates the delay; when the delay time is elapsed, the device will trip operating incoming line while determining whether it has been tripped off.

Backup power automatic switching of incoming line has two operation modes, Backup power automatic switching of incoming line 1 (**BPAS1**) and backup power automatic switching of incoming line 2 (**BPAS2**). In these two operation modes, incoming line 1 and 2 alternate each other in an obvious manner, that means, CB01 and CB02 are alternate for each other.

The operation process of BPAS1 is tripping CB01 and closing CB02 when busbar 1 and 2 are in dead voltage status;

The operation process of BPAS2 is tripping CB02 and closing CB01 when busbar 1 and 2 are in dead voltage status.

Backup power automatic switching of busbar has two operation modes, Backup power automatic switching of busbar 1 (**BPAS3**) and backup power automatic switching of busbar 2 (**BPAS4**). In these two operation modes, busbar 1 and 2 alternate each other in a hidden manner, that means, CB03 alternates CB01 and CB02.

The operation process of BPAS3 is tripping CB01 and closing CB03 when busbar 1 is in dead voltage status;

The operation process of BPAS4 is tripping CB02 and closing CB03 when busbar 2 is in dead voltage status.

Table 3.34-1 AC component and input value to be employed for BPAS

Input AC component (A total of 13)	Phase to phase voltages of busbar 1 and 2, i.e. Uab1, Ubc1, Uca1 and Uab2, Ubc2, Uca2; Line voltages of incoming line 1 and 2, i.e. UL1 and UL2; Phase current of incoming line 1 and 2, i.e. IL1 and IL2; Phase current of section, i.e. Ia, Ib and Ic
Input switching value (A total of 10)	CB01_Open, CB02_Open, CB03_Open; CB01_Aft_Cls, CB02_Aft_Cls, CB03_Aft_Cls; BPAS_Blk, BPAS_Ena; Trans01_Op, Trans02_Op

3.34.2 Operation principle

3.34.2.1 Public Part: Live voltage, dead voltage and live current conditions

1) There are two criteria for live busbar:

   Any of the bus phase to phase voltage UAB, UBC and UCA is greater than [Busbar voltage setting value]. It is generally used in action logic to judge the voltage of the standby bus, or when the bus voltage is below the voltage constant value of 15s discharge condition.

All of the bus phase to phase voltages UAB, UBC and UCA are greater than [Busbar voltage setting value]. Generally used in the charging conditions of the bus voltage condition judgment.

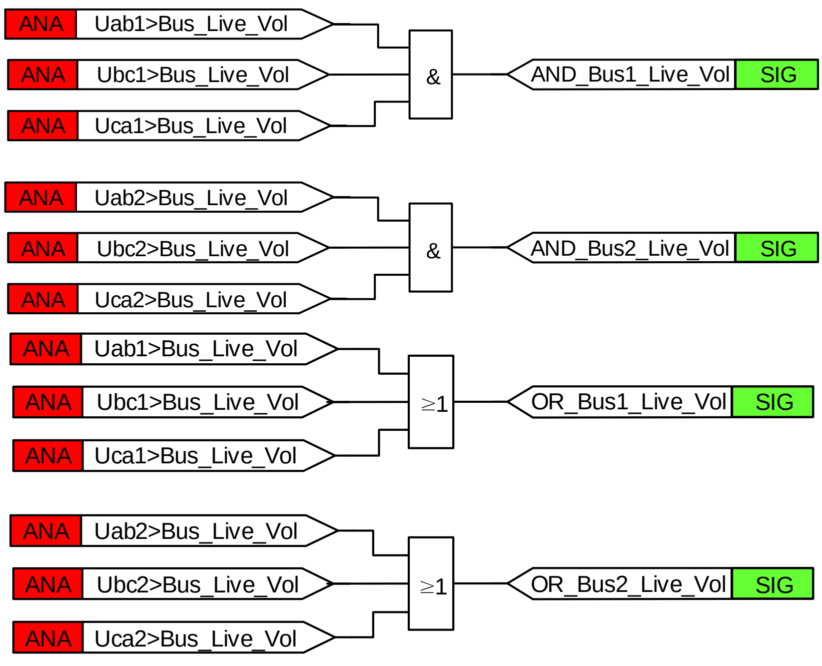


Figure 3.34-2 Diagram of busbar live voltage logic

2) "Busbar dead voltage” means Uab, Ubc and Uca as phase to phase voltage of busbar are all less than busbar dead voltage setting value. Busbar dead voltage conditions of Uab, Ubc and Uca must be satisfied meanwhile in case of 1 or 2 phase line-break of PT of operational power supply.

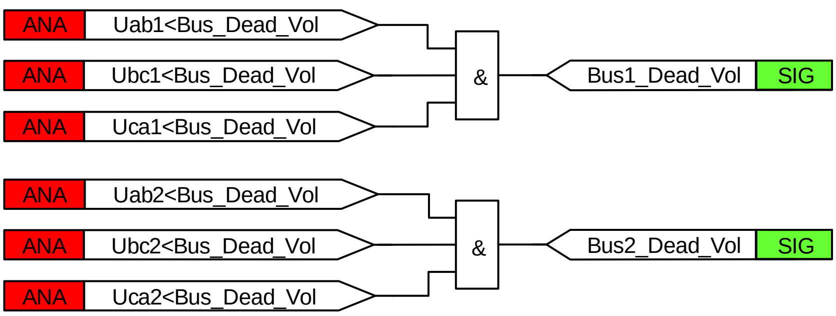


Figure 3.34-3 Diagram of busbar dead voltage logic

3) "Incoming line live voltage” means someone phase voltage (or line voltage) is greater than

incoming line live voltage setting value. If there's no incoming line PT on site, incoming line normal voltage criterion could be disabled through L1_Vol_Ena and L2_Vol_Ena respectively.

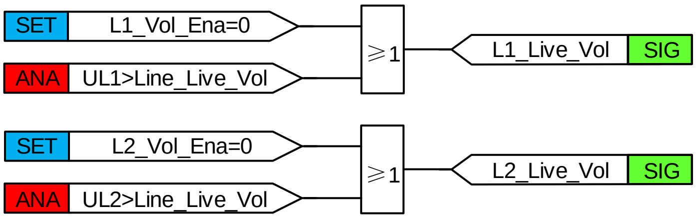


Figure 3.34-4 Diagram of incoming line live voltage logic

4) "Incoming line live current" means the current at one phase of incoming line of operational power supply is more than incoming line live current setting value. This setting value should be less than minimum load current, or backup power automatic switching may malfunction in case of CT three-phase line-break of operational power supply.

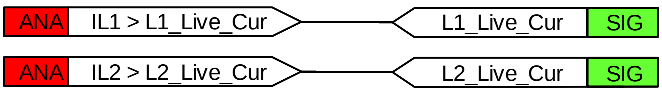


Figure 3.34-5 Diagram of incoming line dead current logic

3.34.2.2 Backup power automatic switching of incoming line 1 (BPAS1)

Discharge Conditions

The logic diagram of the discharge condition of BPAS1 is shown in Figure 3.34-6.

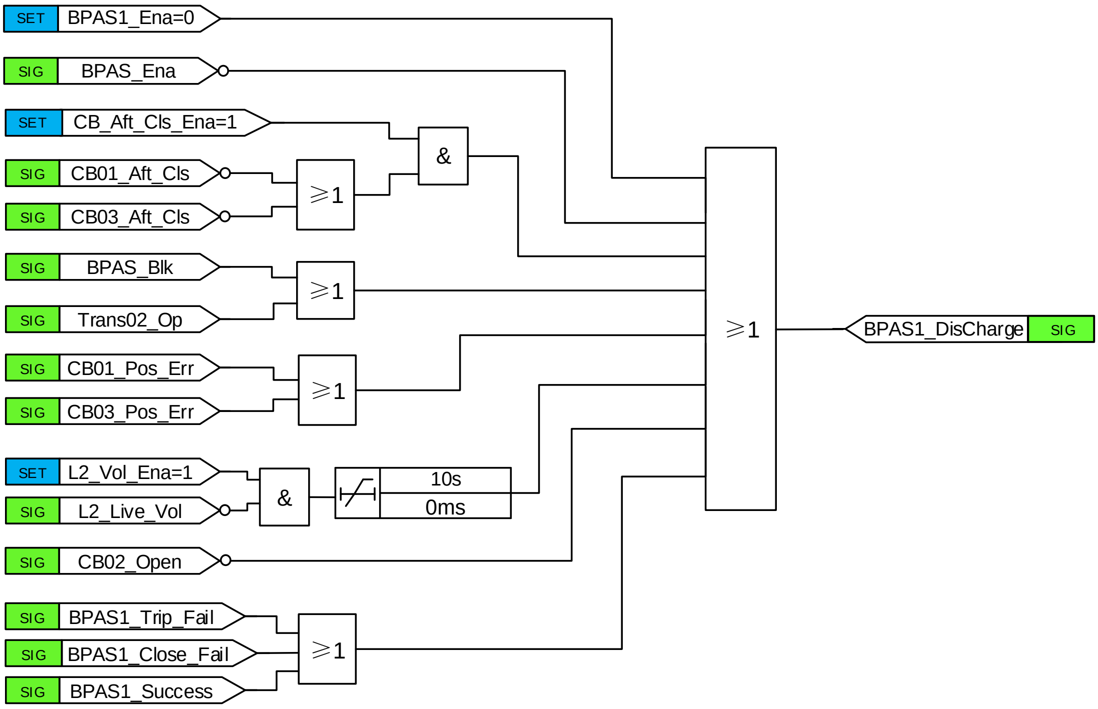


Figure 3.34-6 Diagram of the discharge condition of BPAS1

The discharge conditions of BPAS1 and BPAS2 are similar, so take BPAS1 for example.

Discharge conditions normally cover the following items. Backup power automatic switching would be discharged immediately after any discharge condition is satisfied.

1) Blocking condition is satisfied. Backup power automatic switching is forcibly blocked, regardless of whether it has been started;

2) Backup power automatic switching is disabled, that means the setting value BPAS1_Ena is set to "Disabled", or the binary input BPAS_Ena is "Disable";

3) The binary input CB01_Aft_Cls or CB03_Aft_Cls disappears when setting value CB_Aft_Cls_Ena is set to "Enable";

4) Operation breakers are in error status, that means the current at one phase of incoming line of operational power supply is more than incoming line no-current setting value, although the operation breakers are open. The logic diagram of CB position error is shown in Figure 3.34-7;

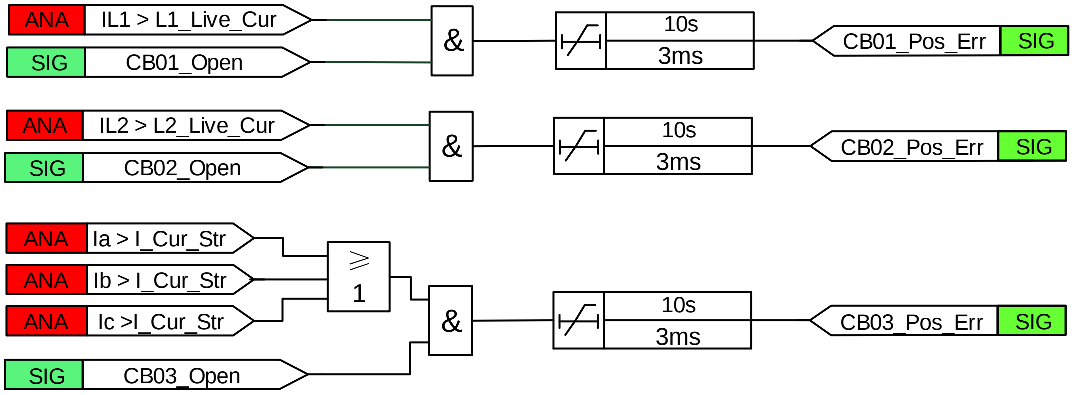


Figure 3.34-7 Diagram of CB position error logic

5) The time period during which backup power supply doesn't meet live voltage condition is longer than 15s;

6) Backup breaker is not in backup status, that means backup breaker has been closed;

7) Operating breaker fails to trip or backup breaker fails to close;

Charge Conditions

The logic diagrams of the charge condition of BPAS1 is shown in Figure 3.34-8.

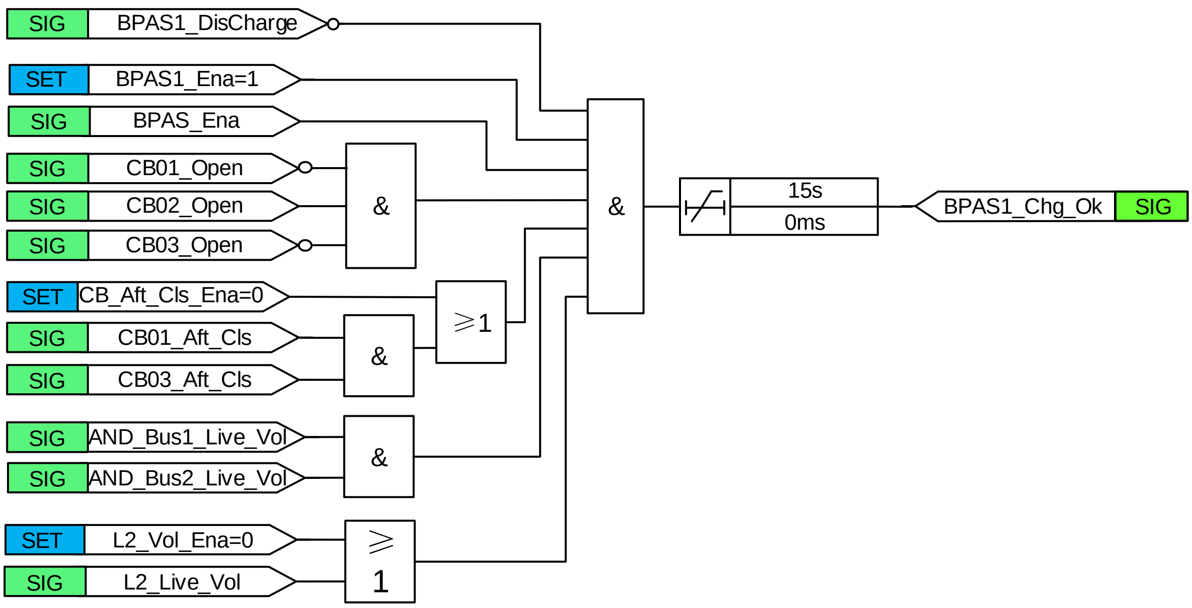


Figure 3.34-8 Diagram of the charge condition of BPAS1

The charge conditions of BPAS1 and BPAS2 are similar, so take BPAS1 for example.

The charge conditions of BPAS1 cover the following items:

1) No blocking condition, discharge condition;

2) Backup power automatic switching device is enabled, that means, the setting value BPAS1_Ena is “enabled”, and the binary input BPAS_Ena is “Enable”;

3) Operating and backup breakers are in normal position, that means, CB01 and CB03 are at close position, while CB02 is at open position;

4) CB01 and CB03 are in after-close status. If there's no CB after-close binary inputs, the criterion could be disabled through setting CB_Aft_Cls_Ena.

5) Both busbar 1 and busbar 2 are in good condition, i.e. meeting live voltage condition;

Backup power automatic switching does not operate unless the device is charged for 15s after all charge conditions are satisfied.

Operation Process

The diagrams of the operation process of BPAS1 is shown in Figure 3.34-9.

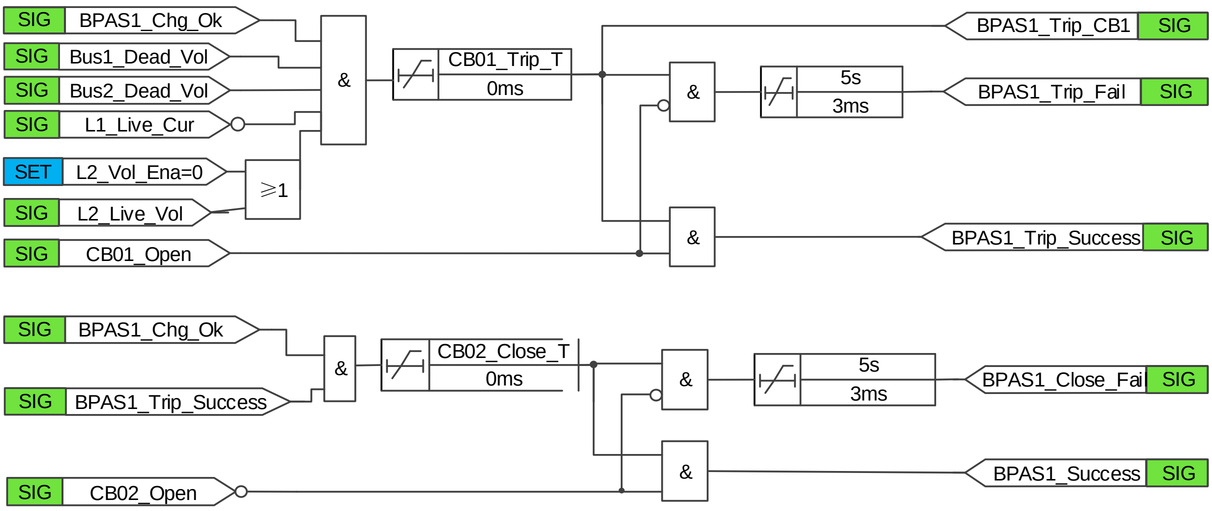


Figure 3.34-9 Diagram of the operation process of BPAS1

The operation processes of BPAS1 and BPAS2 are similar, so take BPAS1 for example.

→After BPAS1 is completed charged, if the line voltage of busbar 1 and 2 is less than Bus_Dead_Vol, current of operating incoming line 1 is less than L1_Live_Cur, and the line voltage of incoming line 2 is more than L2_Live_Vol if the setting L2_Vol_Ena is “Enable”, backup power automatic switching device will send “BPAS Trip CB01” signal and transmit CB01 tripping pulse after CB01_Trip_T. The backup power automatic switching device will intertrip the load of busbar 1 meanwhile if the setting Intertrip_Ena is “Enable”. Once CB01 fails to operate within 5s after the release of “BPAS Trip CB01” signal, terminate BPAS1 logic and discharge BPAS1, and then the device would send “BPAS trip CB fail” signal;

→Countermand CB01 tripping command after CB01 is confirmed have tripped off. Backup power automatic switching device will transmit CB02 closing pulse and send “BPAS Close CB02” signal after CB02_Close_T;

→Countermand “BPAS Close CB02” signal and send “BPAS success” after CB02 is confirmed to have been closed. Once CB02 fails to operate within 5s after the release of “BPAS Close CB02” signal, terminate logic and discharge BPAS1, and then the device would give “BPAS Close CB fail” signal.

3.34.2.3 Backup power automatic switching of incoming line 2 (BPAS2)

Discharge Conditions

The logic diagram of the discharge condition of BPAS2 is shown in Figure 3.34-10.

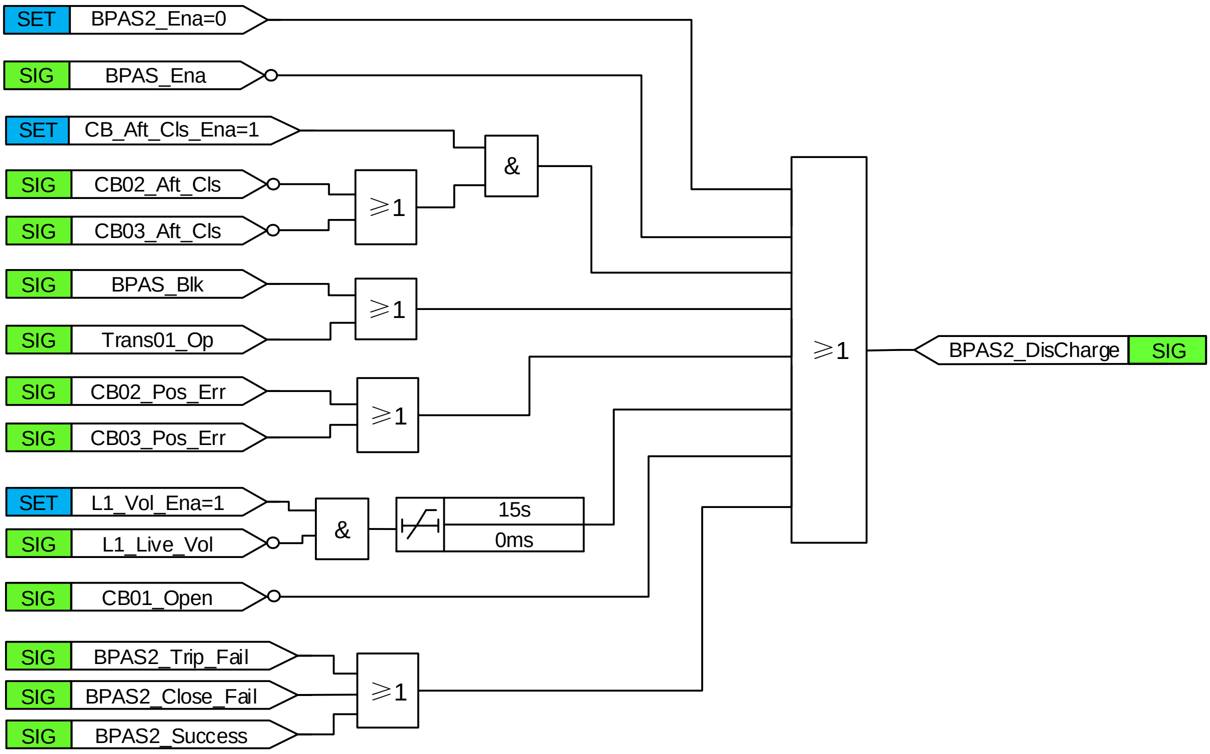


Figure 3.34-10 Diagram of the discharge condition of BPAS2

Charge Conditions

The logic diagrams of the charge condition of BPAS2 is shown in Figure 3.34-11.

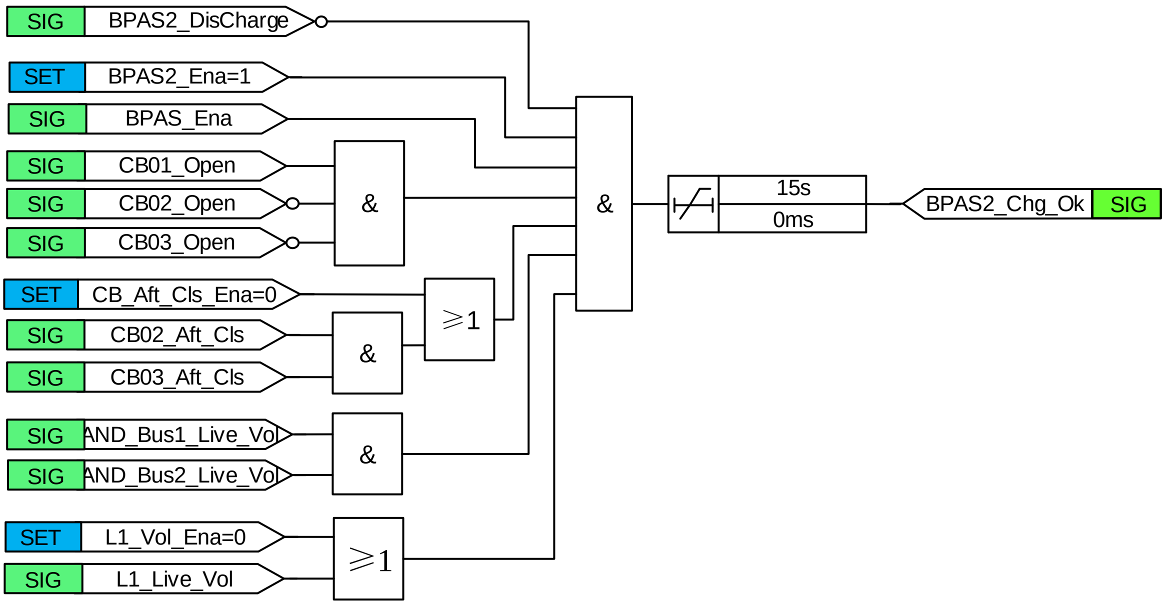


Figure 3.34-11 Diagram of the charge condition of BPAS2

Operation Process

The diagrams of the operation process of BPAS2 is shown in Figure 3.34-12.

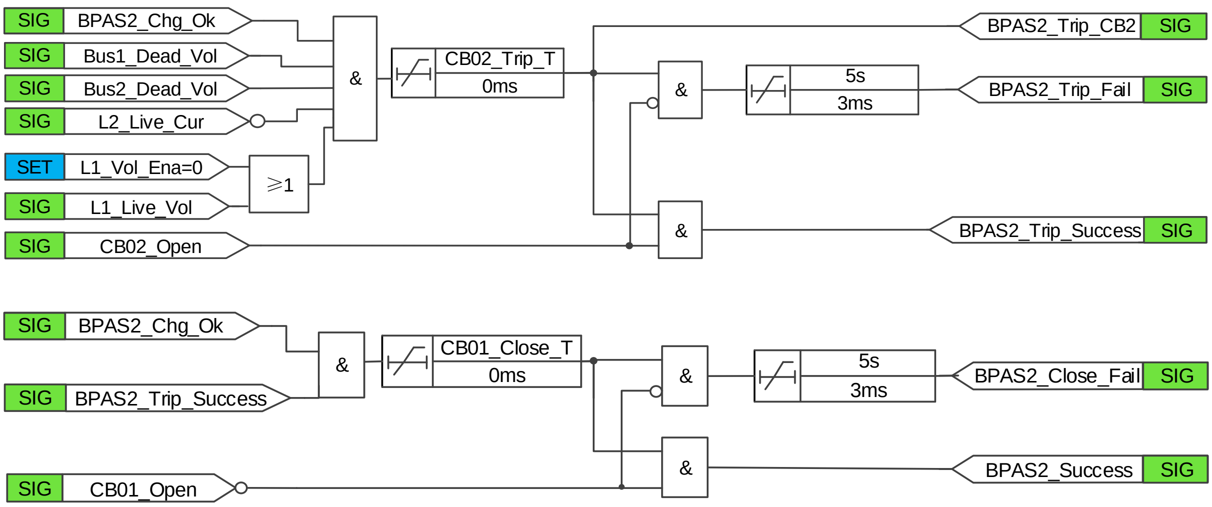


Figure 3.34-12 Diagram of the operation process of BPAS2

3.34.2.4 Backup power automatic switching of busbar 1 (BPAS3)

The logic diagram of the discharge condition of BPAS is shown in Figure 3.34-13.

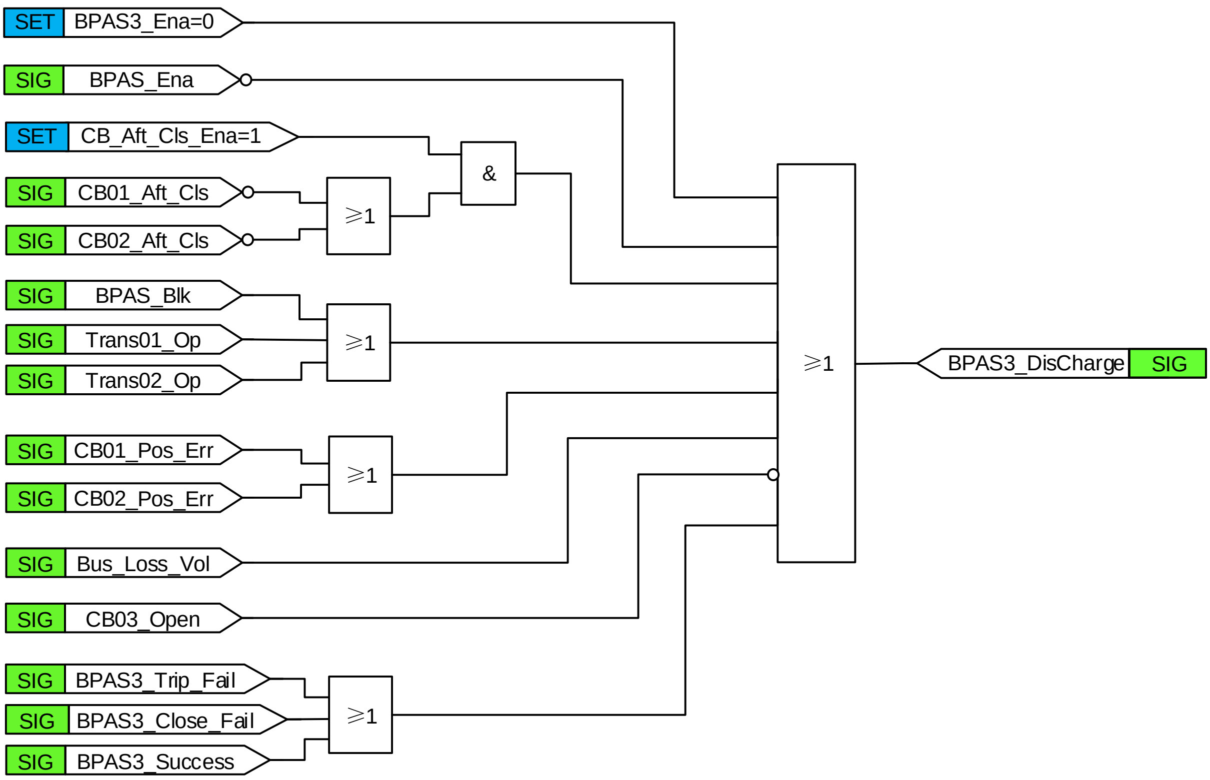


Figure 3.34-13 Diagram of the discharge condition of BPAS3

Discharge conditions normally cover the following items. Backup power automatic switching would be discharged immediately after any discharge condition is satisfied.

1) Blocking condition is satisfied. Backup power automatic switching is forcibly blocked, regardless of whether it has been started;

2) Backup power automatic switching is disabled, that means the setting value BPAS3_Ena is set to “Disabled”, or the binary input BPAS_Ena is “Disabled”;

3) The binary input CB01_Aft_Cls or CB02_Aft_Cls disappears when setting value CB_Aft_Cls_Ena is set to “Enable”

4) Operation breakers are in error status, that means the current at one phase of incoming line of operational power supply is more than incoming line no-current setting value, although the operation breakers are open. The logic diagram of CB position error is shown in Figure 3.34-7;

5) Backup breaker is not in backup status, that means backup breaker has been closed;

6) The time period during which both of operation power supplies do not meet live-voltage condition is longer than 15s. The logic diagram of busbar voltage loss is shown in Figure 3.34-14;

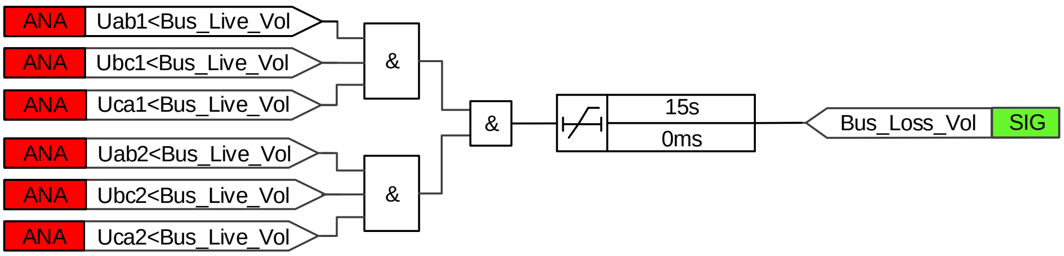


Figure 3.34-14 Diagram of busbar voltage loss logic

7) Operating breaker fails to trip or backup breaker fails to close.

Charge Conditions

The logic diagrams of the charge condition of BPAS3 is shown in Figure 3.34-15.

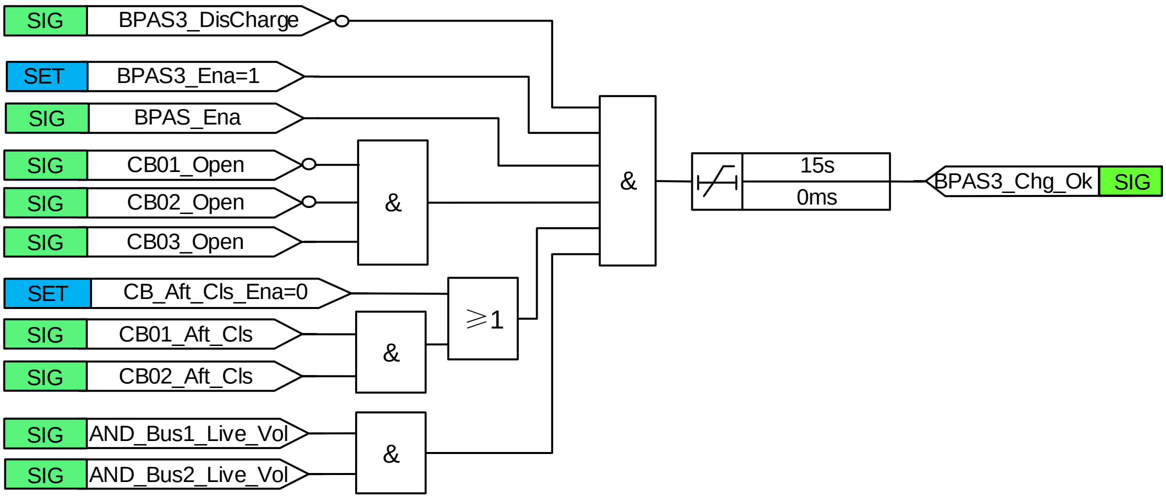


Figure 3.34-15 Diagram of the charge condition of BPAS3

The charge conditions of BPAS3 and BPAS4 are similar, so take BPAS3 for example.

The charge conditions of BPAS3 cover the following items:

1) No blocking condition, discharge condition;

2) Backup power automatic switching device is enabled, that means, the setting value BPAS3_Ena is "enabled";

3) Operating and backup breakers are in normal position, that means, CB01 and CB02 are at close position, while CB03 is at open position;

4) CB01 and CB02 are in after-close status. If there's no CB after-close binary inputs, the criterion could be disabled through setting CB_Aft_Cls_Ena.

5) Both busbar 1 and busbar 2 are in good condition, i.e. meeting live voltage condition;

Backup power automatic switching does not operate unless the device is charged for 15s after all charge conditions are satisfied.

Operation Process

The diagrams of the operation process of BPAS3 is shown in Figure 3.34-16.

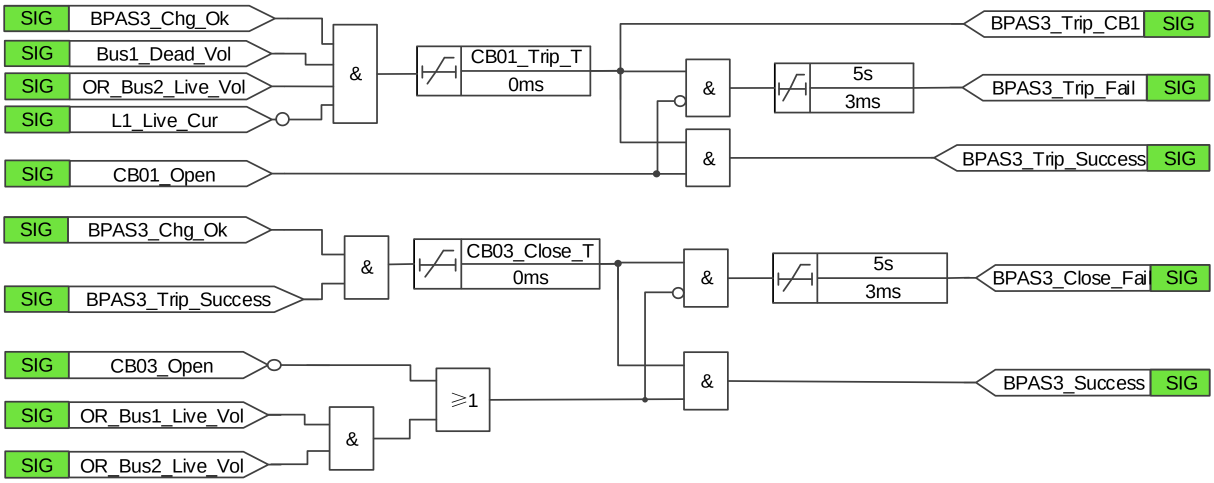


Figure 3.34-16 Diagram of the operation process of BPAS3

The operation processes of BPAS3 and BPAS4 are similar, so take BPAS3 for example.

→After BPAS3 is completed charged, if the line voltage of busbar 1 is less than Bus_Dead_Vol, current of operating incoming line 1 is less than L1_Live_Cur, and the line voltage of busbar 2 is more than Bus_Live_Vol, backup power automatic switching device will send “BPAS Trip CB01” signal and transmit CB01 tripping pulse after CB01_Trip_T. The backup power automatic switching device will intertrip the load of busbar 1 meanwhile if Intertrip_Ena is “Enable”. Once CB01 fails to operate within 5s after the release of “BPAS Trip CB01” signal, terminate BPAS3 logic and discharge BPAS3, and then the device would send “BPAS trip CB fail” signal;

→Countermand CB01 tripping command after CB01 is confirmed have tripped off. Backup power automatic switching device will transmit CB03 closing pulse and send “BPAS Close CB03” signal after CB03_Close_T;

→Countermand “BPAS Close CB03” signal and send “BPAS success” after CB03 is confirmed to have been closed. Once CB03 fails to operate within 5s after the release of “BPAS Close CB03” signal, terminate logic and discharge BPAS3, and then the device would give “BPAS Close CB fail” signal.

3.34.2.5 Backup power automatic switching of busbar 2 (BPAS4)

Discharge Conditions

The logic diagram of the discharge condition of BPAS4 is shown in Figure 3.34-17.

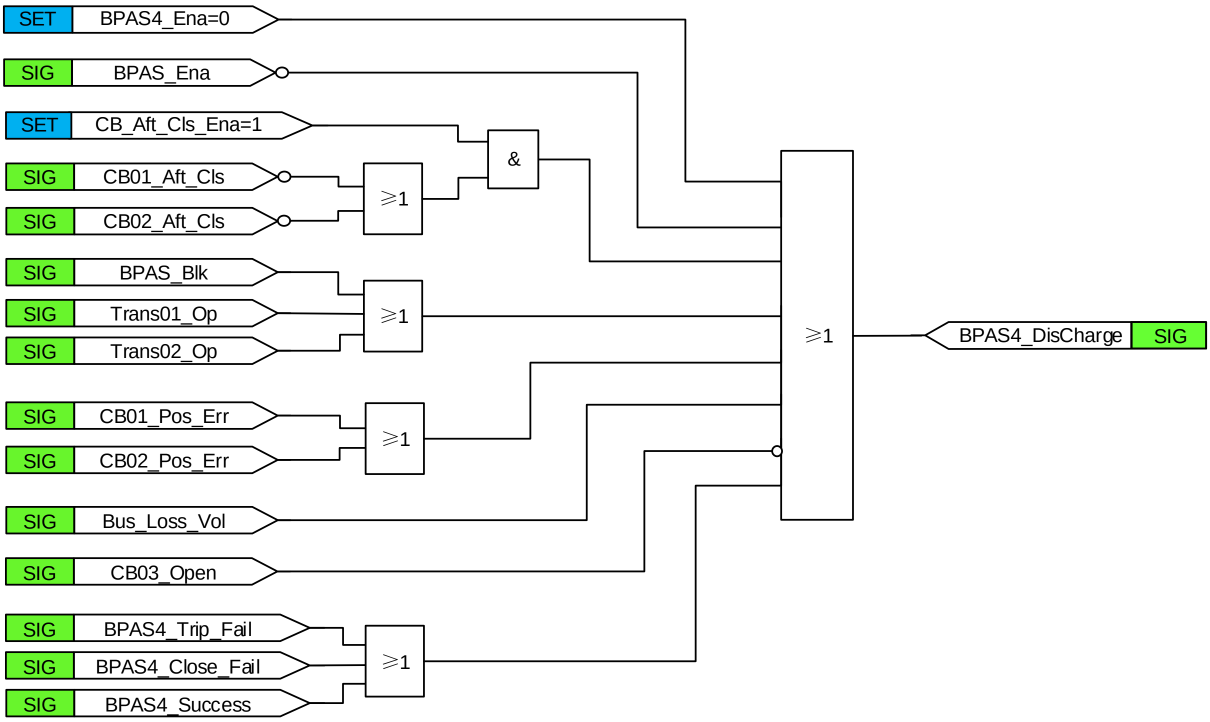


Figure 3.34-17 Diagram of the discharge condition of BPAS4

Charge Conditions

The logic diagrams of the charge condition of BPAS3 is shown in Figure 3.34-18.

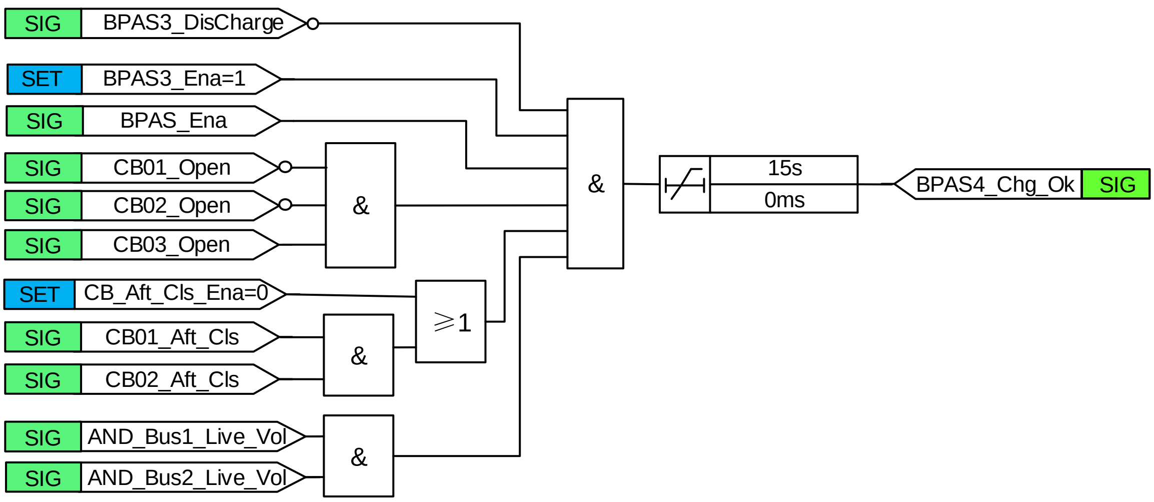


Figure 3.34-18 Diagram of the charge condition of BPAS4

Operation Process

The diagrams of the operation process of BPAS4 is shown in Figure 3.34-19.

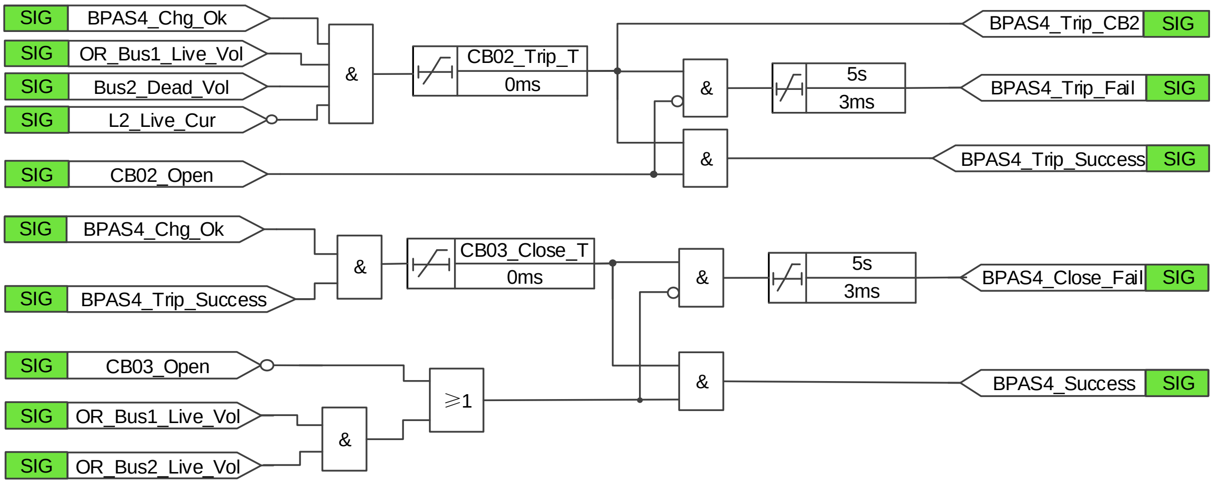


Figure 3.34-19 Diagram of the operation process of BPAS4

3.34.3 Application Scope

Backup power automatic switching of busbar mainly applies to circumstances where single-busbar stage of single-ended substation, for example, stage backup power automatic switching at load side of main transformer and bridge backup power automatic switching at power supply side. The typical application configuration of backup power automatic switching device is shown in Figure 3.34-20.

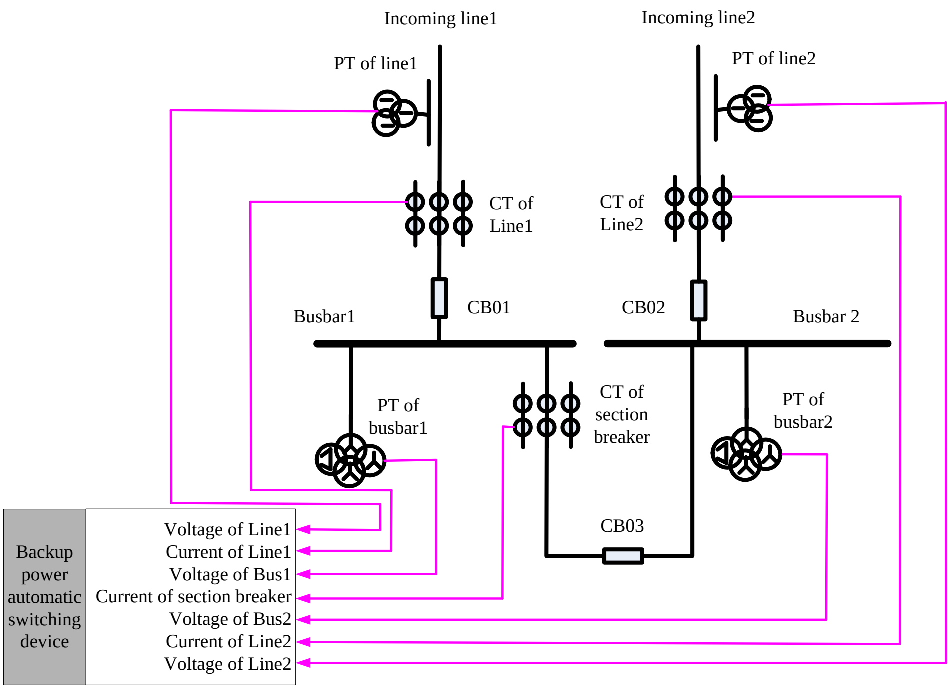


Figure 3.34-20 The typical application configuration of backup power automatic switching device

Backup power supply cannot be put into service unless operational power supply is actually disconnected. Upon the voltage drop of operational power supply, backup power automatic switching device always trips incoming line breaker first after startup delay; backup power automatic switching logic cannot go on unless this breaker is confirmed to be at tripping position. This can prevent the closing of backup power automatic switching upon fault or inverse feeding of backup power supply.

The purpose of backup power automatic switching delay is to steer by transient busbar voltage drop; accordingly, backup power automatic switching delay should be greater than maximum external fault clearing time. Backup power automatic switching shall not operate when operational power supply is manually disabled. Backup power automatic switching shall not operate when backup power supply fails to meet voltage condition.

3.34.4 Settings

Table 3.34-1 BPAS Settings

Name	Range	Unit	Step	Default	Description
BPAS1_Ena	0-1	-	1	0	Backup power automatic switching of incoming line 1 (BPAS1) disable/enable
BPAS2_Ena	0-1	-	1	0	Backup power automatic switching of incoming line 2 (BPAS2) disable/enable
BPAS3_Ena	0-1	-	1	0	Backup power automatic switching of busbar 1 (BPAS3) disable/enable
BPAS4_Ena	0-1	-	1	0	Backup power automatic switching of busbar 2 (BPAS4) disable/enable
L1_Vol_Ena	0-1	-	1	0	Checking incoming line 1 with normal voltage disable/enable
L2_Vol_Ena	0-1	-	1	0	Checking incoming line 2 with normal voltage disable/enable
CB_Aft_Cls_Ena	0-1	-	1	0	Checking CBs are in after-close status disable/enable
Intertrip_Ena	0-1	-	1	0	Intertrip disable/enable
Bus_Live_Vol	10.00-100.00	V	0.01	100.00	Busbar live voltage setting value
Bus_Dead_Vol	10.00-100.00	V	0.01	100.00	Busbar dead voltage setting value
Line_Live_Vol	10.00-100.00	V	0.01	100.00	Incoming line live voltage setting value
L1_Live_Cur	0.02In-In	A	0.01In	In	Incoming line 1 live current setting value
L2_Live_Cur	0.02In-In	A	0.01In	In	Incoming line 2 live current setting value
CB01_Trip_T	0.01-30.00	s	0.01	30.00	Time delay for CB01 tripping
CB01_Close_T	0.01-30.00	s	0.01	30.00	Time delay for CB01 closing
CB02_Trip_T	0.01-30.00	s	0.01	30.00	Time delay for CB02 tripping
CB02_Close_T	0.01-30.00	s	0.01	30.00	Time delay for CB02 closing
CB03_Close_T	0.01-30.00	s	0.01	30.00	Time delay for CB03 closing

3.35 Trip logic 94T

3.35.1 Overview

This relay provides trip logic for tripping BO.

3.35.1.1 Function Block

The function block of the protection is as below.

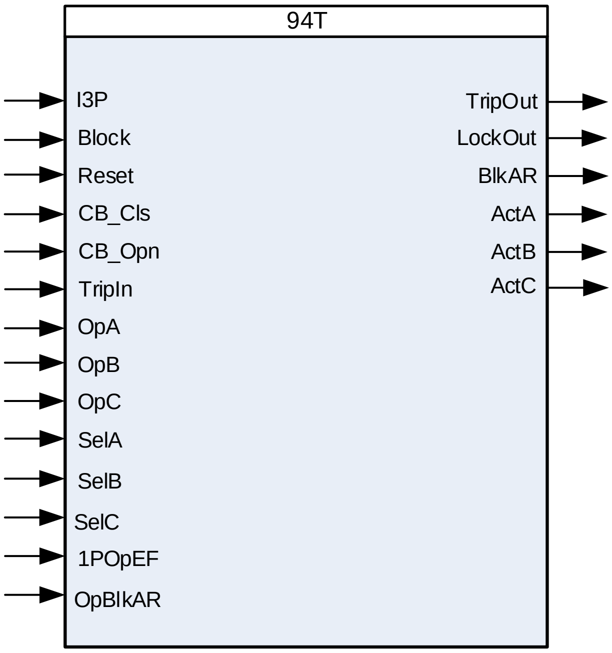


Figure 3.35-1 Function block

3.35.2 Protection Principle

The operation of 94T can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

All relay tripping BO after onDelay time delay

All relay tripping BO will return when Block is 1.

- Lockout Type: The relay tripping BO can be connected to external Lockout relay.
- Pulse type: The relay tripping BO pulse is fixed to time delay with setting 94Ti_PulseTime, the default is 150ms, the minimum is 50ms.
- Steady type
  - The tripping BO last for at least 94Ti_PulseTime.
  - The return condition: no current, CB Open position, no current or CB Open position, no current and CB Open position.
  - The tripping BO will return after the return condition is ok and last for the 94Ti_OffDelay setting.

➢ When CB Open is used, all condition is ok but the CB Open is still not 1, the tripping BO will return after 1s.

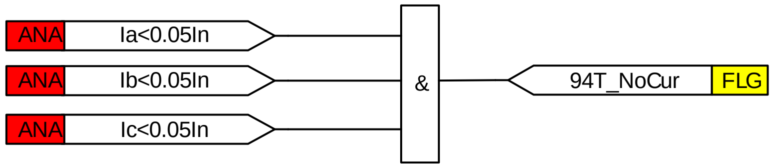


Figure 3.35-2 The No current condition

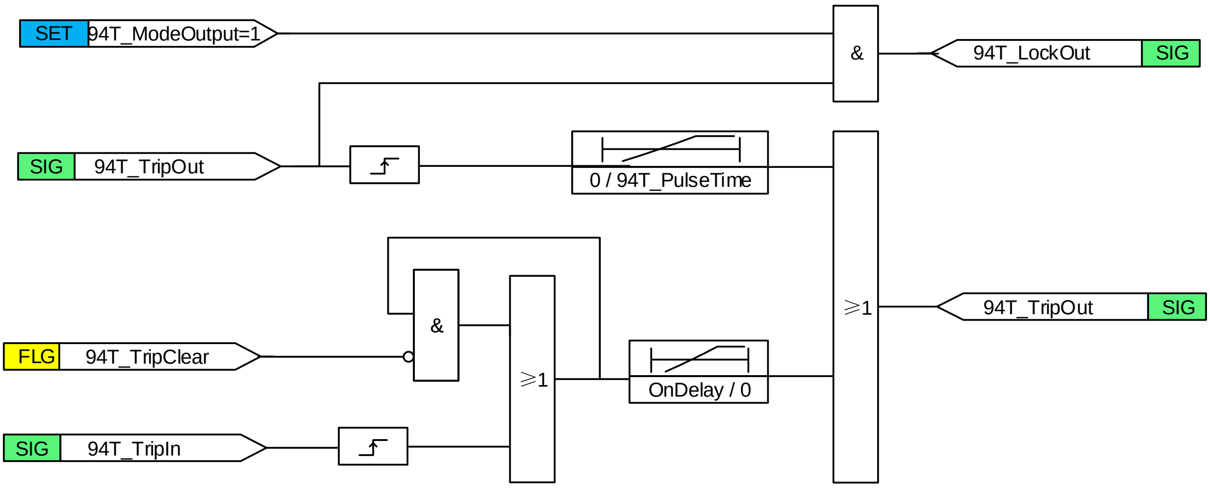


Figure 3.35-3 The 94T tripping and Lockout BO

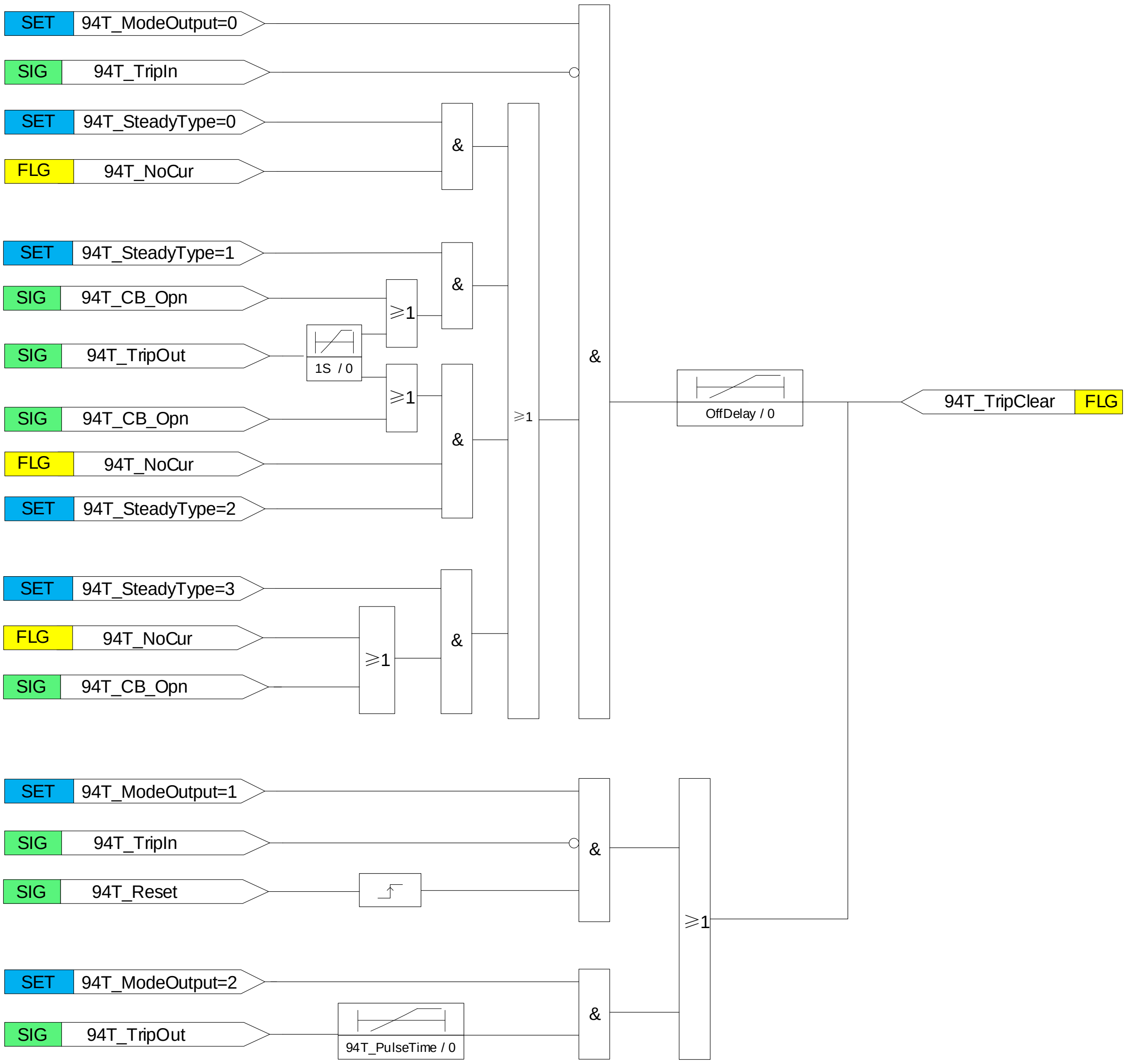


Figure 3.35-4 The 94T tripping BO return

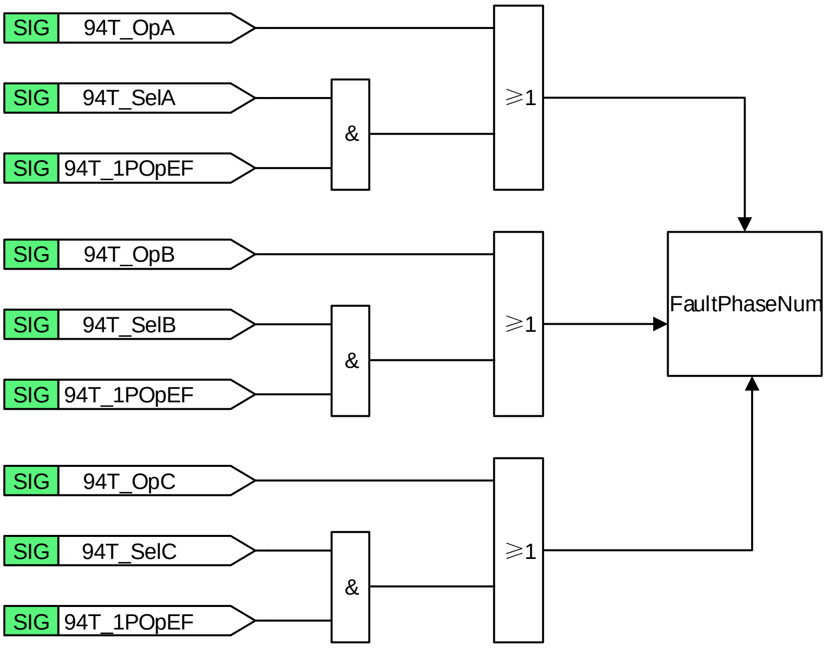


Figure 3.35-5 The 94T fault number condition

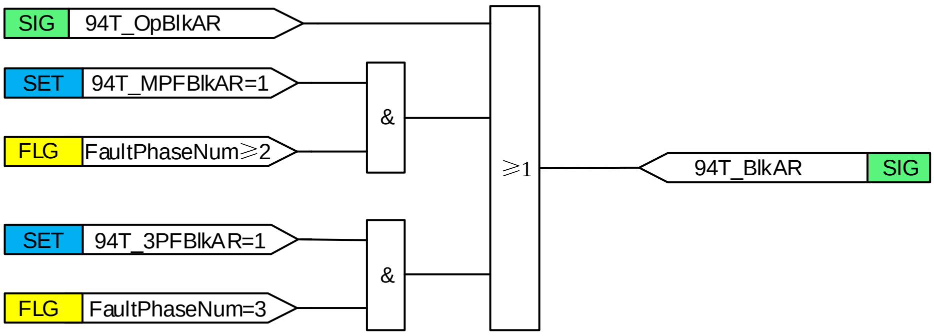


Figure 3.35-6 The 94T fault blocking AR function

3.35.3 Application Scope

All trip signals from different protection functions are routed through the trip logic. The most simplified application of the logic function is linking the trip signal and ensuring that the signal is long enough.

3.35.4 Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.35-1 94T settings

Name	Range	Unit	Step	Default	Description
94Ti_ModeOutput	0-2	-	1	0	BO mode： 0: Steady type 1: Lockout type 2: Pulsed type
94Ti_SteadyType	0-3	-	1	0	Return modes of steady type 0：no current 1：CB open 2：1 and 2 3：1 or 2
94Ti_PulseTime	0.05-60.00	s	0.01	0.15	Pulse delay time
94Ti_OnDelay	0-60.00	s	0.01	0	Output on delay time
94Ti_OffDelay	0-60.00	s	0.01	0.01	Output off delay time
94Ti_MPFBlkAR	0-1	-	1	0	1: Enable 0: Disable
94Ti_3PFBlkAR	0-1	-	1	0	1: Enable 0: Disable

3.36 Close Logic

3.36.1 Overview

This relay provides trip logic for tripping BO.

3.36.1.1 Function Block

The function block of the protection is as below.

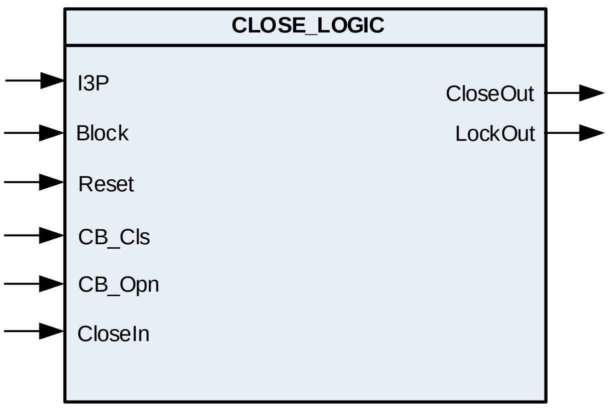


Figure 3.36-1 Function block

3.36.2 Protection Principle

The operation of close logic can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

- Lockout Type: The relay closing BO can be connected to external Lockout relay.
- Steady type
  - The closing BO last for at least 100ms
  - The return condition: using "AND" logic with the closing relay return with no current or CB close position
  - The closing BO will return after the return condition is ok and last for the Closei_OffDelay setting.
  - When CB Close is used, all condition is ok but the CB Close is still not 1, the closing BO will return after 1s.

