BP-2C

Busbar Protection

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 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 procedures, 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 prevent because the improper 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. This 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.

CYG SUNRI CO., LTD.

Headquarters: No.13, Keji North 1st Road, North Area of Hi-tech Industral Park, Nanshan District, Shenzhen, China

Tel: +86-400-678-8099

Website: http://www.sznari.com

P/N: ZL_BP-2C_X_Instruction Manual_EN_Overseas General_X

Version: 2.045

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.

Table of Contents

1 Briefly Introduction

1.1 Application Scope

The BP-2C is a numerical busbar differential protection intended for protecting and monitoring various busbars of various voltage levels, ranging from 1000kV to 110kV. BP-2C can detect and clear all types of internal faults.

BP-2C provides fast and selective protection, monitoring and control for single busbar, single busbar with single bus coupler, double busbar, double busbar with up to 4 bus couplers, breaker and A-Half scheme, etc. 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.

Standard centralized mode busbar relay, one case (6U) relay supports 12 Bays, up to 28 Bays in two cases (6U+6U) supported.

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 61850	IEC 60617	ANSI
Protection			
Busbar differential protection	-	3Id/I	87B
Breaker failure protection	CC_RBRF	3I>BF	50BF
BC/BS Dead Zone Protection			50DZ
Feeder End-fault Protection			50FDZ
Phase OverCurrent Protection	OC_PTOC	3I>	50/51P
Ground OverCurrent Protection	EF_PIOC	IN>>	50/51N
Three-phase Overvoltage Protection	OVPTOV	3U>	59P
Three-phase Undervoltage Protection	UVPTUV	3U<	27P
Supervision and monitoring			
Fuse failure supervision	SEQRFUF	FUSEF	60
Current circuit supervision	CCRDIF	MCS 3I	MCS 31
Circuit Breaker Status Supervision			
Disconnector Status Supervision			

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 to 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 48-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 240×128-dot LCD, a 9-key

keypad and 21 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: 512 latest protection operation reports, 512 latest warming records, 128 latest user operation records and 2000 latest records of time tagged sequence of event (SOE) can be recorded.
- Disturbance recording function is supported: 36 latest fault or 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)		1A and 5A adaptive (settable)
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	≤30W (normal state), ≤40W (maximum state)

2.1.4 Binary Input

Reference	IEC 60255-1, Clause:6.10.5
Binary input number	Up to 90
Rated voltage	24VDC~250VDC, 64VAC~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 70	Up to 35
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	10A @ 380Vac； 10A @ 250Vd	5.0A @ 380Vac； 5.0A @ 250Vdc
Short duration current	30A, 3s 50A, 1s	30A, 3s 50A, 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	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
Bounce time	< 1ms	< 1ms
Pickup time	< 5ms	< 5ms
Dropout time	< 5ms	< 5ms

2.2 Mechanical Specifications

Mounting Way	Flush mounted	
Weight per device	Approx. 20.0kg (fully equipped)	
Merchanical size (width×high×deepth)	482.6mm*266 mm *217.7 mm	
Hole size (width×high)	450 mm *267 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	-40°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

For Station Level			
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.
For Process Level (If required)			
Medium		**Parameters**	
Optical		Port number	4
		Connector type	LC
		Transmission rate	100Mbits/s
		Transmission standard	100Base-FX
		Optical fiber type	Multi-mode
		Wavelength	1310nm
		Transmission distance	≤ 2000m

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
	Safety level	Isolation to ELV level
Optical Ethernet	Port number	1
	Connector type	ST
	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 on power supply terminals	IEC 60255-26, CISPR 22	Conducted Emission Limit for Auxiliary Power 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 connectors	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 ±1°
Frequency	35.00Hz ~ 70.00Hz	≤ 0.01Hz
Current (three phase 3Ip)	0.05In<I<4.00In	±1.0%In, 0.05In~1.00In ±1.0%I, 1.00In~4.00In
Voltage (Phase 3Up, Phase-to-Phase 3Upp)	0.05Un<U<1.50Un	±0.5%Un, 0.05Un~1.00Un; ±0.5%U, 1.00Un~1.50Un

2.8 Protection Function Features

2.8.1 Busbar Differential Protection

Tolerance of current setting	≤ 2.5% Setting or 0.02In, whichever is greater
Accuracy of voltage setting	≤ 2.5% Setting or 0.02Un, whichever is greater
Operation time	≤20ms (Id>2.00×Setting)

2.8.2 Feeder End-fault Protection

Tolerance of current setting	≤ 2.5% Setting or 0.02In, whichever is greater
Dropout time	≤ 30ms
Tolerance of time setting	≤ 1% Setting or 40ms, whichever is greater

2.8.3 Breaker Failure Protection

Tolerance of current setting	≤ 2.5% Setting or 0.02In, whichever is greater
Accuracy of voltage setting	≤ 2.5% Setting or 0.02Un, whichever is greater
Dropout current	0.98×Setting
Dropout time	≤ 12.5ms
Tolerance of time setting	≤ 1% Setting or 40ms, whichever is greater

2.8.4 Phase Overcurrent Protection

Pickup current	1.00×Setting
Dropout current	0.98×Setting
Tolerance of current setting	≤ 2.5% Setting or 0.02In, whichever is greater
Dropout time	≤ 35ms
Tolerance of time setting (Definite-time characteristic)	≤1% Setting or 30ms (at 2 times current setting)
Tolerance of time setting (Inverse-time characteristic)	2.5% of operating time or 30ms, whichever is greater (Start value multiples in range of 1.2...20 when I>In) 5% of operating time or 40ms, whichever is greater (Start value multiples in range of 2...20 when I≤In).

2.8.5 Ground Overcurrent protection

Pickup current	1.00×Setting
Dropout current	0.98×Setting
Tolerance of current setting	≤ 2.5% Setting or 0.02In, whichever is greater
Dropout time	≤ 35ms
Tolerance of time setting (Definite-time characteristic)	≤1% Setting or 30ms (at 2 times current setting)
Tolerance of time setting (Inverse-time characteristic)	5% of operating time or 40ms, whichever is greater (Start value multiples in range of 1.2...20)

2.8.6 Pole Discordance Protection

Tolerance of current setting	≤ 2.5% Setting or 0.02In, whichever is greater
Dropout time	≤ 35ms

2.8.7 Tree-phase Overvoltage Protection

Tolerance of voltage setting	≤ 2.5% Setting or 0.02Un, whichever is greater
Tolerance of time setting (Definite-time characteristic)	≤ 1% Setting or 30ms (at 1.2 times voltage setting)
Tolerance of time setting (Inverse-time characteristic)	5% of operating time or 40ms, whichever is greater (Start value multiples in range of 1.2...20)
Dropout time	≤ 35ms

2.8.8 Tree-phase Undervoltage Protection

Tolerance of voltage setting	≤ 2.5% Setting or 0.02Un, whichever is greater
Tolerance of time setting (Definite-time characteristic)	≤ 1% Setting or 30ms (at 1.2 times voltage setting)
Tolerance of time setting (Inverse-time characteristic)	5% of operating time or 40ms, whichever is greater (Start value multiples in range of 1.2...20)
Dropout time	≤ 35ms

2.8.9 CT Circuit Supervision CTS

Tolerance of current setting	≤ 3.0% Setting or 0.05In, whichever is greater

3 Protection Functions

3.1 Overview

The BP-2C relay is a microprocessor based relay which can provide mature protection for various primary equipments (generally all types of transformers etc.). The following sections detail the individual protection functions of this relay.

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
	Failure	Fail
	Impedence	Imp
	Reactance	React

Category	Profession Vocabulary	Abbreviation
	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
	Energize	Energ
	Weigh	Weig
	Activation / Activate	Activ

Category	Profession Vocabulary	Abbreviation
	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

3.2 System Parameters

3.2.1 Overview

To correct configuration of analog input channels, other protected system information, such as the parameters of voltage transformer and current transformer are also required.

3.2.2 Settings

Table 3.2.1 System parameters for one busbar

No.	Name	Range	Unit	Step	Default	Description
1	Prot_TV_Primary	1.00~1200.00	kV	0.01	220.00	Primary rated voltage of VT
2	Prot_TV_Secondary	30.00~300.00	V	0.01	100.00	Secondary rated voltage of VT
3	Prot_TA_Primary_Bay01	0~12000	A	1	2000	Primary rated current of bay01 CT.
4	Prot_TA_Secondary_Bay01	1 or 5	A	4	1	Secondary rated current of bay01 CT.
5	Prot_TA_Primary_ Bay01_CT2	0~12000	A	1	2000	Primary rated current of bay01 CT2 is used when double CTs are available.

No.	Name	Range	Unit	Step	Default	Description
6	Prot_TA_Secondary_ Bay01_CT2	1 or 5	A	4	1	Secondary rated current of bay01 CT2 is used when double CTs are available.
7	Prot_TA_Primary_Bay02	0~12000	A	1	2000	Primary rated current of bay02 CT
8	Prot_TA_Secondary_Bay02	1 or 5	A	4	1	Secondary rated current of bay02 CT
9	Prot_TA_Primary_Bay03	0~12000	A	1	2000	Primary rated current of bay03 CT
10	Prot_TA_Secondary_Bay03	1 or 5	A	4	1	Secondary rated current of bay03 CT
11	Prot_TA_Primary_Bay04	0~12000	A	1	2000	Primary rated current of bay04 CT
12	Prot_TA_Secondary_Bay04	1 or 5	A	4	1	Secondary rated current of bay04 CT
13	Prot_TA_Primary_Bay05	0~12000	A	1	2000	Primary rated current of bay05 CT
14	Prot_TA_Secondary_Bay05	1 or 5	A	4	1	Secondary rated current of bay05 CT
15	Prot_TA_Primary_Bay06	0~12000	A	1	2000	Primary rated current of bay06 CT
16	Prot_TA_Secondary_Bay06	1 or 5	A	4	1	Secondary rated current of bay06 CT
17	Prot_TA_Primary_Bay07	0~12000	A	1	2000	Primary rated current of bay07 CT
18	Prot_TA_Secondary_Bay07	1 or 5	A	4	1	Secondary rated current of bay07 CT
19	Prot_TA_Primary_Bay08	0~12000	A	1	2000	Primary rated current of bay08 CT
20	Prot_TA_Secondary_Bay08	1 or 5	A	4	1	Secondary rated current of bay08 CT
21	Prot_TA_Primary_Bay09	0~12000	A	1	2000	Primary rated current of bay09 CT
22	Prot_TA_Secondary_Bay09	1 or 5	A	4	1	Secondary rated current of bay09 CT
23	Prot_TA_Primary_Bay10	0~12000	A	1	2000	Primary rated current of bay10 CT
24	Prot_TA_Secondary_Bay10	1 or 5	A	4	1	Secondary rated current of bay10 CT

No.	Name	Range	Unit	Step	Default	Description
25	Prot_TA_Primary_Bay11	0~12000	A	1	2000	Primary rated current of bay11 CT
26	Prot_TA_Secondary_Bay11	1 or 5	A	4	1	Secondary rated current of bay11 CT
27	Prot_TA_Primary_Bay12	0~12000	A	1	2000	Primary rated current of bay12 CT
28	Prot_TA_Secondary_Bay12	1 or 5	A	4	1	Secondary rated current of bay12 CT
29	Prot_TA_Primary_BASE	0~12000	A	1	2000	Primary rated current of CT. This is referenced base ratio for each bay calculation. It allows the bay of different CT ratios to use a uniform standard to convert the current.
30	Prot_TA_Secondary_BASE	1 or 5	A	4	1	Secondary rated current of CT. This is referenced base ratio for each bay calculation. It allows the bay of different CT ratios to use a uniform standard to convert the current.
NOTICE: The conversion coefficient Ra_j of bay j is equal to (Prot_TA_Primary_Bayj / Prot_TA_Secondary_Bayj) divided by (Prot_TA_Primary_BASE / Prot_TA_Secondary_BASE) When Prot_TA_Primary_Bayj is less than 50, it means that the bayj is invalid.						

Table 3.2.2 System parameters for two busbar

No.	Name	Range	Unit	Step	Default	Description
1	Prot_TV_Primary	1.00~1200.00	kV	0.01	220.00	Primary rated voltage of VT
2	Prot_TV_Secondary	30.00~300.00	V	0.01	100.00	Secondary rated voltage of VT
3	Prot_TA_Primary_ BayBC/BS	0~12000	A	1	2000	Primary rated current of bay BC/BS CT.
4	Prot_TA_Secondary_ BayBC/BS	1 or 5	A	4	1	Secondary rated current of bay BC/BS CT.
5	Prot_TA_Primary_ BayBC/BS_CT2	0~12000	A	1	2000	Primary rated current of bay BC/BS CT2 is used when double CTs are available.

No.	Name	Range	Unit	Step	Default	Description
6	Prot_TA_Secondary_ BayBC/BS_CT2	1 or 5	A	4	1	Secondary rated current of bay BC/BS CT2 is used when double CTs are available.
7	Prot_TA_Primary_Bay01	0~12000	A	1	2000	Primary rated current of bay01 CT
8	Prot_TA_Secondary_ Bay01	1 or 5	A	4	1	Secondary rated current of bay01 CT
9	Prot_TA_Primary_Bay02	0~12000	A	1	2000	Primary rated current of bay02 CT
10	Prot_TA_Secondary_ Bay02	1 or 5	A	4	1	Secondary rated current of bay02 CT
11	Prot_TA_Primary_Bay03	0~12000	A	1	2000	Primary rated current of bay03 CT
12	Prot_TA_Secondary_ Bay03	1 or 5	A	4	1	Secondary rated current of bay03 CT
13	Prot_TA_Primary_Bay04	0~12000	A	1	2000	Primary rated current of bay04 CT
14	Prot_TA_Secondary_ Bay04	1 or 5	A	4	1	Secondary rated current of bay04 CT
15	Prot_TA_Primary_Bay05	0~12000	A	1	2000	Primary rated current of bay05 CT
16	Prot_TA_Secondary_ Bay05	1 or 5	A	4	1	Secondary rated current of bay05 CT
17	Prot_TA_Primary_Bay06	0~12000	A	1	2000	Primary rated current of bay06 CT
18	Prot_TA_Secondary_ Bay06	1 or 5	A	4	1	Secondary rated current of bay06 CT
19	Prot_TA_Primary_Bay07	0~12000	A	1	2000	Primary rated current of bay07 CT
20	Prot_TA_Secondary_ Bay07	1 or 5	A	4	1	Secondary rated current of bay07 CT
21	Prot_TA_Primary_Bay08	0~12000	A	1	2000	Primary rated current of bay08 CT
22	Prot_TA_Secondary_ Bay08	1 or 5	A	4	1	Secondary rated current of bay08 CT
23	Prot_TA_Primary_Bay09	0~12000	A	1	2000	Primary rated current of bay09 CT

No.	Name	Range	Unit	Step	Default	Description
24	Prot_TA_Secondary_ Bay09	1 or 5	A	4	1	Secondary rated current of bay09 CT
25	Prot_TA_Primary_Bay10	0~12000	A	1	2000	Primary rated current of bay10 CT
26	Prot_TA_Secondary_ Bay10	1 or 5	A	4	1	Secondary rated current of bay10 CT
27	Prot_TA_Primary_Bay11	0~12000	A	1	2000	Primary rated current of bay11 CT
28	Prot_TA_Secondary_ Bay11	1 or 5	A	4	1	Secondary rated current of bay11 CT
29	Prot_TA_Primary_BASE	0~12000	A	1	2000	Primary rated current of CT. This is referenced base ratio for each bay calculation. It allows the bay of different CT ratios to use a uniform standard to convert the current.
30	Prot_TA_Secondary_ BASE	1 or 5	A	4	1	Secondary rated current of CT. This is referenced base ratio for each bay calculation. It allows the bay of different CT ratios to use a uniform standard to convert the current.

NOTICE:

The conversion coefficient Ra_j of bay j is equal to (Prot_TA_Primary_Bayj / Prot_TA_Secondary_Bayj) divided by (Prot_TA_Primary_BASE / Prot_TA_Secondary_BASE)

When Prot_TA_Primary_Bayj or Prot_TA_Primary_BayBC/BS is less than 50, it means that the bayj or bayBC/BS is invalid.

3.3 Busbar Differential Protection 87B

3.3.1 Overview

In these days, electrical power supply system stability is more important task because it deals with huge-quantity of electrical power. Therefore, any kind of malfunction in busbar sections can cause huge amount of power loss. For the point of view of this important engineering aspect, the design of busbar protection is as sensitive as possible.

Busbar differential protection 87B is the main and core sub-protection function of BP-2C, and it covers all protection zones of the whole busbar. 87B protection is to ensure the accurate, stable and healthy operation of busbar in supply system. The operating characteristics of busbar

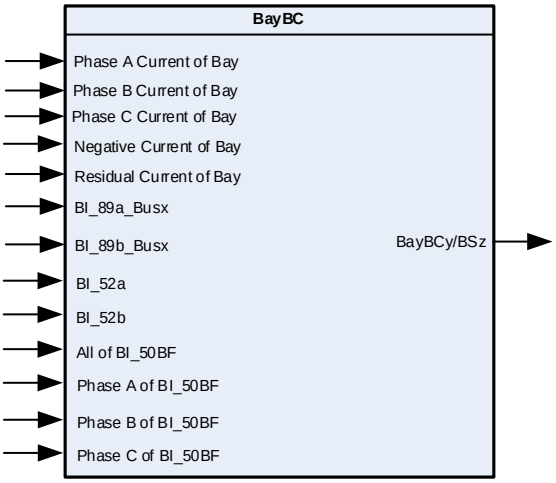
differential protection 87B that are maximum match to any condition of busbar protection are:

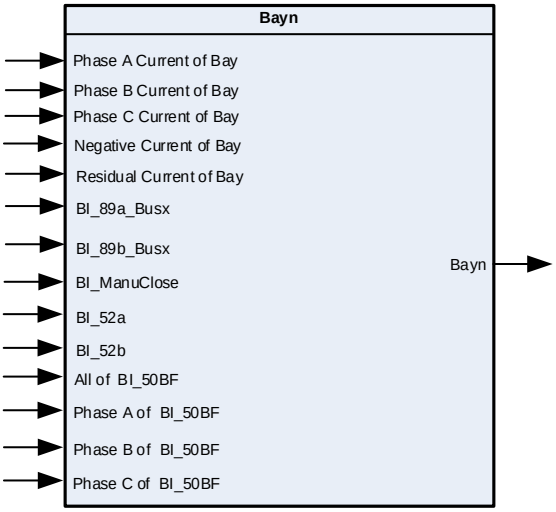
- Highly approved Supervision calculation criteria, including:
  - Arithmetic sum Delta overall current calculation criteria
  - Vectorial sum Differential current threshold calculation criteria.
- Complex percentage differential element defines inner zone or out of zone fault based on calculated restrain current.
- Voltage Block Element to prevent the mal-operation
- Accurate CT saturation detection criteria
- Easily to implement with different type of busbar circuit.

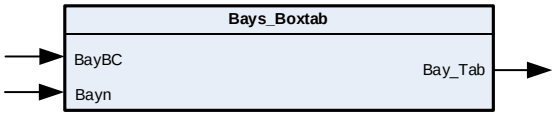
NOTICE!

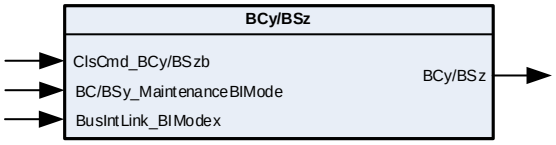
Busbar differential protection 87B is also have blocking capability. In case of fault, if busbar voltage criteria of faulty section are not satisfied.

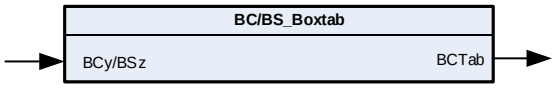
3.3.1.1 Function Block

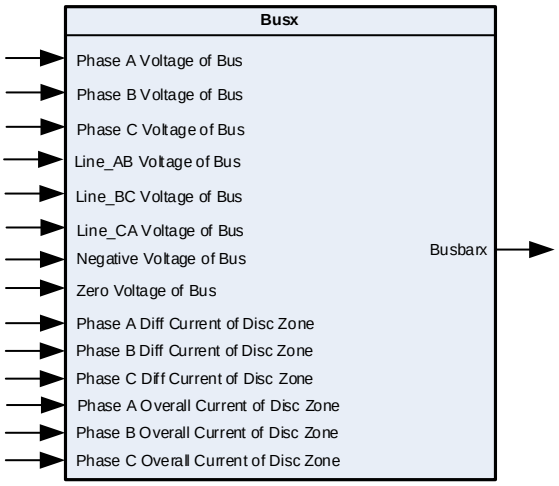


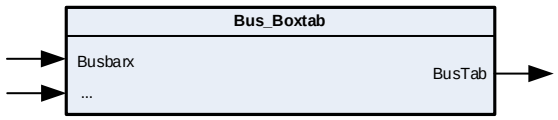

Bayn
Phase A Current of Bay
Phase B Current of Bay
Phase C Current of Bay
Negative Current of Bay
Residual Current of Bay
BI_89a_Busx
BI_89b_Busx
BI_ManuClose
BI_52a
BI_52b
All of BI_50BF
Phase A of BI_50BF
Phase B of BI_50BF
Phase C of BI_50BF
Bayn

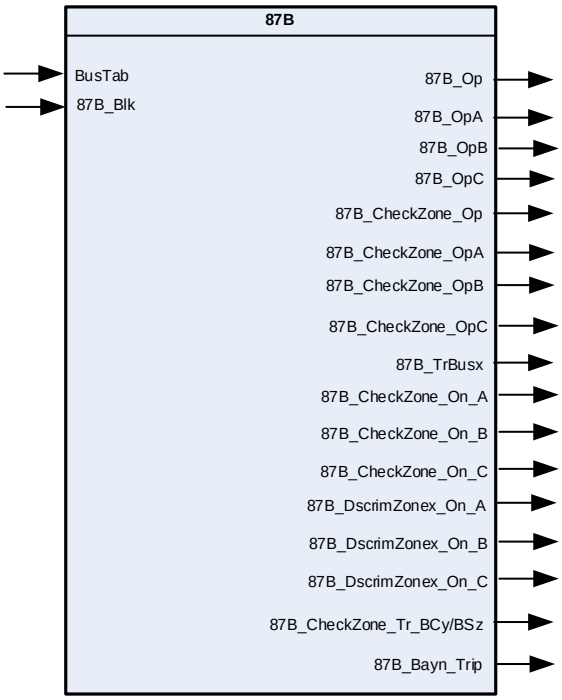

Bays_Boxtab
BayBC
Bayn
Bay_Tab


BCy/BSz
ClsCmd_BCy/BSzb
BC/BSy_MaintenanceBIMode
BusIntLink_BIModex
BCy/BSz


BC/BS_Boxtab
BCy/BSz
BCTab


Busx
Phase A Voltage of Bus
Phase B Voltage of Bus
Phase C Voltage of Bus
Line_AB Voltage of Bus
Line_BC Voltage of Bus
Line_CA Voltage of Bus
Negative Voltage of Bus
Zero Voltage of Bus
Phase A Diff Current of Disc Zone
Phase B Diff Current of Disc Zone
Phase C Diff Current of Disc Zone
Phase A Overall Current of Disc Zone
Phase B Overall Current of Disc Zone
Phase C Overall Current of Disc Zone
Busbarx


Bus_Boxtab
Busbarx
...
BusTab


87B
BusTab
87B_Blk
87B_Op
87B_OpA
87B_OpB
87B_OpC
87B_CheckZone_Op
87B_CheckZone_OpA
87B_CheckZone_OpB
87B_CheckZone_OpC
87B_TrBusx
87B_CheckZone_On_A
87B_CheckZone_On_B
87B_CheckZone_On_C
87B_DscrimZonex_On_A
87B_DscrimZonex_On_B
87B_DscrimZonex_On_C
87B_CheckZone_Tr_BCy/BSz
87B_Bayn_Trip

3.3.1.2 Signals

Table 3.3.1 BayBC Input Signals

NO.	Signal	Description
1	Phase A Current of Bay	Phase-A current input of the bus coupler y or bus section z.
2	Phase B Current of Bay	Phase-B current input of the bus coupler y or bus section z.
3	Phase C Current of Bay	Phase-C current input of the bus coupler y or bus section z.
4	Negative Current of Bay	Negative current input of the bus coupler y or bus section z.
5	Zero Current of Bay	Zero current input of the bus coupler y or bus section z.
6	BI_89a_Busx	Normally open auxiliary contact of bus x disconnector of bus coupler y or bus section z. If there is actual configuration.
7	BI_89b_Busx	Normally closed auxiliary contact of bus x disconnector of bus coupler y or bus section z. It is used if disconnector dual-position auxiliary contacts are adopted. If there is actual configuration.
8	BI_52a	Normally open auxiliary contact of circuit breaker of bus coupler y or bus section z. It is used if breaker dual-position auxiliary contacts are adopted.
9	BI_52b	Normally closed auxiliary contact of circuit breaker of bus coupler y or bus section z.
10	All of BI_50BF	50BF Three-Phase breaker failure initiate binary input of bus coupler y or bus section z.
11	Phase A of BI_50BF	50BF phase-A breaker failure initiate binary input of bus coupler y or bus section z.
12	Phase B of BI_50BF	50BF phase-B breaker failure initiate binary input of bus coupler y or bus section z.
13	Phase C of BI_50BF	50BF phase-C breaker failure initiate binary input of bus coupler y or bus section z.

Table 3.3.2 BayBC Output Signals

NO.	Signal	Description
1	BayBCy/BSz	Resource box 1 of bus coupler y or bus section z.

Table 3.3.3 Bay n Input Signals

NO.	Signal	Description
1	Phase A Current of Bay	Phase-A current input of the bay n.
2	Phase B Current of Bay	Phase-B current input of the bay n.
3	Phase C Current of Bay	Phase-C current input of the bay n.

NO.	Signal	Description
4	Negative Current of Bay	Negative current input of the bay n.
5	Zero Current of Bay	Zero current input of the bay n.
6	BI_89a_Busx	Normally open auxiliary contact of bus x disconnector of bay n.
7	BI_89b_Busx	Normally closed auxiliary contact of bus x disconnector of bay n. It is used if disconnector dual-position auxiliary contacts are adopted.
8	BI_ManuClose	Binary input for closing command of the circuit breaker of bay n.
9	BI_52a	Normally open auxiliary contact of the circuit breaker of bay n.
10	BI_52b	Normally close auxiliary contact of the circuit breaker of bay n.
11	All of BI_50BF	50BF Three-Phase breaker failure initiate binary input of bay n.
12	Phase A of BI_50BF	50BF phase-A breaker failure initiate binary input of bay n.
13	Phase B of BI_50BF	50BF phase-B breaker failure initiate binary input of bay n.
14	Phase C of BI_50BF	50BF phase-C breaker failure initiate binary input of bay n.

Table 3.3.4 Bay n Output Signals

NO.	Signal	Description
1	Bayn	Resource box of bay n.

Table 3.3.5 Bays_BoxTab n Input Signals

NO.	Signal	Description
1	BayBCy/BSz	Resource box 1 of bus coupler y or bus section z.
2	Bayn	Resource box of bay n.

Table 3.3.6 Bays_BoxTab Output Signals

NO.	Signal	Description
1	Bay_Tab	Resource table contains all of bay n, and resource box 1 of bus coupler y and bus section z.

Table 3.3.7 BCy/BSz Input Signals

NO.	Signal	Description
1	ClsCmd_BCy/BSz	Binary input for closing command of the circuit breaker of bus coupler y or bus section z.
2	BC/BSy_MaintenanceBIMode	Busbar Couper breaker is in maintenance.

NO.	Signal	Description
		It will be hidden if there is no BC/BSy(y=1, 2, 3) breaker.
3	BusIntLink_BIModex	When the binary input BusIntLink_BIModex(x=1, 2, 3) is energized, the protection will be in the inter-linked operation mode.

Table 3.3.8 BCy/BSz Output Signals

NO.	Signal	Description
1	BCy/BSz	Resource box 2 of bus coupler y and bus section z.

Table 3.3.9 BCy/BSz_BoxTab Input Signals

NO.	Signal	Description
1	BCy/BSz	Resource box 2 of bus coupler y and bus section z.

Table 3.3.10 BCy/BSz_BoxTab Output Signals

NO.	Signal	Description
1	BCTab	Resource table contains all of resource box 2 of bus coupler y and bus section z.

Table 3.3.11 Busx Input Signals

NO.	Signal	Description
1	Phase A Voltage of Bus	Phase-A voltage input of busbar x.
2	Phase B Voltage of Bus	Phase-B voltage input of busbar x.
3	Phase C Voltage of Bus	Phase-C voltage input of busbar x.
4	Line_AB Voltage of Bus	Line-AB voltage of busbar x.
5	Line_BC Voltage of Bus	Line-BC voltage of busbar x.
6	Line_CA Voltage of Bus	Line-CA voltage of busbar x.
7	Negative Voltage of Bus	Negative voltage of busbar x.
8	Zero Voltage of Bus	Zero voltage of busbar x.
9	Phase A Diff Current of Disc Zone	Discriminative zone phase-A differential current of busbar x.
10	Phase B Diff Current of Disc Zone	Discriminative zone phase-B differential current of busbar x.
11	Phase C Diff Current of Disc Zone	Discriminative zone phase-C differential current of busbar x.
12	Phase A Overall Current of Disc Zone	Discriminative zone phase-A overall current of busbar x.
13	Phase B Overall Current of Disc Zone	Discriminative zone phase-B overall current of busbar x.

NO.	Signal	Description
14	Phase C Overall Current of Disc Zone	Discriminative zone phase-C overall current of busbar x.

Table 3.3.12 Busx Output Signals

NO.	Signal	Description
1	Busbarx	Resource box of busbar x.

Table 3.3.13 Bus_Boxtab Input Signals

NO.	Signal	Description
1	Busbarx	Resource box of busbar x.

Table 3.3.14 Bus_Boxtab Output Signals

NO.	Signal	Description
1	BusTab	Resource table contains all of busbar.

Table 3.3.15 87B Input Signals

NO.	Signal	Description
1	BusTab	Resource table contains all of busbar.
2	87B_Blk	Binary input for blocking 87B function.

Table 3.3.16 87B Output Signals

NO.	Signal	Description
1	87B_Op	Busbar differential protection operates to trip any busbar.
2	87B_OpA	Phase-A Busbar differential protection operates to trip any busbar.
3	87B_OpB	Phase-B Busbar differential protection operates to trip any busbar.
4	87B_OpC	Phase-C Busbar differential protection operates to trip any busbar.
5	87B_CheckZone_Op	Check zone operates.
6	87B_CheckZone_OpA	Phase-A of check zone operates.
7	87B_CheckZone_OpB	Phase-B of check zone operates.
8	87B_CheckZone_OpC	Phase-C of check zone operates.
9	87B_TrBusx	Busbar differential protection operates to trip busbar x.
10	87B_CheckZone_On_A	Phase-A valid flag of check zone differential protection.
11	87B_CheckZone_On_B	Phase-B valid flag of check zone differential protection.

NO.	Signal	Description
12	87B_CheckZone_On_C	Phase-C valid flag of check zone differential protection.
13	87B_DscrimZonex_On_A	Phase-A valid flag of busbar x differential protection.
14	87B_DscrimZonex_On_B	Phase-B valid flag of busbar x differential protection.
15	87B_DscrimZonex_On_C	Phase-C valid flag of busbar x differential protection.
16	87B_CheckZone_Tr_BCy/ BSz	Check zone operates to trip BCy/BSz.
17	87B_Bayn_Trip	87B operates to trip bayn (n=BC/12, 1…11).

3.3.2 Protection Principle

3.3.2.1 Supervision Element

BP-2C provides independent supervision element for 87B, if one of the following two conditions is fulfilled, supervision element of 87B picks up.

1. Delta Overall Current Criterion

The overall current which is the arithmetic sum of the magnitudes of each current, when any one phase of the delta overall current is larger than the threshold, the supervision element of this phase picks up. Its expressed as follow.

Overall current:

$$I_r = \sum_{j=1}^{m} | I_j |$$

The operating criterion:

$$\Delta i_r > \Delta I_{dset}$$

Where：

I_j : The current of bay j (BSz be included for Double Busbar with one BC and Two BS) which connected to busbar is the value that has been converted by conversion coefficient Ra_j.

Δi_r : Delta overall current which means the sudden change quantity of overall current during one cycle.

ΔI_{dset} : The delta overall current threshold, its fixed as 0.5In, In is the rated secondary current of CT.

2. Differential Current Threshold-crossing Criterion

Differential current which is the vectorial sum of the magnitudes of each current. When any one phase of differential current is larger than the differential current setting 87B_CZ_Cur_Str, the supervision element of this phase picks up. Its expressed as follow.

Differential current:

$$I_d = |\sum_{j=1}^{m} I_j|$$

The operating criterion:

$$I_d > 87B\_CZ\_Cur\_Str$$

Where:

I_j : The phase current of bay j (BSz be included for Double Busbar with one BC and Two BS) which connected to busbar is the value that has been converted by conversion coefficient Ra_j.

I_d : Differential phase current of check zone.

$87B\_CZ\_Cur\_Str$: Current setting of busbar differential protection of check zone.

When any one phase of differential current is lower than current setting $87B\_CZ\_Cur\_Str$, and the corresponding phase currents of each bay are lower than 1.5In, the supervision element of this phase returns. The supervision element will last for 40ms after corresponding supervision element return. It's expressed as follow.

$$\begin{cases} I_d < Kf \times 87B\_CZ\_Cur\_Str \\ I_j < 1.5In (j = 1,2...m) \end{cases}$$

Where:

I_d : Differential phase current of check zone.

Kf: The dropout current ratio.

$87B\_CZ\_Cur\_Str$: Current setting of busbar differential protection of check zone.

I_n : The rated secondary current of CT.

3.3.2.2 Complex Percentage Differential Element

Compared with the traditional percentage restrain criterion, the complex percentage differential criterion is added with differential current in calculation of restrain current, which providing it with a strong restrain characteristic when it is faulty outside of the protection zone and providing no restrain when it is faulty inside of the protection zone.

The operating criteria of complex ratio differential are described as follow:

$$\begin{cases} I_d > 87B\_CZ / DZ\_Cur\_Str \\ I_d > K_r \times (I_r - I_d) \end{cases}$$

Where:

I_d : Differential phase current of check zone or discriminating zone.

87B_CZ / DZ_Cur_Str : Current setting of busbar differential protection of check zone or discriminating zone.

I_r : Overall current of check zone or discriminating zone.

K_r : Setting of complex percentage restraint coefficient of check zone or discriminating zone，that is 87B_ CZ_ Slope_Kr or 87B_ DZ_ Slope_Kr.

The operating characteristic of complex percentage differential element is shown in figure below.

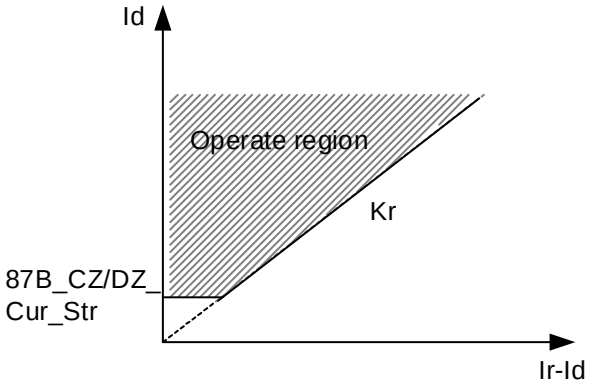


Figure 3.3.1 Operating characteristic of complex percentage differential element

Take into consideration the sensitivity of check zone differential element for a fault occurred in the weak source busbar zone when the BC breaker is open, dual restraint coefficient 87B_CZ_Slope_Kr and 87B_ DZ_ Slope_Kr are adopted for check zone and discriminative zones respectively. The K_r of complex percentage differential element both are recommended as 0.43.

Where:

I_d : Differential phase current of check zone or discriminating zone.

$$I_d = \left| \sum_{j=1}^{m} I_j \right|$$

Ir-Id: Overall current minus Differential phase current of check zone or discriminating zone.

$$I_r - I_d = \sum_{j=1}^{m} |I_j| - \left| \sum_{j=1}^{m} I_j \right|$$

3.3.3 Differential circuits

The differential circuit include check zone differential circuit and discriminating zone differential circuit. The check zone differential element is used to distinguish whether the fault occurs outside or within the overall busbar system, and the discriminating zone differential elements are used to select faulty zone

3.3.3.1 Single Busbar

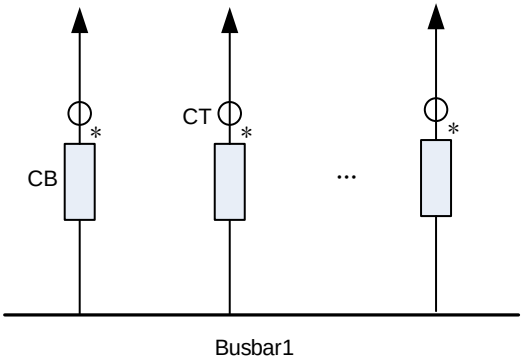


Figure 3.3.2 Single busbar arrangement

The single busbar arrangement is shown in Figure 3.3.2.Check zone differential circuit is constituted by currents of all circuits connected to busbar 1, and discriminative zone has the same differential circuit as Check zone.

Differential current is calculated as follow.

$$I_d = I_1 + I_2 + ... + I_n$$

Where:

$I_1, I_2 ... I_n$: The current of each bay connected to busbar1 is the value that has been converted by conversion coefficient Ra_j.

NOTICE!

The polarity mark of CB (circuit breaker) CT is on the busbar side. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.2.

3.3.3.2 Single Busbar with One BS (Bus Section)

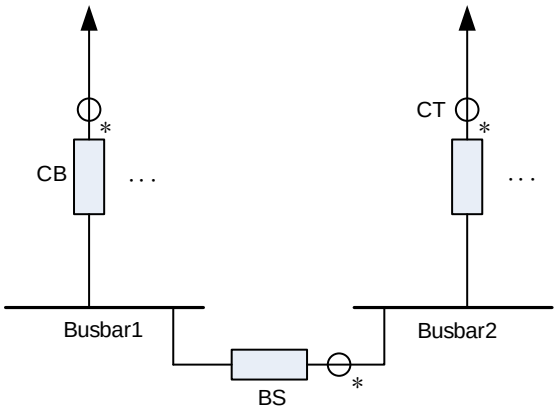


Figure 3.3.3 Single busbar with one BS arrangement (Single CT)

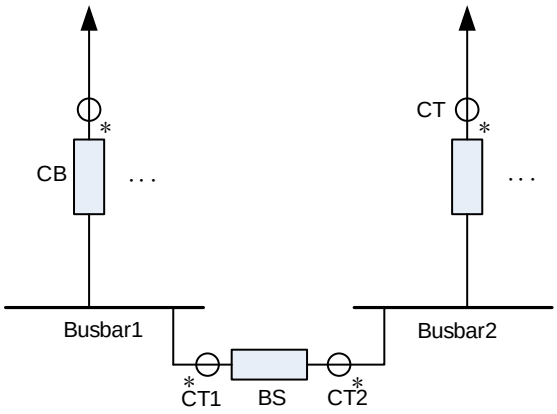


Figure 3.3.4 Single busbar with one BS arrangement (Double CTs)

The single busbar with one BS arrangement is shown in Figure 3.3.3, Figure 3.3.4. Check zone differential circuit is constituted by currents of all circuits connected to busbar1 and busbar2 except BS. The discriminative zone differential circuit is constituted by currents of all circuits connected to individual zone (busbar 1 or busbar 2) which separated by BS.

For the BC/BS that double CTs are available, the two CTs should be cross-connected to the discriminating zone differential circuit of the two busbars that connected to the BC/BS.

Differential current is calculated as follow.

Check zone: $I_d = I_1 + I_2 + ... + I_n$

For Single CT arrangement:

Discriminative zone1: $I_{d1} = \sum_{i=4}^{n} (I_i \times S_{1i}) - I_{BS} \times S_{BS}$

Discriminative zone2: $I_{d2} = \sum_{i=4}^{n} (I_i \times S_{2i}) + I_{BS} \times S_{BS}$

For Double CT arrangement:

Discriminative zone1: $I_{d1} = \sum_{i=4}^{n}(I_i \times S_{1i}) - I_{BSCT2} \times S_{BS}$

Discriminative zone2: $I_{d2} = \sum_{i=4}^{n}(I_i \times S_{2i}) - I_{BSCT1} \times S_{BS}$

Where:

I_{BS} : The current of BS is the value that has been converted by conversion coefficient Ra_j.

I_{BSCT1} : The BS current of CT side busbar 1 is the value that has been converted by conversion coefficient Ra_j.

I_{BSCT2} : The BS current of CT side busbar 2 is the value that has been converted by conversion coefficient Ra_j.

I_1,I_2...I_n : The current of each bay connected to busbar1 and busbar2 except BS current is the value that has been converted by conversion coefficient Ra_j.

S_{BS} : Signal “1”indicates that BS is in closed position, “0”indicates it is open.

S_{1i} : Signal “1”indicates that bay i is connected to busbar1.

S_{2i} : Signal “1”indicates that bay i is connected to busbar2.

NOTICE!

The polarity mark of CB (circuit breaker) CT of feeder is on the busbar side.

For bus section with single CT arrangement, the polarity mark of BS (bus section) CT is on busbar 2 side. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.3

For bus section with double CTs arrangement, the polarity mark of BS (bus section) CTs are on the busbar side, and CT1 will be taken as the main CT of bus section. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.4.

3.3.3.3 Double Busbar with One BC (Bus Coupler)

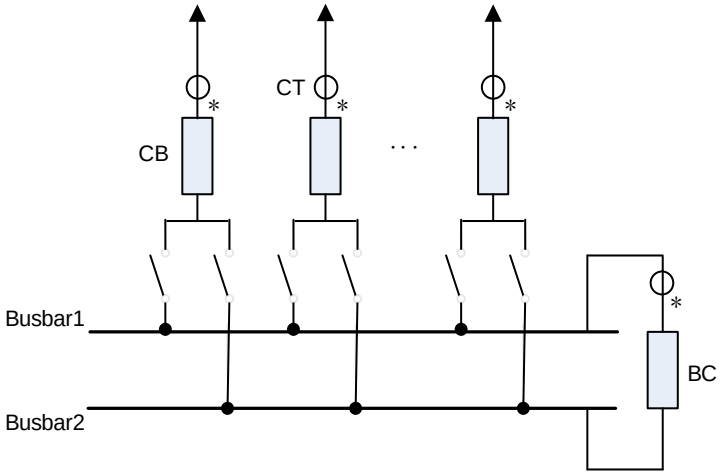


Figure 3.3.5 Double busbar with One BC arrangement (Single CT)

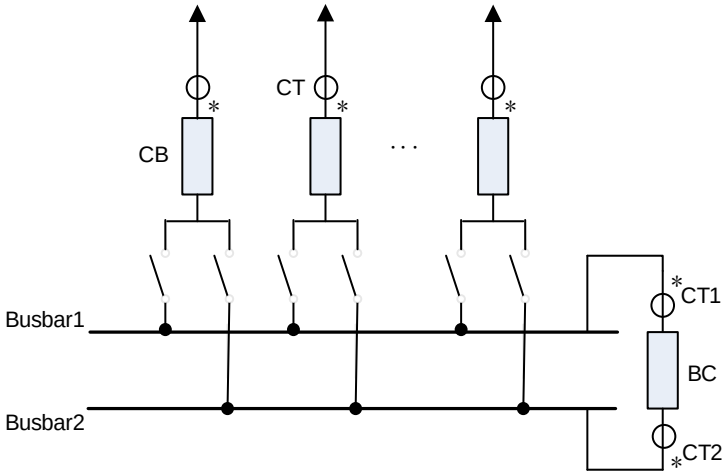


Figure 3.3.6 Double busbar with One BC arrangement (Double CTs)

The double busbar with one BC arrangement is shown in Figure 3.3.5, Figure 3.3.6. Check zone differential circuit is constituted by currents of the circuits connected to busbar1 and busbar2 except BC. The discriminative zone differential circuit is constituted by currents of all circuits connected to individual zone (busbar 1 or busbar 2) which separated by BC.

For the BC/BS that double CTs are available, the two CTs should be cross-connected to the discriminating zone differential circuit of the two busbars that connected to the BC/BS.

Differential current is calculated as follow.

Check zone: $I_d = I_1 + I_2 + ... + I_n$

For Single CT arrangement:

Discriminative zone1: $I_{d1} = \sum_{i=4}^{m}(I_i \times S_{1i}) - I_{BC} \times S_{BC}$

Discriminative zone2: $I_{d2} = \sum_{i=4}^{m}(I_i \times S_{2i}) + I_{BC} \times S_{BC}$

For Double CT arrangement:

Discriminative zone1: $I_{d1} = \sum_{i=4}^{m}(I_i \times S_{1i}) - I_{BCCT2} \times S_{BC}$

Discriminative zone2: $I_{d2} = \sum_{i=4}^{m}(I_i \times S_{2i}) - I_{BCCT1} \times S_{BC}$

Where:

I_{BC} : The current of BC is the value that has been converted by conversion coefficient Ra_j.