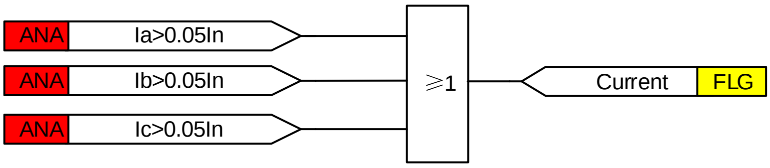


Figure 3.36-2 The No current condition

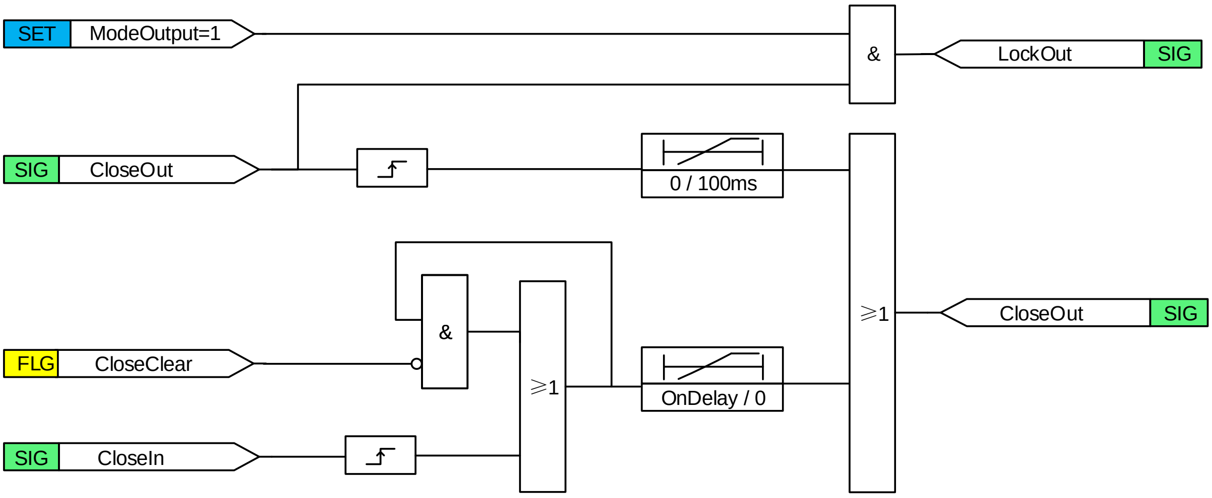


Figure 3.36-3 The closing and Lockout BO

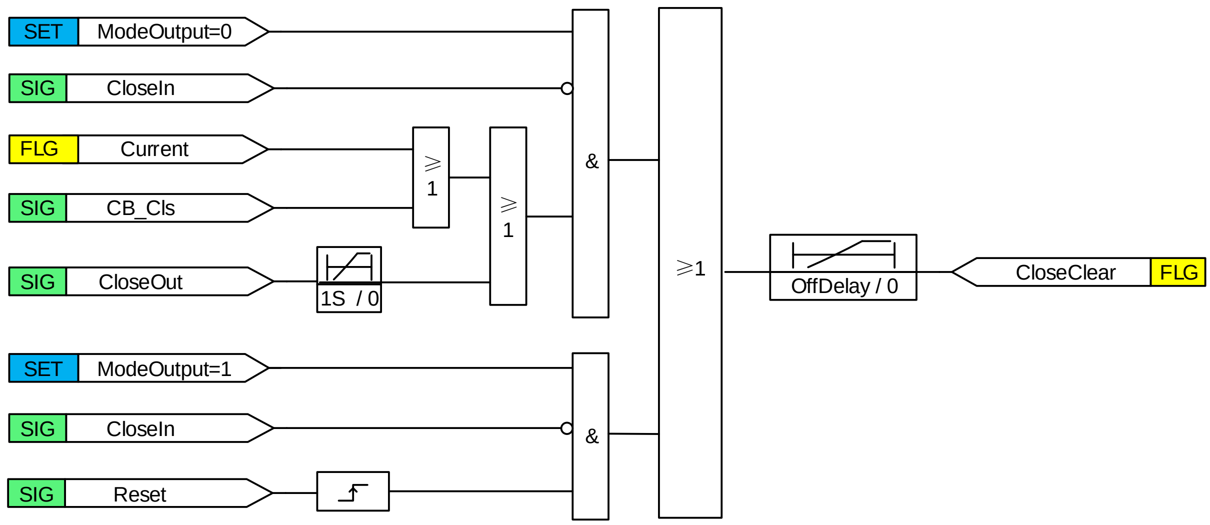


Figure 3.36-4 The closing BO return

3.36.3 Application Scope

All close signals from different protection functions are routed through the close logic. The most simplified application of the logic function is linking the close signal and ensuring that the signal is long enough.

3.36.4 Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.36-1 Close settings

Name	Range	Unit	Step	Default	Description
Close_ModeOutput	0-1	-	1	0	BO mode： 0: Steady 1: Lockout
Close_OnDelay	0-60.00	s	0.01	0	Output pulse time
Close_OffDelay	0-60.00	s	0.01	0.01	Output on delay time

3.37 Three phase inrush function OCR_INR

3.37.1 Overview

This relay provides three phase inrush for current protection.

3.37.1.1 Function Block

The function block of the protection is as below.

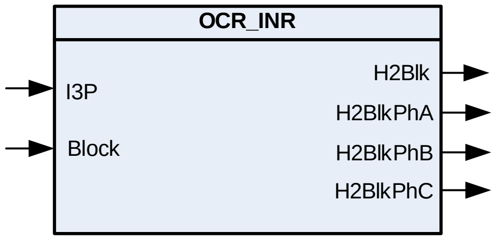


Figure 3.37-1 Function block

3.37.2 Protection Principle

The inrush detection function can be used to selectively initialize the EnaMultCur signal of overcurrent and earth fault function stages when the ratio of second harmonic component over the fundamental component exceeds the set value.

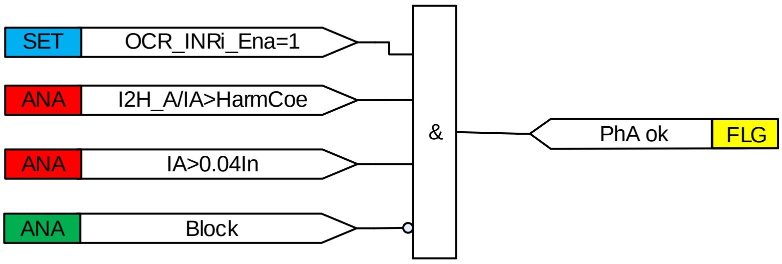


Figure 3.37-2 The phase A initial condition

This module calculates the ratio of the second harmonic (I_2Hp) and fundamental frequency (Ip) phase currents. The calculated value is compared to the set Start value. If the calculated value exceeds the set Start value, the protection is initial.

The output of the phase specific level detector is activated when the fundamental frequency current Ip exceeds 0.04In.

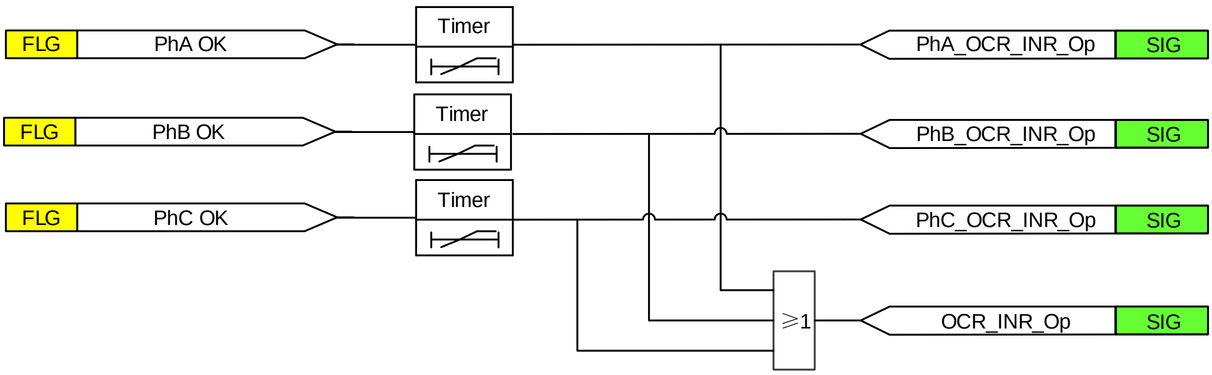


Figure 3.37-3 The inrush operation condition

Once activated, the timer runs until the set Operate delay time value. The time characteristic is according to DT. When the operation timer has reached the Operate delay time value, the H2Blk output is activated. After the timer has elapsed and the inrush situation still exists, the H2Blk signal remains active until the I2H_p/Ip ratio drops below the value set for the ratio in all phases, that is, until the inrush situation is over. If the drop-off situation occurs within the operate time up counting, the reset timer is activated. If the drop-off time exceeds Reset delay time, the operate timer is reset.

The binary input Blk can be used to block the function. The activation of the Block input deactivates all outputs and resets internal timers.

3.37.3 Application Scope

Transformer protections require high stability to avoid tripping during magnetizing inrush conditions. A typical example of an inrush detector application is doubling the start value of an overcurrent protection during inrush detection

Other applications of this function include the detection of inrush in lines connected to a transformer.

3.37.4 Settings

In the following table, i is the protection stage number, it can be set according to the requirements.

Table 3.37-1 OCR settings

Name	Range	Unit	Step	Default	Description
OCR_INRi_Ena	0-1	-	1	0	0: Disable 1: Enable
OCR_INRi_HarmCoe	0.05-1	s	0.001	0.2	The ratio setting for second Harmonic Current to fundamental current
OCR_INRi_Op_T	0.02-60.00	s	0.01	0.02	Operate time delay
OCR_INRi_Reset_T	0-60.000	s	0.001	0.02	Reset time delay

3.38 Wattmetric sensitive earth-fault protection SEF

3.38.1 Overview

The function measures the earth-fault power and gives an operating signal when the residual current, residual voltage and earth-fault power exceed the pickup settings value and the angle between the residual current and residual voltage is inside the set operating region, that is, forward or backward region. The operating time characteristic can be selected to be either definite time (DT) or a special wattmetric-type inverse definite minimum type (wattmetric type IDMT).

The wattmetric earth-fault protection is very sensitive to current transformer errors and it is recommended that a core balance CT is used for measuring the residual current (the core balance CT should be check the pole before used).

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself, if desired.

3.38.1.1 Function block

The function block of the protection is as below.

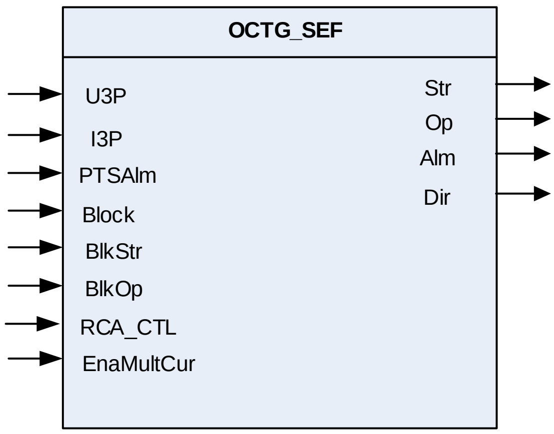


Figure 3.38-1 Function block

3.38.1.2 signals

Table 3.38-1 Input signal

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
PTSAlm	The PT Alarm signal
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.

Signal	Description
RCA_CTL	when the signal RCA_CTL=1, the Characteristic angle setting should be adding -90˚.
EnaMultCur	This signal enables the current multiplier.

Table 3.38-2 Output signal

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.
Alm	This is the integrated Alarm signal
Dir	This is the Direction result

3.38.2 Protection Principle

The protection function can be enabled or disabled by setting the corresponding SEF_Ena parameter values as "1" or "0".

The operation of the protection can be described using a module diagram. All the modules in the diagram are explained in the next sections.

- **Direction element**

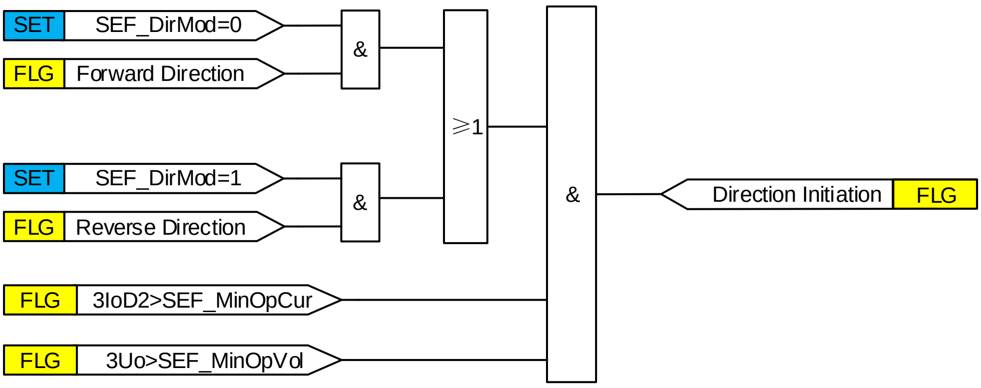


Figure 3.38-2 Directional Initiation Logic

Note: 3IoD2 is the second group of sample zero sequence current, 3Uo is the first group of calculated zero sequence voltage.

The evaluation of the forward directionality is according to the equation:

$$-90^\circ(+CorAng) < \arg\frac{\dot{I}_o e^{jRCA}}{-\dot{U}_o} < 90^\circ(-CorAng)$$

Or, $$-90^\circ(+CorAng) < \arg\frac{-\dot{U}_o e^{j\text{-}RCA}}{\dot{I}_o} < 90^\circ(-CorAng)$$

Also, it can be calculated by following equation:

-90° (+CorAng)< angle(Io) + RCA - angle(Uo) -180° < 90° (-CorAng)

Or, -90° (+CorAng)< angle(Uo) +180° - RCA - angle(Io) < 90° (-CorAng)

Where, Uo=Zero Sequence Voltage 3Uo, Io= Zero Sequence Current 3IoD2.

The evaluation of the backward directionality is according to the equation:

$$90^{\circ}(+\text{CorAng}) < \arg\frac{\dot{I}_o e^{jRCA}}{-\dot{U}_o} < 270^{\circ}(-\text{CorAng})$$

Or, $$90^{\circ}(+\text{CorAng}) < \arg\frac{-\dot{U}_o e^{j\text{-}RCA}}{\dot{I}_o} < 270^{\circ}(-\text{CorAng})$$

Also, it can be calculated by following equation:

90° (+CorAng)< angle(Io) + RCA - angle(Uo) -180° < 270° (-CorAng)

Or, 90° (+CorAng)< angle(Uo) +180° - RCA - angle(Io) < 270° (-CorAng)

Where, Uo=Zero Sequence Voltage 3Uo, Io= Zero Sequence Current 3IoD2.

The operating area and non-operating area can be described in the follow figure.

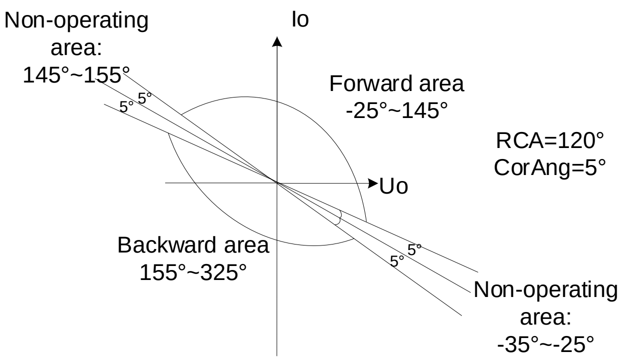


Figure 3.38-3 The operating area and non-operating area

The RCA setting can be automatically changed by the RCA_CTL signal. The RCA_CTL is used in the compensated networks where the compensation coil sometimes is temporarily disconnected. When the coil is disconnected, the compensated network becomes isolated and the Characteristic angle setting must be changed. The RCA setting should be added -90˚ when RCA_CTL=1.

The CorAng is used to improve the selectivity when there are inaccuracies due to the measurement transformer.

The relay calculates the forward and backward operate area by directionality formula. The directional calculation module enables the residual power calculation only if both of the zero current and zero voltage are exceeding the minimum operation value.

➢ Residual power calculation

The residual power calculation module calculates the magnitude of residual power Ires·Ures·Cos(Φ-RCA). Angle Φ is the angle between the operating quantity and polarizing quantity, compensated with a characteristic angle RCA. The angle value is received from the directional calculation module.

The power setting can be set as:

$$Ires \bullet Ures \bullet Cos(\Phi - RCA) = 3Io \bullet 3Uo \bullet Cos(\Phi - RCA)$$

Where:

Φ=Angle between the Polarizing Voltage (-Ures) and the Residual Current(Ires)

RCA=Relay Characteristic Angle Setting

Ures=Residual Voltage

Ires= Residual Current

3Uo=Zero Sequence Voltage 3Uo

3Io= Zero Sequence Current 3IoD2

➢ Initiation logic

The initiation logic diagram of the protection is as below:

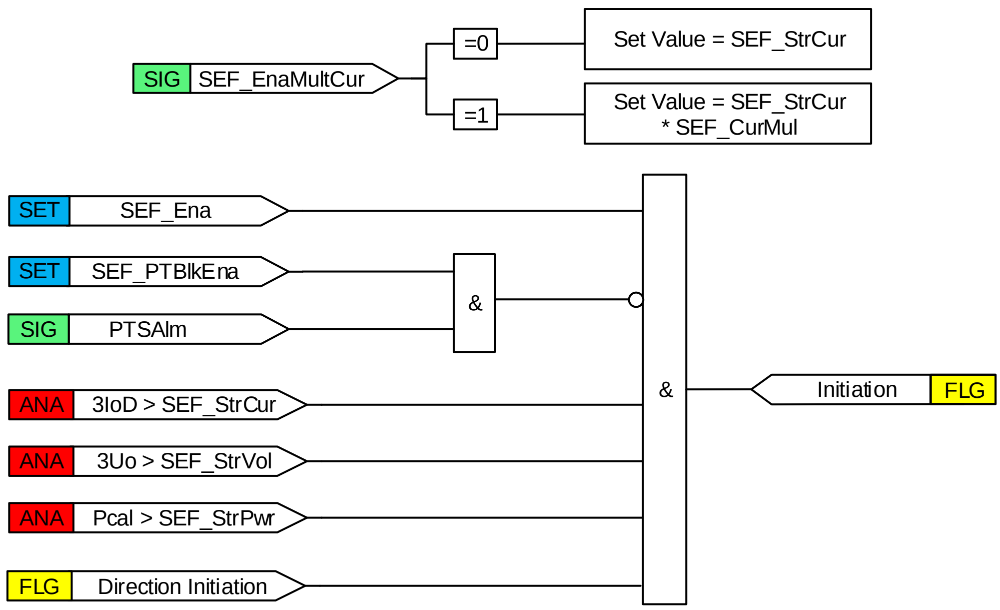


Figure 3.38-4 Wattmetric SEF Initiation Logic

The level detector compares the magnitudes of the measured operating quantity, polarizing quantity and calculated residual power to the set Current start value, Voltage start value and Res power start value respectively. When all three quantities exceed the limits, the relay initialized.

➢ **Timer**

Once initiation logic is fulfilled and no blocking signal is activated, the Start signal is set. The timer model is determined by depending on the value of the Operating curve type setting, the time characteristics are according to DT or Wattmetric IDMT. When the operation timer has reached the value of operate delay time in the DT mode or the maximum value defined by the inverse time curve, the Operate output is activated. If a drop-off situation happens, that is, a fault suddenly disappears before the operate delay is exceeded, the timer reset state is activated. The reset time is DT and depends on the Reset delay time setting.

Wattmetric IDMT:

$$t = \arg \frac{k * Pref}{Pcal}$$

Where:

T = Operation time in seconds

k = Setting value of Timer multiplier

Pref= Setting value of Reference power

Pcal=Calculated residual power

The operation type can be set to trip or alarm by setting.

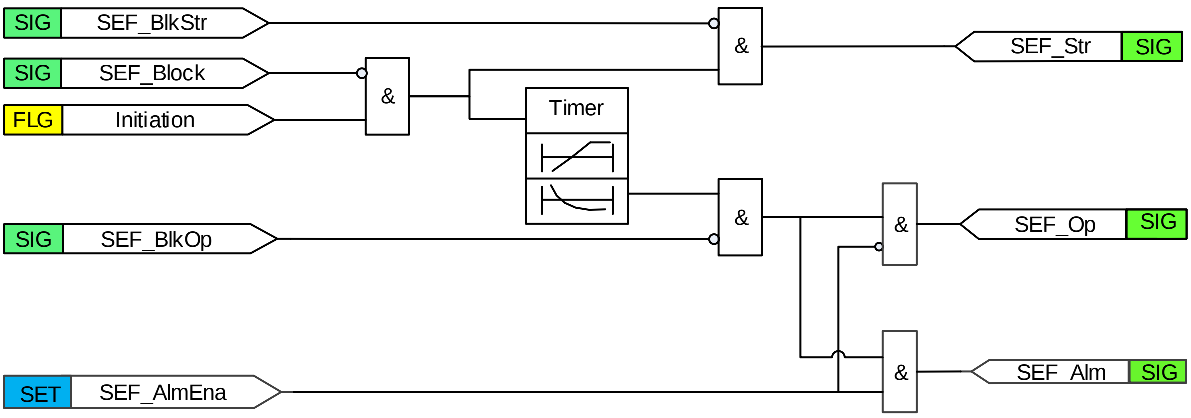


Figure 3.38-5 Wattmetric SEF Operation Logic

3.38.3 Application Scope

The sensitive earth fault protection in this relay includes direction element and wattmetric element, it can be used to detect earth faults in networks with a high-impedance earthing, unearthed networks or compensated networks (Peterson coil-earthed networks).

3.38.4 Settings

Table 3.38-3 SEF settings

No	Name	Range	Unit	Step	Default	Description
1	SEF_Ena	0-1	-	1	0	The Stage i SEF Operation Enable/Disable
2	SEF_AlmEna	0-1	-	1	0	The Stage i SEF Alarm Enable/Disable: =1: Alarm, =0: Trip
3	SEF_DirMod	0-1	-	1	0	The Stage i SEF direction: =0: forward =1:backward
4	SEF_PolRev	0-1	-	1	0	The Stage i SEF polarizing voltage value: =0: polarizing voltage, =1: polarizing voltage become negative
5	SEF_RefPwr	0.1-400In	W	0.001In	0.866In	The Reference value of residual power for Wattmetric IDMT curves
6	SEF_MinOpVol	0.02-160	V	0.01	1	The minimum operation voltage
7	SEF_MinOpCur	0.01-20In	A	0.01	0.1In	The minimum operation current
8	SEF_StrPwr	0.100-400.000In	W	0.001In	0.173In	The operation power
9	SEF_StrVol	0.02-160	V	0.01	10	The operation voltage
10	SEF_StrCur	0.01-20In	A	0.01	0.1In	The operation current
11	SEF_CurMul	0.1-10	-	0.1	1	The operation current multiple value
12	SEF_RCA	0-360	°	1	0	The Characteristic angle
13	SEF_CorAng	0-10	°	1	5	Angle correction
14	SEF_CurTyp	0-1	-	1	0	Selection of time delay curve type: =0: definite =1: IDMT
15	SEF_CoeK	0.05-2	-	0.01	1	Time multiplier for Wattmetric IDMT curves
16	SEF_Op_T	0-60.000	s	0.001	0.1	Operate delay time for definite time
17	SEF_Reset_T	0-60.000	s	0.001	0.02	Reset delay time
18	SEF_PTBlkEna	0-1	-	1	0	PTs alarm blocking enable

3.39 Under Current Protection 37C

3.39.1 Overview

This relay provides one stage under current protection for monitoring a motor or capacitor.

3.39.1.1 Function Block

The function block of the protection is as below.

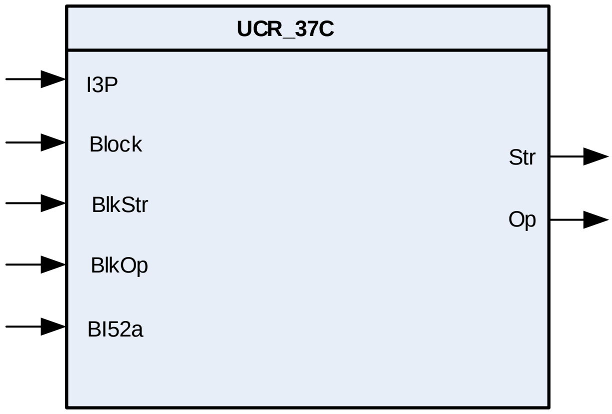


Figure 3.39-1 Function block

3.39.1.2 Signals

Table 3.39-1 Input Signals

Signal	Description
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function
BlkOp	This signal blocks all the trip signals of the function.
BI52a	The binary input from the auxiliary normally opened contact of circuit breaker

Table 3.39-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operate signal

3.39.2 Protection Principle

If the circuit breaker of the protected equipment is closed and the current is less than the predefined setting, the undercurrent protection will operate.

The following figure shows the logic diagram:

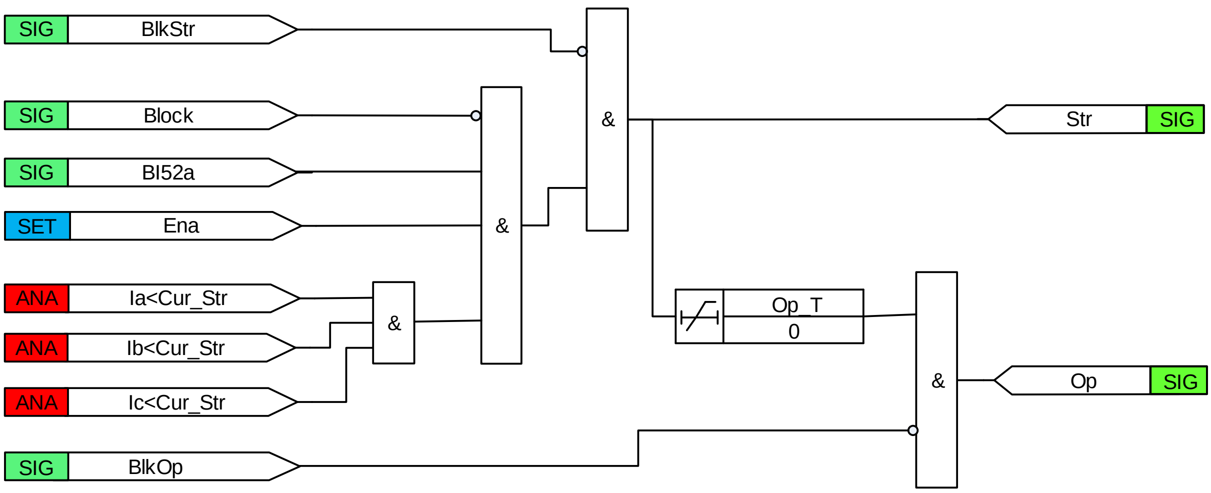


Figure 3.39-2 Functional module diagram for 37C

Where:

[Ena] is the enable/disable setting

[Cur_Str] is the current starting setting

[Op_T] is the time delay setting

[BI52a] is the binary input from the auxiliary normally opened contact of circuit breaker.

[Blk] is binary input for blocking all the binary output signals of the function

[BlkStr] is binary input for blocking all the start outputs of the function

[BlkOp] is binary input for blocking all the trip signals of the function

3.39.3 Application Scope

The speed of dc motor is inversely proportional to the excitation current. When the magnetic field weakens, the speed of motor increases. Therefore, the excitation current of dc motor must be greater than a certain value, otherwise there will be under excitation or under current situation, the motor speed will exceed the rated speed, causing a flying accident (Power machinery over speed accident). In case of undercurrent fault, if the motor has not been started, it is not allowed to start. If the motor has been running, cut off the main circuit and stop the motor running immediately.

3.39.4 Settings

Table 3.39-3 37C settings

No	Name	Range	Unit	Step	Default	Description
1	37C_Ena	0-1	-	1	0	Operation Enable/Disable =1: enable, =0: disable
2	37C_Cur_Str	0.100-1.000In	A	0.001In	0.1In	the current starting setting
3	37C_Op_T	0-100	s	0.001	0.040	the time delay setting

3.40 Block Busbar Protection

3.40.1 Overview

Block busbar protection, together with transformer backup protection, provides blocking protection for busbar that are not specially configured with main protection.

3.40.1.1 Function Block

The function block of the protection is as below.

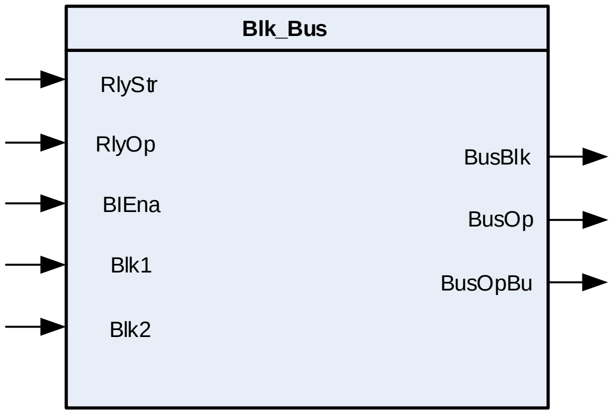


Figure 3.40-1 Function block

3.40.1.2 Signal

Table 3.40-1 Input Signals

Signal	Description
RlyStr	Relay Start BI
RlyOp	Relay Operation BI
BIEna	Block Busbar Enable BI
Blk1	Block 1 BI
Blk2	Block 2 BI

Table 3.40-2 Output Signals

Signal	Description
BusBlk	Busbar Block BO
BusOp	Busbar Operation Trip BO
BusOpBu	Busbar Operation Trip Adjacent CB BO

3.40.2 Protection Principle

The protection operates still does not return after 0.2s, indicating that the fault is outside the bus protection area, but the related protection refuses to trip, so the bus protection action needs to be removed to isolate the fault. Therefore, the Block busbar protection will automatically return and recover the Block exit after 0.2s of operation.

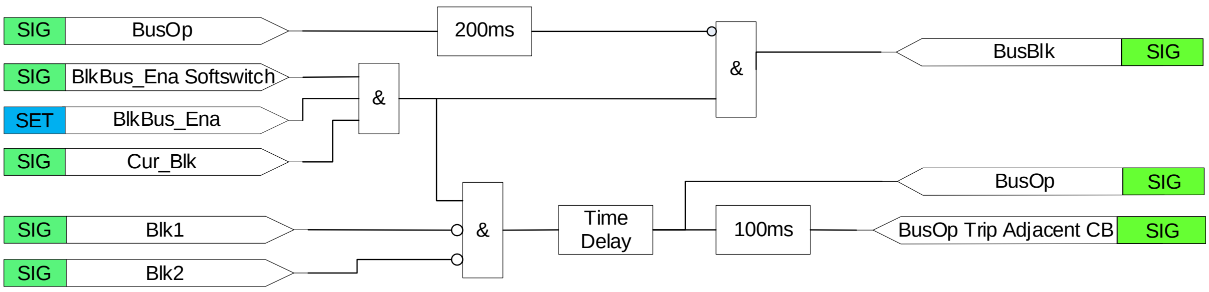


Figure 3.40-2 Common Block Busbar Protection

Block Busbar protection is a general component, which can be applied to feeder, section and main transformer protection device respectively by configuring corresponding setting value, soft switch, starting, action and locking conditions. Configuration examples are as follows:

1) When used as feeder protection, connect the "over-current operation" to the terminal of "Block Busbar trip". Block 1, 2 and Block Busbar Operation will not be used by default. The logic can be simplified as follows:

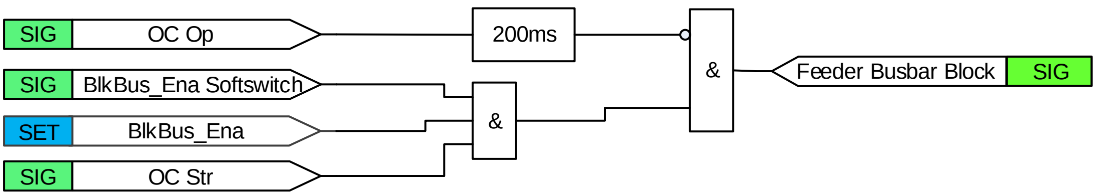


Figure 3.40-3 Feeder Block Busbar Protection

2) When the main transformer protection is used, Block Busbar protection is usually configured in the main transformer 1 and the main transformer 2 respectively. Take the main transformer 1 as an example, Block 1 is used as the Busbar1 overcurrent block, Block 2 is not used by default, or is used for another Block conditions. For output, take the Block Busbar trip terminal trip to be low, take the adjacent sides of the Block Busbar trip to be low failure or dead zone trip, and the logical configuration is:

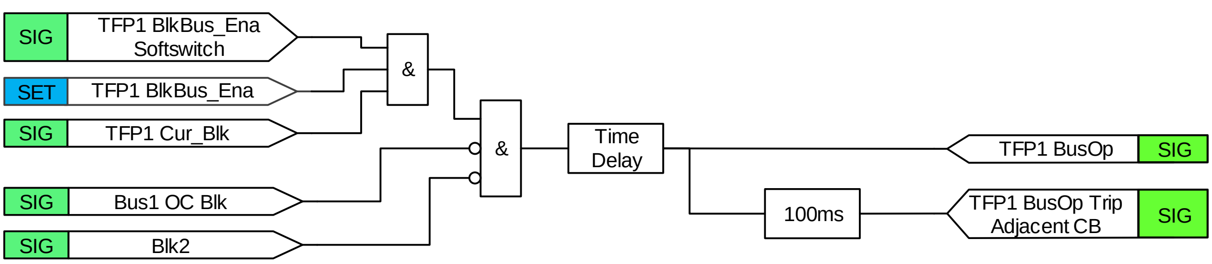


Figure 3.40-4 Transformer Block Busbar Protection

3) When used as section protection, connect the output of Block Busbar trip to the terminal of "Block BusOp", and output Block Busbar block and trip. Block1,2 are the overcurrent block of I and

II bus feeder respectively. The bus block is realized through "current block" logic, which is as follows:

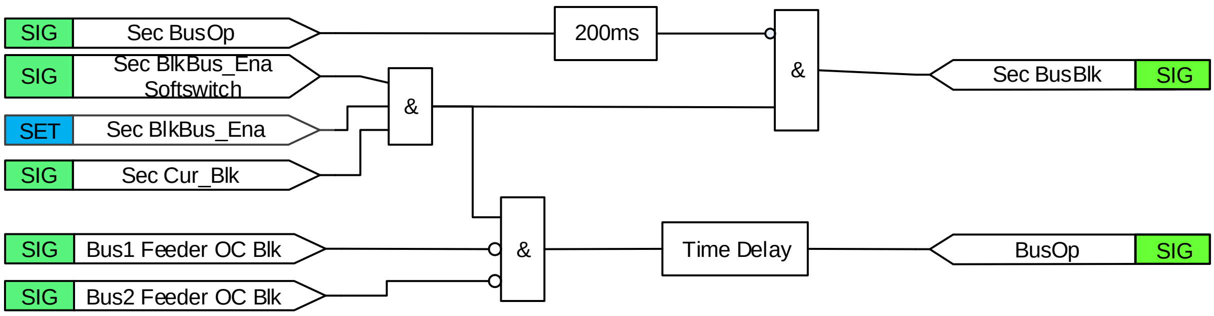


Figure 3.40-5 Section Block Busbar Protection

4) Current Block: Usually used in combination with the block logic of sectional Block Busbar protection, as feeder overcurrent block logic, it can be used for Busbar I or Busbar II. Taking Busbar I as an example, the default number of feeder i is 16 at most, that is, there are 16 overcurrent block inputs such as IL1-16, and each block input can be respectively cast back through the soft switch. If any feeder ILI (I =1-16) is enabled and the BIs of ILI (I =1-16) overcurrent block is 1 and there is no chain break blocking, then the overcurrent blocking condition of Busbar I feeder is satisfied. The logic is as follows:

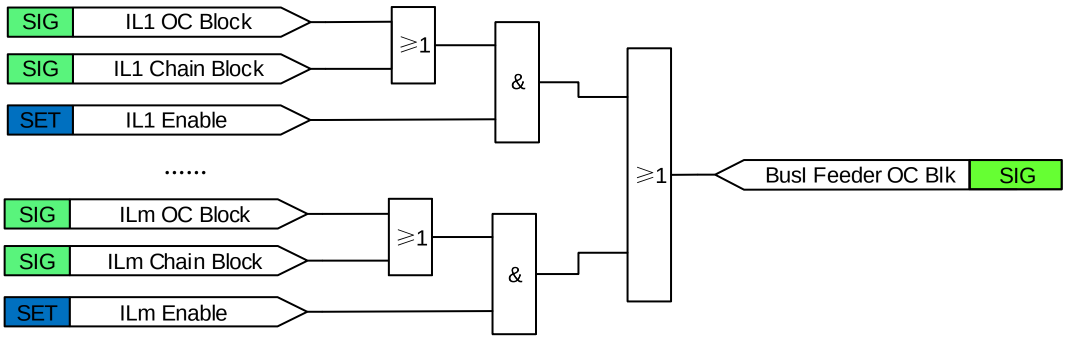


Figure 3.40-6 Bus I feeder OC Block

3.40.3 Application Scope

Block busbar protection, together with transformer backup protection, provides simple protection for busbar that are not specially configured with main protection. When it is used for sectional block busbar protection, it should be used together with feeder overcurrent blocking logic.

3.40.4 Settings

Table 3.40-3 Block Busbar settings

No	Name	Range	Unit	Step	Default	Description
1	BlkBus_Ena_Feeder	0-1	-	1	0	Feeder Block Busbar Enable =1: enable, =0: disable

2	BlkBus_Ena_Sec	0-1	-	1	0	Section Block Busbar Enable =1: enable, =0: disable
3	BlkBus_T_Sec	0.08-200	s	0.01	200	Section Block Busbar time delay
4	BlkBus_Ena_TFPi (i=1,2)	0-1	-	1	0	The stage i(i=1,2) of Transformer Block Busbar Enable =1: enable, =0: disable
5	BlkBus_T_TFPi (i=1,2)	0.08-200	s	0.01	200	The stage i(i=1,2) of Transformer Block Busbar time delay

3.41 Gap Over Current & Zero Sequence Over Voltage Protection

3.41.1 Overview

The device provides two-stage Gap overcurrent and zero sequence overvoltage protection, which is used for transformer backup protection in ungrounded system.

3.41.1.1 Function Block

The function block of the protection is as below.

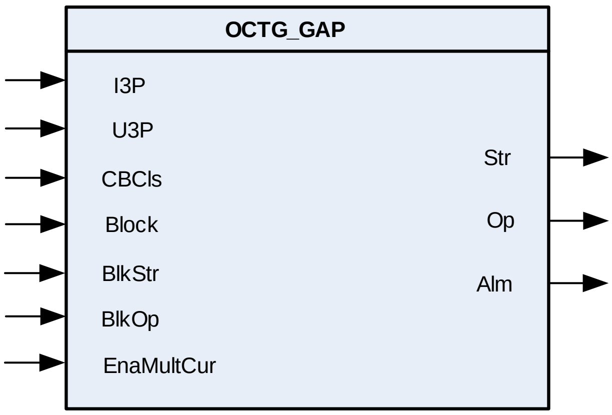


Figure 3.41-1 Function block

3.41.1.2 Signal

Table 3.41-1 Input Signals

Signal	Description
U3P	The voltage in all the three phases
I3P	The current magnitude in all the three phases
CBCls	The binary input of CB close position
Block	This signal blocks all the binary output signals of the function
BlkStr	This signal blocks all the start outputs of the function

Signal	Description
BlkOp	This signal blocks all the trip signals of the function.
EnaMultCur	This signal enables the current multiplier.

Table 3.41-2 Output Signals

Signal	Description
Str	This is the integrated start signal
Op	This is the integrated operation signal.
Alm	This is the integrated alarm signal

3.41.2 Protection Principle

GAP over current zero sequence over voltage protection can be independent enabled. The gap overcurrent is zero sequence overcurrent, which is used for the gap current generated after the neutral overvoltage breaks down the gap when the normally open contact of the ground switch at the neutral point of the transformer is disconnected. The gap zero sequence overcurrent CT is generally used in the transformer zero sequence casing CT, and the open voltage of bus PT is used in the zero sequence overvoltage CT.

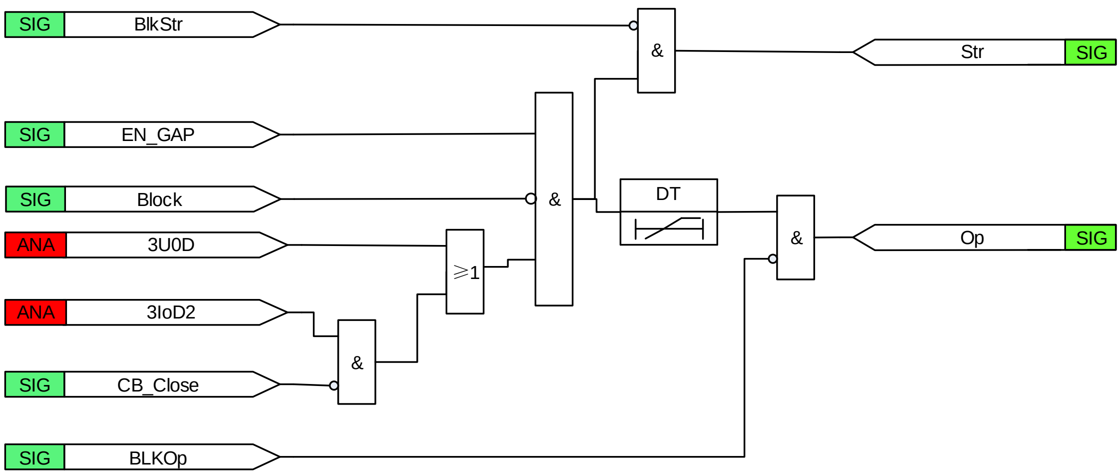


Figure 3.41-2 Logic Diagram for Gap

Note: EN_Gap is the binary input signal, usually used to indicate a hard switch. The 3IoD2 is the second group of sample zero sequence current.

3.41.3 Application Scope

In the ungrounded system of 110K and above voltage level, the gap current is generated after the overvoltage of the neutral point of the transformer breaks down the gap. In this case, the gap protection needs to be put in.

3.41.4 Settings

Table 3.41-3 Gap settings

No	Name	Range	Unit	Step	Default	Description
1	GAPi_Ena	0-1	-	1	0	The Stage i GAP Enable/Disable
2	GAPi_AlmEna	0-1	-	1	0	The Stage i GAP Alarm Enable/Disable
3	GAP1_ResCur_Str	0.04-20.00In	A	0.01In	0.04In	The Stage i GAP Start current value
4	GAPi_Mul_Cur	0.8-10.0	-	0.1	1	The Stage i GAP Multiplier current start value
5	GAP1_ResVol_Str	10-100	V	0.01	10	The Stage i GAP Start voltage value
6	GAPi_Op_T	0.100-10.000	s	0.001	0.1	The Stage i GAP operation time delay
7	GAPi_Reset_T	0.040 -60.000	s	0.001	0.04	The Stage i GAP Reset time delay

3.42 Restricted Earth Fault Protection 64REF

3.42.1 Overview

In electrical power industry, power transformer is the one of the most precious and main important primary equipment. For this main point of view, the protection of power transformer is very important task (internal fault or external fault). The operation of power transformer is totally dependent on windings. So, the protection of power transformer winding is great task and the main purpose of Restricted Earth Fault Protection (64REF) is to monitored the power transformer internal fault likes winding fault.

The operating calculation criteria of Restricted Earth Fault Protection (64REF) is based on differential current and restrained current.

- The vector difference of neutral current is known as differential current
- Lines current is known as residual current

When the internal fault is happening in the winding of power transformer and the total earth fault current is equal to the deference of current. To increase the high operated accuracy of Restricted Earth Fault Protection (64REF) is dependently operate only fault current without any interference of load current.

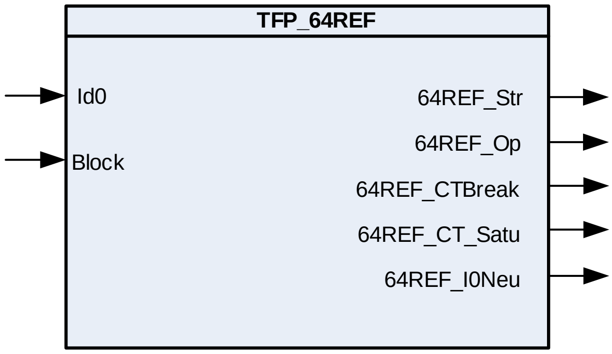
Notice!

> For the connection point of view of transformer delta connected winding must be earthed with earthing transformer and its electronically nominated between winding connection and current transformer.

This protection can be easily configured with any type of transformer likes two winding, three winding, scot T connection transformer and auto transformer.

In addition, the 64REF can be configured on the high-voltage side, middle-voltage side or low-voltage side of the transformer.

3.42.1.1 Function Block



3.42.1.2 Signals

Table 3.42-1 64REF Input Signals

NO.	Signal	Description
1	ID0	The differential and restrained current
2	Block	This signal blocks all the binary output signals of the function

Table 3.42-2 64REF Output Signals

NO.	Signal	Description
1	64REF_Str	Start signal from 64REF
2	64REF_Op	Operation signal from 64REF
3	64REF_CTBreak	CT fail signal of 64REF
4	64REF_CT_Satu	CT Saturation signal of 64REF
5	64REF_I0Neu	I0>B0×I Signal of 64REF

3.42.2 Protection Principle

3.42.2.1 Fault Detector

REF's pickup criterion is:

$$I_{0d} = 64REF\_Cur\_Str$$

Where:

I_{0d} is the residual differential current of one side

3.42.2.2 Amplitude Compensation

If CTs used for REF have different primary rated values, the device will automatically adjust the currents with respective correction ratio shown as below.

$$K_{lph-X} = \frac{K_{TA-X}}{K_{TA-H}}$$

Where:

K_{TA-X} primary side sampled zero-seq CT ratio.

K_{TA-H} primary side CT ratio. Primary side is reference and Kp is 1.

Transformer balance factor is calculated by this formula. When compensation, multiply current and Kp.

3.42.2.3 Calculate Differential and Restraint Current

REF differential current and restraint current are calculated as the following formulas:

$$I_{0d} = \left|\dot{I}_{0Cal} + \dot{I}_{0Neu}\right|$$

$$I_{0r} = \max\left\{\left|\dot{I}_{0Cal}\right|, \left|\dot{I}_{0Neu}\right|\right\}$$

Where:

I_{0d} is the REF differential current;

I_{0r} is the residual restraint current;

I_{0Cal} is the residual current of the phase currents;

I_{0Neu} is the neutral measured current;

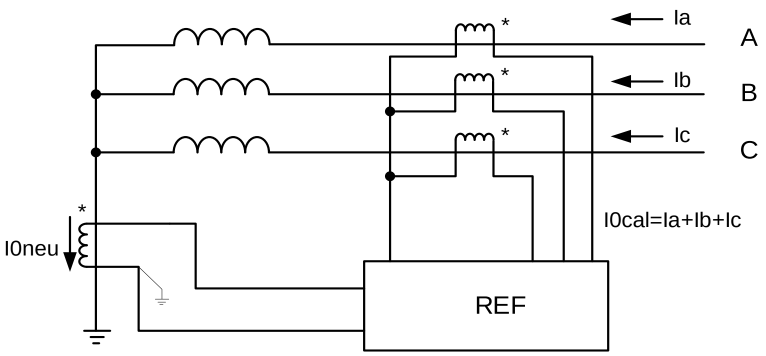


Figure 3.42-1 REF principle diagram

3.42.2.4 Operation Criterion

The operation criteria of REF protection are as follows:

$$\begin{cases} I_{0d} > I_{0cdqd} \\ I_{0d} > K * I_{0r} \\ I_{0Neu} > I_{0cdqd} / 4 \end{cases}$$

Where:

$I_{0d} = \left|\dot{I}_{0Cal} + \dot{I}_{0Neu}\right|, I_{0r} = \max\left\{\left|\dot{I}_{0Cal}\right|, \left|\dot{I}_{0Neu}\right|\right\}$. $\dot{I}_{0Cal}$、 $\dot{I}_{0Neu}$ are respectively residual current of the phase currents and neutral measured current. For this device, the ratio restrained coefficient fixedly takes 0.6.

3.42.2.5 Operation Characteristic

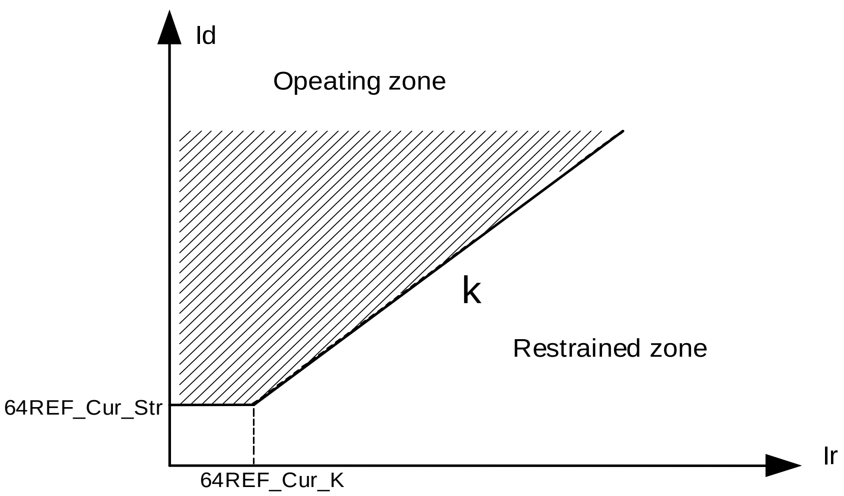


Figure 3.42-2 Operation characteristic of REF

Where:

Id is the differential current, Ir is the restraint current；64REF_Cur_Str is the start of differential current.

3.42.2.6 CT Transient Characteristic Difference Detection

To prevent the effect of incorrect differential circuit zero-sequence current on DIFF_REF in case of CT transient characteristic difference and CT saturation induced by external faults, the device integrates CT saturation criterion with positive-sequence current restraint at each side. When DIFF_REF protection trips, zero-sequence current at each side must fulfill the following formula.

$$3I_0 > B_0 \times I_1$$

Where：

$3I_0$: the zero-sequence current at a side

I_1: its corresponding positive-sequence current

B_0: a proportional constant and the value is 0.6

3.42.2.7 CT Saturation Detection

To prevent incorrect tripping of differential protection caused by CT saturation in case of external fault, CT saturation detection element of the device would judge the saturation of CT and determine whether to block relevant differential protection.

In case of internal fault:

$$\sum_{i=1}^{n}\left|D\dot{I}_i\right| = \left|\sum_{i=1}^{n} D\dot{I}_i\right|$$

Where：

"n" means the number of sides shared by transformers.

The left part of above equation is restraint current, while the right part is differential current. The equation is not fulfilled in case of either external fault or external fault under the condition of saturated CT. As a matter of fact, since CT saturation induced differential current always comes into being after a certain period of time of CT saturation, the device determines if saturation has occurred by taking advantage of the temporal consistency between restraint current and differential current. If saturation has occurred, the percentage differential restraint coefficient would be automatically driven up so as to assure the reliability of differential protection and the quick operation in case of conversion of external fault saturation into internal fault.

3.42.2.8 CT Circuit Failure

This is a differential protection CT circuit failure criterion.

First of all, the possibility of concurrence of multi-side CT line-break and fault is not taken into consideration. Under this premise, it's possible to distinguish between CT circuit failure and fault based on the following characteristic. In case of CT circuit failure, it's necessary to specifically identify circuit failure phase.

Single-phase or two-phase CT circuit failure:

	CT circuit failure	**Fault**
Current variation	Abrupt change of current at line-break side only	Abrupt change of current at multiple sides
Current variation tendency	From high to low	From low to high

	CT circuit failure	Fault
Current amplitude	$\leq 0.08In$	$\geq In$

In case the abrupt current variation is greater than 5-10%IN, abrupt current variation would be deemed to have occurred.

Alarm signal will be issued when CT circuit failure lasts for 10s (or 40ms if the differential protection trips), and in such a case, whether or not to instantaneously block relevant differential protection is determined by setting. The condition for reset of CT circuit failure is that there's no negative-sequence current at this side. The negative-sequence current at this side is lower than threshold of CT line-break negative-sequence current (fixed value).

Blocking of biased differential protection by CT circuit failure follows the following principle:

- When “CTS_Blk_Ena” is set to “1”, REF protection would be blocked in case of CT circuit failure;
- When “CTS_Blk_Ena” is set to “0”, REF protection would not be blocked in case of CT circuit failure.

Where:

It should be noted that CT circuit failure induced blocking is principally designed to prevent malfunction of differential protection caused by CT circuit failure and follows the following principles:

Firstly, concurrence of multi-side CT circuit failure is not taken into account; secondly, differential protection trip is allowed in case of concurrence of failure and CT circuit failure; thirdly, relevant protection should be blocked when fault occurs after CT circuit failure; fourthly, protection shall operate if CT circuit failure occurs after the occurrence of fault.

3.42.3 Logic Diagram

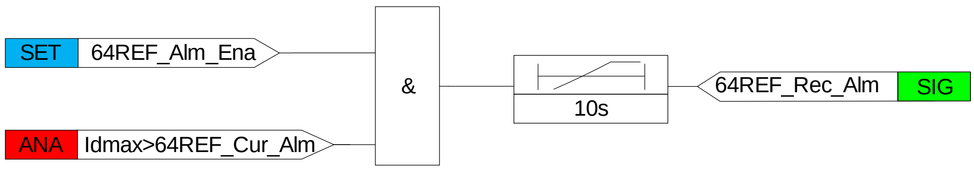


Figure 3.42-3 Logic diagram of restricted earth fault alarm

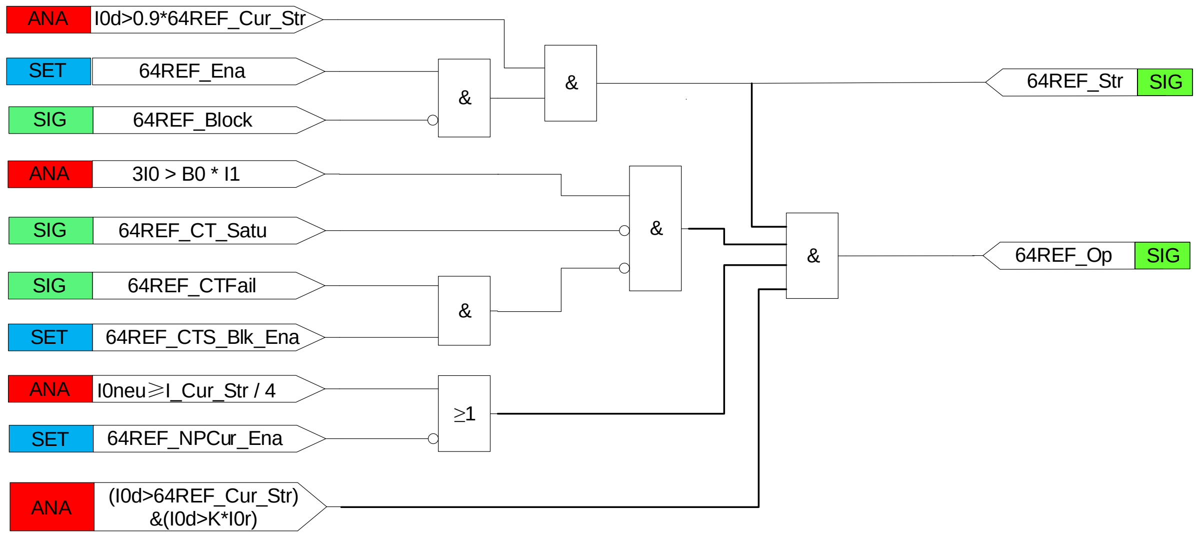


Figure 3.42-4 Logic diagram of restricted earth fault protection

Where:

I0neu is the neutral measured residual current

3.42.4 Settings

Table 3.42-3 64REF settings

No.	Name	Range	Unit	Step	Default	Description
1	64REF_Cur_Str	0.05-20.00	IE[Note1]	0.01	0.40	Pickup setting of REF
2	64REF_Cur_Alm	0.05-20.00	IE[Note1]	0.01	1.00	Alm setting of REF
3	64REF_Slope	0-0.9	-	0.1	0.6	Percentage restraint coefficient of REF 0.5 is recommended.
4	64REF_Ena	0-1	-	1	0	Logic setting of enabling/disabling REF 0: disable 1: enable
5	64REF_Alm_Ena	0-1	-	1	0	Logic setting of enabling/disabling REF_Alm 0: disable 1: enable
6	64REF_NPCur_Ena	0-1	-	1	1	Logic setting of enabling/disabling neutral current criterion 0: disable 1: enable
7	64REF_CTS_Blk_Ena	0-1	-	1	0	Logic setting of enabling/disabling block biased differential element during CT circuit failure 0: disable 1: enable

[Note1]: IE=1000.0 * Sn / (Un_SV *I1n_S1V * 1.732);

Sn and Un_SV are Parameters; I1n_S1V means one side rated Current Primary parameter, up to the configuration of I1n in Side _SC, the default parameter is Prot_TA_Primary.

3.43 Transformer Current circuit supervision TF CTS

3.43.1 Overview

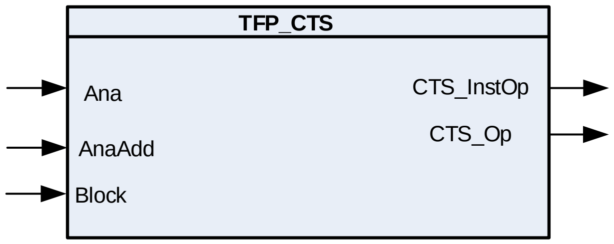
The main purpose of Current circuit supervision (CTS) is to monitor the protected electrical network by the help of instrument transformer (CT). This is a backup function for CT circuit failure. If CT balance coefficient at one side is relatively little, the different current resulting from CT circuit failure is very small. Therefore, the CT circuit failure alarm cannot be issued. The function is used to prompt the operator to check and confirm whether the CT is normal or not.

The operation principle criteria of Current circuit supervision CT’s based on the following points:

- Three phase zero-sequence current
- Three phase zero-sequence voltage

In addition, the CTS can be configured on the high-voltage side, middle-voltage side or low-voltage side of the transformer as a backup protection for each side.

3.43.1.1 Function Block



3.43.1.2 Signals

Table 3.43-1 CTS Input Signals

NO.	Signal	Description
1	Ana	Three-phase current inputs from one branch
2	AnaAdd	The add three current inputs from one side
3	Block	Block signal of CTS

Table 3.43-2 CTS Output Signals

NO.	Signal	Description
1	CTS _InstOp	Instantaneous operation signal from CTS
2	CTS _Op	Time delay operation signal from CTS

3.43.2 Logic Diagram

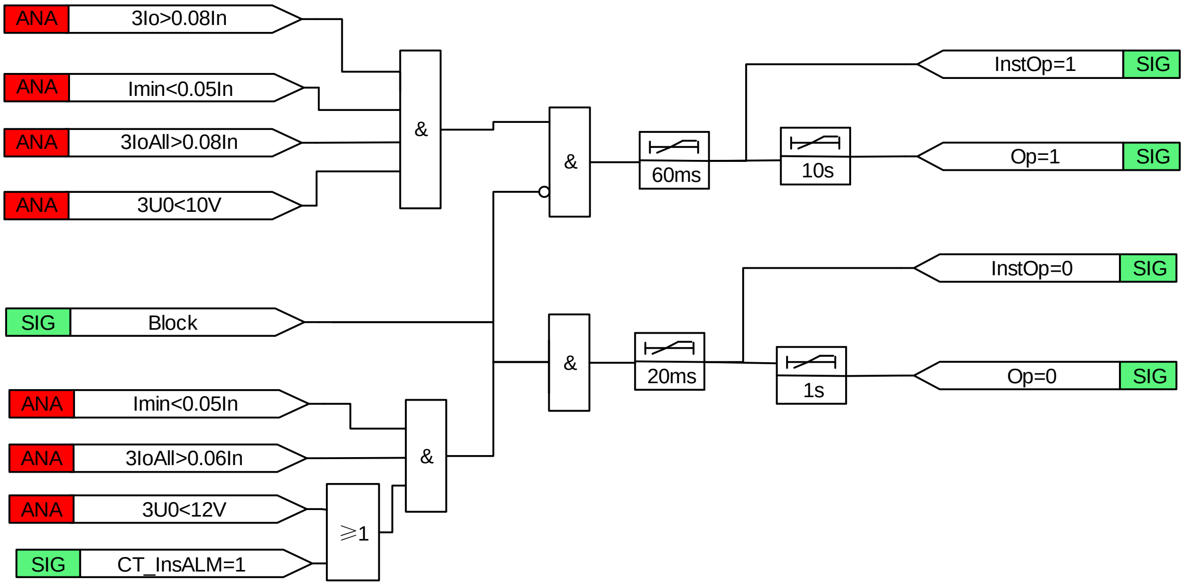


Figure 3.43-1 CTS criterion logic diagram

3.43.3 Protection Principle

This is a backup function of CT circuit failure criterion.

Each side of the device is furnished with CT circuit failure alarm element

To prevent incorrect tripping of zero-sequence overcurrent protection caused by CT circuit failure or anomaly, the device is provided with CT circuit failure judgment element using the following criterion:

$$\begin{cases} 3I_0 > I_{0CT} \\ 3U_0 < U_{0CT} \end{cases}$$

Where：

I_{0TA}=0.08In: zero-sequence current

U_{0TA}=10V: zero-sequence voltage

CT circuit failure will be deemed to have occurred once the situation that meets above-noted criterion lasting for 10s.