I_{BCCT1} : The BC current of CT side busbar 1 is the value that has been converted by conversion coefficient Ra_j.

I_{BCCT2} : The BC current of CT side busbar 2 is the value that has been converted by conversion coefficient Ra_j.

I_1,I_2...I_n : The current of each bay connected to busbar1 and busbar2 except BC current is the value that has been converted by conversion coefficient Ra_j.

S_{BC} : Signal “1”indicates that BC is in closed position, “0”indicates it is open.

S_{1i} : Signal “1”indicates that the disconnector of bay i connected to busbar 1 is in closed position, “0”indicates it is open.

S_{2i} : Signal “1”indicates that the disconnector of bay i connected to busbar 2 is in closed position; “0”indicates it is open.

NOTICE!

The polarity mark of CB (circuit breaker) CT of feeder is on the busbar side.

For bus coupler with single CT arrangement, the polarity mark of BC (bus coupler) CT is on busbar 2 side. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.5.

For bus section with double CTs arrangement, the polarity mark of BC (bus coupler) CTs are on the busbar side, and CT1 will be taken as the main CT of bus section. The polarity

mark definition of usual busbar system arrangements are shown in figure 3.3.6.

3.3.3.4 Double Busbar with Two BC and One BS

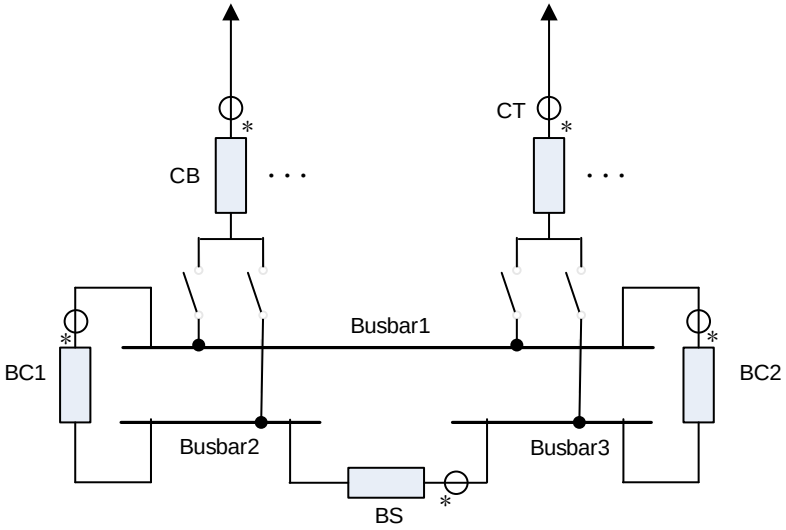


Figure 3.3.7 Double busbar with two BC and one BS arrangement (Single CT)

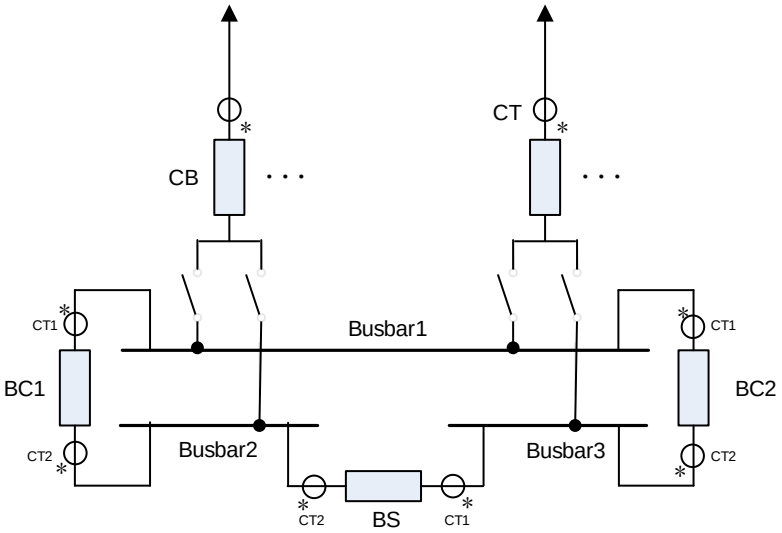


Figure 3.3.8 Double busbar with two BC and one BS arrangement (Double CTs)

The double busbar with two BC and one BS arrangement is shown in Figure 3.3.7, Figure 3.3.8. Check zone differential circuit is constituted by currents of all circuits connected to busbar1, busbar2 and busbar3 except BC1, BC2 and BS. The discriminative zone differential circuit is constituted by currents of all circuits connected to individual zone (busbar1, busbar2 or busbar3) which separated by BC1, BC2 and BS.

Differential current is calculated as follow.

Check zone: $I_d = I_1 + I_2 + ... + I_n$

Discriminative zone1: $I_{d1} = \sum_{i=4}^{m}(I_i \times S_{1i}) - I_{BC1} \times S_{BC1} - I_{BC2} \times S_{BC2}$

Discriminative zone2: $I_{d2} = \sum_{i=4}^{m}(I_i \times S_{2i}) + I_{BC1} \times S_{BC1} + I_{BS} \times S_{BS}$

Discriminative zone3: $I_{d3} = \sum_{i=4}^{m}(I_i \times S_{3i}) + I_{BC2} \times S_{BC2} - I_{BS} \times S_{BS}$

Where:

I_{BC1}, I_{BC2}, I_{BS} : The current of BC1, BC2, BS is the value that has been converted by conversion coefficient Ra_j.

$I_1, I_2 ... I_n$: The current of each bay connected to busbar 1, busbar 2 and busbar 3 except I_{BC1}, I_{BC2}, I_{BS} is the value that has been converted by conversion coefficient Ra_j.

S_{BC1}: Signal “1”indicates that BC1 is in closed position, “0”indicates its open.

S_{BC2}: Signal “1”indicates that BC2 is in closed position, “0”indicates its open.

S_{BS} : Signal “1”indicates that BS is in closed position, “0”indicates its open.

S_{1i} : Signal “1”indicates that the disconnector of bay i connected to busbar 1 is in closed position, “0”indicates its open.

S_{2i} : Signal “1”indicates that the disconnector of bay i connected to busbar 2 is in closed position; “0”indicates its open.

S_{3i} : Signal “1”indicates that the disconnector of bay i connected to busbar 3 is in closed position; “0”indicates it is in open position.

NOTICE!

The polarity mark of CB (circuit breaker) CT of feeder is on the busbar side.

For BC/BS with single CT arrangement, the polarity mark of BC1 (bus coupler) CT is on busbar 2 side, the polarity mark of BC2 (bus coupler) CT is on busbar 3 side, the polarity mark of BS (bus section) CT is on busbar 2 side. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.7.

For BC/BS with double CTs arrangement, the polarity mark of BC/BS CTs are on the busbar side, and CT1 will be taken as the main CT of BC/BS. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.8.

3.3.3.5 Double Busbar with One BC and Two BS

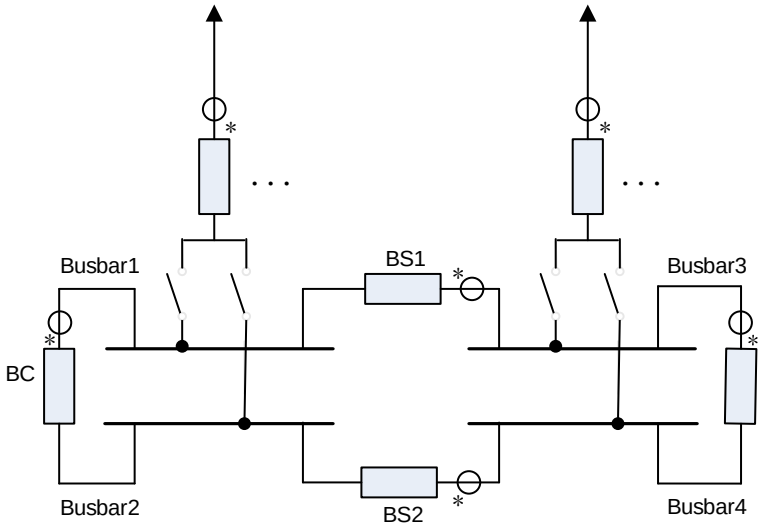


Figure 3.3.9 Double busbar with one BC and two BS arrangement (Single CT)

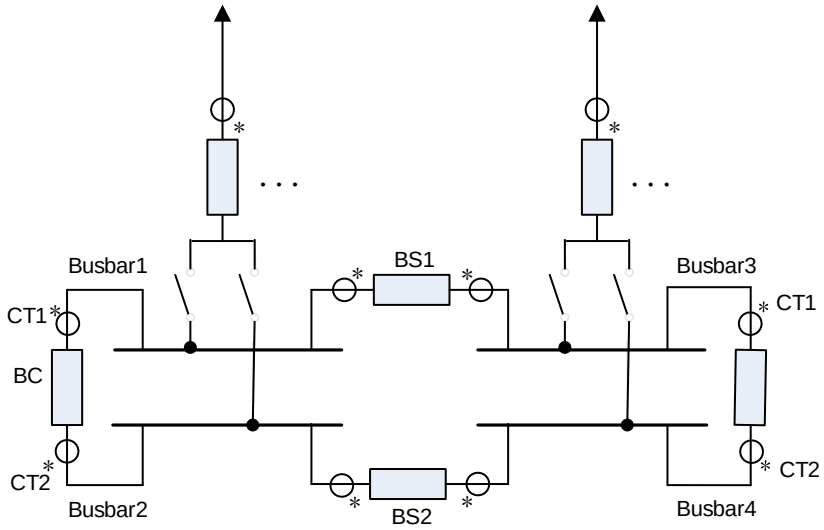


Figure 3.3.10 Double busbar with one BC and two BS arrangement (Double CTs)

The double busbar with one BC and two BS arrangement is shown in Figure 3.3.9, Figure 3.3.10. We usually use two IEDs to provide protection for this system arrangements because of more bays. One IED protect left region of the busbar (busbar 1, busbar 2), and the other protect right region (busbar 3, busbar 4). The protected area of two IEDs overlaps in the breaker section (BS1, BS2).For the occasion of this arrangement, the BS current will be included in check zone differential element.

NOTICE!

The polarity mark of CB (circuit breaker) CT of feeder is on the busbar side.

For bus coupler with single CT arrangement, the polarity mark of BC (bus coupler) CT is on busbar 2 side. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.9.

For bus section with double CTs arrangement, the polarity mark of BC (bus coupler) CTs are on the busbar side, and CT1 will be taken as the main CT of bus section. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.10.

3.3.3.6 Breaker and A-Half

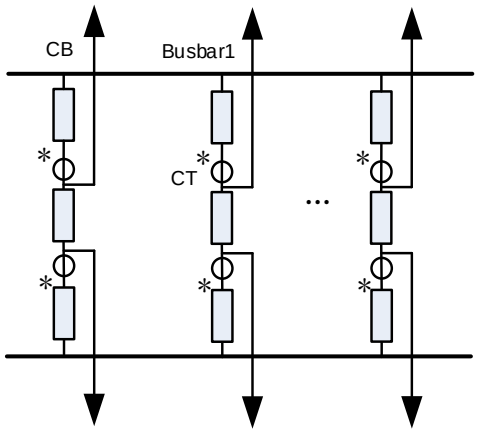


Figure 3.3.11 Breaker and A-Half Scheme arrangement

The breaker and A-Half scheme arrangement is shown in Figure 3.3.11. Check zone differential circuit is constituted by currents of all circuits connected to Busbar 1(or Busbar 2), and discriminative zone has the same differential circuit as Check zone.

Differential current is calculated as follow.

$$I_d = I_1 + I_2 + ... + I_n$$

Where:

$I_1, I_2 ... I_n$: The current of each bay connected to busbar 1 is the value that has been converted by conversion coefficient Ra_j.

NOTICE!

The polarity mark of CB (circuit breaker) CT is on the busbar side. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.11.

3.3.3.7 Double Busbar Double Breaker

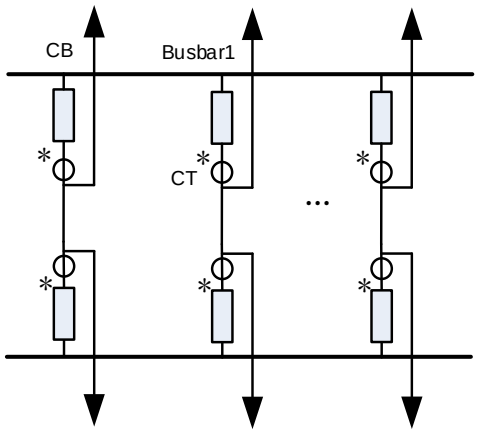


Figure 3.3.12 Double Busbar Double Breaker arrangement

The Double Busbar Double Breaker arrangement is shown in Figure 3.3.12. Check zone differential circuit is constituted by currents of all circuits connected to Busbar 1(or Busbar 2), and discriminative zone has the same differential circuit as Check zone.

Differential current is calculated as follow.

$$I_d = I_1 + I_2 + ... + I_n$$

Where:

$I_1, I_2 ... I_n$: The current of each bay connected to busbar 1 is the value that has been converted by conversion coefficient Ra_j.

NOTICE!

The polarity mark of CB (circuit breaker) CT is on the busbar side. The polarity mark definition of usual busbar system arrangements are shown in figure 3.3.12.

3.3.3.8 Double Main and Transfer

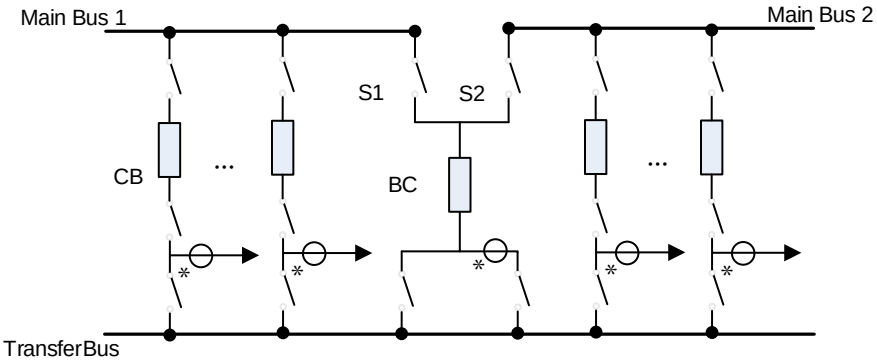


Figure 3.3.13 Double Main and Transfer arrangement

The Double Main and Transfer arrangement is shown in Figure 3.3.13. Check zone differential circuit is constituted by currents of all circuits connected to Main Bus1, transfer Bus and Main Bus2 except BC. The discriminative zone differential circuit is constituted by currents of all circuits connected to individual zone (transfer Bus, Main Bus1 or Main Bus2).

Differential current is calculated as follow.

Check zone: $I_d = I_1 + I_2 + ... + I_n$

Discriminative zone1: $I_{d1} = \sum_{i=2}^{m} (I_i \times S_{1i})$

Discriminative zone2: $I_{d2} = \sum_{i=2}^{m} (I_i \times S_{2i}) - I_{BC} \times S_{BC}$

Discriminative zone3: $I_{d3} = \sum_{i=3}^{m} (I_i \times S_{3i}) + I_{BC} \times S_{BC}$

Where:

I_{BC} : The current of BC is the value that has been converted by conversion coefficient Ra_j.

$I_1, I_2 ... I_n$: The current of each bay connected to Main Bus1, transfer Bus and Main Bus2 except I_{BC} is the value that has been converted by conversion coefficient Ra_j.

S_{BC} : Signal “1”indicates that BC is in closed position, “0”indicates its open.

S_{1i} : Signal “1”indicates that the disconnector of bay i connected to Main Bus1 is in closed position, “0”indicates its open.

S_{2i} : Signal “1”indicates that the disconnector of bay i connected to transfer Bus is in closed

position; “0”indicates its open.

S_{3i} : Signal “1”indicates that the disconnector of bay i connected to Main Bus2 is in closed position; “0”indicates it is in open position.

The double main and transfer bus scheme arrangement needs to collect S1 and S2 disconnector signals and BC status to participate in protection logic. The operation mode of the busbar is as follows.

When S1 and S2 disconnectors are open, and BC is open, the busbars operate independently.

When S1 disconnector is close, and S2 disconnector is open, with BC closed, Main Bus1 is interconnected with transfer Bus.

When S1 disconnector is open, and S2 disconnector is close, with BC closed, transfer Bus and Main Bus2 are in parallel operation.

3.3.4 Voltage Block Element 87B_VBE

Voltage block element is used as a blocking condition of 87B. If the fault voltage doesn’t fulfills the voltage criteria, the 87B will be blocked.

The releasing criteria of 87B_VBE are:

$$\begin{cases} U_p \le 87B\_Vol\_Blk \\ 3U_0 \ge 87B\_ResVol\_Blk \\ U_2 \ge 87B\_NegVol\_Blk \end{cases}$$

Where:

U_p : The phase-to-earth voltages of the busbar.

$3U_0$: Residual voltage of the busbar (calculated internally).

U_2 : Negative voltage of the busbar (calculated internally).

87B_Vol_Blk: Phase voltage setting of 87B_VBE.

87B_ResVol_Blk: Residual voltage setting of 87B_VBE.

87B_NegVol_Blk: Negative voltage setting of 87B_VBE.

When the protective device is applied to an unearthed system, the system setting UnearthedSys_Mod is set as “1”, the criteria of 87b_VBE will be changed.

$$\begin{cases} U_{pp} \le \sqrt{3} \times 87B\_Vol\_Blk \\ U_2 \ge 87B\_NegVol\_Blk \end{cases}$$

Where:

U_{pp} : Phase-to-phase voltage.

U_2 : Negative sequence voltage.

87B_Vol_Blk: Phase-to-earth voltage setting of 87B_VBE.

87B_NegVol_Blk: Negative voltage setting of 87B_VBE.

3.3.5 Detection of CT Saturation

In order to prevent the misoperation caused by severe CT saturation during an external fault occurred in adjacent region, the protection is provided with CT saturation detection element to check if differential current is caused by external fault.

The saturation detection element is based on CT saturation generation mechanism and characteristic of secondary current waveform after CT saturation. In case of busbar fault occurs, ΔI_d element will operate almost at the same time with ΔI_r element, whereas for external fault, the ΔI_d element will not operate before CT saturation at the fault incipient stage, it will only operate after ΔI_r element in case CT is saturated. And although differential current waveform is distorted during CT saturation, each cycle has a linear transfer region, and there are rich harmonic in the transient saturation waveform, which can accurately detect the time of CT saturation occurs and adjust the protection algorithm in real-time, thus blocking busbar differential protection to prevent mal-operation if the differential current is determined to be caused by CT saturation.

3.3.6 Inter-linked Operation Mode

In multiple busbar, it is common requirement to use the possibility of zone interconnection. The protection will be in the inter-linked operation mode under following conditions.

1. When the binary input BusIntLink_BIModex(x=1, 2, 3) is energized.

2. When the setting BusIntLink_EnModex(x=1, 2, 3) is set as “1”.

3. When BC/BS which is connected to two busbar occurs CT circuit failure, and the setting CTS_IntLink_Mode_BC/BS is set as 1(Phase-segregated inter-linked) or 2(Three-segregated inter-linked).

4. On DS force enable condition. (When the setting DS_ForceEnable_Bayn, DS1_Force_Bayn, DS2_Force_Bayn are enable).

5. On load transfer condition. (When two disconnectors of one feeder connected to busbar are closed at the same time).

On Inter-linked operation mode, the protection will merge two or more differential zone, and discriminating zone element will be disable. The discriminating zone differential current are the same as that of check zone differential current. When a busbar fault occurs, and the checkzone element operates, the corresponding inter-linked busbars will trip at the same time.

It is common requirement to use the possibility of zone interconnection to switch the load current in any bay from one busbar to the other. On load transfer condition, in order to prevent mal-operation of protection due to the unreliable contacts of the disconnectors, it is recommended to manually force the relay to inter-linked operation mode by binary input or settings.

3.3.7 Logic

The logic of Voltage Block Element is shown as follows:

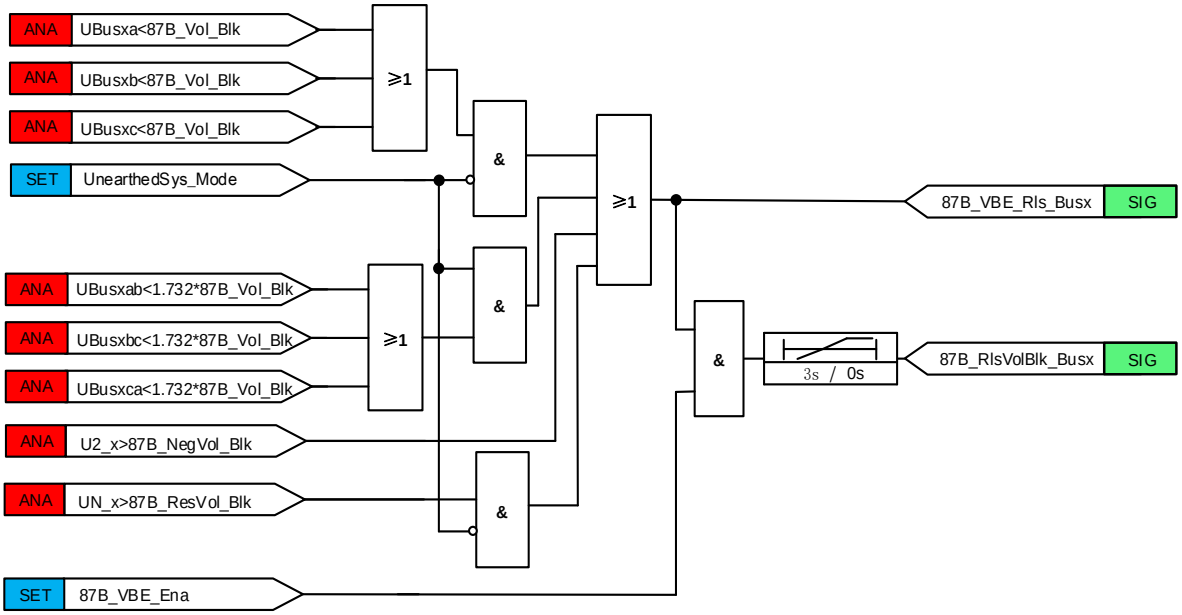
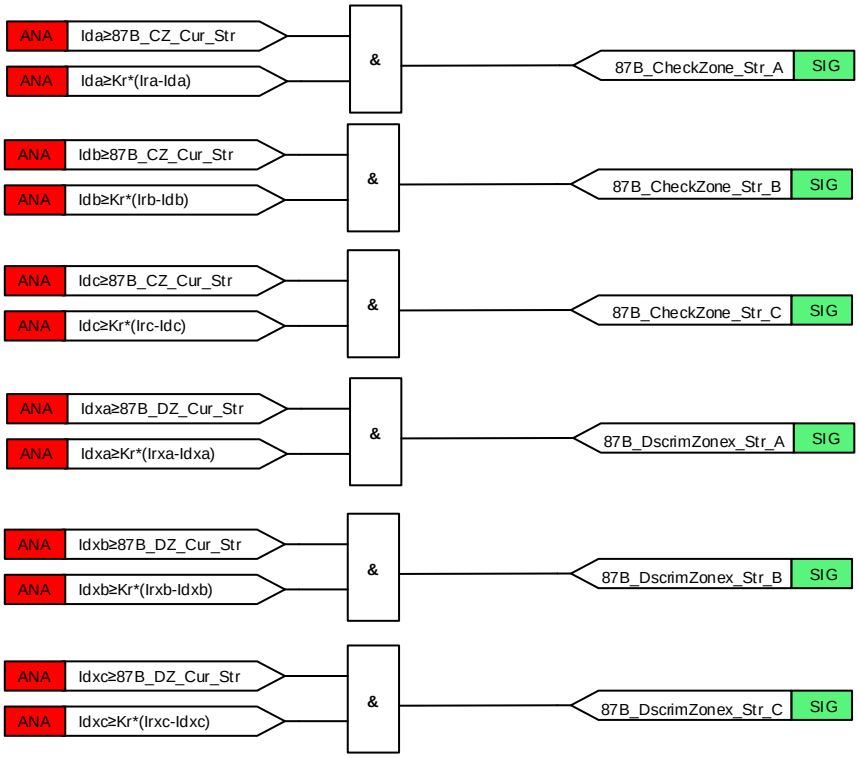
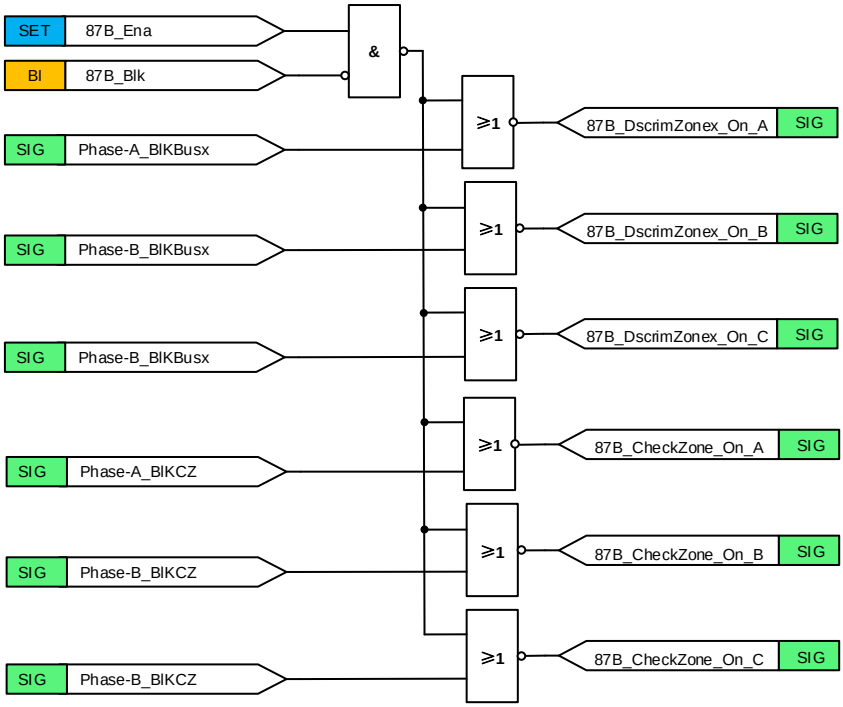
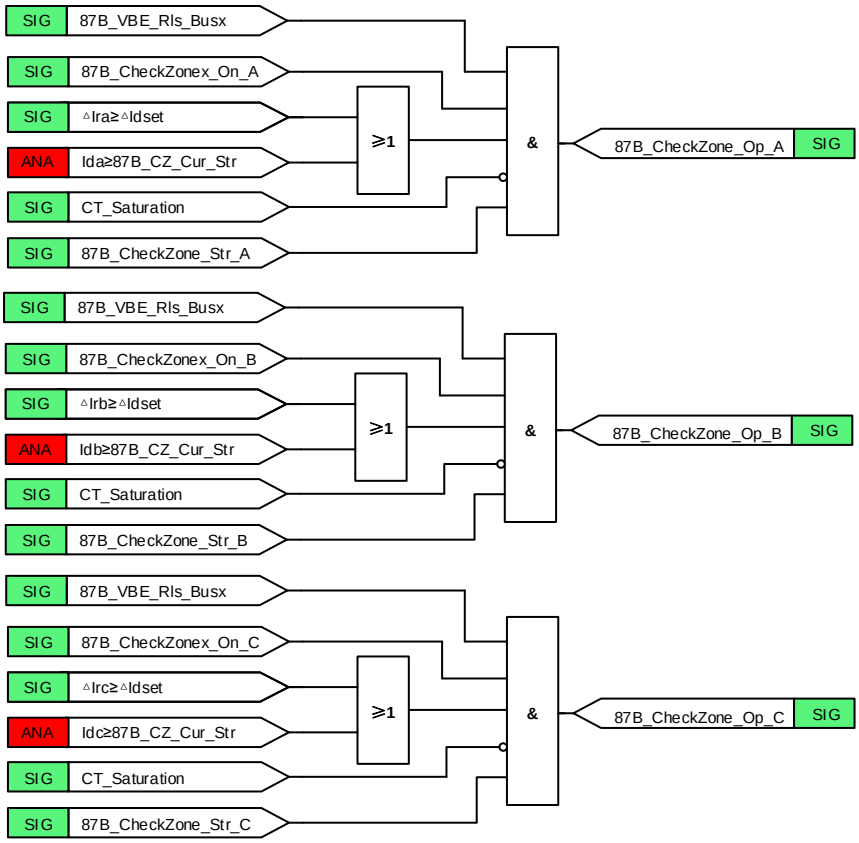
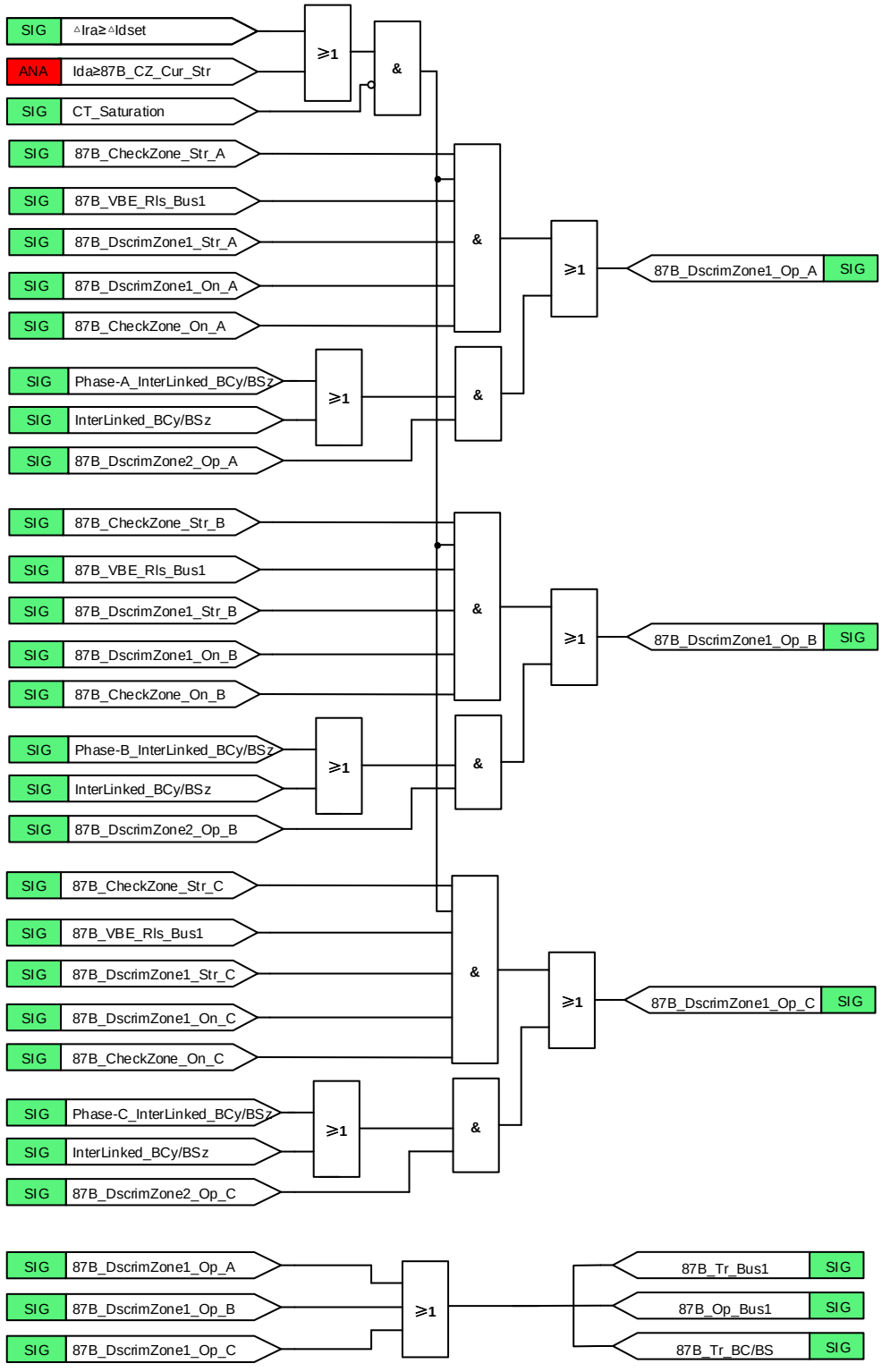


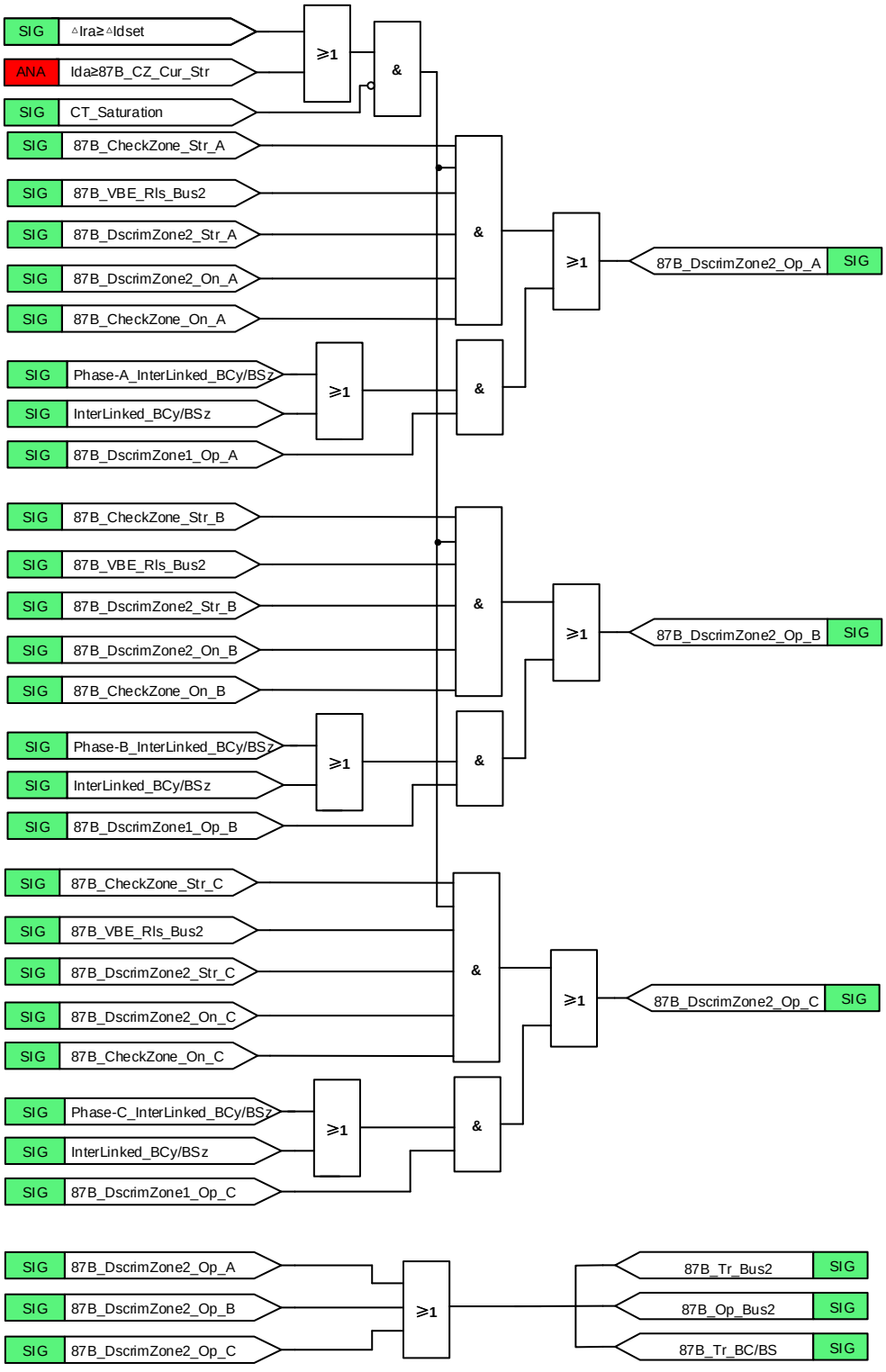
Figure 3.3.13 Logic Block Diagram of 87B_VBE


ANA
Ida≥87B_CZ_Cur_Str
ANA
Ida≥Kr*(Ira-Ida)
&
87B_CheckZone_Str_A
SIG
ANA
Idb≥87B_CZ_Cur_Str
ANA
Idb≥Kr*(Irb-Idb)
&
87B_CheckZone_Str_B
SIG
ANA
Idc≥87B_CZ_Cur_Str
ANA
Idc≥Kr*(Irc-Idc)
&
87B_CheckZone_Str_C
SIG
ANA
Idxa≥87B_DZ_Cur_Str
ANA
Idxa≥Kr*(Irxa-Idxa)
&
87B_DscrimZonex_Str_A
SIG
ANA
Idxb≥87B_DZ_Cur_Str
ANA
Idxb≥Kr*(Irxb-Idxb)
&
87B_DscrimZonex_Str_B
SIG
ANA
Idxc≥87B_DZ_Cur_Str
ANA
Idxc≥Kr*(Irxc-Idxc)
&
87B_DscrimZonex_Str_C
SIG


SET
87B_Ena
BI
87B_Blk
&
SIG
Phase-A_BlKBusx
SIG
Phase-B_BlKBusx
SIG
Phase-B_BlKBusx
SIG
Phase-A_BlKCZ
SIG
Phase-B_BlKCZ
SIG
Phase-B_BlKCZ
≥1
≥1
≥1
≥1
≥1
≥1
87B_DscrimZonex_On_A
SIG
87B_DscrimZonex_On_B
SIG
87B_DscrimZonex_On_C
SIG
87B_CheckZone_On_A
SIG
87B_CheckZone_On_B
SIG
87B_CheckZone_On_C
SIG


SIG
87B_VBE_Rls_Busx
SIG
87B_CheckZonex_On_A
SIG
▵Ira≥▵Idset
ANA
Ida≥87B_CZ_Cur_Str
SIG
CT_Saturation
SIG
87B_CheckZone_Str_A
≥1
&
87B_CheckZone_Op_A
SIG
SIG
87B_VBE_Rls_Busx
SIG
87B_CheckZonex_On_B
SIG
▵Irb≥▵Idset
ANA
Idb≥87B_CZ_Cur_Str
SIG
CT_Saturation
SIG
87B_CheckZone_Str_B
≥1
&
87B_CheckZone_Op_B
SIG
SIG
87B_VBE_Rls_Busx
SIG
87B_CheckZonex_On_C
SIG
▵Irc≥▵Idset
ANA
Idc≥87B_CZ_Cur_Str
SIG
CT_Saturation
SIG
87B_CheckZone_Str_C
≥1
&
87B_CheckZone_Op_C
SIG


SIG
△Ira≥△Idset
ANA
Ida≥87B_CZ_Cur_Str
SIG
CT_Saturation
≥1
&
SIG
87B_CheckZone_Str_A
SIG
87B_VBE_Rls_Bus1
SIG
87B_DscrimZone1_Str_A
SIG
87B_DscrimZone1_On_A
SIG
87B_CheckZone_On_A
&
≥1
87B_DscrimZone1_Op_A
SIG
SIG
Phase-A_InterLinked_BCy/BSz
SIG
InterLinked_BCy/BSz
SIG
87B_DscrimZone2_Op_A
≥1
&
SIG
87B_CheckZone_Str_B
SIG
87B_VBE_Rls_Bus1
SIG
87B_DscrimZone1_Str_B
SIG
87B_DscrimZone1_On_B
SIG
87B_CheckZone_On_B
&
≥1
87B_DscrimZone1_Op_B
SIG
SIG
Phase-B_InterLinked_BCy/BSz
SIG
InterLinked_BCy/BSz
SIG
87B_DscrimZone2_Op_B
≥1
&
SIG
87B_CheckZone_Str_C
SIG
87B_VBE_Rls_Bus1
SIG
87B_DscrimZone1_Str_C
SIG
87B_DscrimZone1_On_C
SIG
87B_CheckZone_On_C
&
≥1
87B_DscrimZone1_Op_C
SIG
SIG
Phase-C_InterLinked_BCy/BSz
SIG
InterLinked_BCy/BSz
SIG
87B_DscrimZone2_Op_C
≥1
&
SIG
87B_DscrimZone1_Op_A
SIG
87B_DscrimZone1_Op_B
SIG
87B_DscrimZone1_Op_C
≥1
87B_Tr_Bus1
SIG
87B_Op_Bus1
SIG
87B_Tr_BC/BS
SIG


SIG
△Ira≥△Idset
ANA
Ida≥87B_CZ_Cur_Str
SIG
CT_Saturation
≥1
&
SIG
87B_CheckZone_Str_A
SIG
87B_VBE_Rls_Bus2
SIG
87B_DscrimZone2_Str_A
SIG
87B_DscrimZone2_On_A
SIG
87B_CheckZone_On_A
&
≥1
87B_DscrimZone2_Op_A
SIG
SIG
Phase-A_InterLinked_BCy/BSz
SIG
InterLinked_BCy/BSz
SIG
87B_DscrimZone1_Op_A
≥1
&
SIG
87B_CheckZone_Str_B
SIG
87B_VBE_Rls_Bus2
SIG
87B_DscrimZone2_Str_B
SIG
87B_DscrimZone2_On_B
SIG
87B_CheckZone_On_B
&
≥1
87B_DscrimZone2_Op_B
SIG
SIG
Phase-B_InterLinked_BCy/BSz
SIG
InterLinked_BCy/BSz
SIG
87B_DscrimZone1_Op_B
≥1
&
SIG
87B_CheckZone_Str_C
SIG
87B_VBE_Rls_Bus2
SIG
87B_DscrimZone2_Str_C
SIG
87B_DscrimZone2_On_C
SIG
87B_CheckZone_On_C
&
≥1
87B_DscrimZone2_Op_C
SIG
SIG
Phase-C_InterLinked_BCy/BSz
SIG
InterLinked_BCy/BSz
SIG
87B_DscrimZone1_Op_C
≥1
&
SIG
87B_DscrimZone2_Op_A
SIG
87B_DscrimZone2_Op_B
SIG
87B_DscrimZone2_Op_C
≥1
87B_Tr_Bus2
SIG
87B_Op_Bus2
SIG
87B_Tr_BC/BS
SIG

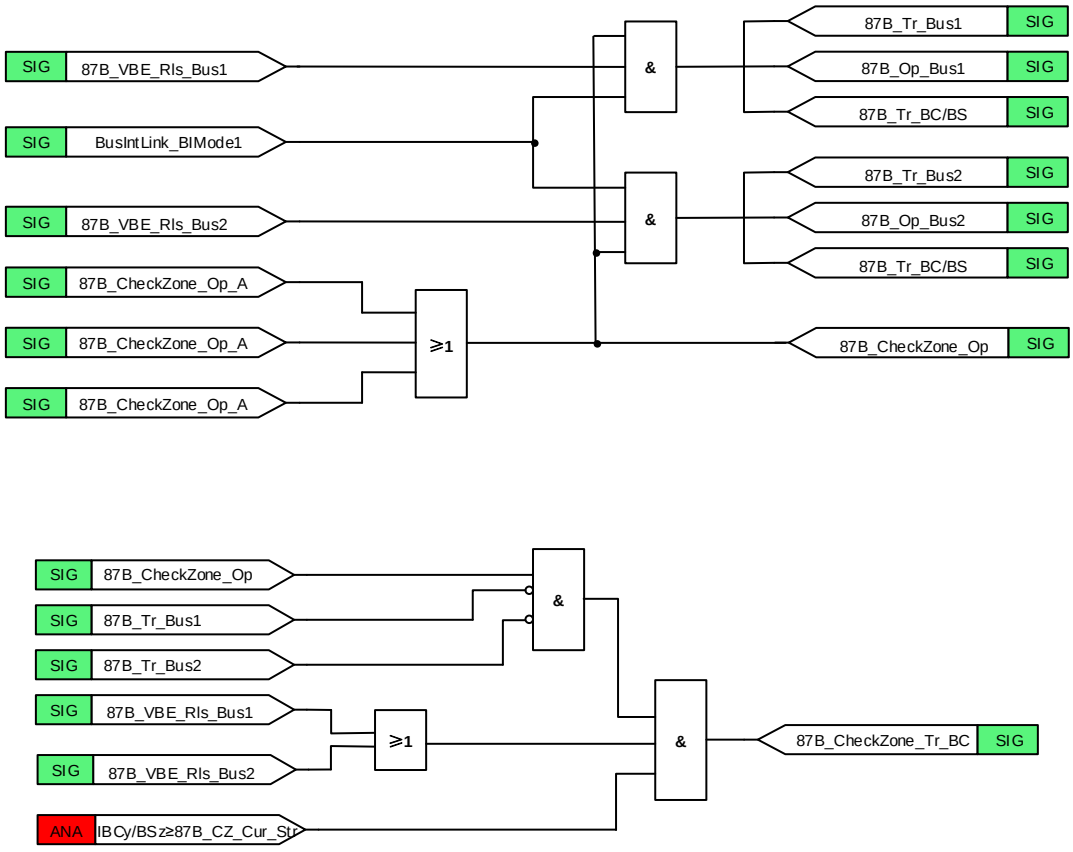


Figure 3.3.14 Logic Block Diagram of 87B

Where:

Ida: differential current of check zone.

Idx: differential current of discriminative zone x(x=1, 2, 3).

3.3.8 Settings

Table 3.3.17 Public Settings

No.	Name	Range	Unit	Step	Default	Description
1	BusIntLink_ EnMode1	0 or 1	-	1	0	Force Zone1 and Zone2 to inter-linked mode. It will be hidden if there is no Zone2.
2	BusIntLink_ EnMode2	0 or 1	-	1	0	Force Zone1 and Zone3 to inter-linked mode. It will be hidden if there is no Zone3.
3	BusIntLink_ EnMode3	0 or 1	-	1	0	Force Zone2 and Zone3 to inter-linked mode. It will be hidden if there is no Zone3.

No.	Name	Range	Unit	Step	Default	Description
4	BC\BS1_ MaintenanceMode	0 or 1	-	1	0	Busbar Couper breaker is in maintenance and the current will be excluded from the busbar differential current calculation. It will be hidden if there is no BC/BS1 breaker.
5	BC\BS2_ MaintenanceMode	0 or 1	-	1	0	Busbar Couper breaker is in maintenance and the current will be excluded from the busbar differential current calculation. It will be hidden if there is no BC/BS2 breaker.
6	BC\BS3_ MaintenanceMode	0 or 1	-	1	0	Busbar Couper breaker is in maintenance and the current will be excluded from the busbar differential current calculation. It will be hidden if there is no BC/BS3 breaker.
7	UnearthedSys_ Mode	0 or 1	-	1	0	0: Earthed system; 1: Unearthed system.
8	DS_DualPositon	0 or 1	-	1	0	0: Only normally open auxiliary contact of disconnector is used to identify the position status. 1: Both normally open auxiliary contact and normally closed auxiliary contact of disconnector are used to identify the position status.
9	CB_DualPositon	0 or 1	-	1	0	0: Only normally closed auxiliary contact of circuit breaker is used to identify the position status. 1: Both normally open auxiliary contact and normally closed auxiliary contact of circuit breaker are used to identify the position status.
10	DS_OperMode_ INT	0~2	-	1	1	Setting for selecting the mode when both of the normally open auxiliary contact and normally closed auxiliary contact of a disconnector are de-energized at the same time. Only for the disconnector side busbar. 0: The disconnector will be forced to closed position.

No.	Name	Range	Unit	Step	Default	Description
						1: The disconnector will be taken last valid position. 2: The disconnector will be taken last valid position, and block the disconnector side busbar.
11	DS_OperMode_BAD	0~2	-	1	1	Setting for selecting the mode when both of the normally open auxiliary contact and normally closed auxiliary contact of a disconnector are energized at the same time. Only for the disconnector side busbar. 0: The disconnector will be forced to closed position. 1: The disconnector will be taken last valid position. 2: The disconnector will be taken last valid position, and block the disconnector side busbar.
12	DS_SingleBusUse	0 or 1	-	1	0	Setting for selecting the mode for single busbar using the disconnector or fixed connect. 0: Fixed connect. 1: Using the disconnector connect.
13	DS_ SingleBusUpdate	0 or 1	-	1	0	Setting for selecting the mode for single busbar enable or disable the function of the disconnector update. 0: Disable the disconnector update for single busbar. 1: Enable the disconnector update for single busbar.
14	Prot_TripPulse_T	0.040~10.000	s	0.001	0.200	Pulse timer is used to ensure minimum trip pulse to the circuit breaker trip coils
NOTICE: Setting DS_SingleBusUse and DS_SingleBusUpdate just maybe used for single busbar or a one-and-a-half breaker scheme.						

Table 3.3.18 87B Settings for Single Busbar

No.	Name	Range	Unit	Step	Default	Description
1	87B_CZ_Cur_Str	0.05In~20In	A	0.01	20In	Current setting of 87B for CheckZone.

No.	Name	Range	Unit	Step	Default	Description
2	87B_ CZ_ Slope_Kr	0.20~0.80	-	0.01	0.43	Setting of 87B complex percentage restraint coefficient for CheckZone. 0.43 is recommended.
3	87B_Vol_Blk	0~100	V	0.01	40	Under voltage setting of 87B_VBE
4	87B_ResVol_Blk	0~70	V	0.01	6	Residual voltage setting of 87B_VBE
5	87B_NegVol_Blk	0~70	V	0.01	4	Negative-sequence voltage setting of 87B_VBE
6	87B_Ena	0 or 1	-	1	0	Enabling or disabling 87B
7	87B_VBE_Ena	0 or 1	-	1	0	Enabling or disabling 87B_VBE

Table 3.3.19 87B Settings for one-and-a-half breaker scheme and Double Busbar Double Breaker

No.	Name	Range	Unit	Step	Default	Description
1	87B_CZ_Cur_Str	0.05In~20In	A	0.01	20In	Current setting of 87B for CheckZone.
2	87B_ CZ_ Slope_Kr	0.20~0.80	-	0.01	0.43	Setting of 87B complex percentage restraint coefficient for CheckZone. 0.43 is recommended.
3	87B_Ena	0 or 1	-	1	0	Enabling or disabling 87B

Table 3.3.20 87B Settings for two Busbars

No.	Name	Range	Unit	Step	Default	Description
1	87B_CZ_Cur_Str	0.05In~20In	A	0.01	20In	Current setting of 87B for CheckZone.
2	87B_ CZ_ Slope_Kr	0.20~0.80	-	0.01	0.43	Setting of 87B complex percentage restraint coefficient for CheckZone. 0.43 is recommended.
3	87B_ DZ_ Cur_Str	0.05In~20In	A	0.01	20In	Current setting of 87B for DiscriminativeZone.
4	87B_ DZ _ Slope_Kr	0.20~0.80	-	0.01	0.43	Setting of 87B complex percentage restraint coefficient for DiscriminativeZone. 0.43 is recommended.
5	87B_Vol_Blk	0~100	V	0.01	40	Under voltage setting of 87B_VBE
6	87B_ResVol_Blk	0~70	V	0.01	6	Residual voltage setting of 87B_VBE
7	87B_NegVol_Blk	0~70	V	0.01	4	Negative-sequence voltage setting of 87B_VBE

No.	Name	Range	Unit	Step	Default	Description
8	87B_Ena	0 or 1	-	1	0	Enabling or disabling 87B
9	87B_VBE_Ena	0 or 1	-	1	0	Enabling or disabling 87B_VBE

NOTICE!

When calculating all the current setting of 87B, the primary current should be converted to the secondary value according to the reference CT ratio.

3.4 BC/BS Dead Zone Protection 50DZ

3.4.1 Overview

The fault between the current measuring circuit CT and circuit breaker is known as BC/BS dead zone (fault figure 3.4.1 shows the structural detail). in this kind of fault situation, the large fault current will not decrease even though the busbar zone connected with the BC/BS breaker operate, which cause a severe damage to the electricity system. BC/BS dead zone protection 50DZ can immediately detect the dead zone fault and trip the respective busbar circuit breaker, to make sure the fault clearance time is short as possible and ensure the supply system stability against fault,

In order to make sure the operation of BC/BS dead zone protection (50DZ) is more advance, secure and meet the modern age requirement of deed zone fault, both of the BC/BS circuit breaker open and close position will be considered.

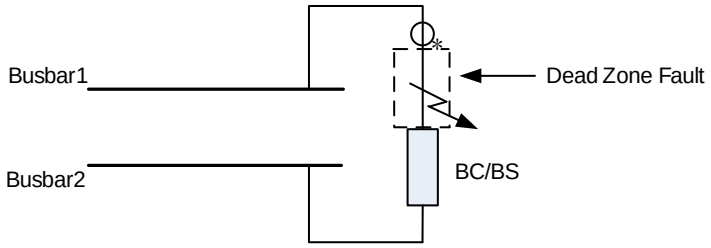
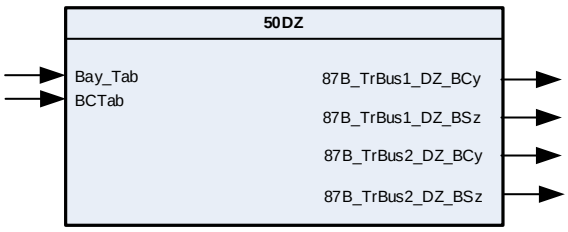


Figure 3.4.1 Fault in the Dead Zone of the BC/BS

3.4.1.1 Function Block



3.4.1.2 Signals

Table 3.4.1 50DZ Input Signals

NO.	Signal	Description
1	Bay_Tab	Resource table contains all of bay n, and resource box 1 of bus coupler y and bus section z.
2	BCTab	Resource table contains all of resource box 2 of bus coupler y and bus section z.

Table 3.4.2 50DZ Output Signals

NO.	Signal	Description
1	87B_TrBus1_DZ_BCy/BSz	50DZ of BCy/BSz operates to trip busbar 1.
2	87B_TrBus2_DZ_BCy/BSz	50DZ of BCy/BSz operates to trip busbar 2.

3.4.2 Protection Principle

BC/BS dead zone protection can operate under two conditions: BC/BS breaker is open and BC/BS breaker is closed.

3.4.2.1 BC/BS breaker is open

In this case, in order to prevent both busbars from tripping for an dead zone fault, the BC/BS current will be excluded from discriminating zone differential elements, and then the 87B will operate to trip the busbar on the CT side directly and thus to final fault clarification.

3.4.2.2 BC/BS breaker is Closed

In this case, first busbar on the breaker side is switched off, however the fault current is not yet interrupted. The circuit breaker opens and is detected by the 50DZ through its tap indication after time delay setting 50DZ_ChkCB_T, and the BC/BS current will be excluded from discriminating zone differential elements .The operating criteria of 87B for busbar on the breaker side is fulfilled, and then 87B operates to trip the corresponding busbar.

3.4.2.3 BC/BS breaker Maintenance Mode

The protection has a feature of “BC/BS Maintenance Mode”. It can be initiated externally by binary input “BC/BSy_MaintenanceBIMode” (y=1, 2, 3) or settings “BC/BSy_MaintenanceMode” (y=1, 2, 3).

1. It is only allowed to force to BC/BS maintenance mode when the BC/BS circuit breaker is in maintenance.

2. Under BC/BS Maintenance Mode condition, the BC/BS current will be excluded from discriminating zone differential current.

3. In order to prevent the misoperation of the “BC/BS Maintenance Mode”, when the condition of “BC/BS Maintenance Mode” does not correspond to the circuit breaker current state for more than

2s, BC/BS Maintenance Mode will be exited automatically and the alarm “BC/BSy_MaintenanceMode_Abnormal” (y=1, 2, 3) will be issued.

3.4.3 Logic

The logic of 50DZ is shown as follows:

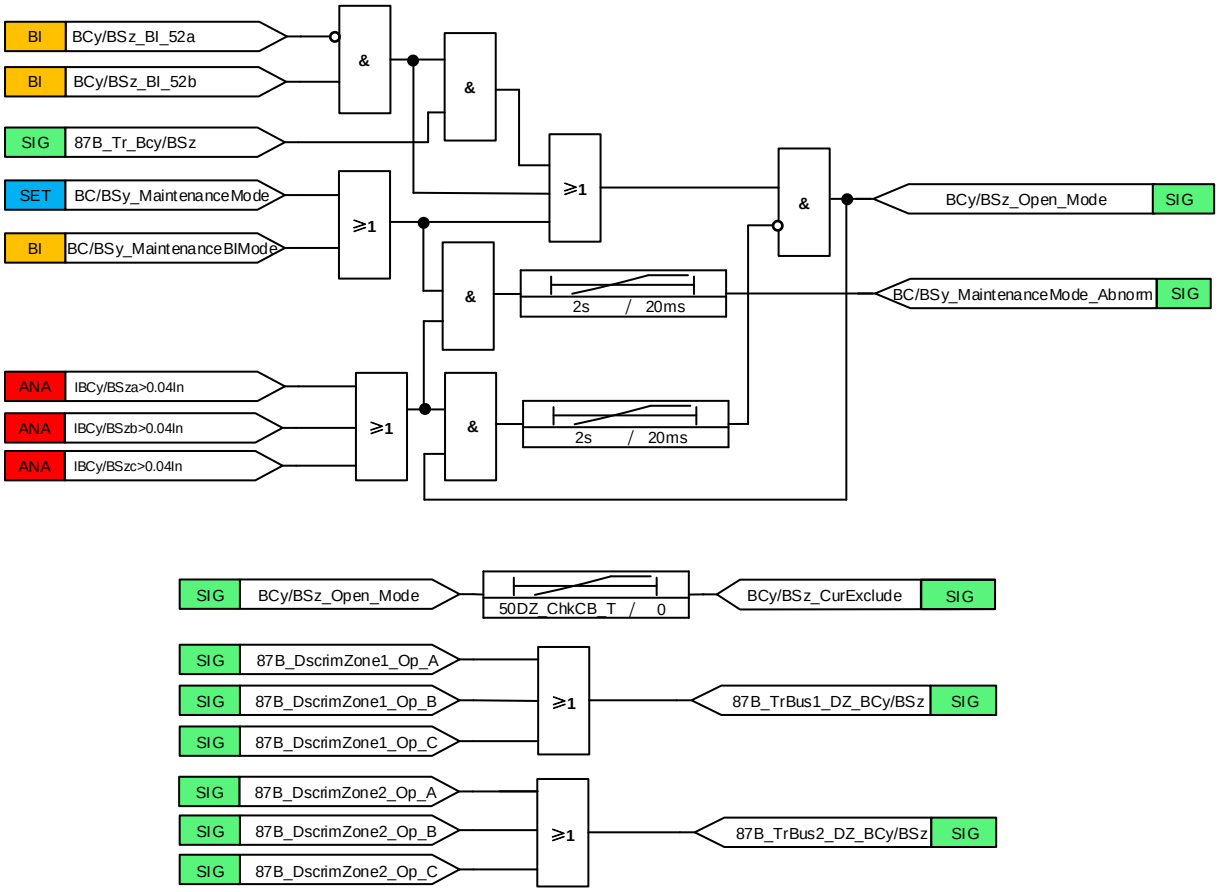


Figure 3.4.2 Logic Block Diagram of 50DZ

3.4.4 Settings

Table 3.4.3 Related Settings

No.	Name	Range	Unit	Step	Default	Description
1	50DZ_ChkCB_T	0.050~0.300	s	0.001	0.150	The breaker open position confirmation time for BC/BS dead zone fault protection, 150ms is recommended

No.	Name	Range	Unit	Step	Default	Description
2	BC/BS1_ MaintenanceMode	0 or 1	-	1	0	Busbar Couper breaker is in maintenance. It will be hidden if there is no BC/BS1 breaker.
3	BC/BS2_ MaintenanceMode	0 or 1	-	1	0	Busbar Couper breaker is in maintenance. It will be hidden if there is no BC/BS2 breaker.
4	BC/BS3_ MaintenanceMode	0 or 1	-	1	0	Busbar Couper breaker is in maintenance. It will be hidden if there is no BC/BS3 breaker.

3.5 Feeder End-fault Protection 50FDZ

3.5.1 Overview

Lines or feeder's protection of designing scheme criteria is totally different from transformer or motors protection of designing scheme because the length of feeder is too long and it runs through the open environment. That's why feeder protection is too much complex and need to be taken more attention as compare to other equipment's of protection.

The fault between the current measuring circuit CT and open position circuit breaker of feeder is known as feeder end fault figure 3.5.1 shows the structural detail. If the fault happens in the end of feeder, the feeder end-fault protection (50FDZ) will operate and secure the bus supply system.

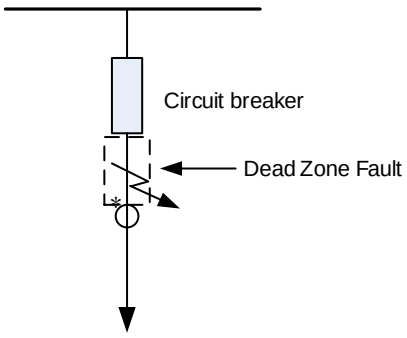
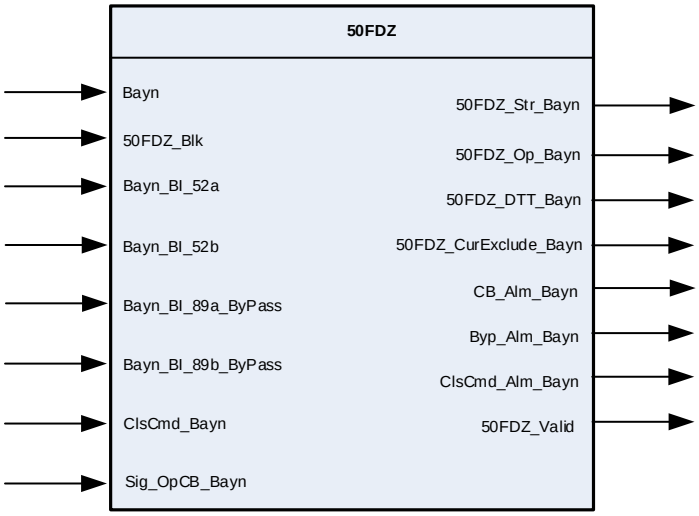


Figure 3.5.1 Fault in the Dead Zone of the Feeder Bay

NOTICE!

If feeder end-fault protection is enabled, the closing binary input of the feeder **"ClsCmd_Bayn" MUST** be connected to the device, otherwise mal-operation of busbar current differential protection maybe happens.

3.5.1.1 Function Block



3.5.1.2 Signals

Table 3.5.1 50FDZ Input Signals

NO.	Signal	Description
1	Bayn	Resource box of bay n.
2	50FDZ_Blk	Binary input for blocking 50FDZ function.
3	Bayn_BI_52a	Normally open auxiliary contact of the circuit breaker of bay n.
4	Bayn_BI_52b	Normally close auxiliary contact of the circuit breaker of bay n.
5	Bayn_BI_89a_ByPass	Normally open auxiliary contact of the transfer bus disconnector of bay n.
6	Bayn_BI_89b_ByPass	Normally close auxiliary contact of the transfer bus disconnector of bay n.
7	ClsCmd_Bayn	Binary input for closing command of the circuit breaker of bay n.
8	Sig_OpCB_Bayn	Signal of 87B operate to trip the circuit breaker of bay n.

Table 3.5.2 50FDZ Output Signals

NO.	Signal	Description
1	50FDZ_Str_Bayn	50FDZ of bay n starts.
2	50FDZ_Op_Bayn	50FDZ of bay n operates.
3	50FDZ_DTT_Bayn	50FDZ of bay n operates to initiate transfer trip, to trip remote circuit breaker.
4	50FDZ_CurExclude_Bayn	The current of bay n is excluded from differential current.
5	CB_Alm_Bayn	Alarm signal indicating that the position of CB is abnormal.

NO.	Signal	Description
6	Byp_Alm_Bayn	Alarm signal indicating that the position of transfer bus disconnector is abnormal.
7	ClsCmd_Alm_Bayn	Alarm signal indicating that close command of bay n is energized for over 10s.
8	50FDZ_Valid	Valid flag of 50FDZ.

3.5.2 Protection Principle

If the breaker of a feeder is open, and three phase currents of the feeder are all smaller than 0.04In, then the feeder current will be excluded from differential elements of 87B, and the signal 50FDZ_CurExclude_Bayn and 50FDZ_ConfirmCBOpen_Bayn will be issued. Also, if the break is firstly close and tripped by the busbar differential protection when a dead zone fault occurs, the feeder CT current is still larger than the current setting 50FDZ_Cur_Str_Bayn, so after a time delay 50FDZ_ChkCB_T_Bayn, the signal 50FDZ_ConfirmCBOpen_Bayn will be issued. For a fault occurs between circuit breaker and CT, with the conditions that the signal 50FDZ_ConfirmCBOpen_Bayn is set and any phase current of feeder bay n is larger than the current setting 50FDZ_Cur_Str_Bayn, 50FDZ will operate and initiate a transfer-trip command to trip remote circuit breaker after the setting time delay 50FDZ_Op_T_Bayn.

50FDZ is blocked during the following events and operating states:

1. Abnormal position of circuit breaker (dual positions do not correspond, the circuit breaker is open but there is current).
2. With the transfer bus disconnector closed.
3. After issuing the close command for the circuit breaker within a fixed time 1s.
4. The binary input signal 50FDZ_Blk is energized.

If the binary input ClsCmd_Bayn is energized for over 10s, an alarm ClsCmd_Alm_Bayn will be issued.

3.5.3 Logic

The logic of 50FDZ is shown as follows:

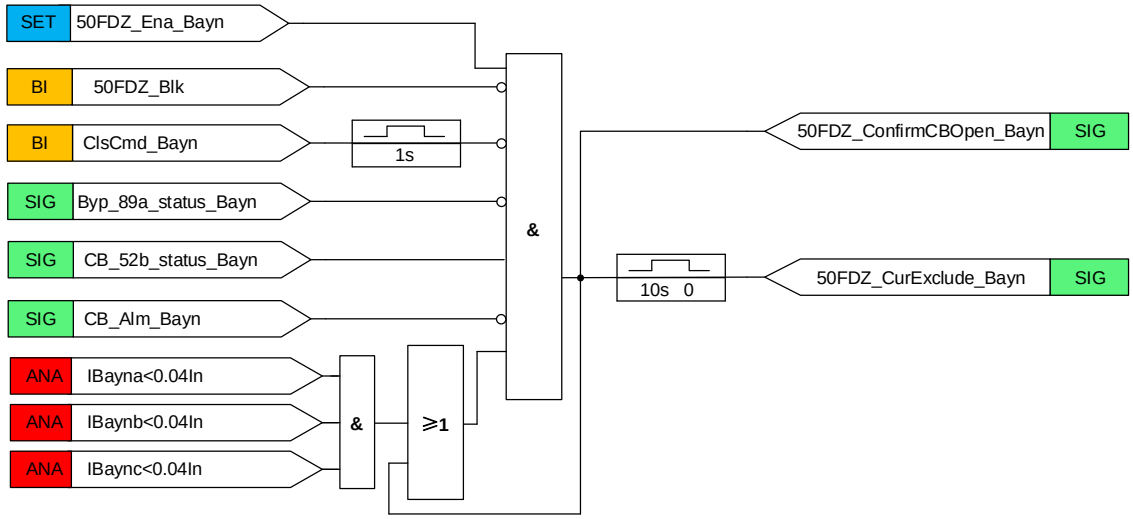


Figure 3.5.2 Logic Block Diagram of 50FDZ when feeder breaker is open

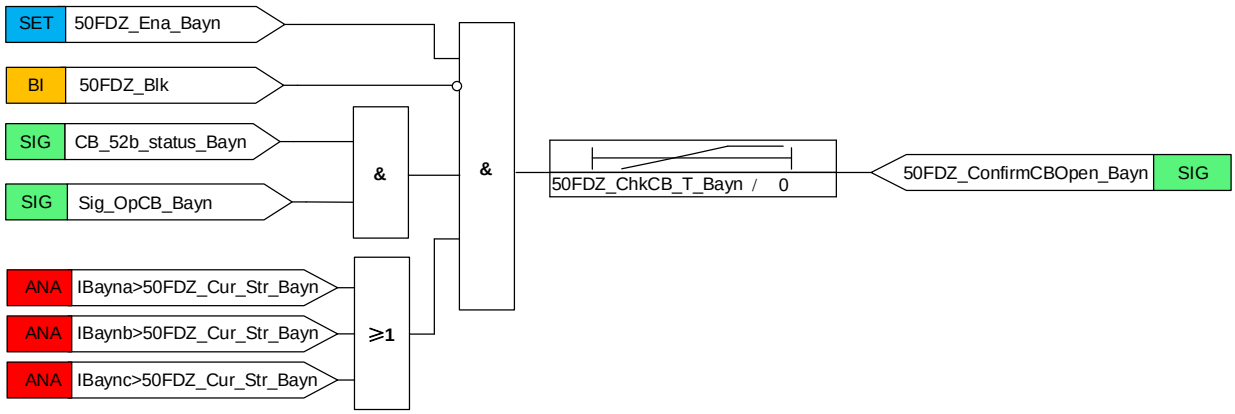


Figure 3.5.3 Logic Block Diagram of 50FDZ when feeder breaker is close

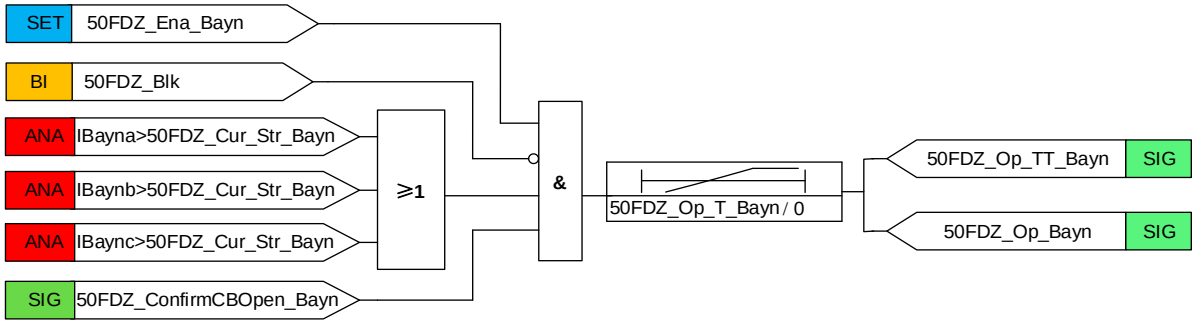


Figure 3.5.4 Logic Block Diagram of 50FDZ transfer trip

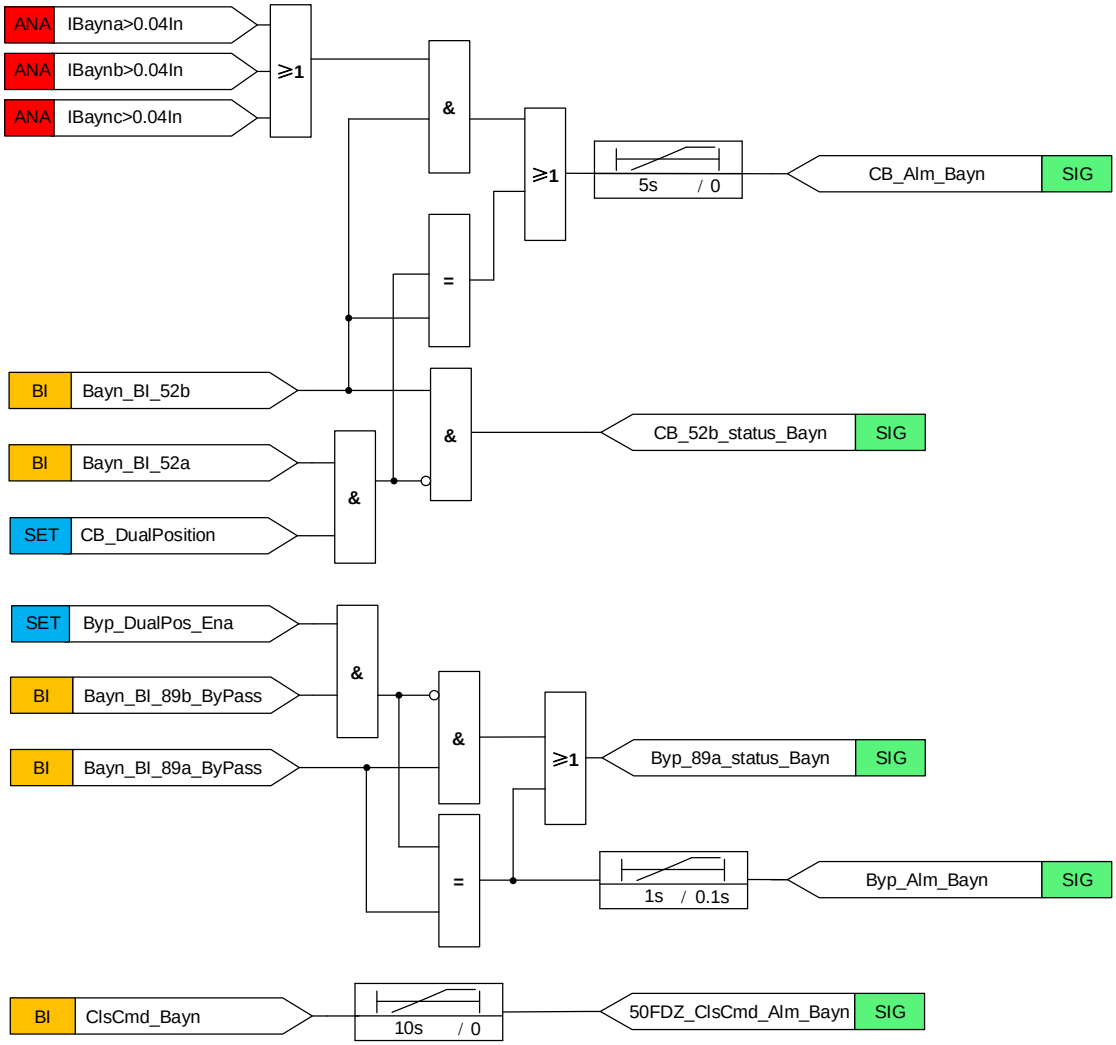


Figure 3.5.5 Logic Block Diagram of 50FDZ auxiliary functions

3.5.4 Settings

Table 3.5.3 50FDZ Settings

No.	Name	Range	Unit	Step	Default	Description
1	50FDZ_Cur_Str_Bayn	0.05In~20In	A	0.01	20In	Current setting of 50FDZ function.
2	50FDZ_Op_T_Bayn	0.000~4.900	S	0.001	0.020	Time delay setting of 50FDZ transfer trip. 20ms is recommended
3	50FDZ_ChkCB_T _Bayn	0.000~10.000	S	0.001	0.150	Time delay setting of 50FDZ to confirm that circuit breaker is open. 150ms is recommended
4	50FDZ_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling 50FDZ function of bay n.

NOTICE!

When calculating all the current setting of 50FDZ, the primary current should be converted to the secondary value according to the reference CT ratio instead of the actual CT ratio of each bay.

3.6 Breaker Failure Protection 50BF

3.6.1 Overview

The main and important function of Breaker Failure Protection 50BF is to provide backup tripping in case of the feeder circuit breaker is fail to trip. For the economic and engineering point of view this protection is very important for power system because harm situations initiate many damages. The Feeder Breaker Failure Protection 50BF continuously monitored the respective feeder circuit breaker tripping contact position. In case of abnormality 50BF provide backup support of protection to retrip the feeder circuit breaker. If the feeder circuit breaker does not open, the 50BF will trip all the adjacent feeders and initiate transfer trip to remote circuit breaker.

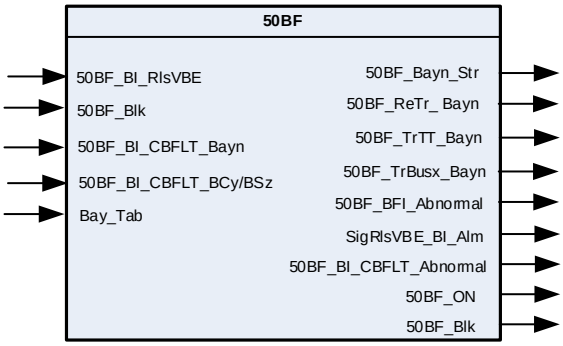
Breaker Failure Protection 50BF starting operation criteria are:

- Provide independent supervision element for 50BF
- Current criteria to detect the fault situation
- Precise Voltage Blocking element checking criteria
- Different checking criteria of binary input to increase the capability of protection

NOTICE!

In this protection there are many current checking aspects to determine the current calculation criteria and timer start time delay according to pick up signal and the 50BF protection function will operate at the ending of time delay signal.

3.6.1.1 Function Block



3.6.1.2 Signals

Table 3.6.1 50BF Input Signals

NO.	Signal	Description
1	50BF_BI_RlsVBE	The binary input that releasing the voltage blocking element of 50BF.
2	50BF_Blk	Binary input for blocking 50BF function.
3	50BF_BI_CBFLT_Bayn	The binary input indicates that the circuit breaker is incapable to clear faults, for example at low gas pressure.
4	50BF_BI_CBFLT_ BCy/BSz	The binary input indicates that the circuit breaker is incapable to clear faults, for example at low gas pressure.
5	Bay_Tab	Resource table contains all of bay n, bus coupler y and bus section z.

Table 3.6.2 50BF Output Signals

NO.	Signal	Description
1	50BF_Bayn_Str	This signal indicating that 50BF of Bay n (n=BC/12, 1 …, 11) picks up.
2	50BF_ReTr_Bayn	50BF of bay n (n=BC/12, 1 …, 11) operates to re-trip the breaker.
3	50BF_TrTT_Bayn	50BF operates to initiate transfer trip to remote circuit breaker of bay n (n=BC/12, 1 …, 11).
4	50BF_TrBusx_Bayn	50BF operates to trip busbarx.
5	50BF_BFI_Abnormal	Alarm signal indicating that failure initiating binary input for 50BF of any bay is energized for over 20s.
6	SigRlsVBE_BI_Alm	Alarm signal indicating that the binary input releasing the voltage blocking element of 50BF is energized for over 20s.
7	50BF_BI_CBFLT_Abnormal	Alarm signal indicating that CB faulty binary input of any bay is energized for over 20s.
8	50BF_ON	Valid flag of 50BF.
9	50BF_Blk	Block flag of 50BF.

3.6.2 Protection Principle

Circuit breaker failure protection 50BF is available for each connected bay of the busbar. When a breaker is determined failure to open, the 50BF will re-trip the breaker after time delay of 50BF_ReTr_T_Bayn (n=BC/12, 1 …, 11). If the fault is still existed, the 50BF will trip all circuit breakers connected to the busbar after time delay of 50BF_TrBus_T_Bayn (n=BC/12, 1 …, 11). 50BF also provides the function to initiate transfer trip to remote circuit breaker or inter-trip the breakers on other sides of a main-transformer with the time delay of 50BF_TrBus_T_Bayn (n=BC/12, 1 …, 11).

3.6.2.1 Function Mode

BP-2C provides three function mode for 50BF, the function mode description and detection are shown as Table 3.6.3.

Table 3.6.3 Breaker Failure Protection Function Mode

NO.	Function Mode	Description
0	Current	Detection for trip based on current.
1	Intertrip	Detection for trip without current or contact criterion. 50BF receive the breaker failure trip (BFT) signal and intertrip all the bus breakers that are presently connected.
2	Contact	It is mainly used for mechanical protection operates to initiate breaker failure protection or where the fault current through the breaker is small.

NOTICE!

If the function mode of breaker failure protection of Bay n and BCy/BSz is set as contact mode, the auxiliary contact of the circuit breaker must be connected to the device. Otherwise, the auxiliary contact of the circuit breaker do not need to connect to the device in other function mode.

3.6.2.2 Supervision Element

BP-2C provides independent supervision element for 50BF, if one of the following two conditions is fulfilled, supervision element for 50BF of bay n and BCy/BSz pick up.

- Externally initiate breaker failure protection

1. Phase-segregated breaker failure initiating (BFI) binary input of bay n and BCy/BSz are energized.
2. Three-segregated breaker failure initiating (BFI) binary input of bay n and BCy/BSz are energized.

- Internally initiate breaker failure protection

1. Busbar protection operates to trip the bay.
2. Check Zone operates to trip BC/BS.
3. 50/51 operates to trip the bay and BCy/BSz.

3.6.2.3 Operating Element in Different Function Mode

3.6.2.3.1. Current Mode

- Current Detection Element 50BF_CDE

1. Current criterion 1

Phase current is greater than the setting 50BF_Cur_Str_Bayn (n=BC/12, 1 …, 11).

When breaker failure protection is initiated by phase-segregated BFI, criterion1 can be blocked by residual current criterion (controlled by the setting 50BF_ResCur_BlkPh_Ena_Bayn (n=BC/12, 1 …, 11)) or negative-sequence current criterion (controlled by the setting 50BF_NegCur_BlkPh_Ena_Bayn (n=BC/12, 1 …, 11)).

2. Current criterion 2

Residual current is greater than the setting 50BF_ResCur_Str_Bayn (n=BC/12, 1 …, 11).

3. Current criterion 3

Negative sequence current is greater than the setting 50BF_NegCu_Str_Bayn (n=BC/12, 1 …, 11).

Criterion2 and Criterion3 are controlled by the logic setting of 50BF_ResCur_Ena_Bayn (n=BC/12, 1 …, 11) and 50BF_NegCur_Ena_Bayn (n=BC/12, 1 …, 11) respectively.

The whole bay and BCy/BSz adopt phase current, residual current, and negative current "OR gate" logic, each bay and BCy/BSz have its own current settings.

- Operating Element

When breaker failure protection is initiated from other protection trip command internally or BFI externally, if 50BF_CDE is met, and voltage blocking element operates, the breaker failure protection will re-trip the breaker after time delay of 50BF_ReTr_T_Bayn (n=BC/12, 1 …, 11). If the fault is still existed, the breaker failure protection will trip all circuit breakers connected to the busbar after time delay of 50BF_TrBus_T_Bayn (n=BC/12, 1 …, 11). Breaker failure protection also provides the function to initiate transfer trip to remote circuit breaker or inter-trip the breakers on other sides of a main-transformer with the time delay of 50BF_TrBus_T_Bayn (n=BC/12, 1 …, 11).

When breaker failure protection is initiated, if the circuit breaker faulty binary input is energized, the breaker failure protection will trip all circuit breakers connected to the busbar after time delay of 50BF_TrBusCBFLT_T_Bayn (n=BC/12, 1 …, 11) and initiate transfer trip to remote circuit breaker or inter-trip the breakers on other sides of a main-transformer.

3.6.2.3.2. Breaker Failure Protection Intertrip Mode

In this mode, a stand-alone breaker failure relay is used. Breaker failure protection in busbar relay receive the breaker failure trip (BFT) signal and intertrip all the bus breakers that are presently connected.

When breaker failure protection is initiated from breaker failure trip (Phase-segregated or Three-segregated) externally and voltage blocking element operates, the breaker failure protection will trip all circuit breakers connected to the busbar after time delay of 50BF_TrBus_T_Bayn (n=BC/12, 1 …, 11). Breaker failure protection also provides the function to initiate transfer trip to remote circuit breaker or inter-trip the breakers on other sides of a main-transformer with the time delay of 50BF_TrBus_T_Bayn (n=BC/12, 1 …, 11).

When breaker failure protection is initiated, if the circuit breaker faulty binary input is energized, the breaker failure protection will trip all circuit breakers connected to the busbar after time delay of 50BF_TrBusCBFLT_T_Bayn (n=BC/12, 1 …, 11).

3.6.2.3.3. Contact Mode

It is mainly used for mechanical protection operates to initiate breaker failure protection or where the fault current through the breaker is small. Breaker failure protection is only controlled by circuit breaker contact.

When breaker failure protection is initiated from three-segregated BFI externally, and voltage blocking element operates, the breaker failure protection will re-trip the breaker after time delay of 50BF_ReTr_T_Bayn (n=BC/12, 1 …, 11). If the fault is still existed, the breaker failure protection will trip all circuit breakers connected to the busbar after time delay of 50BF_TrBus_T_Bayn (n=BC/12, 1 …, 11). Brekaer failure protection also provides the function to initiate transfer trip to remote circuit breaker or inter-trip the breakers on other sides of a main-transformer with the time delay of 50BF_TrBus_T_Bayn (n=BC/12, 1 …, 11).

When breaker failure protection is initiated, if the circuit breaker faulty binary input is energized, the breaker failure protection will trip all circuit breakers connected to the busbar after time delay of 50BF_TrBusCBFLT_T_Bayn (n=BC/12, 1 …, 11) and initiate transfer trip to remote circuit breaker or inter-trip the breakers on other sides of a main-transformer.

3.6.2.4 Voltage Block Element 50BF_VBE

Voltage block element is used as a blocking condition of 50BF. If the fault voltage doesn't fulfills the voltage criterion, the 50BF will be blocked.

The releasing criteria of 50BF_VBE are:

$$\begin{cases} U_p \le 50BF\_Vol\_Blk \\ 3U_0 \ge 50BF\_ResVol\_Blk \\ U_2 \ge 50BF\_NegVol\_Blk \end{cases}$$

Where:

Up : The phase-to-earth voltages of the busbar.

$3U_0$: Residual voltage of the busbar (calculated internally).

U_2 : Negative voltage of the busbar (calculated internally).

50BF_Vol_Blk: Phase voltage setting of 50BF_VBE.

50BF_ResVol_Blk: Residual voltage setting of 50BF_VBE.

50BF_NegVol_Blk: Negative voltage setting of 50BF_VBE.

When the protective device is applied to an unearthed system, the system setting UnearthedSys_Mod is set as "1", the criteria of 50BF_VBE will be changed.

$$\begin{cases} U_{pp} \le \sqrt{3} \times 50BF\_Vol\_Blk \\ U_2 \ge 50BF\_NegVol\_Blk \end{cases}$$

Where:

U_{pp} : Phase-to-phase voltage.

U_2 : Negative sequence voltage.

50BF_Vol_Blk: Phase-to-earth voltage setting of 50BF_VBE.

50BF_NegVol_Blk: Negative voltage setting of 50BF_VBE.

If the releasing voltage block element binary input "50BF_BI_RlsVBE" is energized, and the setting 50BF_RlsVBE_Ena_Bayn (n=BC/12, 1 …, 11) is set as "1", the voltage blocking element for breaker failure protection of bay n and BCy/BSz will be released.

3.6.2.5 Binary Input

1. Phase-segregated tripping contact

50BF_BFI_A_Bayn (n=BC/12, 1 …, 11): Phase-A breaker failure initiating binary input of bay n and BCy/BSz.

50BF_BFI_B_Bayn (n=BC/12, 1 …, 11): Phase-B breaker failure initiating binary input of bay n and BCy/BSz.

50BF_BFI_C_Bayn (n=BC/12, 1 …, 11): Phase-C breaker failure initiating binary input of bay n and BCy/BSz.

2. Three-phase tripping contact

50BF_BFI_Bayn (n=BC/12, 1 …, 11): Three-Phase breaker failure initiating binary input of bay n and BCy/BSz.

For a main-transformer bay, only three-phase BFI contact is provided. When the supervision element detects long-time（fixed as 20s）duration of BFI, it will output an alarm signal of 50BF_Activ_Abnormal, and mask the corresponding binary input channel.

3. Binary input for blocking 50BF function

50BF_Blk: The binary input for blocking 50BF function, if it is not configured, its default value is "0".

4. Circuit breaker faulty

50BF_BI_CBFLT_Bayn (n=BC/12, 1 …, 11): The binary input indicates that the circuit breaker is incapable to clear faults, for example at low gas pressure.

When the supervision element detects long-time（fixed as 20s）duration of 50BF_BI_CBFLT_Bayn (n=BC/12, 1 …, 11), it will output an alarm signal of 50BF_BI_CBFLT_Abnormal, and mask the

corresponding binary input channel.