3.44 Transformer Fuse failure supervision TF VTS

3.44.1 Overview

The main and important function of Fuse failure supervision (VTS) is to continuously supervised the protected electrical network by the help of instrument transformer (VT) and to ensure the stability of accurate operation. If any kind of trouble situation happened in the following circuits between instrument transformer (VT) and intelligence electronic device (IED), cause many un-legal operation of protection function are follows:

- Overcurrent protection with voltage controlled element
- Synchronization and many other protections

The operation principle criteria of fuse failure supervision VT's based on the following points:

- Negative-sequence voltage is greater than 8V
- Each phase voltage is less than 30V

In addition, the VTS can be configured on the high-voltage side, middle-voltage side or low-voltage side of the transformer as a backup protection for each side.

3.44.1.1 Function Block

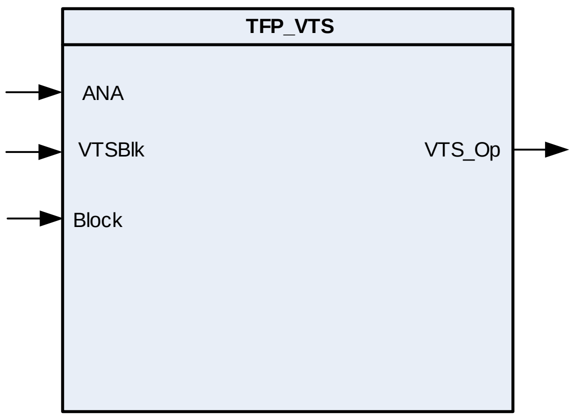


Figure 3.44-1 Function block

3.44.1.2 Signals

Table 3.44-1 VTS Input Signals

NO.	Signal	Description
1	U3P	Three phase group signal for voltage inputs
2	U2	Negative voltage inputs
3	VTS_Blk	Block signal of VTS

Table 3.44-2 VTS Output Signals

NO.	Signal	Description
1	VTS_Op	Operation signal from VTS

3.44.2 Logic Diagram

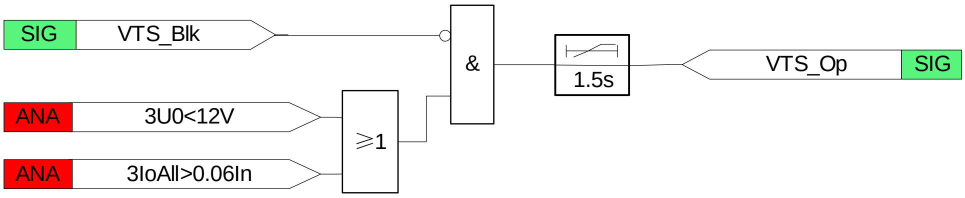


Figure 3.44-2 VTS criterion logic diagram

3.44.3 Protection Principle

Each side of the device is furnished with VT line-break alarm element

In case start-up element fails to activate voltage quantity related protection, VT line-break alarm signal would be given with a delay of 8s once any of the following conditions is satisfied:

- Voltage at each phase is less than 30V;
- Negative-sequence voltage is greater than 8V.

When voltage switch-on hard strap of some certain side is disabled, VT line-break judgment function of this side is automatically lifted.

3.45 Faulty Phase Selection (FPS) and Phase Direction(PHSDIR)

3.45.1 Overview

Faulty phase selection is used to discriminate faulty phase for all kinds of fault type. If protection element operates, faulty phase selection is succeeded and the device output tripping command. Faulty phase selection is adaptive to both earthed system and unearthed system. For the unearthed system, earthed protection elements should be disabled, such as earth fault protection, and only phase-to-phase protection elements are enabled, such as phase overcurrent protection.

Detecting the phase difference between I0 and I2A

When phase overcurrent element operates, pickup phase due to overcurrent is judged as a faulty phase.

3.45.1.1 Function Block

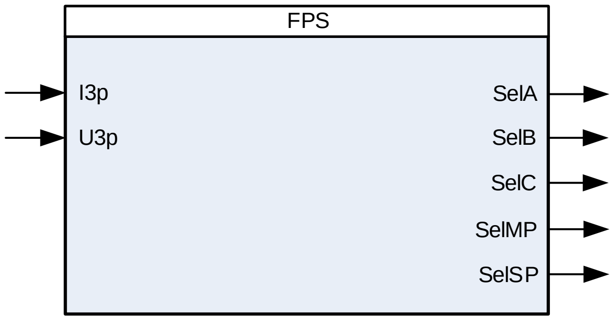


Figure 3.45-1 Function block of FPS

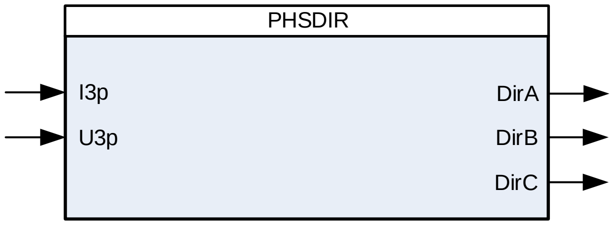


Figure 3.45-2 Function block of PHSDIR

3.45.1.2 Signals

Table 3.45-1 Input Signals

NO.	Signal	Description
1	I3p	The voltage in all the three phases
2	U3p	The current magnitude in all the three phases

Table 3.45-2 Output Signals

NO.	Signal	Description
1	FPS_SelA	Faulty phase selection result of phase A
2	FPS_SelB	Faulty phase selection result of phase B
3	FPS_SelC	Faulty phase selection result of phase C
4	FPS_SelMP	Faulty phase selection result of multi-phase
5	FPS_SelSP	Faulty phase selection result of single phase
6	DirA	The direction condition of phase A is ok
7	DirB	The direction condition of phase B is ok
8	DirC	The direction condition of phase C is ok

3.45.2 Operation Principle

3.45.2.1 I0 and I2A Selection Element

The phase selection algorithm uses the angle relation between I0 and I2A of the device. There are three faulty phase selection regions.

Depended on the phase relation between I0 and I2A, the faulty phase can be determined.

1. -60º<Arg(I0/I2A) <60º, region A is selected, possible faulty phase is phase A or phase BC.
2. 60º<Arg(I0/I2A) <180º, region B is selected, possible faulty phase is phase B or phase CA.
3. 180º<Arg(I0/I2A) <300º, region C is selected, possible faulty phase is phase C or phase AB.

For single-phase earth fault, I0 and I2 of faulty phase are in-phase. Earth fault start up zero sequence current can be set by setting LNP_ResCur_Str.

For phase-to-phase earth fault, I0 and I2 of non-faulty phase are in-phase.

In order to properly expand the ability of grounding distance relay to measure transition resistance, the characteristic circle of grounding MHM relay is offset to the first quadrant, and the value range is 0°, 15° and 30°, it can be set by setting LNP_PE_Phi_Shift. Take a larger value for a short line and a smaller value for a long line. It is recommended that 0° be set when the length of the line is greater than or equal to 40KM, 15° be set when the length is greater than or equal to 10KM, and 30° be set when the length is less than 10KM.

3.45.2.2 Phase Current and Zero Sequence Current

When phase overcurrent protection operates, the corresponding phase which is overcurrent will be judged as a faulty phase. When earth fault protection operates, the fault phase will be judged by FPH element.

3.45.2.3 Directional element

For high voltage, earthed system is common, for middle and low voltage, the unearthed system is common, so the Direction element use cross-polarizing (90°) connection type to meet different conditions.

The cross-polarizing quantity is used to determine the fault direction(Ia→Ubc/Ib→Uca/Ic→Uab). The evaluation of the forward directionality is according to the equation:

$$-90^\circ(+5^\circ) < \arg\frac{\dot{I}_r}{\dot{U}_r} e^{j(RCA-90^\circ)} < 90^\circ(-5^\circ)$$

or $$-90^\circ(+5^\circ) < \arg\frac{\dot{U}_r}{\dot{I}_r} e^{j(90^\circ-RCA)} < 90^\circ(-5^\circ)$$

Also, it can be calculated by following equation:

-90° (+5°)< angle(Ir) + RCA - 90° - angle(Ur)< 90° (-5°)

or -90° (+5°)< angle(Ur) +90° - RCA - angle(Ir)< 90° (-5°)

The evaluation of the backward directionality is according to the equation:

$$90^\circ(+5^\circ) < \arg \frac{\dot{I}_r}{\dot{U}_r} e^{j(RCA-90^\circ)} < 270^\circ(-5^\circ)$$

or $$90^o(+5^o) < \arg \frac{\dot{U}_r}{\dot{I}_r} e^{j(90^o-RCA)} < 270^o(-5^o)$$

Also, it can be calculated by following equation:

90° (+5°)< angle(Ir) + RCA - 90° - angle(Ur)< 270° (-5°)

or 90° (+5°)< angle(Ur) +90° - RCA - angle(Ir)< 270° (-5°)

$\pm 5^o$ is the max angle margin, I_r and U_r are the polarizing current and voltage. RCA is the relay characteristic angle.

The operating area and non-operating area can be described in the follow figure.

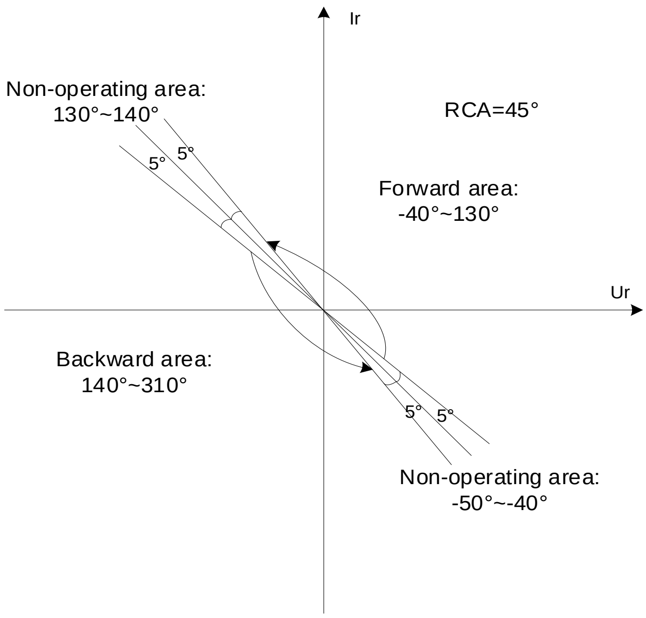


Figure 3.45-3 The operating area and non-operating area

The forward directionality and backward directionality can be set by setting LNP_PDIR_MOD.

RCA is the setting LNP_PRCA.

3.45.3 Settings

Table 3.45-3 FPS settings

No	Name	Range	Unit	Step	Default	Description
1	LNP_PE_Phi_Shift	0-30	deg	15	0	0: Line Length≥40KM; 15: 40KM > Line Length≥10KM; 30: 10KM > Line Length; Line Length is 21FL_LineLen
2	LNP_ResCur_Str	0.04-20.00In	A	0.01In	0.04In	Line Residual current start value

Table 3.45-4 The setting of PHSDIR

No	Name	Range	Unit	Step	Default	Description
1	LNP_PDIR_MOD	0-2	-	1	0	The FPS Directional mode:0-2 for "Non-directional", "Forward" or "Reverse"
2	LNP_PRCA	0-360	°	1	45	The FPS Characteristic angle

3.46 Stabilized differential protection for machines 87MPDIF

3.46.1 Overview

For machines (motor or generator) above 2MW, or when the capacity is 2MW but the sensitivity of fast overcurrent protection is insufficient, stable differential protection should be used. Stable differential protection is used as the main protection for machines in case of phase to phase short circuits. The CT of ordinary current stable differential protection can be installed at the switch cabinet outlet of the power supply cable, and the protection range can include the power supply cable of the machines.

3.46.1.1 Function Block

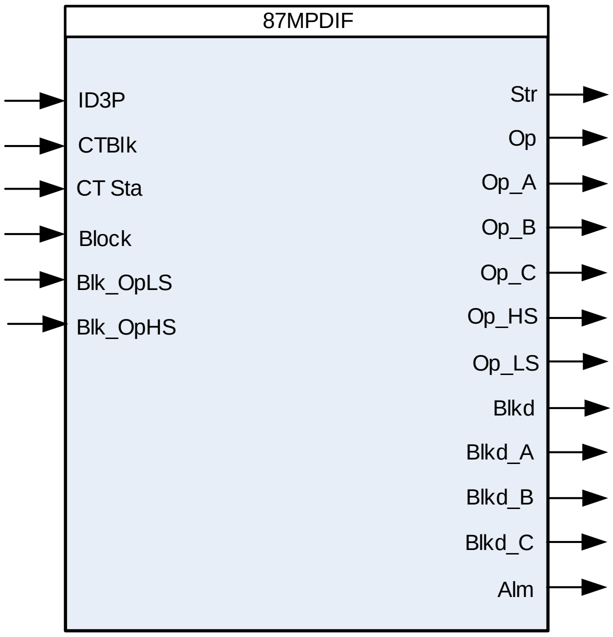


Figure 3.46-1 Function block

3.46.1.2 Signals

Table 3.46-1 Input signal

Signal	Description
ID3P	The differential and biased current, including Ida, Idb, Idc, Ira, Irb, Irc
Block	This signal blocks all the binary output signals of the function
Blk_OpHS	This signal blocks of the instantaneous high stage operation
Blk_OpLS	This signal blocks of the Biased low stage operation
CT_Sta	CT saturation input
CT_Blk	CT block input

Table 3.46-2 Output signal

Signal	Description
Str	The start signal
Op	The operation signal.
OpA	The operation signal of phase A
OpB	The operation signal of phase B
OpC	The operation signal of phase C
Op_HS	The operation signal of instantaneous high stage
Op_LS	The operation signal of biased low stage

Signal	Description
Alm	The differential current off limit Alarm signal
Blkd	The all block signal
Blkd_A	The block signal of phase A
Blkd_B	The block signal of phase B
Blkd_C	The block signal of phase C

3.46.2 Differential Current Off Limit Alarm

If any differential current of the machines exceeds the [87MP_DIF_Idl] * [87MP_DIF_Ie] for 10 seconds, the device will report a differential current off limit alarm. When the differential protection setting is disable, the differential current over limit alarm will disable.

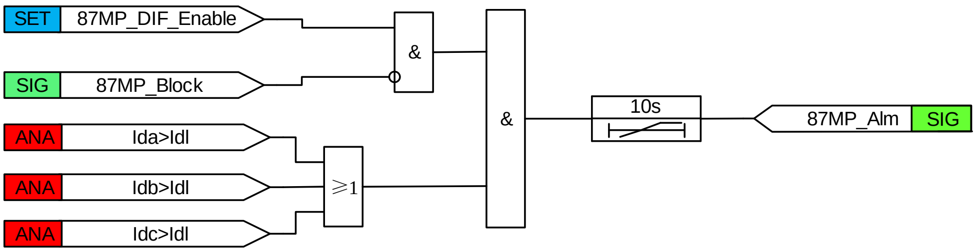


Figure 3.46-2 The logic of differential current off limit alarm

3.46.3 Instantaneous high stage principle

Instantaneous high stage of differential protection quickly operates in case of severe internal faults in the machine. The setting is set based on avoiding the maximum unbalanced current under various conditions and the differential current during CT disconnection. The internal blocking signals of the function block do not prevent the operation of the instantaneous stage. When required, the operate signal due to instantaneous operation can be blocked by the binary inputs BLK_OPR_HS or BLOCK. The protection action equation is shown in the formula:

$I_d \geq I_{dh}$, I_{dh} is Instantaneous high operate value, Idh=87MP_DIF_Coe_Idh*Machine_Ie

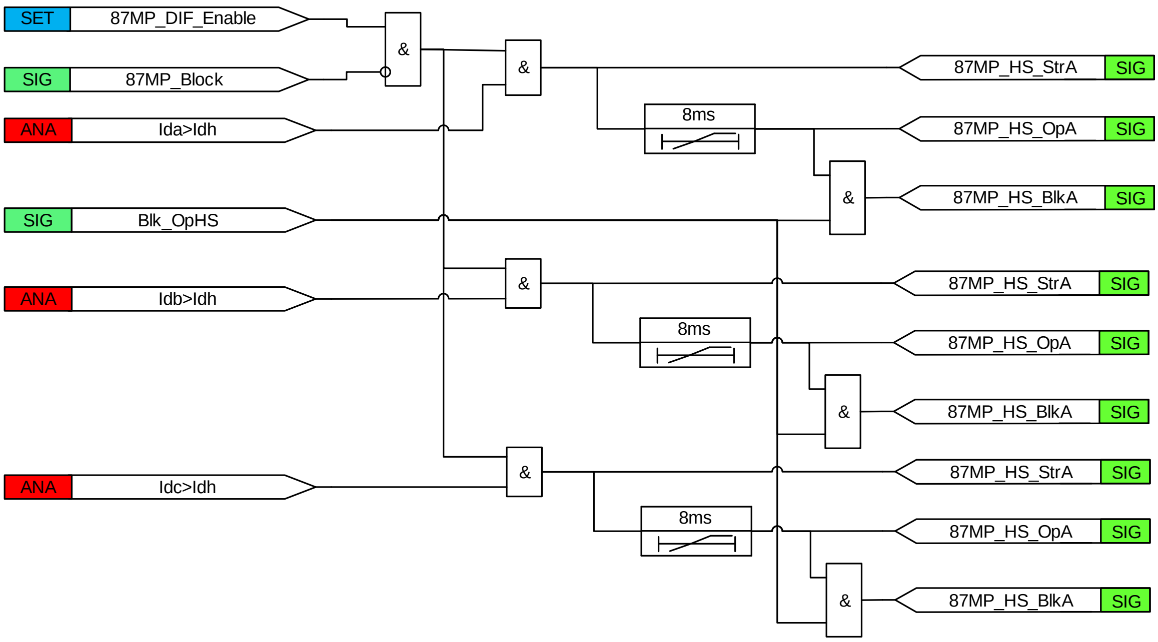


Figure 3.46-3 The Logic of Instantaneous High Stage differential protection

3.46.4 Biased low stage principle

The protection action equation is shown in the formula:

$$\begin{cases} I_d \geq I_{dl} & (I_r \leq I_{r1}) \\ I_d \geq k \cdot (I_r - I_{r1}) + I_{dl} & (I_{r1} < I_r \leq I_{r2}) \\ I_d \geq k_2 \cdot (I_r - I_{r2}) + k_1 \cdot (I_{r2} - I_{r1}) + I_{dl} & (I_r > I_{r2}) \end{cases}$$

Where: Idl=87MP_DIF_Coe_Idl*Machine_Ie

Table 3.46-3 Description of formula symbols

formula symbol	Formula symbol
$I_d = \left\|\dot{I}_1 + \dot{I}_2\right\|$	I_d is the differential current, I_r is biased current; $\dot{I}_1$ and $\dot{I}_2$ denote the fundamental frequency components on the phase and neutral sides of the current. Assuming that the positive direction of the current is towards the machine.
$I_r = \frac{\left\|\dot{I}_1 - \dot{I}_2\right\|}{2}$	
k_1, k_2	k_1 is Slope section 2, the typical setting is 0.6. k_2 is Slope section 3, Optional, the default value is 1 when not configured. If $k_1 = k_2$,

formula symbol	Formula symbol
	there are two operation sections.
I_{r1}, I_{r2}	I_{r1} is the biased current of End section 1; I_{r2} is the biased current of End section 2;
I_{dl}	I_{dl} is the Biased low operate value, it is equal to Low operate value * Machine_Ie

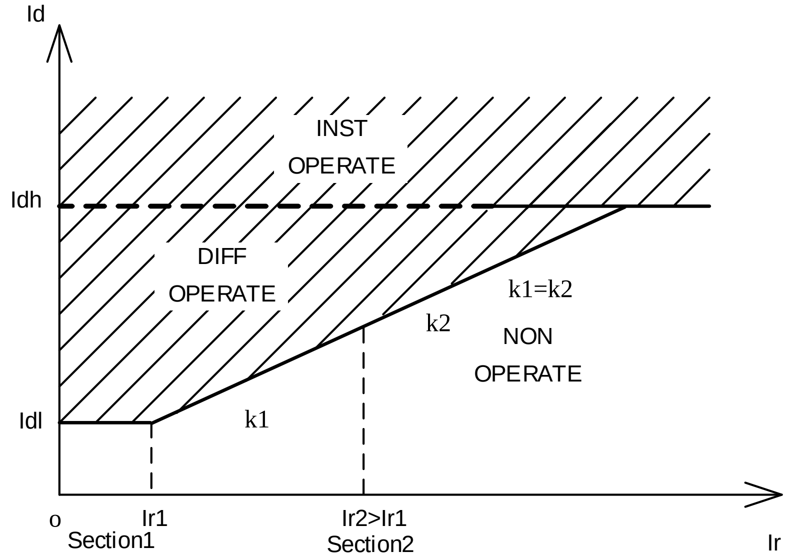


Figure 3.46-4 Differential protection action characteristic curve (two sections)

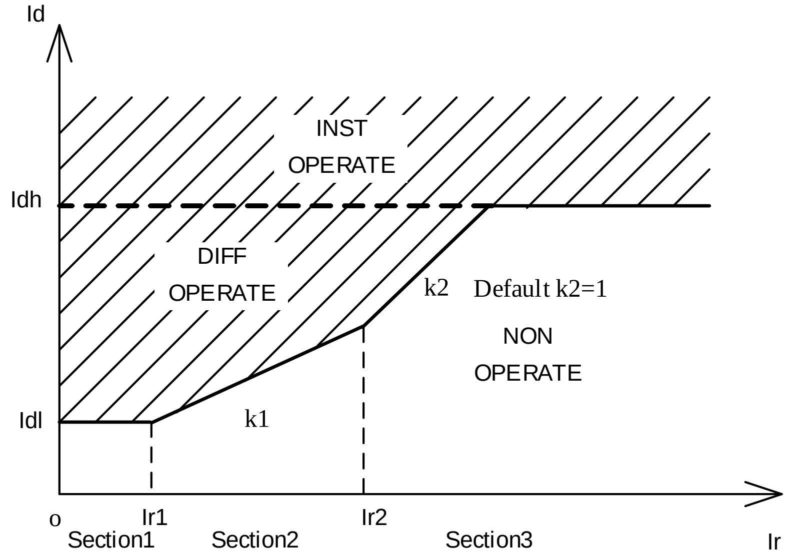


Figure 3.46-5 Differential protection action characteristic curve (three sections)

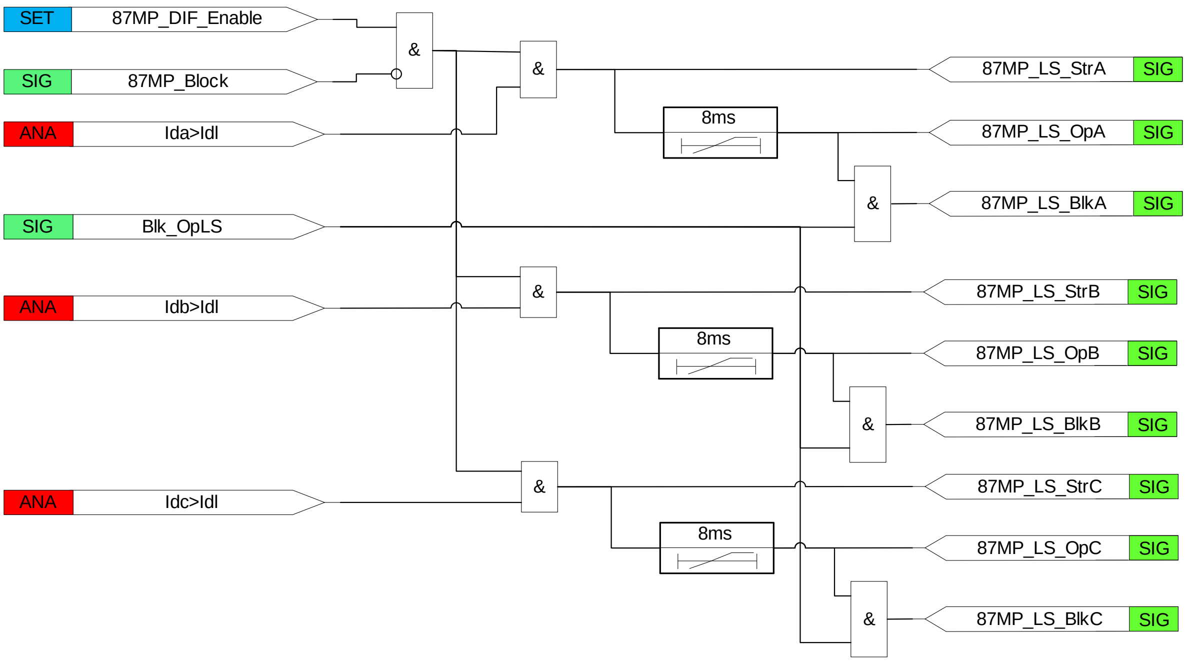


Figure 3.46-6 The Logic of Biased Low Stage differential protection

3.46.5 CT Supervision Block

CT disconnection judgment does not consider (1) simultaneous disconnection of three-phase CT and simultaneous disconnection of phase and neutral sides CT; (2) The fault and CT disconnection occur simultaneously.

The judgment condition of CT disconnection is that the maximum value of three-phase current on one side is more than 0.12In and the minimum value of three-phase current is less than 0.04In.

1. After being judged as CT disconnection: a delay of 5 seconds will result in a CT disconnection alarm signal.

2. After being judged as CT disconnection: if the differential current exceeds the limit and all channel currents do not increase, the decision to block the ratio differential protection is based on the control word.

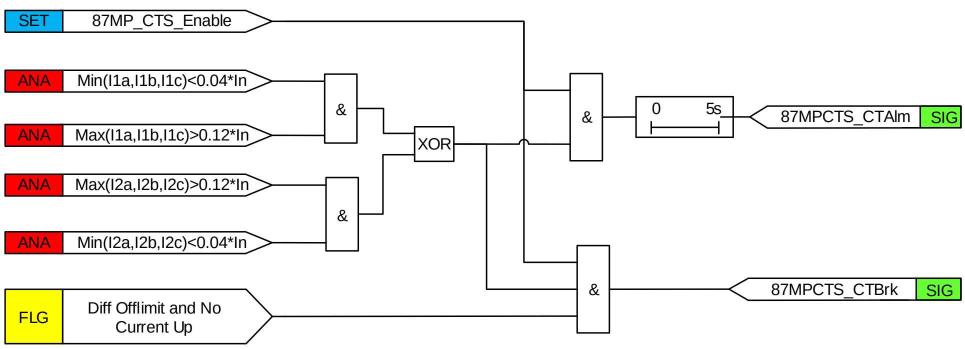


Figure 3.46-7 The Logic of CT supervision alarm and blocking

3.46.6 CT saturation blocking

To prevent differential protection from mis-operation due to CT saturation during external faults, the device has a CT saturation detection element to determine whether the CT is saturated and whether the relevant differential protection is locked. CT saturation determines the second harmonic, as detailed in Three phase inrush function OCR_INR.

3.46.7 Overall Logic

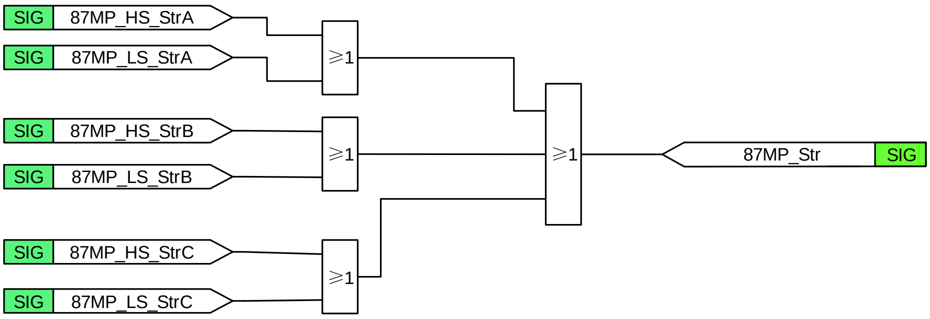


Figure 3.46-8 The Logic of overall start up

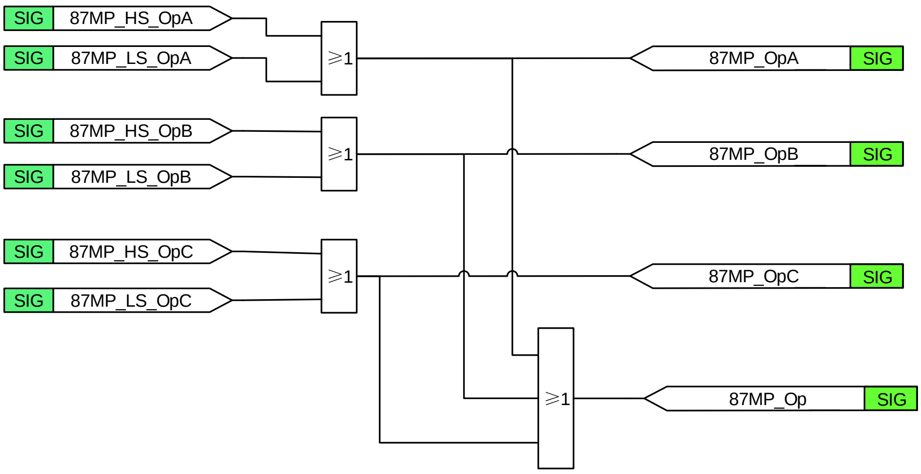


Figure 3.46-9 The Logic of Phase A/B/C and overall operation

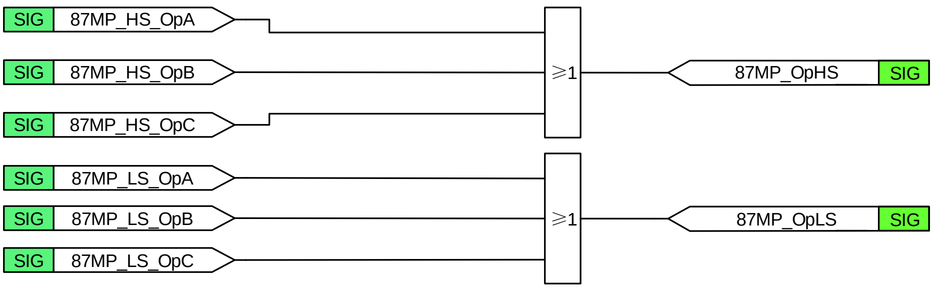


Figure 3.46-10 The Logic of high and low stage operation

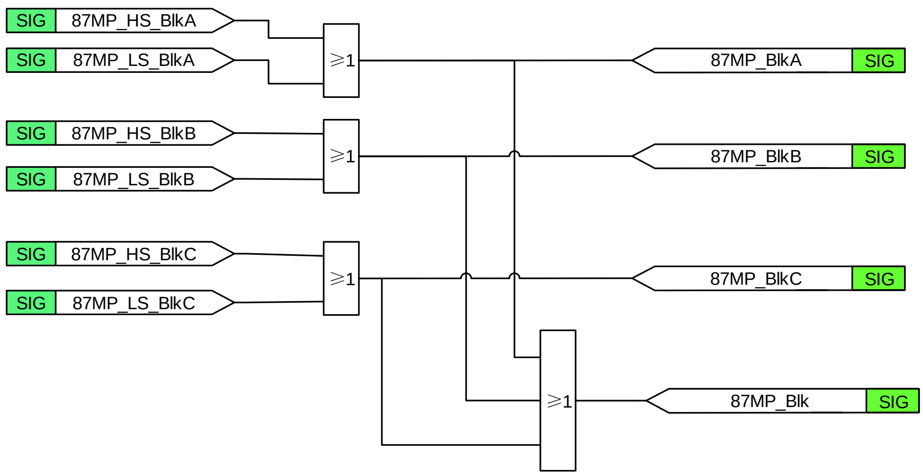


Figure 3.46-11 The Logic of Phase A/B/C and overall block

3.46.8 Settings

Table 3.46-4 87MP settings

No	Name	Range	Unit	Step	Default	Description
1.	87MP_DIF_Enable	0-1	-	1	0	Machine Differential Protection Enable
2.	87MP_DIF_AlmEna	0-1	-	1	0	Differential Current Off limit Alarm Enable
3.	87MP_DIF_CTBrkEna	0-1	-	1	0	CT Supervision Block Enable
4.	87MP_DIF_CTSatEna	0-1	-	1	0	CT Saturation Block Enable
5.	87MP_DIF_Coe_Idh	1.00-10.00	-	0.01	5	Instantaneous high operate value
6.	87MP_DIF_Coe_Idl	0.05-4	-	0.01	0.05	Biased low operate value
7.	87MP_DIF_Coe_Ir1	0.00-1.00	-	0.01	0.8	The biased current of End section 1
8.	87MP_DIF_Coe_Ir2	1.00-5	-	0.01	3	The biased current of End section 2
9.	87MP_DIF_k1	0.10-0.60	-	0.01	0.60	Slope section 2
10.	87MP_DIF_k2	0.10-1	-	0.01	1	Slope section 3, default value is 1. If the k2 is equal to k1, the Slope number is 2.
11.	87MP_DIF_MinOp_T	0.008-0.04	s	0.01	0.02	The minimum operation time
12.	87MP_CTS_Enable	0-1	-	1	0	The CTS function enable
13.	87MP_CTS_CTPh	0-1	-	1	0	The CT phase number: 0: three phases 1: two phases

3.47 Flux-balance based differential protection 87MFDIF

3.47.1 Overview

Flux balance differential protection is used as the main protection for machines (motor or generator) in case of phase to phase short circuits. The magnetic balance differential protection is installed at the entrance of the motor or generator, and the protection range is only within the internal motor or generator.

3.47.1.1 Function Block

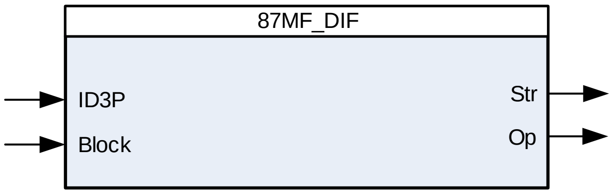


Figure 3.47-1 Function block

3.47.1.2 Signals

Table 3.47-1 Input signal

Signal	Description
ID3P	The differential current, the default value is I3P2
Block	This signal blocks all the binary output signals of the function

Table 3.47-2 Output signal

Signal	Description
Str	The start signal
Op	The operation signal.

3.47.2 Principle

Flux balance differential protection, also known as "small differential protection", should input the current from the neutral side current circuit of the device, and the overcurrent setting should be taken as 87MF_DIF_Coe_Id* Machine_Ie. When installing a flux balance current transformer in the motor or generator, the flux balance differential protection can be put into operation. At this time, the stabilized protection, including instantaneous high stage and biased low stage of differential protection, and CT break supervision block should be set to disabled; If a flux balanced current transformer is not installed, but the current introduced by the device is already differential current, the setting principle is the same.

3.47.3 Logic

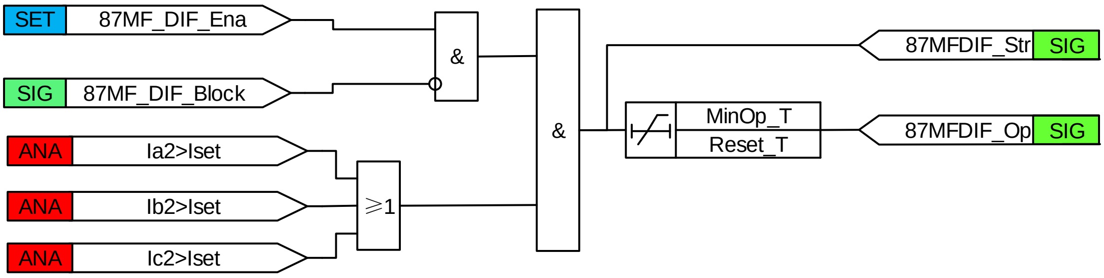


Figure 3.47-2 The logic of flux balance differential protection

3.47.4 Settings

Table 3.47-3 87MF settings

No	Name	Range	Unit	Step	Default	Description
1.	87MF_DIF_Enable	0-1	-	1	0	Machine Flux Balance Differential Protection Enable
2.	87MF_DIF_Coe_Id	0.05-4	-	0.01	0.05	Machine Flux Balance Differential Protection Operate value
3.	87MF_DIF_Op_T	0.02-300.00	s	0.01	0.02	Machine Flux Balance Differential Protection operate time delay
4.	87MF_DIF_Reset_T	0.00-60.00	s	0.01	0.02	Machine Flux Balance Differential Protection reset time delay

3.48 Machine Startup MST

3.48.1 Overview

3.48.1.1 Function Block

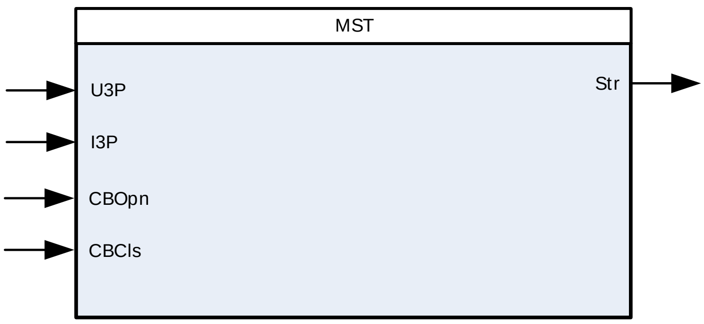


Figure 3.48-1 Function block

3.48.1.2 Signals

Table 3.48-1 Input signal

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
CBOpn	CB Open BI
CBCls	CB Close BI

Table 3.48-2 Output signal

Signal	Description
Str	The start signal

3.48.2 Principle

There are three ways to determine the starting components of the motor: circuit breaker position starting, voltage starting and current starting. The condition for determining the start of the circuit breaker position is that the switch switches from open to closed; The condition for determining voltage start is the process from dead voltage to live voltage; The criterion for determining current start is that there is no current to having current. Three judgment methods can be independently enabled. When the machine startup signal is initialized, it will be selectively to initialize the EnaMultCur signal of Overcurrent or earth fault protections by configuration conditions, or block the MDZS, MQDS, 78O, 40O, 32R, 32 of motor protection, etc.

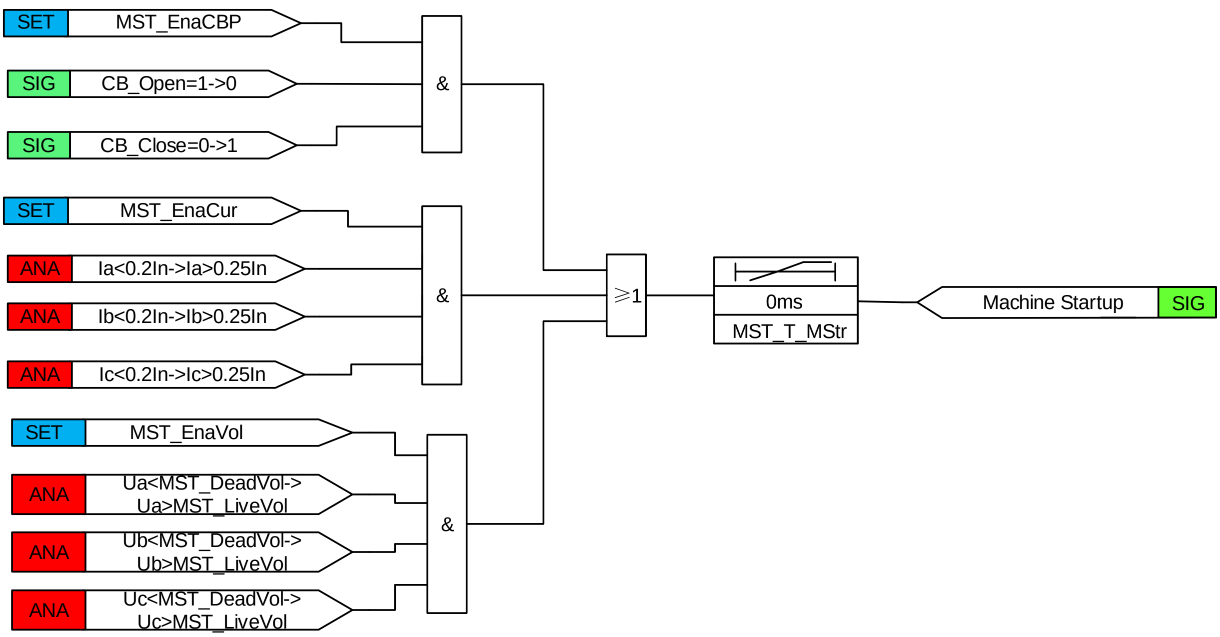


Figure 3.48-2 The logic of Machine Startup

3.48.3 Settings

Table 3.48-3 MST settings

No	Name	Range	Unit	Step	Default	Description
1.	MST_EnaCBP	0-1	-	1	0	Circuit breaker position Enable
2.	MST_EnaVol	0-1	-	1	0	Voltage Enable
3.	MST_EnaCur	0-1	-	1	0	Current Enable
4.	MST_T_MStr	0.00-60	s	0.1	0.02	The machine startup pulse time delay
5.	MST_LiveVol	1.00-120	V	0.01	70	Live voltage setting
6.	MST_DeadVol	1.00-100	V	0.01	30	Dead voltage setting

3.49 Long start protection MQDS

3.49.1 Overview

3.49.1.1 Function Block

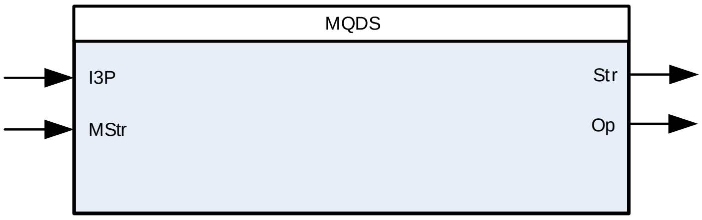


Figure 3.49-1 Function block

3.49.1.2 Signals

Table 3.49-1 Input signal

Signal	Description
I3P	The current magnitude in all the three phases
MStr	Machine Startup Signal

Table 3.49-2 Output signal

Signal	Description
Str	The start signal
Op	The operation signal.

3.49.2 Principle

Long start protection is used during the starting process of an electric motor, where the starting time exceeds the maximum allowable starting time due to heavy loads or blockages. If the starting time of the electric motor is too long, it can cause the rotor to overheat and seriously affect the service life of the electric motor. The long start protection starts timing when the motor starts and the maximum phase current reaches 0.1Ie. If the starting current exceeds the peak value within the [motor start time] and drops to within 1.2Ie, the long start protection returns. Otherwise, the long start protection will trip.

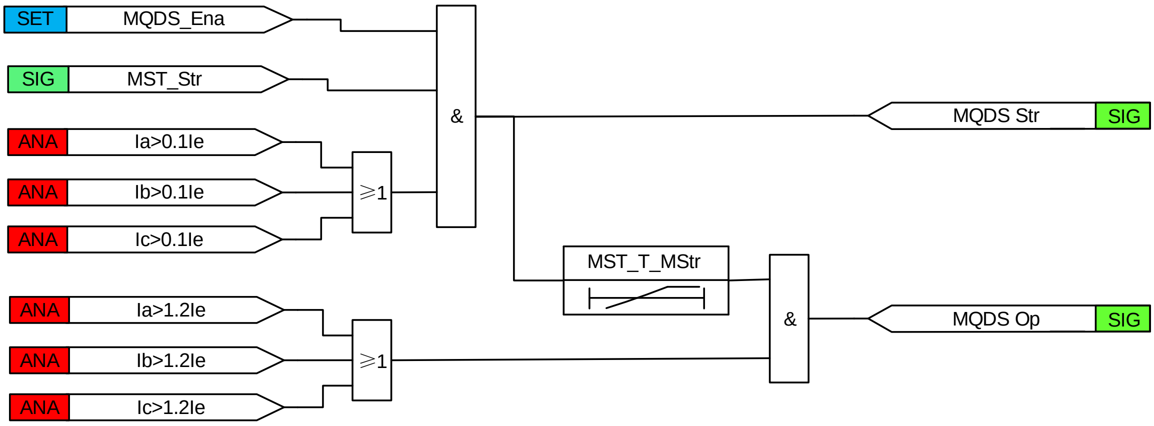


Figure 3.49-2 Machine Long start logic

Note: MST_T_MStr is the Pulsed time of MST.

3.49.3 Settings

Table 3.49-3 MQDS settings

No	Name	Range	Unit	Step	Default	Description
1.	MQDS_Ena	0-1	-	1	0	MQDS enable

3.50 The locked-rotor protection MDZS

3.50.1 Overview

3.50.1.1 Function Block

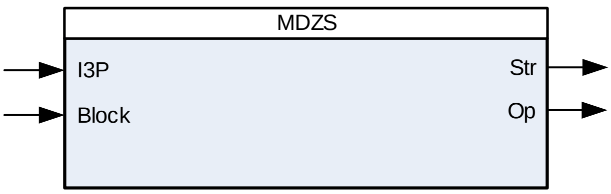


Figure 3.50-1 Function block

3.50.1.2 Signals

Table 3.50-1 Input signal

Signal	Description
I3P	The current magnitude in all the three phases
Block	The block signal, such as Machine Startup Signal

Table 3.50-2 Output signal

Signal	Description
Str	The start signal
Op	The operation signal.

3.50.2 Principle

The locked-rotor protection automatically exits during the starting process of the motor, and is automatically put into operation after starting. It is used for the locked-rotor protection that occurs during the normal operation of the motor. The locked-rotor protection current is composed of positive sequence current, with IA1, IB1, and IC1 being the positive sequence current of the terminal current. The locked-rotor protection time is set according to the maximum allowable locked-rotor operation time.

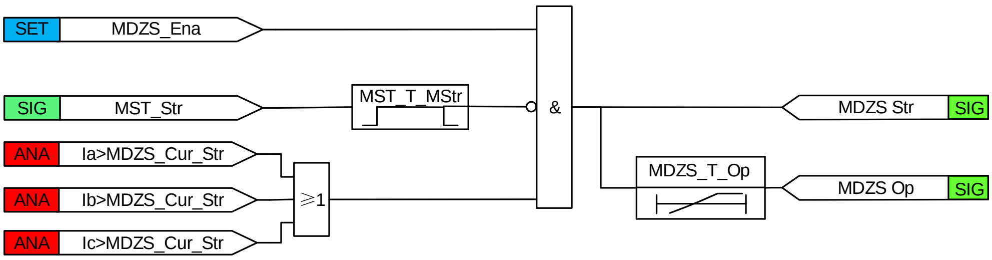


Figure 3.50-2 The locked-rotor protection logic

Note: MST_T_MStr is the Pulsed time of MST, MST_Str is the Block signal connect to MST_Str signal.

3.50.3 Settings

Table 3.50-3 MDZS settings

No	Name	Range	Unit	Step	Default	Description
1.	MDZS_Ena	0-1	-	1	0	MDZS enable
2.	MDZS_Cur_Str	0.04-20In	A	0.01In	0.04In	MDZS current startup setting
3.	MDZS_T_Op	0.00-60	s	0.1	0.02	MDZS operating time delay

3.51 Synchronous Motor Loss of Step 78O

3.51.1 Overview

3.51.1.1 Function Block

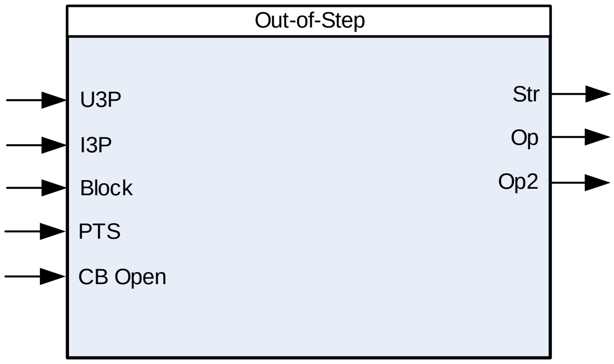


Figure 3.51-1 Function block

3.51.1.2 Signals

Table 3.51-1 Input signal

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
PTS	PT Inst Alarm
CB Open	CB Open

Table 3.51-2 Output signal

Signal	Description
Str	The start signal
Op	The first stage operation signal.
Op2	The second stage operation signal.

3.51.2 Principle

The out of step protection includes two stages of implementation, which can be enabled or disabled separately. When the first stage of out of step protection is enabled, the first stage operation will be triggered after the first stage of delay; When the second out of step protection is enabled, after the second delay, the second stage operation is triggered.

The out of step protection adopts the power factor angle criterion and the static stable impedance circle characteristic criterion. The protection only operates when both criteria are met, that is, the out of step protection action zone is the intersection of the two criteria action zones. The criterion for the impedance circle characteristic of the static stable boundary can be switched on or off;

When the static stable impedance circle criterion disabled, the out of step protection transforms into a pure power factor angle criterion.

The power factor angle criterion is: $\varphi_{set} < \varphi < 180^\circ - \varphi_{set}$;

The static stable impedance circle equation is:

$$Z_M = j\frac{X_d - X_s}{2} - \frac{X_d + X_s}{2} e^{j2\varphi}, \quad \varphi = \arctan(Q/P)$$

The corresponding action equation is: $90^\circ < \arg\frac{\dot{U}_{CA} + \dot{I}_{CA} \times jXs}{\dot{U}_{CA} - \dot{I}_{CA} \times jXd} < 270^\circ$

Where: Xd is setting 78O_MhoZaXd, Xs is settings 78O_MhoZbXs.

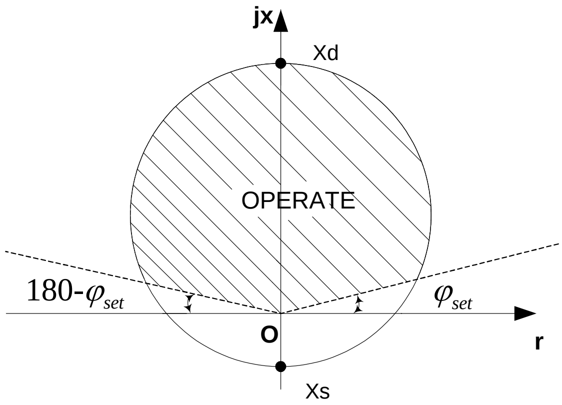


Figure 3.51-2 Schematic diagram of out of step protection action area

Out of step protection automatically disabled during motor startup and is automatically put into operation after startup. In addition, the blocking criteria for out of step protection also include: PT disconnection blocking, circuit breaker tripping blocking, no current blocking (Ia<0.06In and Ic<0.06In), no voltage blocking (Uca<10V), negative sequence current blocking (can be enabled/ disabled, sharing the same negative sequence current blocking element with loss of excitation protection, which is to automatically return after a 10 second delay).

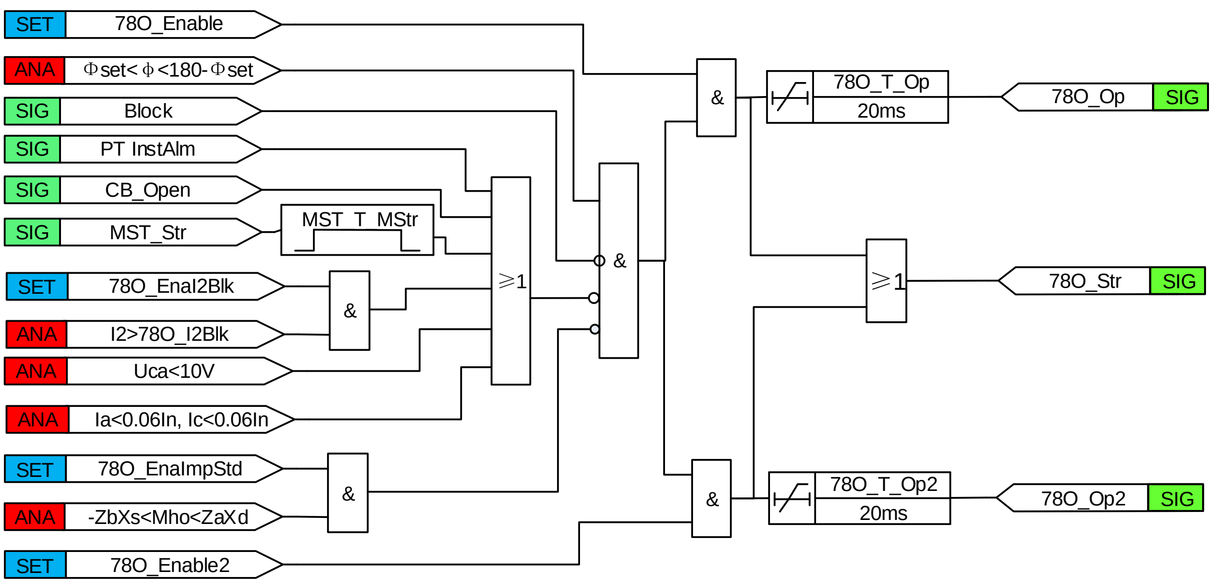


Figure 3.51-3 Logic diagram of synchronous motor out of step protection

Note: MST_T_MStr is the Pulsed time of MST.

3.51.3 Settings

Table 3.51-3 78O settings

No	Name	Range	Unit	Step	Default	Description
1.	78O_Enable	0-1	-	1	0	78O_Enable
2.	78O_Enable2	0-1	-	1	0	78O_Enable2
3.	78O_EnaI2Blk	0-1	-	1	0	78O_EnaI2Blk
4.	78O_EnaImpStd	0-1	-	1	0	78O_EnaImpStd
5.	78O_I2Blk	0.04-20In	A	0.01	0.04In	78O_I2Blk
6.	78O_Ang	0-60°	°	1	60°	78O_Ang
7.	78O_MhoZaXd	0-250/In	Ω	0.01	10/In	78O_MhoZaXd
8.	78O_MhoZbXs	0-250/In	Ω	0.01	10/In	78O_MhoZbXs
9.	78O_T_Op	0-599.900	s	0.001	599.900	78O_T_Op
10.	78O_T_Op2	0-599.900	s	0.001	599.900	78O_T_Op2

3.52 Synchronous Motor Loss of Excitation 40O

3.52.1 Overview

3.52.1.1 Function Block

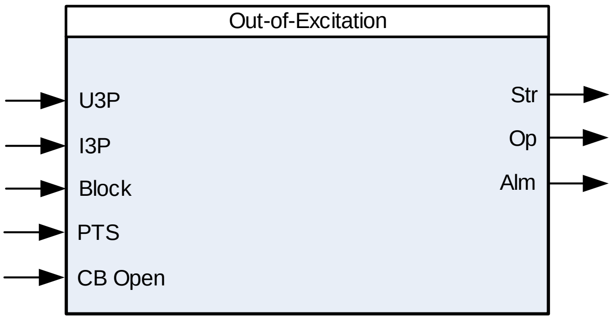


Figure 3.52-1 Function block

3.52.1.2 Signals

Table 3.52-1 Input signal

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
Block	This signal blocks all the binary output signals of the function
PTS	PT Inst Alarm
CB Open	CB Open

Table 3.52-2 Output signal

Signal	Description
Str	The start signal
Op	The operation signal.
Alm	The Alarm signal.

3.52.2 Principle

The loss of excitation protection adopts the principle of asynchronous boundary condition impedance circle. The condition for the loss of excitation protection action is when the positive sequence impedance of the measuring machine end falls within the asynchronous boundary circle. The impedance characteristics are shown in the following figure:

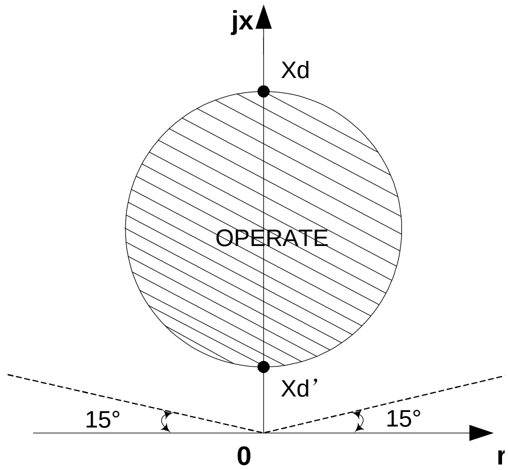


Figure 3.52-2 Asynchronous boundary impedance circle for loss of excitation protection

The asynchronous boundary impedance value is:

$$Z_M = j\frac{X_d + X_d'}{2} + \frac{X_d - X_d'}{2} e^{j2\varphi}, \quad \varphi = \arctan(Q/P)$$

The corresponding action equation is:

$$90 < \arg\frac{U_{CA} - I_{CA} \cdot jX_d'}{U_{CA} - I_{CA} \cdot jX_d} < 270$$

Where: Xd is setting 40O_MhoZaXd, Xd' is settings 40O_MhoZbXs.

The impedance Mho can be calculated by UCA and ICA by the following equation:

Mho= U_{CA}/I_{CA}

To prevent misoperation of the stator impedance criterion during normal phase operation of synchronous motors, two diagonal lines passing through the origin and forming a 15 º angle are specially designed as the blocking criterion. The opening conditions are: 15°<ψ<165°.

The angle ψ can be calculated by the following equation:

Ψ= argtan(U1/I1)

Where: U1 is the positive voltage, I1 is the positive current.

The loss of excitation protection automatically exits during the motor startup process and is automatically put into operation after startup. In addition, the blocking criteria for loss of excitation protection also include: PT disconnection blocking, circuit breaker tripping blocking, no current blocking (Ia1<0.06In and Ic1<0.06In), no voltage blocking (Uca<10V), negative sequence current blocking (can be on/off, and shares the same negative sequence current blocking element with out of step protection, which needs to automatically return after a 10 second delay).

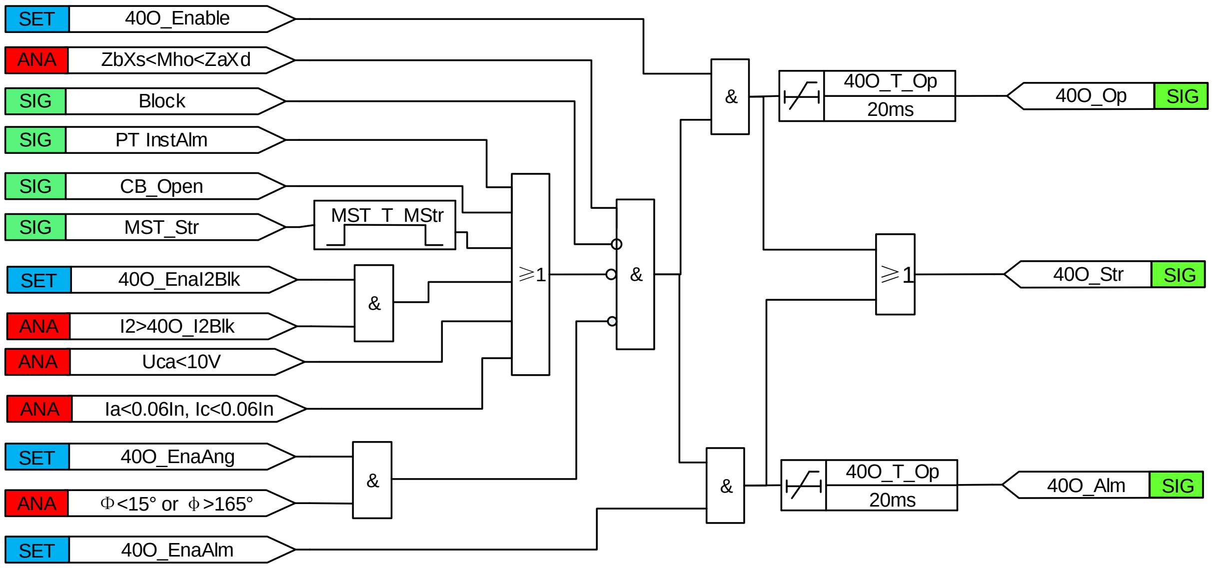


Figure 3.52-3 Logic diagram of synchronous motor loss of excitation protection

Note: MST_T_MStr is the Pulsed time of MST.

3.52.3 Settings

Table 3.52-3 40O settings

No	Name	Range	Unit	Step	Default	Description
1.	40O_Enable	0-1	-	1	0	40O trip enable
2.	40O_EnaAlm	0-1	-	1	0	40O alarm Enable
3.	40O_EnaI2Blk	0-1	-	1	0	40O negative current blocking enable
4.	40O_EnaAng	0-1	-	1	0	40O impedance line angle enable
5.	40O_I2Blk	0.04-20In	A	0.01	0.04In	40O negative current setting
6.	40O_MhoZaXd	0-250/In	Ω	0.01	10/In	40O direct axis synchronous reactance setting Xd
7.	40O_MhoZbXs	0-250/In	Ω	0.01	10/In	40O direct axis transient reactance
8.	40O_T_Op	0-599.900	s	0.001	599.900	40O time delay setting

4 Supervision Functions

4.1 Overview

Though the protection system is in non-operating state under normal conditions, it is waiting for a power system fault to occur at any time and must operate for the fault without fail.

When the equipment is in energizing process, the equipment needs to be checked to ensure there are no errors. Therefore, the automatic supervision function, which checks the health of the protection system during startup and normal operation procedure, plays an important role.

The numerical relay based on the microprocessor operations has the capability for implementing this automatic supervision function of the protection system.

In case a fatal fault is detected during automatic supervision, the equipment will be blocked out. It means that this relay is out of service. Therefore, you must re-energize the relay or even replace a module to make this relay back into service.

4.2 Supervision Alarm and Block

The relay device has powerful real-time self-check capability. The device will automatically check its own software and hardware running state during the process of operation. If there is any abnormal situation, the abnormal information will be displayed on the LCD, and the corresponding indicator and signal relay will issue prompt. Besides, these abnormal self-check and alarm signal can be uploaded to the SCADA through the IEC 61850 or IEC 60870-103 communication protocol.

Self-check scope of the device is as follows:

1. Self-check about the hardware:
   - Alarm signal of analog quantity circuit self-check
   - Alarm signal of BI circuit self-check
   - Alarm signal of BO circuit self-check
   - Alarm signal of storage self-check
   - Alarm signal of watchdog self-check
2. Self-check about the software and configuration
   - Alarm signal of software running state self-check
   - Alarm signal of configuration self-check
   - Alarm signal of internal communication self-check
3. Self-check about the external communication
   - Alarm signal of external communication self-check

If the relay device is in abnormal status, alarm signal will be issued. Some alarm signals will block the protection function, while some will not. The detailed information is shown as the following table.