3.6.3 Logic

The logic of 50BF_VBE is shown as follows:

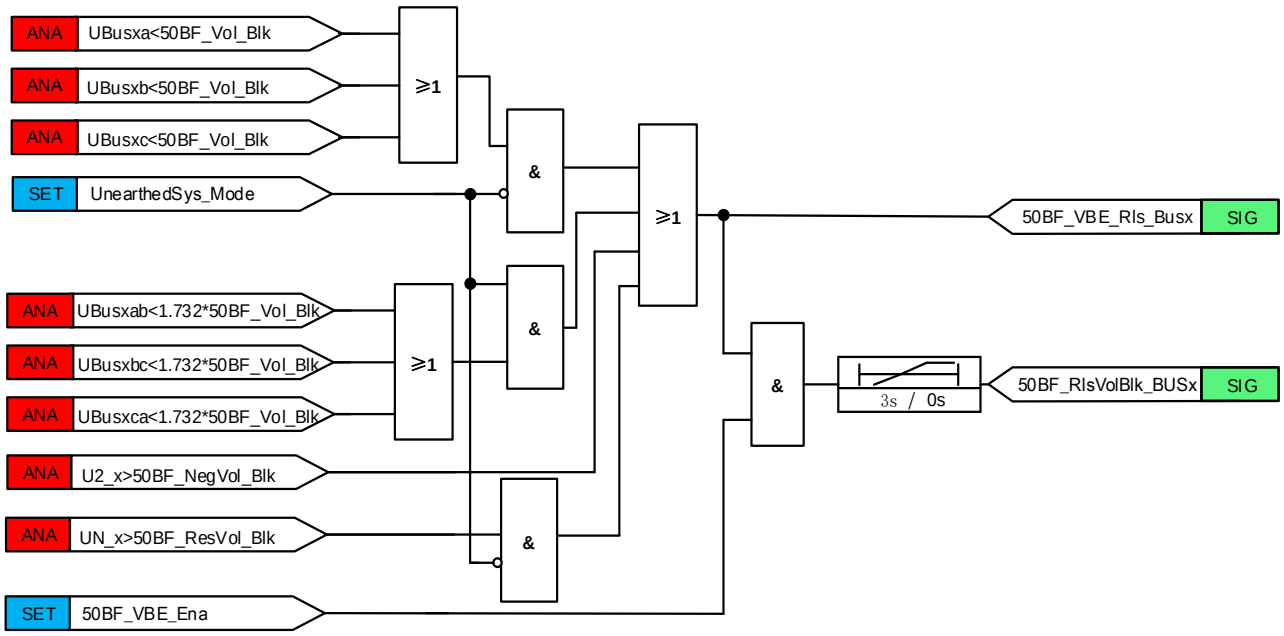


Figure 3.6.1 Logic Block Diagram of 50BF_VBE

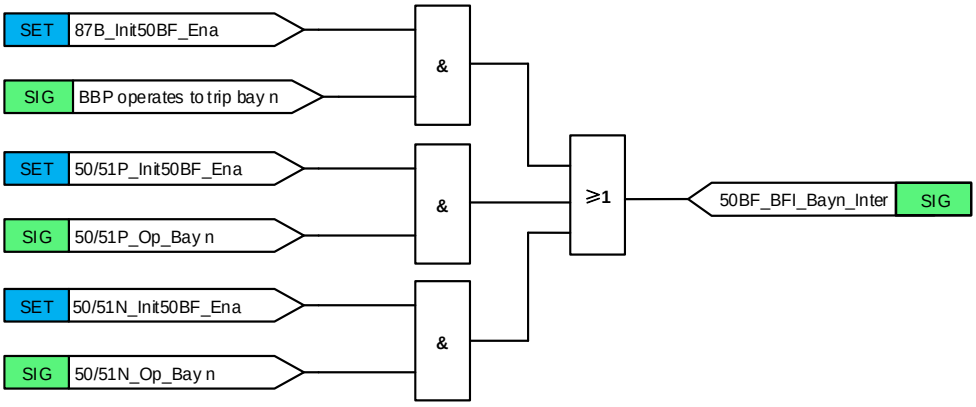


Figure 3.6.2 Internally initiate breaker failure protection for bay n

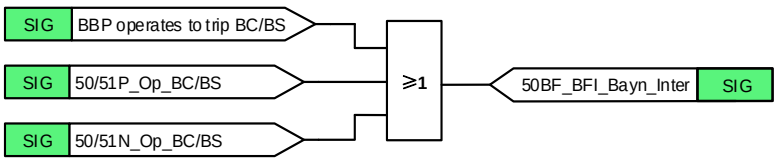


Figure 3.6.3 Internally initiate breaker failure protection for BCy/BSz

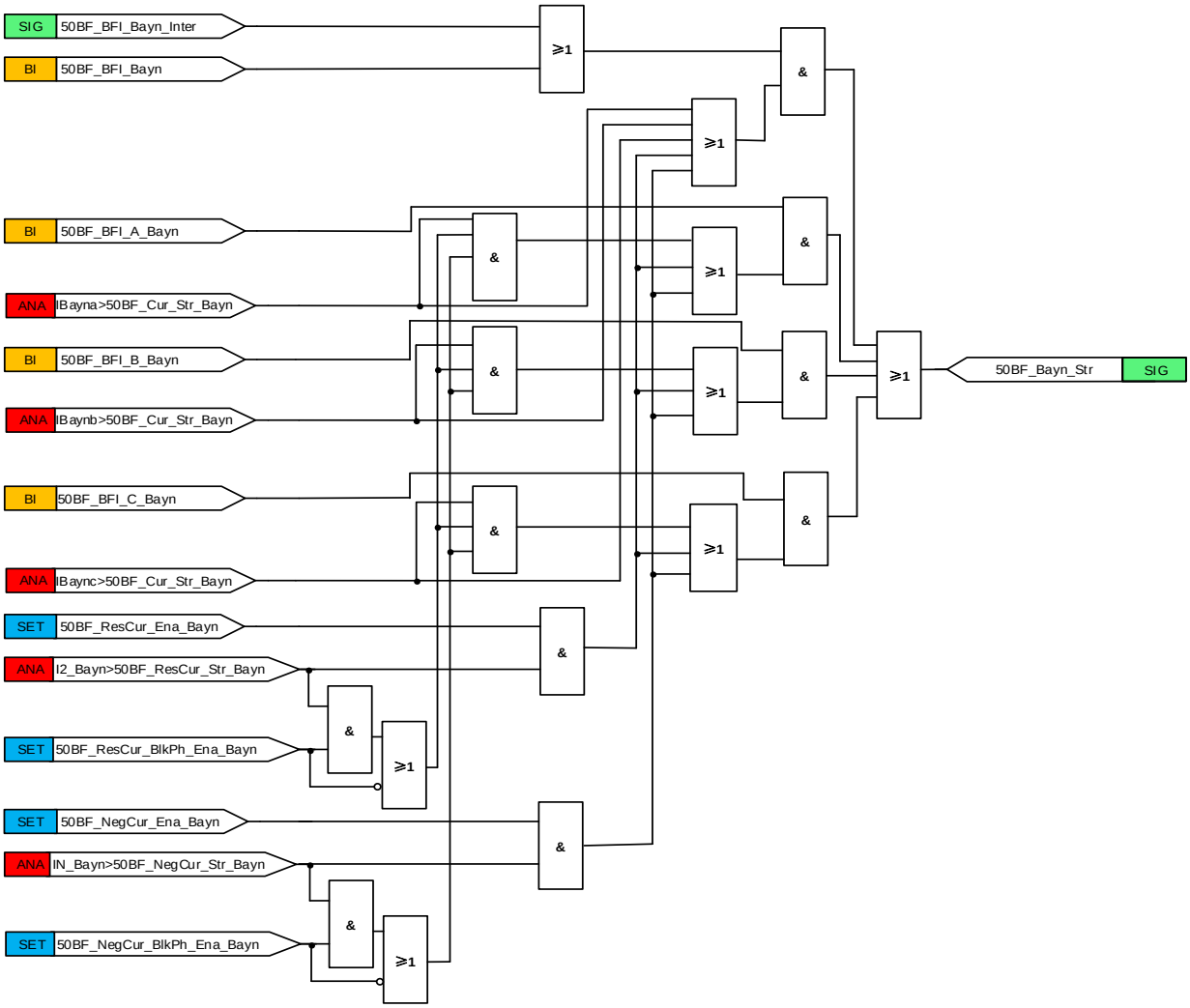


Figure 3.6.4 Logic Block Diagram of 50BF_CDE

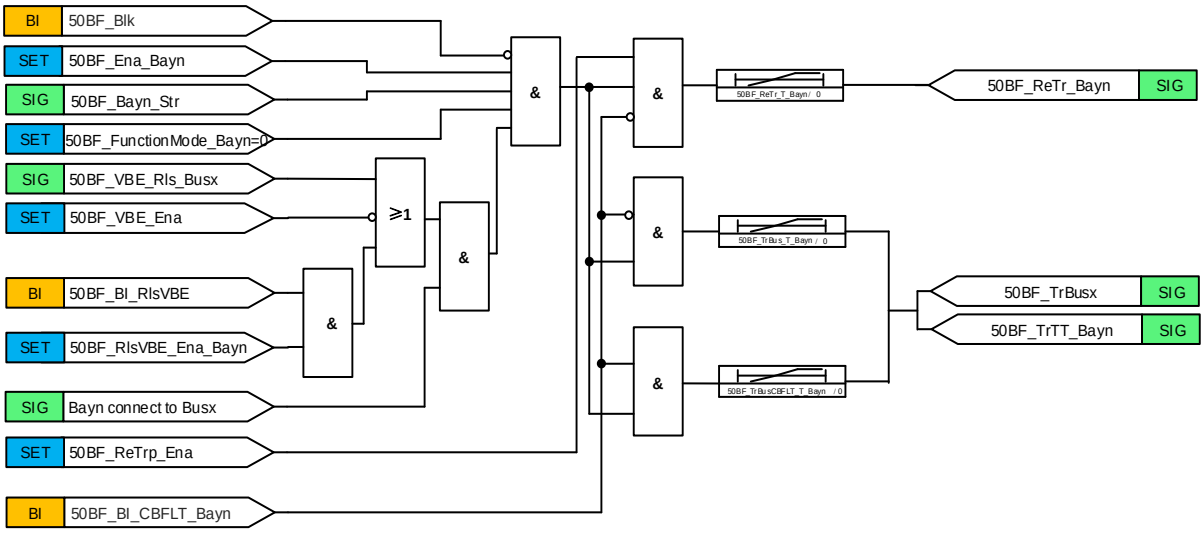


Figure 3.6.5 Logic Block Diagram of 50BF Output In Current Mode

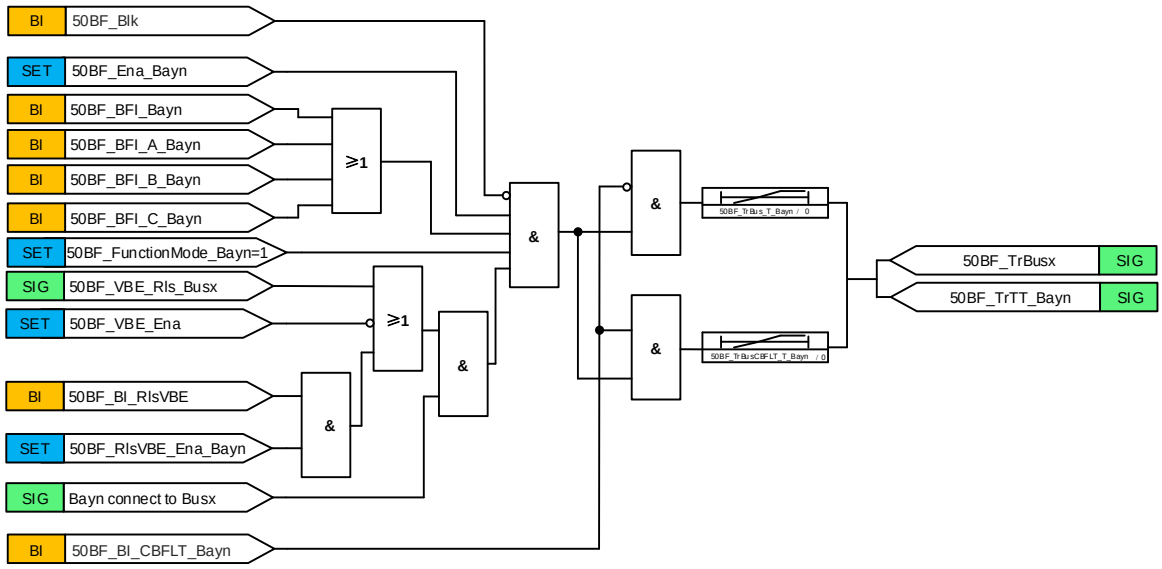


Figure 3.6.6 Logic Block Diagram of 50BF Output In Intertrip Mode

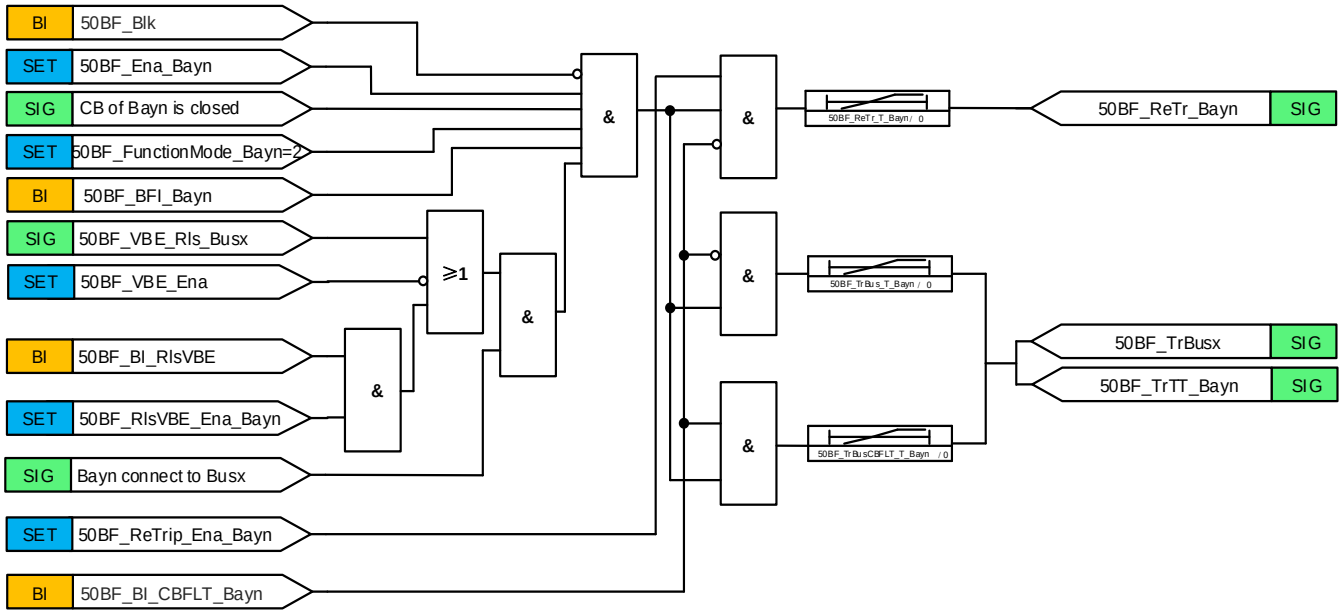


Figure 3.6.7 Logic Block Diagram of 50BF Output In Contact Mode

Where:

Bayn (n=BC/12, 1 …, 11) for Figure 3.6.5, Figure 3.6.6, Figure 3.6.7.

3.6.4 Settings

Table 3.6.4 50BF Settings for Single Busbar

No.	Name	Range	Unit	Step	Default	Description
1	50BF_Vol_Blk	0~100	V	0.01	40	Under voltage setting of 50BF_VBE.
2	50BF_ResVol_Blk	0~70	V	0.01	6	Residual voltage setting of 50BF_VBE.
3	50BF_NegVol_Blk	0~70	V	0.01	4	Negative-sequence voltage setting of 50BF_VBE.
4	50BF_VBE_Ena	0 or 1	-	1	0	Enabling or disabling 50BF_VBE.
5	87B_Init50BF_Ena	0 or 1	-	1	1	Enabling or disabling 87B to initiate 50BF.
6	50/51P_Init50BF_Ena	0 or 1	-	1	0	Enabling or disabling 50/51P to init 50BF.
7	50/51N_Init50BF_Ena	0 or 1	-	1	0	Enabling or disabling 50/51N to init 50BF.
8	50BF_Cur_Str_Bayn	0.05In~20In	A	0.01	20In	Phase current setting of 50BF of bay n.
9	50BF_ResCur_Str_Bayn	0.05 In ~20In	A	0.01	20In	Residual current setting of 50BF of bay n.

No.	Name	Range	Unit	Step	Default	Description
10	50BF_NegCur_Str_Bayn	0.05In~20In	A	0.01	20In	Negative-sequence current setting of 50BF of bay n.
11	50BF_ReTr_T_Bayn	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of bay n operates to re-trip breaker.
12	50BF_TrBus_T_Bayn	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of bay n operates to trip busbar.
13	50BF_TrBusCBFLT_T_Bayn	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of bay n operates to trip busbar when CB faulty binary input is energized.
14	50BF_FunctionMode_Bayn	0~2	-	1	0	0: Detection for trip based on current criterion. 1: Detection for trip not based on current criterion or contact criterion. 2: Detection for trip based on contact criterion.
15	50BF_ResCur_Ena_Bayn	0 or 1	-	1	0	1: Residual current criterion of 50BF of bay n is enabled. 0: Residual current criterion of 50BF of bay n is disabled.
16	50BF_NegCur_Ena_Bayn	0 or 1	-	1	0	1: Negative-sequence current criterion of 50BF of bay n is enabled. 0: Negative-sequence current criterion of 50BF of bay n is disabled.
17	50BF_ResCur_BlkPh_Ena_Bayn	0 or 1	-	1	0	1: The phase current criterion will be blocked by residual current criterion. 0: The phase current criterion will not be blocked by residual current criterion.
18	50BF_NegCur_BlkPh_Ena_Bayn	0 or 1	-	1	0	1: The phase current criterion will be blocked by negative-sequence current criterion. 0: The phase current criterion will not be blocked by negative-sequence current criterion.
19	50BF_ReTrip_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling 50BF operates to re-trip breaker of bay n.
20	50BF_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling breaker failure protection of bay n.
21	50BF_RlsVBE_Ena_Bayn	0 or 1	-	1	0	1: The binary input for releasing blocking controlled element of breaker failure protection of bay n is enabled.

No.	Name	Range	Unit	Step	Default	Description
						0: The binary input for releasing blocking controlled element of breaker failure protection of bay n is disabled.

Table 3.6.5 50BF Settings for for one-and-a-half breaker scheme and Double Busbar Double Breaker

No.	Name	Range	Unit	Step	Default	Description
1	87B_Init50BF_Ena	0 or 1	-	1	1	Enabling or disabling 87B to initiate 50BF.
2	50/51P_Init50BF_Ena	0 or 1	-	1	0	Enabling or disabling 50/51P to init 50BF.
3	50/51N_Init50BF_Ena	0 or 1	-	1	0	Enabling or disabling 50/51N to init 50BF.
4	50BF_Cur_Str_Bayn	0.05In~20In	A	0.01	20In	Phase current setting of 50BF of bay n.
5	50BF_ResCur_Str_Bayn	0.05 In ~20In	A	0.01	20In	Residual current setting of 50BF of bay n.
6	50BF_NegCur_Str_Bayn	0.05In~20In	A	0.01	20In	Negative-sequence current setting of 50BF of bay n.
7	50BF_ReTr_T_Bayn	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of bay n operates to re-trip breaker.
8	50BF_TrBus_T_Bayn	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of bay n operates to trip busbar.
9	50BF_TrBusCBFLT_T_Bayn	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of bay n operates to trip busbar when CB faulty binary input is energized.
10	50BF_FunctionMode_Bayn	0~2	-	1	0	0: Detection for trip based on current criterion. 1: Detection for trip not based on current criterion or contact criterion. 2: Detection for trip based on contact criterion.
11	50BF_ResCur_Ena_Bayn	0 or 1	-	1	0	1: Residual current criterion of 50BF of bay n is enabled. 0: Residual current criterion of 50BF of bay n is disabled.
12	50BF_NegCur_Ena_Bayn	0 or 1	-	1	0	1: Negative-sequence current criterion of 50BF of bay n is enabled. 0: Negative-sequence current criterion of 50BF of bay n is disabled.

No.	Name	Range	Unit	Step	Default	Description
13	50BF_ResCur_BlkPh_Ena_Bayn	0 or 1	-	1	0	1: The phase current criterion will be blocked by residual current criterion. 0: The phase current criterion will not be blocked by residual current criterion.
14	50BF_NegCur_BlkPh_Ena_Bayn	0 or 1	-	1	0	1: The phase current criterion will be blocked by negative-sequence current criterion. 0: The phase current criterion will not be blocked by negative-sequence current criterion.
15	50BF_ReTrip_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling 50BF operates to re-trip breaker of bay n.
16	50BF_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling breaker failure protection of bay n.
17	50BF_RlsVBE_Ena_Bayn	0 or 1	-	1	0	1: The binary input for releasing blocking controlled element of breaker failure protection of bay n is enabled. 0: The binary input for releasing blocking controlled element of breaker failure protection of bay n is disabled.

Table 3.6.6 50BF Settings for two Busbars

No.	Name	Range	Unit	Step	Default	Description
1	50BF_Vol_Blk	0~100	V	0.01	40	Under voltage setting of 50BF_VBE.
2	50BF_ResVol_Blk	0~70	V	0.01	6	Residual voltage setting of 50BF_VBE.
3	50BF_NegVol_Blk	0~70	V	0.01	4	Negative-sequence voltage setting of 50BF_VBE.
4	50BF_VBE_Ena	0 or 1	-	1	0	Enabling or disabling 50BF_VBE.
5	87B_Init50BF_Ena	0 or 1	-	1	1	Enabling or disabling 87B to initiate 50BF.
6	50/51P_Init50BF_Ena	0 or 1	-	1	0	Enabling or disabling 50/51P to init 50BF.
7	50/51N_Init50BF_Ena	0 or 1	-	1	0	Enabling or disabling 50/51N to init 50BF.
8	50BF_Cur_Str_BayBC	0.05In~20In	A	0.01	20In	Phase current setting of 50BF of the BCy/BSz.
9	50BF_ResCur_Str_BayBC	0.05 In ~20In	A	0.01	20In	Residual current setting of 50BF of the BCy/BSz.

No.	Name	Range	Unit	Step	Default	Description
10	50BF_NegCur_Str_BayBC	0.05In~20In	A	0.01	20In	Negative-sequence current setting of 50BF of the BCy/BSz.
11	50BF_ReTr_T_BayBC	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of the BCy/BSz operates to re-trip breaker.
12	50BF_TrBus_T_BayBC	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of the BCy/BSz operates to trip busbar.
13	50BF_TrBusCBFLT_T_BayBC	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of the BCy/BSz operates to trip busbar when CB faulty binary input is energized.
14	50BF_FunctionMode_BayBC	0~2	-	1	0	0: Detection for trip based on current criterion. 1: Detection for trip not based on current criterion or contact criterion. 2: Detection for trip based on contact criterion.
15	50BF_ResCur_Ena_BayBC	0 or 1	-	1	0	1: Residual current criterion of 50BF of bay n is enabled. 0: Residual current criterion of 50BF of bay n is disabled.
16	50BF_NegCur_Ena_BayBC	0 or 1	-	1	0	1: Negative-sequence current criterion of 50BF of the BCy/BSz is enabled. 0: Negative-sequence current criterion of 50BF of the BCy/BSz is disabled.
17	50BF_ResCur_BlkPh_Ena_BayBC	0 or 1	-	1	0	1: The phase current criterion will be blocked by residual current criterion. 0: The phase current criterion will not be blocked by residual current criterion.
18	50BF_NegCur_BlkPh_Ena_BayBC	0 or 1	-	1	0	1: The phase current criterion will be blocked by negative-sequence current criterion. 0: The phase current criterion will not be blocked by negative-sequence current criterion.
19	50BF_ReTrip_Ena_BayBC	0 or 1	-	1	0	Enabling or disabling 50BF operates to re-trip breaker of the BCy/BSz.
20	50BF_Ena_BayBC	0 or 1	-	1	0	Enabling or disabling breaker failure protection of the BCy/BSz.

No.	Name	Range	Unit	Step	Default	Description
21	50BF_RlsVBE_Ena_BayBC	0 or 1	-	1	0	1: The binary input for releasing blocking controlled element of breaker failure protection of the BCy/BSz is enabled. 0: The binary input for releasing blocking controlled element of breaker failure protection of the BCy/BSz is disabled.
22	50BF_Cur_Str_Bayn	0.05In~20In	A	0.01	20In	Phase current setting of 50BF of bay n.
23	50BF_ResCur_Str_Bayn	0.05 In ~20In	A	0.01	20In	Residual current setting of 50BF of bay n.
24	50BF_NegCur_Str_Bayn	0.05In~20In	A	0.01	20In	Negative-sequence current setting of 50BF of bay n.
25	50BF_ReTr_T_Bayn	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of bay n operates to re-trip breaker.
26	50BF_TrBus_T_Bayn	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of bay n operates to trip busbar.
27	50BF_TrBusCBFLT_T_Bayn	0.000~10.000	s	0.001	10.000	Time delay setting of 50BF of bay n operates to trip busbar when CB faulty binary input is energized.
28	50BF_FunctionMode_Bayn	0~2	-	1	0	0: Detection for trip based on current criterion. 1: Detection for trip not based on current criterion or contact criterion. 2: Detection for trip based on contact criterion.
29	50BF_ResCur_Ena_Bayn	0 or 1	-	1	0	1: Residual current criterion of 50BF of bay n is enabled. 0: Residual current criterion of 50BF of bay n is disabled.
30	50BF_NegCur_Ena_Bayn	0 or 1	-	1	0	1: Negative-sequence current criterion of 50BF of bay n is enabled. 0: Negative-sequence current criterion of 50BF of bay n is disabled.
31	50BF_ResCur_BlkPh_Ena_Bayn	0 or 1	-	1	0	1: The phase current criterion will be blocked by residual current criterion. 0: The phase current criterion will not be blocked by residual current criterion.

No.	Name	Range	Unit	Step	Default	Description
32	50BF_NegCur_BlkPh_Ena_Bayn	0 or 1	-	1	0	1: The phase current criterion will be blocked by negative-sequence current criterion. 0: The phase current criterion will not be blocked by negative-sequence current criterion.
33	50BF_ReTrip_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling 50BF operates to re-trip breaker of bay n.
34	50BF_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling breaker failure protection of bay n.
35	50BF_RlsVBE_Ena_Bayn	0 or 1	-	1	0	1: The binary input for releasing blocking controlled element of breaker failure protection of bay n is enabled. 0: The binary input for releasing blocking controlled element of breaker failure protection of bay n is disabled.

NOTICE!

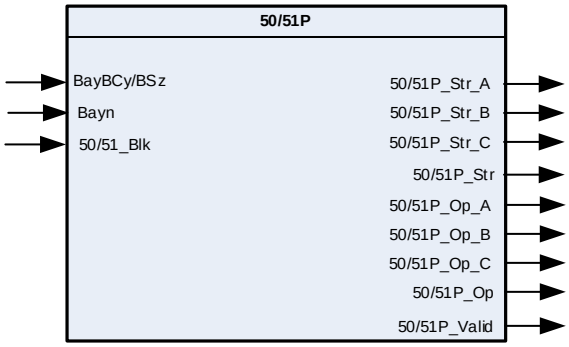
When calculating all the current setting of 50BF, the primary current should be converted to the secondary value according to the reference CT ratio instead of the actual CT ratio of each bay and BCy/BSz.

3.7 Phase OverCurrent Protection 50/51P

3.7.1 Overview

The main and important function of phase overcurrent protection 50/51P is to continuously track the electrical feeder passing current. For the point of view of continuously power supply and minimum damage during fault condition (at the time of fault the normal current value is increases suddenly and this current is too harmful for supply system). If the measured current value is greater than the set level, the sub protection function of BP-2C phase overcurrent protection 50/51P will operates or gives alarm signal with dependable definite time delay (DT) or inverse definite time (IDMT) delay characteristics and each has same logic of operation settings.

3.7.1.1 Function Block



3.7.1.2 Signals

Table 3.7.1 50/51P Input Signals

NO.	Signal	Description
1	BayBCy/BSz	Resource box 1 of bus coupler y or bus section z.
2	Bayn	Resource box of bay n.
3	50/51_Blk	Binary input for blocking 50/51 function.

Table 3.7.2 50/51P Output Signals

NO.	Signal	Description
1	50/51P_Str_A	This signal indicating that phase A of 50/51P picks up.
2	50/51P_Str_B	This signal indicating that phase B of 50/51P picks up.
3	50/51P_Str_C	This signal indicating that phase C of 50/51P picks up.
4	50/51P_ Str	This signal indicating that 50/51P picks up.
5	50/51P_Op_A	This signal indicating that phase A of 50/51P operates.
6	50/51P_Op_B	This signal indicating that phase B of 50/51P operates.
7	50/51P_Op_C	This signal indicating that phase C of 50/51P operates.
8	50/51P_Op	This signal indicating that 50/51P operates.
9	50/51P_Valid	Valid flag of 50/51P.

3.7.2 Protection Principle

3.7.2.1 Supervision Element

The phase overcurrent protection is provided with independent logic, current and time delay settings. When any phase current of bay n or BCy/BSz is larger than the current setting, phase overcurrent element picks up. The operating criteria are shown as follow.

$$\max\{I_{a\_Bayn}, I_{b\_Bayn}, I_{c\_Bayn}\} > 50/51P\_Cur\_Str\_Bayn$$

Where:

I_{a_Bayn} , I_{b_Bayn} , I_{c_Bayn} : Phase-A,B,C current of bay n respectively.

50/51P_Cur_Str_Bayn: Current setting of bay n (n=BC/12, 1 …, 11).

3.7.2.2 Characteristic Curve

50/51P can be selected as definite-time or inverse-time characteristic. The timer model is determined by **IDMT curves for over quantity protection and under quantity protection**.

The user can select the operating characteristic from various inverse-time characteristic curves by setting 50/51P_Op_Curve_Type_Bayn (n=BC/12, 1 …, 11) corresponding second column of **table 3.11.1**, and parameters of available characteristics for selection are shown in the **table 3.11.1 Inverse-time curve parameters**.

3.7.3 Logic

The logic of 50/51P is shown as follows:

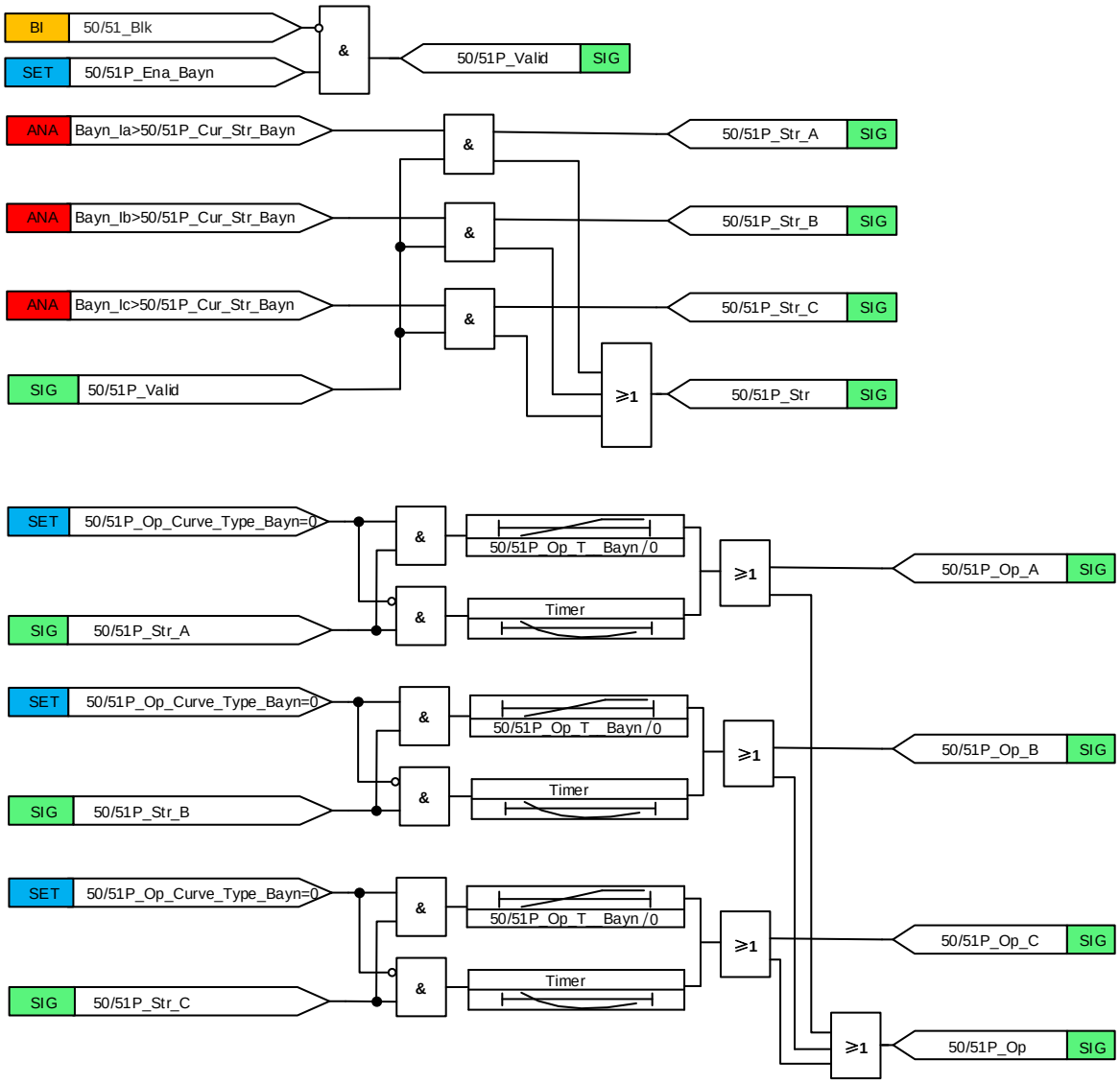


Figure 3.7.1 Logic Block Diagram of 50/51P

Where:

Bayn_Ia: Phase-A current of any bay (including BCy/BSz).

Bayn_Ib: Phase-B current of any bay (including BCy/BSz).

Bayn_Ic: Phase-C current of any bay (including BCy/BSz).

3.7.4 Settings

Table 3.7.3 50/51P Settings for Single Busbar

No.	Name	Range	Unit	Step	Default	Description
1	50/51P_Cur_Str_Bayn	0.05In~20In	A	0.01	20In	Current setting of bay n.
2	50/51P_Op_T_Bayn	0.000~100.000	s	0.001	0.1	Definite Time delay setting.
3	50/51P_Op_Curve_Type_Bayn	ANSIE ANSIV ANSIN ANSIM ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine	-	-	IECDefTime	Characteristic curve for 50/51P. Including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
4	50/51P_T_Mult_Bayn	0.001~200.000	-	0.001	1	The time factor setting of IDMT phase overcurrent protection.
5	50/51P_Min_Op_T_Bayn	0.000~60.000	s	0.001	0.020	Minimum operate time for inverse curves.
6	50/51P_Alpha_Bayn	0.010~5.000	-	0.001	0.020	Constant α of 50/51P.
7	50/51P_C_Bayn	0.000~20.000	-	0.001	0	Constant C of 50/51P.
8	50/51P_K_Bayn	0.005~200.000	-	0.001	0.140	Constant K of 50/51P.
9	50/51P_CurMul	20~40.0	-	0.1	30	It used to IDMT with I=CurMul*Ip, when I> CurMul *Ip, the IDMT time delay is calculated by CurMul. It is invalid if it is not configured or the CurMulEna is disable.
10	50/51P_CurMulEna	0 or 1	-	1	0	Enable: CurMul is effective. Disable: CurMul is ineffective.
11	50/51P_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling phase overcurrent protection of bay n.

Table 3.7.4 50/51P Settings for one-and-a-half breaker scheme and Double Busbar Double Breaker

No.	Name	Range	Unit	Step	Default	Description
1	50/51P_Cur_Str_Bayn	0.05In~20In	A	0.01	20In	Current setting of bay n.
2	50/51P_Op_T_Bayn	0.000~100.000	S	0.001	0.1	Definite Time delay setting.
3	50/51P_Op_Curve_Type_Bayn	ANSIE ANSIV ANSIN ANSIM ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine	-	-	IECDefTime	Characteristic curve for 50/51P. Including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
4	50/51P_T_Mult_Bayn	0.001~200.000	-	0.001	1	The time factor setting of IDMT phase overcurrent protection.
5	50/51P_Min_Op_T_Bayn	0.000~60.000	S	0.001	0.020	Minimum operate time for inverse curves.
6	50/51P_Alpha_Bayn	0.010~5.000	-	0.001	0.020	Constant α of 50/51P.
7	50/51P_C_Bayn	0.000~20.000	-	0.001	0	Constant C of 50/51P.
8	50/51P_K_Bayn	0.005~200.000	-	0.001	0.140	Constant K of 50/51P.
9	50/51P_CurMul	20~40.0	-	0.1	30	It used to IDMT with I=CurMul*Ip, when I> CurMul *Ip, the IDMT time delay is calculated by CurMul. It is invalid if it is not configured or the CurMulEna is disable.
10	50/51P_CurMulEna	0 or 1	-	1	0	Enable: CurMul is effective. Disable: CurMul is ineffective.
11	50/51P_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling phase overcurrent protection of bay n.

Table 3.7.5 50/51P Settings for two Busbars

No.	Name	Range	Unit	Step	Default	Description
1	50/51P_Cur_Str_ BayBC	0.05In~20In	A	0.01	20In	Current setting of BCy/BSz.
2	50/51P_Op_T_ BayBC	0.000~100.000	s	0.001	0.1	Definite Time delay setting.
3	50/51P_Op_Curve _Type_BayBC	ANSIE ANSIV ANSIN ANSIM ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine	-	-	IECDef Time	Characteristic curve for 50/51P. Including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
4	50/51P_T_Mult_ BayBC	0.001~200.000	-	0.001	1	The time factor setting of IDMT phase overcurrent protection.
5	50/51P_Min_Op_T _BayBC	0.000~60.000	s	0.001	0.020	Minimum operate time for inverse curves.
6	50/51P_Alpha_ BayBC	0.010~5.000	-	0.001	0.020	Constant α of 50/51P.
7	50/51P_C_BayBC	0.000~20.000	-	0.001	0	Constant C of 50/51P.
8	50/51P_K_BayBC	0.005~200.000	-	0.001	0.140	Constant K of 50/51P.
9	50/51P_CurMul_ BayBC	20~40.0	-	0.1	30	It used to IDMT with I=CurMul*Ip, when I> CurMul *Ip, the IDMT time delay is calculated by CurMul. It is invalid if it is not configured or the CurMulEna is disable.
10	50/51P_ CurMulEna_ BayBC	0 or 1	-	1	0	Enable: CurMul is effective. Disable: CurMul is ineffective.
11	50/51P_Ena_ BayBC	0 or 1	-	1	0	Enabling or disabling phase overcurrent protection of BCy/BSz.
12	50/51P_Cur_Str_ Bayn	0.05In~20In	A	0.01	20In	Current setting of bay n.

No.	Name	Range	Unit	Step	Default	Description
13	50/51P_Op_T_ Bayn	0.000~100.000	s	0.001	0.1	Definite Time delay setting.
14	50/51P_Op_Curve _Type_Bayn	ANSIE ANSIV ANSIN ANSIM ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine	-	-	IECDef Time	Characteristic curve for 50/51P. Including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
15	50/51P_T_Mult_ Bayn	0.001~200.000	-	0.001	1	The time factor setting of IDMT phase overcurrent protection.
16	50/51P_Min_Op_T _Bayn	0.000~60.000	s	0.001	0.020	Minimum operate time for inverse curves.
17	50/51P_Alpha_ Bayn	0.010~5.000	-	0.001	0.020	Constant α of 50/51P.
18	50/51P_C_Bayn	0.000~20.000	-	0.001	0	Constant C of 50/51P.
19	50/51P_K_Bayn	0.005~200.000	-	0.001	0.140	Constant K of 50/51P.
20	50/51P_CurMul_ Bayn	20~40.0	-	0.1	30	It used to IDMT with I=CurMul*Ip, when I> CurMul *Ip, the IDMT time delay is calculated by CurMul. It is invalid if it is not configured or the CurMulEna is disable.
21	50/51P_ CurMulEna_Bayn	0 or 1	-	1	0	Enable: CurMul is effective. Disable: CurMul is ineffective.
22	50/51P_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling phase overcurrent protection of bay n.

NOTICE!

When calculating all the current setting of 50/51P, the primary current should be converted to the secondary value according to the reference CT ratio instead of the actual CT ratio of each bay and BCy/BSz.

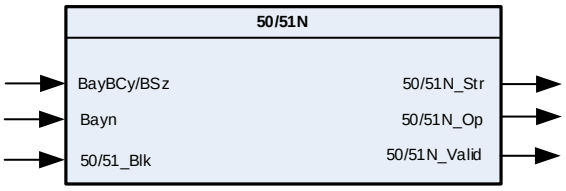
3.8 Ground OverCurrent Protection 50/51N

3.8.1 Overview

In electrical power industry, ground overcurrent protection (50/51N) is very important and need to detect very accurate ground or earth fault value and clear this fault as soon as possible. When the ground fault is happening in the bus system, according to ohm law current always flows to the low resistive path and all current goes into the grounding system and it's a main reason to increase the current level of zero-sequence current and its effect on increasing the bay and BCy/BSz residual current.

50/51N is based on residual current of bay or BCy/BSz. If the detected residual current of bay or BCy/BSz is greater than set value, the 50/51N will operates or gives alarm signal with dependable definite time delay (DT) or inverse definite time (IDMT) delay characteristics and each has same logic of operation settings.

3.8.1.1 Function Block



3.8.1.2 Signals

Table 3.8.1 50/51N Input Signals

NO.	Signal	Description
1	BayBCy/BSz	Resource box 1 of bus coupler y or bus section z.
2	Bayn	Resource box of bay n.
3	50/51_Blk	Binary input for blocking 50/51 function.

Table 3.8.2 50/51N Output Signals

NO.	Signal	Description
1	50/51N_Str	This signal indicating that 50/51N picks up.
2	50/51N_Op	This signal indicating that 50/51N operates.
3	50/51N_Valid	Valid flag of 50/51P.

3.8.2 Protection Principle

3.8.2.1 Supervision Element

When residual current of bay n or BCy/BSz is larger than the threshold, ground overcurrent element picks up, the operating criterion shown as follow.

$$3I_{0\_Bayn} > 50/51N\_Cur\_Str\_Bayn$$

Where:

$3I_{0\_Bayn}$: Residual current of bay n (calculated internally, n=BC/12, 1 …, 11).

50/51N_Cur_Str_Bayn: Residual current setting of bay n (n=BC/12, 1 …, 11).

3.8.2.2 Characteristic Curve

50/51N can be selected as definite-time or inverse-time characteristic. The timer model is determined by **IDMT curves for over quantity protection and under quantity protection**.

The user can select the operating characteristic from various inverse-time characteristic curves by setting 50/51N_Op_Curve_Type_Bayn (n=BC/12, 1 …, 11) corresponding second column of **table 3.11.1**, and parameters of available characteristics for selection are shown in the **table 3.11.1 Inverse-time curve parameters**.

3.8.3 Logic

The logic of 50/51N is shown as follows:

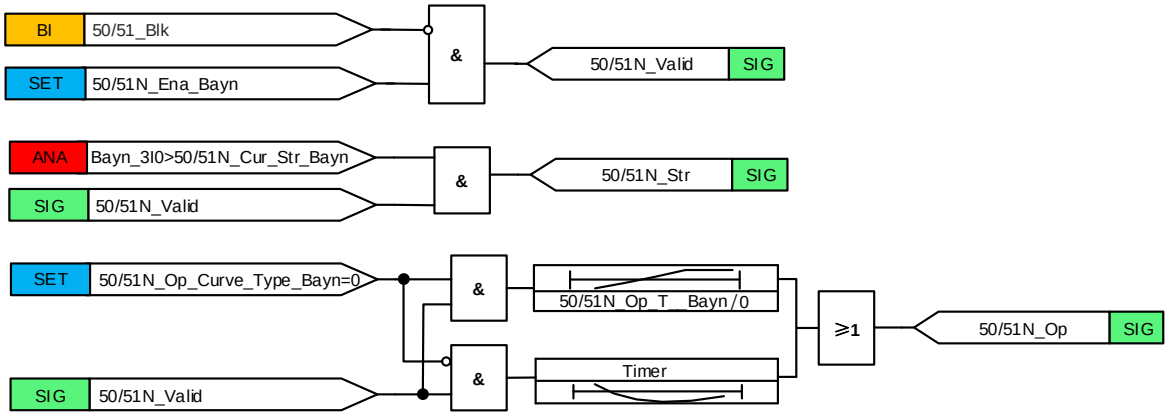


Figure 3.8.1 Logic Block Diagram of 50/51N

Where:

Bayn_3I0: Zero current of any bay (including BCy/BSz).

3.8.4 Settings

Table 3.8.3 50/51N Settings for Single Busbar

No.	Name	Range	Unit	Step	Default	Description
1	50/51N_Cur_Str_Bayn	0.05In~20In	A	0.01	20In	Residual current setting of bay n.

No.	Name	Range	Unit	Step	Default	Description
2	50/51N_Op_T_Bayn	0.000~100.000	s	0.001	0.1	Definite Time delay setting of bay n.
3	50/51N_Op_Curve_Type_Bayn	ANSIE ANSIV ANSIN ANSIM ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine	-	-	IECDefTime	Characteristic curve for 50/51N. Including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
4	50/51N_T_Mult_Bayn	0.001~200.000	-	0.001	1	The time factor setting of IDMT ground overcurrent protection of bay n.
5	50/51N_Min_Op_T_Bayn	0.000~60.000	s	0.001	0.020	Minimum operate time for inverse curves.
6	50/51N_Alpha_Bayn	0.010~5.000	-	0.001	0.020	Constant α of 50/51N.
7	50/51N_C_Bayn	0.000~20.000	-	0.001	0	Constant C of 50/51N.
8	50/51N_K_Bayn	0.005~200.000	-	0.001	0.140	Constant K of 50/51N.
9	50/51N_CurMul	20.0~40.0	-	0.1	30	It used to IDMT with I=CurMul*Ip, when I> CurMul *Ip, the IDMT time delay is calculated by CurMul. It is invalid if it is not configured or the CurMulEna is disable.
10	50/51N_CurMulEna	0 or 1	-	1	0	Enable: CurMul is effective. Disable: CurMul is ineffective.
11	50/51N_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling ground overcurrent protection of bay n.

Table 3.8.4 50/51N Settings for one-and-a-half breaker scheme and Double Busbar Double Breaker

No.	Name	Range	Unit	Step	Default	Description
1	50/51N_Cur_Str_Bayn	0.05In~20In	A	0.01	20In	Residual current setting of bay n.
2	50/51N_Op_T_Bayn	0.000~100.000	s	0.001	0.1	Definite Time delay setting of bay n.
3	50/51N_Op_Curve_Type_Bayn	ANSIE ANSIV ANSIN ANSIM ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine	-	-	IECDefTime	Characteristic curve for 50/51N. Including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
4	50/51N_T_Mult_Bayn	0.001~200.000	-	0.001	1	The time factor setting of IDMT ground overcurrent protection of bay n.
5	50/51N_Min_Op_T_Bayn	0.000~60.000	s	0.001	0.020	Minimum operate time for inverse curves.
6	50/51N_Alpha_Bayn	0.010~5.000	-	0.001	0.020	Constant α of 50/51N.
7	50/51N_C_Bayn	0.000~20.000	-	0.001	0	Constant C of 50/51N.
8	50/51N_K_Bayn	0.005~200.000	-	0.001	0.140	Constant K of 50/51N.
9	50/51N_CurMul	20~40.0	-	0.1	30	It used to IDMT with I=CurMul*Ip, when I> CurMul *Ip, the IDMT time delay is calculated by CurMul. It is invalid if it is not configured or the CurMulEna is disable.
10	50/51N_CurMulEna	0 or 1	-	1	0	Enable: CurMul is effective. Disable: CurMul is ineffective.
11	50/51N_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling ground overcurrent protection of bay n.

Table 3.8.5 50/51N Settings for two Busbars

No.	Name	Range	Unit	Step	Default	Description
1	50/51N_Cur_Str _BayBC	0.05In~20In	A	0.01	20In	Residual current setting of BCy/BSz.
2	50/51N_Op_T_ BayBC	0.000~100.000	s	0.001	0.1	Definite Time delay setting of BCy/BSz.
3	50/51N_Op_ Curve_Type_ BayBC	ANSIE ANSIV ANSIN ANSIM ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine	-	-	IECDef Time	Characteristic curve for 50/51N. Including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
4	50/51N_T_Mult_ BayBC	0.001~200.000	-	0.001	1	The time factor setting of IDMT ground overcurrent protection of BCy/BSz.
5	50/51N_Min_Op _T_BayBC	0.000~60.000	s	0.001	0.020	Minimum operate time for inverse curves.
6	50/51N_Alpha_ BayBC	0.010~5.000	-	0.001	0.020	Constant α of 50/51N.
7	50/51N_C_ BayBC	0.000~20.000	-	0.001	0	Constant C of 50/51N.
8	50/51N_K_ BayBC	0.005~200.000	-	0.001	0.140	Constant K of 50/51N.
9	50/51N_CurMul_ BayBC	20~40.0	-	0.1	30	It used to IDMT with I=CurMul*Ip, when I> CurMul *Ip, the IDMT time delay is calculated by CurMul. It is invalid if it is not configured or the CurMulEna is disable.
10	50/51N_ CurMulEna_ BayBC	0 or 1	-	1	0	Enable: CurMul is effective. Disable: CurMul is ineffective.

No.	Name	Range	Unit	Step	Default	Description
11	50/51N_Ena_BayBC	0 or 1	-	1	0	Enabling or disabling ground overcurrent protection of BCy/BSz.
12	50/51N_Cur_Str_Bayn	0.05In~20In	A	0.01	20In	Residual current setting of bay n.
13	50/51N_Op_T_Bayn	0.000~100.000	s	0.001	0.1	Definite Time delay setting of bay n.
14	50/51N_Op_Curve_Type_Bayn	ANSIE ANSIV ANSIN ANSIM ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine	-	-	IECDefTime	Characteristic curve for 50/51N. Including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
15	50/51N_T_Mult_Bayn	0.001~200.000	-	0.001	1	The time factor setting of IDMT ground overcurrent protection of bay n.
16	50/51N_Min_Op_T_Bayn	0.000~60.000	s	0.001	0.020	Minimum operate time for inverse curves.
17	50/51N_Alpha_Bayn	0.010~5.000	-	0.001	0.020	Constant α of 50/51N.
18	50/51N_C_Bayn	0.000~20.000	-	0.001	0	Constant C of 50/51N.
19	50/51N_K_Bayn	0.005~200.000	-	0.001	0.140	Constant K of 50/51N.
20	50/51N_CurMul_Bayn	20~40.0	-	0.1	30	It used to IDMT with I=CurMul*Ip, when I> CurMul *Ip, the IDMT time delay is calculated by CurMul. It is invalid if it is not configured or the CurMulEna is disable.
21	50/51N_CurMulEna_Bayn	0 or 1	-	1	0	Enable: CurMul is effective. Disable: CurMul is ineffective.
22	50/51N_Ena_Bayn	0 or 1	-	1	0	Enabling or disabling ground overcurrent protection of bay n.

NOTICE!

When calculating all the current setting of 50/51N, the primary current should be converted to the secondary value according to the reference CT ratio instead of the actual CT ratio of each bay.

3.9 Three-phase Overvoltage Protection 59P

3.9.1 Overview

The main operating function of Three-phase overvoltage protection (59P) is to continuously measure the protected busbar voltage limit caused by different faults. If the detected voltage limit is greater than the set threshold, the protection will operate or give alarm signal with dependable two stage definite time delay (DT) or inverse definite minimum time (IDMT) delay characteristics. This protection has extra ordinary feature to operate with overcurrent protection.

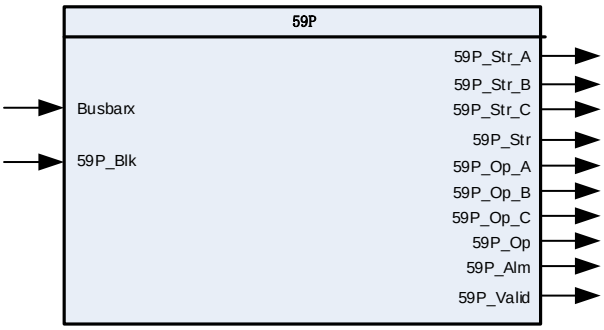
59P can support several kind of VT connection:

- Three phase voltage (Ua, Ub, Uc)
- Three phase-to-phase voltages (Uab, Ubc, Uca)
- Two phase-to-phase voltages (Uab, Ubc)

Three-phase overvoltage protection 59P has also blocking function capability.

In addition, the 59P can be configured as a backup protection for each busbar.

3.9.1.1 Function Block



3.9.1.2 Signals

Table 3.9.1 59P Input Signals

NO.	Signal	Description
1	Busbarx	Resource box of busbar x.
2	59P_Blk	Block signal of 59P

Table 3.9.2 Output Signals

NO.	Signal	Description
1	59P_Str _A	Phase A Start signal from 59P.
2	59P_Str _B	Phase B Start signal from 59P.
3	59P_Str _C	Phase C Start signal from 59P.
4	59P_ Str	Common Start signal from 59P.
5	59P_Op _A	Phase A Operation signal from 59P.
6	59P_Op _B	Phase B Operation signal from 59P.
7	59P_Op _C	Phase C Operation signal from 59P.
8	59P_ Op	Operation signal from 59P.
9	59P_ Alm	Alarm signal from 59P.
10	59P_Valid	Valid flag of 59P.

3.9.2 Protection Principle

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

The fundamental frequency component of the measured three phase voltages is compared phase-wise to the set value of the 59Pi_Vol_Str setting. If the measured value is higher than the set value of the 59Pi_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 matches the set 59Pi_Str_Ph_Num and no blocking signal input is activated, the phase selection logic activates the timer and the 59P_Str output and the corresponding output of the respective phases (59P_Str_A/B/C).

The 59Pi_Vol_Opt setting is used for selecting phase-to-earth (59Pi_Vol_Opt=0) or phase-to-phase (59Pi_Vol_Opt=1) voltages for protection.

59Pi_Vol_Str is the preset value to check for the voltage.

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

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

Depending on the value of the set 59Pi_Op_Curve_Type corresponding second column of **table 3.11.1**.

When the operation timer has reached the value set by 59Pi_Op_T in the DT mode or the value set by the IDMT operate time curve, the 59P_Op output is activated. The corresponding output for the respective phases (59P_Op_A/B/C) is also activated. For the IDMT model, 59Pi_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, the timer is reset and the 59P_Str output is deactivated.

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

3.9.3 Logic

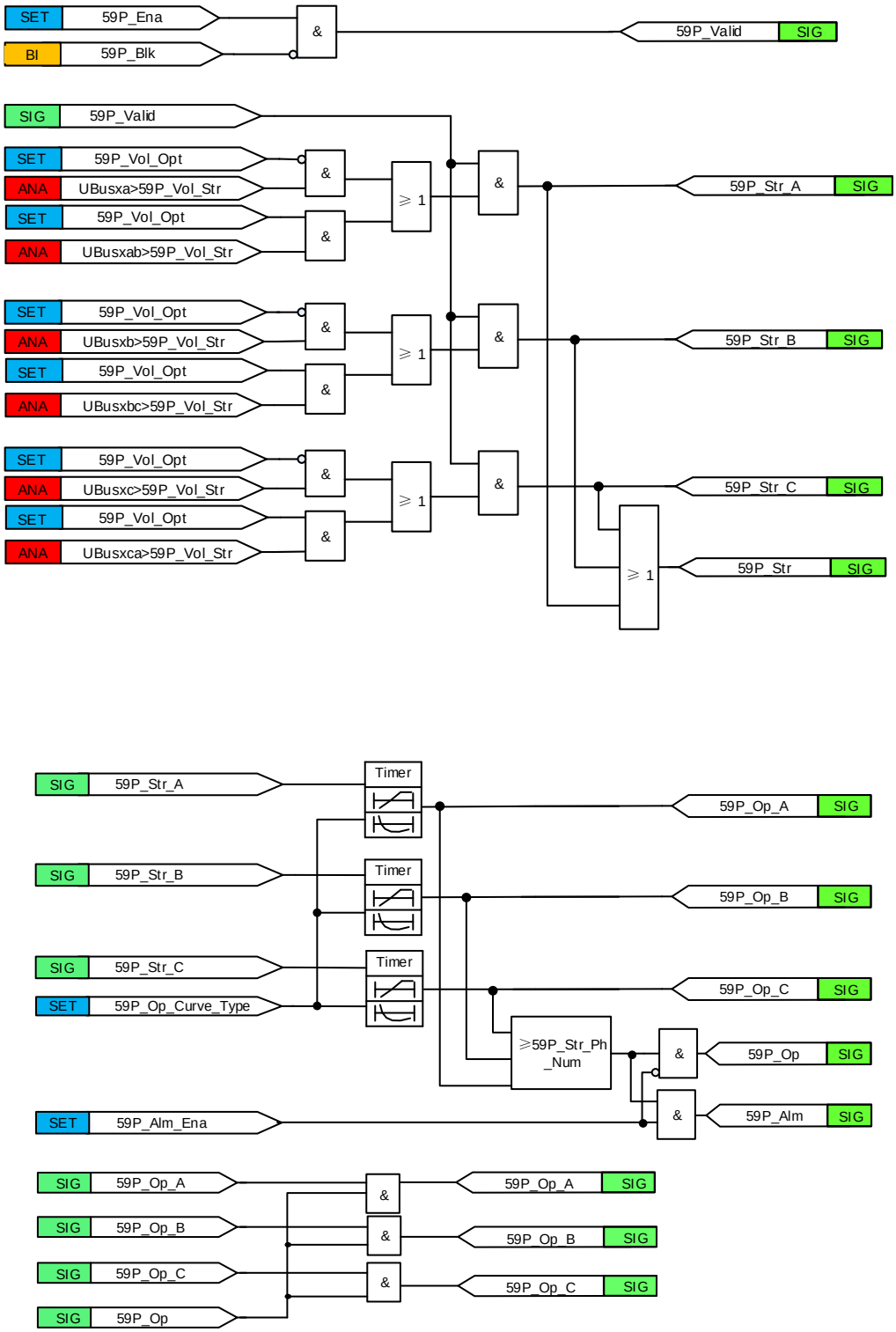


Figure 3.9.1 Functional module diagram

3.9.4 Settings

Table 3.9.3 Settings of Two stage Three-phase overvoltage protection

No.	Name	Range	Unit	Step	Default	Description
1	59Pi_Vol_Str	0.00~160.00	V	0.01	160.00	The stage i start value of overvoltage.
2	59Pi_Op_T	0.040~300.000	s	0.01	10.000	The stage i operating time delay for definite time curve.
3	59Pi_Str_Ph_Num	1~3	-	1	3	The stage i number of phases required for operate activation: 1 for 1 phase, 2 for 2 phases, 3 for 3 phases.
4	59Pi_Op_Curve_ Type	ANSIE ANSIV ANSIN ANSIM ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine	-	-	IECDe fTime	Characteristic curve for 59Pi including Definite time, IEC and ANSI typical curve and user programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
5	59Pi_T_ Mult	0.05~200.00	-	0.01	200.00	The stage i time multiplier in IEC curves.
6	59Pi_Min_Op_T	0.000~60.000	s	0.01	0.05	The stage i minimum operate time delay for IDMT curves.
7	59Pi_Alpha	0.00~3.00	-	0.01	1.00	The stage i constant α of 59P.
8	59Pi_C	0.000~60.000	-	0.001	0.000	The stage i constant C of 59P.
9	59Pi_K	0.001~100.000	-	0.001	1.000	The stage i constant K of 59P.
10	59Pi_Vol_Opt	0 or 1	-	1	0	The stage i parameter to select phase or phase-to- phase voltages: 0 for phase voltages: 1 for phase-to- phase voltages.
11	59Pi_Alm_Ena	0 or 1	-	1	0	The stage i alarm Off/On.
12	59Pi_Ena	0 or 1	-	1	0	The stage i operation Off/On.

3.10 Three-phase Undervoltage Protection 27P

3.10.1 Overview

The main operating function of Three-phase undervoltage protection (27P) is to continuously measure the protected busbar voltage limit caused by different faults. If the detected voltage limit is below to set threshold, the protection will operate or give alarm signal with dependable two stage definite time delay (DT) or inverse definite minimum time (IDMT) delay characteristics. This protection has extra ordinary feature to operate with overcurrent protection.

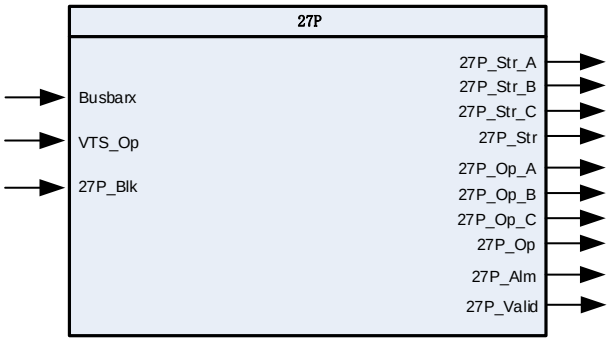
27P can support several kind of VT connection:

- Three phase voltage (Ua, Ub, Uc)
- Three phase-to-phase voltages (Uab, Ubc, Uca)
- Two phase-to-phase voltages (Uab, Ubc)

Three-phase undervoltage protection (27P) has also blocking function capability.

In addition, the 27P can be configured as a backup protection for each busbar.

3.10.1.1 Function Block



3.10.1.2 Signals

Table 3.10.1 27P Input Signals

NO.	Signal	Description
1	Busbarx	Resource box of busbar x.
2	VTS_Op	VTS operates. Its signal comes from VT_Failure_Busx.
3	27P_Blk	Block signal of 27P.

Table 3.10.2 27P Output Signals

NO.	Signal	Description
1	27P_Str _A	Phase A Start signal from 27P.
2	27P_Str _B	Phase B Start signal from 27P.
3	27P_Str _C	Phase C Start signal from 27P.
4	27P_Str	Common Start signal from 27P.

NO.	Signal	Description
5	27P_Op _A	Phase A Operation signal from 27P.
6	27P_Op _B	Phase B Operation signal from 27P.
7	27P_Op _C	Phase C Operation signal from 27P.
8	27P_Op	Operation signal from 27P.
9	27P_Alm	Alarm signal from 27P.
10	27P_Valid	Valid flag of 27P.

3.10.2 Protection Principle

The three-phase undervoltage protection function can be enabled or disabled by setting the corresponding 27Pi_Ena parameter values as "1" or "0".

The fundamental frequency component of the measured three phase voltages are compared phase-wise to the set value of the 27Pi_Vol_Str setting. If the measured value is lower than the set value of the 27Pi_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 matches the set 27Pi_Str_Ph_Num and no blocking signal input is activated, the phase selection logic activates the timer and the 27P_Str output and the corresponding output of the respective phases (27P_Str_A/B/C).

The 27Pi_Vol_Opt setting is used for selecting phase-to-earth (27Pi_Vol_Opt=0) or phase-to-phase (27Pi_Vol_Opt=1) voltages for protection.

27Pi_Vol_Str is the preset value to check for the voltage.

27Pi_Str_Ph_Num shows the number of phases required for operate activation.

Blocking for low current levels is activated by setting. The desired blocking level can be adjusted by the 27Pi_I_Blk_Ena setting.

For example: If the measured current level decreases below the 0.05A, either the trip output of stage 1, or both the trip and the START outputs of stage 1, are blocked. Blocking for low voltage levels is activated by default.

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

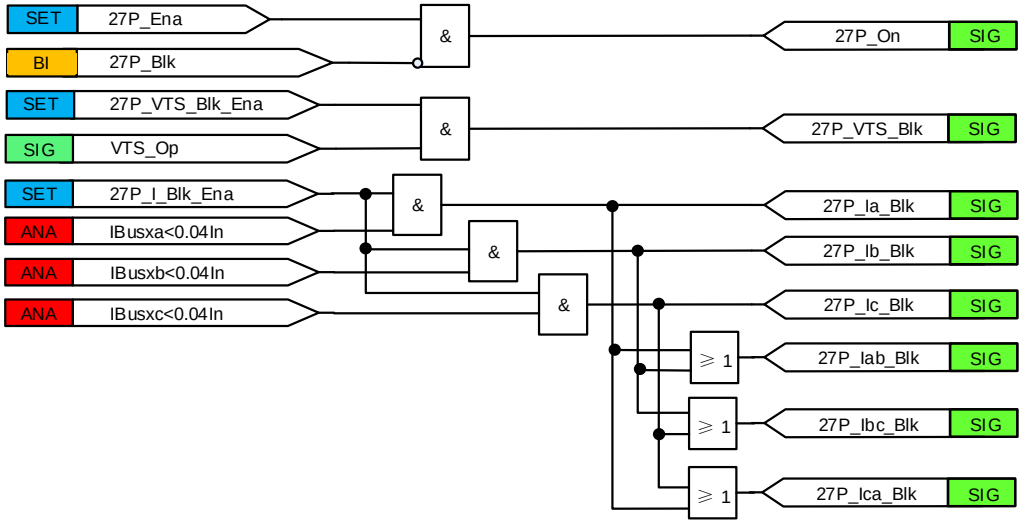
Depending on the value of the set 27Pi_Op_Curve_Type corresponding second column of **table 3.11.1**.

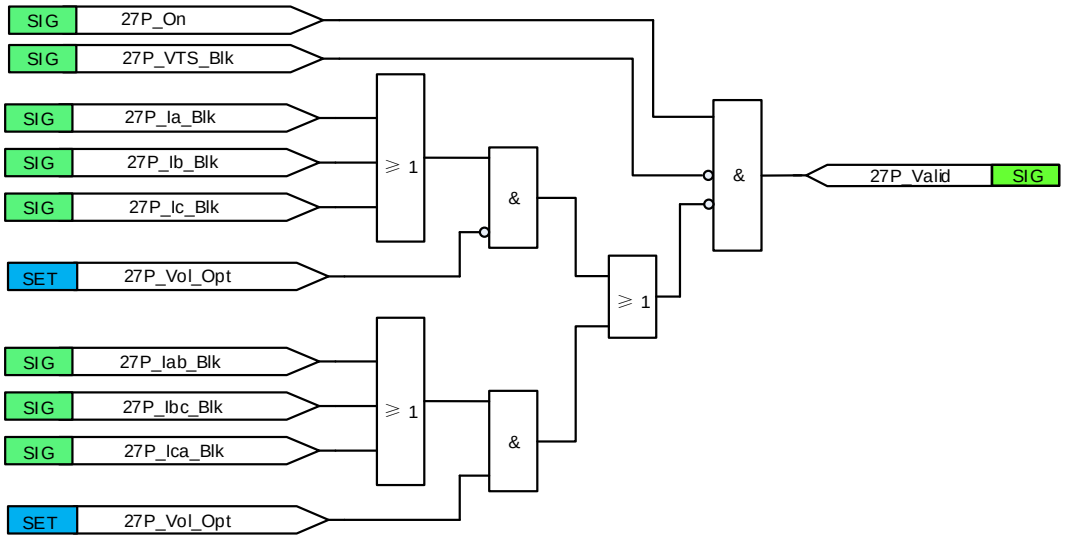
When the operation timer has reached the value set by 27Pi_Op_T in the DT mode or the value set by the IDMT operate time curve, the 27P_Op output is activated. The corresponding output for the respective phases (27P_Op_A/B/C) is also activated. For the IDMT model, 27Pi_Min_Op_T defines the minimum desired operate time for IDMT.

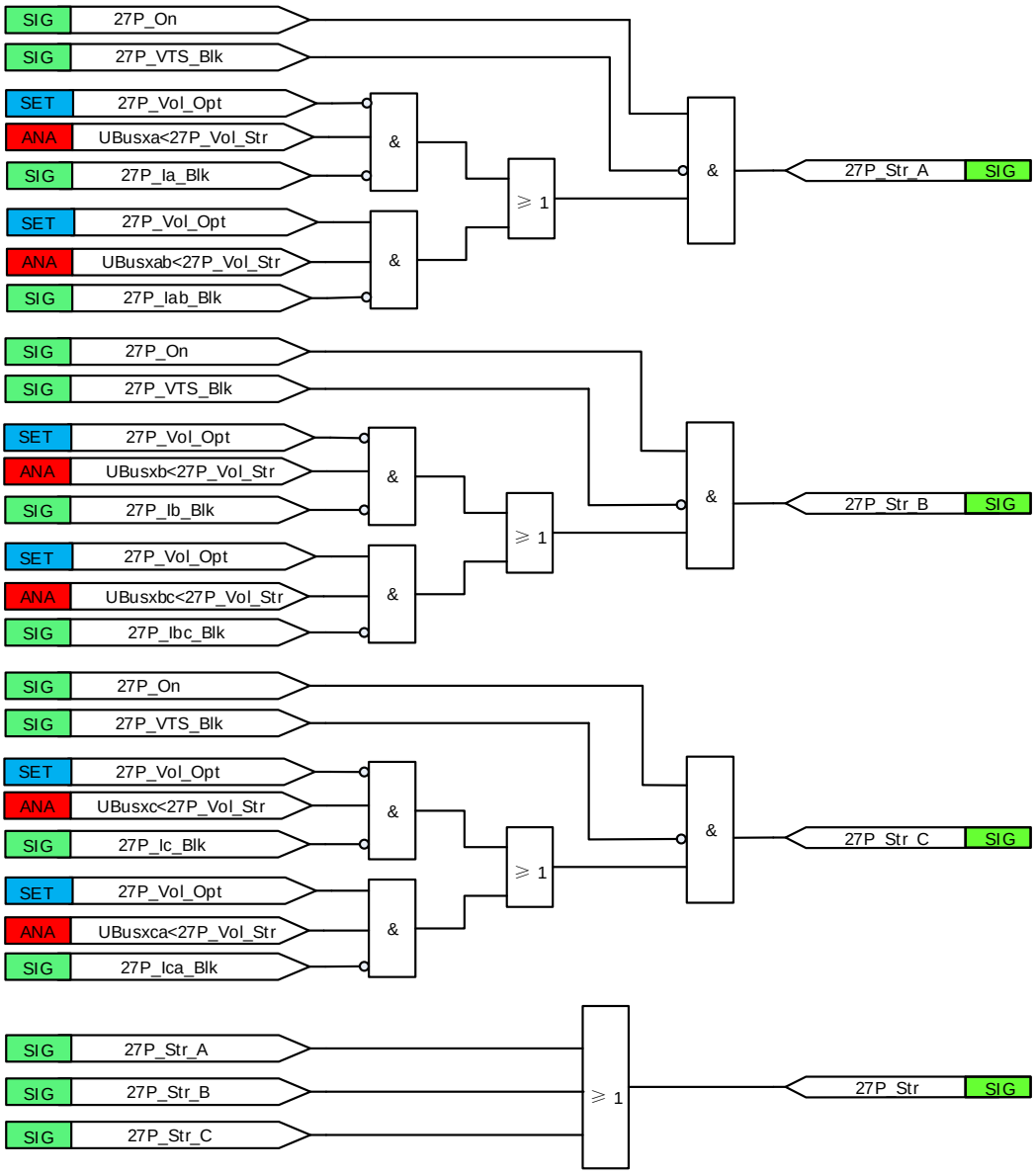
If a drop-off situation occurs, that is, a fault suddenly disappears before the operation delay is exceeded, the reset state is activated, the timer is reset and the 27P_Str output is deactivated.

The binary input 27P_Blk can be used to block the function. The activation of the 27P_Blk input deactivates all outputs and resets the internal timers.

3.10.3 Logic


SET
27P_Ena
BI
27P_Blk
&
27P_On
SIG
SET
27P_VTS_Blk_Ena
SIG
VTS_Op
&
27P_VTS_Blk
SIG
SET
27P_I_Blk_Ena
ANA
IBusxa<0.04In
ANA
IBusxb<0.04In
ANA
IBusxc<0.04In
&
&
&
27P_Ia_Blk
27P_Ib_Blk
27P_Ic_Blk
⩾ 1
27P_Iab_Blk
⩾ 1
27P_Ibc_Blk
⩾ 1
27P_Ica_Blk
SIG


SIG
27P_On
SIG
27P_VTS_Blk
SIG
27P_Ia_Blk
SIG
27P_Ib_Blk
SIG
27P_Ic_Blk
⩾ 1
&
SET
27P_Vol_Opt
⩾ 1
&
27P_Valid
SIG
SIG
27P_Iab_Blk
SIG
27P_Ibc_Blk
SIG
27P_Ica_Blk
⩾ 1
&
SET
27P_Vol_Opt


SIG
27P_On
SIG
27P_VTS_Blk
SET
27P_Vol_Opt
ANA
UBusxa<27P_Vol_Str
SIG
27P_Ia_Blk
&
SET
27P_Vol_Opt
ANA
UBusxab<27P_Vol_Str
SIG
27P_Iab_Blk
&
≥ 1
&
27P_Str_A
SIG
SIG
27P_On
SIG
27P_VTS_Blk
SET
27P_Vol_Opt
ANA
UBusxb<27P_Vol_Str
SIG
27P_Ib_Blk
&
SET
27P_Vol_Opt
ANA
UBusxbc<27P_Vol_Str
SIG
27P_Ibc_Blk
&
≥ 1
&
27P_Str_B
SIG
SIG
27P_On
SIG
27P_VTS_Blk
SET
27P_Vol_Opt
ANA
UBusxc<27P_Vol_Str
SIG
27P_Ic_Blk
&
SET
27P_Vol_Opt
ANA
UBusxca<27P_Vol_Str
SIG
27P_Ica_Blk
&
≥ 1
&
27P_Str_C
SIG
SIG
27P_Str_A
SIG
27P_Str_B
SIG
27P_Str_C
≥ 1
27P_Str
SIG

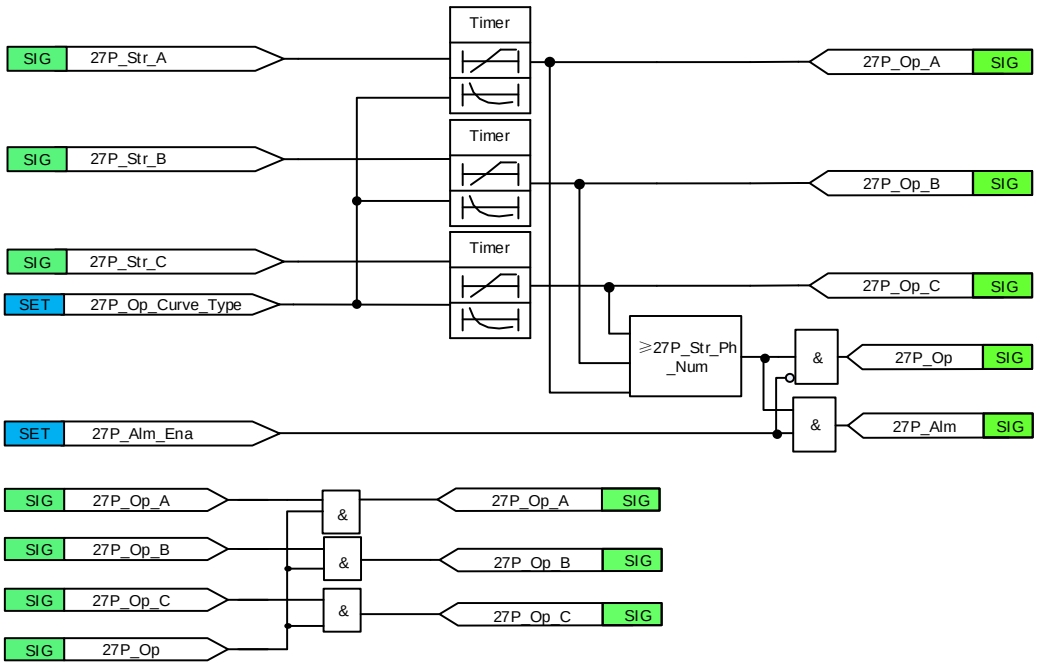


Figure 3.10.1 Functional module diagram

Where:

IBusxa: Phase-A current of any bay (including BCy/BSz) connected to busbar x(x=1, 2, 3).

IBusxb: Phase-B current of any bay (including BCy/BSz) connected to busbar x(x=1, 2, 3).

IBusxc: Phase-C current of any bay (including BCy/BSz) connected to busbar x(x=1, 2, 3).

3.10.4 Settings

Table 3.10.3 Settings of Two stage Three-phase undervoltage protection

No.	Name	Range	Unit	Step	Default	Description
1	27Pi_Vol_Str	0.00~160.00	V	0.01	40.00	The stage i start value of undervoltage.
2	27Pi_Op_T	0.04~300.00	s	0.01	10.00	The stage i operating time delay for definite time curve.
3	27Pi_Str_Ph_Num	1~3	-	1	1	The stage i number of phases required for operate activation: 1 for 1 phase, 2 for 2 phases, 3 for 3 phases.
4	27Pi_Op_Curve_ Type	ANSIE ANSIV ANSIN ANSIM	-	-	IECDef Time	Characteristic curve for 27Pi Including Definite time, IEC and ANSI typical curve and user

No.	Name	Range	Unit	Step	Default	Description
		ANSIDefTime ANSILTE ANSILTV ANSILT IECN IECV IEC IECE IECST IECLT IECDefTime Resv UserDefine				programmable curve. The detail is defined in **Table 3.11.1 Inverse-time curve parameters**.
5	27Pi_T_ Mul、t	0.05~200.00	-	0.01	200.00	The stage i time multiplier in IEC curves.
6	27Pi_Min_Op_T	0.00~60.00	s	0.01	0.05	The stage i minimum operate time delay for IDMT curves.
7	27Pi_Alpha	0.00~3.00	-	0.01	1.00	The stage i constant α of 27P.
8	27Pi_C	0.000~60.000	-	0.001	0.000	The stage i constant C of 27P.
9	27Pi_K	0.001~100.000	-	0.001	1.000	The stage i constant K of 27P.
10	27Pi_Vol_Opt	0 or 1	-	1	0	The stage i parameter to select phase or phase-to-phase voltages: 0 for phase voltages, 1 for phase-to-phase voltages.
11	27Pi_VTS_Blk_Ena	0 or 1	-	1	0	The stage i undervoltage protection can be blocked due to VT circuit failure if the setting 27P_VTS_Blk_Ena is set as “1”.
12	27Pi_I_Blk_Ena	0 or 1	-	1	0	The stage i undervoltage protection can be blocked when the corresponding busbar has no current if the setting 27P_I_Blk_Ena is set as “1”.
13	27Pi_Alm	0 or 1	-	1	0	The stage i logic setting of enabling/disabling undervoltage protection for alarm purpose. 0: disable. 1: enable.
14	27Pi_Ena	0 or 1	-	1	0	The stage i operation Off/On.

3.11 General function block

3.11.1 IDMT curves for over quantity protection and under quantity protection

The inverse-time modes of over quantity protection, 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 time duration of over quantity protection can be calculated according to the formula:

$$t = \left(\frac{K}{(\frac{G}{G_p})^{\alpha} - 1} + C \right) \times T_P$$

The inverse-time modes of under quantity protection, the operation time depends on the momentary value of the quantity (such as fault current or voltage): the lower the quantity, the faster the operation time.

The time duration of under quantity protection can be calculated according to the formula:

$$t = \left(\frac{K}{1 - (\frac{G}{G_p})^{\alpha}} + C \right) \times T_P$$

Where:

G_p : The Start setting value of the characterizing quantity.

T_p : Time multiplier setting.

α: A constant setting.

K: A constant setting.

C: A constant setting.

G: The value of the characterizing quantity.

The user can select the operating characteristic from various inverse-time characteristic curves by setting Curve_Type, and parameters of available characteristics for selection are shown in the following table.

If the Curve_Type= ANSIDefTime or IECDefTime or Resv, the operate time is Definite Time mode.

If the Curve_Type= UserDefine, the operate time is user-defined. The timer model is determined by the parameter C, α, k setting value.

Table 3.11.1 Inverse-time curve parameters

Curve_Value	Curve_Type	Time Characteristic	K	α	C
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	0.1140
5	ANSIDefTime	ANSI Definite Time	x	x	x
6	ANSILTE	ANSI Long Time Extremely Inverse	64.07	2	0.250
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	0
11	IEC	IEC Inverse	0.14	0.02	0
12	IECE	IEC Extremely Inverse	80.0	2.0	0
13	IECST	IEC Short Time Inverse	0.05	0.04	0
14	IECLT	IEC Long Time Inverse	120.0	1.0	0
15	IECDefTime	IEC Definite Time	x	x	x
16	Resv	Reserve	x	x	x
17	UserDefine	User-defined Time Inverse	User-defined	User-defined	User-defined

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

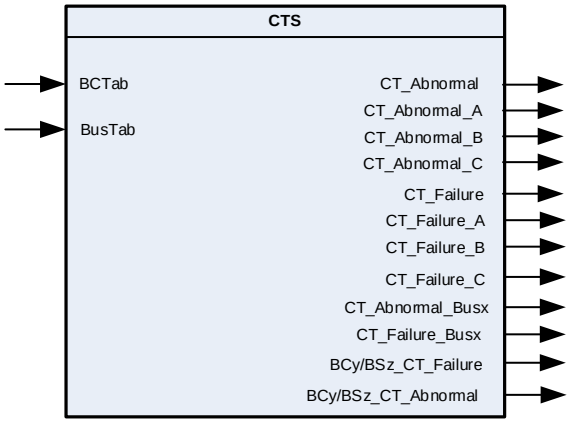
4.3 CT Circuit Supervision CTS

4.3.1 Overview

The CT circuit supervision CTS is to detect the open circuit occurring in the secondary circuits between current transformers and IED. Differential current of discriminating zone would appear immediately when BC/BS CT fuse is opened. Furthermore, the faulty current transformer corresponding to a feeder can produce differential current in check zone, which will cause mal-

operation of the current related protection (87B). The IED detecting such a condition issues respective alarm report and blocks related protection. What is important, it is possible to block 87B when a CT open circuit is detected.

4.3.1.1 Function Block



4.3.1.2 Signals

Table 4.3.1 CTS Input Signals

NO.	Signal	Description
1	BCTab	Resource table contains all of resource box 2 of bus coupler y and bus section z.
2	BusTab	Resource box of busbar x.

Table 4.3.2 CTS Output Signal

NO.	Signal	Description
1	CT_Abnormal	CT circuit abnormality of CheckZone.
2	CT_Abnormal_A	Phase-A CT circuit abnormality of CheckZone.
3	CT_Abnormal_B	Phase-B CT circuit abnormality of CheckZone.
4	CT_Abnormal_C	Phase-C CT circuit abnormality of CheckZone.
5	CT_Failure	CT circuit failure of CheckZone.
6	CT_Failure_A	Phase-A CT circuit failure of CheckZone.
7	CT_Failure_B	Phase-B CT circuit failure of CheckZone.
8	CT_Failure_C	Phase-C CT circuit failure of CheckZone.
9	CT_Abnormal_Busx	CT circuit abnormality of discriminating zone x.
10	CT_Failure_Busx	CT circuit failure of discriminating zone x.
11	BCy/BSz_CT_Abnormal	BCy/BSz CT circuit abnormality.
12	BCy/BSz_CT_Failure	BCy/BSz CT circuit failure.

4.3.2 Protection Principle

4.3.2.1 Feeder CT Circuit Failure

During normal operation, the check zone differential current should be zero or negligible, but if the secondary circuit of a CT becomes open circuited, the check zone differential current will result.

An alarm CT_Failure will be issued with a time delay of the setting CTS_Alm_T if the check zone differential current or discriminating zone differential current is larger than the setting CT_Failure_Cur_FB. The alarm will be reset automatically with a time delay of 0.2s after the CT circuit returns to normal. Users can select the 87B blocking mode through the setting CTS_Blk87B_Mode.

- Phase-segregated blocking checkzone

The CT circurit failure corresponding to a feeder can produce differential current in check zone. If the check zone differential current of phase A (B or C) is larger than the setting CT_Failure_Cur_FB, the check zone differential element of corresponding failure phase will be blocked with a time delay of the setting CTS_Alm_T.

- Three-phase blocking checkzone

The CT circurit failure corresponding to a feeder can produce differential current in check zone. If the check zone differential current of any phase is larger than the setting CT_Failure_Cur_FB, the check zone differential element of three phase will be blocked with a time delay of the setting CTS_Alm_T.

- Phase-segregated blocking respective discriminating zone

If the check zone differential current and discriminating zone differential current of phase A (B orC) are larger than the setting CT_Failure_Cur_FB, only the discriminating zone element of corresponding failure phase of connected busbar will be blocked with a time delay of the setting CTS_Alm_T.

- Three-phase blocking respective discriminating zone

If the check zone differential current and discriminating zone differential current of any phase are larger than the setting CT_Failure_Cur_FB, only the discriminating zone element of three phase of connected busbar will be blocked with a time delay of the setting CTS_Alm_T.

4.3.2.2 Feeder CT Circuit Abnormality

An alarm CT_Abnormal will be issued with a time delay of the setting CTS_Alm_T if the check zone differential current or discriminating zone differential current is larger than the setting CT_Abnormal_Cur_FB. The alarm will be reset automatically with a time delay of 0.2s after the CT circuit returns to normal. 87B will not be blocked when CT circuit is abnormal.

4.3.2.3 BC/BS CT Circuit Failure

If the check zone differential current is smaller than the setting CT_Failure_Cur_BC /BS, and both discriminating zone differential currents of the two connected busbars are larger than CT_Failure_Cur_BC /BS, BC/BS CT circuit failure alarm signal BCy/BSz_CT_Failure will be issued

with a time delay of the setting CTS_Alm_T. Under this situation, user can select different inter-linked mode.

- No inter-linked

If BC/BS CT circuit failure of phase A (B or C) occurs, the discriminating zone differential element of corresponding phase will be blocked. If any internal fault of corresponding phase occurs, the device will trip BC/BS first, if the fault is still existed, then the discriminating zone will be tripped after 100ms. The discriminating zone differential element of other phase will not be blocked, if the internal fault of normal CT phase occurs, 87B will operate to trip faulty busbar instantaneously.

- Phase-segregated inter-linked

If BC/BS CT circuit failure of phase A (B or C) occurs, corresponding phase of busbar connected to the BC/BS will be forced to inter-linked mode. If any internal fault of corresponding phase occurs, the device will operate to trip two busbar at the same time.

- Three-phase inter-linked

If BC/BS CT circuit failure of any phase occurs, three phase of busbar connected to the BC/BS will be forced to inter-linked mode. If any internal fault of any phase occurs, the device will operate to trip two busbar at the same time.

4.3.2.4 BC/BS CT Circuit Abnormality

If the check zone differential current is smaller than the setting CT_Abnormal_Cur_BC/BS, and both discriminating zone differential currents of the two connected busbars are larger than CT_Abnormal_Cur_BC/BS, BC/BS CT circuit failure alarm signal BCy/BSz_CT_ Abnormal will be issued with a time delay of the setting CTS_Alm_T. Under this situation, the protection function will not be affected.

NOTICE!

If voltage blocking element of any busbar is released, CTS will be blocked. If VT circuit failure is detected, CTS will not be blocked. If voltage blocking element is disabled, CTS will not be affected by voltage.