Table 4.2-1 Alarm Signal and Block

Alarm Signal Name	Alarm Signal Description	Block Protection or Not
Kernel Comm Abn	Kernel Communication Abnormal	YES
Databus Comm Intr	Databus Communication Interrupt	YES
Databus Data Abn	Databus Data Abnormal	YES
LVDSIO Input Err	LVDSIO Input Error	YES
LVDSBus SelfChk Abn	LVDSBus SelfCheck Abnormal	YES
Comp SelfChk Abn	Component SelfCheck Abnormal	YES
RAM Scan Err	RAM Scan Error	YES
Sys Const SelfChk Abn	System Const SelfCheck Abnormal	YES
SelfChk Comp Port Err	SelfCheck Component Port Error	YES
SelfChk Comp Cfg Err	SelfCheck Component Configuration Error	YES
Setting SelfChk Err	Setting SelfCheck Error	YES
Setting CRC Err	Setting CRC Error	YES
Soft Sw SelfChk Err	Soft Switch SelfCheck Error	YES
Soft Sw CRC Err	Soft Switch CRC Error	YES
BO Cfg SelfChk Err	BO Configuration SelfCheck Error	YES
BO Cfg CRC Err	BO Configuration CRC Error	YES
Para SelfChk Err	Parameter SelfCheck Error	YES
Para CRC Err	Parameter CRC Error	YES
Prot Comp RAM Scan Err	Prot Component RAM Scan Error	YES
Databus Longtime Losing Pkg	Databus Longtime Losing Package	NO
Databus Wrong Pkg Alarm	Databus Wrong Package Alarm	NO
A/D Sampling Err	A/D Sampling Error	NO
IRIG-B Syn Abn	IRIG-B Synchronization Abnormal	NO
Mana Bus Comm Intr	Mana Bus Comm Interrupt	NO
Setting Set CRC Err	Setting Set CRC Error	NO
Soft Sw Set CRC Err	Soft Switch Set CRC Error	NO
Para Set CRC Err	Parameter Set CRC Error	NO
Main Cfg Check Abn	Main Configuration Check Abnormal	NO
Cfg File Check Abn	Configuration File Check Abnormal	NO
Comp Cfg Check Err	Component Configuration Check Error	NO
WaveRcd Cfg File Abn	Wave Record Configuration File Abnormal	NO
WaveRcd File Abn	Wave Record File Abnormal	NO

4.3 Current circuit supervision CTS

4.3.1 CTS Overview

The main purpose of the current circuit supervision function is to detect faults in the secondary circuits of the current transformer and avoid influence on the operation of relevant protection functions. This current circuit supervision function will be in operation at any time, whether the general fault detection picks up or not.

4.3.1.1 Function Block

The function block of the protection is as below.

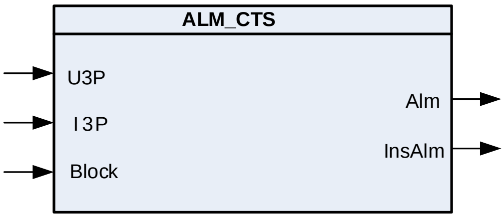


Figure 4.3-1 Function block

4.3.1.2 Signals

Table 4.3-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
Block	This signal blocks of the function

Table 4.3-2 Output Signals

Signal	Description
Alm	This is the integrated alarm signal
InsAlm	This is the integrated instantaneous Alarm signal

4.3.2 CTS Operation principle

The current circuit supervision function can be enabled or disabled by setting the corresponding CTS_Ena parameter value as "1" or "0".

The operation of current circuit supervision can be described by using a module diagram. All the modules in the diagram are explained in the next sections.

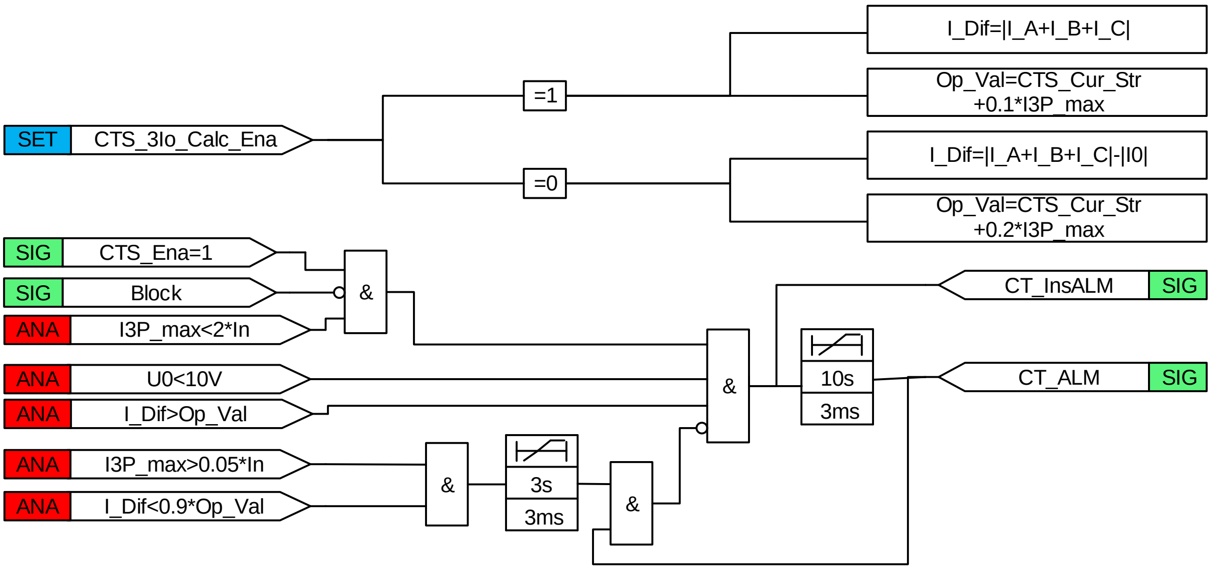


Figure 4.3-2 Functional module diagram

➢ **Differential current calculation**

Differential current calculation and operate value depend on whether there is an external CT to measure the residual current.

If the external CT is unavailable, that is to say CTS_3Io_Calc_Ena=1, differential current is the summed phase currents I_A, I_B and I_C. The formula is shown as below.

$$I\_Dif = |I\_A + I\_B + I\_C|$$

Then the operate value is according to the following formula:

$$Op\_Val = Set\_value + 0.1*I3P\_max$$

If the external CT is available, that is to say CTS_3Io_Calc_Ena=0, differential current is the difference between the summed phase currents I_A, I_B, I_C and the measured residual current. The formula is shown as below.

$$I\_Dif = |I\_A + I\_B + I\_C| - |I_0|$$

The operate value is according to the following formula:

$$Op\_Val = Set\_value + 0.2*I3P\_max$$

"CTS_3Io_Calc_Ena" is the signal to judge whether there is an external CT to measure the residual current;

"CTS_Cur_Str" is the operation start current value;

"I3P_max" is the max phase current of three phases;

➢ **Current circuit failure criteria**

The current operating characteristics can be selected with the CTS_3Io_Calc_Ena value. Detailed contents of differential current and operate value have been given out in the upper part.

When the highest phase current is less than 2.0 × In, if the differential current exceeds the operate value and the internally calculated residual voltage is below 10V, the CT_InsALM output signal is activated instantly. VT_Alm output signal is activated with a fixed 10s delay. CT_InsALM signal needs to be active during the delay.

When the highest phase current is more than 2.0 × In, the function is internally blocked. When the internal blocking activates, the CT_InsALM output is deactivated immediately, however the VT_Alm output deactivates after a fixed delay of 3s. The internal blocking is used for avoiding false operation during a fault situation when the current transformers are saturated due to high fault currents.

The function resets with a fixed delay of 3s when the differential current is below the value of 0.9*Op_Val and highest phase current is more than five percent of the nominal current (0.05 × In).

4.3.3 CTS Application Scope

Open or short-circuited current transformer cores can cause unwanted operation in many protection functions such as differential, earth-fault current and negative sequence current functions. So, when an error in any CT circuit is detected, the protection functions concerned can be blocked and an alarm is given.

It must be remembered that the blocking of protection functions at an occurring open CT circuit means that the situation remains unchanged and extremely high voltages stress the secondary circuit which may damage the insulation and cause further problems.

4.3.4 CTS Settings

Table 4.3-3 CTS settings

No.	Name	Range	Unit	Step	Default	Description
1	CTS_Ena	0-1	-	1	0	Operation disable/enable
2	CTS_Cur_Str	0.04-20.00In	A	0.01In	0.04In	operation start current value
3	CTS_3Io_Calc_Ena	0-1	-	1	0	CT external zero-sequence current calculation criteria Disable/Enable

4.4 Fuse failure supervision PTS

4.4.1 PTS Overview

The fuse failure supervision feature is used to detect failure of the AC voltage input circuit of this relay.

The fuse failure supervision logic in the relay is designed to detect the voltage failure and automatically adjust the configuration of protective elements whose stability would otherwise be compromised. A time delay alarm output is also available.

4.4.1.1 Function Block

The function block of the protection is as below.

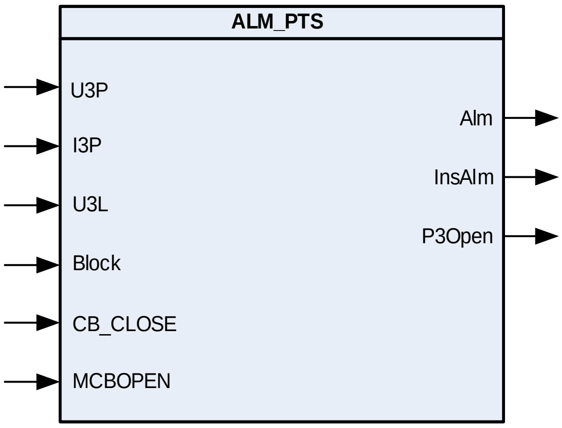


Figure 4.4-1 Function block

4.4.1.2 Signals

Table 4.4-1 Input Signals

Signal	Description
U3P	The voltage magnitude in all the three phases
I3P	The current magnitude in all the three phases
U3L	The voltage magnitude in all the three phases
Block	This signal blocks of the function
CB_CLOSE	The closed position of circuit breaker
MCBOPEN	It is activated when external MCB opens protected voltage circuit

Table 4.4-2 Output Signals

Signal	Description
Alm	This is the integrated alarm signal
InsAlm	This is the integrated instantaneous Alarm signal
3POLE_OPEN	The open signal of the three phases

4.4.2 PTS Operation principle

The fuse failure supervision function can be enabled or disabled by setting the corresponding PTS_Ena parameter values as "1" or "0".

The operation of the fuse failure supervision function can be described with a module diagram. All the modules in the diagram are explained in the next sections.

The PTS_MCB_Open is external BI signal MCB_Open, the HoldSet is normally set to be 10ms.

The PTS_InsEna setting is default not used, the logic is (a) The PTS alarm Functional module diagram without PTS_InsEna; when this setting is used, the logic is (b) The PTS alarm Functional module diagram with PTS_InsEna.

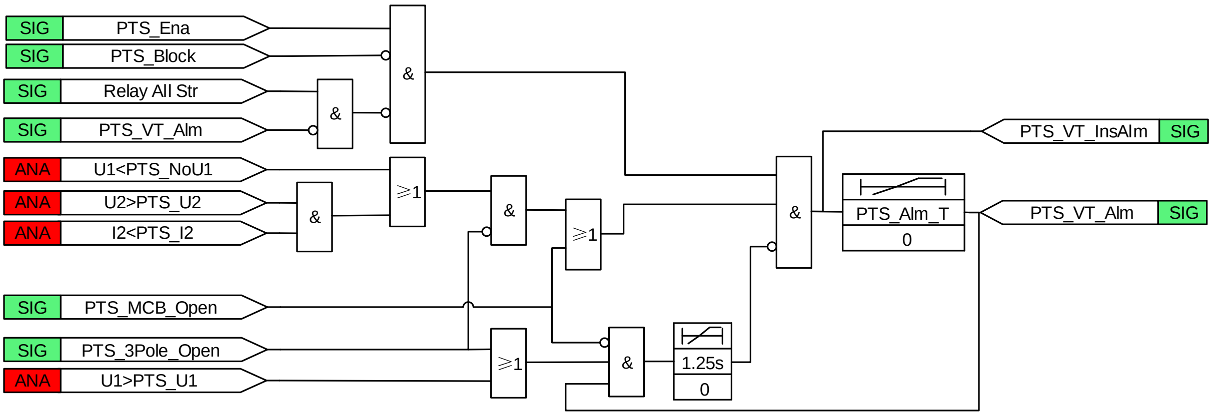


Figure 4.4-2 (a) The PTS alarm Functional module diagram without PTS_InsEna

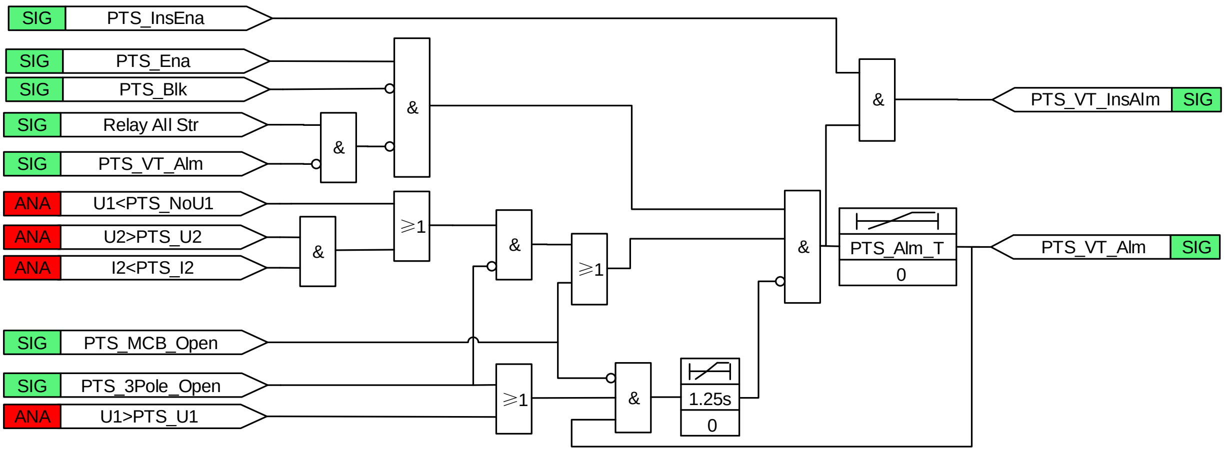


Figure 4.4-3 (b) The PTS alarm Functional module diagram with PTS_InsEna

- **Dead-line detection**

The three phase dead-line detection logic of the function is shown as the below diagram.

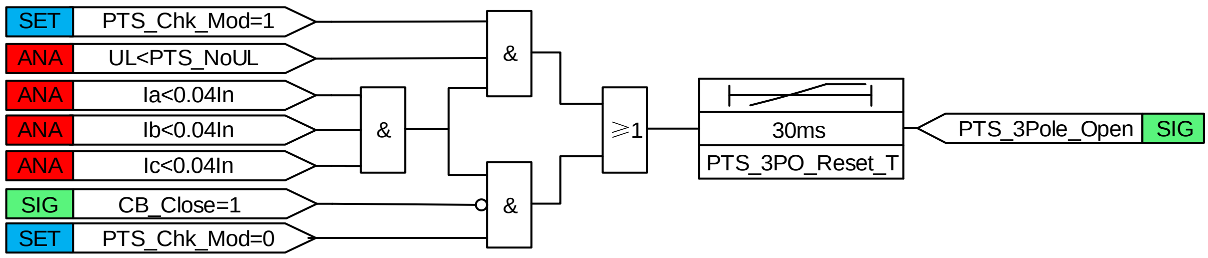


Figure 4.4-4 The dead-line detection logic

If any of the two criteria is fulfilled, 3POLE_OPEN signal is activated.

- When PTS_Chk_Mod signal is 1, the voltage and current in any phase are below the respective set values of PTS_NoUL and 0.04In.
- When PTS_Chk_Mod signal is 0, the current in any phase is below the value of 0.04In and the position of min CB is open, that is to say, PTS_Chk_Mod signal is 0.

This prevents the blocking of the impedance protection by fuse failure detection during the dead-line condition. This also occurs during single pole auto-reclosing. The drop-off timer prolongs the dead-line condition after the line energization to prevent the blocking of the impedance protection for unequal pole closing. The time is decided by the set value PTS_3PO_Reset_T.

➢ **Fuse failure criteria**

The fuse failure based on positive-sequence criterion is detected if the measured positive sequence voltage is less than the set PTS_NoU1 value as 3POLE_OPEN signal is deactivated.

The fuse failure based on negative-sequence criterion is detected if the measured negative sequence voltage exceeds the set PTS_U2 value and the measured negative-sequence current is below the set PTS_I2 value.

If the positive-sequence criterion or the negative-sequence criterion is fulfilled, VT_InsAlm output signal is activated instantly to block all the voltage-related functions. VT_Alm output signal is activated with a fixed 10s delay. VT_InsAlm signal needs to be active during the delay.

When VT_InsAlm=1 and VT_Alm=0, Relay All Str=1 (it means any protection start up and the general relay startup signal become 1), then the VT_InsAlm will return.

The MINCB_OPEN input signal is supposed to be connected through an IED binary input to the auxiliary contact of the miniature circuit breaker protecting the VT secondary circuit.

The MINCB_OPEN signal activates VT_InsAlm signal instantly to block all the voltage-related functions when MINCB is in the open state. Similarly, VT_Alm output signal is activated with a fixed 10s delay. VT_InsALM signal needs to be active during the delay.

The activation of the VT_Blk input deactivates the VT_Alm output.

➢ **Fuse failure reset**

When fuse failure alarm signal is activated and MINCB is closed, the VT_Alm signal will automatically reset after a fixed 1.25s delay if any of the following criterion is fulfilled.

- The measured positive-sequence voltage exceeds the set PTS_U1 value;
- 3POLE_OPEN signal is activated;

4.4.3 PTS Application Scope

A fault in the voltage measuring circuit is referred to as a fuse failure. A fuse failure occurs due to blown fuses, broken wires or intended substation operations. Since incorrectly measured voltage can result in a faulty operation of some of the protection functions, it is important to detect the fuse failures. A fast fuse failure detection is one of the means to block voltage-based functions before they operate.

4.4.4 PTS Settings

Table 4.4-3 PTS settings

No.	Name	Range	Unit	Step	Default	Description
1	PTS_Ena	0-1	-	1	0	Operation Enable/Disable
2	PTS_InsEna	0-1	-	1	1	InsAlm Operation Enable/Disable. If not needed, this setting can be cancelled.
3	PTS_NoU1	1-100	V	0.01	10	Operate level of positive sequence under voltage
4	PTS_U1	1-100	V	0.01	50	Reset level of positive sequence over-voltage
5	PTS_U2	1-100	V	0.01	10	Operate level of negative sequence over-voltage
6	PTS_NoUL	1-100	V	0.01	10	Operate level of line under voltage
7	PTS_I2	0.04-20In	A	0.01	0.04	Operate level of negative sequence over-current
8	PTS_Chk_Mod	0-1	-	1	0	Check model of PT failure
9	PTS_Alm_T	0-60	s	0.01	10	Operate Delay Time
10	PTS_3PO_Reset_T	0-60	s	0.01	0.50	Reset time of 3-pole open

4.5 Trip circuit supervision TCS

4.5.1 TCS Overview

This relay provides the trip circuit supervision function. This function can be realized by programming the logic function of this device through the PRS IED Studio configuration tool auxiliary software according to the practical application experience of the user.

4.5.1.1 Function Block

The function block of the protection is as below.

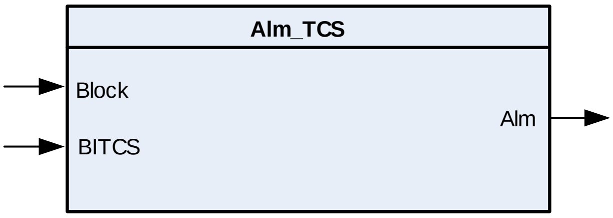


Figure 4.5-1 Function block

4.5.1.2 Signals

Table 4.5-1 Input Signals

Signal	Description
Block	This signal blocks of the function
BITCS	the trip circuit supervision from TCS hardware circuit

Table 4.5-2 Output Signals

Signal	Description
Alm	This is the integrated alarm signal

4.5.2 TCS Operation principle

The trip circuit supervision function can be enabled or disabled by setting the corresponding TCS_Ena parameter values as "1" or "0".

The operation of trip circuit supervision can be described by using a module diagram.

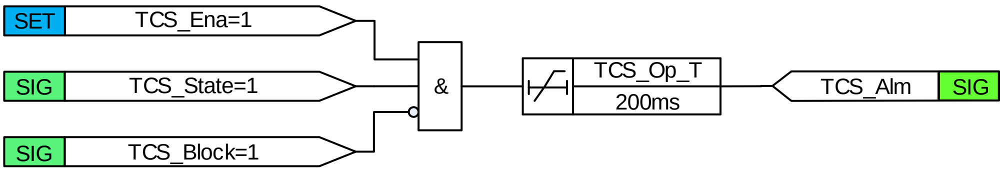


Figure 4.5-2 Functional module diagram

The function starts when the TCS_STATE signal is 1, which means TCS detects a trip circuit failure.

The function contains a blocking functionality. The activation of the TCS_Block input deactivates the TCS_Alm output and resets the internal timers.

The operating time characteristic for the function is DT. Once activated, the timer runs until the set value of TCS_Op_T has elapsed. When the operation timer has reached the maximum time value, the ALARM output is activated. If a drop-off situation occurs during the operate time up counting, the fixed 200 ms reset timer is activated. After that time, the operation timer resets.

4.5.3 TCS Application Scope

TCS detects faults in the electrical control circuit of the circuit breaker. The function can supervise both open and closed coil circuits. This kind of supervision is necessary to find out the vitality of the control circuits continuously.

The circuit breaker coil current is normally cut by an internal contact of the circuit breaker. In case of a circuit breaker failure, there is a risk that the protection trip contact is destroyed. An auxiliary relay can be used between the protection IED trip contact and the circuit breaker coil. This way the breaking capacity question is solved, but the TCS circuit in the protection device monitors the healthy auxiliary relay coil, not the circuit breaker coil. The separate trip circuit supervision relay is applicable for this to supervise the trip coil of the circuit breaker.

4.5.4 TCS Settings

Table 4.5-3 TCS settings

No.	Name	Range	Unit	Step	Default	Description
1	TCS_Ena	0-1	-	1	0	Operation Enable/Disable
2	TCS_Op_T	0-100	s	0.01	10	Operate Delay Time

5 Monitor & Control

5.1 Overview

Besides the protection and supervision functions, the relay provides some other auxiliary functions, such as protection and metering measurement quantities sampling, remote control, BI signaling, event recording and fault & disturbance recording etc. All these sub-functions are integrated components to fulfill the protection and control functions of the device.

5.2 Measure and Control SYNC(MC_25SYNC)

5.2.1 Overview

This relay supports synchro check function. The synchro check can be used in a local control operation or remote control operation from a supervision and control system. Three check modes described below can be selected for the synchro check function.

5.2.1.1 Function Block

The function block of the protection is as below.

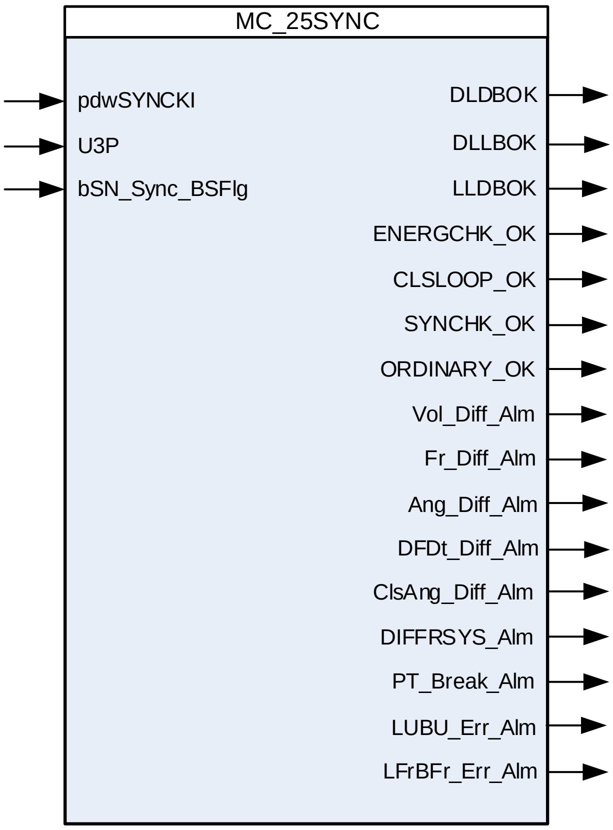


Figure 5.2-1 Function block

5.2.1.2 Signals

Table 5.2-1 Input Signals

Input Signal	Function
bSN_Sync_BSFlg	Input signal of block Sync function(includes PT break)
pdwSYNCKI	Input signal of start Sync command
U3P	Voltage of system side and line side

Table 5.2-2 Output Signals

Output Signal	Function
DBDL_OK	DBDL Condition is met
LBDL_OK	LBDL Condition is met
DBLL_OK	DBLL Condition is met
ENERGCHK_OK	ENERGCHK Condition is met
CLSLOOP_OK	CLSLOOP Condition is met
SYNCHK_OK	SYNCHK Condition is met
ORDINARY_OK	ORDINARY Condition is met
Vol_Diff_Alm	Alarm signal of voltage difference is not satisfied
Fr_Diff_Alm	Alarm signal of frequency difference is not satisfied
Ang_Diff_Alm	Alarm signal of angle difference is not satisfied
DfDt_Diff_Alm	Alarm signal of frequency change difference is not satisfied
ClsAng_Diff_Alm	Alarm signal of Closing angle is not satisfied
DIFFRSYS_Alm	Alarm signal of Non-co-frequency system
PT_Break_Alm	Alarm signal of PT break
LUBU_Err_Alm	Alarm signal of Synchronous voltage abnormal
LFrBFr_Err_Alm	Alarm signal of Synchronous frequency abnormal

5.2.2 Operation Principle

- **Energy Check**

The voltage selection includes the selection of appropriate line and bus voltages depending on the type of system configuration. The module includes a fuse supervision feature which supervises the voltage transformer fuses for the selected voltage transformer.

The dead charge check conditions have three types: live-bus and dead-line check(LBDL), dead-bus and live-line check(DBLL) and dead-bus and dead-line check(DBDL). The above three modes can be enabled and disabled by the corresponding parameter of [MC_25SYN_LBDL], [MC_25SYN_DBLL] and [MC_25SYN_DBDL]. The device can calculate the measured bus voltage and line voltage at both sides of the circuit breaker and compare them with the settings. When the voltage is higher than the [MC_25SYN_VOL_Lv] parameter, the bus/line is regarded as live. When the voltage is lower than the [MC_25SYN_VOL_Dd] parameter, the bus/line is regarded as dead.

The [MC_25SYN_3PLinePT] parameter indicates whether to select bus voltage or line voltage as the system-side voltage. This parameter should be set according to the actual situation, otherwise an error alarm signal will be generated.

When the device injects three-phase bus voltages and single-phase line voltage, the [MC_25SYN_3PLinePT] parameter should be set to 0; when injecting three-phase line voltage and single-phase bus voltage, the [MC_25SYN_3PLinePT] parameter should be set to 1.

When injecting three-phase bus voltages and single-phase line voltage, Uref represents the bus voltage, while Usyn represents the line voltage. Conversely, when injecting three-phase line voltage and single-phase bus voltage, Uref represents the line voltage, and Usyn represents the bus voltage.

25SYN_START is the start signal for the synchronization check function, which can be initiated in two ways. The first method is to select a certain MC_CSWI component and associate a BO terminal under "dwSYNCKOPinNO". This BO terminal should also be configured to "dwSYNCKOPinNO" of the MC_25SYNC component. When the device is in the "remote" state, remote closing operations can be performed through this MC_CSWI component, and the synchronization check function can be initiated when the remote control is successful. When the device is in the "local" state, a BI signal can be associated to the "bSN_LCLSynStart" terminal of this MC_CSWI component. When the associated BI signal changes from 0 to 1, the synchronization function is initiated. The second method is to associate a BI signal to the "pdwSYNCKI" terminal of this MC_25SYNC component. When the associated BI signal changes from 0 to 1, the synchronization function is initiated. Energy Check, Check Sync, and Close Loop are all initiated in the above manner.

Note: if the MANUSYNC is used in MC_CSWI component, the R/L status should be set to be L, it means the MANUSYNC signal is local signal. The MANUSYNC BI debounce time is 1s.

The logic is as follows:

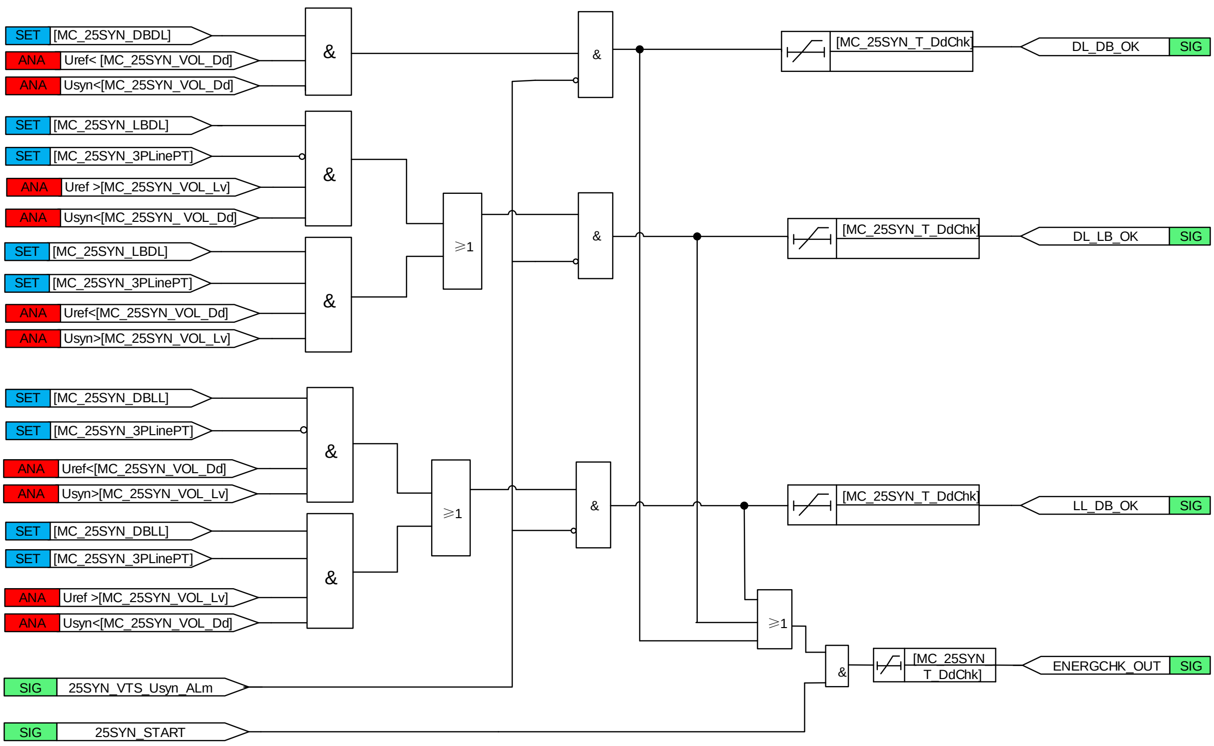


Figure 5.2-2 Logic diagram of Energy Check function

The main purpose of the **Energy Check** is to facilitate the controlled reconnection of the disconnected lines and buses to the energized lines and buses. The energizing function in the module is defined as a situation where a dead section of the network is connected to an energized one.

NOTICE!

If Uref <[MC_25SYN_VOL_Dd], it means Ua< [MC_25SYN_VOL_Dd], Ub<[MC_25SYN_VOL_Dd], Uc< [MC_25SYN_VOL_Dd].

If Uref > [MC_25SYN_VOL_Lv], it means Ua> [MC_25SYN_VOL_Lv], Ub> [MC_25SYN_VOL_Lv], Uc> [MC_25SYN_VOL_Lv].

➢ Check Sync

The **Check Sync** module measures the conditions across the circuit breaker. The module also determines the angle change occurring during the closing delay of the circuit breaker from the value of the measured slip frequency. The output is only given when all the measured conditions are simultaneously within their set limits. The issue of the output signal is timed to give closure at the optimal time including the time for the circuit breaker and the closing circuit.

The **Check Sync** module measures the amplitude, frequency and phase angle of the voltages on both sides of the circuit breaker and compares them to the threshold limit detectors. The voltage, frequency and phase angle difference values between the two sides of the circuit breaker are measured and available for evaluation before the synchronizing. If the available bus voltage is phase-to-phase and the line voltage is phase-to-neutral (or the opposite), a compensation is required. This is done with the voltage ratio, which scales up the line voltage to a level equal to the bus voltage.

The [MC_25SYN_SynPhs] parameter is used for selection of measuring phase of the voltage for power system. The voltages can be single-phase (phase-to-neutral) or two-phase (phase-to-phase) voltage. If the value of [MC_25SYN_SynPhs] is from 0 to 2, the voltage is single-phase voltage (A/B/C) and [MC_25SYN_SynPhs] value is from 3 to 5, the voltage is phase-to-phase voltage (AB, BC, CA).

The frequency difference, voltage difference and Frequency changing rate difference(dFr/dt) of voltages from both sides of the circuit breaker are calculated in the device, they are used as input conditions of the synchronism check. When the synchronism check function is enabled and the voltages of both ends meet the requirements of the voltage difference, Frequency changing rate difference(dFr/dt), and frequency difference, and the measured bus voltage and line voltage for synchro-check should not exceed the overvoltage threshold [MC_25SYN_OV] or lag the undervoltage threshold [MC_25SYN_UV],, and the measured bus frequency and line frequency for synchro-check should not exceed the overfrequency threshold [MC_25SYN_OF] or lag the underfrequency threshold [MC_25SYN_UF], it is regarded that the synchronism check conditions are met.

Considering the closing time of the circuit breaker, the calculation of phase angle difference should be according to the following formulas:

$$dA = \left|\Delta\varphi - \varphi_{dq}\right|$$

$$\varphi_{dq} = 2\pi\Delta f \times T_{dq} + \pi\frac{d\Delta f}{dt} \times T_{dq}^2 - \Delta\varphi_{\mathrm{in}}$$

Where:

$\Delta\varphi$ is the phase angle difference between the line voltage and bus voltage;

φ_{dq} is the variation of phase angle within the operating time of the circuit breaker;

T_{dq} is the circuit breaker operating time, which is the value of parameter [MC_25SYN_T_Close], It is the time between activating the close command for the circuit breaker and CB reaching the closed position;

$\Delta\varphi_{\mathrm{in}}$ is the angle compensation for the variation of phase angle, which is the value of parameter [MC_25SYN_Ang_Inh];

Δf is the frequency difference between the line voltage and bus voltage at the time of activating the close command for the circuit breaker;

The measured frequencies between the settings for the maximum and minimum frequency initiate the evaluation of the angle change to allow operation to be sent at the right moment, including the set value of closing time of the circuit breaker time. There is an internal phase angle

[MC_25SYN_Ang_Close] released to block any incorrect closing pulses. The function also resets if the **Check Sync** conditions are not fulfilled within the set value of the [MC_25SYN_T_Reset] period. This then prevents the functions from being maintained in operation by mistake for a long time waiting for the conditions to be fulfilled.

The logic diagram of **Check Sync** is shown as below:

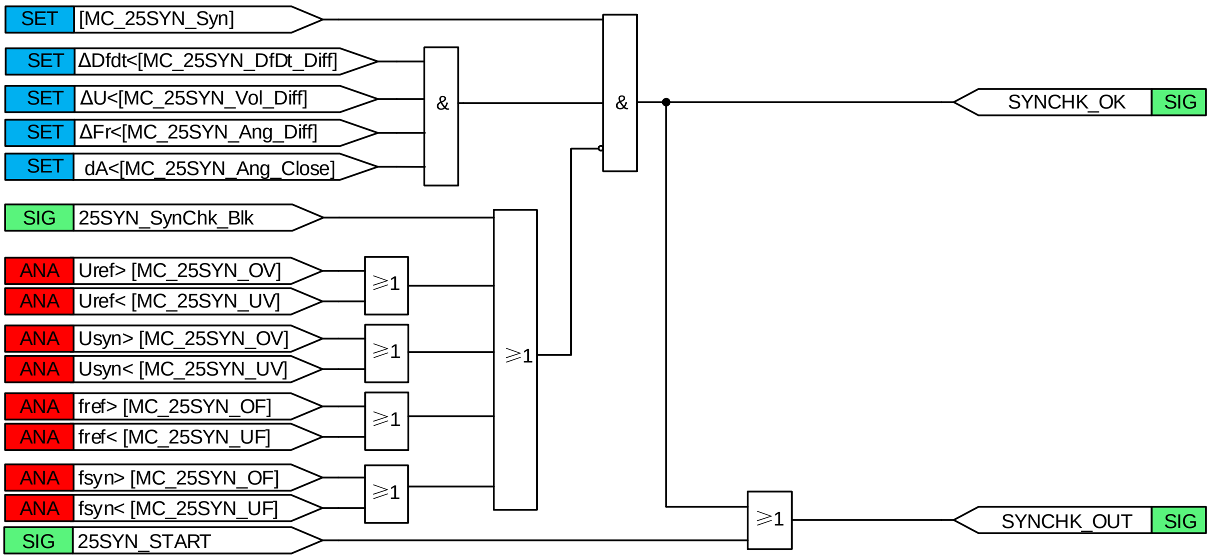


Figure 5.2-3 Logic diagram of the Check Sync function

- ## Close Loop

- The **Close Loop** module is used for the controlled closing of a circuit breaker in an interconnected network. When used, the function gives an enabling signal at satisfying voltage, frequency and phase angle conditions across the breaker to be closed. The function can be used as a condition to be fulfilled before the breaker is closed.

- The **Close Loop** module measures the amplitude, frequency and phase angle of the voltages on both sides of a circuit breaker and compares them to the threshold value of the limit detectors. The differences in voltage, frequency and phase angle values between the two sides of the circuit breaker are measured and available for evaluation before the synchronizing is done. If the available bus voltage is phase-to-phase and the line voltage is phase-to-neutral (or the opposite), a compensation is required. This is done with the voltage ratio, which scales up the line voltage to a level equal to the bus voltage. A typical example is to compensate for the voltage difference caused by connecting the bus voltage as phase-to-phase and the line voltage as phase-to-neutral, in which case the value of the voltage ratio is 1.732.

- The **Close Loop** module starts the synchronizing check if the voltage at both sides of the breaker is above the set value of [MC_25SYN_UV] and not exceed the overvoltage threshold [MC_25SYN_OV] and the frequency at both sides of the breaker is above the set value of [MC_25SYN_UF] and not exceed the overfrequency threshold [MC_25SYN_OF]. When the values of the voltages and frequencies on both sides are fulfilled, the measured values are compared to the set value for phase angle and voltage difference, which are set using [MC_25SYN_Ang_Diff] and [MC_25SYN_Vol_Diff] settings. If a compensation factor is set due to the use of different voltages on the bus and line, the factor is deducted from the line voltage before the comparison is made for the phase angle values.

- The frequency on both sides of the circuit breaker is also measured. It is also required that the difference in frequencies on both sides of the breaker must be below [MC_25SYN_SamFr].

- The CLSLOOP_OK output are activated when the actual measured conditions match the set conditions. If the conditions do not persist for the specified time, the procedure is restarted until the conditions are fulfilled again. The circuit breaker closing is thus not permitted until the **Close Loop** situation has remained constant throughout the set delay [MC_25SYN_T_LoopChk].

The logic diagram of **Close Loop** is shown as below:

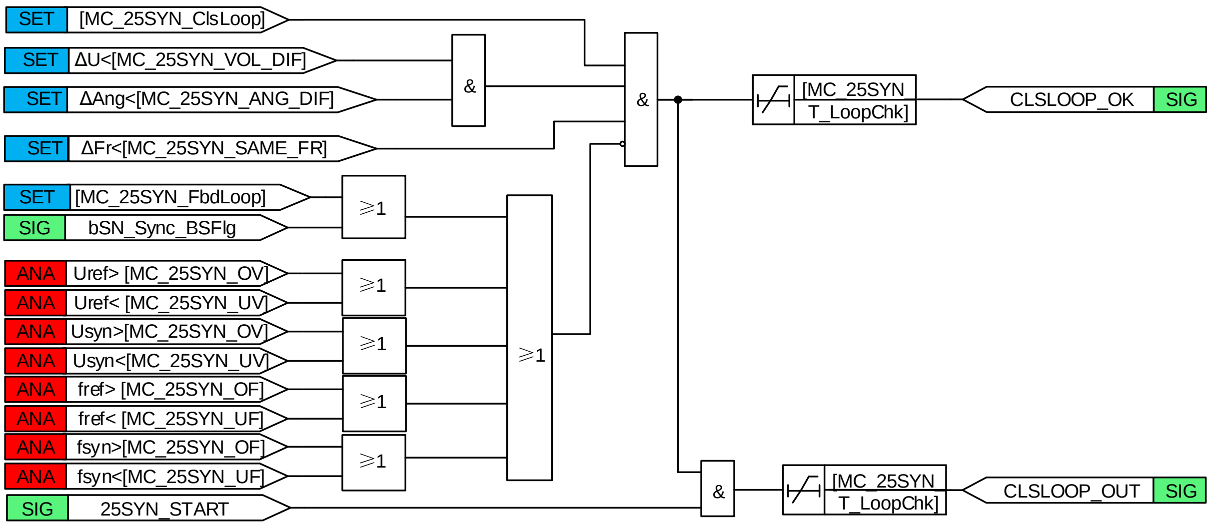


Figure 5.2-4 Logic diagram of the Close Loop function

5.2.3 Check Result

If the result of any check mode is right, synchro check result is right.

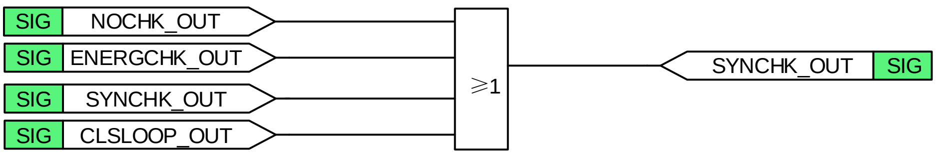


Figure 5.2-5 Logic diagram of the Synchrocheck_OUT

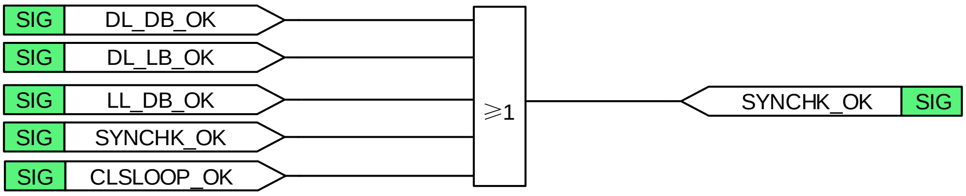


Figure 5.2-6 Logic diagram of the Synchrocheck_OK

NOTICE!

During the **Energy Check** or **Close Loop**, there is a special case that must be considered. If the synchronization period is stated (Time period is [MC_25SYN_T_Reset]), and the result is not satisfied in the time from **Treset** to **T1**. The condition is OK at the time of **T1**, but the remaining time **T1** is less than the exit delay time([MC_25SYN_T_DdChk]/[MC_25SYN_T_LoopChk]). In this case, when the time of **T1** is over, the device will stop the exit logic and the Synchrocheck is failure.

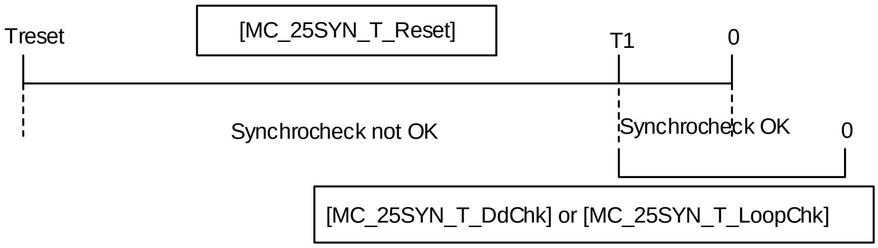


Figure 5.2-7 Logic diagram of the special case

5.2.4 Check Block

PT disconnection monitoring(MC_VTFF) is to lock the synchronization function when the connection between the PT secondary circuit and the device fails, to prevent possible malfunction.

5.2.4.1 Function Block

The function block is as below:

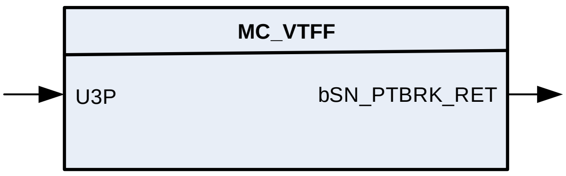


Figure 5.2-8 Function block

5.2.4.2 Signal

The signals of this function is as below:

Table 5.2-3 Input Signals

Input Signal	Description
U3P	Voltage of system side and line side

Table 5.2-4 Output Signal

Output Signal	Description
bSN_PTBRK_RET	The PT break signal.

The "bSN_PTBRK_RET" signal should be connected to the input signal "bSN_Sync_BSFlg" of the "MC_25SYN" component. When the "bSN_PTBRK_RET" signal is 1, the synchronization check function is locked.

5.2.4.3 Logic

There are two main logics in this function:

1) System zero sequence voltage(U0) or negative sequence voltage (U2) is greater than 10%Un;

2) No voltage on the system side but current: Any system phase voltage(Ua、Ub、Uc) is less than 30%Un, system positive sequence voltage(U1) is less than 70%Un, and any system current(Ia, Ib, Ic) is greater than 0.5%In;

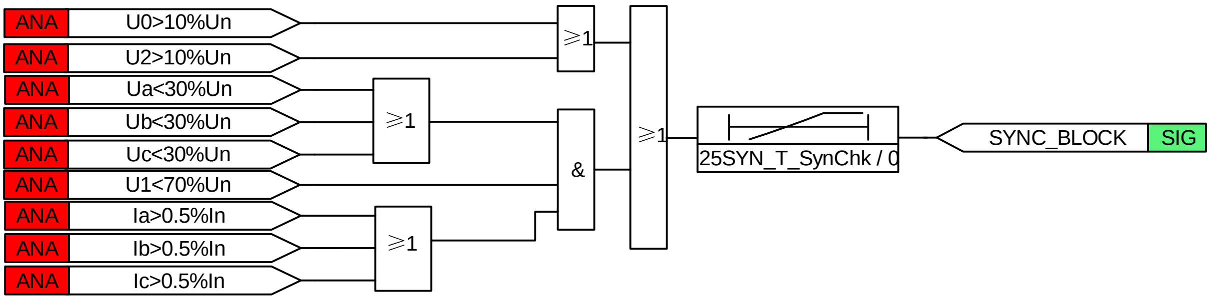


Figure 5.2-9 Logic diagram of the 25SYN Check Block function

NOTICE!

During the **Synchrocheck**, if **SYNC_BLOCK** is established, the 25SYN function is blocked and the module considers the analog that device acquired is invalid. So 25SYN will no longer judge other synchronization logic and all logic results will be cleaned.

5.2.5 Application Scope

➢ **Energy Check**

Energizing check the subsystem of synchro check is to make easier the regulated or monitored disconnected transmission lines or buses to connect again with energized transmission lines or buses as soon as possible. The main and important application of the energizing check module is to reconnect dead network of power system (T/L or buses) with energized or working network of power system.

➢ Check Sync

Synchronizing the subsystem of synchro check, the main purpose of using the synchronizing function is to check the operating values difference (Amplitude, frequency and angle of the operated voltages) between two operated asynchronous electrical power systems. If the synchronization condition is satisfied, then circuit breaker close command will issue to reconnect the two judged electrical power system. The big advantage this process is to prevent power system from any kind of trouble or damages.

The application of Synchronization module is:

- To reconnect different power generating systems
- To reconnect different operating distribution network or transmission lines
- In electrical power industry where precis and accurate automation is required

The synchronizing module provide a very accurate monitored date for synchronization operation of circuit breaker.

➢ Close Loop

The main and important purpose of implementation of Synchrocheck module is in power system to check the value of two unsynchronized systems for parallel operation. If the Synchrocheck condition is satisfied, then IED system will issue the reconnect command signal for CB close or use auto reclosing function.

5.2.6 Settings

Table 5.2-5 MC_25SYN settings

No.	Name	Range	Unit	Step	Default	Description
1	MC_25SYN_NoChk	0-1	-	1	0	Enabling/disabling 25SYN without any check 0: disable 1: enable
2	MC_25SYN_DBDL	0-1	-	1	0	Enabling/disabling dead line and dead bus (DBDL) check 0: disable 1: enable
3	MC_25SYN_DBLL	0-1	-	1	0	Enabling/disabling live line and dead bus (DBLL) check 0: disable 1: enable
4	MC_25SYN_LBDL	0-1	-	1	0	Enabling/disabling dead line and live bus (LBDL) check 0: disable 1: enable
5	MC_25SYN_Syn	0-1	-	1	0	Enabling/disabling synchronism check 0: disable

No.	Name	Range	Unit	Step	Default	Description
						1: enable
6	MC_25SYN_ClsLoop	0-1	-	1	0	Enabling/disabling closing loop check 0: disable 1: enable
7	MC_25SYN_FbdLoop	0-1	-	1	0	When synchronism check enable, it will disable closing loop check
8	MC_25SYN_T_DdChk	0 .000-10.000	s	0.001	0.200	Dead check signal and exit delay parameters
9	MC_25SYN_T_LoopChk	0 .000-10.000	s	0.001	0.200	Loop check signal and exit delay parameters
10	MC_25SYN_SynPhs	0 - 5	-	1	0	Set Sync Vol Chosen 0-2:UA/UB/UC 3-5:UAB/UBC/UCA
11	MC_25SYN_3PLinePT	0-1	-	1	0	Selecting either bus voltage or line voltage as the system-side voltage 0: bus voltage 1: line voltage
12	MC_25SYN_OV	57.74-200.00	V	0.01	57.74	Threshold of over voltage for synchronism blocking
13	MC_25SYN_UV	0.00-57.74	V	0.01	42.41	Threshold of under voltage for synchronism blocking
14	MC_25SYN_OF	50-70	Hz	0.01	60.00	Threshold of over frequency for synchronism blocking
15	MC_25SYN_UF	30-50	Hz	0.01	40.00	Threshold of under frequency for synchronism blocking
16	MC_25SYN_SamFr	0-0.5	Hz	0.01	0.05	Frequency difference limit of same frequency system check
17	MC_25SYN_Vol_Diff	0-100.00	V	0.01	10.00	Voltage difference limit of synchronism check
18	MC_25SYN_Ang_Diff	0-180	deg	1	10	Phase difference limit of synchronism check
19	MC_25SYN_Fr_Diff	0.00-2.00	Hz	0.01	0.5	Frequency difference limit of synchronism check
20	MC_25SYN_DfDt_Diff	0.00-2.00	Hz/s	0.01	1	Frequency change rate of synchronism check
21	MC_25SYN_Vol_Dd	0-120.00	V	0.01	17.32	Voltage threshold of dead check
22	MC_25SYN_Vol_Lv	0-120.00	V	0.01	42.41	Voltage threshold of live

No.	Name	Range	Unit	Step	Default	Description
						check
23	MC_25SYN_T_Close	0.000-5.000	s	0.001	0.005	Inherent Time-difference Value
24	MC_25SYN_Ang_Inh	0.00-180	deg	1	10	Inherent Angle-difference Value
25	MC_25SYN_Ang_Close	0.00-180	deg	1	10	Set Sync Closing-angle Value
26	MC_25SYN_T_Reset	10.000-60.000	s	0.001	30.000	Max Time of Sync process

➢ Conversion Explanation

1) Judgment method of the voltage difference

During the operations of synchronization check and loop closure, it is required that the voltage difference be less than the set value.

Chosen Sync Voltage	Judgment method
UA/UB/UC	|Uref-Usyn| <[Dif_Vol]
UAB/UBC/UCA	|Uref /1.732-Usyn/1.732|<[Dif_Vol]

This means that the set value of the voltage difference is set based on the phase voltage. When the phase selection for synchronization is line voltage, it needs to be converted to the phase voltage value before comparing it with the set value of the voltage difference.

2) Judgment method of the normal range

During the operation of synchronization check and loop closure, it is required that the voltage be within the normal range.

Chosen Sync Voltage	system-side	extraction-side
UA/UB/UC	[MC_25SYN_UV] < Ua < [MC_25SYN_OV] && [MC_25SYN_UV] < Ub < [MC_25SYN_OV] && [MC_25SYN_UV] < Uc < [MC_25SYN_OV]	[MC_25SYN_UV] < Ux < [MC_25SYN_OV]
UAB/UBC/UCA	[MC_25SYN_UV] < Ua < [MC_25SYN_OV] && [MC_25SYN_UV] < Ub < [MC_25SYN_OV] && [MC_25SYN_UV] < Uc < [MC_25SYN_OV]	[MC_25SYN_UV] < Ux/1.732< [MC_25SYN_OV]

This means that the upper and lower limit values of the voltage are set based on the phase voltage. When the phase selection for synchronization is line voltage, and the extracted side voltage is also line voltage, it needs to be converted to the phase voltage value before comparing it with the upper and lower limit values of the voltage.

3) Judgment method of the dead voltage

During the operation of checking for no voltage, it is required that the voltage be less than the set value.

Chosen Sync Voltage	system-side	extraction-side
UA/UB/UC	Ua < [MC_25SYN_Vol_Dd] &&Ub < [MC_25SYN_Vol_Dd] &&Uc < [MC_25SYN_Vol_Dd]	Ux < [MC_25SYN_Vol_Dd]
UAB/UBC/UCA	Ua < [MC_25SYN_Vol_Dd] &&Ub < [MC_25SYN_Vol_Dd] &&Uc < [MC_25SYN_Vol_Dd]	Ux/1.732 < [MC_25SYN_Vol_Dd]

This means that the set value for the no-voltage condition is determined based on the phase voltage. When the phase selection for synchronization is set to line voltage, the voltage on the extraction side is also line voltage. In this case, it needs to be converted to the phase voltage value before comparing it with the set value for the no-voltage condition.

4) Judgment method of the live voltage

When determining whether there is voltage, the following method should be followed.

Chosen Sync Voltage	system-side	extraction-side
UA/UB/UC	Ua > [MC_25SYN_Vol_Lv] &&Ub > [MC_25SYN_Vol_Lv] &&Uc > [[MC_25SYN_Vol_Lv]	Ux > [MC_25SYN_Vol_Lv]
UAB/UBC/UCA	Ua > [MC_25SYN_Vol_Lv] &&Ub > [[MC_25SYN_Vol_Lv] &&Uc > [[MC_25SYN_Vol_Lv]	Ux/1.732 > [MC_25SYN_Vol_Lv]

This means that the set value for the no-voltage condition is determined based on the phase voltage. If the phase selection for synchronization is set to line voltage, the voltage on the extraction side will also be line voltage. In this case, it needs to be converted to the phase voltage value before comparing it with the set value for the no-voltage condition.

5.3 Measurement

The general measurement quantities include both directly sampling and calculated quantities. These quantities are generally used for protection analyzing and metering calculation. All these quantities can be displayed in the local HMI or transmitted to the PRS IED Studio, SCADA or dispatching center through network communication.

Through the PRS IED Studio configuration tool, the measurement channels in the transformer module can be flexibly connected to any measurement quantity according to the designing requirements.

5.3.1 Protection Sampling

The protection sampling rate is 40/48 points per cycle. Different protection logics use different measurement quantities, including the RMS value, the phase angle, the frequency, the harmonic content, the sequence components and so on. All these protections sampled values are displayed in HMI with 0.5s updating rate.

5.3.2 Metering

The metering rate is at least 128 points per cycle. Different functions, such as controlling, monitoring and metering, use different measurement quantities, including the RMS value, the phase angle, the frequency, the harmonic content, the sequence components and so on. All these metering values are displayed in HMI with 0.5s updating rate.

Parameter setting of AC measure quantity contains the following items:

Here is the calculation theory of measurement voltage U and current I, N is the sampling rate of measurement:

$$U = \sqrt{\frac{1}{N}\sum_{n=1}^{N} U^2(n)}$$

$$I = \sqrt{\frac{1}{N}\sum_{n=1}^{N} I^2(n)}$$

The active power and reactive power can be calculated by voltage U and current I, the current phase number can be set to two or three according to the project requirements, the calculated formula is different as following:

(1) P , Q Active/Reactive power calculated by three-meter method

$$P = \frac{1}{N}[U_a(n)I_a(n) + U_b(n)I_b(n) + U_c(n)I_c(n)]$$

$$Q = \frac{1}{N}[U_a(n)I_a(n - \frac{3}{4}N) + U_b(n)I_b(n - \frac{3}{4}N) + U_c(n)I_c(n - \frac{3}{4}N)]$$

(2) P , Q Active/Reactive power calculated by two-meter method

$$P = \frac{1}{N}[U_{ab}(n)I_a(n) + U_{cb}(n)I_c(n)]$$

$$Q = \frac{1}{N}[U_{ab}(n)I_a(n - \frac{3}{4}N) + U_{cb}(n)I_c(n - \frac{3}{4}N)]$$

The power factor $\cos\Phi$ can be calculated by P and Q as following formula:

$$\cos\Phi = \frac{P}{\sqrt{P^2 + Q^2}}$$

5.3.3 Settings

Table 5.3-1 AC Measure Quantity in MC_PMMXU settings

No.	Name	Range	Unit	Step	Default	Description
1.	MC_PWR_CAL_MODE	0-1	-	1	0	Power calculation method: 0: three-watt meter; 1: Two-watt meter
2.	MC_P_READ_ZONE	0.00-1.00	%	0.01	0.5	Mutation dead zone setting value of active power P
3.	MC_ZERO_P_READ_ZONE	0.00-1.00	%	0.01	0.5	Zero dead zone setting value of active power P
4.	MC_Q_READ_ZONE	0.00-1.00	%	0.01	0.5	Mutation dead zone setting value of reactive power Q.
5.	MC_ZERO_Q_READ_ZONE	0.00-1.00	%	0.01	0.5	Zero dead zone setting value of reactive power Q
6.	MC_S_READ_ZONE	0.00-1.00	%	0.01	0.5	Mutation dead zone setting value of apparent power S
7.	MC_ZERO_S_READ_ZONE	0.00-1.00	%	0.01	0.5	Zero dead zone setting value of apparent power S
8.	MC_PF_READ_ZONE	0.00-1.00	%	0.001	0.005	Mutation dead zone setting value of power factor PF
9.	MC_ZERO_PF_READ_ZONE	0.00-1.00	%	0.001	0.005	Zero dead zone setting value of power factor PF

Table 5.3-2 Parameter Setting of AC Measure Quantity in MC_CMMXU

No.	Name	Range	Unit	Step	Default	Description
1.	MC_CUR_READ_ZONE	0.00-1.00	%	0.01	0.5	Mutation dead zone setting value of current
2.	MC_ZERO_CUR_READ_ZONE	0.00-1.00	%	0.01	0.5	Zero dead zone setting value of current

Table 5.3-3 Parameter Setting of AC Measure Quantity in MC_VMMXU

No.	Name	Range	Unit	Step	Default	Description
1.	MC_VOL_READ_ZONE	0.00-1.00	%	0.01	0.5	Mutation dead zone setting value of voltage
2.	MC_ZERO_VOL_READ_ZONE	0.00-1.00	%	0.01	0.5	Zero dead zone setting value of voltage
3.	MC_ZERO_ACQ_MOD	0-1	-	1	0	Neutral sample type:

No.	Name	Range	Unit	Step	Default	Description
						0: calculate, 1: sample
4.	MC_ZERO_CONVER_MOD	0-2	-	1	0	Neutral calculation type: 0: voltage is original value, 1: voltage divided by 1.732, 2: voltage multiplied by 1.732

5.4 Binary Input

5.4.1 Function Description

PRS-7367 relay can collect BI signals, and each BI shall generate reflection records after undergoing optoelectronic isolation and software impulse filtering.

Parameter setting of status signal quantity contains the following items:

After the filter circuit and debouncing algorithm processing, external interference can be filtered effectively. As shown in the following figure, a well-designed debouncing technique is adopted in this device. Binary input state change within "Debouncing time" (t0-t1 can be set 0-30s) will be ignored, in order to ensure the accuracy of the signal status. Once there is a confirmation of change status of signal (start from t1), a SOE record will be noted in the device.

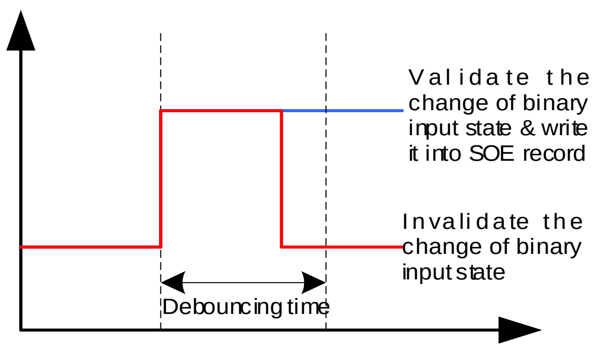


Figure 5.4-1 Debouncing technique for binary input

If any input changes more than a defined number of times (N) in a given period (P), then it shall be automatically suppressed and indication of this presented to the operator, corresponding LED alarm lights will be lit. when these fault inputs change less than N in new given period (P), then it shall be recuperative, corresponding LED alarm lights will be going out. Selection of the variable N and P can be carried out during system configuration.

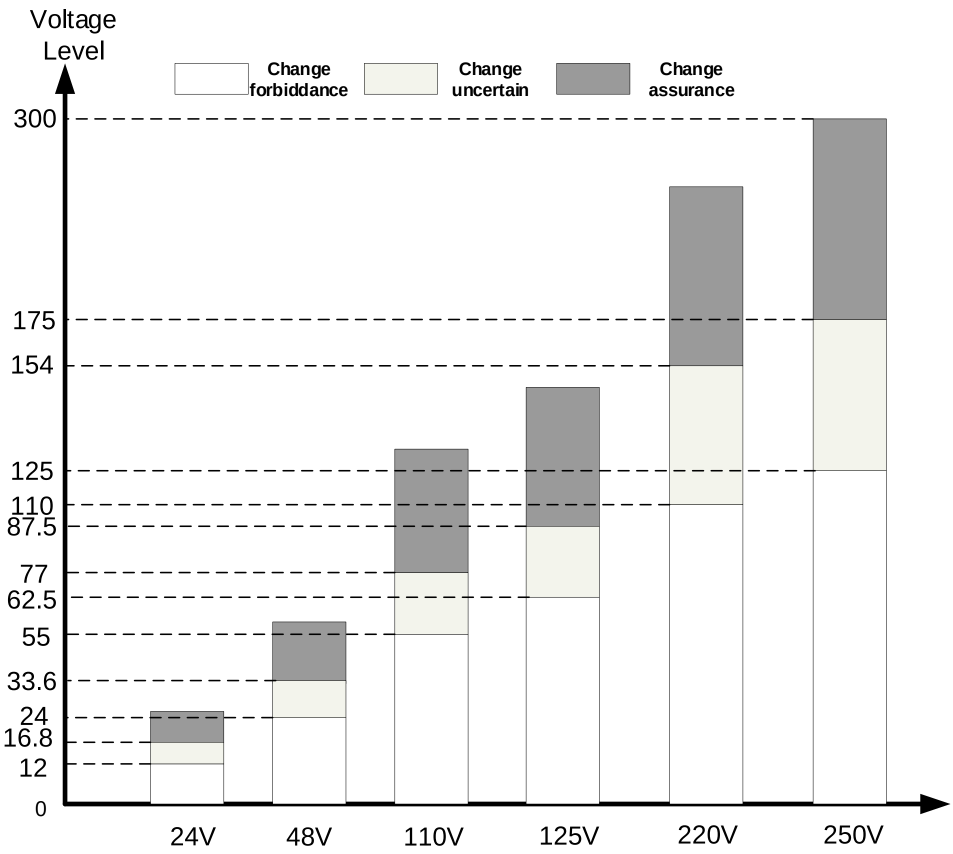
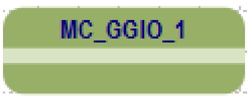


Figure 5.4-2 Voltage dependence for binary inputs

A double point status (DPS), which usually indicates primary switchgear status, can be derived from 2 ordinary binary inputs. The user-defined DPS is configurable through the auxiliary configuration software PRS-Explorer. The signification of a DPS is shown in the following table. For primary switchgear status, only the 2 status "01" and "10" indicates respectively the positions "Open" and "Close" are valid.

DPS	Bit0=0	Bit0=1
Bit1 = 0	DPS_INT	DPS_ON
Bit1 = 1	DPS_OFF	DPS_BAD

5.4.2 Function Block



	Data Iitem Name	Description	Attribute Name
1	dwOpenVal	dwOpenVal	stVal
2	dwCloseVal	dwCloseVal	stVal
3	dwDPosPinNO	dwDPosPinNO	stVal

5.4.3 I/O Signal

Table 5.4-1 Description of Binary Input

No.	Input Signal	Description
1	OpenVal	Double point of normally open

No.	Input Signal	Description
2	CloseVal	Double point of normally close
3	DPosPinNO	Double point

5.5 Binary Output

5.5.1 Function Description

The control output function performs execution to primary equipment, such as CB/DS/ES switching and tap position changer for signaling purpose.

PRS-7367 relay has flexible remote control and interlock which are applicable to various service.

PRS-7367 relay is configured with 4 remote outputs by default. If more are needed, it can be configured according to the hardware situation.

Remote control command selection time can be set; and remote control selection and remote control operation can be indicated by corresponding LED lights.

The interlock logic function of PRS-7367 relay is programmable. Through the visual logic configuration tool, the interlock logic configuration files can be modify based on the actual requirements.

To ensure more security of this function, each binary output consists of power relay, fault detector relay and output relay in series. An error of one relay will not cause any undesired output, to enhance the dependability. Furthermore, the circuit to block control is also available to prevent output by mistake during breakdown of hardware.

If the interlock logic is not fulfilled, the remote preset will fail. In the operation record, the failure reason of remote control can be viewed.

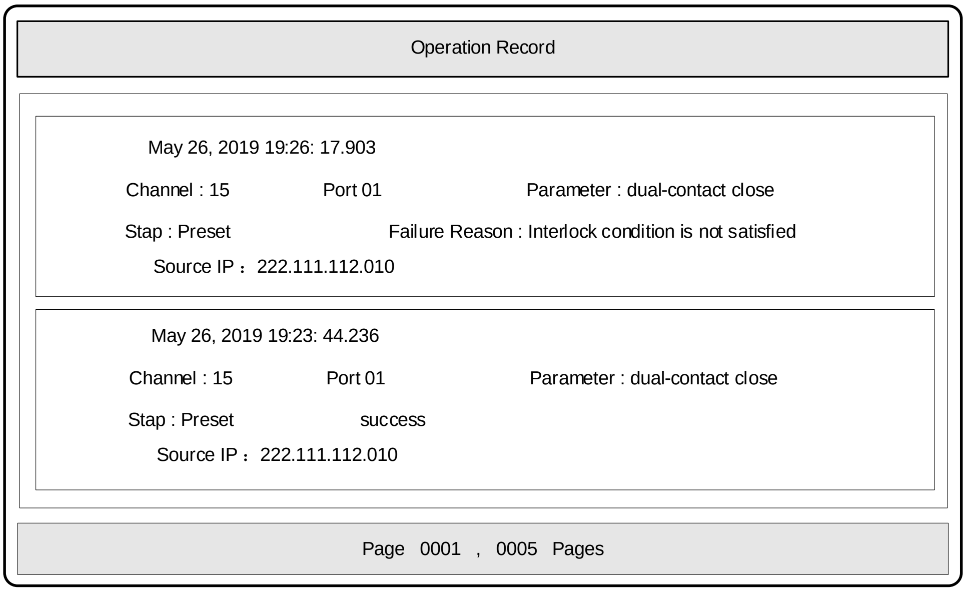
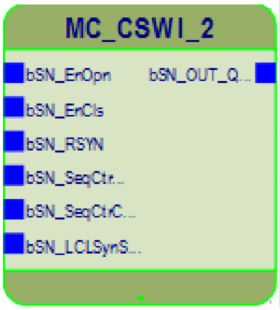


Figure 5.5-1 Operation Record

Parameter setting of remote control and blocking contains the following items:

5.5.2 Function Block



	Data Iitem Name	Description	Attribute Name
1	SetSN_PW_Opn	SetSN_PW_Opn	stVal
2	SetSN_PW_Cls	SetSN_PW_Cls	stVal
3	dwSetSN_SelTm	dwSetSN_SelTm	stVal
4	dwSetSN_ExecTm	dwSetSN_ExecTm	stVal
5	dwSetSN_DBlHoldTm	dwSetSN_DBlHoldTm	stVal
6	dwNorOpnVal	dwNorOpnVal	stVal
7	dwNorClsVal	dwNorClsVal	stVal
8	dwDPosPinNO	dwDPosPinNO	stVal
9	dwYFKOPinNO	dwYFKOPinNO	stVal
10	dwYHKOPinNO	dwYHKOPinNO	stVal
11	dwSYNCKOPinNO	dwSYNCKOPinNO	stVal

5.5.3 I/O Signal

Table 5.5-1 Description of Binary Output

No.	Input Signal	Description
1	bSN_EnOpn	Interlocking signal of remote open
2	bSN_EnCls	Interlocking signal of remote close
3	bSN_LCLSynStart	Signal of sync start, When it changes from 0 to 1, the synchronization check function MC_25SYNC will be initiated after 1 second.
4	bSN_OUT_QDEnaSig	Signal of Starting the outlet switch

5.5.4 Settings

Table 5.5-2 Binary Output settings

Name	Range	Unit	Stage	Default	Description
MC_CSWI01_OPN_PULSE	0.1-60	s	-	0.2	remote-control trip pulse width
MC_CSWI01_CLS_PULSE	0.1-60	s	-	0.2	remote-control close pulse width
MC_CSWI01_SEL_T_MAX	0-60	s	-	10	Time period of selection operation
MC_CSWI01_EXE_T_MAX	0-60	s	-	10	Time period of operate operation
MC_CSWI01_DBI_HOLD_T	0-5	s	-	0	Time period of debouncing

5.6 Interlocking Logic Output

5.6.1 Function Description

PRS-7367 relay has flexible remote control and interlock which are applicable to various service. In general, interlocking logic provides such kind of suitable scheme for operation of power system apparatus. Interlocking scheme of logic have function to block the switching control operation of primary equipment. The process of each IED has completed this logic function. For communication, IEC 61850-8-1 CODE is used as reference. The logic of interlocking scheme standard depends on the configuration and primary apparatus status. For modern standard requirements, interlocking logic scheme must have this flexibility to meet any specific condition.

Busbar wide interlocking for busbar earthing switches and closing of busbar isolators shall be arranged via the LAN between the BCUs. For security reasons, the position of the bus coupler and the bus bar earthing switching shall be communicated from the bus coupler bay BCU to all other BCUs via hard bus wires. Also the position of the busbar isolators for closing of the busbar earth switches shall be communicated from all feeders to the bus coupler BCU via hard bus wires.

The interlocking logic scheme of function is easily enabled/disabled by setting parameters. Before a switching command, output is executed, the interlocking logic of the BCU will check whether the preprogrammed interlocking logic equations are met to permit the operation or not. The interlocking conditions depend on the circuit configuration and apparatus position status at switching commanding time. Some important technical terms of Interlocking functions are follow:

- PRS-7367 relay is configured with 4 remote outputs by default. If more are needed, it can be configured according to the hardware situation.
- Remote control command time easily set to any specific condition.
- Remote control selection and remote control operation can be indicated by corresponding LED lights.
- The interlock logic function of PRS-7367 relay is programmable. Through the visual logic configuration tool, the interlock logic configuration files can be modify based on the actual requirements.

However, any condition the logic scheme of interlocking is not fulfilled and the remote function preset will fail (not operated in due time). The failure reason of remote control can be viewed.

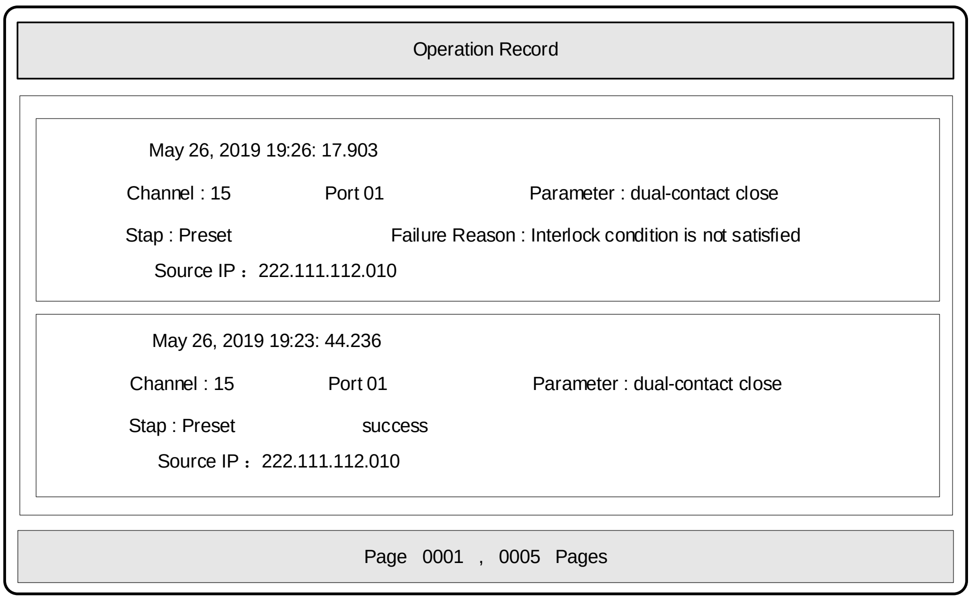
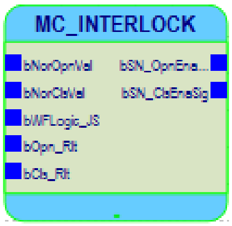


Figure 5.6-1 Block Diagram of Operation Recorded

5.6.2 Functional Block



	Data Iitem Name	Description	Attribute Name
1	dwYFYXPinNO	dwYFYXPinNO	stVal
2	dwYHYXPinNO	dwYHYXPinNO	stVal
3	dwBSKOPinNO	dwBSKOPinNO	stVal

Figure 5.6-2 Functional Block Diagram of Logic Configuration Tool

5.6.3 I/O Signal

No.	Input Signal	Description
1	bNorOpnVal	Signal of normally open
2	bNorClsVal	Signal of normally close
3	bWFLogic_JS	Signal of unlock
4	bOpn_Rlt	Interlocking logic result of remote trip
5	bCls_Rlt	Interlocking logic result of remote close
6	bSN_OpnEnaSig	Output signal of allowing remote trip
7	bSN_ClsEnaSig	Output signal of allowing remote close

5.7 Apparatus Control

The apparatus control is a combination of functions which continuously supervise and control the circuit breakers, switches and earthing switches within a bay. The selection and operation command to control an apparatus is given after the evaluation of other functions' conditions such as interlocking, synchro check, operator place selection and the external or internal blockings.

The commands to an apparatus can be initiated from the local self-customized BI, the station HMI or the dispatching center. The local control self-customized BI can be configured on the PRS IED Studio. The control operation can be started by the activation of the corresponding BI signal. The remote control command can be remotely dispatched through the network communication like IEC61850 or DNP. Before executing a remote control command, it is necessary to turn the Local/Remote control switch to the "Remote" position.

The output relays in the BO module can be configured as output contacts so as to close or trip the apparatus. Each control output can be control with an interlock module (which can be configured through the PRS IED Studio) if the corresponding interlock logic setting (see Section 7.4.3) is set to activation.

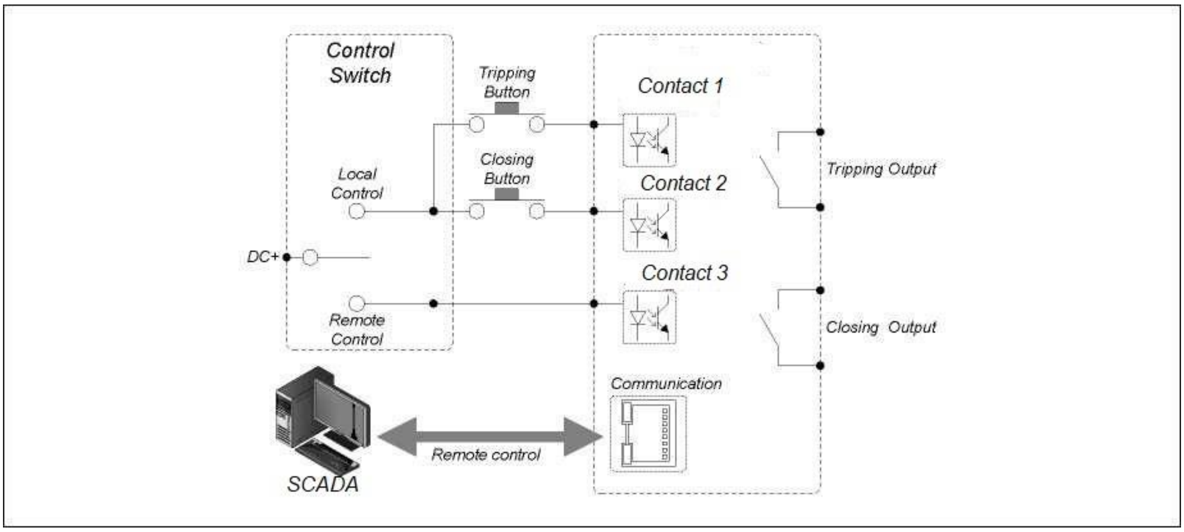


Figure 5.7-1 Demonstration Diagram of the Control Function

5.8 Signaling

All inputs of the protection hardware unit are configurable via PRS IED Studio software. Common binary inputs can be configured for the following purposes:

- Bay primary equipment state acquisition, such as circuit breaker position, insulator position. These signals can be sent to the substation monitoring system or dispatching automation system through the protection device.
- Used for BI condition of the protection logic to achieve the block or release of inner logic.
- Used to monitor the health condition of primary equipment such as SF6 low pressure alarm and transformer high oil temperature. These signals can be used as function input of protection logic, and also can be sent to substation monitoring system or dispatching automation system as separate alarm signals. Achieve remote monitoring.
- Transformer tap position input

All hardware input denouncing time can be set separately. Denouncing time setting can be done through the LCD or PRS IED Studio software.

5.9 Event Records

5.9.1 Overview

The protective device record events in an event log. This allows you to establish the sequence of events that led up to a particular situation. For example, a change in a digital input signal or protection element output signal would cause an event record to be created and stored in the event log. This could be used to analyze how a particular power system condition was caused. These events are stored in the IED's non-volatile memory. Each event is time tagged. The time resolution is 1ms.

The event records can be displayed on an IED's front panel but it is easier to view them through the configuration software. This can extract the events log from the device and store it as a file for analysis on a PC.

The event records are detailed in the EVENTS column. The first event (0) is always the latest event. After selecting the required event, you can scroll through the menus to obtain further details.

5.9.2 Fault Record Events (FaultEvents)

An event record is created for every fault the IED detects. This is also known as a fault record.

The IED contains a separate register containing the latest fault records. This provides a convenient way of viewing the latest fault records and saves searching through the event log. You access these fault records using the Select Fault setting, where fault number 0 is the earliest fault.

The event is logged as soon as the fault recorder stops. The time stamp assigned to the fault corresponds to the start of the fault. The fault operating relative time is the subtraction between the fault stop moment and the fault start moment, and the time is in milliseconds.

The IED can store 512 latest time tagged fault record events.

5.9.3 Alarm Record Events

The IED monitors itself on power up and continually thereafter. If it notices any problems, it will register an alarm event. The alarm records include protection alarm records and device self-check records.

5.9.3.1 Protection Alarm Record (WarmingRecords)

The IED provides self-check alarm information that reflects the communication status between devices, such as carrier channel abnormal, fiber channel abnormal, SV communication abnormal, GOOSE communication abnormal, etc.

The IED provides self-check alarm information that reflects the external circuit such as analog error information (CT disconnection, PT disconnection, etc.) and abnormal information of primary switch state (abnormal trip position, trip signal long time input, etc.)

The IED can store 512 latest time tagged alarm records.

5.9.3.2 Device self-check record (ChkRecords)

- **Hardware self-check record**

The IED provide hardware health condition self-check alarm, such as analog sampling circuit abnormal self-check, memory status self-check alarm.

- **Software self-check record**

The IED provides software operation status self-check alarm records, such as setting error, parameter verification error and the like.

- **Configuration file self-check record**

The IED provides self-check records that reflect the status of the device configuration file, such as configuration file error, configuration file change, etc.

The IED can store 128 latest time tagged alarm records.

5.9.4 Device Record

5.9.4.1 Remote Control Record (YKRecords)

Device control objects include circuit breakers, disconnectors, earthing disconnectors close and open, reset signal, transformer tap adjustment, etc., when the device receives the remote control command, the device will generate control operation record. The remote control contents contain the command source, command time, operation result, failure reason, etc.

The IED can store 128 latest time tagged control records.

5.9.4.2 Device Operation Record (OptRecords)

The operation record includes the time when the event was generated, the operation object, the content of the operation, and the description of the operation result.

The IED can store 128 latest time tagged device operation records.

5.9.4.3 Device Running Record (RunRecords)

The running record is the device power-on, power-off record.

The IED can store 128 latest time tagged device running records.

5.9.5 Sequence of Event (SoeRecords)

The IED provides a sequence of event (SOE) function:

When the state quantity input signal is from a hard contact, the time tag of the state quantity is marked by the device, and the time is defined before debouncing.

When the state quantity input is GOOSE signal, the time tag of the state quantity adopts the external input source signal time tag, and GOOSE signal acquisition has no debouncing time.

The IED can store 2000 latest SOE records.

5.10 Fault and Disturbance Recording

This IED provides the fault and disturbance recorder for recording the sampled values of the fault and disturbance wave when a fault is occurred in the power system, which can be triggered by pickup signals, trip signals and configurable binary signal. The fault recorder feature allows you to record selected current and voltage inputs to the protection elements, together with selected digital signals.

The integral fault recorder has an area of memory specifically set aside for storing disturbance records. The fault memory of the device is automatically updated with every recording. When the fault memory is filled completely, the oldest records are overwritten automatically. Thus, the latest records are always stored safely. The maximum number of time tagged records is 36, contain16 fault disturbance waves, 16 start disturbance waves and 4 manual disturbance waves.

Each fault waveform includes the wave recording data both before and after the fault. Each trigger element operation will extend the wave recording time, until the appointed time delay is over after the trigger element restores, or until the maximum number of wave recording points is reached.

5.10.1 Wave Recording File Format

The wave recording file adopts COMTRADE common format, complying with the requirements of IEC 60255-24. Each COMTRADE record has up to four files associated with it, namely: a title file (xxxxxxxx.HDR), a configuration file (xxxxxxxx.CFG), a data file (xxxxxxxx.DAT), and an information file (xxxxxxxx.INF), where information file is optional file. The wave recording files can be extracted communication with relay.

5.10.2 Fault Wave File

For each fault wave file, the following items are included:

1. Sequence number

Each operation will be recorded with a sequence number in the record and displayed on LCD screen.

2. Date and time of fault occurrence

The date and time is recorded when a system fault is detected. Time & date stamped by relay real time clock. The time resolution is 1ms.

3. Relative operating time

An operating time (not including the operating time of output relays) is recorded in the record. The time resolution is 1ms.

4. Fault information

Including faulty phase, fault location and protection elements

5.10.3 Waveform Recording Duration

A fault waveform contains all analog and digital quantities related to IED such as currents, voltages, differential current, alarm elements, and binary inputs and etc.

The overall duration of a single fault recording comprises the total duration of the recording criterion, the pre-trigger time and the post-trigger time. With the fault recording parameter, these components can be individually set. The pre-trigger waveform recorded duration is configured via the setting [RecT_PreFault]. The waveform recorded duration after the fault disappears is configured via the setting [RecT_PostFault]. The maximum waveform recorded duration is configured via the setting [MaxT_OneRec].

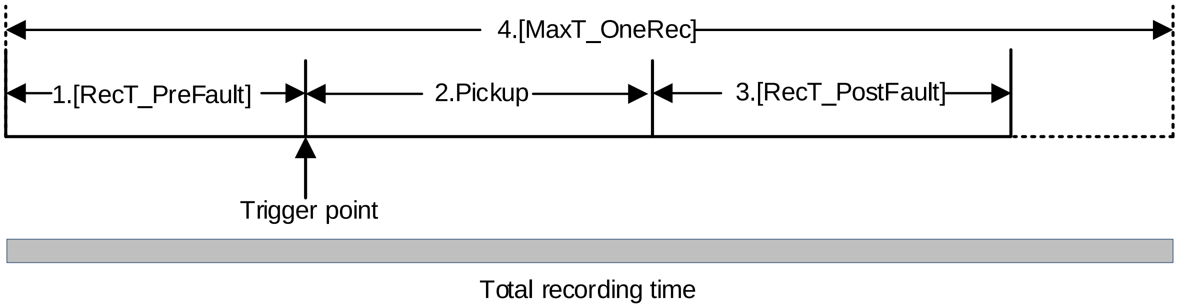


Figure 5.10-1 Recording time diagram

1. Pre-trigger recording time

Use the setting [RecT_PreFault] to set this time.

2. Pickup recording time

The pickup recording time cannot be set. It continues as long as any valid trigger condition, binary or analog, persists.

3. Post-fault recording time

The recording time begins after all activated triggers are reset. Use the setting [RecT_PostFault] to set this time.

4.Maximum recording time

Use the setting [MaxT_OneRec] to set this time. If the summation of wave recording duration is larger than maximum recording time, the one recording time shall be equal to the setting [MaxT_OneRec].

Table 5.10-1 Recording Time Settings

No.	Name	Range	Unit	Step	Default	Description
1	RecT_PreFault	20-1000	ms	1	60	Pre-trigger recording time.
2	RecT_PostFault	20-1000	ms	1	40	Post-fault recording time.
3	MaxT_OneRec	1000-5000	ms	1	5000	Maximum recording time

5.10.4 Fault Wave Recording

You can select any of the IED's analogue inputs as analogue channels to be recorded. You can also map any of the opto-inputs and output contacts to the digital channels. In addition, you may also map a number of DDB signals such as Starts and LEDs to digital channels.

The path to the configuration tool:

[IED]->[Const]->[WAVEANA]/[WAVEKI]/[WAVEKO]-**>** [Ana Channel]/ [KI Channel]/ [KO Channel].

5.10.5 Logic Event Recording(EventRecords)

When there is wave recording, the relay will record all of the process signals in logic diagram by

EventRecords, which configured by manufacture or super (If the permission setting is Show, it means super configuration is available).

The path to the configuration tool: [IED]->[Const]->[LNDOSOECFG].

6 Hardware

6.1 Overview

The modular design structure of this relay enables a qualified commissioning technician to easily check and locate the damaged hardware modular, so as to eliminate the fault in the very first time. The hinged front panel allows easy access to the HMI modules and the back-plugging design makes it easy to upgrade, maintain or replace any module.

There are several types of hardware modules in this relay, which play different roles in the practical application. The specific modules can be configured flexibly according to the practical engineering demands.

The overall hardware designing frame of this relay is shown as below.

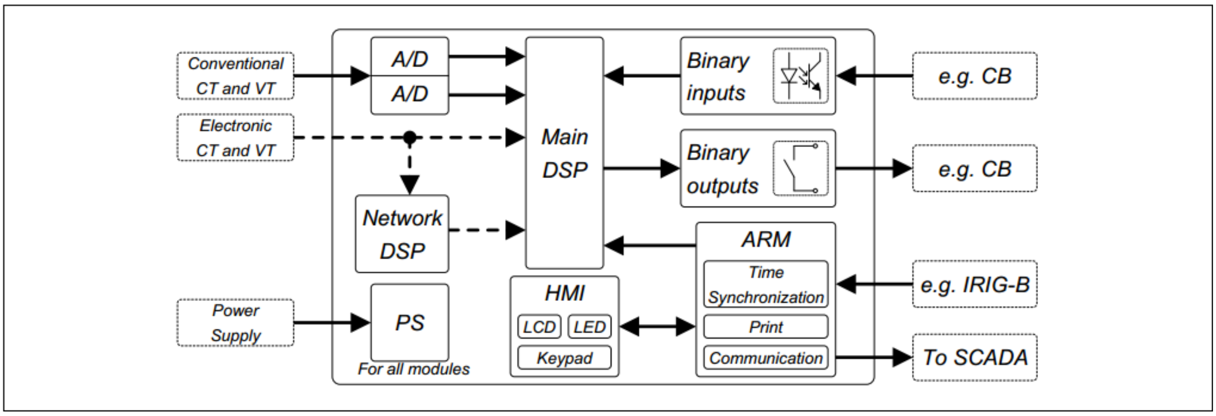


Figure 6.1-1 Hardware structure of this relay

The following figures show the front panel and the rear panel of this device.

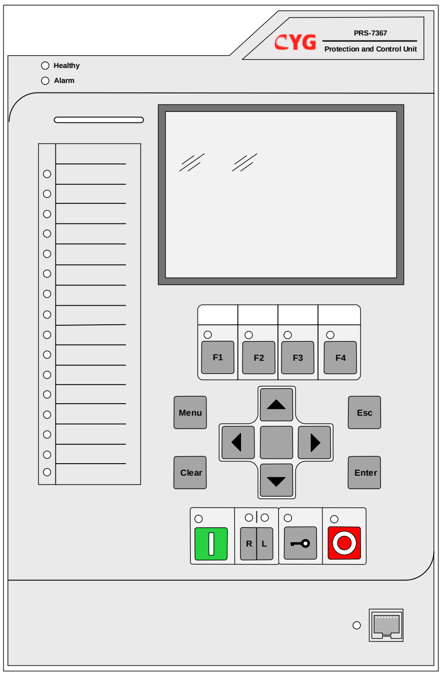


Figure 6.1-2 Front panel of this relay

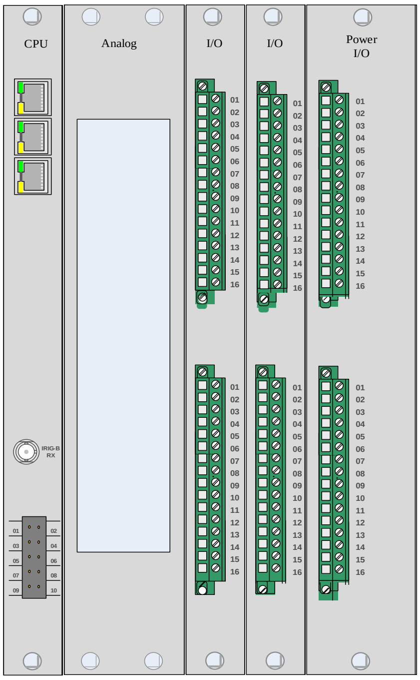


Figure 6.1-3 Rear panel of this relay

NOTICE!

The hardware module configuration in the above figure is only for demonstrating one kind of typical configuration. Most often, the configuration has to be modified in most of the project. The hardware module configuration of a practical engineering should be modified based on the practical designing requirement.

6.2 Hardware Module

The PRS-7367 is comprised of randomly coordinated modules, except that a few particular modules, e.g., PWR module, CPU module and HMI module, cannot be replaced in the whole device. The other modules, including TF (current or voltage transformer) module and IO (input and output) module, can be flexibly configured and then placed in the remained slots. The TF module includes AC current transformer and AC voltage transformer The IO (input and output) module includes binary input, tripping output, signal output and etc.

Table 6.2-1 Module Configuration

No.	ID	Module Description	Remark
1	SR7601	Power supply module (PWR module)	standard
2	SR7267	Protection calculation module (CPU module)	standard
3	SR7160	Current/voltage transformer module (TF module)	standard
4	SR7330	Binary input module (BI module)	standard
5	SR7300	Binary output module (BO module)	standard
6	SR7302	Binary output module (BO module)	standard
7	SR7310	Binary input/output module (IO module)	standard

6.3 Human Machine Interface Module

The human machine interface (HMI) module is installed behind the front panel of this device. It contains an LCD screen to modify the protection settings and system parameters and display information of this device, including the analogue quantities, the running status and event lists.

The menus are showed as tree structure, which facilitates the users to enter any specific menu. After entering the menu, the big LCD show all the relevant information in one screen, making it easier to get all the information.

6.4 Power Supply Module

The power supply module contains a small voltage converter with enough electrical insulation between the converter and the input/output terminals. A wide range input voltage is provided due to the sophisticated circuit design. The output voltage from the voltage converter are continuously monitored to ensure the stability and safety.

The power supply module provides 13 binary outputs, some dry contacts, which conduct the signal functions showing the operating conditions (device error) or tripping and closing commands (protection, auto-reclose or remote control). The specific function is performed by setting the relevant settings and wiring the external copper cable.

Except for the Dev_Err Cls and Dev_Err Open output contacts (fixed as indication output contacts), all the other binary inputs or outputs can be visually and flexibly configured through the PRS IED Studio configuration tool, which determine what information do they transmit between the CPU module and PWR module.

The frame of all the power supply module terminals are shown below.

Table 6.4-1 Frame of the Power Supply Module Terminals

PWR			
1	PWR+	TRIP05 Common	14
2	PWR-	TRIP05 Open	15
3	Dev_err Common	TRIP06 Common	16
4	Dev_err Cls	TRIP06 Open	17
5	Dev_err Open	SIGN07 Common	18
6	TRIP01 Common	SIGN07 Open	19
7	TRIP01 Open	SIGN07 Cls	20
8	TRIP02 Common	SIGN08 Common	21
9	TRIP02 Open	SIGN08 Open	22
10	TRIP03 Common	SIGN08 Cls	23
11	TRIP03 Open	SIGN09 Common	24
12	TRIP04 Common	SIGN09 Open	25
13	TRIP04 Open	SIGN09 Cls	26

The specific terminal definition of the connector is described as below.

Table 6.4-2 Terminal Definition and Description of PWR Module

Name	Description
PWR+	Positive input of power supply for the device.
PWR-	Negative input of power supply for the device.
Dev_Err Common	Device abnormality alarm common terminal.
Dev_Err Cls	Device abnormality alarm normal close terminal.
Dev_Err Open	Device abnormality alarm normal open terminal.
TRIP01-06	The No.1 -6 programmable tripping or closing binary output. BOi (i=1-6) Open is the normal open binary output.
TRIP07-09	The No.2 programmable signal binary output. BOi (i=7-9) Open is the normal open binary output, BOi (i=7-9) Cls is the normal close binary output.

Table 6.4-3 The self-check information about Dev_Err

Name	Description
Init Cfg Err	Initial configuration error
Module Cfg SelfChk Err	Module configuration selfcheck error

Name	Description
LVDS SelfChk Abnormal	Lvds selfcheck abnormal
Setting SelfChk Err	Setting selfcheck error
Softswitch SelfChk Err	Softswitch selfcheck error
Para SelfChk Err	Para selfcheck error
LVDSKI Comm Interrupt	Lvdski communication interrupt
LVDSKI Data Abnormal	Lvdski data abnormal

6.5 Main CPU Module

The main CPU module, containing powerful microchip processors and some necessary electronic accessories, is the core part of this relay. This powerful processor executes all the functions of the relay and conduct the commands, including the protection logics, the control function and the internal and external information interfacing functions.

A high-accuracy crystal oscillator is installed on the module as well, ensuring the relay to operate exactly based on the accurate current time.

The main functions of the main CPU module include as below:

- Sampling information processing

  The values of each sampling point will be stored and then sent to different processing module for different function, including display, calculation, communication.

  The values of each binary IO contacts will also be stored and then sent to different processing module for different function, including display, calculation, communication.

- Protection, measuring and metering quantities calculation

  The CPU module can calculate all the relevant quantities (zero sequence current and voltage, negative sequence current and voltage, harmonic quantities of up to 13^{th}) on the basis of the directly sampling quantities (phase-to-earth voltages and currents, phase-to-phase voltages and currents) and binary inputs. After the calculation, all the quantities are sent to the protection function module or control module to decide whether the relevant dry contacts trip or close.

- Communication management

  The CPU module can effectively execute all communication procedures parallel and reliably interface coded messages through the selected communication interfaces. These interfaces are usually used to communicate with a SCADA or a Station Gateway through a switcher. The CPU module is also responsible for information exchanging with the HMI module. If any monitoring condition changes or any event occurs (SOE, protection tripping event, device abnormality), this module will send out the relevant event information to all relevant receivers, so as to ensure a first time alarm to notice the users.

- Auxiliary calculations

  Besides all the quantities mentioned above, the CPU module can also calculate the metering values, such as active power, reactive power and power factor, etc., to provide overall monitoring information. All these quantities can be sent to a SCADA or a Station Gateway through a switcher.

- Time Synchronization

  The module provides an interface to receive time synchronized signals from external clock synchronization source. This module also has a local crystal oscillator to maintain the internal time accuracy when outside synchronization source breaks down. The synchronization mode includes PPS (pulse per second) mode and IRIG-B mode. Basing on the outside timing message (from SCADA or Station Gateway) or the PPS signal or the IRIG-B signal, this module can adjust its time within the timing accuracy.

The frame of the CPU module terminal is described as below. The detailed configuration is up to the project requirements.

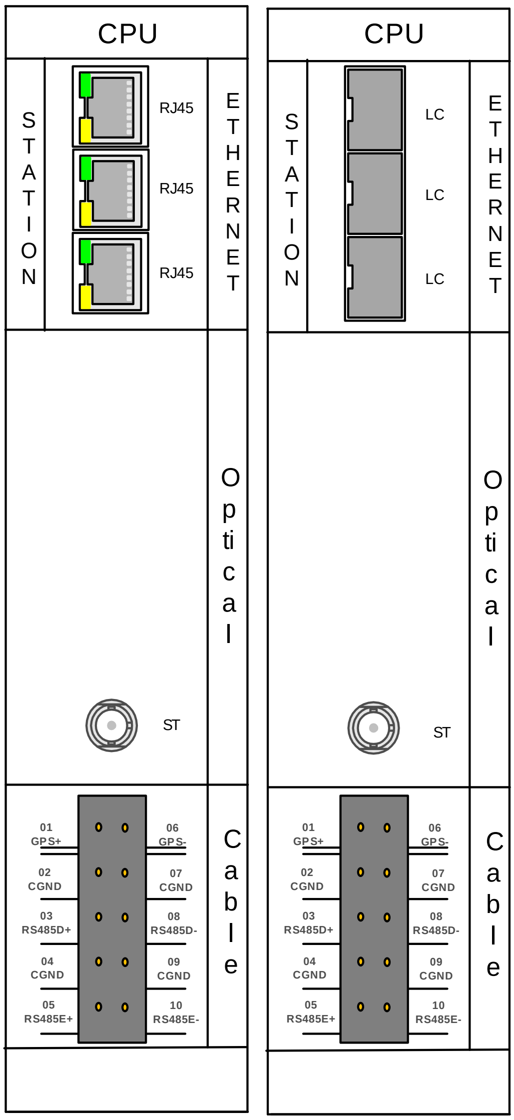


Figure 6.5-1 The frame of the CPU module terminal

6.6 Transformer Module

The transformer module can decrease the high input analog values to relevant low output analog values as to the small transformer ratio, acting as an effective isolation between the relay and the power system. The low output analog values, within the range of the AD module after the conversion, are sent to the AD module for further processing. A low pass filter circuit is used to reduce the noise of each analog channel.

The frame of two typical transformer modules of different specifications are shown below. The first transformer module consists of 7 voltage channels and 8 current channels. The second one consists of 8 voltage channels and 7 current channels. The current terminal will be automatically short circuited when it is plugged out.

Table 6.6-1 Transformer Module of Two Different Specifications

TF1: 7U8I			
No.	Name	Name	No.
1	Ua	Ub	2
3	Uc	Un	4
5	Ua2	Ub2	6
7	Uc2	Un2	8
9	Ux/3UoD	Ux'/3UoD’	10
11	Ia	Ia'	12
13	Ib	Ib'	14
15	Ic	Ic'	16
17	3I0D	3I0D'	18
19	Ia2	Ia2'	20
21	Ib2	Ib2'	22
23	Ic2	Ic2'	24
25	3I0D2	3I0D2'	26

TF2: 8U7I			
No.	Name	Name	No.
1	Ua	Ub	2
3	Uc	Un	4
5	Ua2	Ub2	6
7	Uc2	Un2	8
9	UL1	UL1'	10
11	UL2	UL2'	11
13	Ia	Ia'	12
15	Ib	Ib'	14
17	Ic	Ic'	16
19	IL1	IL1'	20
21	IL2	IL2'	22
23	I6	I6'	24
25	I7	I7'	26

DANGER!

NEVER allow the secondary side of the current transformer (CT) to be opened while the primary apparatus is energized. The opened CT secondary circuit will produce an extremely high voltage and high heat. Although the current terminal will be automatically short circuited when it is plugged out, the safety precaution should be obeyed in order to prevent severe personal injury, person death or considerable equipment damage.

The terminal definition of the connector is described in the below diagram.

Table 6.6-2 Terminal Definition and Description of 7U+8I Module

Name	Description
Ua	The first group of three voltage input channels with inner star connection (Y) for protection and metering.
Ub	
Uc	
Un	
Ua2	The second group of three voltage input channels with inner star connection (Y) for protection and metering. For example, it used for capacitor three phase voltage unbalance protection 59NT; The Ua2 also can be used for capacitor voltage unbalance protection 59NA.
Ub2	
Uc2	
Un2	
Ux/3UoD	The phase voltage inputs of line for protection and metering, for example, it can be used for line synchronic voltage Ux. Or the phase voltage inputs of neutral for protection and metering, for example, it can be used for earth fault protection 3UoD.
Ux’/3UoD’	
Ia	The first group of three phase current inputs. For example, it used for overcurrent protection.
Ia’	
Ib	
Ib’	
Ic	
Ic’	
3IoD	The first zero sequence current inputs .
3IoD’	
Ia2	The Ia2/Ib2/Ic2 are the second group of three phase current inputs. For example, it used for capacitor three phase current unbalance protection 51NT; The Ia2 also can be used for capacitor current unbalance protection 51NA.
Ia2’	
Ib2	
Ib2’	
Ic2	
Ic2’	
3IoD2	The second zero sequence current inputs. For example, it used for SEF or GAP protection.
3IoD2’	

Table 6.6-3 Terminal Definition and Description of 8U+7I Module

Name	Description
Ua	The first group of three voltage input channels with inner star connection (Y) for protection and metering. For example, it can be used to bus1 voltage of BPAS.
Ub	
Uc	
Un	
Ua2	The second group of three voltage input channels with inner star connection (Y) for protection and metering. For example, it can be used to bus2 voltage of BPAS.
Ub2	
Uc2	
Un2	
UL1	The phase voltage inputs of line for protection and metering. For

Name	Description
UL1n	example, it can be used to line1 voltage of BPAS.
UL2	The phase voltage inputs of line for protection and metering. For example, it can be used to line2 voltage of BPAS.
UL2n	
Ia	The three phase current inputs. For example, it can be used to CTS protection of BPAS device.
Ia’	
Ib	
Ib’	
Ic	
Ic’	
IL1	The phase current inputs of line1 of BPAS.
IL1’	
IL2	The phase current inputs of line2 of BPAS.
IL2’	
I6	The phase current inputs of line6. It is spare.
I6’	
I7	The phase current inputs of line7. It is spare.
I7’	

Note: the 8U7I module always used for BPAS device.

6.7 Binary Input Module

The BI module contains 18 binary inputs, the optical isolated input terminals, which can perform different monitoring functions, such as detecting the breaker and switch positions of the corresponding bay. All the BI terminals can be used as general purpose binary inputs or special purpose (protection function or control function) binary inputs. For example, the general purpose binary inputs can be used to indicate the status (0 for normal condition and 1 for abnormal condition) of a certain apparatus. For another example, the special purpose binary inputs can be used to acting as the blocking or start signal for a certain protection function.

All the binary inputs can be visually and flexibly configured through the PRS IED Studio configuration tool, which determine what information do they transmit between the CPU module and BI module.

The frame of the BI module terminal is described as below.

Table 6.7-1 Frame of Input Terminal

Input			
1	BI01+	BI10+	17
2	BI02+	BI11+	18
3	Common-	Common-	19
4	BI03+	BI12+	20
5	BI04+	BI13+	21
6	Common-	Common-	22
7	BI05+	BI14+	23
8	BI05-	BI14-	24
9	BI06+	BI15+	25
10	BI06-	BI15-	26
11	BI07+	BI16+	27
12	BI07-	BI16-	28
13	BI08+	BI17+	29
14	BI08-	BI17-	30
15	BI09+	BI18+	31
16	BI09-	BI18-	32

The specific terminal definition of the connector is described as below.

Table 6.7-2 Terminal Definition and Description of BI Module

Name	Description
BI01+	The No.1 and No.2 programmable binary input.
BI02+	
BI01- BI02-	
BI03+	The No.3 and No.4 programmable binary input.
BI04+	
BI03- BI04-	
BI05+	The No.5programmable binary input.
BI05-	
BI06+	The No.6 programmable binary input.
BI06-	
BI07+	The No.7 programmable binary input.
BI07-	
BI08+	The No.8 programmable binary input.
BI08-	
BI09+	The No.9 programmable binary input.
BI09-	
BI10+	The No.10 and No.11 programmable binary input.
BI11+	

Name	Description
BI10- BI11-	
BI12+	The No.12 and No.13 programmable binary input.
BI13+	
BI12- BI13-	
BI14+	The No.14programmable binary input.
BI14-	
BI15+	The No.15 programmable binary input.
BI15-	
BI16+	The No.16 programmable binary input.
BI16-	
BI17+	The No.17 programmable binary input.
BI17-	
BI18+	The No.18 programmable binary input.
BI18-	

6.8 Binary Output Module

The BO module consists of 16 binary output, dry contacts, which conduct the signal functions showing the operating conditions or tripping and closing commands (protection, auto-recloser or remote control). The specific function is performed by setting the relevant settings and wiring the external copper cable. All the contacts can independently receive tripping or closing commands from the main CPU module and then conduct these commands.

All the binary outputs can be visually and flexibly configured through the PRS IED Studio configuration tool, which determine what information do they transmit between the CPU module and BO module.

The frame of the BO module terminal is described as below.

Table 6.8-1 Frame of BO Terminal

Output1	
1	TRIP01 Common
2	TRIP01 Open
3	TRIP02 Common
4	TRIP02 Open
5	TRIP03 Common
6	TRIP03 Open
7	TRIP04 Common
8	TRIP04 Open
9	TRIP05 Common
10	TRIP05 Open
11	TRIP06 Common
12	TRIP06 Open
13	SIGN07 Common

Output2	
1	TRIP01 Common
2	TRIP01 Open
3	TRIP02 Common
4	TRIP02 Open
5	TRIP03 Common
6	TRIP03 Open
7	TRIP04 Common
8	TRIP04 Open
9	TRIP05 Common
10	TRIP05 Open
11	TRIP06 Common
12	TRIP06 Open
13	TRIP07 Common

Output3	
1	SIGN01 Common
2	SIGN01 Open
3	SIGN02 Common
4	SIGN02 Open
5	SIGN03 Common
6	SIGN03 Open
7	SIGN04 Common
8	SIGN04 Open
9	SIGN05 Common
10	SIGN05 Open
11	SIGN06 Common
12	SIGN06 Open
13	SIGN07 Common

Output1		Output2		Output3	
14	SIGN07 Open	14	TRIP07 Open	14	SIGN07 Open
15	SIGN08 Common	15	TRIP08 Common	15	SIGN08 Common
16	SIGN08 Open	16	TRIP08 Open	16	SIGN08 Open
17	SIGN09 Common	17	TRIP09 Common	17	SIGN09 Common
18	SIGN09 Open	18	TRIP09 Open	18	SIGN09 Open
19	SIGN10 Common	19	TRIP10 Common	19	SIGN10 Common
20	SIGN10 Open	20	TRIP10 Open	20	SIGN10 Open
21	SIGN11 Common	21	TRIP11 Common	21	SIGN11 Common
22	SIGN11 Open	22	TRIP11 Open	22	SIGN11 Open
23	SIGN11 Cls	23	TRIP12 Common	23	SIGN12 Common
24	SIGN12 Common	24	TRIP12 Open	24	SIGN12 Open
25	SIGN12 Open	25	TRIP13 Common	25	SIGN13 Common
26	SIGN12 Cls	26	TRIP13 Open	26	SIGN13 Open
27	SIGN13 Common	27	TRIP14 Common	27	SIGN14 Common
28	SIGN13 Open	28	TRIP14 Open	28	SIGN14 Open
29	SIGN13 Cls	29	TRIP15 Common	29	SIGN15 Common
30	SIGN14 Common	30	TRIP15 Open	30	SIGN15 Open
31	SIGN14 Open	31	TRIP16 Common	31	SIGN16 Common
32	SIGN14 Cls	32	TRIP16 Open	32	SIGN16 Open

The specific terminal definition of the connector is described as below.

Table 6.8-2 Terminal Definition and Description of output module 1

Name	Description
TRIP01-06	The No.1 -6 programmable tripping or closing binary output. TRIPi (i=1-6) Open is the normal open binary output.
SIGN07-10	The No.7-10 programmable signal binary output. SIGNi (i=7-10) Open is the normal open binary output
SIGN11-14	The No.11-14 programmable signal binary output. SIGNi (i=11-14) Open is the normal open binary output, SIGNi (i=11-14) Cls is the normal close binary output.

Note: The signal BO can only be used for signal transmission.

Table 6.8-3 Terminal Definition and Description of output module 2

Name	Description
TRIP01-16	The No.1 -16 programmable tripping or closing binary output.

Table 6.8-4 Terminal Definition and Description of output module 3

Name	Description
SIGN01-16	The No.1 -16 programmable signal output

Note: The signal BO can only be used for signal transmission.

6.9 Binary Input and Output Module

The IO module provides 7 binary outputs, some dry contacts, which conduct the signal functions showing the operating conditions (device error) or tripping and closing commands (protection, auto-reclose or remote control). The specific function is performed by setting the relevant settings and wiring the external copper cable.

The IO module also contains 9 binary inputs, the optical isolated input terminals, which can perform different monitoring functions, such as detecting the breaker and switch positions of the corresponding bay. All the BI terminals can be used as general purpose binary inputs or special purpose (protection function or control function) binary inputs.

All the binary inputs and outputs can be visually and flexibly configured through the PRS IED Studio configuration tool, which determine what information do they transmit between the CPU module and BO module.

The frame of the IO module terminal definition is described as below.

Table 6.9-1 Frame of the IO Module Terminal

IO Type1			
1	BI01+	TRIP01 Common	17
2	BI02+	TRIP01 Open	18
3	Common-	TRIP02 Common	19
4	BI03+	TRIP02 Open	20
5	BI04+	TRIP03 Common	21
6	Common-	TRIP03 Open	22
7	BI05+	TRIP04 Common	23
8	BI05-	TRIP04 Open	24
9	BI06+	TRIP05 Common	25
10	BI06-	TRIP05 Open	26
11	BI07+	TRIP06 Common	27
12	BI07-	TRIP06 Open	28
13	BI08+	TRIP06 Close	29
14	BI08-	TRIP07 Common	30
15	BI09+	TRIP07 Open	31
16	BI09-	TRIP07 Close	32

IO Type2			
1	BI01+	SIGN01 Common	17
2	BI02+	SIGN01 Open	18
3	Common-	SIGN02 Common	19
4	BI03+	SIGN02 Open	20
5	BI04+	SIGN03 Common	21
6	Common-	SIGN03 Open	22
7	BI05+	SIGN04 Common	23
8	BI05-	SIGN04 Open	24
9	BI06+	SIGN05 Common	25
10	BI06-	SIGN05 Open	26
11	BI07+	SIGN06 Common	27
12	BI07-	SIGN06 Open	28
13	BI08+	SIGN06 Close	29
14	BI08-	SIGN07 Common	30
15	BI09+	SIGN07 Open	31
16	BI09-	SIGN07 Close	32

The terminal definition of the IO module is described as below.

Table 6.9-2 Terminal Definition and Description of IO Type1 Module

Name	Description
BI01+	The No.1 and No.2 programmable binary input.
BI02+	
BI01- BI02-	
BI03+	The No.3 and No.4 programmable binary input.
BI04+	
BI03- BI04-	
BI05+	The No.5programmable binary input.
BI05-	
BI06+	The No.6 programmable binary input.
BI06-	
BI07+	The No.7 programmable binary input.
BI07-	
BI08+	The No.8 programmable binary input.
BI08-	
BI09+	The No.9 programmable binary input.
BI09-	
TRIP01-05	The No.1-5 programmable tripping or closing operation binary output. TRIPi (i=1-5) Open is the normal open binary output. It operates when both the pickup and operation signal are ok.
TRIP06-7	The No.6-7 programmable tripping or closing operation binary output. Normal open and close contacts are both equipped. BOi (i=6-7) Open is the normal open binary output, TRIPi (i=6-7) Cls is the normal close binary output. It operates when both the pickup and operation signal are ok.

Table 6.9-3 Terminal Definition and Description of IO Type2 Module

Name	Description
BI01+	The No.1 and No.2 programmable binary input.
BI02+	
BI01- BI02-	
BI03+	The No.3 and No.4 programmable binary input.
BI04+	
BI03- BI04-	
BI05+	The No.5programmable binary input.
BI05-	
BI06+	The No.6 programmable binary input.
BI06-	
BI07+	The No.7 programmable binary input.
BI07-	

Name	Description
BI08+	The No.8 programmable binary input.
BI08-	
BI09+	The No.9 programmable binary input.
BI09-	
SIGN01-05	The No.1-5 programmable tripping or closing signal binary output. SIGNi (i=1-5) Open is the normal open binary output. It operates when the operation signal is ok.
SIGN06-07	The No.6-7 programmable tripping or closing signal binary output. Normal open and close contacts are both equipped. SIGNi (i=6-7) Open is the normal open binary output, SIGNi (i=6-7) Cls is the normal close binary output. It operates when the operation signal is ok.

7 MAN MACHINE INTERFACE

7.1 Overview

HMI is known as the Human Machine Interface. HMI is the main communication interface between the control system and the operator. The friendly LCD facilitates the operator, providing all operating system information in the screen of the front display panel, including binary inputs or outputs, circuit breakers status, version of operating system program, alarm signals, tripping operation, disturbance records, and signal of measuring quantities (voltage, current and angle) etc., Besides these, it’s also useful for modifying the operating system configuration settings and protection function settings as well. The HMI can also be helpful during commissioning work.

Additionally, the PRS IED studio software helps to conduct all above listed function through communication port (Ethernet cable) on the PC or laptop.

7.1.1 Design Structure

The design structural of PRS-7367 Human Machine Interface (HMI) is user friendly and easy to operate in different situations. The design structure detail of HMI is follow:

- For monitoring the signal status, fault records and configuration of settings, high quality 320×240 dot matrix LCD with dim lite green back light display is equipped.
- For the access of device functions and control settings. 1 enter and 1 cancel keys, 4 functional keys, 4 arrow keys, 2 remote and local control keys and 2 CB control keys.
- For the indication of different types of alarming and tripping signals. Front panel of HMI includes 28 LEDs light indicator.
- For the remote access from the PRS IED studio configuration software, Ethernet commissioning interface is available.

The front and back panels of PRS-7367 relay shown in Figure 6.1-2 and Figure 6.1-3 respectively.

7.1.2 Function mode

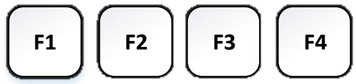
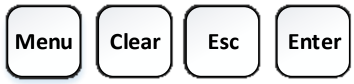
- HMI screen is used to monitor the successively status and information of various events, and also helps to configure the protection settings and device operating mode
- Navigation menu keys help the operator to locate the required data or information.
- Data record and printing function is available in PRS-7367 relay setting.

In simple words, all functions of PRS-7367 are user friendly.

7.1.3 Operating panel keypad and keys

The PRS-7367 relay front penal have 9 keypads and 8 function keys help the operator to change the device settings according to the required situation and locate the different kind of data access. These all keys and keypad have different kinds of functions.

Table 7.1-1 Keys information table

Symbol of keys	Description
	Arrow keys left, right up and down respectively
	Functional keys F1, F2, F3 and F4 respectively. These are configure according to user’s demand.
	Different keys like Menu, Clear, Esc and Enter keys
	CB close key, Remote/Local control key, User login key and CB opening key respectively.

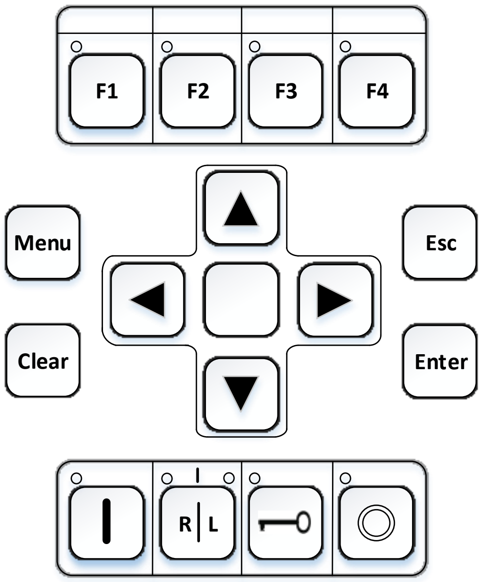


Figure 7.1-1 Overview of Front Panel Keypad and Keys

7.1.4 Indication of LED

The IED consists of 28 front panel LEDs. The local view of front panel HMI consists of two IED status LEDs above the display level; healthy and alarm. The sixteen other configurable LEDs on the front panel of local-HMI and each LEDs can be configured with three colors like green, red and yellow according to user requirement. These LEDs can be configured through local HMI or PRS IED Studio. Additionally, There are 16 LEDs, each of which can be configured with 3 colors. These LEDs can be triggered by a fault, alarm event or device record, and it indicate last information.

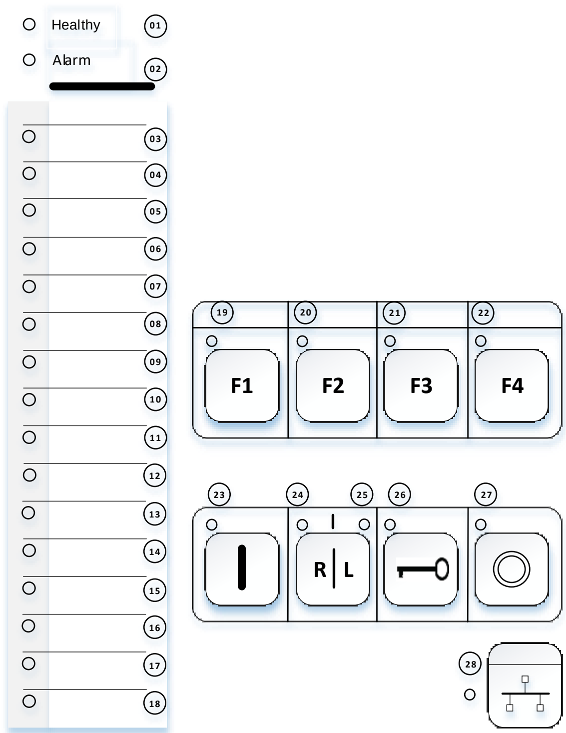


Figure 7.1-2 Overview of Front Panel LED's

Table 7.1-2 LED indications

No.	Key label	Status	Description
01	Healthy	Off	When the device is not energized.
		Green	When the device is in normal working mode and ready to operate
02	Alarm	Off	No alarm signal is energized when the device running normally.
		Yellow	Alarm signal is issued.
03-18	Configurable	Off	None of signal is energized when the device running normally. If state configuration is "hold", it only can be reset by Pushbutton or Keypad.
		Green/Yellow/Red	These LEDs can be configured according to user demand like different operating functions, such as tripping, alarm, reclose, CB open or close and synchro-check etc.
19-22	Configurable	Off	None of signal is energized when the functional key is deactivated.
		Red	These LEDs indicate the functional keys are deactivated
23	CB Close	Off	None of signal is energized when the functional key is deactivated.
		Yellow	This LED indicate the CB Close key is activated.
24	Remote	Off	The operation mode is determined by the BI.
		Yellow	The device is in the "remote" mode
25	Local	Off	The operation mode is determined by the BI.
		Yellow	The device is in the "Local" mode

No.	Key label	Status	Description
26	User login	Off	When user login function is not enable.
		Yellow	This LED indicate when it is activated.
27	CB Open	Off	None of signal is energized when the functional key is deactivated.
		Yellow	This LED indicate the CB Open key is activated.
28	Ethernet interface port	Off	When no Ethernet cable is connected with device.
		Green	When it works normally.

NOTICE!

No.01-02 and No.19-28 cannot set status because it is the fixed value

- **General description of LEDs indication**

Healthy

This LED indication shows, device is energized through normal power supply, and ready to work under the normal atmosphere.

Alarm

This LED indication shows, when any abnormality alarm is detected in the system.

Trip

This LED indication shows, when any protection function is operated.

Reclose

This LED indication shows, when auto-recloser function is operated.

CB Open

This LED indication shows, when the circuit breaker is in open position.

CB Close

This LED indication shows, when the circuit breaker is in close position.

7.1.5 Configurable keys

The PRS-7367 device HMI front panel consists of four configurable keys. These configurable functional keys provide shortcuts for certain menu or act as a control button. The default view of configurable functional keys (F1, F2, F3 and F4) are shown in Figure 7.1-1. The detail operation of functional keys is listed in Table 7.1-3:

Table 7.1-3 Information of functional keys

Keys	Function	Description	Remarks
F1, F2, F3 and F4	Control	For binary input and output control instantiated according to the configuration tool	This control function, control through three ways like pulls, hold and exit.

Keys	Function	Description	Remarks
	Shortcut	"System single line", "Measurement", “Binary input” “Fault record “ “Disturbance” “Clear” “Setting group” 7 selected 1	This shortcut function provide easy access to device operation settings and it is configurable according to user demand.
	Sign out	Do not perform the key function	-

7.2 LCD Display description of HMI

7.2.1 Overview

In this part of HMI, the detail of LCD display function is described.

7.2.2 Normal display structure of LCD

The normal operating condition of local HMI LCD display structure is shown in Figure 7.2-1, the single-line diagram is based on the practical arrangement of equipment, monitoring the position status of CB and Isolator in real time.

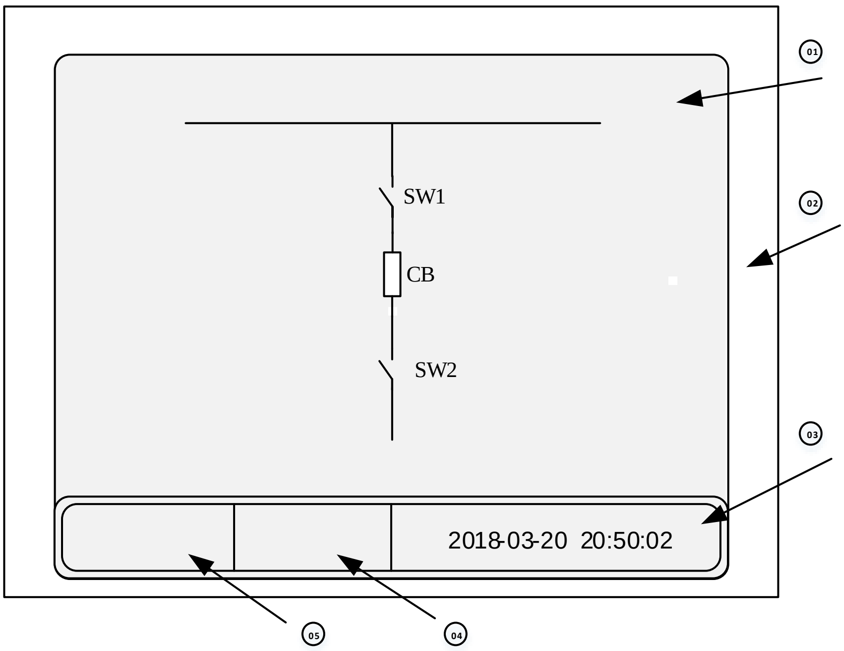


Figure 7.2-1 General Overview Display of Local HMI LCD Screen

According to the overview of local HMI. LCD display is divided into five parts. These parts are listed below:

1. Main data display zone

2. Outer boundary zone
3. Date and time display zone
4. Time synchronization or GPS
5. Data monitoring zone

Main data display zone provides information that the user wants to access like measurement value status, fault records, circuit breaker status, single line diagrams, alarm signals, protection function settings, and synchronization status etc.

Outer boundary zone is known as free text zone and no data display in this zone. It defines the boundary of LCD display zone.