4.3.3 Logic

The logic of CTS is shown as follows:

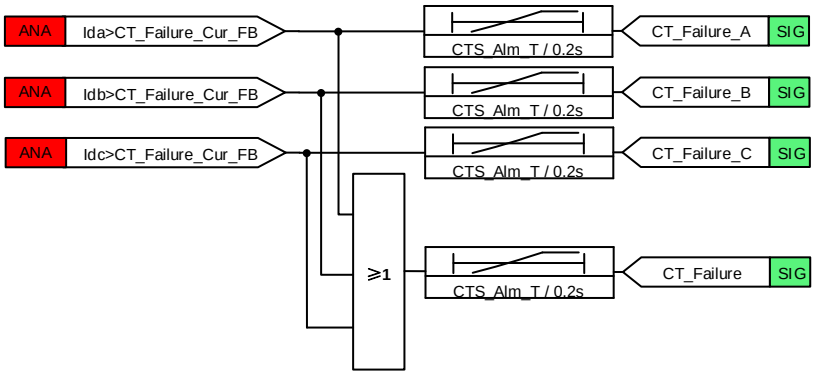


Figure 4.3.1 Logic Block Diagram of CT Circuit Failure (Checkzone)

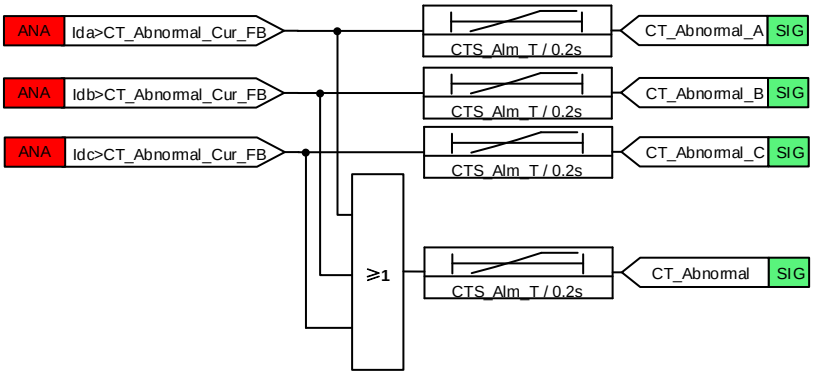


Figure 4.3.2 Logic Block Diagram of CT Circuit Abnormality (Checkzone)

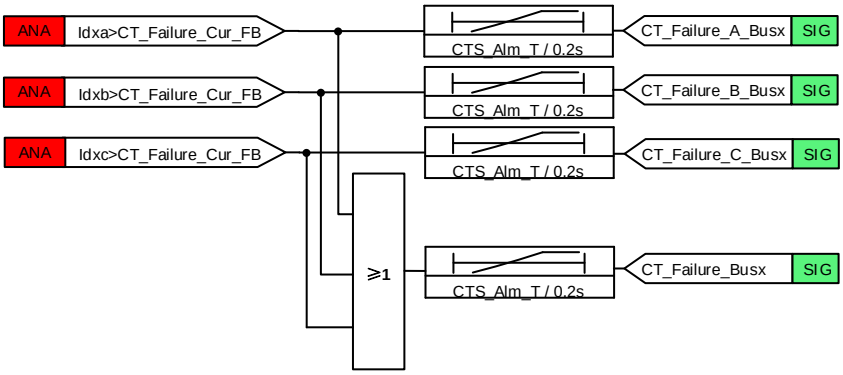


Figure 4.3.3 Logic Block Diagram of CT Circuit Failure (Discriminating Zone)

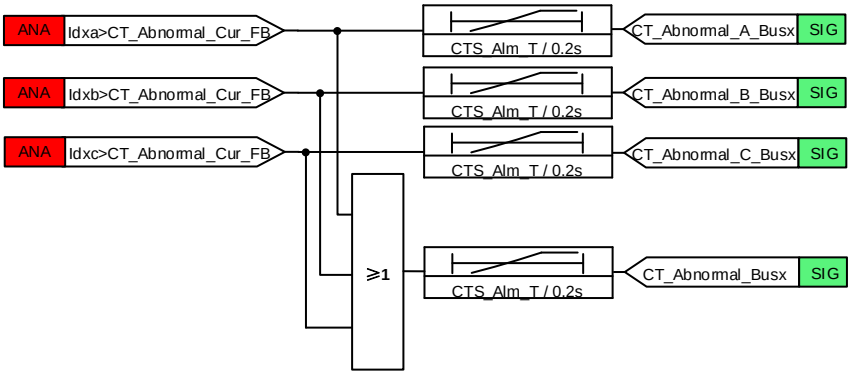
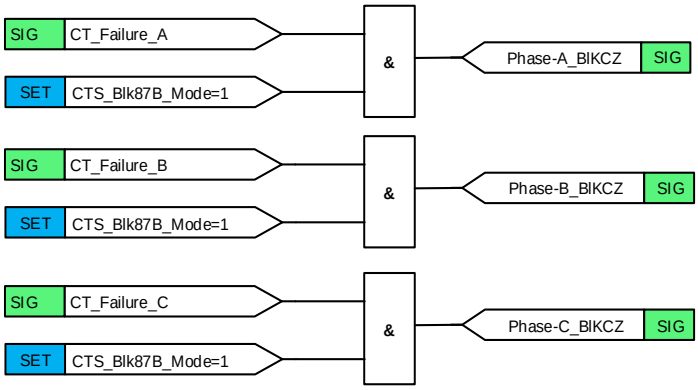


Figure 4.3.4 Logic Block Diagram of CT Circuit Abnormality (Discriminating Zone)



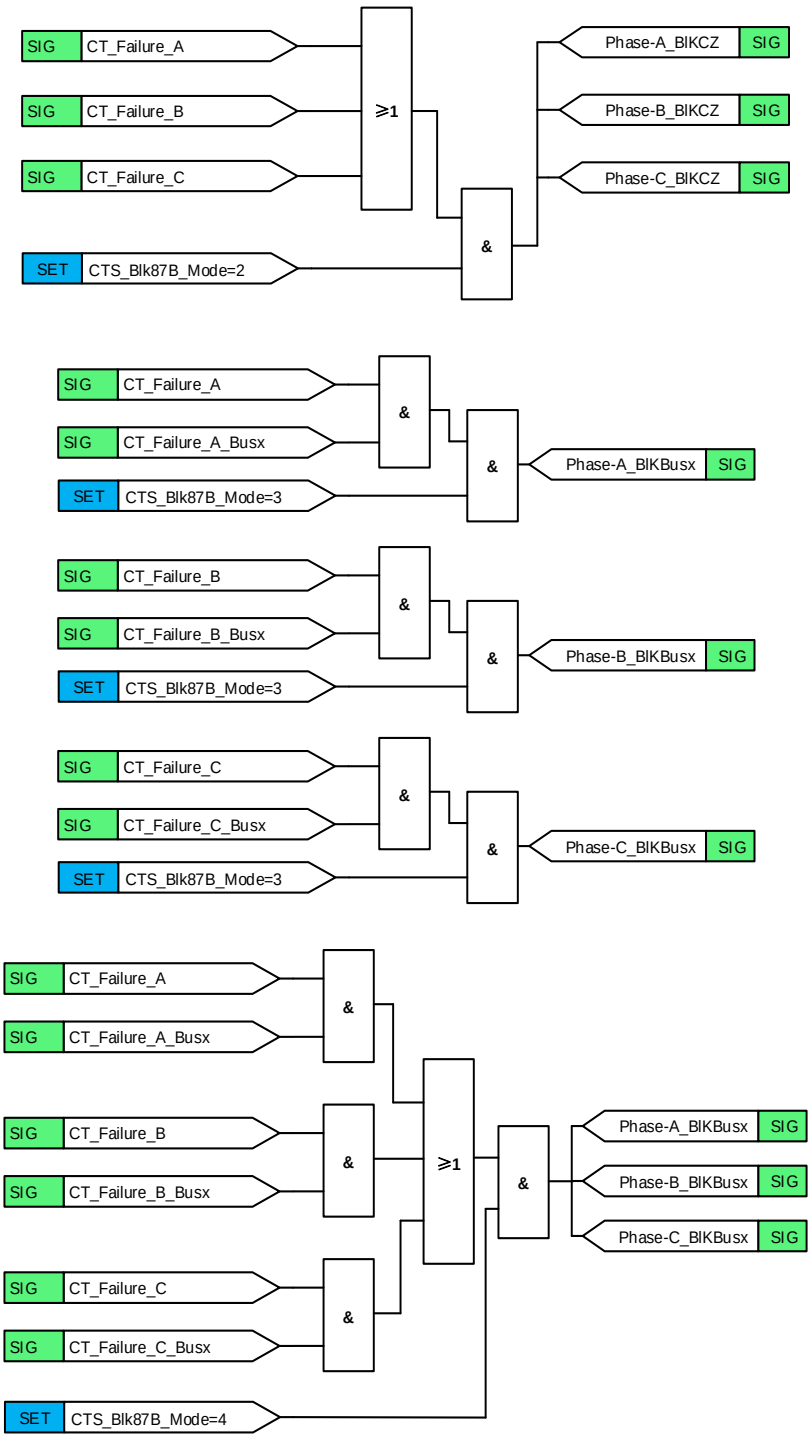


Figure 4.3.5 Logic Block Diagram of 87B blocking mode through the setting CTS_Blk87B_Mode

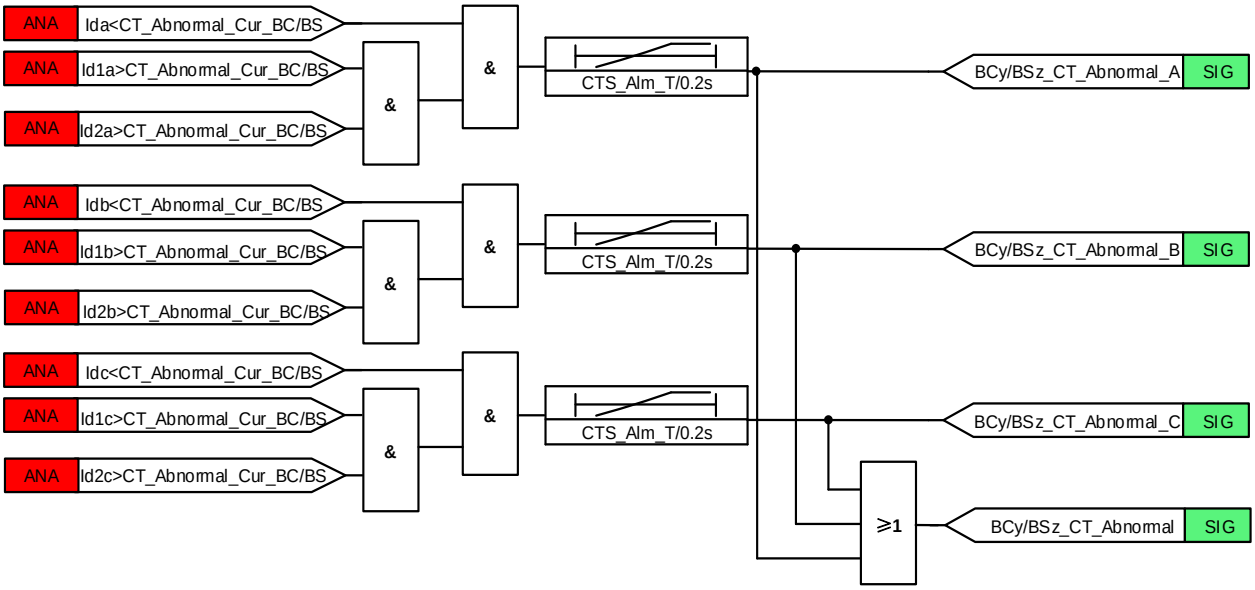


Figure 4.3.6 Logic Block Diagram of BC/BS (Single CT) CT Circuit Abnormality

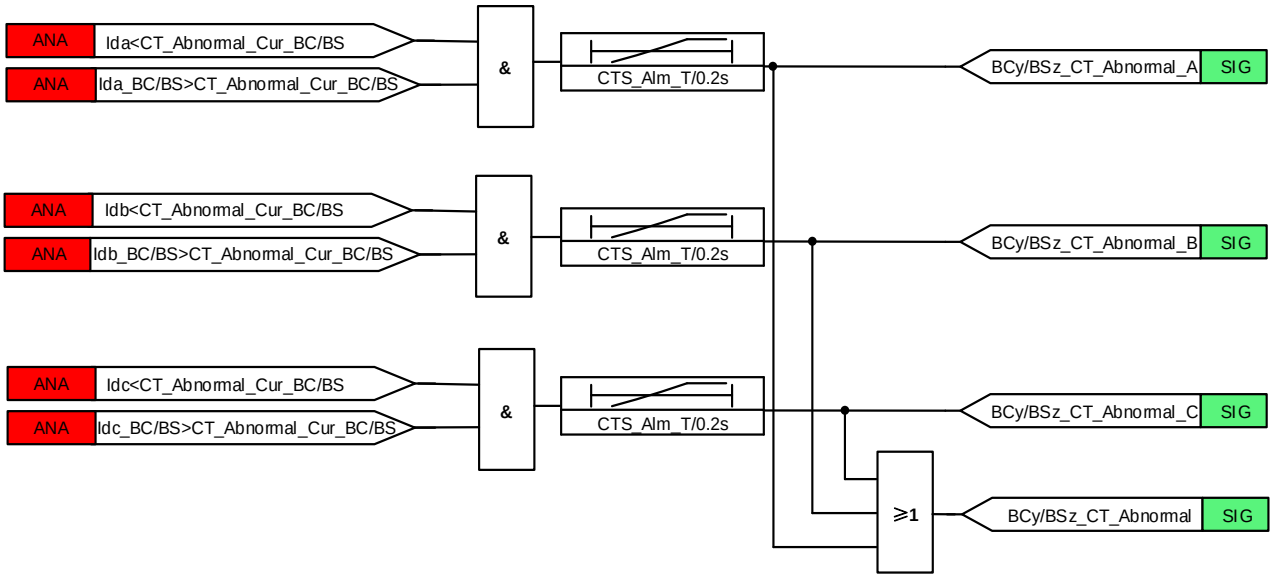


Figure 4.3.7 Logic Block Diagram of BC/BS (Double CT) CT Circuit Abnormality

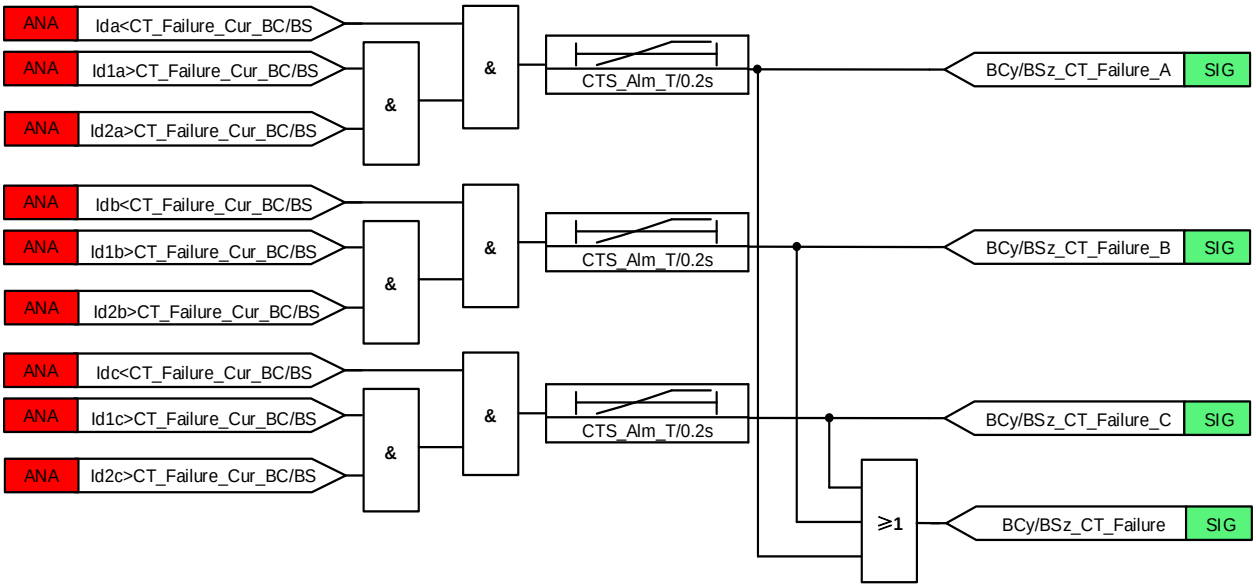


Figure 4.3.8 Logic Block Diagram of BC/BS (Single CT) CT Circuit Failure

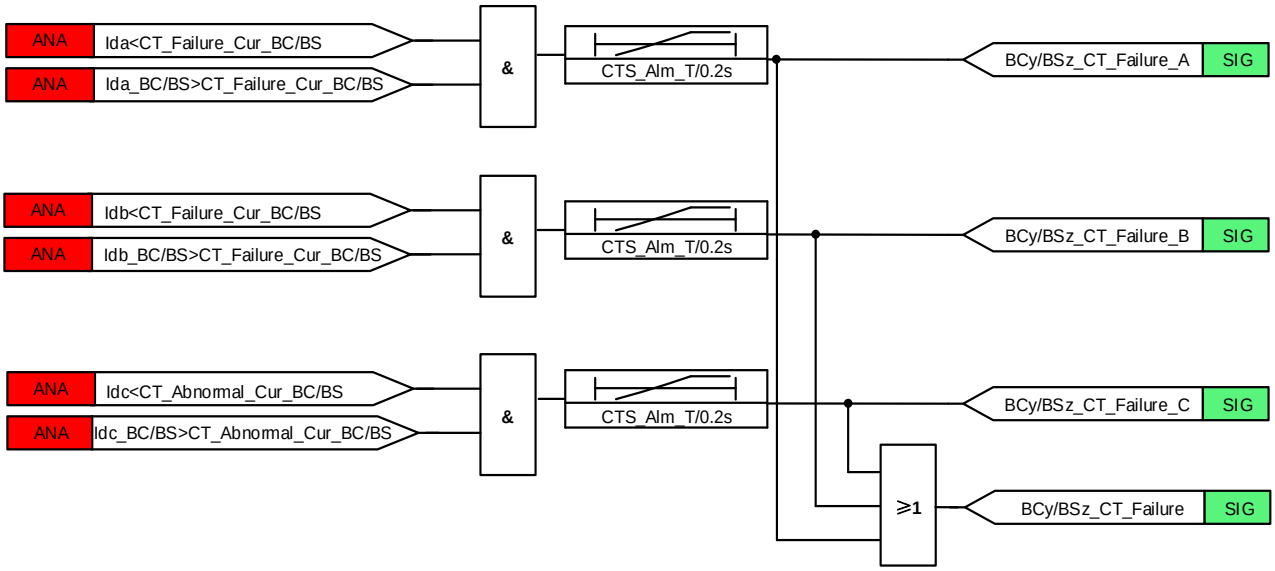


Figure 4.3.9 Logic Block Diagram of BC/BS (Double CT) CT Circuit Failure

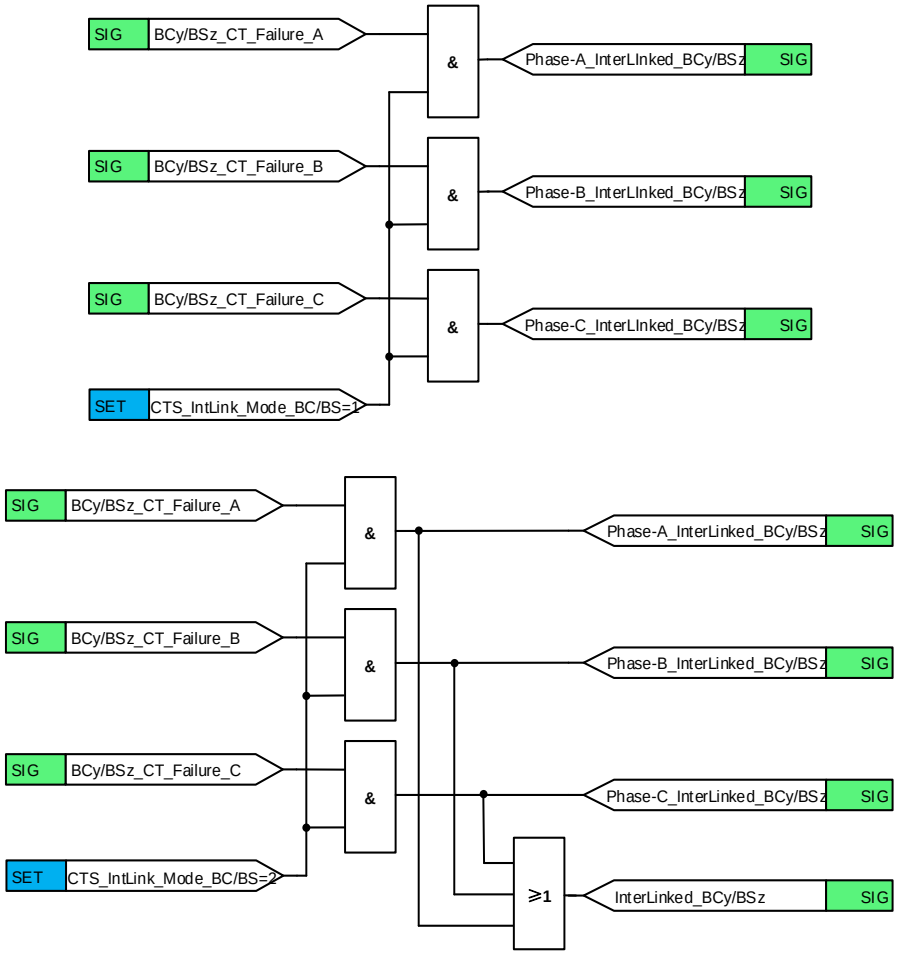


Figure 4.3.10 Logic Block Diagram of inter-linked mode through the setting CTS_IntLink_Mode_BC/BS

Where:

Ida: Phase A differential current of check zone.

Idb: Phase B differential current of check zone.

Idc: Phase C differential current of check zone.

Ida_BC/BS: Phase A differential current of CT on sides of BC/BS.

Idb_BC/BS: Phase B differential current of CT on sides of BC/BS.

Idc_BC/BS: Phase C differential current of CT on sides of BC/BS.

Idxa: Phase A differential current of discriminative zone x(x=1, 2, 3).

Idxb: Phase B differential current of discriminative zone x(x=1, 2, 3).

Idxc: Phase C differential current of discriminative zone x(x=1, 2, 3).

4.3.4 Settings

Table 4.3.3 CTS Settings

No.	Name	Range	Unit	Step	Default	Description
1	CT_Abnormal_Cur_FB	0.05In~20In	A	0.01	20In	The threshold of CT circuit abnormality, only for feeder bays.
2	CT_Failure_Cur_FB	0.05In~20In	A	0.01	20In	The threshold of CT circuit failure, only for feeder bays.
3	CT_Abnormal_Cur_BC/BS	0.05In~20In	A	0.01	20In	The threshold of CT circuit abnormality, only for busbar coupler or bus section.
4	CT_Failure_Cur_BC/BS	0.05In~20In	A	0.01	20In	The threshold of CT circuit failure, only for busbar coupler or bus section.
5	CTS_Alm_T	3.000~10.000	S	0.001	5.000	Time delay of CT circuit abnormality and CT circuit failure.
6	CTS_Blk87B_Mode	0~4	-	1	1	Setting for selecting the differential protection blocking mode with CT circuit failure for feeder bays. 0: Unblocking. 1: Phase-segregated blocking checkzone. 2: Three-phase blocking checkzone. 3: Phase-segregated blocking respective discriminating zone. 4: Three-phase blocking respective discriminating zone.
7	CTS_IntLink_Mode_BC/BS	0~2	-	1	0	Setting for selecting inter-linked mode with CT circuit failure for BC/BS. 0: No inter-link. If any internal fault occurs, the device will tirp BC/BS first and then the discriminating zone will be tripped after 100ms. 1: Phase-segregated inter-linked. 2: Three-segregated inter-linked.
8	CTS_Ena	0 or 1	-	1	0	Enabling or disabling CTS.

NOTICE!

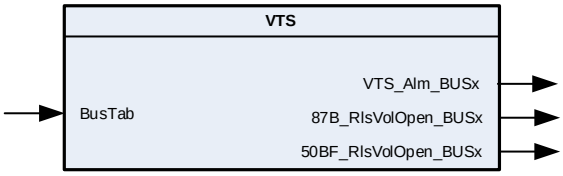
When calculating all the current setting of CTS, the primary current should be converted to the secondary value according to the reference CT ratio.

4.4 VT Fuse Failure Supervision VTS

4.4.1 Overview

The aim of the fuse failure supervision function is to detect the fault occurs in the secondary circuits between voltage instrument transformers and IED and issues alarm signal.

4.4.1.1 Function Block



4.4.1.2 Signals

Table 4.4.1 VTS Input Signals

NO.	Signal	Description
1	BusTab	Resource box of busbar x.

Table 4.4.2 VTS Output Signals

NO.	Signal	Description
1	VTS_Alm_BUSx	Alarm signal indicate that VT circuit fuse failure of busbar x.
2	87B_RlsVolOpen_BUSx	Fault voltage of busbar x fulfills the voltage criterion of 87B.
3	50BF_RlsVolOpen_BUSx	Fault voltage of busbar x fulfills the voltage criterion of 50BF.

4.4.2 Protection Principle

If busbar x(x=1, 2, 3) is in service and the voltage criterion is met, an alarm VT_Failure_Busx will be issued with a time delay of 9s. When the three phase-voltage returns to normal condition, the alarm will be reset automatically with a time delay of 0.1s.The voltage and current criteria of this function are calculated in bus-segregated.

4.4.3 Logic

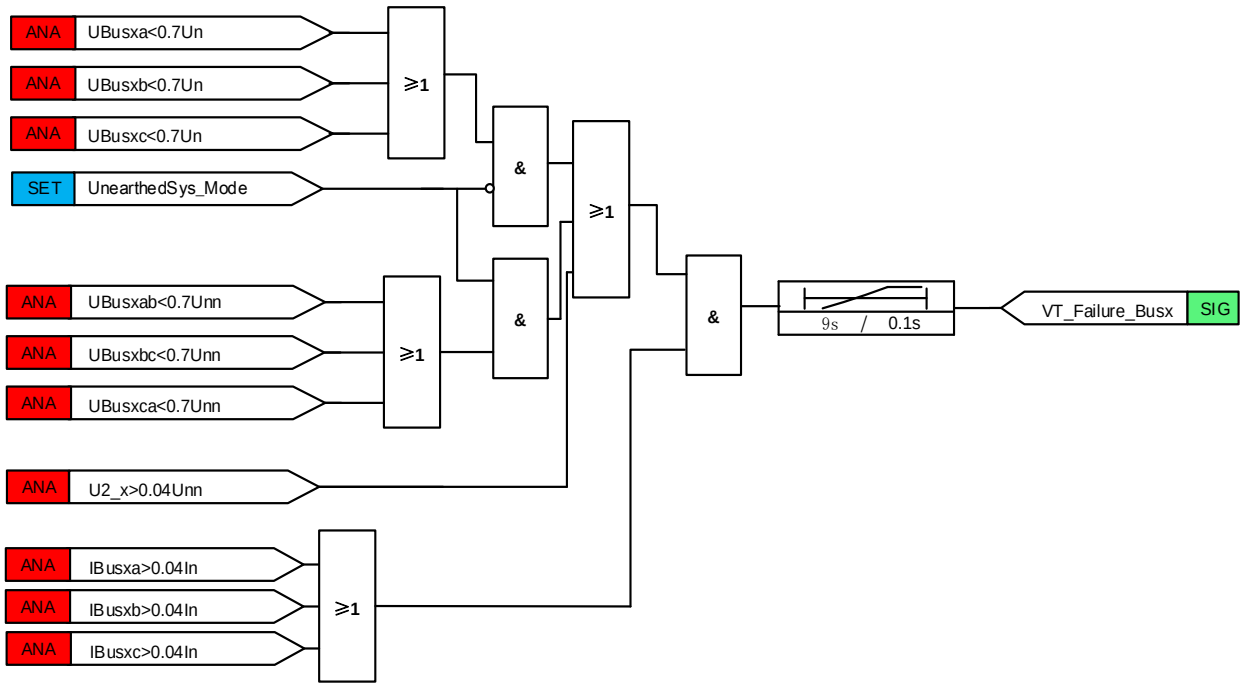


Figure 4.4.1 Logic Block Diagram of VTS

Where:

UBusxa: Phase-A voltage of busbar x(x=1, 2, 3).

UBusxb: Phase-B voltage of busbar x(x=1, 2, 3).

UBusxc: Phase-C voltage of busbar x(x=1, 2, 3).

U2_x: Negative voltage of the busbar x(x=1, 2, 3) (calculated internally).

IBusxa: Phase-A current of any bay (including BCy/BSz) connected to busbar x(x=1, 2, 3).

IBusxb: Phase-B current of any bay (including BCy/BSz) connected to busbar x(x=1, 2, 3).

IBusxc: Phase-C current of any bay (including BCy/BSz) connected to busbar x(x=1, 2, 3).

Un: The rated secondary phase-to-ground voltage of VT.

Unn: The rated secondary phase-to-phase voltage of VT.

4.4.4 Settings

Table 4.4.3 VTS Settings

No.	Name	Range	Unit	Step	Default	Description
1	VTS_Ena	0 or 1	-	1	0	Enabling or disabling VTS.

4.5 Circuit Breaker Status Supervision

4.5.1 Overview

The aim of the circuit breaker supervision function is to detect consistency between the auxiliary contact of circuit breaker and the current through circuit breaker and issues alarm signal.

4.5.2 Protection Principle

When the breaker failure protection is running in contact mode, or the feeder end-fault protection is enabled, the device needs to introduce normally open and normally closed contacts to verify each other. The device can adaptively determine whether the position of circuit breaker is in the closed or divided position according to the normally open and normally closed contact status, and issue an alarm.

Table 4.5.1 Position status of circuit breaker

Normally open contact	Normally closed contact	Status in busbar protection
1	0	closed
0	1	open
0	0	closed
1	1	closed

If the setting CB_DualPosition is enable, both normally open and normally closed auxiliary contact are used to identify the circuit breaker position. Otherwise, only normally closed auxiliary contact is used to identify CB position.

In the following conditions with a time delay 5s, an alarm Bayn_52b_Abnormal will be issued:

- The normally closed auxiliary contact of circuit breaker is energized, but the current through the breaker is larger than 0.04In.
- Both normally open and normally closed auxiliary contact are energized or de-energized.

4.5.3 Logic

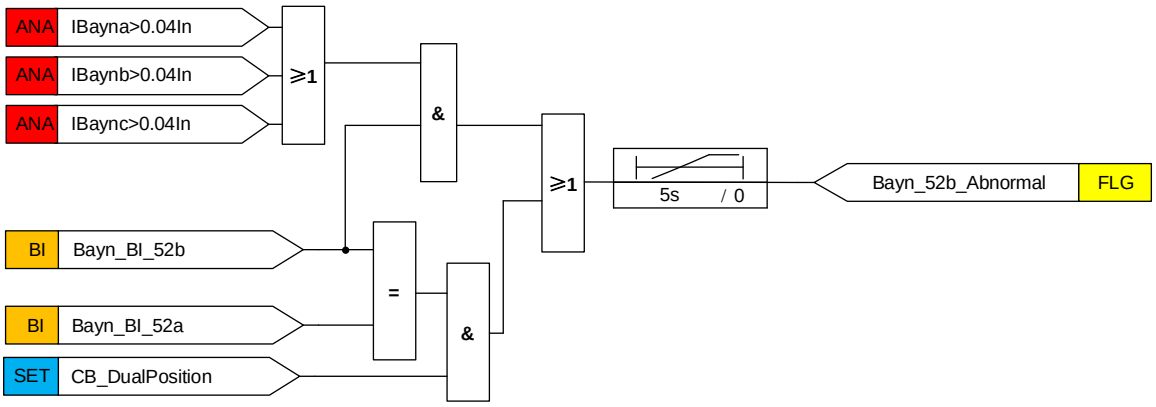


Figure 4.5.1 Logic Block Diagram of CB Status Supervision

4.6 Disconnector Status Supervision

4.6.1 Overview

For multiple busbar with load transfer, the position of disconnector connected to busbar is very important, because the positions of these disconnectors determine actually which CT input is connected to which differential protection zone. The aim of the disconnector status supervision function is to detect consistency between the normally open and normally closed auxiliary contact of disconnector and issues alarm signal.

4.6.2 Protection Principle

If the setting DS_DualPosition is enable, both normally open and normally closed auxiliary contact are used to identify the disconnector position. Otherwise, only normally open auxiliary contact is used to identify disconnector position.

The device can adaptively determine whether the position of disconnector is in the closed or divided position according to the normally open and normally closed contact status and issue an alarm 89a/89b_Abnormal. User can select the mode via the setting DS_OperMode_INT and DS_OperMode_BAD when both of the normally open auxiliary contact and normally closed auxiliary contact of a disconnector are de-energized at the same time.

Table 4.6.1 Position status of disconnector

Normally open contact	Normally closed contact	Status in busbar protection
1	0	closed
0	1	open
0	0	DS_OperMode_INT=0: closed. DS_OperMode_INT=1: take last valid position. DS_OperMode_INT=2: The disconnector will be taken last valid position, and block the disconnector side busbar.
1	1	DS_OperMode_BAD=0: closed. DS_OperMode_BAD=1: take last valid position. DS_OperMode_BAD=2: The disconnector will be taken last valid position, and block the disconnector side busbar.

The device introduces auxiliary contacts of disconnector to realize self-adaptation to the operation mode of busbar. At the same time, each bay current and current distribution are used to verify the correctness of the auxiliary contacts of the disconnector. When it is found that the status of the auxiliary contacts of any disconnector does not match with the actual situation, it will issue an alarm signal DS_Update, and automatically correct the wrong disconnector contact when the state is determined. The device can also use the memory state of the disconnector to solve the situation that the multiple auxiliary contacts of disconnector does not match with the actual situation.

User can determine actually which CT input is connected to which differential protection zone via the setting DS_Force_Ena.

When the setting DS_ForceEnable_Bayn is enabled, if the setting DS1_Force_Bayn is enabled, then the disconnector connected to busbar1 is force to closed position and the current of Bayn will be calculated to discriminating zone1 differential current.

When the setting DS_ForceEnable_Bayn is enabled, if the setting DS1_Force_Bayn is disabled, then the disconnector connected to busbar1 is force to open position and the current of Bayn will be excluded from discriminating zone1 differential current calculation.

When the setting DS_ForceEnable_Bayn is enabled, if the setting DS2_Force_Bayn is enabled, then the disconnector connected to busbar2 is force to closed position and the current of Bayn will be calculated to discriminating zone2 differential current.

When the setting DS_ForceEnable_Bayn is enabled, if the setting DS2_Force_Bayn is disabled, then the disconnector connected to busbar2 is force to open position and the current of Bayn will be excluded from discriminating zone2 differential current calculation.

When the setting DS_ForceEnable_Bayn is enabled, if both the setting DS1_Force_Bayn and DS2_Force_Bayn are enabled, then the disconnectors connected to busbar1 and busbar 2 are forced to closed position, the zone1 and zone2 will force to inter-linked mode.

NOTICE!

Only for multiple busbar with load transfer arrangement, DS_Force_Enable Setting can be settable, otherwise, the setting will be hidden.

4.6.3 Settings

Table 4.6.2 Public Settings

No.	Name	Range	Unit	Step	Default	Description
1	DS_DualPositon	0 or 1	-	1	0	0: Only normally open auxiliary contact of disconnector is used to identify the position status. 1: Both normally open auxiliary contact and normally closed auxiliary contact of disconnector are used to identify the position status.
2	CB_DualPositon	0 or 1	-	1	0	0: Only normally closed auxiliary contact of circuit breaker is used to identify the position status. 1: Both normally open auxiliary contact and normally closed auxiliary contact of circuit breaker are used to identify the position status.
3	DS_OperMode_INT	0~2	-	1	1	Setting for selecting the mode when both of the normally open auxiliary contact and normally closed auxiliary contact of a disconnector are de-energized at the

No.	Name	Range	Unit	Step	Default	Description
						same time. Only for the disconnector side busbar. 0: The disconnector will be forced to closed position. 1: The disconnector will be taken last valid position. 2: The disconnector will be taken last valid position, and block the disconnector side busbar.
4	DS_OperMode_BAD	0~2	-	1	1	Setting for selecting the mode when both of the normally open auxiliary contact and normally closed auxiliary contact of a disconnector are energized at the same time. Only for the disconnector side busbar. 0: The disconnector will be forced to closed position. 1: The disconnector will be taken last valid position. 2: The disconnector will be taken last valid position, and block the disconnector side busbar.

Table 4.6.3 DS_Force_Enable Settings

No.	Name	Range	Unit	Step	Typical	Description
1	DS1_Force_Bayn	0 or 1	-	1	0	0: Force disconnector of bayn connected to busbar 1 to open position. 1: Force disconnector of bayn connected to busbar 1 to closed position.
2	DS2_Force_Bayn	0 or 1	-	1	0	0: Force disconnector of bayn connected to busbar 2 to open position. 1: Force disconnector of bayn connected to busbar 2 to closed position.
3	DS_ForceEnable_Bayn	0 or 1	-	1	0	Enable force disconnector function of Bayn.

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 that fulfill the protection and control functions of the device.

5.2 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.

5.2.1 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 sequence components and so on. Some protection sampled values are displayed in HMI with 0.5s updating rate.

5.2.2 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.

5.3 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, synchrocheck, 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.

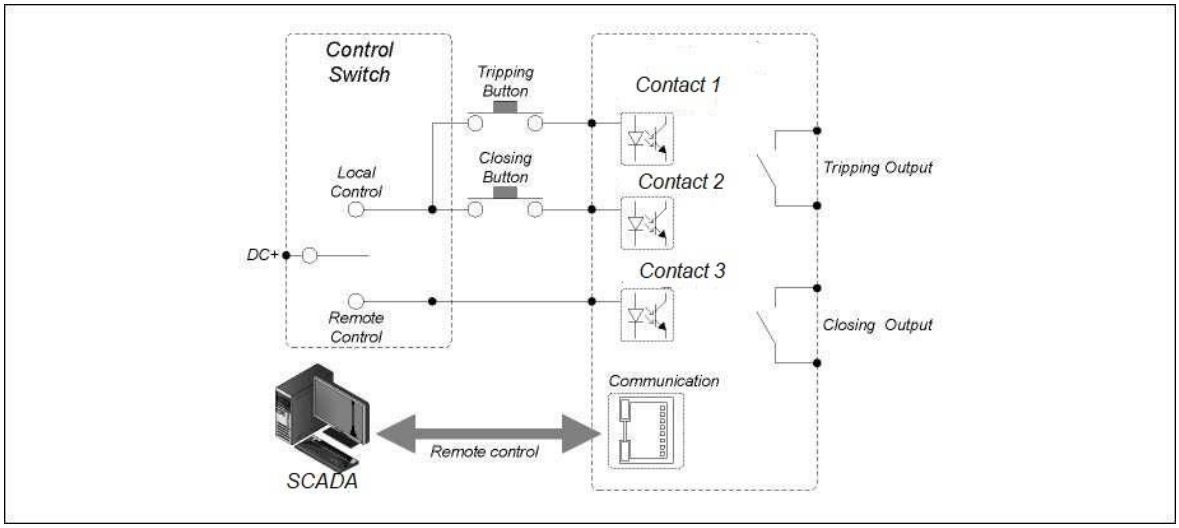


Figure 5.3.1 Demonstration Diagram of The Control Function

5.4 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 debouncing time can be set separately. Debouncing time setting can be done through the LCD or PRS IED Studio software.

5.5 Event Records

5.5.1 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.

5.5.2 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.

5.5.3 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.

5.5.3.1 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.

5.5.3.2 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.

5.5.4 Device Record

5.5.4.1 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.

5.5.4.2 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.

5.5.4.3 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.

5.5.5 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 time tagged SOE records.

5.6 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.

5.6.1 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.

5.6.2 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.

5.6.3 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].

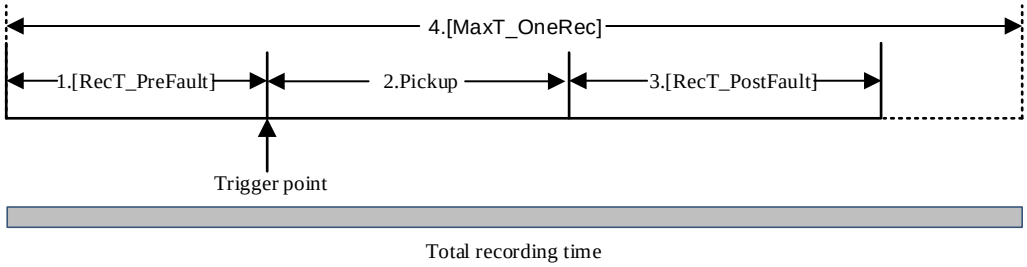


Figure 5.6.1 Recording time diagram

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 5.6.1 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

5.6.4 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].

5.6.5 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.

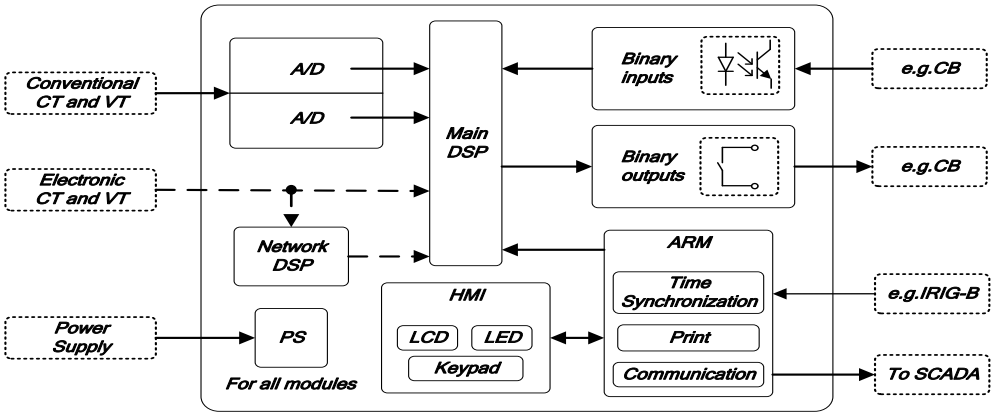


Figure 6.1.1 Hardware Frame of This Relay

The following figures show the front panel and the rear panel of 1/2 19” case.

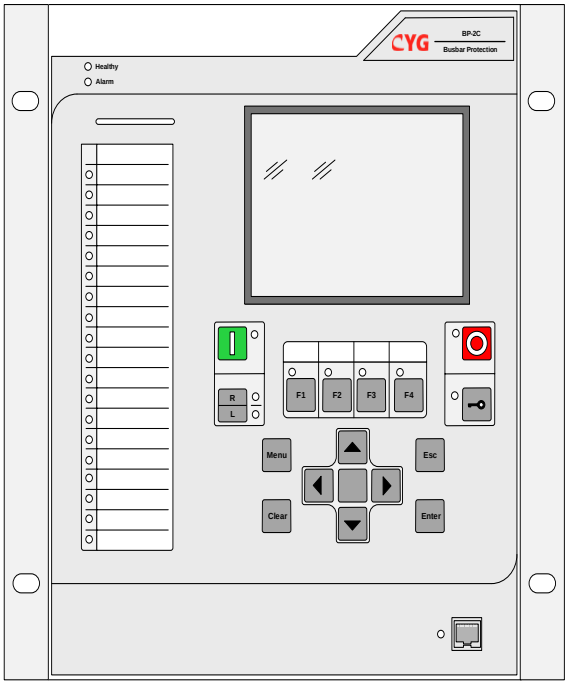


Figure 6.1.2 1/2 19" case front panel of this relay

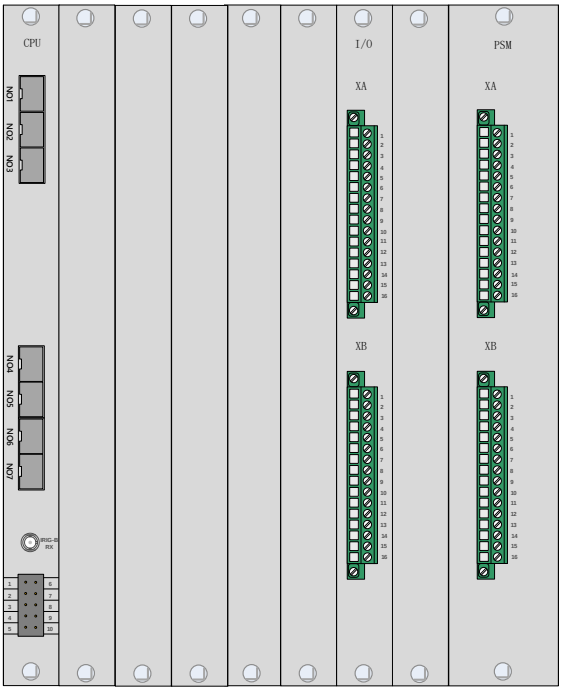


Figure 6.1.3 1/2 19" case rear panel of this relay

The following figures show the front panel and the rear panel of 1/1 19" case.

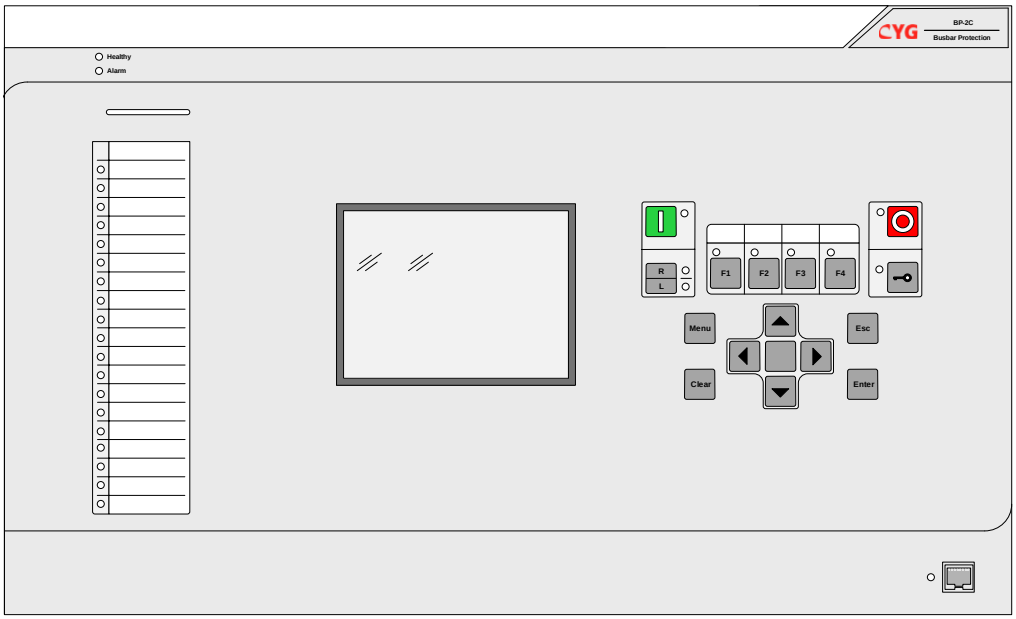


Figure 6.1.4 1/1 19" case front panel of this relay

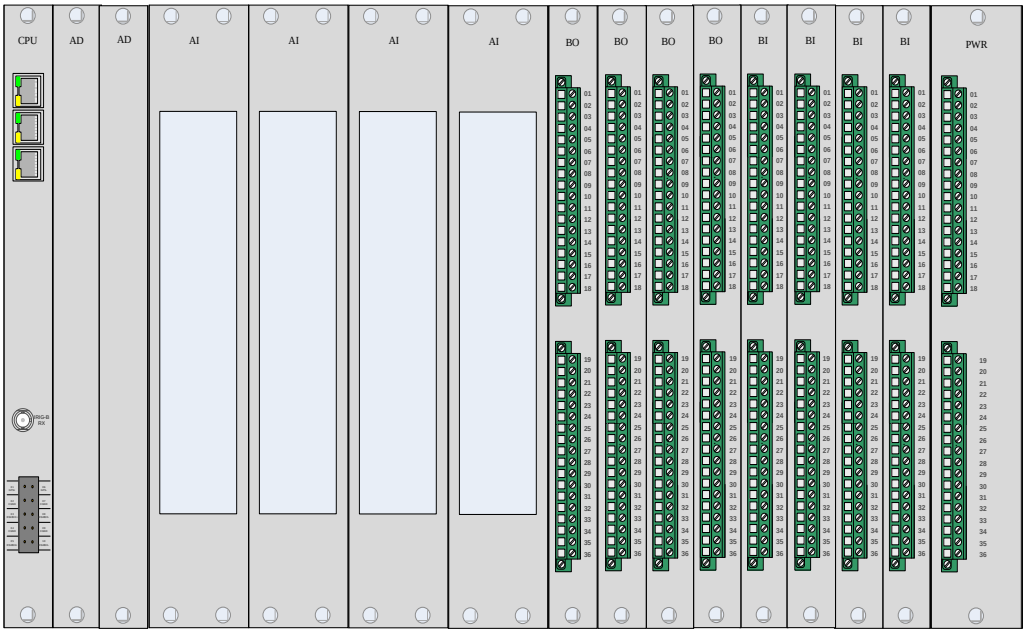


Figure 6.1.5 1/1 19" case rear panel of this relay

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 BP-2C 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, AC voltage transformer, DC current transformer and etc. 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	SR7260	Protection calculation module (CPU module)	standard
3	SR7270	AD conversion(AD module)	standard
4	SR7120	current or voltage transformer module (TF module)	standard
5	SR7100	current or voltage transformer module (TF module)	standard
6	SR7330	Binary input module (BI module)	standard
7	SR7303	Binary output module (BO module)	standard
8	SR7302	Binary output module (BO module)	standard
9	SR7300	Binary output module (BO 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 shows 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 of input voltage is provided due to the sophisticated circuit design. The output voltage from the voltage converter is continuously monitored to ensure stability and safety.