Date and time display zone shows the real monitoring value of date and time. The user can set these date and time value according to requirement. The display format of date and time is yyyy-mm-dd and hh:mm:ss respectively. The time setting format can be easily set to the user time zone demand.

7.2.3 Main menu display

In order to make sure the user can control PRS-7367 relay easier, simple and fast, the CYG Co, Ltd designs a flat-panel of main menu LCD display that contain ten main controlling function.

These controlling function are listed below:

1. Physical
2. Review
3. Monitor
4. Event
5. Record
6. Setting
7. Config
8. Test
9. Clear
10. Language

The main menu display screen shown in Figure 7.2-2. The main menu will deal with the operation of installation work together with providing basic support and instructions to help user control.

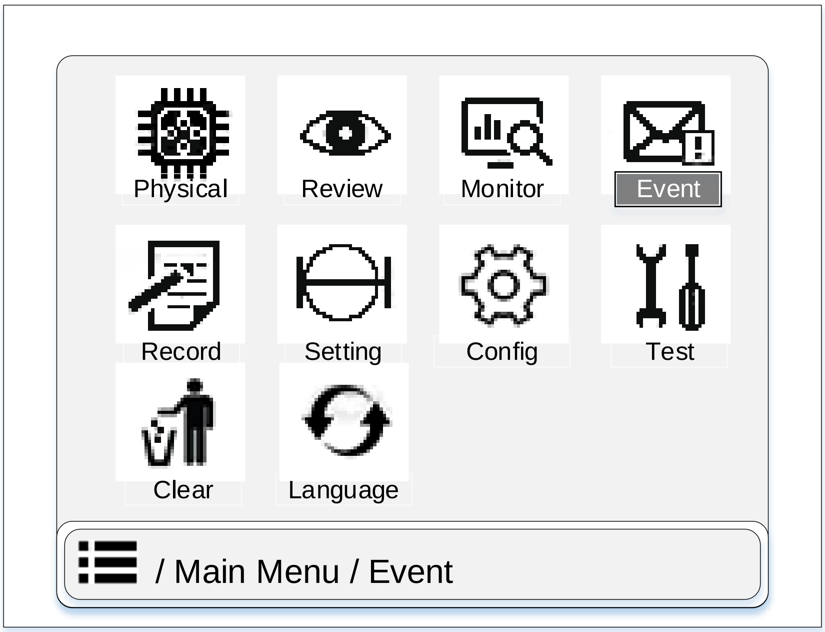


Figure 7.2-2 LCD General Overview Display of Main Menu

7.3 Sub menu functions of main menu

This part of HMI, the detail of menu sub-functions is described. These all sub-functions display on the front panel of HMI LCD.

7.3.1 Physical Information

In this section, describe all the physical information related to device software and device communication. The overview display of physical information is shown in Figure 7.3-1.

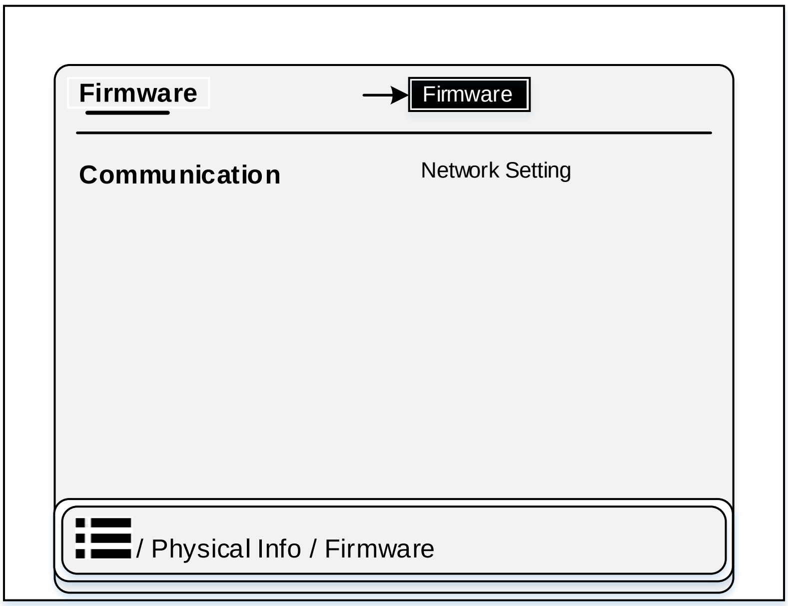


Figure 7.3-1 Overview Display of Physical Information Sub-functions

7.3.1.1 Software

In this sub-section of physical information, the software information of the protection relay is described, including the device type, protection relay software, uniqueness code and protection date etc. User can access this function through the following path: “Physical information > software”. The software information data divided into two pages and the detail of information is listed in Figure 7.3-2 and Table 7.3-1:

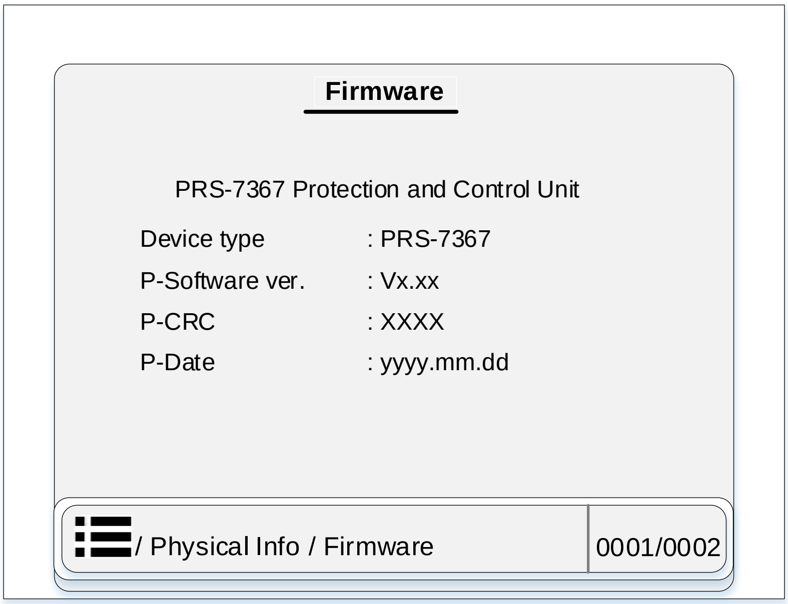


Figure 7.3-2 Overview Display Diagram of Software Information

Table 7.3-1 Detail of Software information

Name	Function display	Description
Device type	PRS-7367	Describe the type of protection relay
P-Software ver	Vx.xx	Describe the version of protection relay software
P-CRC	XXXX	Protection Cyclic redundancy check code
P-Date	yyyy-mm-dd	Protection CPU date
M-Software ver.	Vx.xx	MCPU software version
M-CRC	XXXX	MCPU Cyclic redundancy check error
M-Date	yyyy-mm-dd	Management CPU date
Device code	***_****************	Device code
Ordering Code	***_****_*_******_*****_**.**	Ordering Code
Config. Ver.	Vx.xx	The configuration version

For example: the relay used in one project in Thailand, the detail of software information can be display in Table 7.3-2.

Table 7.3-2 Detail of Software information example

Name	Function display	Description
Device type	PRS-7367	Describe the type of protection relay
P-Software ver	V1.20	Describe the version of protection relay software
P-CRC	8AB5	Protection Cyclic redundancy check code
P-Date	2019-09-16	Protection CPU date
M-Software ver.	V1.20	MCPU software version
M-CRC	7E36	MCPU Cyclic redundancy check error
M-Date	2019-09-16	Management CPU date
Device code	C99-300000000138493	Device code
Ordering Code	PRS-7367-T-FACAAT-CABAE-R1.20	Ordering Code
Config. Ver.	V4.17	The configuration version

7.3.1.2 Communication

This section, describes the information communication of network setting of the protection relay including IP, MAC and NetMask of network 1, 2 and 3 respectively. User can access this function through the following path: “Physical information > communication”. The network setting data of communication information is listed in Figure 7.3-3 and Table 7.3-3:

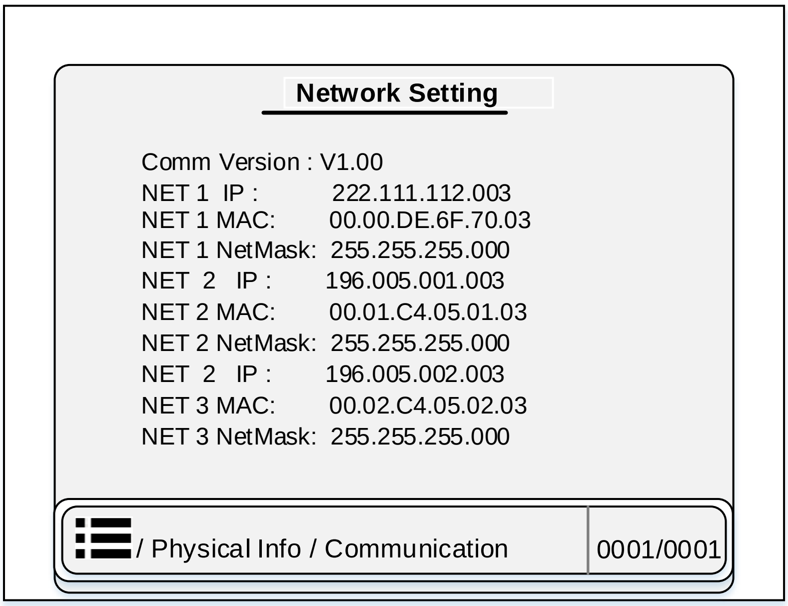


Figure 7.3-3 Overview Display Diagram of Network Setting

Table 7.3-3 Communication data detail

Name	Function display	Description
NET 1 IP	222.111.112.003	IP address of internet protocol for Ethernet port 1
NET 1 MAC	00.00.DE.6F.70.03	MAC address of internet protocol for Ethernet port 1

Name	Function display	Description
NET 1 NetMask	255.255.255.000	NetMask address of internet protocol for Ethernet port 1
NET 2 IP	196.005.001.003	IP address of internet protocol for Ethernet port 2
NET 2 MAC	00.01.C4.05.01.03	MAC address of internet protocol for Ethernet port 2
NET 2 NetMask	255.255.255.000	NetMask address of internet protocol for Ethernet port 2
NET 3 IP	196.005.002.003	IP address of internet protocol for Ethernet port 3
NET 3 MAC	00.02.C4.05.02.03	MAC address of internet protocol for Ethernet port 3
NET 3 NetMask	255.255.255.000	NetMask address of internet protocol for Ethernet port 3

7.3.2 Review Information

This section is divided into two sub-parts, including time mode and the information how to review protection relay monitoring data. This section only provides the setting view display and user can't change the display information of relay. The overview display of review information is shown in Figure 7.3-4.

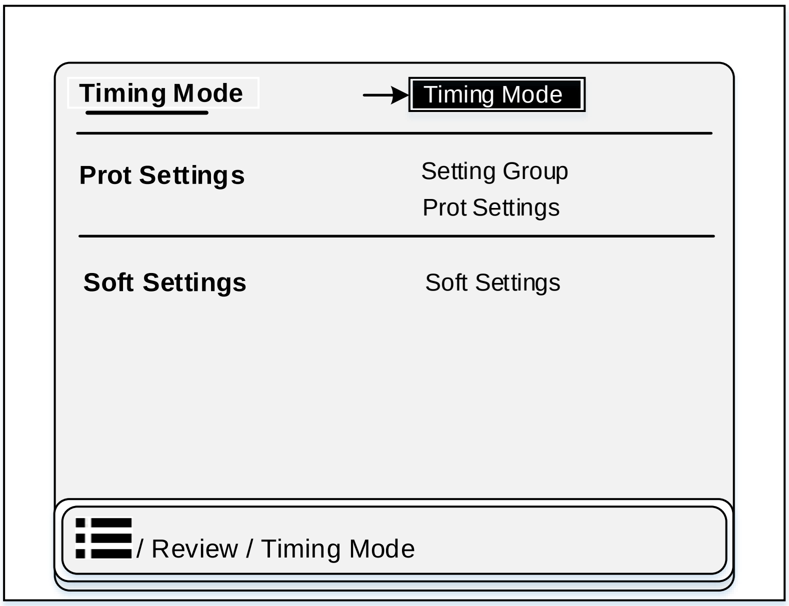


Figure 7.3-4 Overview Display of Review Information Sub-functions

7.3.2.1 Timing Mode

This section, the user can see the time information like Uart IRIG-B, Opti IRIG-B and SNTP (Simple Network Time Protocol) information and the user can't change any kind of information. Users can access this function through the following path: "Review > Timing Mode". The overview display of timing mode is shown in Figure 7.3-5.

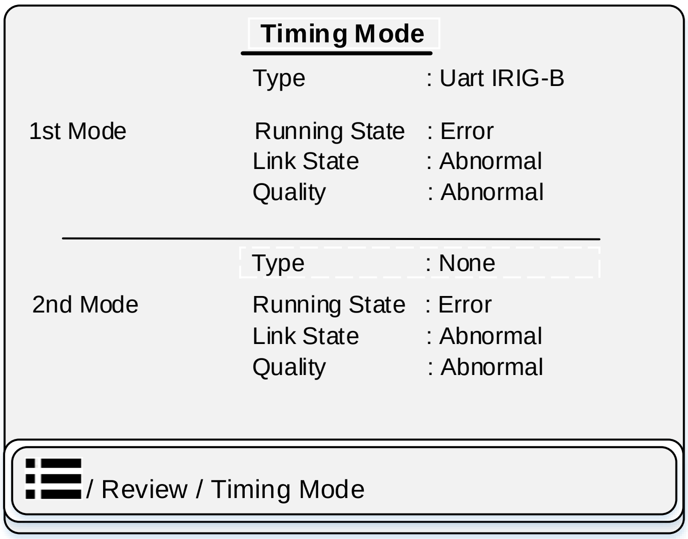


Figure 7.3-5 Overview Display of Timing Mode

7.3.2.2 Prot Settings

This section is divided into two sub-parts like setting group and protection settings.

1- Setting Group

This sub-section the user can see the information about which group is the current group. There are totally 4 groups, and the setting groups can be switched locally or remotely respectively.

2- Prot Settings

This section the user can see the different kind of information like public, measurement and protection function operation settings etc. User can access this function through the following path: "Review > Prot Settings". This section contains 01 to 11 pages and 42 parts of relay settings. The information data structure of protection setting is listed in Figure 7.3-6:

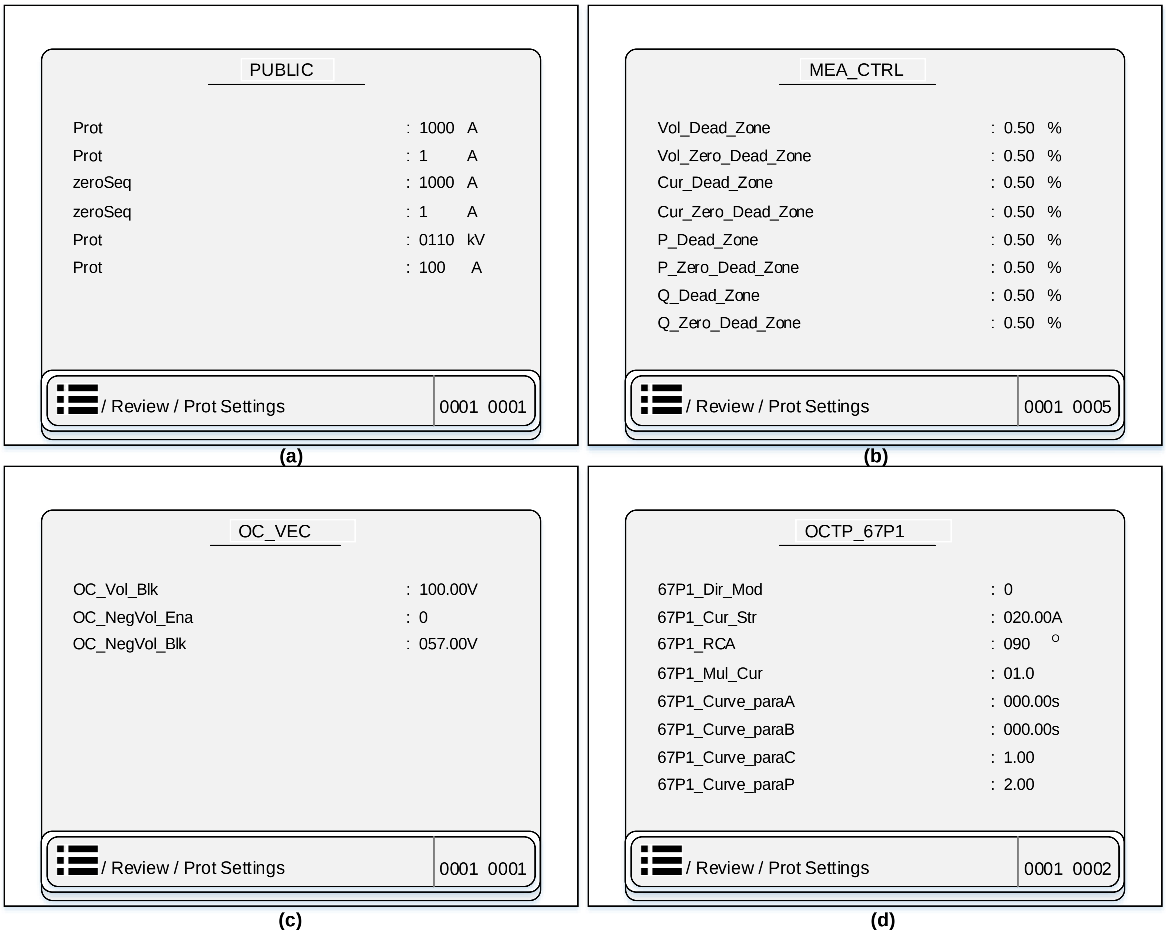


Figure 7.3-6 Overview Diagram of Prot Setting

(a) Public Setting (b) Measurement Control Setting (c) Overcurrent Protection Setting (d) Phase Overcurrent Protection Setting of Stage 1

7.3.3 Monitoring Information

This section divided into three sub-parts and describe the information of real time monitoring data of PRS-7367 feeder protection relay. This section only provides the sample, harmonics and BI data information. In this section user can easily access the real-time monitoring data view of relay through arrow keys. The measurements can show in primary or secondary value. The overview display of monitoring information are shown in Figure 7.3-7.

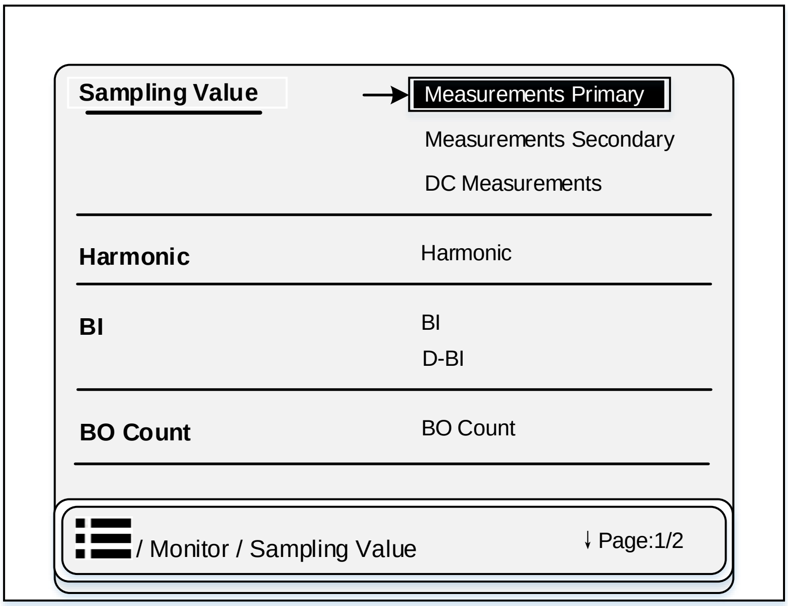


Figure 7.3-7 Overview Display of Monitoring Information Sub-functions

7.3.3.1 Sample

This section divided into one sub part like measurements and describe the detail information of all measurement values such as current, voltage and angle etc. User can access this function through the following path: “Monitor > Sample”. This section contains 01 to 04 pages and 36 measuring quantities. The measurement data structure of relay is listed in Figure 7.3-8.

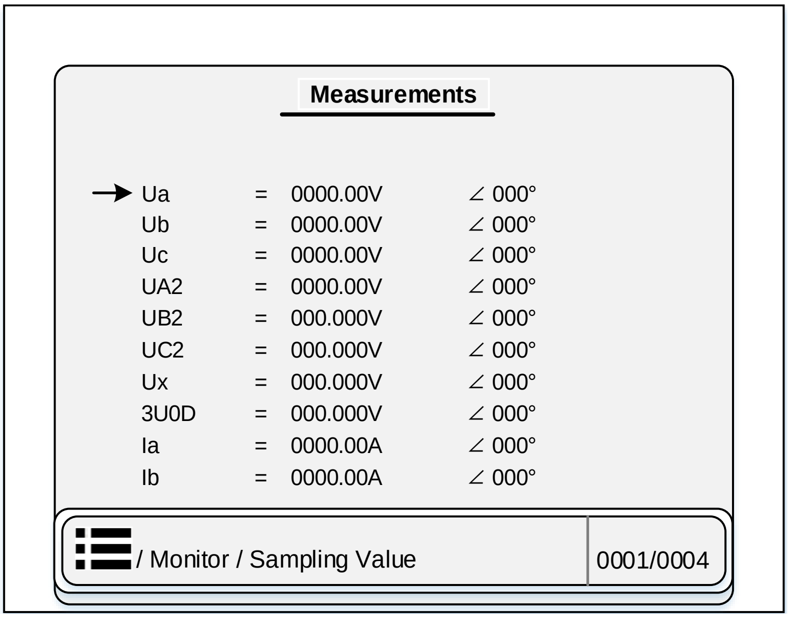


Figure 7.3-8 Overview Display of Measurement Section Quantities

7.3.3.2 Harmonic

In this section, the user can see the calculated harmonic content data list of all phase voltage and current and also the RMS value of all three phase voltage and current. User can access this function through the following path: “Monitor > Harmonic”. The harmonic overview display diagram of relay is listed in Figure 7.3-9. After the measurement channel is selected, the harmonic data of the channel can be viewed.

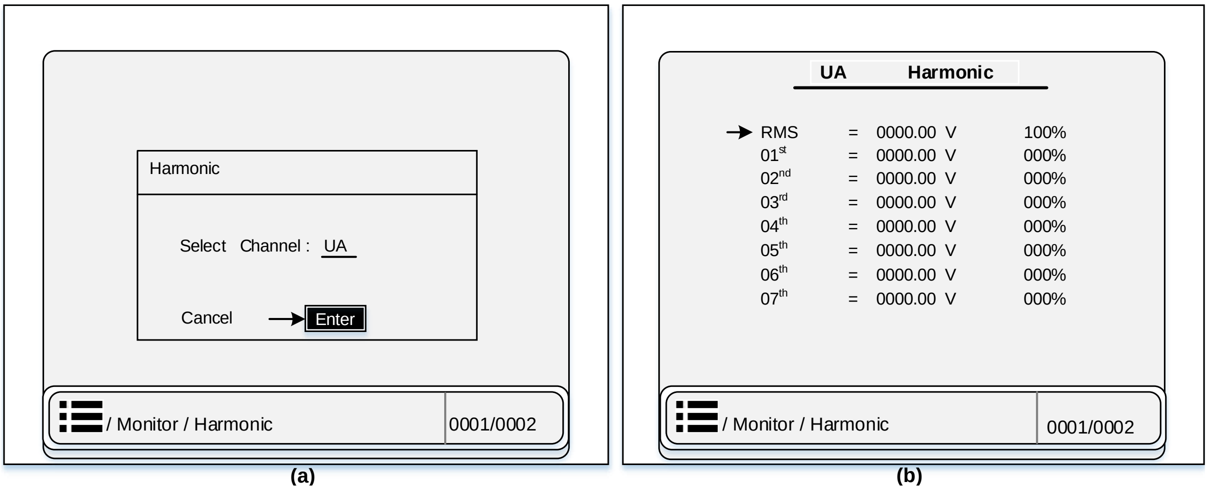


Figure 7.3-9 LCD Display Diagram

(a) Overview of Entrance Harmonic Monitoring Chart (b) Ua Harmonic Content Display Chart of Page 1

7.3.3.3 BI

This section divided into two sub-parts and describe the information of binary input (BI) of this IED seen in the above figure 7.3.5. This section only displays all the binary input data. User can access this function through the following path: “Monitor > BI”.

1- BI

This part of single BI monitoring data contains 01 to 04 pages and 32 binary inputs. The BI display diagram of the IED is listed in Figure 7.3-10.

2- D-BI

D-BI is stand for double binary input function. The D-BI display diagram of relay is listed in Figure 7.3-10.

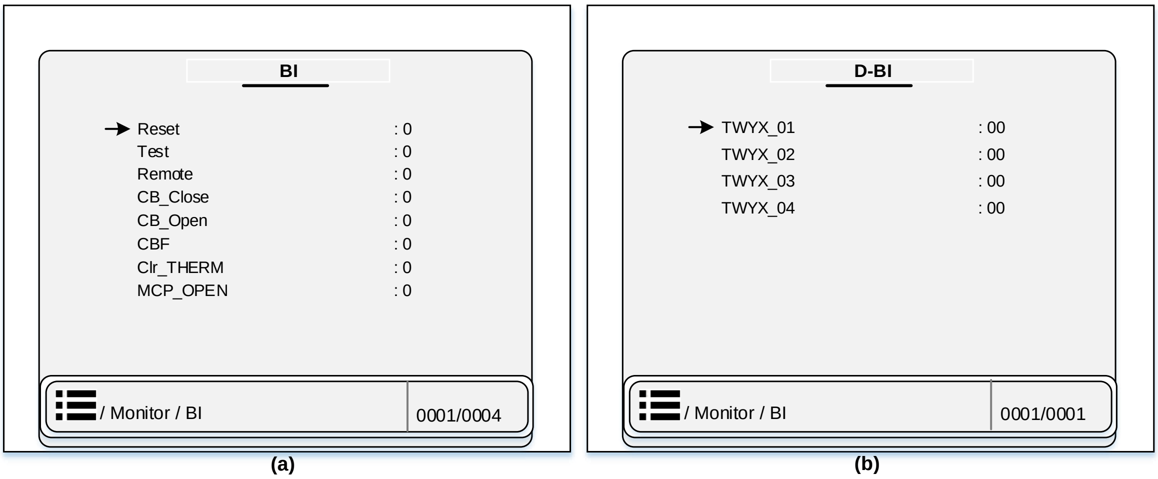


Figure 7.3-10 LCD Display Diagram of (a) BI Monitored Data (b) D-BI Monitored Data

7.3.4 Event Information

This section is divided into four sub-section and describe the information of all events, like fault events, alarming information (warning records), selfchk info, SOE, remote control, user records and power records etc. The LCD display event diagram of the IED is listed in Figure 7.3-11.

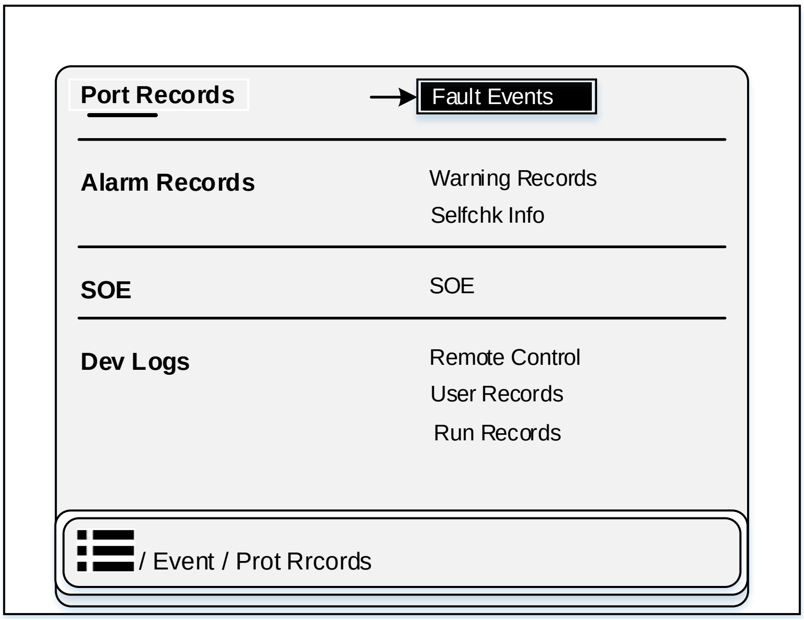


Figure 7.3-11 Overview Display of Event Information Sub-functions

7.3.4.1 Port Records

This section divided into one sub-function like fault events and this device can store 1024 latest protection records. User can access this function through the following path: "Event > Port Records". The detail of this section divided into nine points:

1. Shows date and time
2. Protection function status
3. Shows operation of protection function like which protection function is acted.

4. Shows operated phases information
5. Shows fault clearance delay time
6. Shows slot info like management slot (slot3) or protection slot (slot9).
7. Shows fault number
8. Not reverted
9. Shows fault events page number information, it will be increase or decrease w.r.to numbers of fault.

The diagram of fault event display of relay is listed in Figure 7.3-12:

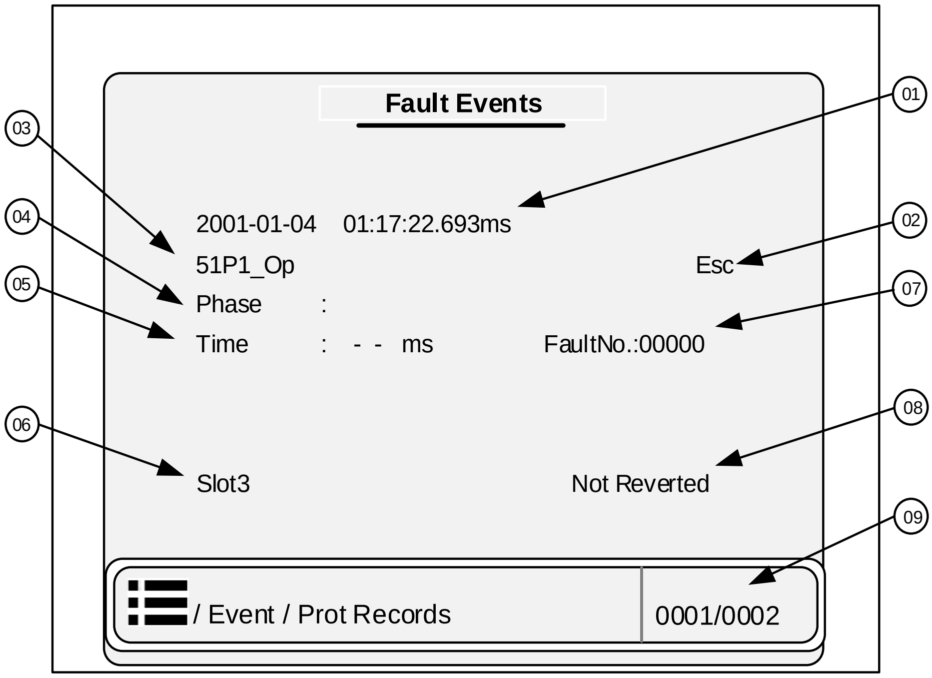


Figure 7.3-12 Overview Display of Fault Events

7.3.4.2 Alarm Records

This section divided into two sub-functions like warning records and selfchk Info see in Figure 7.3-12. This devise can save latest 1024 alarm records.

1- Warning Records

In this section user can see all warning records like protection warning records and Timing Err warning records etc. User can access this function through the following path: “Event > Alarm Records”. The overview display of warning record is shown in Figure 7.3-13.

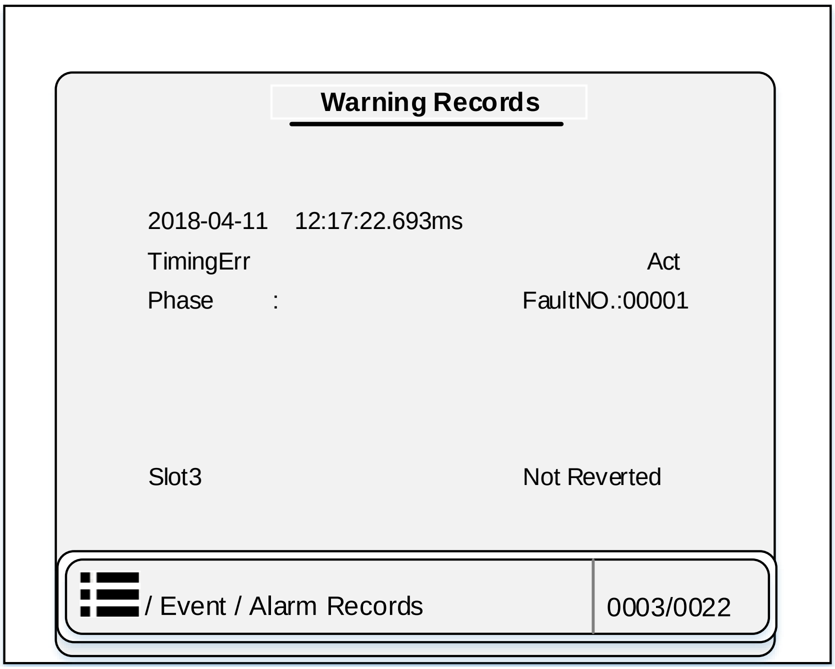


Figure 7.3-13 Overview Diagram of Warning Records Info

2- Selfchk Info

The self-check info checks the communication status between devices, such as carrier channel abnormality, fiber channel abnormality, GOOSE communication abnormality and internal AD sampling abnormality and etc. To summarize, this device also checks hardware, software and configuration file and it can totally save latest 1024 records. User can access this function through the following path: “Event > Alarm Records”. The overview display of SelfChk info is shown in Figure 7.3-14.

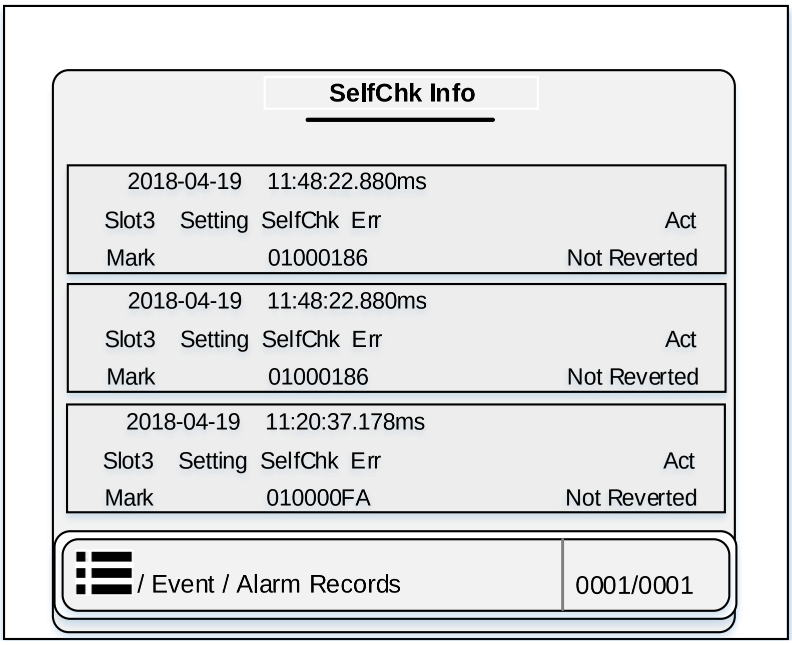


Figure 7.3-14 Overview Display Diagram of SelfChk Info

7.3.4.3 SOE

In this section SOE checks following condition:

- When the state of binary input signal changes, e.g. a hard contact, the time tag of the state quantity is marked by the device and the time is defined after denouncing.
- When the state of GOOSE signal changes, the time tag of the state quantity adopts the external input source signal time tag. The GOOSE signal acquisition has no denouncing time.

User can access this function through the following path: “Event > SOE”. This device can save 1024 latest SOE records. The diagram of SOE record is shown in Figure 7.3-15.

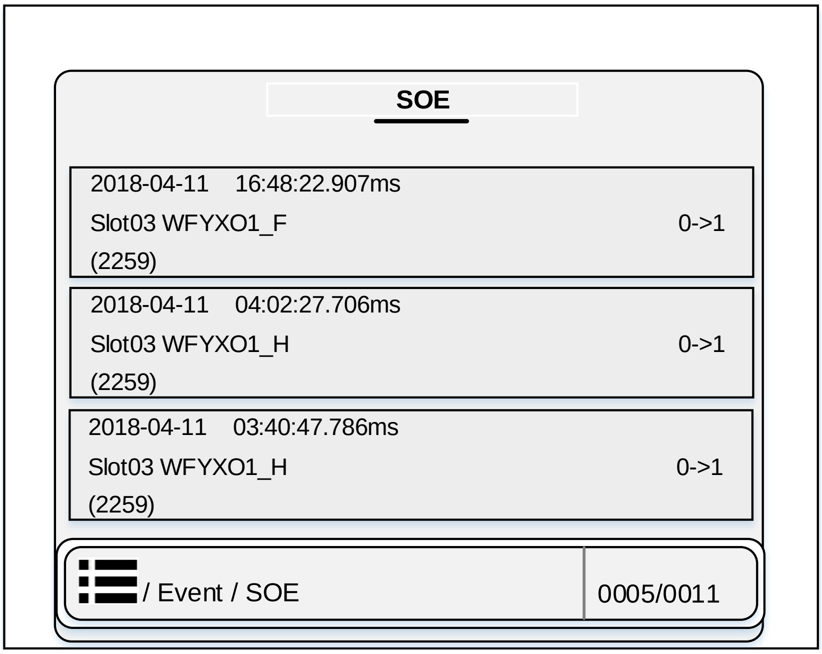


Figure 7.3-15 Overview Display Diagram of SOE

7.3.4.4 Dev Logs

This section divided into three sub-function like remote control, user records and power records see figure 7.3.11.

1- Remote Control

This part shows the remote control signals like circuit breaker, disconnector, reset signal, transformer tap changer, earthing switches etc. The recorded information includes the command source, command time, operation result and failure reason etc. This device can store 1024 latest remote control records. User can access this function through the following path: “Event > Dev Logs”. The diagram of remote control functions is shown in Figure 7.3-16.

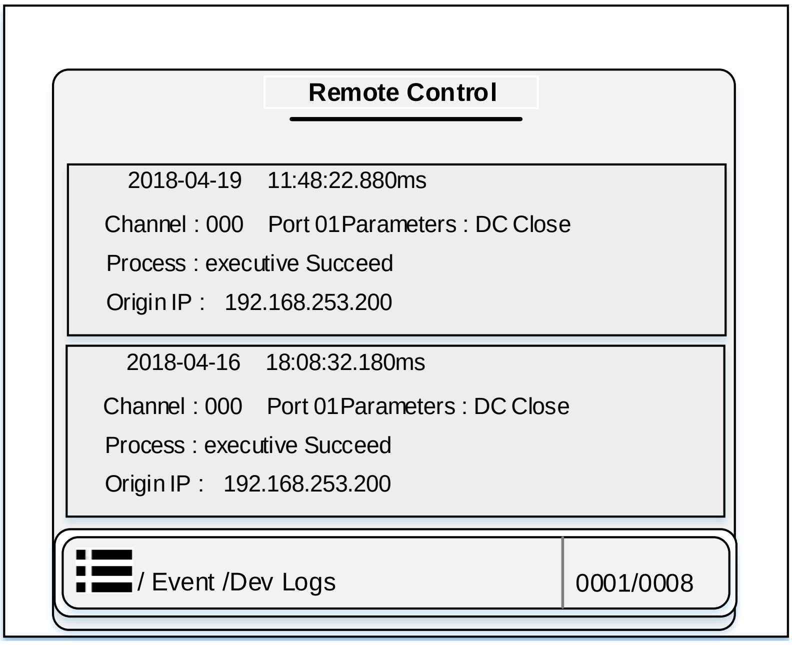


Figure 7.3-16 Overview Display Diagram of Remote Control Access

2- User Records

In this section user can see the setting of user records with slot number, time and date. User can access this function through the following path: "Event > Dev Logs". The diagram of user records is shown in Figure 7.3-17.

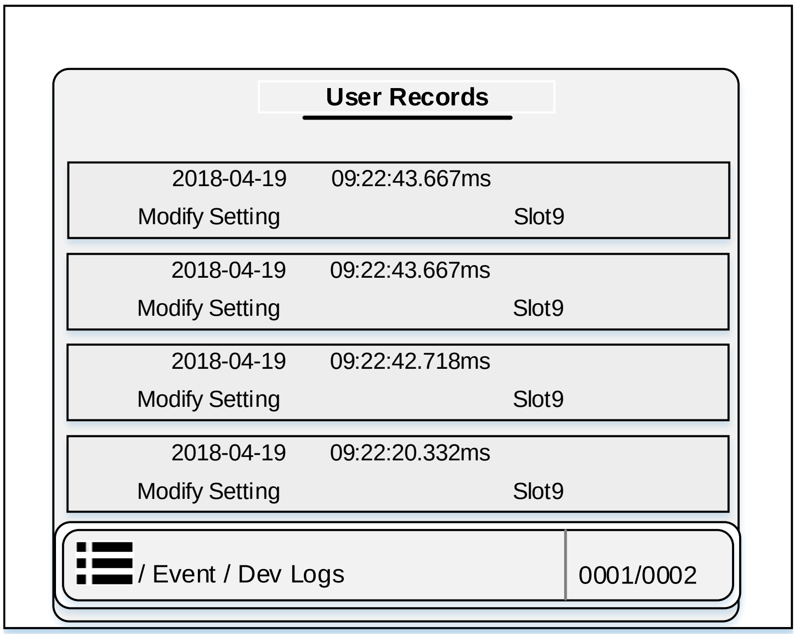


Figure 7.3-17 Overview Diagram of User Records

3- Power records

In this section user can see the setting of power records date and time with energizing and dis-energizing slot number. The number of pages of this section can be increase or decrease through the storage of power records. User can access this function through the following path: “Event > Dev Logs”. The diagram of power record is shown in Figure 7.3-18.

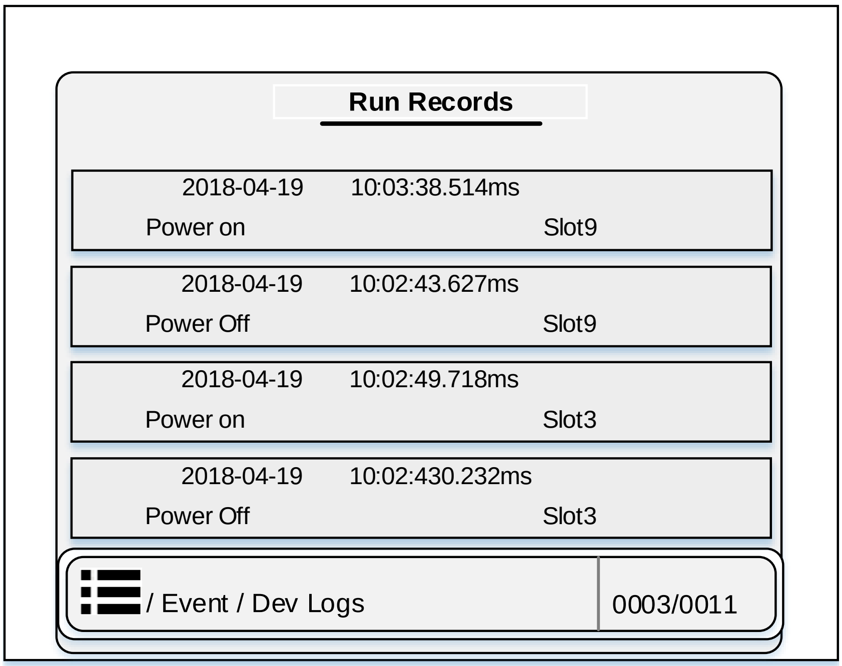


Figure 7.3-18 Overview Diagram of Power Records

7.3.5 Record Information

In this section, user can see the disturbance records and this section is divided into one sub-section. The diagram of disturbance record is shown in Figure 7.3-19.

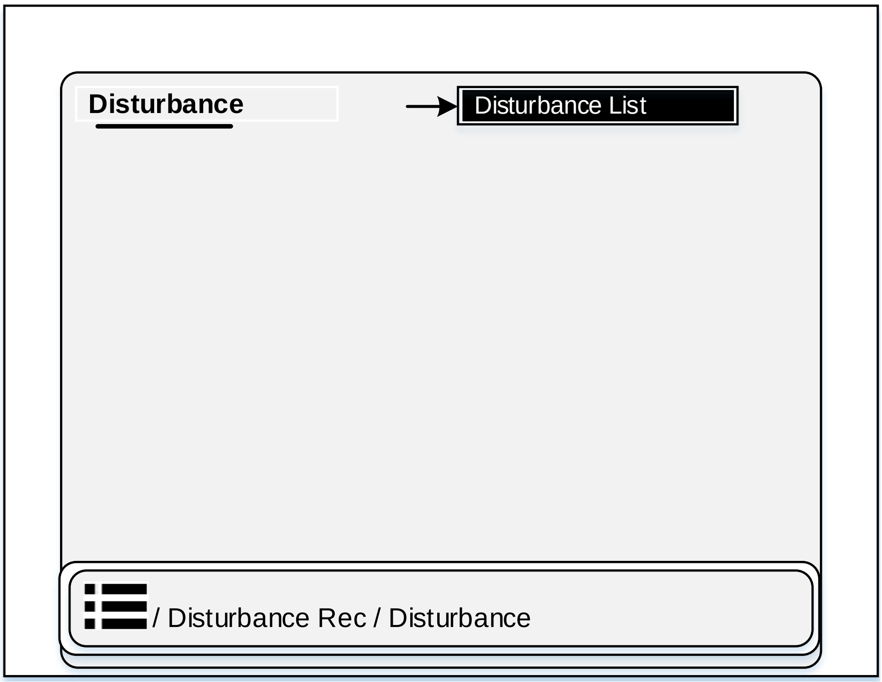


Figure 7.3-19 Overview Display of Records Information

7.3.5.1 Fault wave

In this section user can see the disturbance records of all the faults. User can access this function through the following path: “Disturbance Records > Disturbance”. The diagram of faulty wave records is shown in Figure 7.3-20.

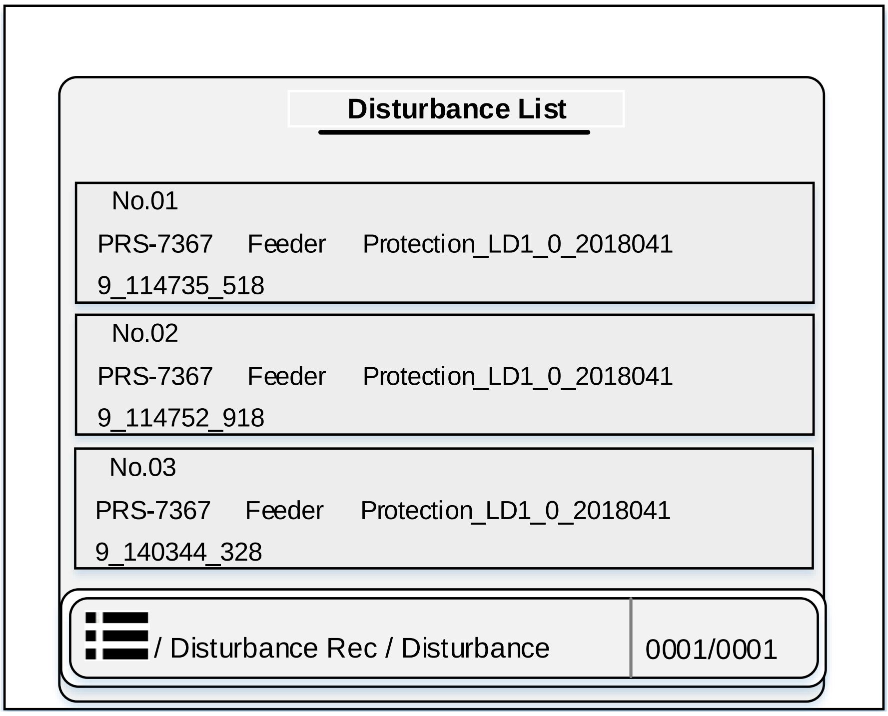


Figure 7.3-20 Overview Diagram of Fault Wave List

7.3.6 Setting Information

This section divided into two sub-section like set group and protection settings. In this part user can set the device configuration according to operation demand. The overview display of setting information is shown in Figure 7.3-21.

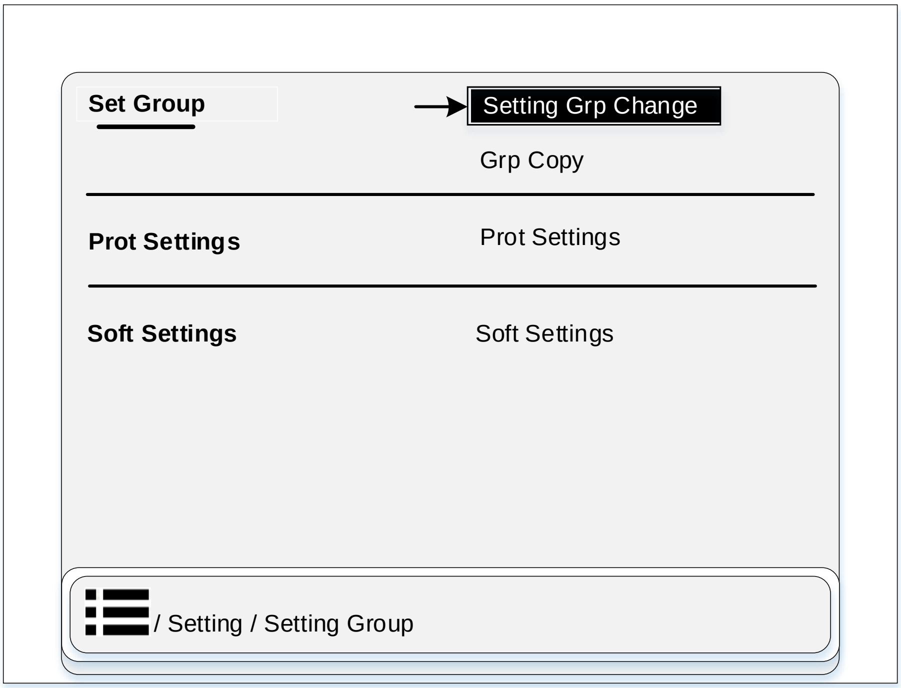


Figure 7.3-21 Overview Display of Setting Information Sub-functions

7.3.6.1 Set Group

This sub-section is divided into two further sub-section like Setting Grp change and Grp Copy and in this part user can change the group setting.

1- Setting Grp change

This device has four setting groups and user can easily configure the group setting according to operation demand. This setting is divided into four steps. User can access this function through the following path: "Setting > Set group". The procedure of group setting change is explaining in Figure 7.3-22.

Firstly, enter the device login password. Secondly, select group setting. Thirdly, download new configuring setting. Fourthly, cancel to return back or exit.

Figure 7.3-22 Procedure Diagram of Group Setting Change

2- Grp Copy

This device has four setting groups and user can easily copy one group settings and save this same setting in other group. User can access this function through the following path: "Setting > Set group". The procedure detail of group setting copy is explaining in Figure 7.3-23.

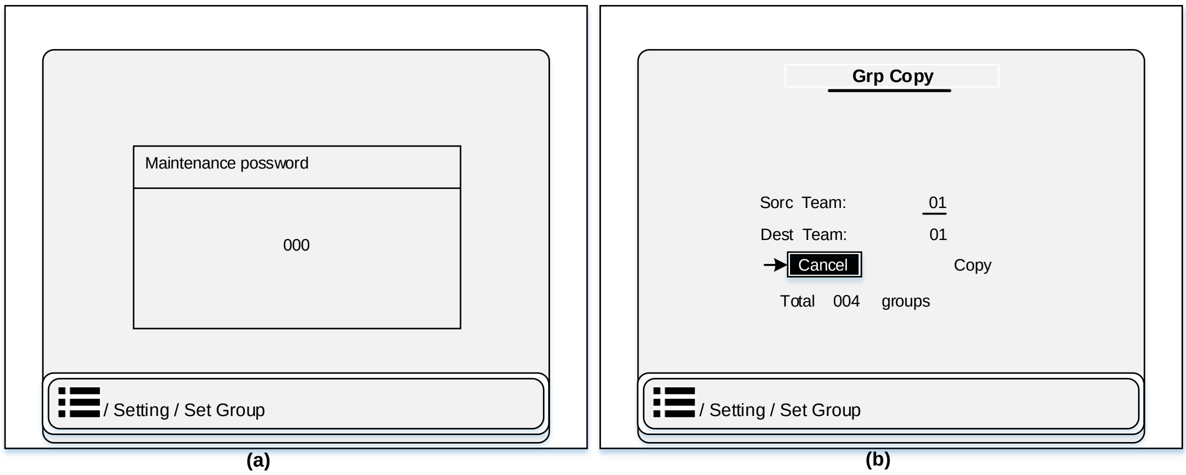


Figure 7.3-23 Procedure Diagram of Group Setting Copy

7.3.6.2 Prot Settings

In this section user can change the different kind of information like public, measurement and protection operation function settings etc. This section contains 01 to 11 pages and 42 parts of relay settings. User can access this function through the following path: “Setting > Prot Settings”. The detail of protection setting is listed in Figure 7.3-24.

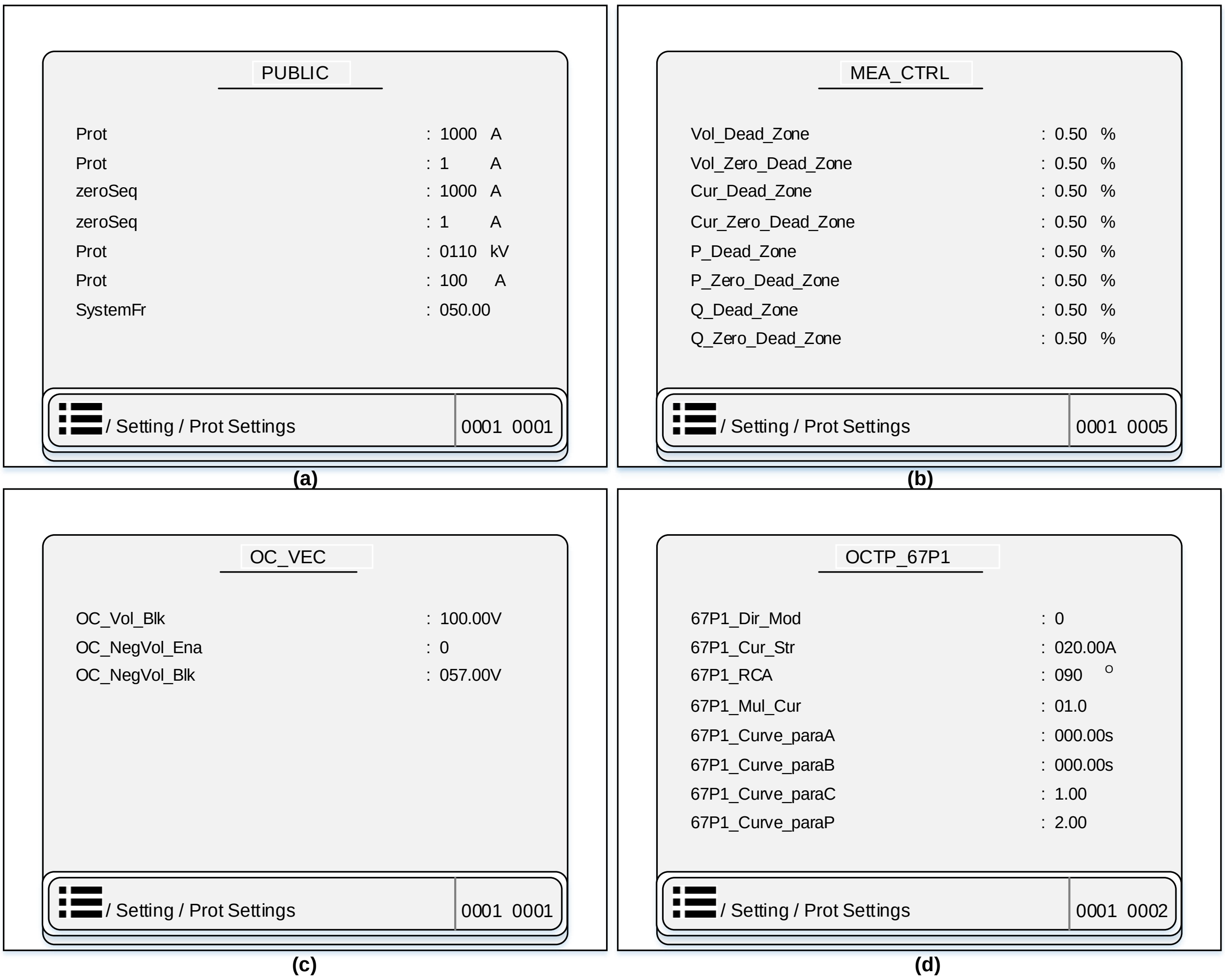


Figure 7.3-24 Diagram of Protection Setting

7.3.7 Configuration Information

This section divided into two sub-function like time and authorization. In this part user can set the device date and time according to the time zone of certain country. Besides that, the monitoring and controlling authorization of different users (of different post) can also be modified. The diagram of configuration information is shown in Figure 7.3-25.

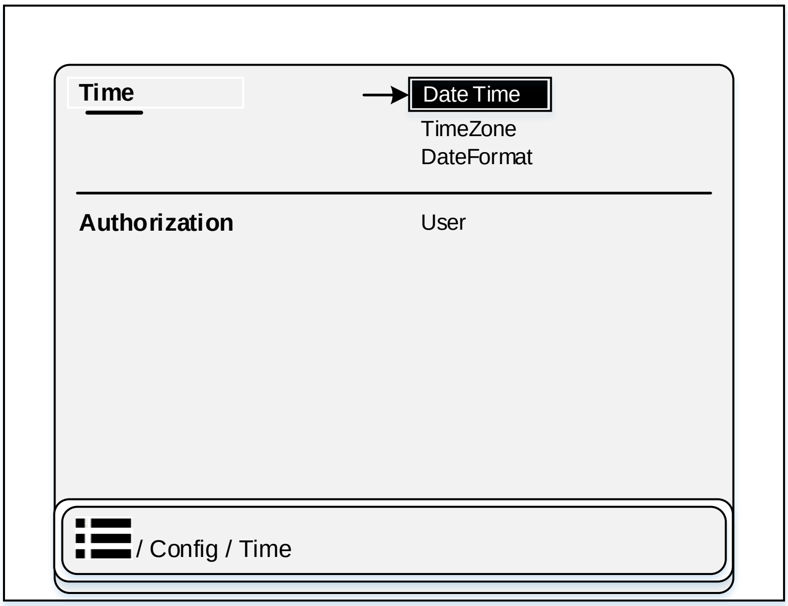


Figure 7.3-25 Overview Display of Configuration Information Sub-functions

7.3.7.1 Time

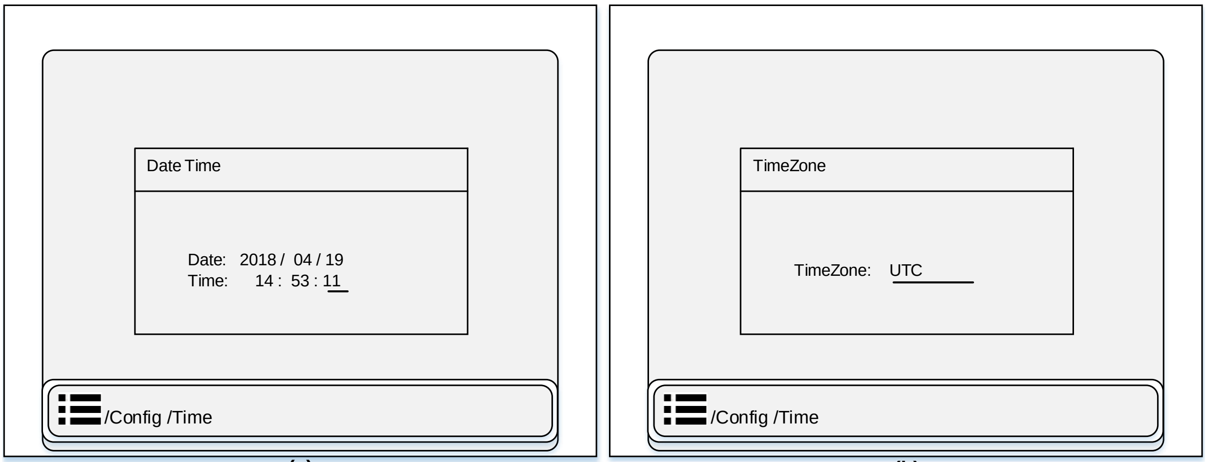
This part is divided into two sub-section date & time and time zone in Figure 7.3-25. User can access this function through the following path: “Configuration > Time”.

1- Date and time

In this section user can easily set date and time according to practical demand. See Figure 7.3-26 (a):

2- Time zone

In this section user can easily set time zone according to their region. See Figure 7.3-26 (b):



(a) **(b)**

Figure 7.3-26 Diagram of (a) Date & Time Setting (b) Time Zone Setting

7.3.7.2 Authorization

This part is divided into one sub-function. see Figure 7.3-27. User can access this function through the following path: “Configuration > Authorization”.

1- User

In this section user can easily set relay operator setting like operator 1 or 2 or guest. See Table 7.3-4 and Figure 7.3-27:

Table 7.3-4 User setting detail

User operator selection options	Authorization
Manuf	The manufacturer user has all the configuration functions of access to device setting. At the same time, only the manufacturer's user has the access to hide, read, and write (display) to the logical device LD, logical component LN and logical component data item DO of 61850 protocol and logical picture subgraph. Therefore, as to realize the manufacturer's basic configuration of the device and not be suitable for opening up the correlation. The content settings for users are hidden and should not be opened to users to modify, but the contents they need to view are set to read-only. ***Note!*** None of other users have access to this setting function except manufacturer.
Engineer	The engineering user staff account has all the general access of configuration (view and modification) functions of the configuration tool, including drawing logical pictures, main wiring diagrams etc. ***Note!*** In this user login section, user cannot create an account configuration of the configuration device setting. The engineering account can only view and modify its own password.
Operator1, Operator2	The operator user account, generally it can only view the configuration of the device, the logical picture, wiring diagram and the logical device component. In this section user can’t create and modify any of its configuration, such as moving the map element position and deleting port association etc.
Guest	Guest user account is only for visitors. In this section user have no rights to change or view any kind of configuration information.
Default	Default user is same as Guest, it is only for visitors, the device will recover to default user after the other types of user login for 3 minutes.

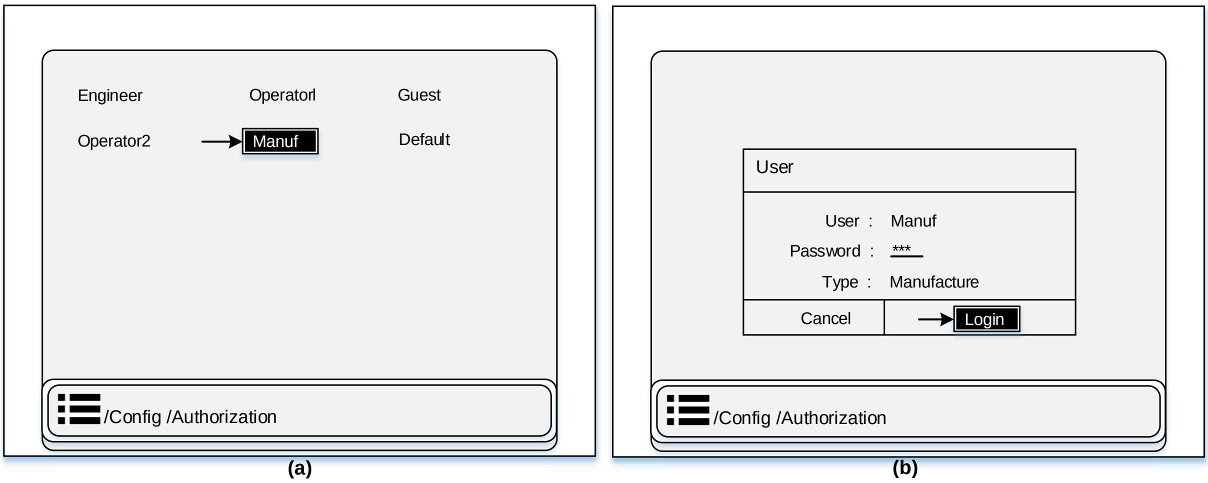


Figure 7.3-27 Diagram of Authorization User (a) Operator Selection List (b) Login or Cancel

7.3.8 Test Information

This section is divided into three sub-parts. In this section user can check the testing accuracy of relay like tripping test, signal test, operation test, warning test, block test, self-check test, measurement test and mandatory wave etc. The overview display diagram of test information is shown in Figure 7.3-28:

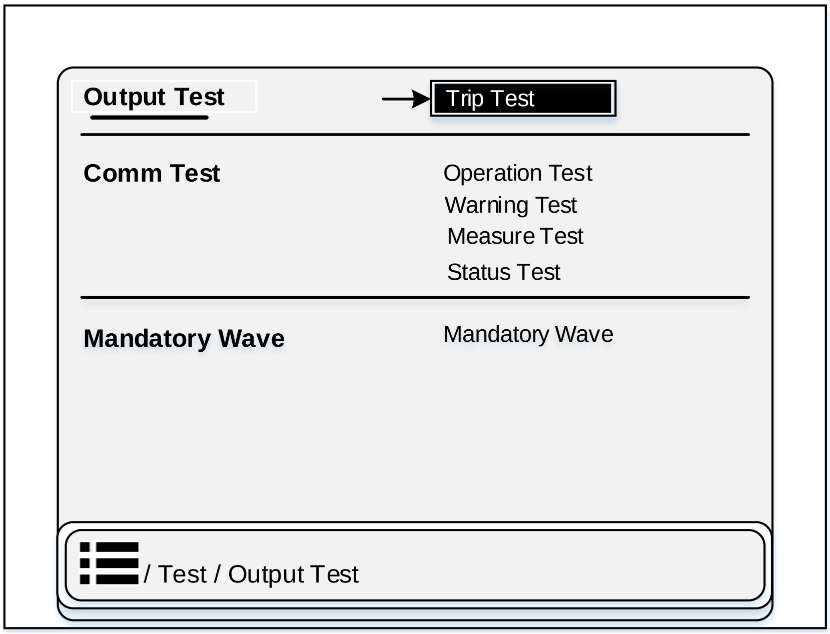


Figure 7.3-28 Overview Display of Test Information Sub-functions

7.3.8.1 Output Test

Output test is divided into two sub-test like tripping test and signal test. See Figure 7.3-29. User can access this function through the following path: “Test > Output Test”.

1- Trip Test

In this section user can simulate different trip signal, but the tripping simulation can only be conducted when the IED is under maintenance.

2- Signal Test

In this section user can simulate all kind of signal test like operation signal, alarm signal and signal reset.

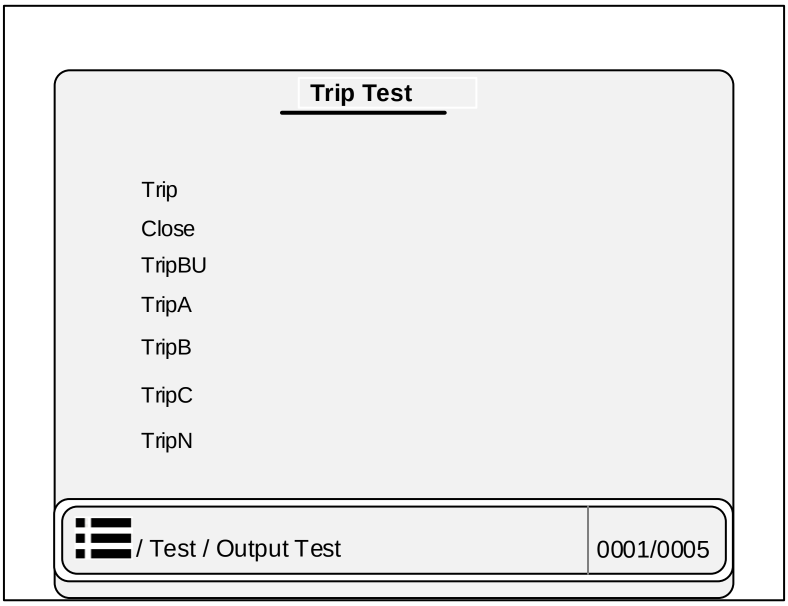


Figure 7.3-29 Overview Diagram of Trip Test

7.3.8.2 Comm Test

Common test is divided into six sub-test like operation test, warning test, block test, SelfChk test, measure test and status test, etc. User can access this function through the following path: “Test > Comm Test”. The LCD overview display diagram of common test information of every tests is shown in Figure 7.3-30.

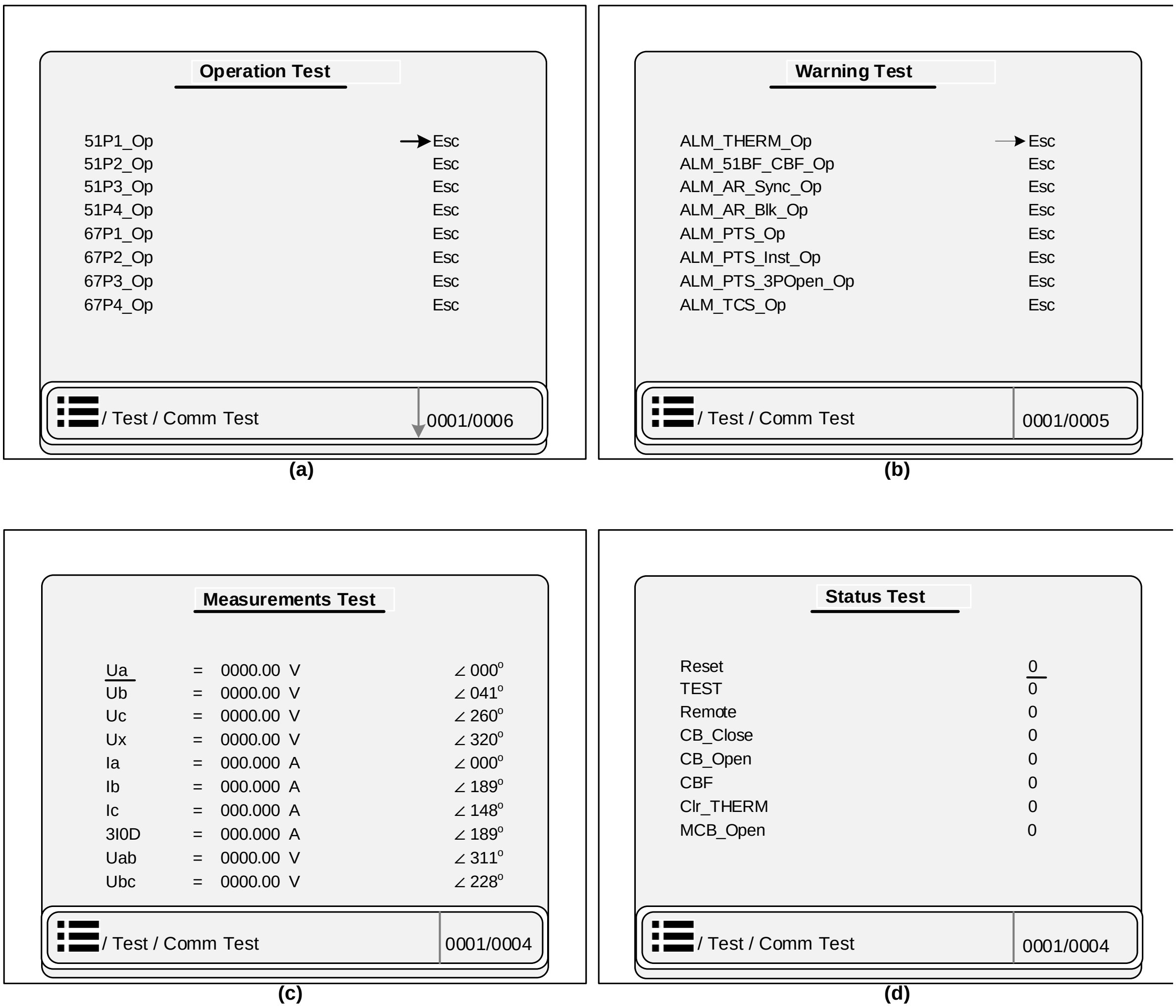


Figure 7.3-30 LCD Display Diagram of (a) Operation Test (b) Warning Test (c) Measurement Test (d) Status Test

1- Operation Test

In this section user can simulate the protection operation event like 51P, 51G and 67P operation function etc. see Figure 7.3-30 (a):

2- Warning Test

In this section user can simulate the warning event like thermal alarm, breaker failure alarm and PTS alarm etc. see Figure 7.3-30 (b):

3- Measurement Test

In this section user can simulate the measurement values like voltage and current of phase A, B & C, zero sequence voltage and current, frequency and angle etc. see Figure 7.3-30 (c):

4- Status Test

In this section user can simulate the BI changing status, like reset, remote, CB close or open, 50BF, TCS, SOTF start and BI open or close etc. see Figure 7.3-30 (d):

7.3.8.3 Mandatory Wave

In this section user can check the mandatory wave function. User can access this function through the following path: "Test > Mandatory wave". After enter this section user can manually start disturbance recording in disturbance record section. See Figure 7.3-20 (fault wave):

7.3.9 Clear Information

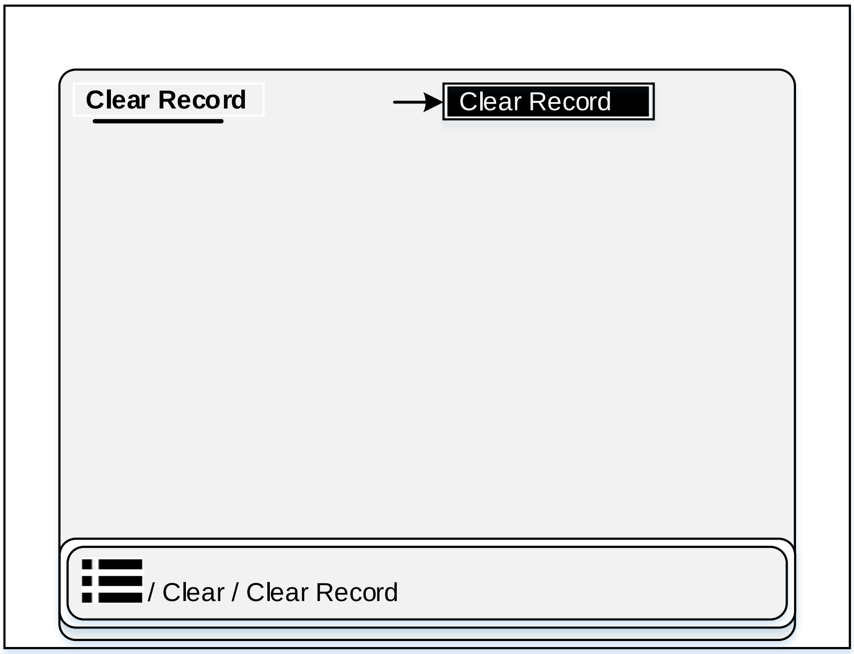


Figure 7.3-31 Overview Display of Clear Information Sub-functions

7.3.9.1 Clear record

In this section user can clear the record history of different functions like Alarm record, LED record and act record etc. User can access this function through the following path: “Clear > Clear record”. The clear record structure of LCD display is listed in Figure 7.3-32:

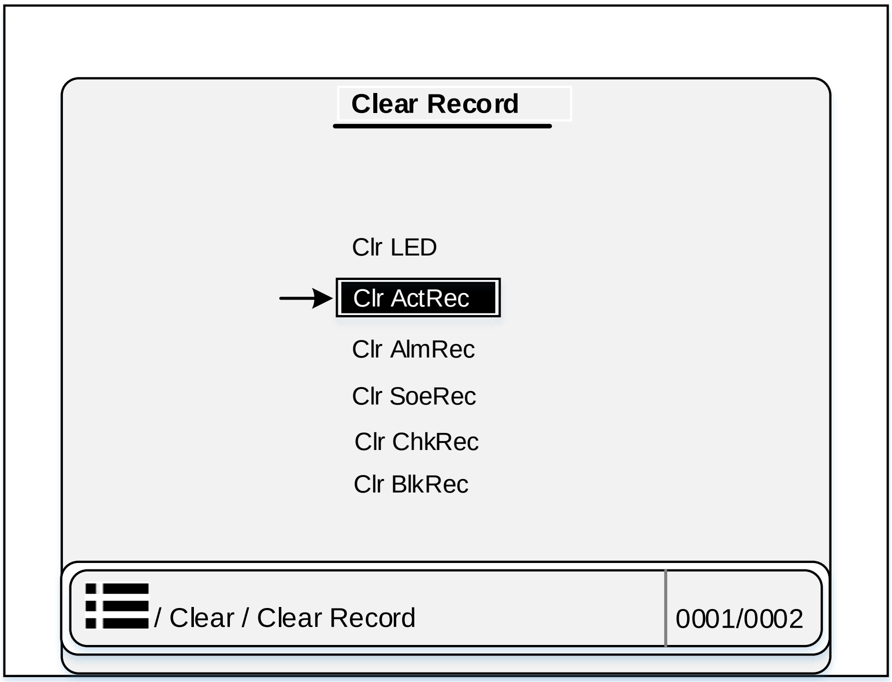


Figure 7.3-32 Diagram of Clear Record Display

7.3.10 Language Information

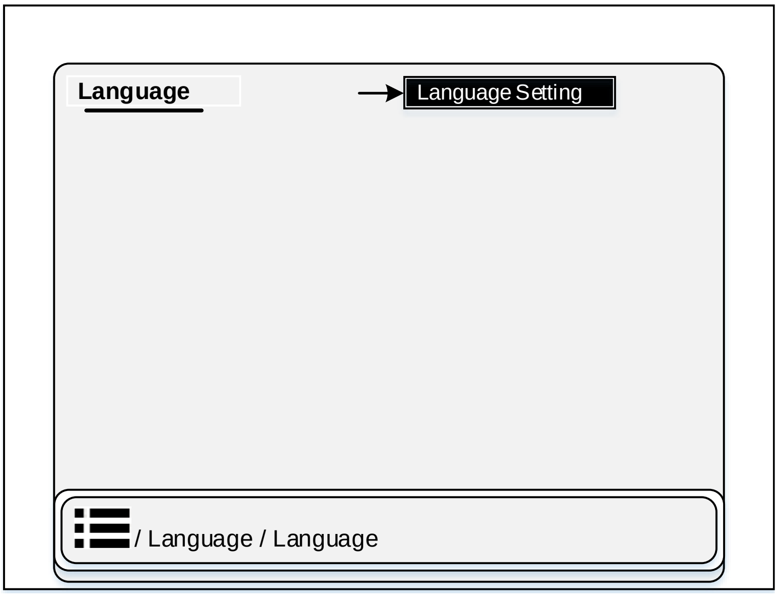


Figure 7.3-33 Overview Display of Language Information Sub-functions

7.3.10.1 Language Setting

In this section user can set the IED language according to their demand like Chinese, English, Hindi, German and Russian etc. User can access this function through the following path: “Language > Language setting”. The language setting diagram of relay is listed in Figure 7.3-34:

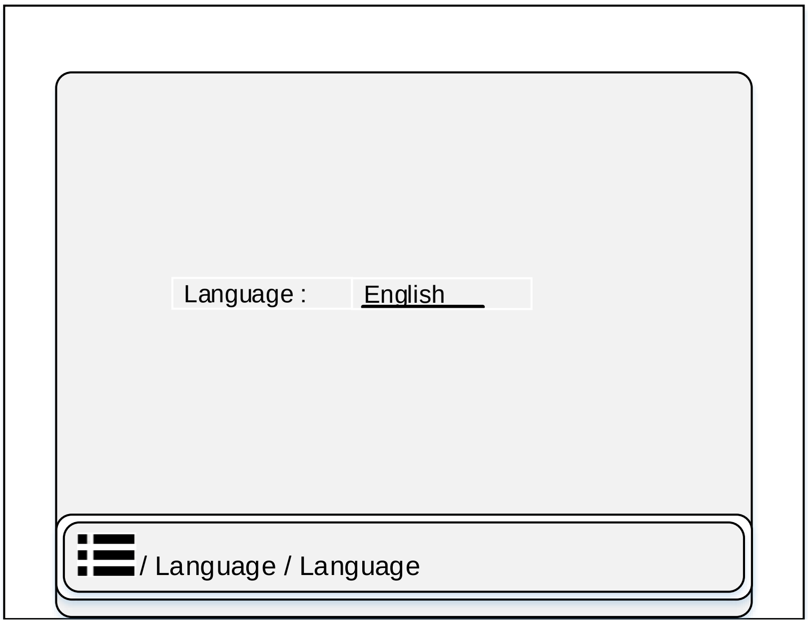


Figure 7.3-34 LCD Display diagram of Language Setting

8 Configurable Function

8.1 General Description

Each product has different configuration parameters according to the functions it has been designed to perform. There is a common methodology used across the entire product series to set these parameters.

The IED is equipped with flexible and powerful configuration functions, including the system configuration, the protection logic configuration, the binary input configuration, the binary output configuration, the setting groups selection and the LED indicator configuration through the auxiliary software, which makes this IED meet various practical requirements.

8.2 PRS IED Studio Software

The PRS IED Studio software is developed in order to meet customer's demand on functions of the UAPC platform device, such as device configuration and programmable design. It selects substation as the core of data management and the device as fundamental unit, supporting one substation to supervise many devices.

The software provides two kinds of operation modes: on-line mode and off-line mode. The on-line mode supports the Ethernet connection with the device through the standard IEC60870-5-103 and can be capable of uploading and downloading the configuration files through Ethernet net. The relay parameters and status can be monitored while the device is connected, and the fault wave recording can read and analyzed. The off-line mode supports the off-line setting configuration, including protection logic programming, the binary input configuration, the binary output configuration and etc.

The software provides Online and Off-line comparison function, contain the setting and logic comparison. Online comparison can compare relay configuration and PC backup configuration. Off-line comparison can compare two devices off-line configuration.

8.3 Setting Group Selection

You can select the setting group using binary inputs. You can choose binary inputs through the configuration tool, different binary inputs correspond to different setting groups. You can set the setting group with binary inputs according to the following table:

Table 8.3-1 Recording Time Settings

BI_SETGRP1	setting group01
BI_SETGRP2	setting group02
BI_SETGRP3	setting group03
BI_SETGRP4	setting group04

The path to the configuration tool:

[IED]->[Logic]->[PLAT]->[PUB_SetVal].

8.4 Configuration File Introduction

8.4.1 Parameter-PUBLIC

8.4.1.1 Macro Cfg Functions and Parameters

Configuration location: [Parameter]-[PUBLIC]- [Macro Cfg]

This module is used to set the basic functions of the device, such as rated frequency, analog signal transmission type, PRP/HSR function disable and enable, device naming, etc.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
Sys_Frequency	Rated frequency (fn): 50/60Hz
If_Comm_Primary_Val	FALSE: send with secondary values TRUE: send with primary values
NetMode_Stationbus	NORMAL: AB network enable PRP: PRP function enable HSR: HSR function enable
NetMode_Processbus1	NORMAL: AB network enable PRP: PRP function enable HSR: HSR function enable
NetMode_Processbus2	NORMAL: AB network enable PRP: PRP function enable HSR: HSR function enable
g_cEquipName	Device name

8.4.1.2 Timing Mode Functions and Parameters

Configuration location: [Parameter]-[PUBLIC]- [Timing mode]

This module is used to set up devices that support two synchronization methods simultaneously.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
TmrType1	The device supports two timing methods: TmrType1 and TmrType2. Normally the first timing method TmrType1 is preferred for timing, while the second timing method TmrType2 is backup. When the first timing method is interrupted, it automatically switches to the second timing method.
TmrType2	

Configuration location: [Parameter]-[PUBLIC]- [Timing mode]-[TmrType1/TmrType2]

This module is a timing method supported by the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
SNTP	SNTP timing requires setting the IP address of the timing server on the corresponding timing component
IRIG-B	When checking the B code, it is necessary to set the electrical B or optical B code and verification method on the corresponding timing component
1588	1588 PTP timing requires setting a transparent clock (P2P or E2E) and receiving message network port on the corresponding timing component
None	No timing

8.4.1.3 SR76XX\SR73XX Module with Output Parameters

Configuration location: [Parameter]- [PUBLIC] -[SR76XX-XXIXXO] or [Parameter] -[PUBLIC] -[SR73XX-XXIXXO].

XXI means the XX binary input(BI), XXO means XX binary output(BO). SR76XX is power module with BOs, such as: SR7601_0I11O is with 11 BOs; SR73XX is module type with some or whole BOs, such as: SR7300_0I14O is with 14 BOs, SR7302_0I16O is 16 with BOs, SR7310_9I7O is 7 with BOs.

This module is for setting up the device output board.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
SlotNO	The module number in the device
KOXXIndex	XX means the BO number. The Index means the BO can be associated with output resources in the OUTPUT of the CONST node.
KOXXDspStat	XX means the BO number. The DspStat means maintain condition: Not Hold: the hardware BO is not maintained, it will reset when the associated output resources are reset when there is no fault. Hold: the hardware BO is maintained, it will reset when both the associated output resources and the Start signal are reset when there is no fault, the Start signal is default last for pulse time about 7s. Condition Hold: only used for OC with 79AR functions, when the 79AR reclosed several shots, only the last OC trip phase BO will be hold.

8.4.1.4 SR78X LED module Parameters

Configuration location: [Parameter]-[PUBLIC]-[SR780_32LED]

SR78X is an LED module with 32 LEDs.

This module is for setting up the device LED module.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
LED_XX_Index	XX means the LED number. The Index means the LED can be associated with output resources in the OUTPUT of the CONST node.
LED_XX_DspStat	XX means the LED number. Maintain the attribute, Not Hold is not held, and automatically extinguishes if the condition is not met; Hold is held, automatically held when illuminated; Conditional Hold is a condition held, and only a trip after the device coincides will extinguish the lights that do not meet the conditions
LED_XX_ColStat	XX means the LED number. Select colors, green, yellow, and red are optional

8.4.1.5 SR73XX Input module parameters

Configuration location: [Parameter]-[PUBLIC]-[SR73XX-XXIXXO]

XXI means the XX binary input(BI), XXO means YY binary output(BO). SR73XX is module type with some or whole BIs, such as: SR7330_18I0O is with 18 BIs, SR7310_9I7O is 9 with BIs and 7BOs.

This module is for setting up the device input module.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
KIXXIndex	XX means the KI number. The Index means the BI can be associated with input resources in the INPUT of the CONST node.
KIXXHoldSet	XX means the KI number. Debouncing time setting, in milliseconds. If the input power is a DC power supply, the hard switch input debouncing time is usually set to 1000ms, the remote signal input debouncing time is usually set to 20ms, and the protection input debouncing time is usually set to 10ms; If the input power is AC power, the debouncing time is usually set to 6ms

Data item description	The detail explanation
KIXXHoldVol	XX means the KI number. Set the power supply voltage according to the actual situation

8.4.1.6 SR71XX Analog module parameters

Configuration location: [Parameter]-[PUBLIC]-[SR71XX]

SR71XX is an analog module with two configurations: 7U8I (8 sets of voltage and 7 sets of current) and 8U7I (7 sets of voltage and 8 sets of current).

This module is for setting up the device analog module.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
CtXTAIn1	X means the ANA number. Associate CT with primary values, which can be associated with fixed value resources in SET under the CONST node
CtXTAIn2	X means the ANA number. Associate CT with secondary values, which can be associated with fixed value resources in SET under the CONST node.
CtXIndex	X means the ANA number. Associate analog resources, which can be associated with analog resources in ANA under the CONST node
PtXTAIn1	X means the ANA number. Associate PT with primary values, which can be associated with fixed value resources in SET under the CONST node
PtXTAIn2	X means the ANA number. Associate PT with secondary values, which can be associated with fixed value resources in SET under the CONST node
PtXIndex	X means the ANA number. Associate analog resources, which can be associated with analog resources in ANA under the CONST node

8.4.1.7 User Functions and Parameters

Configuration location: [Parameter]-[PUBLIC]-[User]

This module is set for device login users.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
UserName	Login user name
Type	Login user type
Password	Login user password

8.4.1.8 DNP_Para Functions and Parameters

When using the DNP protocol as the communication protocol, corresponding communication parameters need to be set;

Configuration location: [Parameter]-[PUBLIC]-[DNP_Para]

This module is for setting the DNP parameters of the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
RetryTime	Number of retransmissions, default to 0. If there are no special requirements. The parameter can be set by default
Delay1	The retransmission interval 1, which is set to 0 by default. If there are no special requirements, the parameter can be set by default
Delay2	The retransmission interval 2, which is set to 0 by default. If there are no special requirements, the parameter can be set by default
Infinite	If the main station does not confirm whether to infinitely retransmit the flag, it defaults to 0. If there are no special requirements, the parameter can be set by default
FragSize	The application layer buffer size is set to 0 bytes by default
FlgLastConSet	Whether the last CON is set during multi frame transmission it defaults to 0. If there are no special requirements, the parameter can be set by default
TimeCycle	The DNP timing cycle is set to 0 by default. If there are no special requirements, the parameter can be set by default
IfUTCTime	Send with the UTC or local time flag. True: UTC, FALSE: local time, which defaults to FALSE and takes the local time
UNSEnable	The enable flag for non-request submission, Default setting is FALSE
BufferSizeSOE	Judgment mar of Buffer over Flow，Default setting is 512.
BufferSizeCOS	Judgment mar of Buffer over Flow，Default setting is 256.

8.4.1.9 Com_Para Functions and Parameters

Configuration location: [Parameter]-[PUBLIC]-[Com_Para_1/2/3]

This module is for setting the COM port parameters of the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
PortID	The port name corresponds to the hardware serial port
PortType	Port type, configure according to the type of serial port used
IfUsed	Whether to use, default to True
Protocol	Transport Protocol，default to UDP_INC_103
BaudRate	BAUD,default to 9600
DataBit	Data bits，default to 8
VerfMode	Parity verification type: None, Odd, Even, the default is None
StopBit	Stop bit,default to 1
MasterNo	Main Station Number, which is the address of the monitoring host or RTU, default to 1
StationNo	Substation number，for device address，default to 46

8.4.1.10 Net_Para Functions and Parameters

When using a network port communication protocol other than 61850 protocol, corresponding network port communication parameters need to be set.

Configuration location: [Parameter]-[PUBLIC]-[Net_Para_1/2/3]

This module is for setting the NET port parameters of the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
PortID	Monitoring physical network port selection, with NET_1, NET_2, and NET_3 corresponding to the three rear network ports of the CPU board
PortType	Port type, configure according to the type of serial port used
IfUsed	Whether to use, default to True
Protocol	Transport Protocol，default to UDP_INC_103
IfDblMac	Is it a dual MAC address, there is no concept of dual machine dual network in foreign countries, so the parameters related to the dual machine dual network concept do not need to be configured and can be kept as default
IfDblNet	Whether it is a dual network or not, there is no concept of dual machine dual network in foreign countries, so the parameters related to the dual machine dual network concept do not need to be configured and can be kept as default
NetPort	The monitoring number can be flexibly configured according to actual use
MasPortID	Host monitoring port selection, default to NET_A
SlaPortID	The selection of sub machine monitoring port defaults to NET-B
MonIP	Monitor the host IP and configure it according to actual usage needs, with a default value of 222.111.112.200
MonIP2	Monitor the host IP and configure it according to actual usage needs
SlaMonIP	Monitor the IP of the sub machine and configure it according to actual usage needs
SlaMonIP2	Monitor the IP of the sub machine and configure it according to actual usage needs
MasterNo	The main station number, which is the monitoring host or RTU address, defaults to 1
StationNo	The sub-station number is the device address, which defaults to 9

8.4.1.11 GOOSE_GOIN_DPCS Functions and Parameters

Configuration location: [Parameter]-[PUBLIC]-[GOOSE_GOIN_DPCS]

This module is used to set the GOOSE dual point signal parameters for the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
KIXXIndex	Composite dual point single point closing input signal, XX is the number
KIXXIndexDPS	Composite dual point single point opening input signal, XX is the number

8.4.1.12 PUB_DPC_BOX Functions and Parameters

Configuration location: [Parameter]-[PUBLIC]-[PUB_DPC_BOX]

This module is used to set the input signal parameters for synthesizing GOOSE dual points for the device.

The detail explanation of the data item description is as following:

DBPinX: Composite dual point input signal

DBPinXOpn: Composite dual point single point closing input signal

Data item description	The detail explanation
DBPinX	Composite dual point input signal
DBPinXOpn	Composite dual point single point closing input signal

Note: GOOSE_GOIN_DPCS and PUB_DPC_BOX need to be used in conjunction to synthesize GOOSE dual point inputs for device display.

8.4.2 Const

8.4.2.1 INPUT Functions and Parameters

Configuration location: [Const]-[INPUT]

This module is for setting the input parameters of the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
Index	Resource sequence number
Name	Input Name
DNP Upload	Resource transmission method USE DNP: DNP protocol submission USE MMS: MMS protocol submission GOOSE IN: GOOSE input GOOSE OUT: GOOSE output STATION GOOSE: As a station goose PROCES BUS: As a process goose SV: Used as SV
Desc	Input Description

8.4.2.2 OUTPUT Functions and Parameters

Configuration location: [Const]-[OUTPUT]

This module is for setting the output parameters of the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
Index	Resource sequence number
Name	Output Name
DNP Upload	Resource transmission method USE DNP: DNP protocol submission USE MMS: MMS protocol submission GOOSE IN: GOOSE input GOOSE OUT: GOOSE output STATION GOOSE: As a station goose PROCES BUS: As a process bus SV: Used as SV
Desc	Output Description

8.4.2.3 ANA Functions and Parameters

Configuration location: [Const]-[ANA]

This module is for setting the analog parameters of the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
Index	Resource sequence number
Unit	Analog quantity secondary value unit
KiloUnit	Analog quantity primary value unit
Name	Analog quantity name
Related Set	The primary rated value of analog quantity
TA Index	The secondary rated value of analog quantity
DNP Upload	Resource transmission method USE DNP: DNP protocol submission USE MMS: MMS protocol submission GOOSE IN: GOOSE input GOOSE OUT: GOOSE output STATION GOOSE: As a station goose PROCES BUS: As a process bus SV: Used as SV
Desc	Analog quantity description

8.4.2.4 WAVANA Functions and Parameters

Configuration location: [Const]-[WAVANA]

This module is used to set the parameters for the analog recording of the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
Ana Number	Analog quantity number in waveform recording
Ana Channel	Analog channels in waveform recording

8.4.2.5 WAVAKI Functions and Parameters

Configuration location: [Const]-[WAVAKI]

The detail explanation of the data item description is as following:

Data item description	The detail explanation
StateCode	Number of input in waveform recording
SrcPinNO	Corresponding input in waveform recording

8.4.2.6 WAVAKO Functions and Parameters

Configuration location: [Const]-[WAVAKI]

This module sets the parameters for the recording input of the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
StateCode	Number issued in the recording
SrcPinNO	Corresponding output in waveform recording

8.4.2.7 ACTREC Functions and Parameters

Configuration location: [Const]-[ACTREC]

This module sets the parameters for device action events.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
Index	Number issued in the recording
Name	Action Event Name
DNP Upload	Resource transmission method USE DNP: DNP protocol submission USE MMS: MMS protocol submission GOOSE IN: GOOSE input GOOSE OUT: GOOSE output STATION GOOSE: As a station goose PROCES BUS: As a process bus SV: Used as SV
Desc	Action Event Description

8.4.2.8 ALMREC Functions and Parameters

Configuration location: [Const]-[ALMREC]

This module sets the parameters for device alarm events.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
Index	Number issued in the recording
Name	Alarm Event Name
DNP Upload	Resource transmission method USE DNP: DNP protocol submission USE MMS: MMS protocol submission GOOSE IN: GOOSE input GOOSE OUT: GOOSE output STATION GOOSE: As a station goose PROCES BUS: As a process bus SV: Used as SV
Desc	Alarm Event Description

8.4.2.9 WAVECFGBOOL Functions and Parameters

The device supports monitoring the exit sign output of a certain component as a WAVECFGBOOL, when a change in the flag is detected, it can be set as a wave start flag or a recording action flag. When monitoring the output of a component outlet on site, create a new WAVECFGBOOL in the component and modify the corresponding detection point parameters in WAVECFGBOOL under the CONST node.

Configuration location: [CONST]-[WAVECFGBOOL]-[WaveType/Name/Desc]

The detail explanation of the data item description is as following:

Data item description	The detail explanation
WaveType	Note: Recording type： TYPE_STR represents startup type, When the flag is set, it serves as the startup flag in recording. If there is only startup but not operation or action, the startup waveform file will be produced with type “_s”. TYPE_ACT represents the type of action, and when the flag is set, it will be used as an action flag in the wave, if there are one or more operation or action, the action waveform file will be produced with type “_f”. TYPE_NULL indicates other types, and the state of this type is normally monitored in “_s” or “_f” waveform recording file, but it will not trigger to product a new waveform recording file.
Name	The name of the disturbance wave signal.
Desc	The description of the disturbance wave signal.

Note: After creating the WAVECFGBOOL, the WaveType must be set, otherwise the device will not run.

8.5 User login permissions

This module provides user login permissions.

Main Function Category	Function description	Super	Engineer	Operator
Create new users	Create new users with a lower level than the current user	Engineer, Operator	-	-
Change password	Change the login password	√	√	√
Right click dropdown menu for “New interval”	Creating a device through backup files	√	√	√
	Delete device group	√	√	√
Right click dropdown menu for "device"	Editing device: create, delete, copy	√	√	√
	Export backup files and driver files	√	√	-
Parameter	Edit parameters: New, Delete, Copy	√	-	-
	ANA module channel association	√	-	-
	IO module channel association, Module channel settings association, Renaming, Language, Timing method, IP address	√	√	-
Const	Edit interface resource properties (such as name, maximum, minimum, step size, setting value, etc.)	√	-	-
	Edit interface resource description	√	√	-
Logic	View logic diagram	√	√	√
	Renaming logical nodes, creating and editing subgraphs and properties, primitives, connections, signals, recording, etc.	√	√	-

Note: “√” means this function is available, and “-” means this function is not unavailable.

9 Communication Protocol

9.1 Overview

This chapter introduces the data communication and the corresponding hardware of the IEDs. The IED support a wide range of protocols via communication interface (RS-485 or Ethernet port). The protocols are of international standard for communication in substations and it can be selected by modifying the communication parameters.

Local communication with the IED via a computer is achievable thought both the front and back Ethernet ports. Furthermore, remote communication with SCADA or the station gateway is also achievable by choosing the IEC60870-5-103, IEC61850, DNP3.0 communication protocol via RS485 or Ethernet port.

It should be noted that the descriptions contained within this chapter do not aim to fully detail the protocol itself. This section serves to describe the specific implementation of the protocol in the relay.

9.2 Rear Communication Interface

9.2.1 Ethernet Interface

This protective device can provide three rear Ethernet interfaces (optional) and they are unattached each other. Parameters of each Ethernet port can be configured in the menu.

9.2.1.1 Ethernet Standardized Communication Cable

It is recommended to use twisted screened eight-core cable as the communication cable. A picture is shown below.

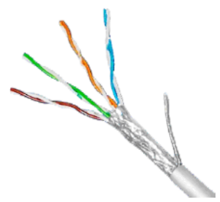


Figure 9.2-1 Ethernet communication cable

9.2.1.2 Ethernet Communication protocol

Ethernet communication protocols are supported by the device including: IEC60870-5-103, PRP/HSR, DNP3.0, IEC61850 etc. For more details about these communication protocols, see the correlative standards.

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9.3 Network Topology

9.3.1 Star Topology

Each equipment is connected with an exchanger via communication cable, and thereby it forms a star structure network. Dual-network is recommended in order to increase reliability. SCADA is also connected to the exchanger and will play a role of master station, so every equipment which has been connected to the exchanger will play a role of slave unit.

9.3.2 PRP/HSR Topology

The IED supports the PRP/HSR (IEC 62439-3) protocol..

9.4 IEC61850 Protocol

9.4.1 Overview

The IEC 61850 standard is the result of years of work by electric utilities and vendors of electronic equipment to produce standardized communications systems. IEC 61850 is a series of standards describing client/server and peer-to-peer communications, substation design and configuration, testing, environmental and project standards. The complete set includes:

- IEC 61850-1: Introduction and overview
- IEC 61850-2: Glossary
- IEC 61850-3: General requirements
- IEC 61850-4: System and project management
- IEC 61850-5: Communications and requirements for functions and device models
- IEC 61850-6: Configuration description language for communication in electrical substations related to IEDs
- IEC 61850-7-1: Basic communication structure for substation and feeder equipment–Principles and models
- IEC 61850-7-2: Basic communication structure for substation and feeder equipment - Abstract communication service interface (ACSI)
- IEC 61850-7-3: Basic communication structure for substation and feeder equipment–Common data classes
- IEC 61850-7-4: Basic communication structure for substation and feeder equipment–Compatible logical node classes and data classes
- IEC 61850-8-1: Specific Communication Service Mapping (SCSM)-Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
- IEC 61850-9-1: Specific Communication Service Mapping (SCSM)-Sampled values over serial unidirectional multidrug point to point link

- IEC 61850-9-2: Specific Communication Service Mapping (SCSM)-Sampled values over ISO/IEC 8802-3
- IEC 61850-10: Conformance testing

These documents can be obtained from the IEC (http://www.iec.ch). It is strongly recommended that all those involved with any IEC 61850 implementation obtain this document set.

9.4.2 Communication Profiles

The PRS-7000 series relay supports IEC 61850 server services over TCP/IP communication protocol stacks. The TCP/IP profile requires the PRS-7000 series to have an IP address to establish communications.

9.4.2.1 MMS protocol

IEC 61850 specifies the use of the Manufacturing Message Specification (MMS) at the upper (application) layer for transfer of real-time data. IEC 61850-7-2 abstract services and objects are mapped to actual MMS protocol services in IEC61850-8-1.

9.4.2.2 Client/server

The core ACSI defined by IEC 61850 is mapped to manufacturing message specifications (ISO 9506-1, ISO 9506-2). This is a connection-oriented type of communication. The connection is initiated by the client, and communication activity is controlled by the client.

The rules to map the ACSI services supported by PRS-7000 series units to the MMS are as shown in following table

Table 9.4-1 Mapping of ACSI to MMS service

Name		Range
Server model	GetServerDirectory (read server directory)	GetNameList (read name list service)
Associate model	Associate (associate)	Initiate (initial service)
	Abort (abnormal abort)	Abort (abort service)
	Release (release)	Conclude (end service)
Logic device model	GetLogicalDeviceDirectory (read logic device directory)	GetNameList (read name list service)
Logic node model	GetLogicalNodeDirectory (read logic node directory)	GetNameList (read name list service)
	GetAllDataValues (read all data value)	Read (read service)
Data model	GetDataValues (read data value)	Read (read service)
	SetDataValues (set data value)	Write (write service)
	GetDataDirectory (define read data)	GetVariableAccessAttribute (read variable access attribute service)
	GetDataDefinition (read data directory)	GetVariableAccessAttribute (read variable access attribute service)
Data set model	GetDataSetValue (read data set value)	Read (read service)

Name		Range
	SetDataSetValue (set data set value)	Write (write service)
	CreateDataSet (establish data set)	DefineNamedVariableList (define named variable list service)
	DeleteDataSet (delete data set)	DeleteNamedVariableList (delete named variable list service)
	GetDataSetDirectory (read data set directory)	GetNamedVariableListAttribute (read named variable list attribute service)
Substituting model	SetDataValues (set data value)	Write (write service)
	GetDataValues (read data value)	Read (read service)
Setting group control block model	SelectActiveSG (select activating setting group)	Write (write service)
	SelectEditSG (select edit setting group)	Write (write service)
	SetSGValues (set setting group value)	Write (write service)
	ConfirmEditSGValues (confirm editting setting group value)	Write (write service)
	GetSGValues (read setting group value)	Read (read service)
	GetSGCBValues (read setting group control block value)	Read (read service)
Buffered report control block	Report (report)	InformationReport (information report)
	GetBRCBValues (read buffered report control block value)	Read (read service)
	SetBRCBValues (set buffered report control block value)	Write (write service)
Non-buffered report control block	Report (report)	InformationReport (information report)
	GetURCBValues (read non-buffered report control block value)	Read (read service)
	SetURCBValues (set non-buffered report control block value)	Write (write service)
Log control block model	GetLCBValues (read log control block value)	Read (read service)
	SetLCBValues (set log control block value)	Write (write service)
	QueryLogByTime (query log by time)	ReadJournal (read log service)
	QueryLogAfter (query log after)	ReadJournal (read log service)
	GetLogStatusValues (read log status values)	Read (read service)
GOOSE	GetGoCBValues (read GOOSE control block values)	Read (read service)
	SetGoCBValues (set GOOSE control block values)	Write (write service)
GSSE	GetGsCBValues (read GSSE control block values)	Read (read service)
	SetGsCBValues (set GSSE control block values)	Write (write service)
MSV	GetMSVCBValues (read MSV control block values)	Read (read service)

Name		Range
	SetMSVCBValues (set MSV control block values)	Write (write service)
USV	GetUSVCBValues (read USV control block values)	Read (read service)
	SetUSVCBValues (set USV control block values)	Write (write service)
Control model	Select (select)	Read (read service)
	SelectWithValue (select with value)	Write (write service)
	Cancel (cancel)	Write (write service)
	Operate (operate)	Write (write service)
	CommandTermination (command termination)	InformationReport (information report)
	TimeActivatedOperate (time activated operation)	Write (write service)
File transmission model	GetFile (read file)	FileOpen, FileRead, FileClose (file open, file read and file close service sequence)
	SetFile (set file)	ObtainFile (obtain file service)
	DeleteFile (delete file)	FileDelete (file delete service)
	GetFileAttributeValues (read file attribute values)	FileAttributes (file attribute service)

9.4.2.3 Peer-to-peer

This is a non-connection-oriented, high speed type of communication usually between substation equipment, such as protection relays, intelligent terminal. GOOSE is the method of peer-to-peer communication.

9.4.2.4 Substation configuration language (SCL)

IEC 61850 has defined a series of configuration documents (ICD, IID, SCD, SED, CID), which are prepared with SCL (substation configuration language). The SCL includes the following:

Head: it is used to identify a SCL configuration document and its version, and also to designate relevant names into the mapping option of information (Function Name)

Substation: it is used to describe the function structure of the substation, and mark the primary devices and their electrical connection relationship.

IED: intelligent electronic device description, to describe the IED pre-configuration, access points, logic devices, logic nodes, data objects, etc.

DataTypeTemplate: the instantiated logic node type, and logic node type is a specific sample of logic node data.

The purpose to define and use SCL is that the description of intelligent electronic device capability and description of substation automation system can be exchanged in a compatible manner between the intelligent electronic device management tools and system configuration tools provided by different manufacturers.

9.4.2.5 GOOSE

GOOSE service is used to transmit fast messages, such as trip signal and switch position.

The GOOSE service adopts the peer-to-peer transmission, and is classified as GOOSE sending and GOOSE receiving.

9.4.2.6 GOOSE sending mechanism

GOCB is automatically enabled when the unit is powered on. When all status of the unit is determined, it performs sending according to the data set shifting mode, to quickly send the initial status of the own GOOSE information;

The time interval for immediate re-sending after shifting of GOOSE message is the MinTime parameter (i.e. T1). The “timeAllowedtoLive” parameter in GOOSE message is 2 times of the “MaxTime” configuration parameter (i.e. 2T0);

9.4.2.7 GOOSE receiving mechanism

The GOOSE receiving buffer zone of the unit receives the new GOOSE messages, after a strict check of the relevant parameters of GOOSE messages. The receiving side first compares whether the StNum (status number) of the newly received frame and that in the GOOSE message of the previous frame are equal. If the StNum of the two frames of GOOSE messages are equal, the SqNum (sequence number) of the two frames of GOOSE messages are compared. If the SqNum of the newly received GOOSE frame is bigger than the SqNum of the previous frame, this GOOSE message is discarded, otherwise the data of the receiving side is updated. If the two GOOSE messages have different StNums, the data of the receiving side are updated;

When receiving GOOSE messages, the PRS-7000 series unit strictly checks if parameters such as AppID, GOID, GOCBRef, DataSet and ConfRev are matching.

In receiving GOOSE messages, it will take into account cases of communication interruption of fault with issuing unit. When the GOOSE communication is interrupted or the configured versions are not identical, the received GOOSE message should maintain the status before interruption.

9.4.3 Data set and control block

PRS-7000 series devices support real-time sending of data. The data objects requiring real-time monitoring are configured into data set, and the data set is associated to report control and GoCB, so that the change information of monitored objects can be sent in real-time to the SCADA via the report service and GOOSE.

9.4.3.1 Data set

PRS-7000 series devices usually configure data sets in advance in the ICD document, such as protection event, protection digital input and protection measurement. The SCT (system configuration tool) can also add, delete and modify data set configuration according to the needs of existing actual projects.

A data set is an ObjectReference set of orderly DATA or DataAttrubutes. It usually includes the following attributes:

- ldInst: the logic device containing the DATA or DataAttrubutes;
- lnClass: the logic node class containing the DATA or DataAttrubutes;
- lnInst: the logic node instant number containing the DATA or DataAttrubutes;
- Fc: all attributes of functional constraint required by DATA or DataAttrubutes;
- doName: name of DATA, or name belonging to the DataAttrubutes;
- daName: attribute name.

9.4.3.2 Report control block

IEC 61850 has defined the report control block, to describe how the changed information is actively submitted via report service when the data set members have changed. Report control blocks are classified into buffered report control block and non-buffered report control block. In case of communication interruption, the newly occurring event will still be stored as buffered report control block, otherwise, it is a non-buffered report control block.

The report control block performs the control of report submission via a series of attribute configurations. Specifically, it has the following important attributes:

RptID

The identity of report control block, globally unique within the scope of LD. If the RptID of the RCB is set by the client side as NULL, RptID is full path in the report submitted by device.

OptFlds

The option fields OptFlds contained in the report. The PRS-7000 series device supports the following option fields:

— Bit 1: Sequence-number
— Bit 2: Report-time-stamp
— Bit 3: Reason-for-inclusion
— Bit 4: Data-set-name
— Bit 5: Data-reference
— Bit 7: EntryID (for buffered reports only)
— Bit 8: Conf-revision
— Bit 9: Segmentation

When an item is set as 1, the corresponding information will be embodied in the report.

DatSet

The name of the data set associated with the report control block and under the same LD. The members of this data set are monitored by this report control block.

BufTm

Buffer time, it is the buffer time internally prompted by the dchg (data change), qchg (quality change), and dupd (data updating) of the rcb, in ms, with default value as 0, indicating not using the buffer time attribute, and the maximum value is 1h.

The timer will start when the first internal prompt arrives. When timer reaches the time value, all event messages within the buffer time are packed into one report, and submitted to the client side.

When the second change of the same signal arrives in the buffer time, the buffered report is submitted immediately, and the timer is reseted, to start again the subsequent internal prompt buffer.

TrgOps

Trigger option, used to filter the conditions for sending reports. PRS-7000 supports the following trigger options:

- Bit 1*:* Data change
- Bit 2: Quality change
- Bit 3: Data updating (the service follow-up of Ed2)
- Bit 4: Completeness period
- Bit 5: Total call

IntgPd

Completeness period time, to be set by the client side. After successful device enabling (RptEna = TRUE), the timer is started immediately, and after the expiration of completeness period time, the current values of all members in the data set associated by the report are packed and submitted.

The completeness period time set as 0 means the completeness submission function is not enabled.

GI

Total call is launched by the client side with initiative. After the report is enabled, the client side takes initiative to issue GI = TRUE, then the device immediately submits all data values in the current data set.

PurgeBuf

Purge buffer. When the client side sets PurgeBuf = TRUE, all report in the IED buffer report are purged.

When the client side modifies RptID, DataSet, BufTime, TrgOps, IntgPd, the device will automatically set purging buffer reports, equivalent to setting PurgeBuf = TRUE.

9.4.3.3 GOOSE control block

The fast messages of the PRS-7000 series device are transmitted via GOOSE, and the transmission characteristics of GOOSE is controlled by the GOOSE control block (GoCB). GoCB has the following important characteristics:

App ID

The application ID, representing the logic device where the GoCB is located. The missing value of App ID is the Object Reference of GoCB.

DatSet

The values of members of the data set associated by GoCB are transmitted by GOOSE.

9.4.4 Logic nodes and data modeling

9.4.4.1 Logic nodes

IEC 61850 7-4 has defined a series of logic nodes, which constitute the minimum communication unit of intelligent electronic devices as classified by functions. There are three types of logic nodes used by the PRS-7000 series unit: management logic nodes (LLN0), physical device logic nodes (LPHD) and application function logic nodes.

LLN0

Management logic nodes provide the management and control functions for all logic nodes and data objects within the logic devices. Some common services are modeled in LLN0, such as setting group control block (SGCB), GOOSE control block (GoCB), SV control block (MsvCB), reported control block (BRCB and URCB) and log control block (LCB); some common data objects are modeled in this node, such as Loc, to represent the local and remote operation enabling of the unit, basing on function soft switch and common settings; some data objects represent the meaning of the whole logic device, such as Beh, which is jointly formed by the Beh value of all logic nodes in the logic device, to represent the behavior and status of the whole logic device.

LPHD

It represents the information of physical devices, including the device manufacturer, unit model, software version, unit serial number, whether agented and the device health status. In this logic node, it is also extended to include device information such as name of protected device and unit time calibration method.

Application function logic nodes

Application function logic nodes include when classified by functions:

A: automatic control logic nodes

C: monitoring related logic nodes, such as CSWI

G: general purpose function logic nodes, such as GGIO, GAPC

I: filing related logic nodes,

M: measurement and metering related logic nodes, such as MMXU

P: protection function logic nodes, such as PDIF, PDIS, PTOC, PTRC

R: protection related functional logic nodes, such as RREC, RBRF

S: sensors, monitoring

T: instrument transducer logic nodes, such as TVTR, TCTR

X: switching device logic nodes, such as XCBR, XSWI

Y: power transformer and related function logic nodes

PRS-7000 series unit uses the corresponding logic nodes according to the functions selected by user. For the corresponding logic nodes, please refer to the instruction manual for unit of the specific model.

9.4.4.2 Data object

IEC 61850 7-3 defined common data types, including:

- Status information: such as SPS, INS, ACT, ACD
- Measured value information: such as MV, CMV, WYE
- Controllable status information: such as SPC, INC, DPC
- Status set values: such as SPG, ING
- Analog set values: such as ASG
- Description information: such as LPL, DPL

The PRS-7000 series unit uses the above common data types, and instantiate the specific data objects according to the need of application functions, to meet the need of application functions. There are the following common data objects in all logic nodes (except for LPHD):

Mod

The model of logic node. It represents the behavior mode of the logic node, such as normal, testing and blocked.

Beh

The performance of the logic node, represents the current performance status of the logic node. the value of the same Mod is read-only and cannot be modified.

Health

Health status, it reflects the status of the relevant software and hardware of the logic node.

NamPlt

The name plate of the logic node

9.5 DNP3.0 Protocol

9.5.1 Overview

The descriptions given here are intended to accompany this relay. The DNP3.0 protocol is not described here; please refer to the DNP3.0 protocol standard for the details about the DNP3.0 implementation. This manual only specifies which objects, variations and qualifiers are supported in this relay, and also specifies what data is available from this relay via DNP3.0.

The DNP3.0 communication uses the Ethernet ports (electrical or optical) at the rear side of this relay.

9.5.2 Link Layer Functions

Please see the DNP3.0 protocol standard for the details about the linker layer functions.

9.5.3 Transport Functions

Please see the DNP3.0 protocol standard for the details about the transport functions.

9.5.4 Application Layer Functions

9.5.4.1 Function Code

Table 9.5-1 Function Code

Function Code	Function
0 (0x00)	Confirm
1 (0x01)	Read
2 (0x02)	Write
3 (0x03)	Select
4 (0x04)	Operate
5 (0x05)	Direct Operate
6 (0x06)	Direct Operate No Acknowledgment
13 (0x0D)	Cold Restart
14 (0x0E)	Warm Restart
20 (0x14)	Enable Unsolicited Responses
21 (0x15)	Disable Unsolicited Responses
22 (0x16)	Assign Class
23 (0x17)	Delay Measurement

9.5.4.2 Communication Table Configuration

This relay now supports 3 Ethernet clients and 2 serial port clients. Each client can be set the DNP related communication parameters respectively and be selected the user-defined communication table.

The user can configure the user-defined communication table through the PRS IED Studio configuration tool auxiliary software. The object groups “Binary Input”, “Binary Output”, “Analog Input” and “Analog Output” can be configured according to the practical engineering demand.

9.5.4.3 Analog Input and Output Configuration

To the analog inputs, the attributes “deadband” and “factor” of each analog input can be configured independently. To the analog outputs, only the attribute “factor” of each analog output needs to be configured. If the integer mode is adopted for the data formats of analog values (to “Analog Input”, “Object Variation” is 1, 2 and 3; to “Analog Output”, “Object Variation” is 1 and 2.), the analog values will be multiplied by the “factor” respectively to ensure their accuracy. And if the float mode is adopted for the data formats of analog values, the actual float analog values will be sent directly.

The judgment method of the analog input change is as below: Calculate the difference between the current new value and the stored history value and make the difference value multiply by the "factor", then compare the result with the "deadband" value. If the result is greater than the "deadband" value, then an event message of corresponding analog input change will be created. In normal communication process, the master can online read or modify a "deadband" value by reading or modifying the variation in "Group34".

9.5.4.4 Binary Output Configuration

The remote control signals, logic links and external extended output commands can be configured into the "Binary Output" group.

To an extended output command, if a selected command is controlled remotely, this command point will output a high level pulse. The pulse width can be decided by the "On time" in the related "Binary Command" which is from the DNP3.0 master. If the "On time" is set as "0", the default pulse width is 500ms.

9.5.4.5 Class Configuration

If the DNP3.0 master calls the Class0 data, this relay will transmit all actual values of the "Analog Input", "Binary Input" and "Analog Output". The classes of the "Analog Input" and "Binary Input" can be defined by modifying relevant settings. In communication process, the DNP3.0 master can online modify the class of an "Analog Input" or a "Binary Input" through "Function Code 22" (Assign Class).

10 Commissioning

10.1 General

This part contains a brief description about how to verify the function, including functional verification items, functional verification methods and more.

With high degree of self-checking, any fault with the internal hardware and software can be diagnosed by the device itself. So for the commissioning, only hardware interface and the application-specific software function are necessary to verify.

Before carrying out commissioning, users should pay close attention to the safety, technical data and the ratings on the front panel label.

10.2 Safety Instructions

This section contains some safety information, some of which are given warning signs to avoid personal injury or equipment damage, to prompt the user to be careful.

10.2.1 Safety Identification

Electrical warning icon indicating a danger of electric shock.

Notice icon, indicating important information or warnings involved in the article. This icon may indicate a danger of software, equipment or property damage.

Information icons alert readers to important facts or conditions.

Prompt staff not to forget the dangers of static electricity and make prevention.

Forbid to energize the device while not grounded, to avoid endangering the personal safety due to electrical insulation damage!

Although these markings warn of the danger, it is important to note that operating damaged equipment under certain operating conditions can result in reduced process performance and may result in death or personal injury. Therefore, be sure to fully comply with all warnings and cautions.

10.2.2 Safety Identification Examples

For the various safety instructions given in the previous section, the following are examples

10.2.2.1 Warning Signs

Do not touch the circuit during operation. There may be fatal voltage and current.

Strict compliance with safety regulations. Work in high voltage environment need to be serious to avoid personal injury or equipment damage.

When measuring signals in an open circuit, remember to use a properly isolated test clamp that can have fatal voltages and currents.

During normal operation, never disconnect or connect the wires or connectors connected with the terminals. It may cause deadly dangerous voltage and current, may also interrupt the operation of the equipment, damage the terminals and the measuring circuit.

Never disconnect the secondary winding of the current transformer. Current transformers that operate when the secondary windings are open will create strong potentials that may damage the transformers and may cause personal injury.

When the protective device is energized, never plug the module. Hot plug may damage the protection device and measuring circuit, may also result in injury.

10.2.2.2 Caution Signs

Do not connect the protective shell to the live wire, charging the shell may damage the internal circuit.

During installation and commissioning, be careful not to get an electric shock if you touch the leads and connecting terminals

10.2.2.3 Notice Signs

Do not modify the settings in the running protection device. After modify the setting, verify it according to the rules.

10.2.2.4 Anti-static Signs

Remember to avoid touching circuits, including electronic circuits, and the device may be damaged if subjected to static electricity. Electronic circuits may also contain deadly high voltages.

Remember to use a certified conductive bag when transporting the module. Remember to connect the anti-static wristband to the ground when handling the module and remember to operate it on a suitable anti-static surface. Static electricity discharge may cause damage to the module.

Remember to wear the anti-static wristband connected to the ground when replace the module, Static electricity discharge may damage the module and protection device.

10.2.2.5 Earthing Signs

Regardless of operating conditions, remember to connect the protective device to the earth, also needed for special occasions such as testing, demonstrating and off-line configuration on the desk. Operation of the protective device without proper earthing may damage the protective device and the measuring circuit and may also cause an injuring accident.

10.2.2.6 Information Signs

Effective value and step of settings explanation: The protection setting supports as much as 6 significant figures, of which the decimal point occupies one digit (the highest digit cannot be a decimal point). The minimum setting step is 0.01.

10.3 Commission Tools

10.3.1 Instrumentation and Meters Notice:

- Instruments, meters must pass the inspection, and within the validity of the inspection
- instruments, meters should be accurate level higher than the seized equipment related indicators 2 to 4 levels.

10.3.2 Tools Requirement:

- Relay protection testing devices: Multifunctional dynamic current and voltage injection test set with interval timer.
- Regulative DC power: DC output can be adjustable within 0 - 240V.
- Accuracy meter: support three-phase voltage, three-phase current output.
- Tong-type ammeter
- Multifunction phase meter
- Multimeter
- Megger
- Laptop: with appropriate software
- Network cable
- Optical power meter
- EIA RS-485 to EIA RS-232 converter

10.4 Commission Preparation

10.4.1 Basic Knowledge

When commissioning this device for the first time, sufficient time should be allowed to become familiar with the manual to understand the basic operation, protection principles, and related basic performance of the devices as much as possible. If find any doubt in the process, consult the manufacturer's field service personnel or technical support staff of our company.

Alternatively, if a laptop is available together with suitable setting software (such as PRS IED Studio software), the menu can be viewed one page at a time to display a full column of data and text. This PC software also allows settings to be entered more easily, saved to a file on disk for future reference or printed to produce a setting record. Refer to the PRS IED Studio Instruction manual for details.

If the application-specific settings have been applied to the relay prior to commissioning, it is advisable to make a copy of the settings so as to allow them restoration later. This could be done by extracting the settings from the relay itself via printer or manually creating a setting record.

10.4.2 Operation Preparation

Check the printer wiring is normal, the print paper is ample, in order to print the test settings, version, and a variety of experiment data.

Attention! The device should be checked before power on. The appearance should be no damage. The module is plugged and fastened, and the insulation of the DC voltage circuit meets the specified requirements. The indicators can refer to the commissioning record of the device.

Attention! Disconnect the external AC circuit of the cubicle before the test to avoid causing a safety accident, which will cause serious damage to the construction workers on site.

Attention! When you need to plug and unplug the device module, you should ensure the device is powered off and make the anti-static measures to prevent the module damage or performance degradation.

Attention! Temporarily open or shorted terminals should be well documented for reliable recovery after the end of the test.

If it has been necessary to disconnect any of the external wiring from the protection in order to perform any of the following tests, it should be ensured that all connections are replaced in accordance with the relevant external connection or scheme diagram. Confirm current and voltage transformer wiring.

10.5 Product Checks

These product checks cover all aspects of the relay which should be checked to ensure that it has not been physically damaged prior to commissioning, is functioning correctly and all input quantity measurements are within the stated tolerances.

10.5.1 Document Check

Document acceptance check include: protection inspection and factory test reports, certificates, drawings, technical manual of related equipment.

10.5.2 Appearance Inspection

Check the front and back of the cubicle of various electrical components, terminal blocks, hard-switch. All should be marked with the number, name, application and operating position. The marked handwriting should be clear, neat, and not easy to bleach.