The power supply module provides 10 binary outputs, some dry contacts, which conduct the signal functions showing the operating conditions (device error) 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.

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 determines what information they transmit between the CPU module and PWR module.

The frame of all the power supply module terminal are shown below.

PWR(SR7601)			
01	POW(+)	TRIP06 Open	17
02	POW(-)	SIGN07 Common	18
03	Dev_Err Common	SIGN07 Open	19
04	Dev_Err Cls	SIGN07 Cls	20
05	Dev_Err Open	SIGN08 Common	21
06	TRIP01 Common	SIGN08 Open	22
07	TRIP01 Open	SIGN08 Cls	23
08	TRIP02 Common	SIGN09 Common	24
09	TRIP02 Open	SIGN09 Open	25
10	TRIP03 Common	SIGN09 Cls	26
11	TRIP03 Open		27
12	TRIP04 Common		28
13	TRIP04 Open		29
14	TRIP05 Common		30
15	TRIP05 Open		31
16	TRIP06 Common		32

Figure 6.4.1 Frame of the Power Supply Module Terminals

The specific terminal definition of the connector is described as below.

Table 6.4.1 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.
SIGN07-09	The No.2 programmable signal binary output. SIGNi (i=7-9) Open is the normal open binary output, SIGNi (i=7-9) Cls is the normal close binary output.

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 execute all the functions of the relay and conducts 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 operates exactly based on the accurate current time.

The main functions of the main CPU module includes as below:

- Sampling information processing

  The values of each sampling point will be stored and then sent to different processing modules for different functions, including display, calculation, communication.

  The values of each binary IO contacts will also be stored and then sent to different processing modules for different functions, 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) 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 parallelly 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 alert 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 an external clock synchronization source. This module also has a local crystal oscillator to maintain the internal time accuracy when the 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.

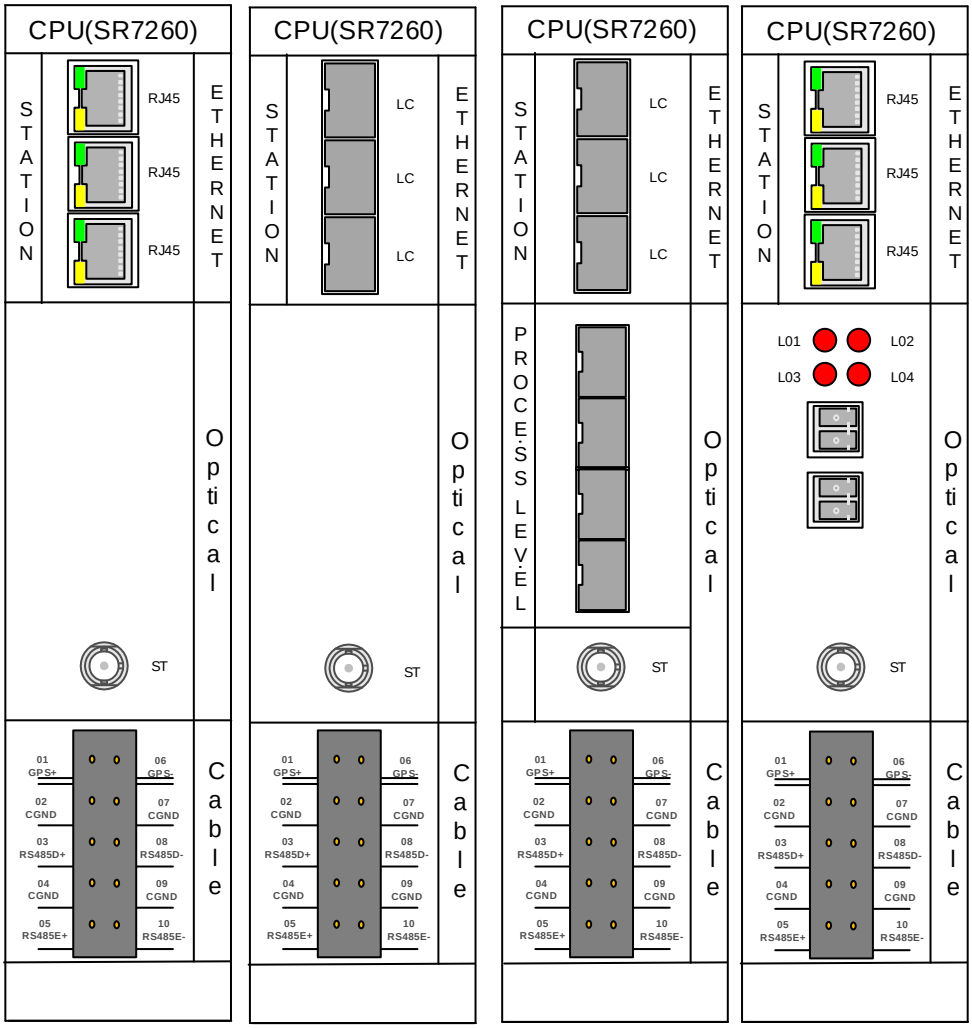


Figure 6.5.1 Frame of Main CPU Module

NOTICE!

The third in the above picture is only used for digital devices.

The fourth in the above picture is only used for two cases (6U+6U).

6.6 AD module

The module consists of a 16-bit high-accuracy AD converter which converters the sampling analog quantities that are continuous in time and amplitude to digital signals channel that are discrete in time and amplitude by channel. After the quick converter, all the digital signals are transmitted to microchip processors for latter application.

6.7 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 frames of two transformer modules of different specifications are shown below. The first transformer module consists of 9 voltage channels and 3 current channels. The second one consists of 12 current channels.

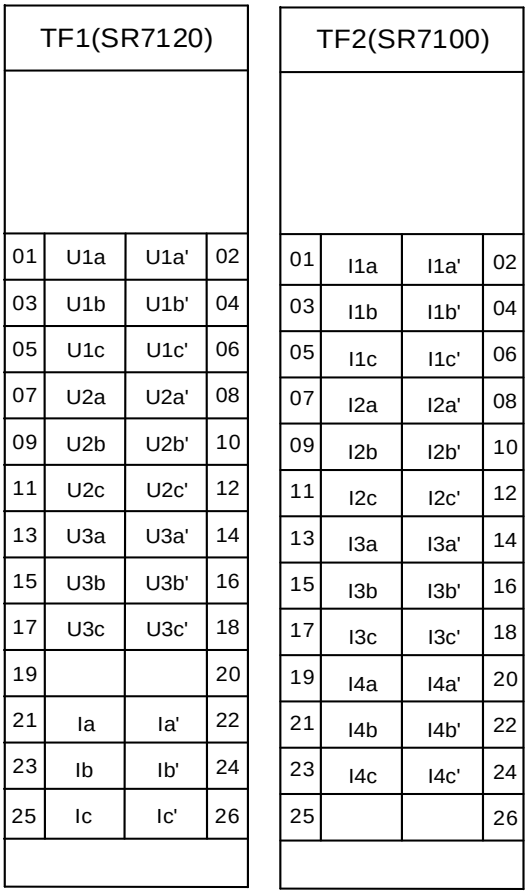


Figure 6.7.1 Transformer Module of Two Different Specifications

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 6.7.1 Terminal Definition and Description of TF Module 1

Name	Description
U1a	The three voltage input channels with inner star connection (Y) for protection and metering of busbar 1.
U1a'	
U1b	

Name	Description
U1b'	
U1c	
U1c'	
U2a	The three voltage input channels with inner star connection (Y) for protection and metering of busbar 2.
U2a'	
U2b	
U2b'	
U2c	
U2c'	
U3a	The three voltage input channels with inner star connection (Y) for protection and metering busbar 3.
U3a'	
U3b	
U3b'	
U3c	
U3c'	
Ia	The three phase current inputs of first bay CT2.
Ia’	
Ib	
Ib’	
Ic	
Ic’	

Table 6.7.2 Terminal Definition and Description of TF Module 2

Name	Description
I1a	The three phase current inputs of first bay.
I1a’	
I1b	
I1b’	
I1c	
I1c’	
I2a	The three phase current inputs of second bay.
I2a’	
I2b	
I2b’	
I2c	
I2c’	
I3a	The three phase current inputs of third bay.
I3a’	
I3b	
I3b’	

Name	Description
I3c	
I3c’	
I4a	The three phase current inputs of fourth bay.
I4a’	
I4b	
I4b’	
I4c	
I4c’	

6.8 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 a normal condition and 1 for an abnormal condition) of a certain apparatus. For another example, the special purpose binary inputs can be used to act 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 determines what information they transmit between the CPU module and BI module.

The frame of the BI module terminal is described as below.

BI(SR7330)			
01	BI01+	BI10+	17
02	BI02+	BI11+	18
03	BI01~02 Common-	BI10~11 Common-	19
04	BI03+	BI12+	20
05	BI04+	BI13+	21
06	BI03~04 Common-	BI12~13 Common-	22
07	BI05+	BI14+	23
08	BI05-	BI14-	24
09	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

Figure 6.8.1 Frame of Input Terminal

Table 6.8.1 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.5 programmable 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-	
BI10+	The No.10 and No.11 programmable binary input.
BI11+	
BI10~ BI11-	
BI12+	The No.12 and No.13 programmable binary input.
BI13+	
BI12~ BI13-	
BI14+	The No.14 programmable 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-	

6.9 Binary Output Module

The BO module consists of 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 determines what information they transmit between the CPU module and BO module.

NOTICE!

There are two types tripping outputs for bus protection, one is tripping output for direct tripping of the circuit breaker(s), the pulse time setting Prot_TripPulse_T shall be set to at least 0.200 seconds in order to obtain satisfactory minimum duration of the trip pulse to the circuit breaker trip coils, and the other is the tripping output that is connected with other relays, the pulse time is fixed 40ms, such as initiating breaker failure protection, initiating lockout relay, blocking auto reclosing, etc.

Table 6.9.1 Public Settings

No.	Name	Range	Unit	Step	Default	Description
1	Prot_TripPulse_T	0.040~10.000	s	0.001	0.200	Pulse timer is used to ensure minimum trip pulse to the circuit breaker trip coils

This device can provide three types of binary output modules: SR7300, SR7302 and SR7303.

The frame of the BO module terminal is described as below.

Table 6.9.2 Frame of BO Terminal

BO1(SR7300)		BO2(SR7302)		BO3(SR7303)	
1	TRIP01 Common	1	TRIP01 Common	1	TRIP01-A Common
2	TRIP01 Open	2	TRIP01 Open	2	TRIP01-A Open
3	TRIP02 Common	3	TRIP02 Common	3	TRIP02-A Common
4	TRIP02 Open	4	TRIP02 Open	4	TRIP02-A Open
5	TRIP03 Common	5	TRIP03 Common	5	TRIP03-A Common
6	TRIP03 Open	6	TRIP03 Open	6	TRIP03-A Open
7	TRIP04 Common	7	TRIP04 Common	7	TRIP04-A Common
8	TRIP04 Open	8	TRIP04 Open	8	TRIP04-A Open
9	TRIP05 Common	9	TRIP05 Common	9	TRIP05-A Common
10	TRIP05 Open	10	TRIP05 Open	10	TRIP05-A Open
11	TRIP06 Common	11	TRIP06 Common	11	TRIP06-A Common
12	TRIP06 Open	12	TRIP06 Open	12	TRIP06-A Open
13	SIGN07 Common	13	TRIP07 Common	13	TRIP07-A Common
14	SIGN07 Open	14	TRIP07 Open	14	TRIP07-A Open
15	SIGN08 Common	15	TRIP08 Common	15	TRIP08-A Common
16	SIGN08 Open	16	TRIP08 Open	16	TRIP08-A Open
17	SIGN09 Common	17	TRIP09 Common	17	TRIP01-B Common
18	SIGN09 Open	18	TRIP09 Open	18	TRIP01-B Open
19	SIGN10 Common	19	TRIP10 Common	19	TRIP02-B Common
20	SIGN10 Open	20	TRIP10 Open	20	TRIP02-B Open
21	SIGN11 Common	21	TRIP11 Common	21	TRIP03-B Common
22	SIGN11 Open	22	TRIP11 Open	22	TRIP03-B Open
23	SIGN11 Cls	23	TRIP12 Common	23	TRIP04-B Common
24	SIGN12 Common	24	TRIP12 Open	24	TRIP04-B Open
25	SIGN12 Open	25	TRIP13 Common	25	TRIP05-B Common
26	SIGN12 Cls	26	TRIP13 Open	26	TRIP05-B Open
27	SIGN13 Common	27	TRIP14 Common	27	TRIP06-B Common
28	SIGN13 Open	28	TRIP14 Open	28	TRIP06-B Open
29	SIGN13 Cls	29	TRIP15 Common	29	TRIP07-B Common
30	SIGN14 Common	30	TRIP15 Open	30	TRIP07-B Open
31	SIGN14 Open	31	TRIP16 Common	31	TRIP08-B Common
32	SIGN14 Cls	32	TRIP16 Open	32	TRIP08-B Open

The specific terminal definition of the connector is described as below.

Table 6.9.3 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 6.9.4 Terminal Definition and Description of output module 2

Name	Description
TRIP01-16	The No.1 -16 programmable tripping or closing binary output.

Table 6.9.5 Terminal Definition and Description of output module3

Name	Description
TRIP01-A/B-08 A/B	The No.1 A/B -8 A/B programmable tripping or closing binary output with 2 contacts for each relay.

7 Human 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 Human Machine Interface (HMI) is user friendly and easy to operate in different situations. The design structure details of HMI are 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 21 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 1/2 BP-2C relay shown in figure 6.1.2 and 6.1.3 respectively. The front and back panels of 1/1 BP-2C relay shown in figure 6.1.4 and 6.1.5 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 BP-2C relay setting.

In simple words, all functions of BP-2C are user friendly.

7.1.3 Operating panel keypad and keys

The BP-2C relay front penal has 9 keypads and 8 function keys that help the operator to change the device settings according to the required situation and locate the different kinds of data access. All these keys and keypads have different kinds of functions.

Table 7.1.1 Keys information table

Symbol of keys	Description
◀ ▶ ▲ ▼	Arrow keys left, right up and down respectively
F1 F2 F3 F4	Functional keys F1, F2, F3 and F4 respectively. These are configure according to user's demand.
Menu Clear Esc Enter	Different keys like Menu, Clear, Esc and Enter keys
| R/L 🔑 ◎	CB close key, Remote/Local control key, User login key and CB opening key respectively.

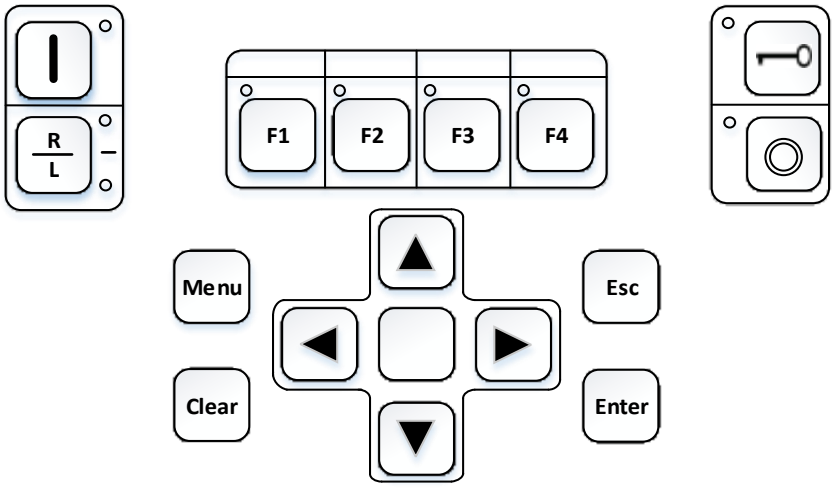


Figure 7.1.1 Overview of Front Panel Keypads and Keys

7.1.4 Indication of LED

The device consists of 31 front panel LEDs. The local view of front panel HMI consists of two relay status LEDs above the display level: healthy and alarm. There are nineteen 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 nineteen LEDs, each of which can be configured with 3 colors. These LEDs can be triggered by a fault, an alarm event or device record, and they indicate last information.

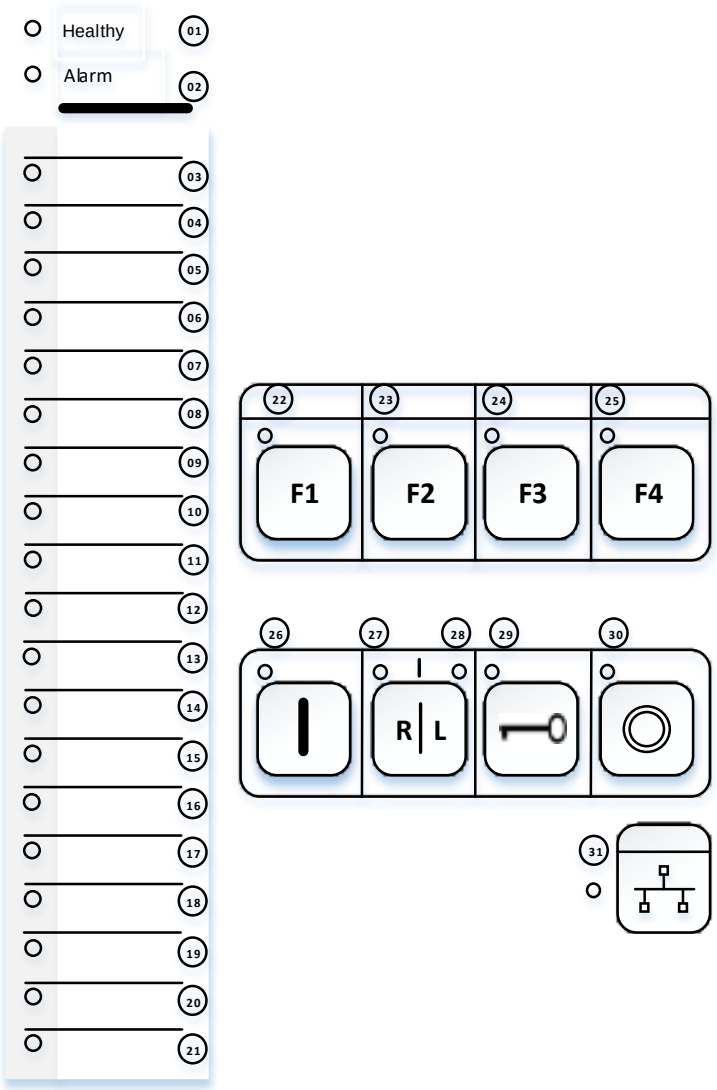


Figure 7.1.2 Overview of Front Panel LED's

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. When any kind of abnormality signal is detected. LED light color is fixed yellow.
03~21	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.

No.	Key label	Status	Description
		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.
22~25	Configurable	Off	None of signal is energized when the functional key is deactivated.
		Red	These LEDs indicate the functional keys are deactivated
26	CB Close	Off	None of signal is energized when the functional key is deactivated.
		Yellow	This LED indicate the CB Close key is activated.
27	Remote	Off	The operation mode is determined by the BI.
		Yellow	The device is in the “remote” mode.
28	Local	Off	The operation mode is determined by the BI.
		Yellow	The device is in the “Local” mode.
29	User login	Off	When user login function is not enable.
		Yellow	When user login function works normally.
30	CB Open	Off	None of signal is energized when the functional key is deactivated.
		Yellow	This LED indicate the CB Open key is activated.
31	Ethernet interface port	Off	When no Ethernet cable is connected with device.
		Green	When it works normally.

NOTICE!

No.01-02 and No.22-31 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 BP-2C device HMI front panel consists of four configurable keys. These configurable functional keys provide shortcuts for certain menus or act as a control button. The default view of configurable functional keys (F1, F2, F3 and F4) are shown in above figure 7.1.1. The detail operation of functional keys is listed in below 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 puls, hold and exit.
	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 below 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.

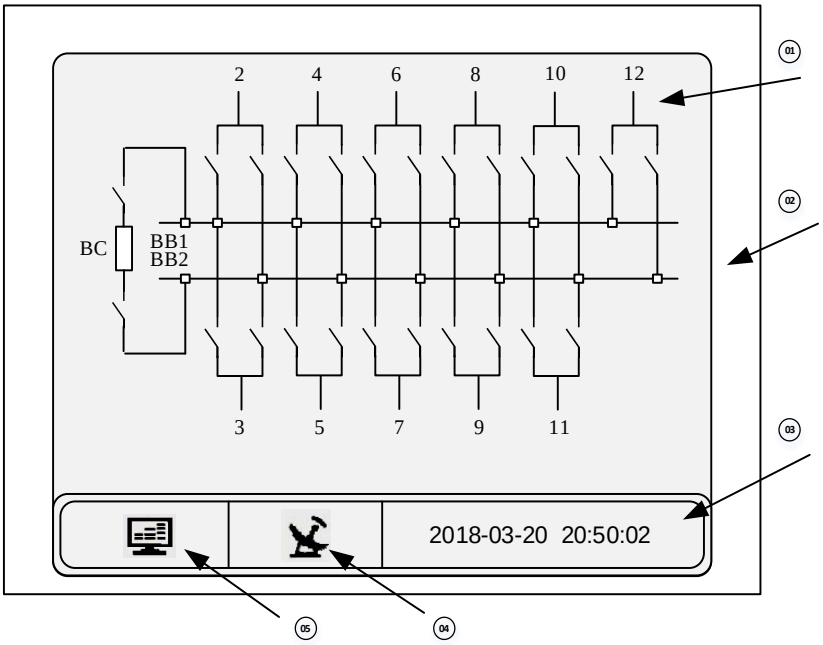


Figure 7.2.1 General Overview Display of Local HMI LCD Screen

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 BP-2C relay easier, simple and fast, the CYG Co, Ltd designes a flat-panel of main menu LCD display that contains ten main controlling functions.

These controlling functions 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 is shown in below 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.

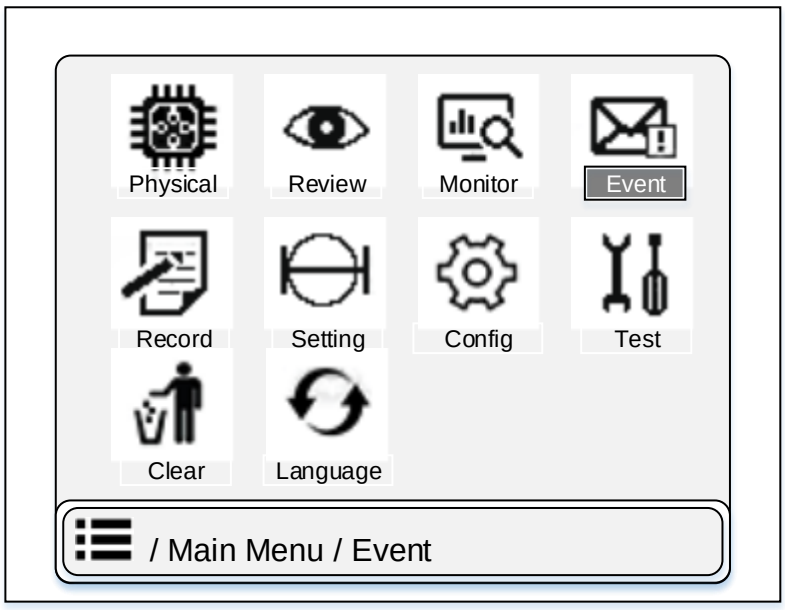


Figure 7.2.2 LCD General Overview Display of Main Menu

7.3 Sub menu functions of main menu

In this part of HMI, the details of menu sub-functions are 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 firmware and device communication. The overview display of physical information is shown in below figure 7.3.1.

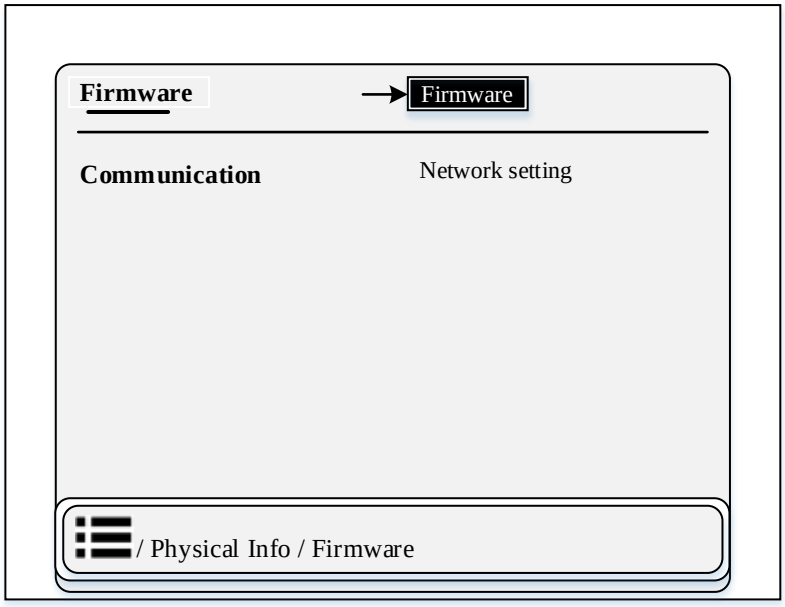


Figure 7.3.1 Overview Display of Physical Information Sub-functions

7.3.1.1 Software

In this sub-section of physical information, the firmware 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 > firmware”. The firmware information data divided into two pages and the detail of information is listed in below figure 7.3.2 and table 7.3.1:

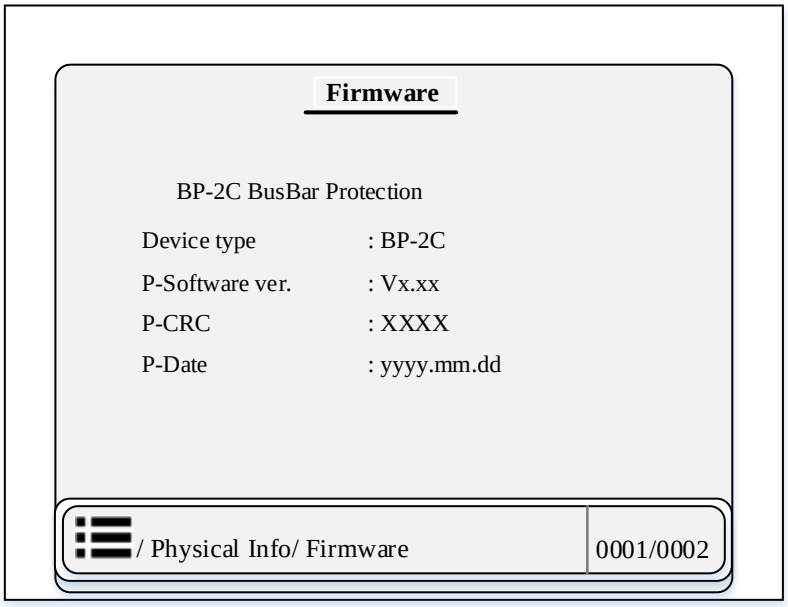


Figure 7.3.2 Overview Display Diagram of Firmware Information

Table 7.3.1 Detail of Firmware information

Name	Function display	Description
Device type	BP-2C	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
S/N	CYSR30000000FFFFFFF	S/N Code, serial number of the device
Ordering Code	BP-2C-XXXXX-XXXXXXXXXXXXXXX	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	BP-2C	Describe the type of protection relay
P-Software ver	V2.03	Describe the version of protection relay software
P-CRC	4B4E	Protection Cyclic redundancy check code
P-Date	2018.03.01	Protection CPU date
M-Software ver.	V2.03	MCPU software version
M-CRC	C710	MCPU Cyclic redundancy check error
M-Date	2018.03.01	Management CPU date
S/N	CYSR300000000138493	S/N Code, serial number of the device
Ordering Code	BP-2C-AACAA-BABXCCAAAAABDDD	Ordering Code
Config. Ver.	V3.06	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 below figure 7.3.3 and table 7.3.3:

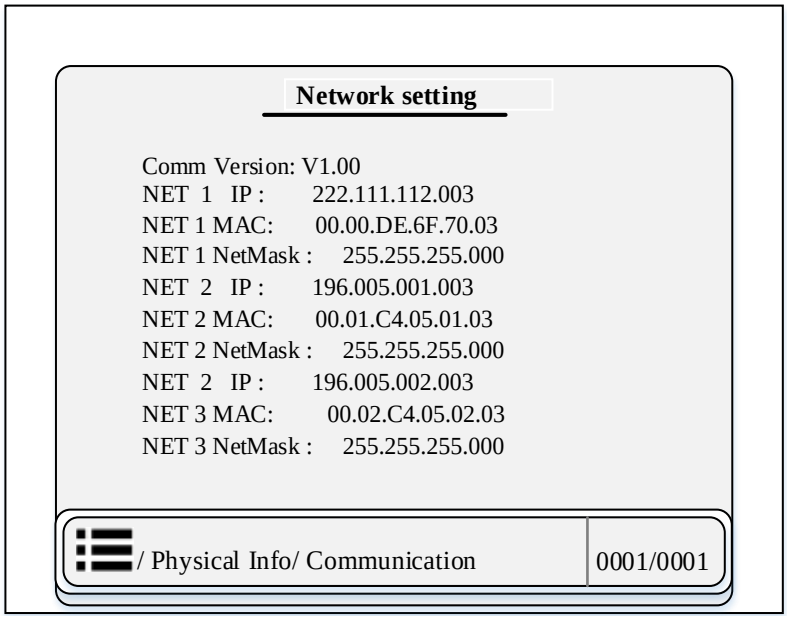


Figure 7.3.3 Overview Display Diagram of Network Setting

Table 7.3.3 Communication data detail

Name	Function display	Description
Comm Version	V1.00	IEC 61850 Communication Version
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 settings. 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 below figure 7.3.4.

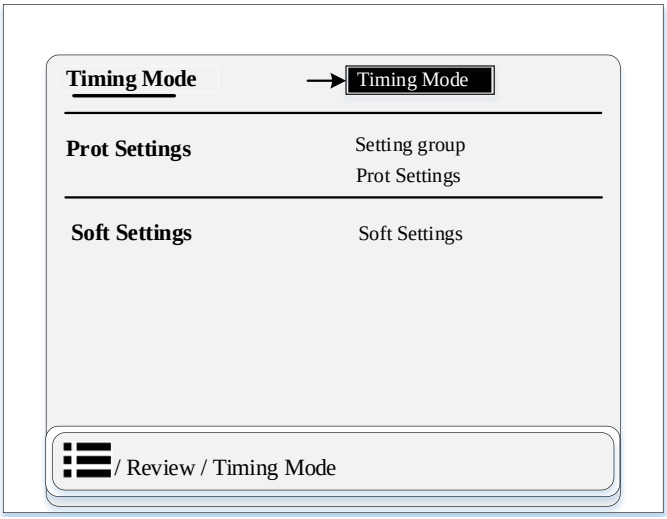


Figure 7.3.4 Overview Display of Review Information Sub-functions

7.3.2.1 Timing Mode

In 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 below figure 7.3.5.

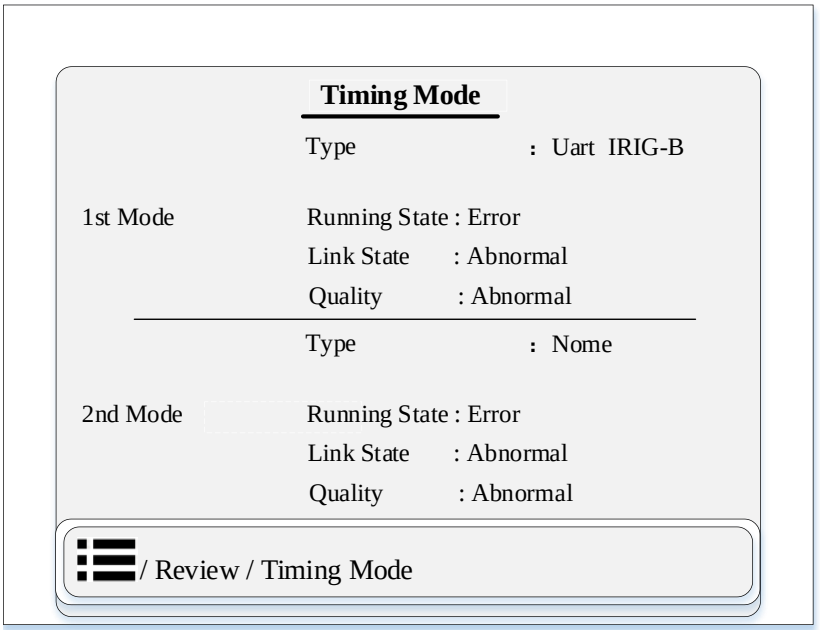


Figure 7.3.5 Overview Display of Timing Mode

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 protection function operation settings. User can access this function through the following path: “Review > Prot Settings”. The information data structure of protection setting is listed in below figure 7.3.6:

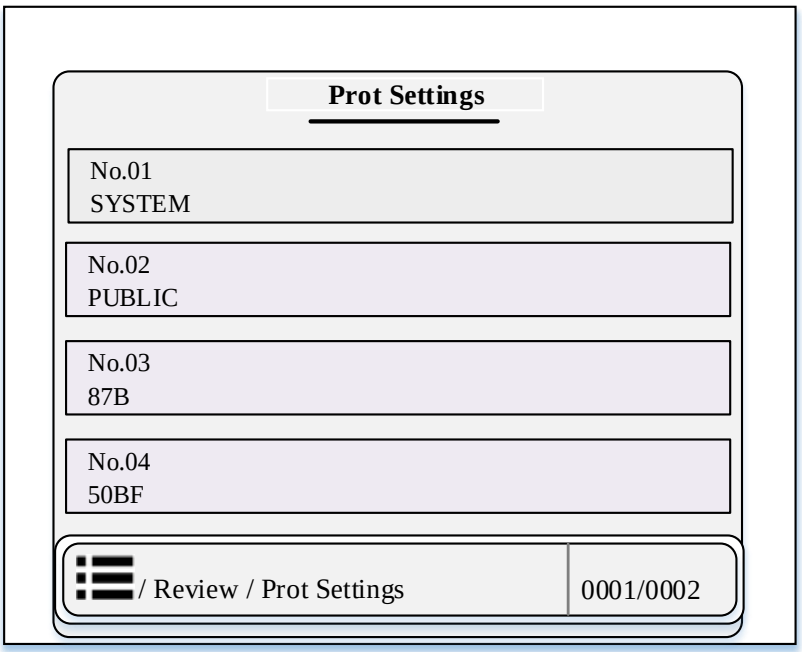


Figure 7.3.6 Overview Diagram of Prot Setting

7.3.3 Monitoring Information

This section is divided into four sub-parts and describes the information of real time monitoring data of BP-2C busbar protection relay. This section only provides the sample, BI data, BO Count, Status information. In this section, user can easily access the real-time monitoring data view of relay through arrow keys. The overview display of monitoring information is shown in below figure 7.3.7.

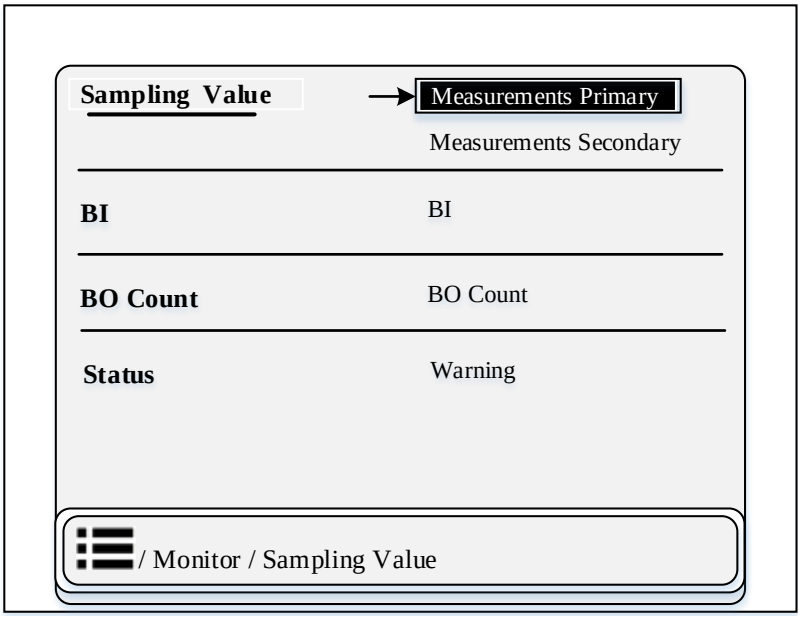


Figure 7.3.7 Overview Display of Monitoring Information Sub-functions

7.3.3.1 Sampling Value

This section is divided into two subpart like Measurements Primary and Measurements Secondary. Both 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 > Sampling Value”. The

measurement data structure of relay is listed in below figure 7.3.8 and table 7.3.4:

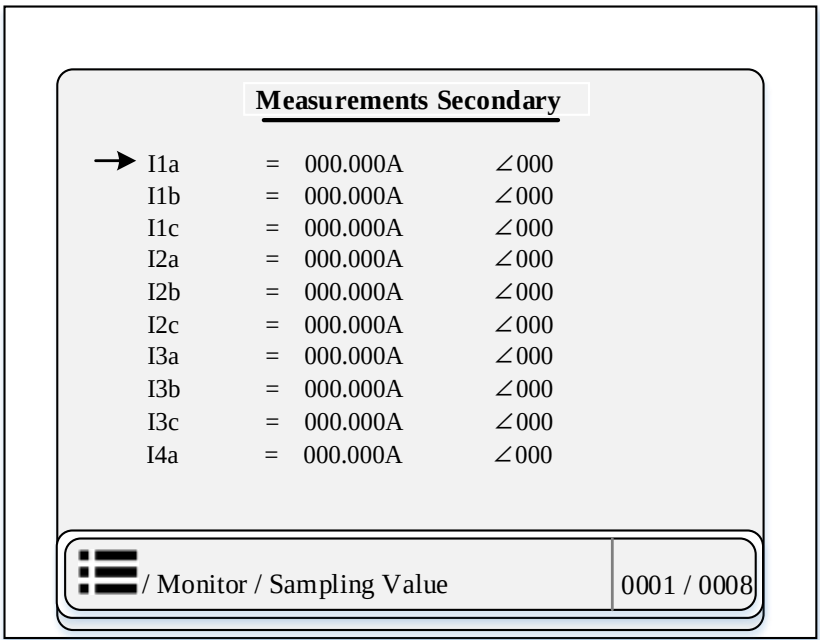


Figure 7.3.8 Overview Display of Measurement Section Quantities

Table 7.3.4 Measurement quantities

No.	Measurement function	Value	Description
1	Ina	000.000A	Phase A measured current of bay n
2	Inb	000.000A	Phase B measured current of bay n
3	Inc	000.000A	Phase C measured current of bay n
4	U1a	0000.00V	Phase A measured voltage of busbar 1
5	U1b	0000.00V	Phase B measured voltage of busbar 1
6	U1c	0000.00V	Phase C measured voltage of busbar 1
7	U2a	0000.00V	Phase A measured voltage of busbar 2
8	U2b	0000.00V	Phase B measured voltage of busbar 2
9	U2c	0000.00V	Phase C measured voltage of busbar 2
10	U3a	0000.00V	Phase A measured voltage of busbar 3
11	U3b	0000.00V	Phase B measured voltage of busbar 3
12	U3c	0000.00V	Phase C measured voltage of busbar 3
13	Ida	000.000A	Phase A measured current of check zone
14	Idb	000.000A	Phase B measured current of check zone
15	Idc	000.000A	Phase C measured current of check zone
16	Id1a	000.000A	Phase A measured current of discriminative zone 1
17	Id1b	000.000A	Phase B measured current of discriminative zone 1
18	Id1c	000.000A	Phase C measured current of discriminative zone 1
19	Id2a	000.000A	Phase A measured current of discriminative zone 2
20	Id2b	000.000A	Phase B measured current of discriminative zone 2
21	Id2c	000.000A	Phase C measured current of discriminative zone 2

No.	Measurement function	Value	Description
22	Id3a	000.000A	Phase A measured current of discriminative zone 3
23	Id3b	000.000A	Phase B measured current of discriminative zone 3
24	Id3c	000.000A	Phase C measured current of discriminative zone 3
25	Ira	000.000A	Phase A restraint current of check zone
26	Irb	000.000A	Phase B restraint current of check zone
27	Irc	000.000A	Phase C restraint current of check zone
28	Ir1a	000.000A	Phase A restraint current of discriminative zone 1
29	Ir1b	000.000A	Phase B restraint current of discriminative zone 1
30	Ir1c	000.000A	Phase C restraint current of discriminative zone 1
31	Ir2a	000.000A	Phase A restraint current of discriminative zone 2
32	Ir2b	000.000A	Phase B restraint current of discriminative zone 2
33	Ir2c	000.000A	Phase C restraint current of discriminative zone 2
34	Ir3a	000.000A	Phase A restraint current of discriminative zone 3
35	Ir3b	000.000A	Phase B restraint current of discriminative zone 3
36	Ir3c	000.000A	Phase C restraint current of discriminative zone 3
37	IN_n	000.000A	Zero sequence measured current of bay n
38	I2_n	000.000A	Negative sequence measured current of bay n
39	U1ab	0000.00V	Phase AB measured voltage of busbar 1
40	U1bc	0000.00V	Phase BC measured voltage of busbar 1
41	U1ca	0000.00V	Phase CA measured voltage of busbar 1
42	UN_1	000.000A	Zero sequence measured voltage of discriminative zone 1
43	U2_1	000.000A	Negative sequence measured voltage of discriminative zone 1
44	U2ab	0000.00V	Phase AB measured voltage of busbar 2
45	U2bc	0000.00V	Phase BC measured voltage of busbar 2
46	U2ca	0000.00V	Phase CA measured voltage of busbar 2
47	UN_2	000.000A	Zero sequence measured voltage of discriminative zone 2
48	U2_2	000.000A	Negative sequence measured voltage of discriminative zone 2
49	U3ab	0000.00V	Phase AB measured voltage of busbar 3
50	U3bc	0000.00V	Phase BC measured voltage of busbar 3
51	U3ca	0000.00V	Phase CA measured voltage of busbar 3
52	UN_3	000.000A	Zero sequence measured voltage of discriminative zone 3
53	U2_3	000.000A	Negative sequence measured voltage of discriminative zone 3

7.3.3.2 BI

This section is divided into one sub-parts and describe the information of binary input (BI) of this IED seen in the above figure 7.3.7. This section only display 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 depends on the actual configuration. The BI display diagram of the IED is listed in below figure 7.3.9:

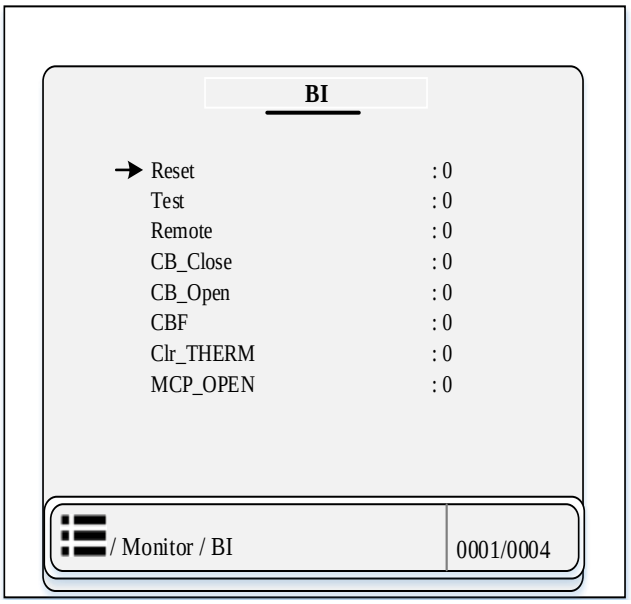


Figure 7.3.9 LCD Display Diagram of BI Monitored Data

7.3.4 Event Information

This section is divided into four sub-section and describe the information of all events, like start records, 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 below figure 7.3.10:

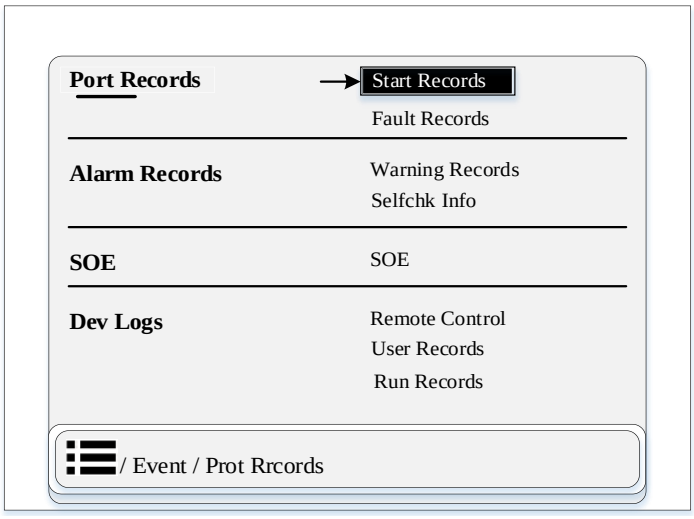


Figure 7.3.10 Overview Display of Event Information Sub-functions

7.3.4.1 Port Records

This section is divided into two sub-function like start records and fault records. This device can store 512 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 below figure 7.3.11:

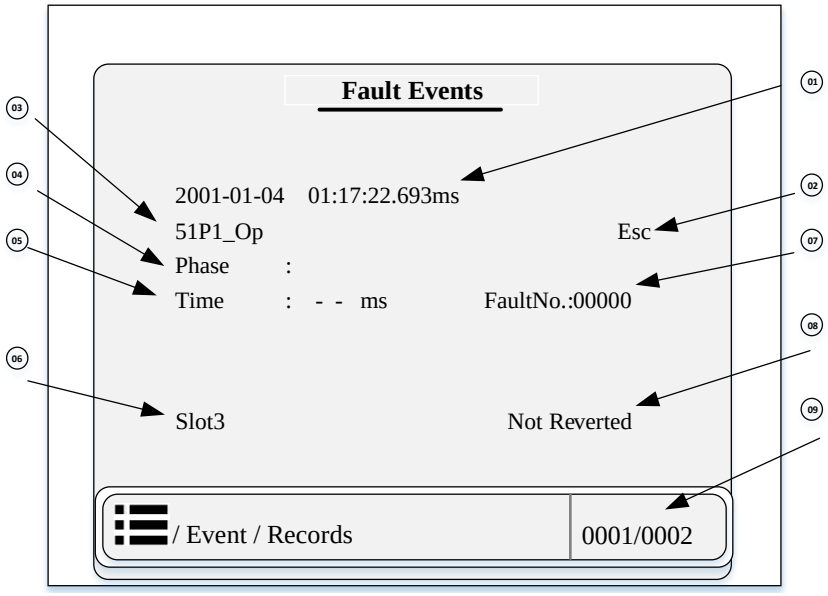


Figure 7.3.11 Overview Display of Fault Events

7.3.4.2 Alarm Records

This section is divided into two sub-functions like warning records and selfchk Info see figure 7.3.10. This device can save latest 512 alarm records.