The device mark inspection shall include the product type, name, manufacturer's name and trademark, date of manufacture and serial number, safety mark, etc., the mark and installation location shall be consistent with the design drawings.

Inspect the surface of the device. There shall not be scratches, bumps, groove marks, rust, deformation and other defects that affect the quality and appearance;

Check the device panel keyboard is complete, flexible operation, the LCD is clear, the indicator shows normal;

Uncharged metal part of the device should be connected as one, and reliable grounding;

Check the cubicle shell of the device must be grounded reliably;

10.5.3 Insulation Check

Disconnect the weak electric link with other devices and short circuit the AC voltage circuit terminal, AC current circuit terminal, DC circuit terminal and signal circuit terminal inside the cubicle terminal block, and measure the insulation resistance value using the tester whose open circuit voltage is 500V. Insulation should meet the following requirements:

Device independent circuit and exposed conductive parts, 500V megger insulation resistance measured value should be no less than 100MΩ;

Between electrically disconnected independent circuits, 500V megger insulation resistance measured value should be no less than 100MΩ;

After the insulation test is completed, make sure that all external wiring is properly connected.

10.5.4 External Wiring Check

External protection wiring should be consistent with the design drawings; Internal and external wiring on the terminal block and cable marking on it is correct, complete, and consistent with the drawings; Secondary circuit wiring should be neat and beautiful, solid and reliable;

All secondary cables and terminal blocks wiring connection should be solid. Cable mark should be complete, correct and clear;

The correct mark should be attached to the optical fiber (including optical cable, pigtail, jumper) and both ends of the device port. Such fiber-optic annotation should include the optical fiber number, destination. The starting point of the fiber should indicate the cubicle number. The content of the port mark should include the port number and destination. The starting point of the port should include the cubicle number, switch number and port number.

10.5.5 Test Category

The following tests are necessary to ensure the normal operation of the equipment before it is first put into service.

These tests are performed for the following hardware to ensure that there is no hardware defect. Defects of hardware circuits other than the following can be detected by self-monitoring when the power supply is energized.

- User interfaces test
- Binary input circuits and output circuits test

- AC input circuits test
- Function tests

These tests are performed for the following functions that are fully software-based. Tests of the protection schemes and fault locator require a dynamic test set.

- Measuring elements test
- Timers test
- Metering and recording test
- Conjunctive tests

The tests are performed after the relay is connected with the primary equipment and other external equipment.

- On load test.
- Phase sequence check and polarity check.

10.6 With the Relay Energized

Check that the input range of the external power supply should meet the power requirements of the "technical data" section within the permissible power supply input voltage range.

Attention! All external circuits connected to the unit must be checked to ensure correct installation before the unit is powered on or the test procedure started.

10.6.1 LCD Display Check

After the device is powered on, the LCD will be lit. After the device is initialized, if the device is in normal operation, the LCD displays the status of the main single line diagram.

Attention! If the device is in the alarm state after power-on, the LCD displays the alarm status information. At this point you can refer to the "Supervision" section to analyze the cause of the alarm and treatment.

10.6.2 Date and Time

If the time and date is not being maintained by substation automation system, the date and time should be set manually.

Set the date and time to the correct local time and date using menu item “Clock”.

For devices using IRIG-B (DC) time code and SNTP, IEEE 1588-time synchronization, you can verify the timing accuracy by modifying the clock setting of the device. For PPM, PPS time synchronization system, through the time synchronization binary input check.

10.6.3 Light Emitting Diodes (LEDs)

The device has two lights that cannot be defined. the two lights are as follows:

"Healthy": indicates that the device is in normal operation, no software, hardware failure. When the "healthy" light goes out, it indicates a serious problem with the device, resulting in the device not functioning properly.

"Alarm": indicates that there are some alarm events on the device. On this condition, you can analyze the cause of the alarm and how to handle it by checking the "supervision" section of the manual.

The rest of the indicators are configurable indicators.

If the indicator of the device is set to the self-retaining state, if the signal is not reset before the latest power-off, the signal will continue to be triggered when the device is powered on again, and the indicator can be reset by resetting operation. It is likely that alarms related to voltage transformer supervision will not reset at this stage.

10.6.3.1 Test the HEALTHY and ALARM LEDs

Apply the rated power supply and check that the “HEALTHY” LED is lighting in green. We need to emphasize that the “HEALTHY” LED is always lighting in operation course except that this device finds serious errors in it.

Produce one of the abnormal conditions listed in Chapter 4, the “ALARM” LED will light in yellow. When abnormal condition reset, the “ALARM” LED extinguishes.

10.6.3.2 Test the Other LEDs

Test the other LEDs according to the configuration of the LEDs (through the PRS IED Studio software). If the conditions which can turn on the selected LED are satisfied, the selected LED will be on.

10.6.4 Test the AC Current Circuit

Attention! The wiring must be checked in strict accordance with the AC current connection drawings provided.

The purpose of this test is to check whether the wiring of the AC circuit in the cubicle is correct and whether the sampling precision meets the requirements. The sampling accuracy and polarity of the device can be checked through sourcing rated AC current at the AC current input terminal on the back of the cubicle.

Protection current measurement accuracy requirement shall follow Measurement Range and Accuracy. However, an additional allowance must be made for the accuracy of the test equipment being used.

Apply current equal to the current transformer secondary winding rating to each current transformer input in turn, see the following table, checking the magnitude using a multimeter/test set readout. The corresponding reading can then be checked in the relays menu.

10.6.5 Test the AC Voltage Inputs

Attention! The wiring must be checked in strict accordance with the AC voltage connection drawings provided.

The purpose of this test is to check whether the wiring of the AC voltage in the cubicle is correct and whether the sampling precision meets the requirements. The sampling accuracy and polarity of the device can be checked through sourcing rated AC voltage at the AC voltage input terminal on the back of the cubicle.

Protection voltage measurement accuracy requirement shall follow Measurement Range and Accuracy. However, an additional allowance must be made for the accuracy of the test equipment being used.

Apply voltage equal to the voltage transformer secondary winding rating to each voltage transformer input in turn, see the following table, checking the magnitude using a multimeter /test set readout. The corresponding reading can then be checked in the relays menu.

10.6.6 Test the Binary Inputs

The purpose of this test is to check whether the connection of binary input circuit is correct. During the test, the voltage applied to the binary input terminal must be within the allowable operating range.

Each binary input status can be checked by the device LCD panel, and the status "1" indicates that the binary input has been applied with an input voltage, and the opening status becomes "0" when the input voltage disappears.

10.6.7 Test the Binary Outputs

The purpose of this test is to check whether the binary output circuit connection is correct. According to the protection logic of the device and various kinds of signal output logic, stimulate a fault condition. The corresponding relay contact of the device shall be operated with the corresponding action or alarm signal.

10.6.8 Protection Function Checks

The purpose of this experiment is to verify the correctness of the protection logic. Protection function tests generally include the following types:

- Impedance protection test
- Current protection test
- Voltage protection test
- Frequency protection test
- Secondary system supervision function test

For details on how to implement the protection logic function, refer to "Operation Theory"

10.6.9 Printing Function Checks

Check the printer cable is connected properly before printing, printing paper is complete. Printing method can be set to "automatic" or "manual". When set to automatic printing, the device will print protection action event, self- checking information and other records initiatively in real time.

10.6.10 On-load Checks

The objectives of the on-load checks are:

- Confirm the external wiring to the current and voltage inputs is correct.
- Measure the magnitude of on-load current and voltage (if applicable).
- Check the polarity of each current transformer.

10.6.11 Final Checks

After the above tests are completed, remove all test or temporary shorting leads, etc. Restore the original correct wiring. Tighten the secondary circuit terminals, especially for the current terminals, circuit breaker closing and opening, operating power supply circuit.

If a test block is installed, remove the test plug and replace the cover so that the protection is put into service.

Ensure that all event records, fault records, disturbance records and alarms have been cleared and LED’s has been reset before leaving the protection.

Ensure that the protection has been restored to service.

11 Installation

11.1 General

Design and installation chapter is suit for design, installation, commissioning and maintenance staff. Designers must have a wealth of experience in electrical design. The installer must have the basic knowledge of electronic equipment and cubicle drawing reading. Commissioning and maintenance personnel must have extensive experience in operating protective equipment and test equipment. The equipment must be shipped, stored and installed with the greatest care.

Choose the place of installation such that the communication interface and the controls on the front of the device are easily accessible.

Air must circulate freely around the equipment. Observe all the requirements regarding place of installation and ambient conditions given in this instruction manual.

Take care that the external wiring is properly brought into the equipment and terminated correctly and pay special attention to grounding. Strictly observe the corresponding guidelines contained in this section.

11.2 Safety Instructions

Warning! Only insert or withdraw a module while the device power supply is switched off. To this end, disconnect the power supply cable that connects with the power supply module.

Attention! A module can only be inserted in the reserved slot. Components can be damaged or destroyed by inserting module in a wrong slot.

The basic precautions to guard against electrostatic discharge are as follows:

- Should boards have to be removed from this relay installed in a grounded cubicle in an HV switchgear installation, please discharge yourself by touching station ground (the cubicle) beforehand.
- Only hold electronic boards at the edges, taking care not to touch the components.
- Only works on boards that have been removed from the cubicle on a workbench designed for electronic equipment and wear a grounded wristband.
- Always store and ship the electronic boards in their original packing. Place electronic parts in electrostatic screened packing materials.

11.3 Checking the Shipment

Vehicles, trains, ships and all other means of transport are available, but to prevent snow and rain, shock, impact and collision, to ensure product packaging integrity.

Check that the consignment is complete immediately upon receipt. Notify the nearest CYG SUNRI CO., LTD. Company or agent, should departures from the delivery note, the shipping papers or the order be found.

Visually inspect all the material when unpacking it. When there is evidence of transport damage, lodge a claim immediately in writing with the last carrier and notify the nearest CYG SUNRI CO., LTD. Company or agent.

- **Unpacking and checking procedures**

1. Remove the shipping package.
2. Before unpacking, you should first check the equipment packaging intact, whether there are signs of serious collision and phenomenon's that equipment in the box may be damaged. If found abnormal, it is recommended to take pictures as a record, confirm and contact with the manufacturer at first time.
3. When unpacking, you should use a claw, and pull out the nails, and then pry off the box lid; If the crowbar is used, never take the device as a fulcrum, and it is forbidden to stick into the wooden box carelessly with the crowbar. Open the box with the greatest care and avoid excessive vibration.
4. Check the appearance of the device is intact.
5. Check the delivery list. Check the device certificate of competency, supporting documents, attachments, spare parts, etc. are consistent with the order requirements, whether the packing list and the type, name, quantity, etc. are consistent and complete. If correct, sign the confirmation.
6. Manufacturer documents and spare parts should be assigned to personal keeping and registration.
7. If any abnormalities occur during unpacking, feedback CYG SUNRI CO., LTD. Company or agent at the first time, so as to avoid the follow-up of unclear responsibilities.

If the equipment is not going to be installed and commissioned immediately, store all the parts in their original packing in a clean dry place and keep air circulation. And to prevent the intrusion of various harmful gases, non-corrosive items stored in the same place.

11.4 Material and Tools Required

The necessary mounting kits will be provided, including screws, pincers and assembly instructions.

A suitable drill and spanners are required to secure the cubicles to the floor using the plugs provided (if this relay is mounted in cubicles).

11.5 Device Location and Ambient Conditions

The mechanical and electrical environmental conditions at the installation site must comply with the requirements of "Chapter 2 Technical Data". Avoid adverse conditions caused by the environment:

- Avoid installing in wet, dark and other places likely to cause damp and rust. If in unavoidable rainy area, install the device in a higher position;
- If the area is an earthquake prone area, fix the protection device tightly;
- If there is a lot of dust in the installation place, clean it before installing.

The place of installation should permit easy access specially to front of the device, i.e. to the human machine interface of the equipment. There should also be free access at the rear of the equipment for additions and replacement of electronic boards.

11.6 Mechanical Installation

In the case of equipment supplied in cubicles, place the cubicles on the foundations that have been prepared. Take care while doing so not to jam or otherwise damage any of the cables that have already been installed. Secure the cubicles to the foundations.

The device should be firmly fixed in the cubicle(cabinet), and the connecting screws should be tightened. The grounding wire of each device should be connected with the copper grounding bus bar inside the cubicle, and reliably connected with the secondary grounding network. Device wiring should be consistent with the wiring diagram requirements.

The device features a 6U height, 1/3 19" width chassis, integral panel and pluggable functional modules with lock. The device is designed conforming to IEC 60297-3. Embedded Installation as a whole, rear wiring. The current/ voltage connector structure is in the same size, and can be expanded, combined flexibly. Installation hole size as below.

Attention! It is necessary to leave enough space top and bottom of the cut-out in the cubicle for heat emission of this relay.

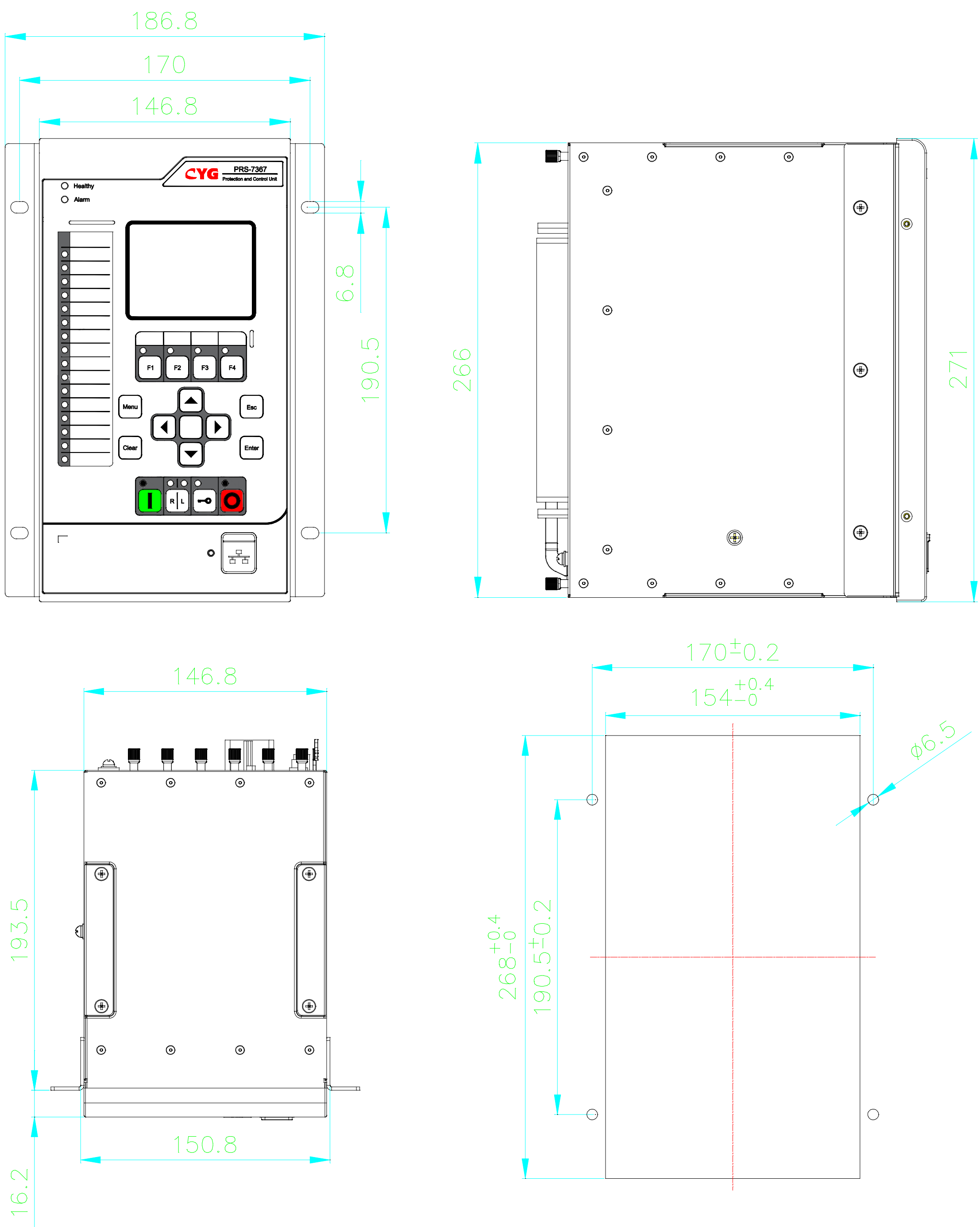


Figure 11.6-1 Dimensions of this relay and the cut-out in the cubicle (unit: mm)

11.7 Electrical Installation and Wiring

11.7.1 TA Circuit Connection

According to the wiring diagram of the device, connect the terminal block of rear AC module with the CT loop using multiple wires, of which the cross-sectional area should be 2.5 - 4.0mm^2.

11.7.2 Power Supply, TV, BI and BO, Signal Wiring

According to the wiring diagram of the device, connect the AC, Phoenix terminal of module and the terminal block in the cubicle side with multiple wires.

DC voltage power supply wiring power +, power - should be distinguish in different colors, for example power + (brown), power - (blue).

Power supply, binary inputs & outputs: stranded conductor, 1.0mm^2 - 2.5mm^2.

AC voltage inputs: stranded conductor, 1.5mm^2.

Grounding: braided copper cable, 2.5mm^2 - 6.0mm^2.

For wires connected to two points, there should be no joint in the middle, and the wire core should not be damaged. If the wire length is not enough during the process of wiring or rewiring, the worker must replace it. There should be no excess wire in the slot. If it is required to remove the wire, the whole wire must be completely removed.

When wiring the AC terminal of module, current and voltage wires must adopt 12mm size cable lug, to avoid loose contact. Strictly prohibit electric screwdriver, so as to avoid terminals damage.

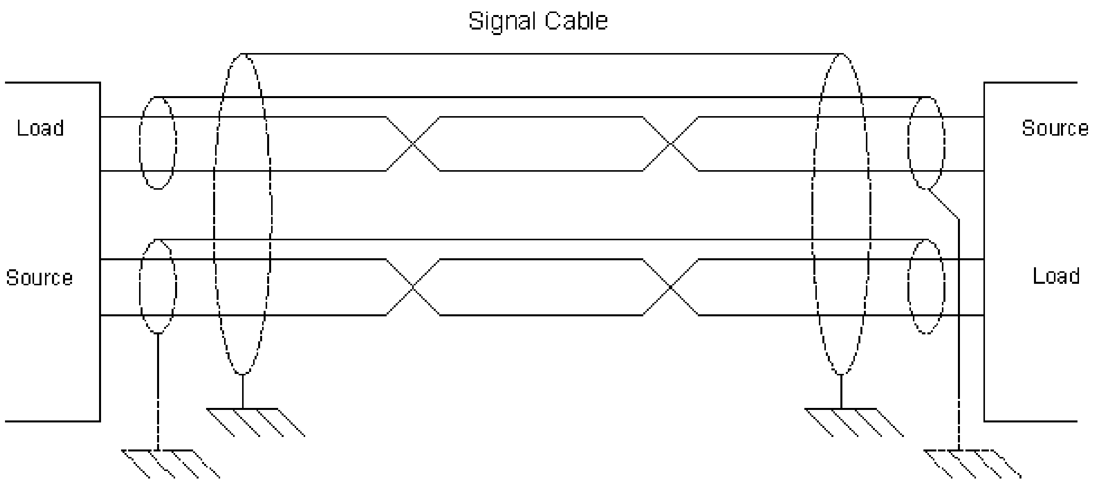
Attention! Never allow the current transformer (CT) secondary circuit connected to this equipment to be opened while the primary system is live. Opening the CT circuit will produce a dangerously high voltage.

11.7.3 Grounding

Use a yellow-green multi-core cable with a cross-section of at least 2.5 mm^2 to connect the grounded copper bars. The cubicle should reliably have connected to the secondary ground network.

11.7.4 Shielded cable connection

When using a shielded cable, connect the shielded cable to ground and follow the engineering application method. This includes checking of the appropriate grounding point near the device, such as the grounding point inside the cubicle and the grounding point near the measurement source. Ensure a single shield connection a suitable short cross-sectional wire (maximum 10CM) for ground connection.



11.8 Installation check

11.8.1 Check the installation

Check that all terminal screws with external wiring are tightened, the wiring is neat, and all wiring labels are clearly defined.

11.8.2 Confirm the hardware and software version

Hardware and software version information is available on the device label. After the device is powered on, the software version can also be checked through the LCD interface.

11.8.3 Device start

if confirm that the wiring is correct during the installation check, you can supply device with power and start it.

Configuration file needs to read during device startup process. It needs a certain period of time for the startup process. The startup time is related to the size of configuration file. In general, the startup time is less than 1 minute.

The "HEALTHY" indicator lights up when the unit starts up normally. If a fault is detected during the startup procedure, the "ALARM" indicator is lit and the internal fault code, alarm information can be checked via LEDs.

11.8.4 Install the optical cable

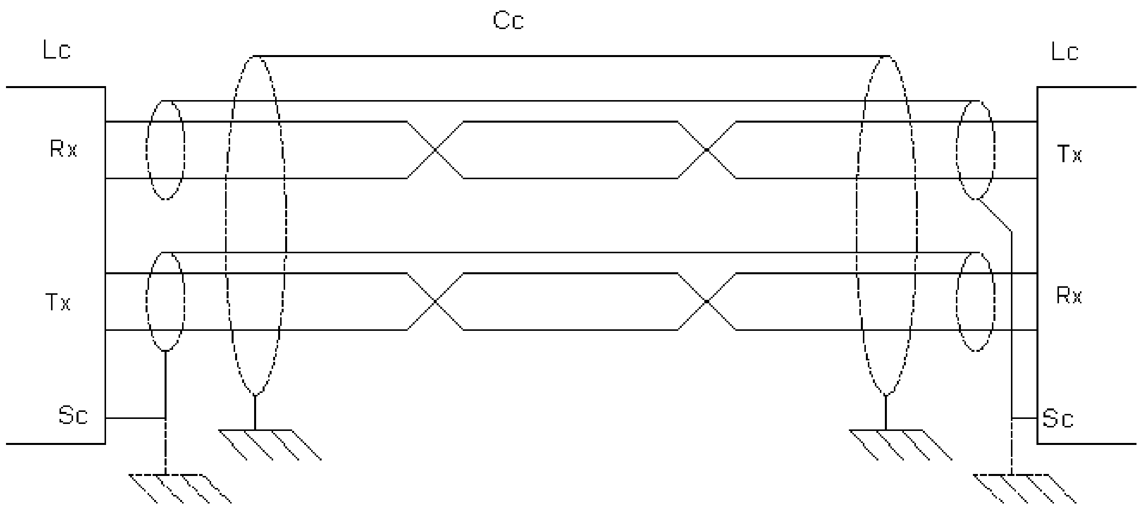
Care should be taken to handle the cable without substantial bending. The minimum curvature radius of the plastic optical fiber is 15 cm and the glass optical fiber is 25 cm. To use the cable clamp, a loose buffer sleeve should be used.

When connecting or removing the optical fiber, please take hold of the connection ends. Do not take the cable. Do not twist, stretch, bend the cable. Invisible damage can increase the attenuation of the fiber and can destroy the communication.

11.8.5 Install the communication cable

When using electrical connections between the protection device and the communication device, or point-to-point electrical connections between the two protection devices, it is important to install the cables carefully. Due to the low electrical level of communication signals, the factors susceptible to noise interference must be considered.

The best way is to use shielded twisted pair(STP), one for each twisted pair and the other for the all twisted pairs for surround shielding. Each signal uses the twisted pair shown in the following figure to shield each individual twisted-pair cable by connecting its internal shielded cable to the device's ground connection or, alternatively, to a device near the signal transmitter Connected, at the receiving end, shielded line let it hang in the air, not connected with the ground. The outer shield surrounding all twisted pairs is physically connected near each end of the equipment.



Cc: communication cable

Lc: line connector

Rx: receive signal input

Tx: transmit signal output

Sc: shielded (grounding) connection

12 Maintenance

12.1 Maintenance General

A strict and detailed laboratory test is carried out in the development and design of the relay device. All the relay devices are strictly tested according to national or international standards.

The relay device has powerful real-time self-check capability. However, during the long time running of the relay device, there is no real time supervision for the input terminals and output circuits. Therefore, some periodic tests should be done to ensure that the relay is functioning correctly and the external wiring is intact.

The maintenance of the relay device mainly includes the following two conditions:

- Regular testing;
- Failure maintenance

12.2 Regular Testing

Regular testing is to test the normal relay devices in a certain period of time, so as to find potential defects or failures and eliminate hidden dangers to ensure the healthy operation of the devices.

The regular testing cycle depends on a number of factors, such as the environment conditions, the complexity, etc. Advices of CYG are as the following:

- The relay device must be tested for the first time in the first year of operation, mainly including protection logic, AC circuit, tripping circuit and power supply circuit.
- A partial test should be carried out every 3 years, mainly including the inspection of the AC circuit and the tripping circuit.
- An overall test should be carried out every 6 years, mainly including the protection function logic, the AC circuit, the tripping and closing circuit, the power supply circuit.

12.3 Failure Maintenance

Failure maintenance refers to the maintenance of a faulty relay device.

12.3.1 Hardware Failure

1) Check whether the hardware is in trouble or not according to the device alarm signal.
2) visual check of the device
   - Check whether the device has obvious physical fault
   - If you can find a clear physical fault point of the device, please contact CYG for repair or replacement
3) Confirm the scope of the fault

- Check whether this fault is caused by an external circuit.
- Carry out the input and output test for the relay device by test instrument.
- If it is determined that the fault belongs to the relay device, please contact CYG for repair or replacement

12.3.2 Software Failure

1) Check whether the hardware is in trouble or not according to the device alarm signal.
2) Try to restart the device and check if the fault is recoverable if possible.
3) If the fault is not recoverable, please contact CYG for repair or replacement

12.4 Replace Failed Modules

If the failure is identified to be in the relay module and the user has spare modules, the user can replace the failed modules to recover the protection device.

Repair at the site should be limited to module replacement. Maintenance at the component level is not recommended.

Before replacement, the user should check that the replacement module has an identical module name and hardware type-form as the removed module. Furthermore, the replaced module should have the same software version. For the replaced analog input module and power supply module, it should be confirmed of the same ratings.

NOTICE!

After replacing modules, it must be checked that the same configuration is set before and after the replacement. If it is not the case, there is a danger of the unintended operation of switchgear taking place or of relay device not running correctly. Persons may also be in danger.

Units and modules must only be replaced while the power supply is switched off and only by appropriately trained and qualified personnel. Strictly observe the basic precautions to guard against electrostatic discharge.

Take anti-static measures such as wearing an earthed wrist band and placing modules on an earthed conductive mat when handling a module. Otherwise, the electronic components may suffer damage. After replacing the main CPU module, check the settings and configurations.

13 Decommissioning and Disposal

13.1 Decommissioning

13.1.1 Switching off

To switch off this relay, break down the cable connected to the power supply module or switch off the external miniature circuit breaker.

13.1.2 Disconnecting cables

Disconnect the cables in accordance with the rules and recommendations made by relational department.

⚠ **DANGER!**

Before disconnecting the power supply cables that connected with the power supply module of this relay, make sure that the external miniature circuit breaker of the power supply is switched off.

⚠ **DANGER!**

To decline the possibility of electrical shock, all current terminal should be shorted before attempting to remove or replace any modules.

13.1.3 Dismantling

The rack of this relay may be removed from the system cubicle, after which the cubicles may also be removed.

⚠ **DANGER!**

When the station is in operation, make sure that there is an adequate safety distance to other operating parts or equipment, especially as dismantling is often performed by unskilled personnel.

13.2 Disposal

In every country there are companies specialized in the proper disposal of electronic waste.

NOTICE!

Each module used in the device is fixed to several specific module type, as often indicated with a label on the backside of the chassis. There are some chances that the modules will be damaged if they are installed in the wrong chassis slot. When removing and replacing modules, it is best to use the label in the chassis as an indicator, so as to make sure each module is installed in the proper slot.

NOTICE!

Strictly observe all local and national regulations when disposing of the device.

14 Connection Diagrams

14.1 Drawing of structure

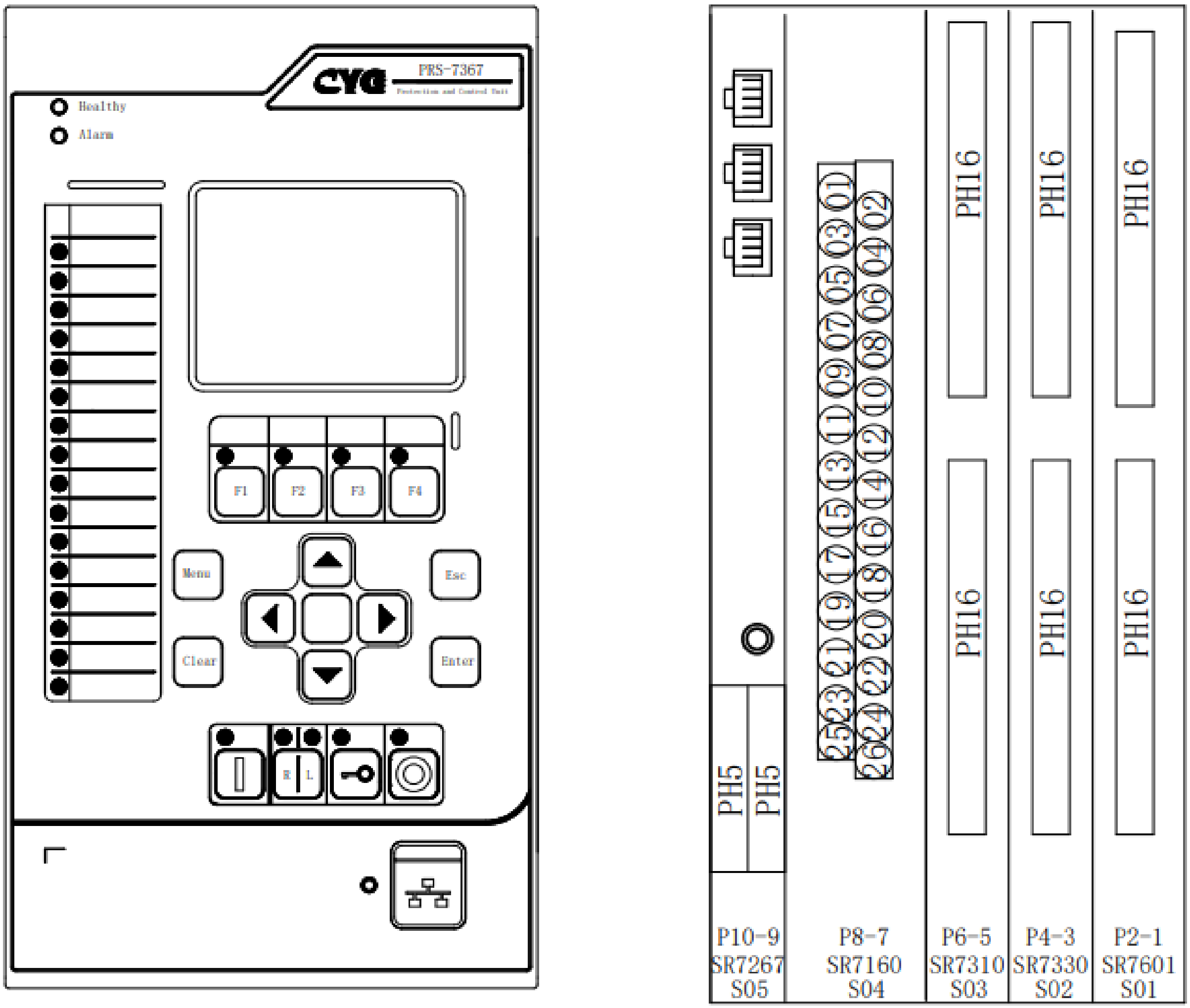


Figure 14.1-1 Drawing of structure

14.2 Drawing of Modules

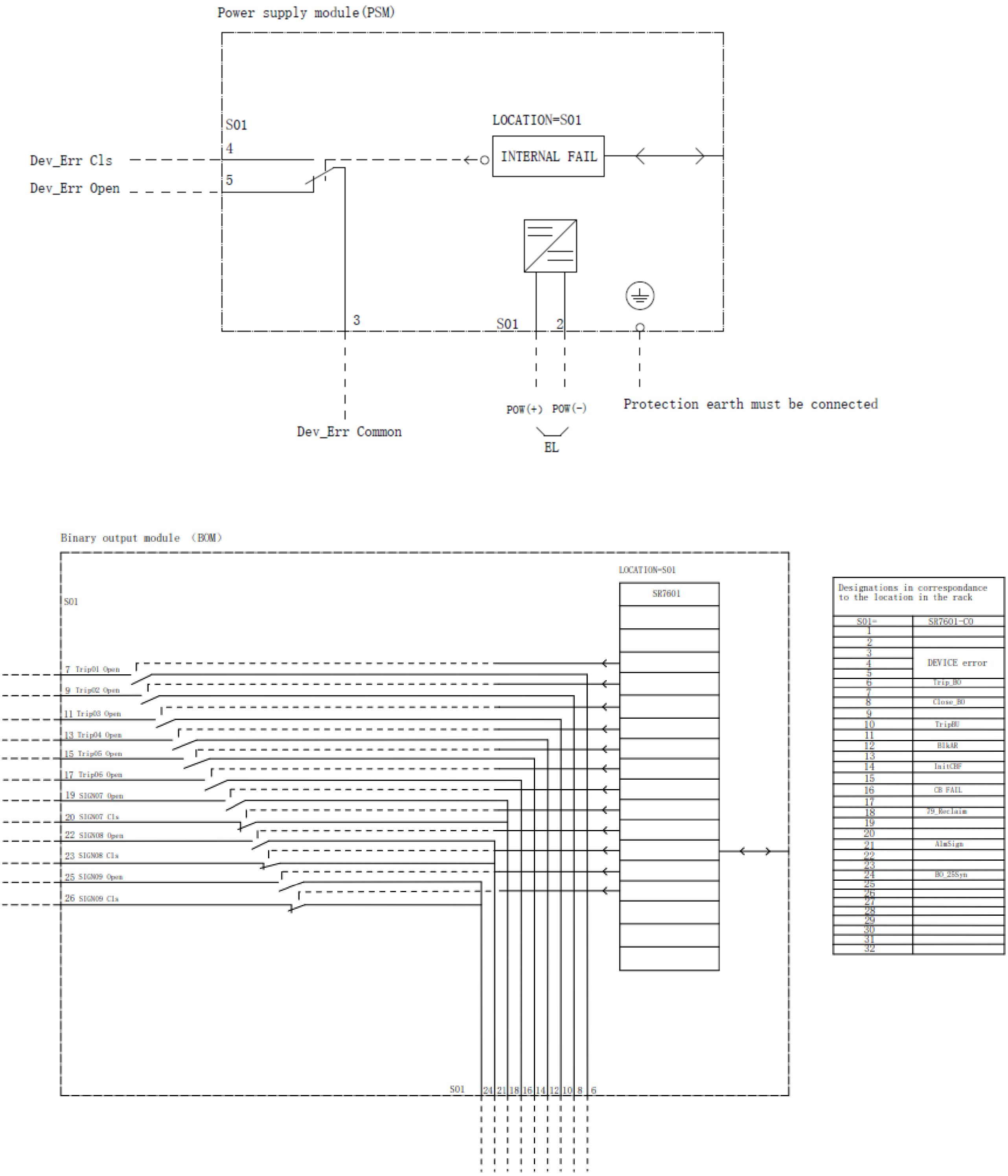


Figure 14.2-1 Power supply module

Communication interfaces Option

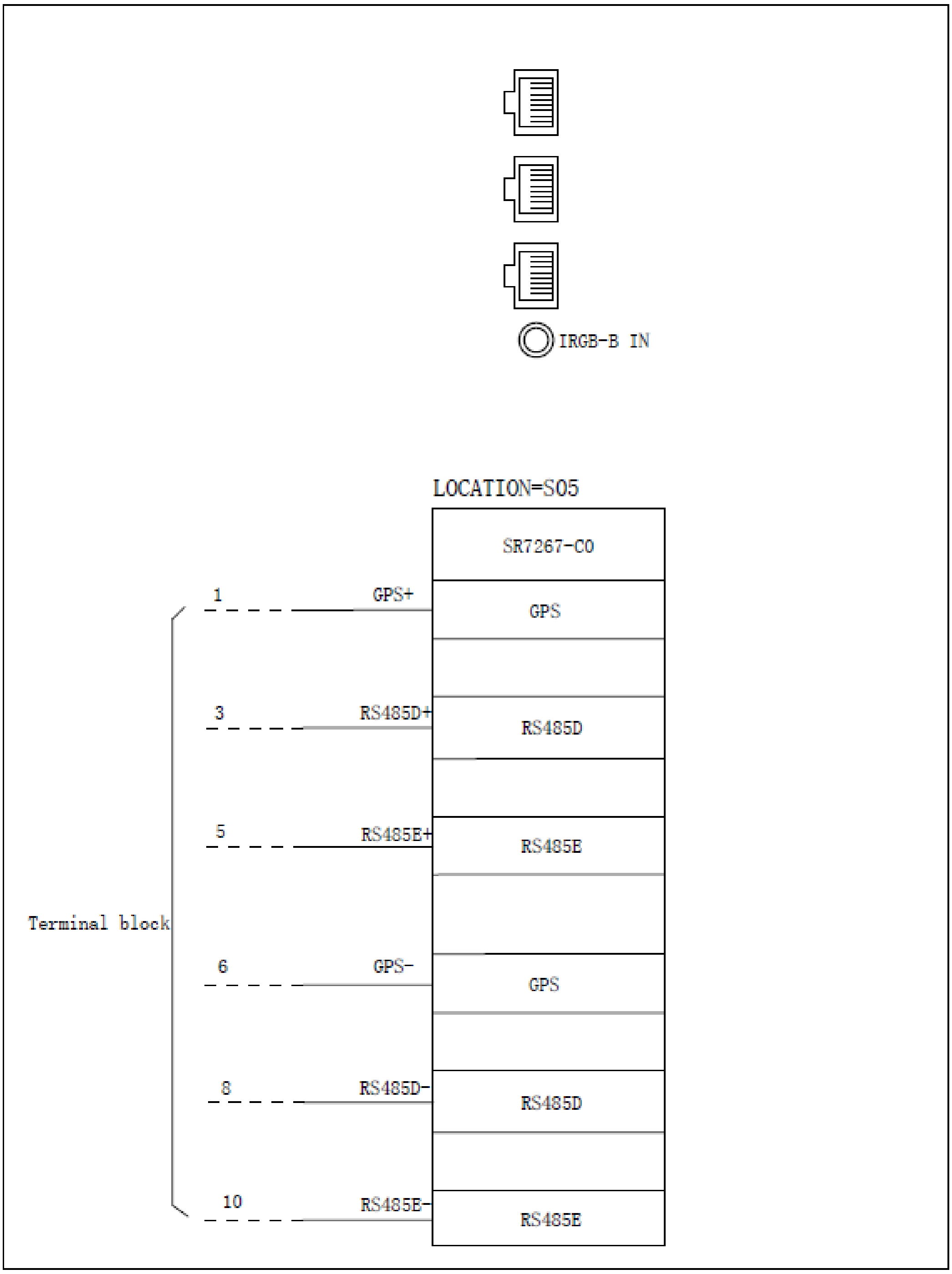


Figure 14.2-2 Communication interfaces

Note: The diagram of all CPU modules are same.

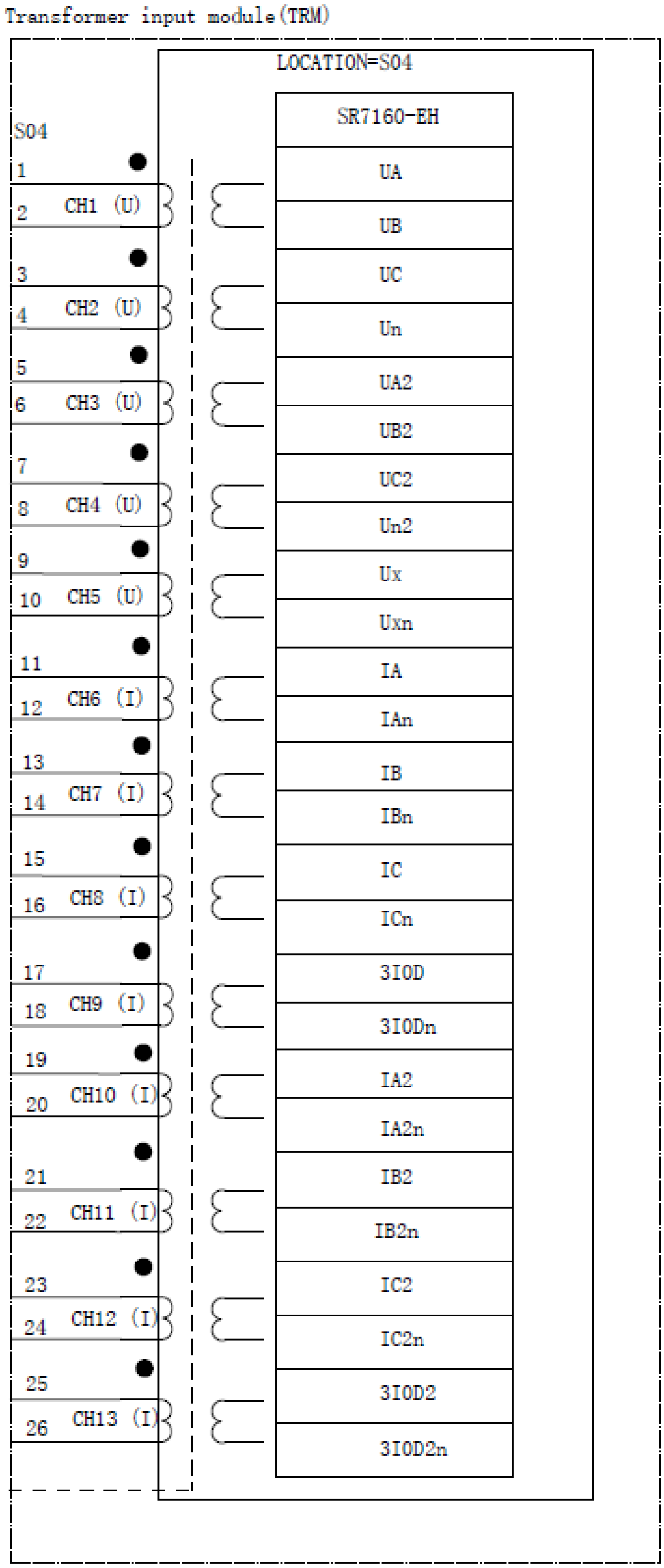


Figure 14.2-3 Transformer input module

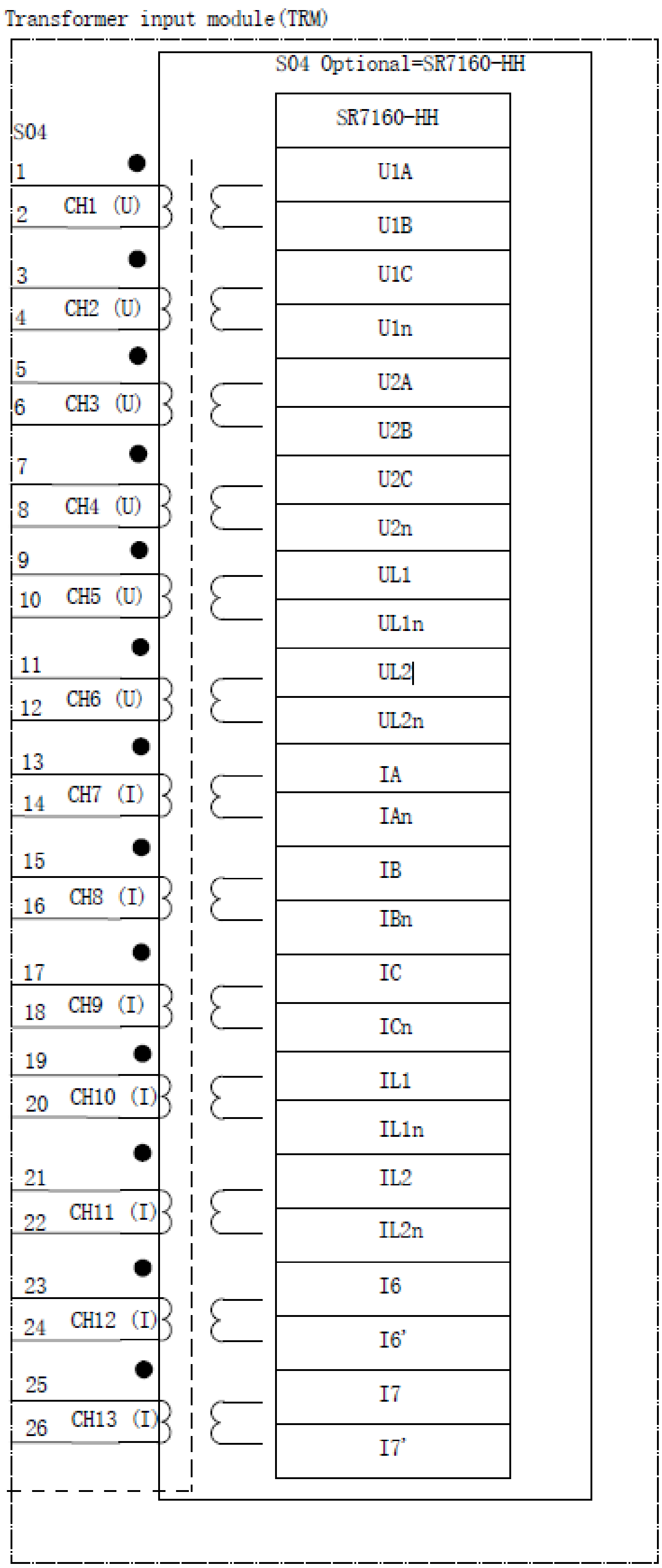
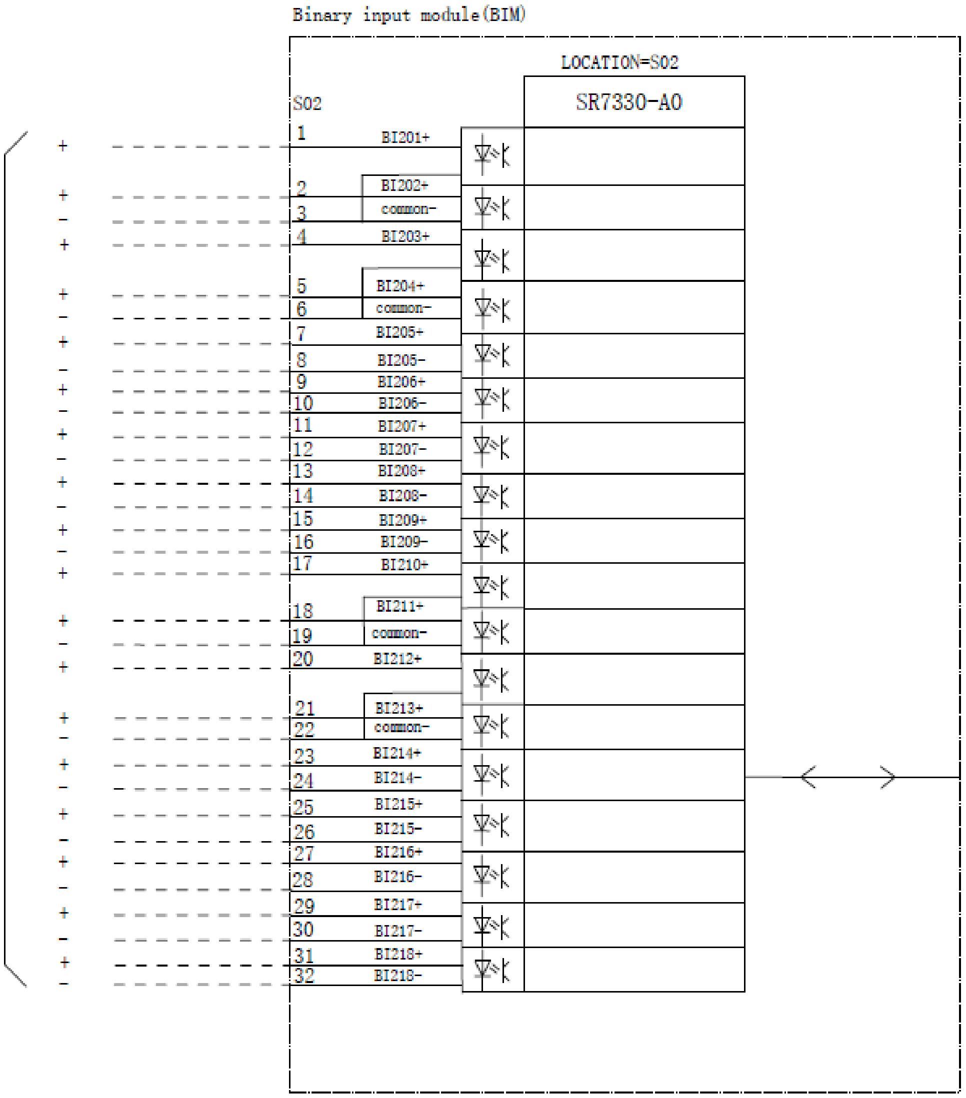
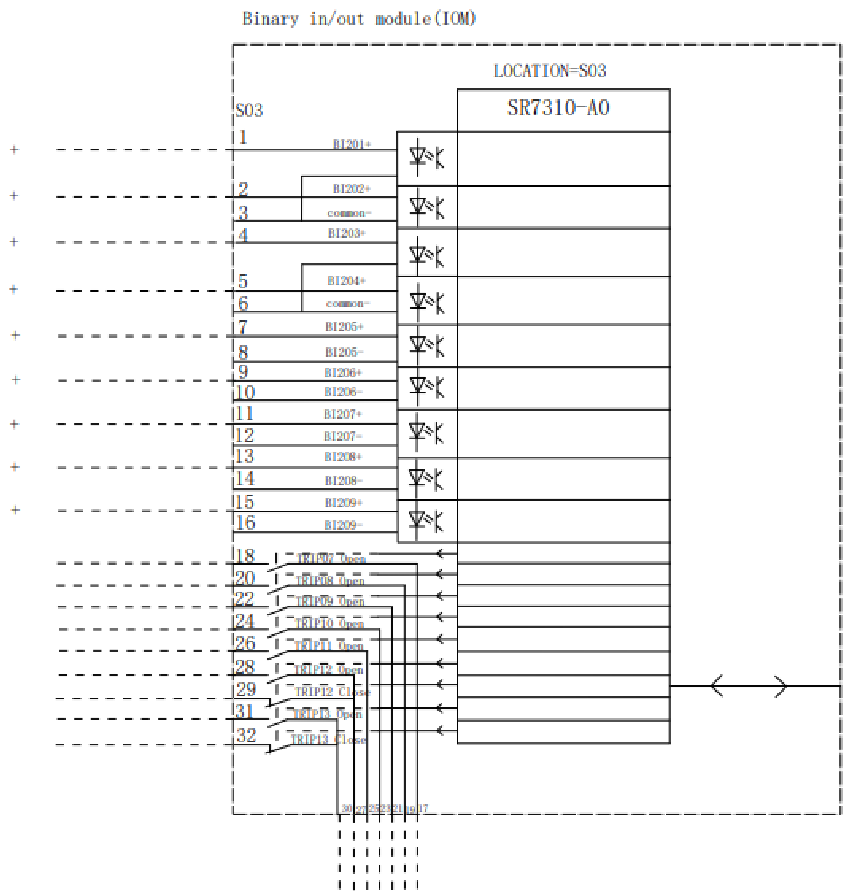


Figure 14.2-4 Transformer input module Optional: SR7160-HH



Designations in correspondance to the location in the rack	
S02=	SR7330-A0
1	Reset
2	Test
3	
4	Remote_Switch
5	CB_Open
6	
7	CB_Close
8	
9	AR_CB_Healthy
10	
11	AR_Block
12	
13	MP_BI01
14	
15	MP_BI02
16	
17	ExStrAR
18	CBFault
19	
20	ExStrBF
21	AR_Reset
22	
23	AR_Enable
24	
25	ManuSync
26	
27	Clr_Therm
28	
29	SOTF_Start
30	
31	SOTF_StrDly
32	

Figure 14.2-5 Binary input module



Designations in correspondance to the location in the rack	
S03=	SR7310-A0
1	MCB_Open
2	VEC Open
3	
4	MP BI03
5	MP_BI04
6	
7	TCS
8	
9	AR_Disable
10	
11	BI GSIN01
12	
13	BI_GSIN02
14	
15	BI_GSIN03
16	
17	Merge_Trip
18	
19	Pickup
20	
21	Merge Close
22	
23	79_Inprog
24	
25	UF Trip
26	
27	79 Lockout
28	
29	
30	46BC Op
31	
32	

Figure 14.2-6 Binary I/O module

*Note: The connection of I/O module **SR7310-B0** is same as **SR7310-A0**, these BO of **SR7310-B0** should be used for signal outputs.*

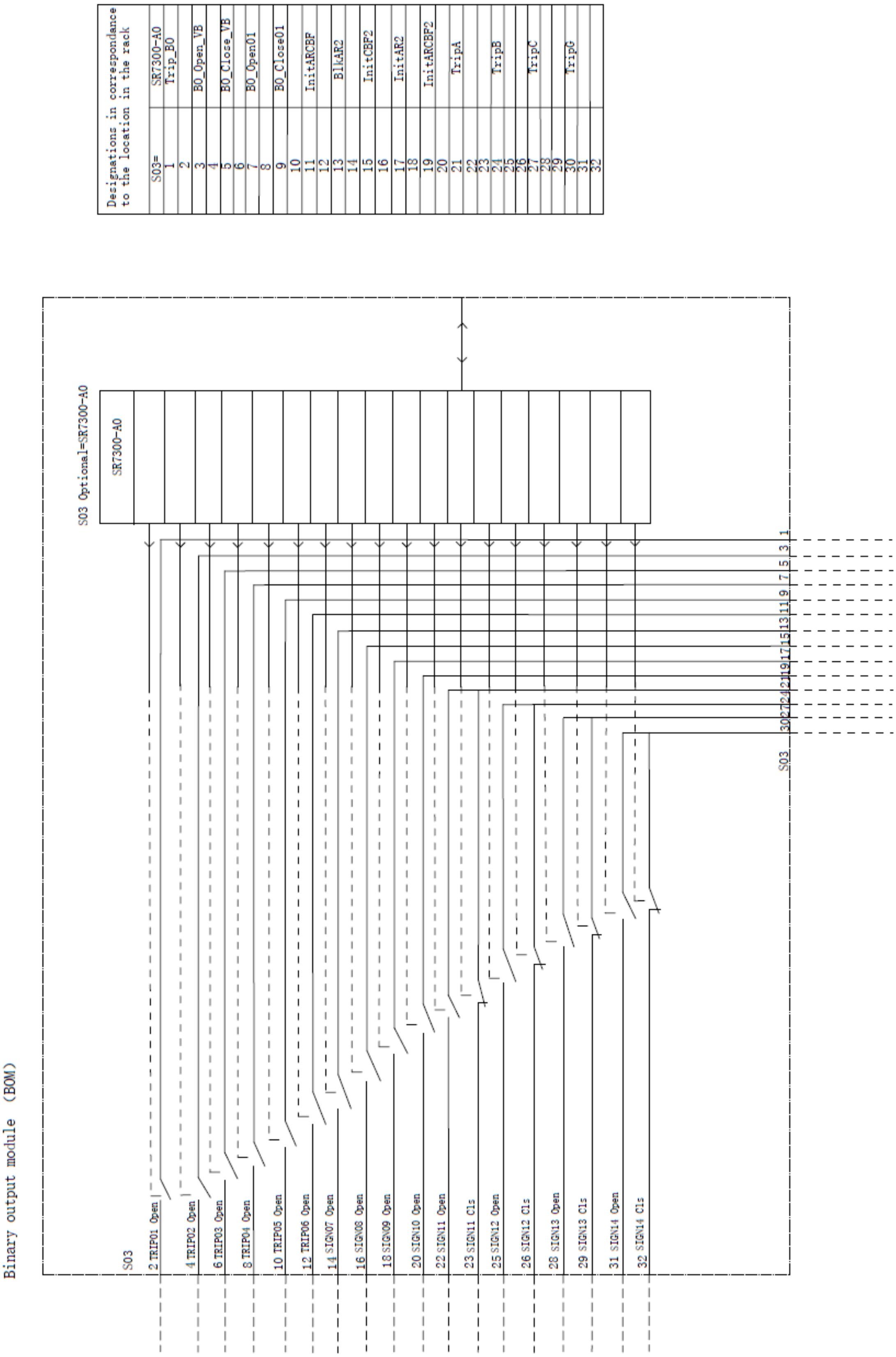


Figure 14.2-7 S03 Optional=Binary output module: SR7300-A0

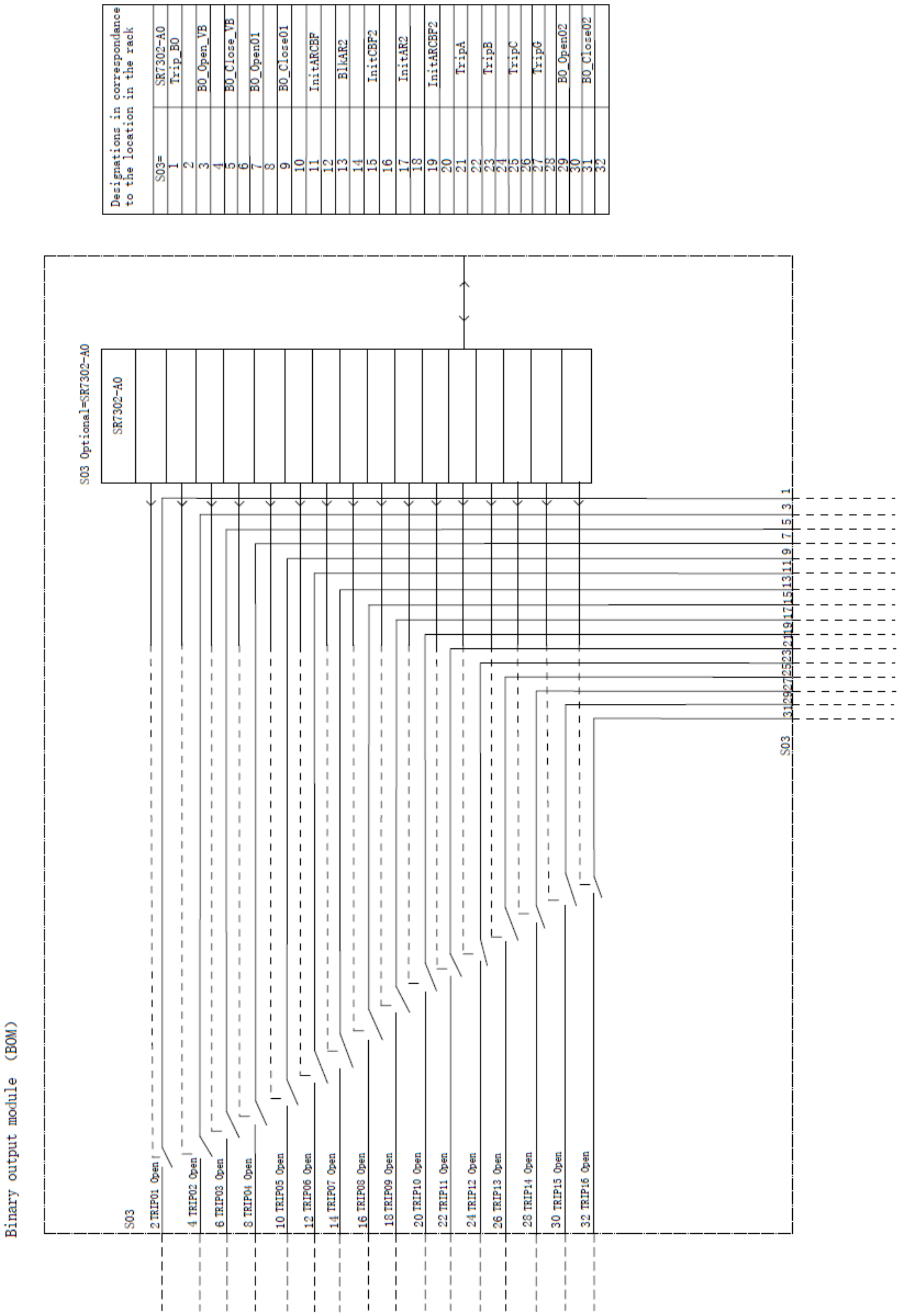


Figure 14.2-8 S03 Optional=Binary output module: SR7302-A0

*Note: The connection of BO module **SR7302-B0** is same as **SR7302-A0**, these BO of **SR7302-B0** should be used for signal outputs.*

15 Manual Version History

In the current version of the instruction manual, several descriptions on existing features have been modified.

Manual Version		Software Version	Date	Description of change
Source	New			
Beta	1.00	1.00	2014-04-15	Form the original manual.
1.00	1.01	1.01	2015-05-21	Update the technical specification.
1.01	1.02	1.02	2016-01-24	Add parameters and configurable signals.
1.02	1.03	1.03	2016-08-16	Update technical specification and setting tables.
1.03	2.01	1.10	2017-12-16	Update some protection functions.
2.01	2.02	1.19	2018-02-28	Add IDMT function.
2.02	2.03	1.20	2018-12-31	Add some protection functions.
2.03	2.04	1.20	2019-03-28	Update some protection functions.
2.04	2.05	1.20	2019-04-17	Update some protection functions.
2.05	2.06	1.20	2019-04-23	Update some protection functions.
2.06	2.07	1.20	2019-04-27	Update some protection functions.
2.07	2.08	1.20	2019-06-11	Update some protection functions. Update the setting table and figure according to the configuration condition. Update the technical specification.
2.08	2.09	1.20	2019-06-12	Update some protection functions. Update the setting table and figure according to the configuration condition.
2.09	2.10	1.20	2019-06-27	Update some protection functions. Update the technical specification. Update the setting table and figures
2.10	2.11	1.20	2019-10-16	Update some protection functions. Update the setting table and figures.
2.11	2.12	1.20	2023-09-28	Add some protection functions. Update the setting table and figures. Add some configuration functions description about PRS tool.
2.12	2.13	1.20	2024-10-17	Add the protection functions of motor relay. Add some configuration functions description about PRS tool. Add the connection diagrams. Update the setting table and figures.