1- Warning Records

In this section, user can see all warning records like protection warning records and TimingErr warning records etc. User can access this function through the following path: “Event > Alarm Records”. The overview display of warning record is shown in below figure 7.3.12.

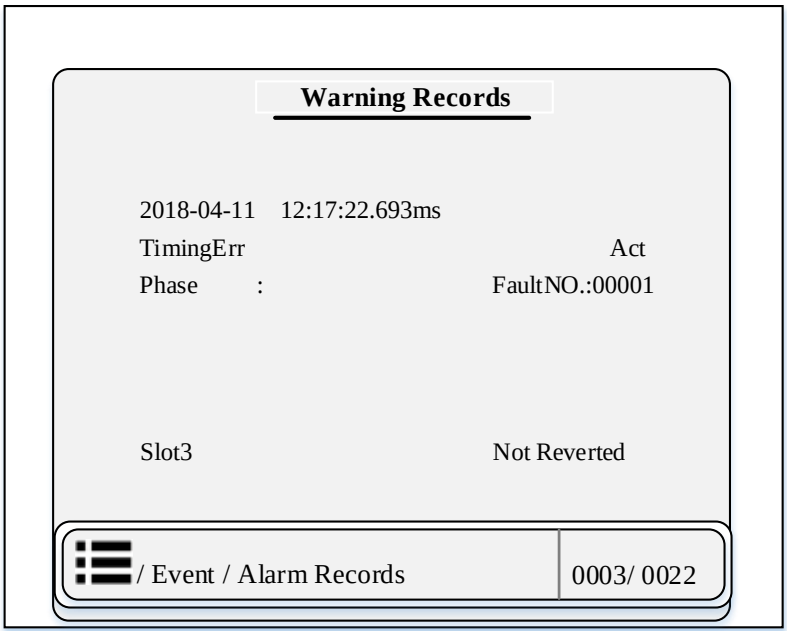


Figure 7.3.12 Overview Diagram of Warning Records Info

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 check hardware, software and configuration file and it can totally save latest 128 records. User can access this function through the following path: “Event > Alarm Records”. The overview display of SelfChk info is shown in below figure 7.3.13.

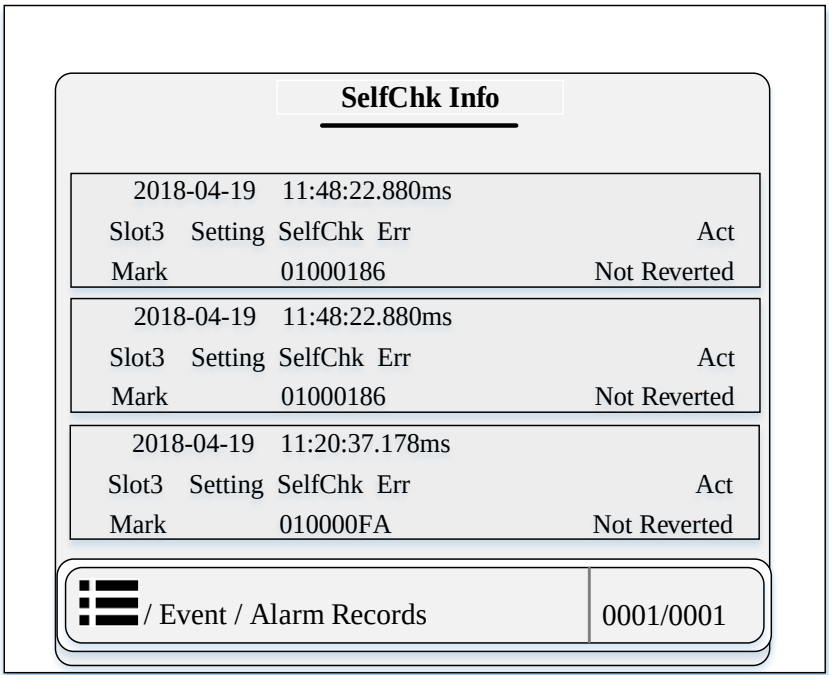


Figure 7.3.13 Overview Display Diagram of SelfChk Info

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 debouncing.
- 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 debouncing time.

User can access this function through the following path: “Event > SOE”. This device can save 2000 latest SOE records. The diagram of SOE record is shown in below figure 7.3.14.

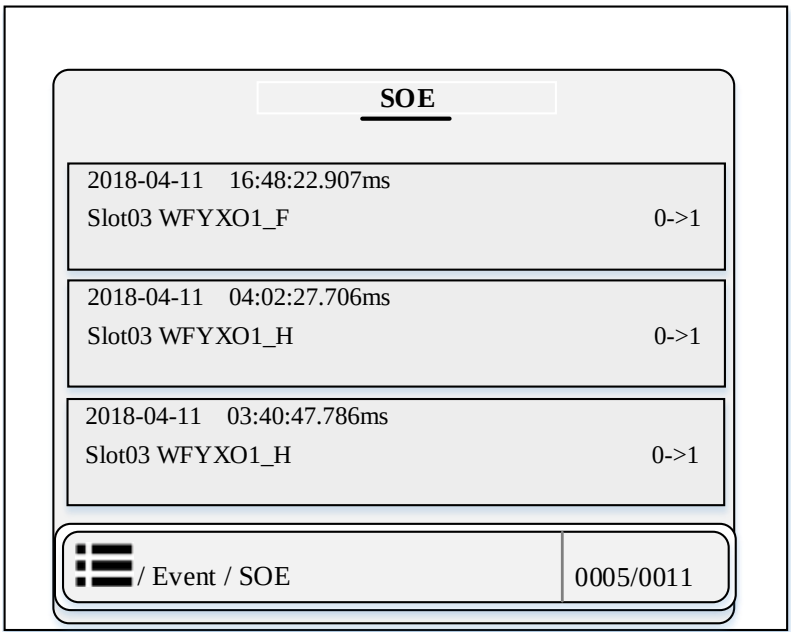


Figure 7.3.14 Overview Display Diagram of SOE

7.3.4.4 Dev Logs

This section is divided into three sub-function like remote control, user records and power records see figure 7.3.10.

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 128 latest remote control records. User can access this function through the following path: “Event > Dev Logs > Remote Control”. The diagram of remote control functions are shown in below figure 7.3.15.

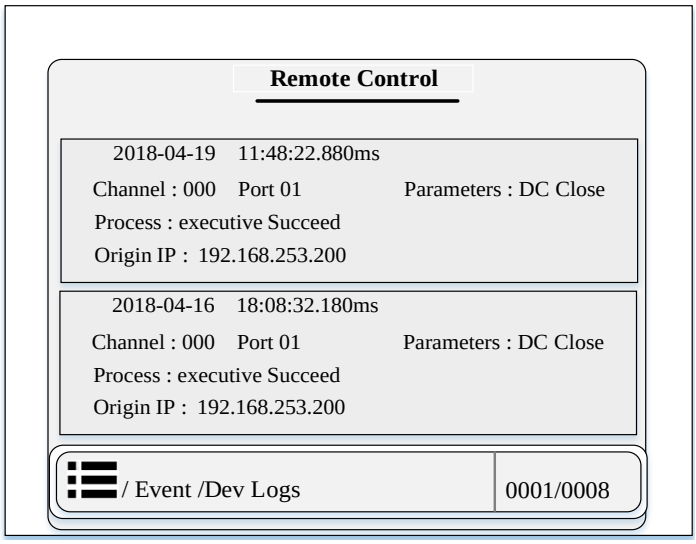


Figure 7.3.15 Overview Display Diagram of Remote Control Access

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 > User Records”. The diagram of user records are shown in below figure 7.3.16.

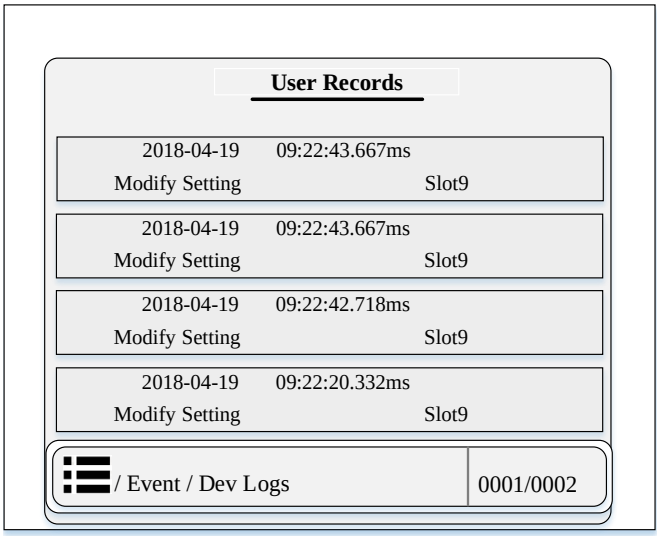


Figure 7.3.16 Overview Diagram of User Records

3- Run records

In this section, user can see the setting of run 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 run records. User can access this function through the following path: “Event > Dev Logs > Run Records”. The diagram of run record is shown in below figure 7.3.17.

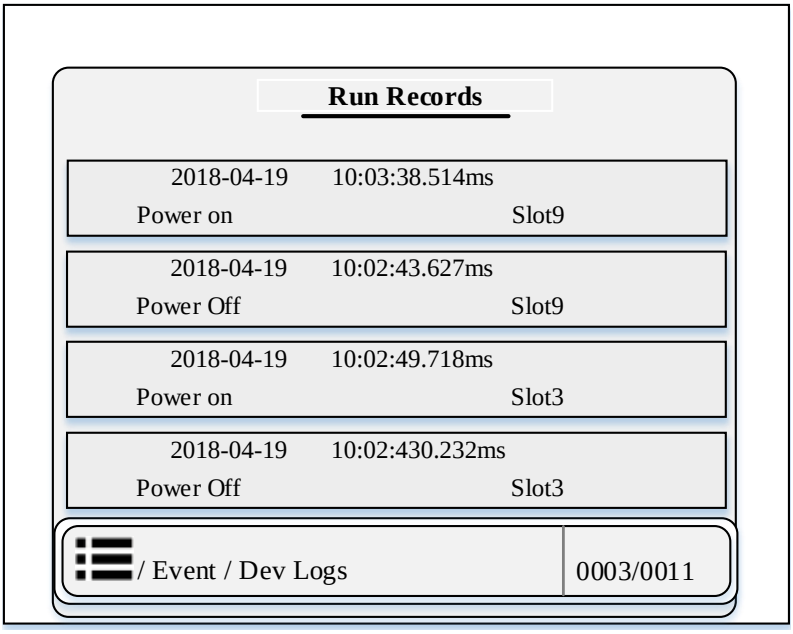


Figure 7.3.17 Overview Diagram of Power Records

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 below figure 7.3.18.

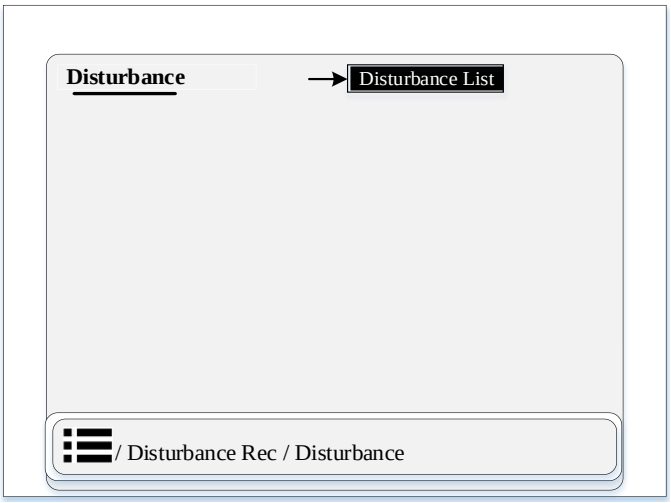


Figure 7.3.18 Overview Display of Records Information

7.3.5.1 Disturbance List

In this section, user can see the disturbance records of all the faults. User can access this function through the following path: “Disturbance > Disturbance List”. The diagram of faulty wave records are shown in below figure 7.3.19.

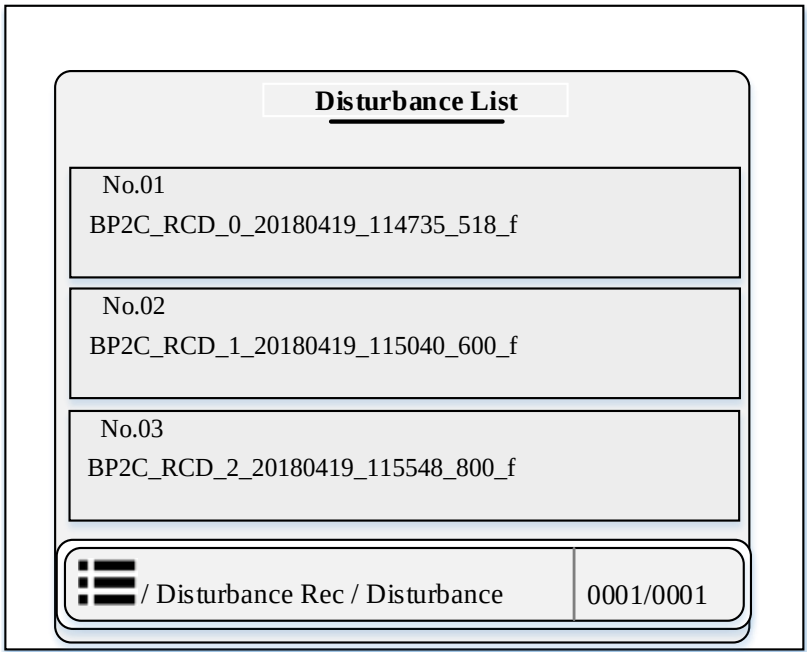


Figure 7.3.19 Overview Diagram of Disturbance List

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 below figure 7.3.20.

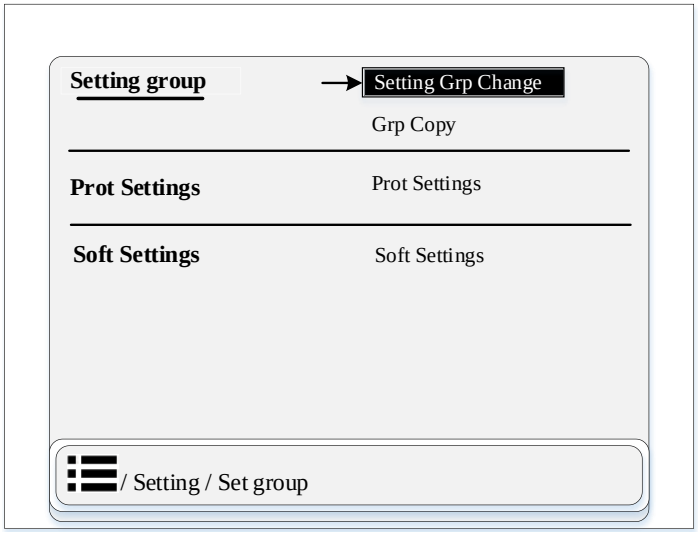


Figure 7.3.20 Overview Display of Setting Information Sub-functions

7.3.6.1 Setting 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 below figure 7.3.21.

Firstly, enter “Setting > Setting group > Setting Grp Change”. Secondly, select group setting. Thirdly, download new configuring setting. Fourthly, cancel to return back or exit.

Figure 7.3.21 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 below figure 7.3.22.

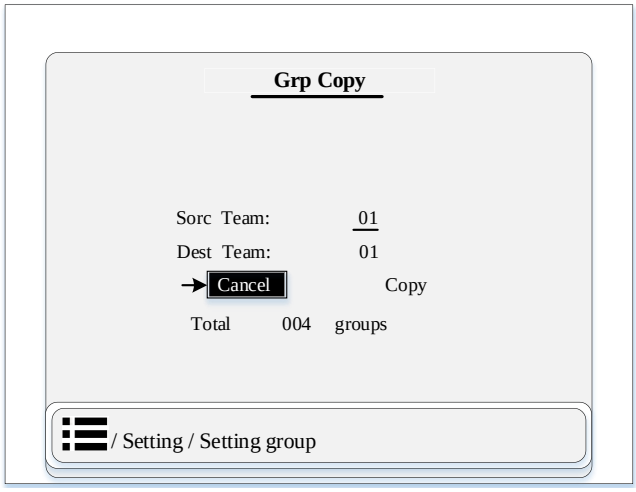


Figure 7.3.22 Procedure Diagram of Group Setting Copy

7.3.6.2 Prot Settings

In this section, user can change the different kind of protection function settings. User can access this function through the following path: “Setting > Prot Settings”. The detail of protection setting is listed below figure 7.3.23:

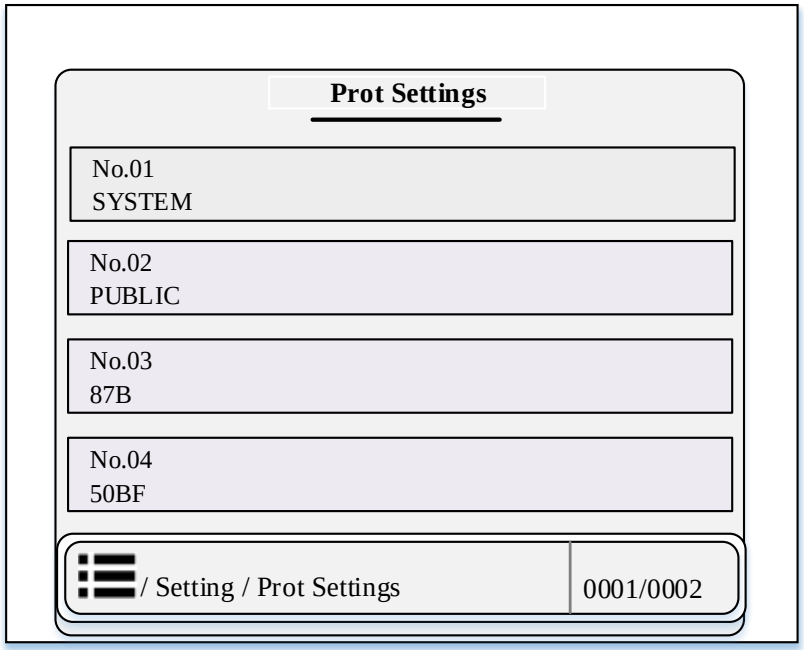


Figure 7.3.23 Diagram of Protection Setting

7.3.7 Configuration Information

This section is divided into two sub-function like time and authorization. In this part, the 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 posts) can also be modified. The diagram of configuration information is shown in below figure 7.3.24.

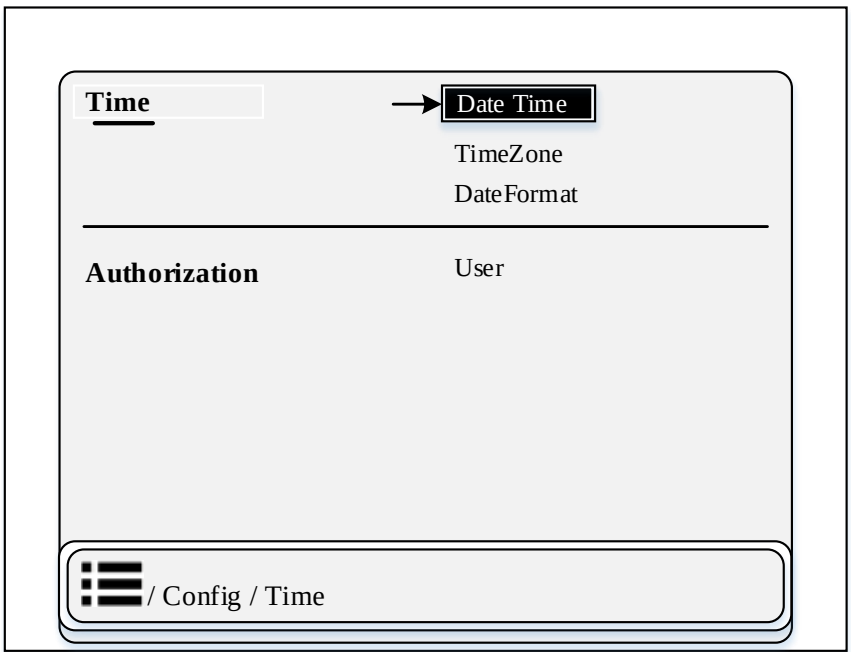


Figure 7.3.24 Overview Display of Configuration Information Sub-functions

7.3.7.1 Time

This part is divided into three sub-section date & time, time zone and date format, see figure 7.3.24. User can access this function through the following path: “Config > Time”.

1- Date and time

In this section, user can easily set date and time according to practical demand. See figure 7.3.25 (a):

2- Time zone

In this section, user can easily set time zone according to their region. See figure 7.3.25 (b):

3- Date Format

In this section user can easily set date format according to their region, such as yyyy-mm-dd, dd-mm-yyyy, MM/dd/yyyy and other 9 date formats. See figure 7.3.25 (c):

Figure 7.3.25 Diagram of (a) Date & Time Setting (b) Time Zone Setting (c) DateFormat Setting

7.3.7.2 Authorization

This part is divided into one sub-function, see figure 7.3.26. User can access this function through the following path: “Config > Authorization”.

1- User

In this section, user can easily set relay operator setting like operator 1 or 2 or guest 1. See below table 7.3.5 and figure 7.3.26:

Table 7.3.5 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 sub graph. 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

User operator selection options	Authorization
	contents they need to view are set to read-only. ***Note!*** None of other users have access to this setting function except manufacturer.
Engin_1	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.
Oper_1 & Oper_2	The operator user account, generally, it can only view the configuration of the device, the logical picture, the wiring diagram and the logical device component. In this section, user can't create or modify any of its configuration, such as moving the map element position and deleting port association etc.
Guest_1	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 account is only for visitors. In this section, user have no rights to change or view any kind of configuration information.

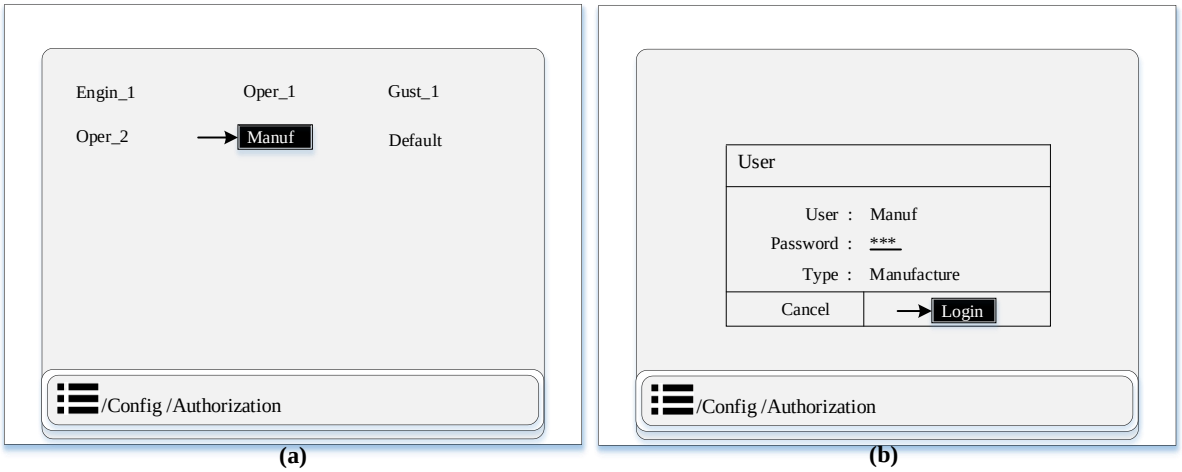


Figure 7.3.26 Diagram of Authorization User (a) Operator Selection List (b) Login or Cancel

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, operation test, warning test, Status test, and mandatory wave etc. The overview display diagram of test information is shown in below figure 7.3.27:

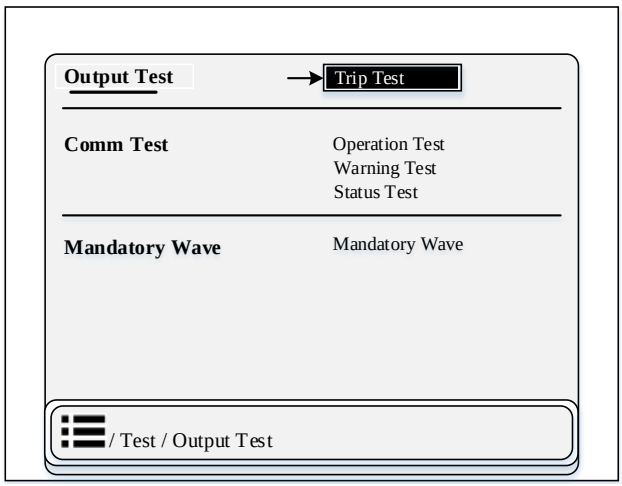


Figure 7.3.27 Overview Display of Test Information Sub-functions

7.3.8.1 Output Test

This section mainly realizes output test, including tripping test and signal test. See figure 7.3.28. 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. See below figure 7.3.28:

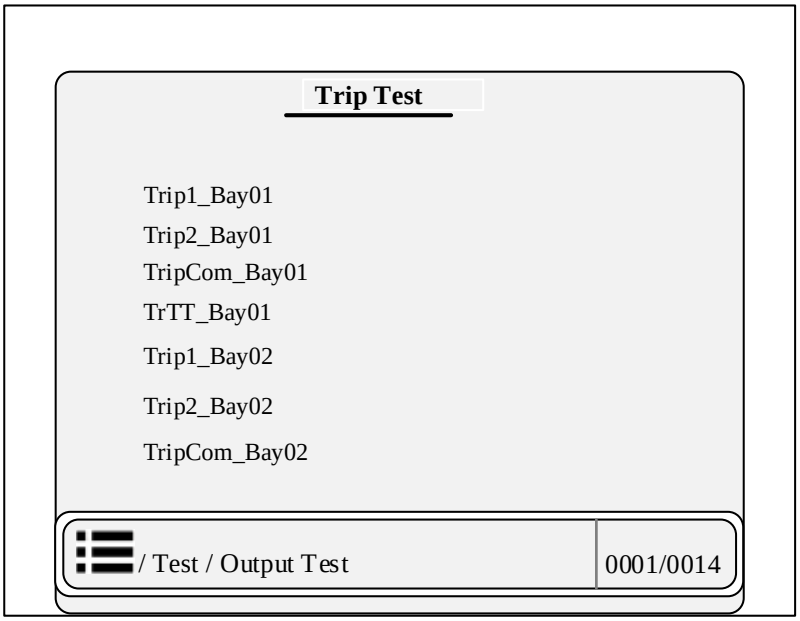


Figure 7.3.28 Overview Diagram of Trip Test

7.3.8.2 Comm Test

Common test is divided into three sub-test like operation test, warning 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 below figure 7.3.29.

Figure 7.3.29 LCD Display Diagram of (a) Operation Test (b) Warning Test (c) Status Test

1- Operation Test

In this section, user can simulate the protection operation event like 50BF_TrBus_Bay06, 87B_Op and 50BF_TrBus1 operation function etc. see above figure 7.3.29 (a):

2- Warning Test

In this section, user can simulate the warning event like CT_Failure, CT_Abnormal and IrigB_Timing Err etc. see above figure 7.3.29 (b):

3- Status Test

In this section, user can simulate the BI changing status, like reset, remote, test, etc. see above figure 7.3.29(c):

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 entering this section, user can manually start disturbance recording in disturbance record section. See above figure7.3.27 (fault wave).

7.3.9 Clear Information

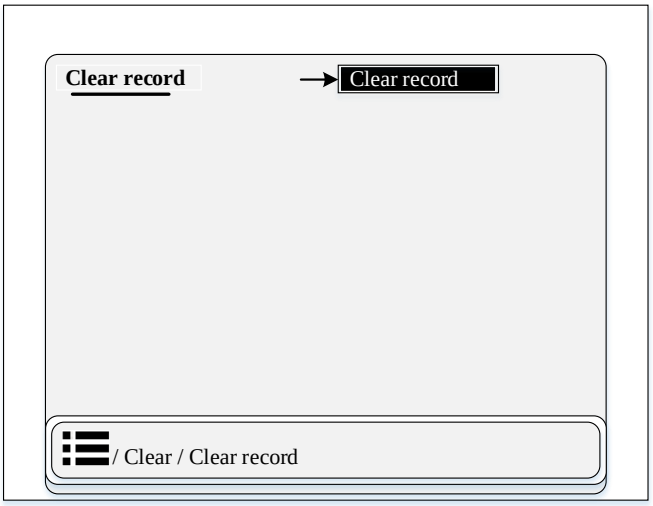


Figure 7.3.30 Overview Display of Clear Information Sub-functions

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 below figure 7.3.31:

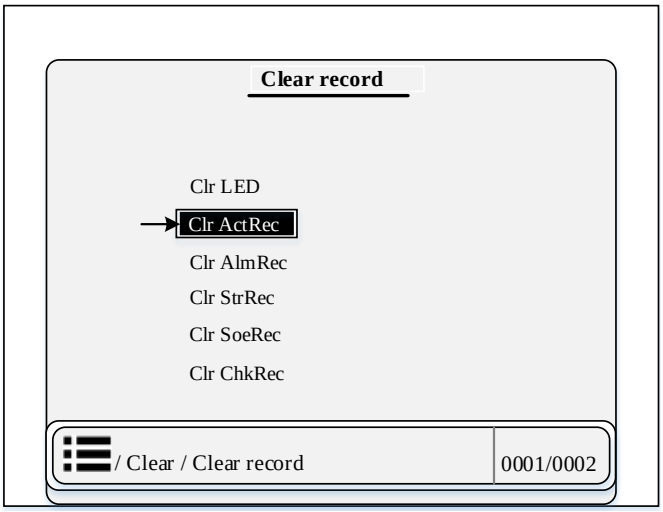


Figure 7.3.31 Diagram of Clear Record Display

7.3.10 Language Information

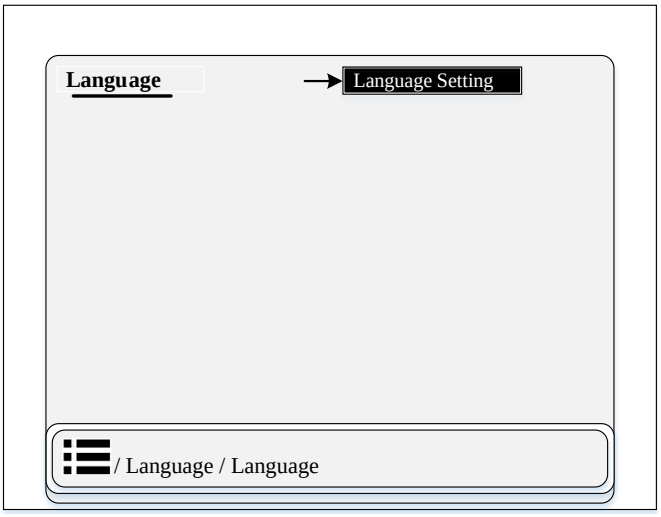


Figure 7.3.32 Overview Display of Language Information Sub-functions

7.3.10.1 Language Setting

In this section, user can set the IED language according to their demand like Chinese, English, Spanish, and Russian, etc. User can access this function through the following path: “Language > Language setting”. The language setting diagram of relay is listed in below figure 7.3.33:

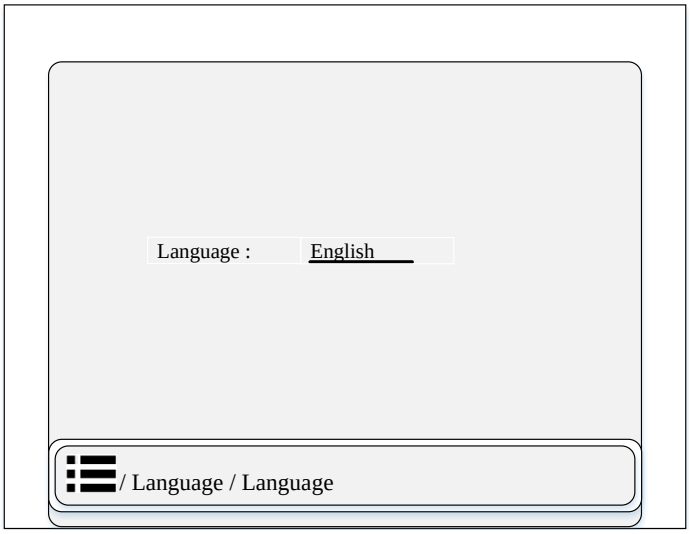


Figure 7.3.33 LCD Display diagram of Language Setting

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 function 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 Set Functions and Parameters

Configuration location: [Parameter]-[PUBLIC]-[Macro Set]

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
System 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 Timing Mode1 is preferred for timing, while the second timing method Timing Mode2 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
SlotNO	The module number in the device
LEDXXIndex	XX means the LED number. The Index means the LED can be associated with output resources in the OUTPUT of the CONST node.
LEDXXDspStat	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.
LEDXXColStat	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 XX binary output (BO). SR3XX 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
SlotNO	The module number in the device
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, range: 0-10000ms. If DC power supply is used, 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 AC power supply is used, the debouncing time is usually set to 6ms.
KIXXHoldVol	XX means the KI number. Set the power supply voltage according to the actual situation. Voltage range: 24V~250VDC, 64V~250VAC.

8.4.1.6 SR71XX Analog module parameters

Configuration location: [Parameter]-[PUBLIC]-[SR71XX]

SR71XX is an analog module with two configurations: 9U3I (9 sets of voltage and 3 sets of current) and 0U12I (0 sets of voltage and 12 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_1/2/3/4/5/6]

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, NET_3, NET_4, NET_5, NET_6 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]-[DPCS_BayXX]

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

Note: GOOSE_GOIN_DPCS needs 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
COMDef	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
DNP Class	Data Class: Class0/ Class1/Class2/Class3
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
COMDef	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
DNP Class	Data Class: Class0/ Class1/Class2/Class3
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
COMDef	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
DNP Class	Data Class: Class0/ Class1/Class2/Class3
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
KI Number	Number of input in waveform recording
KI Channel	Corresponding input in waveform recording

8.4.2.6 WAVAKO Functions and Parameters

Configuration location: [Const]-[WAVAKO]

This module sets the parameters for the recording output of the device.

The detail explanation of the data item description is as following:

Data item description	The detail explanation
KO Number	Number issued in the recording
KO Channel	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
COMDef	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
DNP Class	Data Class: Class0/ Class1/Class2/Class3
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
COMDef	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
DNP Class	Data Class: Class0/ Class1/Class2/Class3
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 Super permissions

This module provides SUPER 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 sub graphs 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 supports a wide range of protocols via a communication interface (RS-485 or Ethernet port). The protocols are of international standard for communication in substations and they can be selected by modifying the communication parameters.

Local communication with the IED via a computer is achievable through 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 protocols 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 via PRS IED Studio.

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.

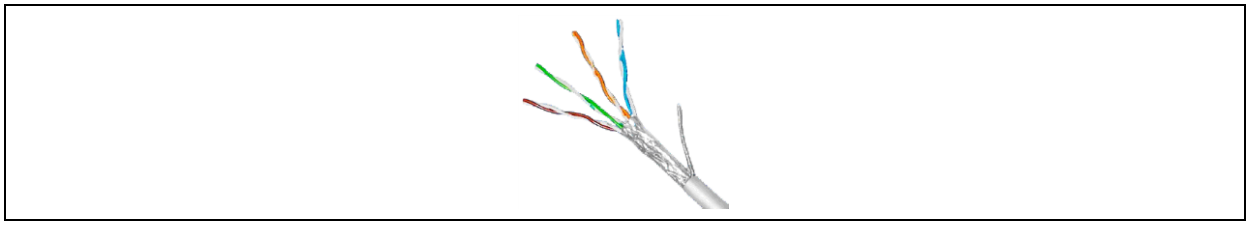


Figure 9.2.1 Ethernet communication cable

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.

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 the 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 multidrop 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 and BP series relays support IEC 61850 server services over TCP/IP communication protocol stacks. The TCP/IP profile requires the PRS-7000 series and BP 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)
	SetDataSetValue (set data set value)	Write (write service)

Name		Range
	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)
	SetMSVCBValues (set MSV control block values)	Write (write service)

Name		Range
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 terminals. GOOSE is a 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 (FuntionName)

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: 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 and switch position.

The GOOSE service adopts the pear-to-pear transmission or network 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 are 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 shift of GOOSE message is the MinTime parameter (i.e. T1); the “timeAllowedtoLive” parameter in GOOSE message is 2 times 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 if 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 StNum, 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 and BP series devices support real-time sending of data. The data objects requiring real-time monitoring are configured into data set, and the data set are associated to report control and GoCB, so that the change information of monitored objects can be sent in real-time to the background 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 include 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, in the report submitted by device, RptID is full path.

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 missing value as 0, indicating not using the buffer time attribute, and the maximum value is 1h.

The timer is started when the first internal prompt arrives, after it is reached in timer, 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 booted again, 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 submit all data values in the current data set.

PurgeBuf

Purge buffer. When the client side sets PurgeBuf = TRUE, all report entries 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 and BP series device is 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 and BP 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 and BP 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, representing 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).

9.6 IEEE 1588-2008 Protocol

9.6.1 Overview

The Precision Time Protocol (PTP) is a protocol used to synchronize clocks throughout LAN. On a local area network, it achieves clock accuracy in the sub-microsecond range, making it suitable for measurement and control systems.

9.6.2 Time Synchronization

Time synchronization of the device support IEEE 1588-2008 Protocol via ethernet interface or optical interface.

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 can not 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 can not 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, 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, 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
- Frequence 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 phenomenons 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 especially 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 busbar 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, 1/1 19 "or 1/2 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 are 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.

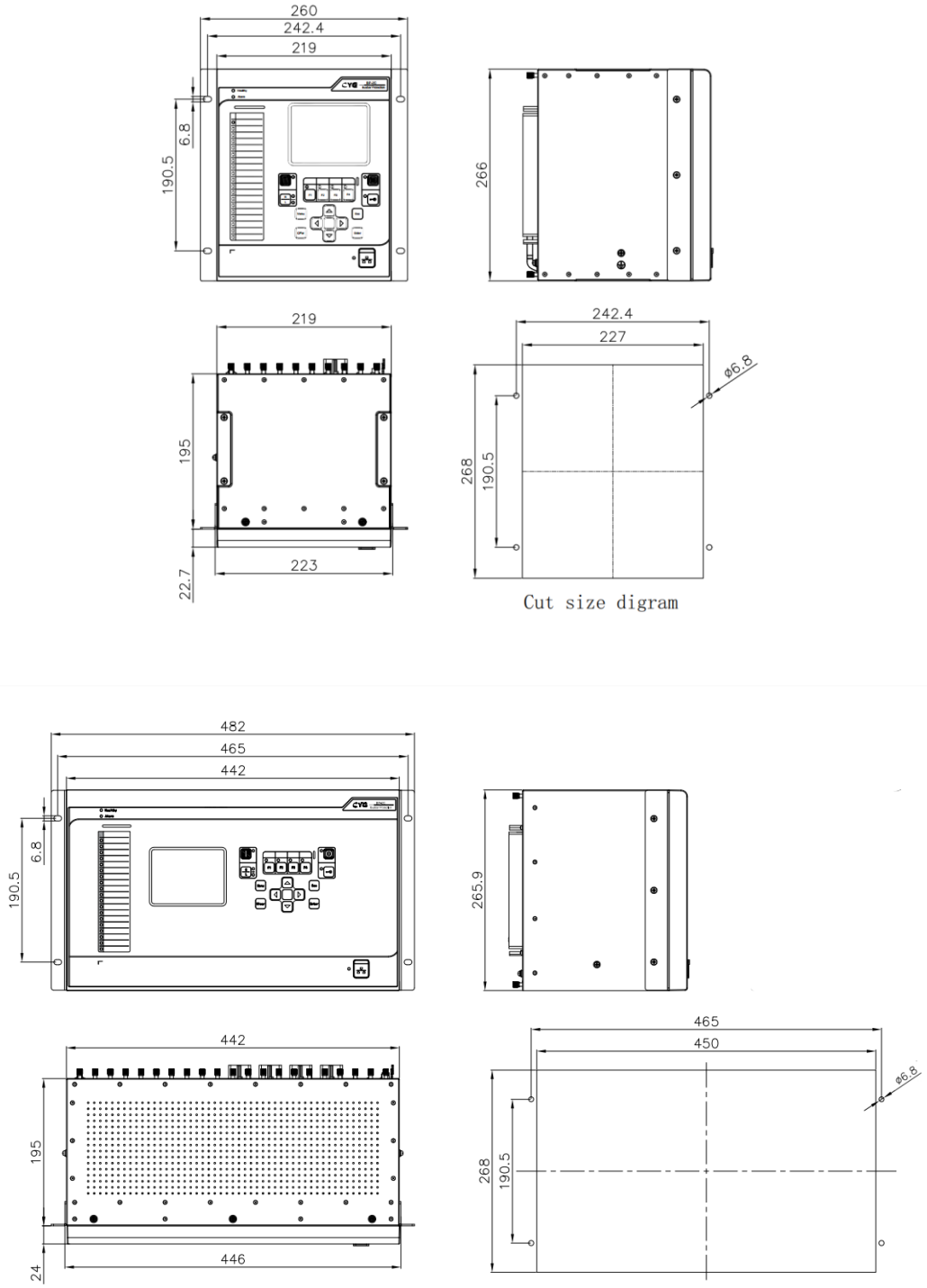


Figure 11.6.1 Dimensions of this relay and the cut-out in the cubicle (unit: mm)

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 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.

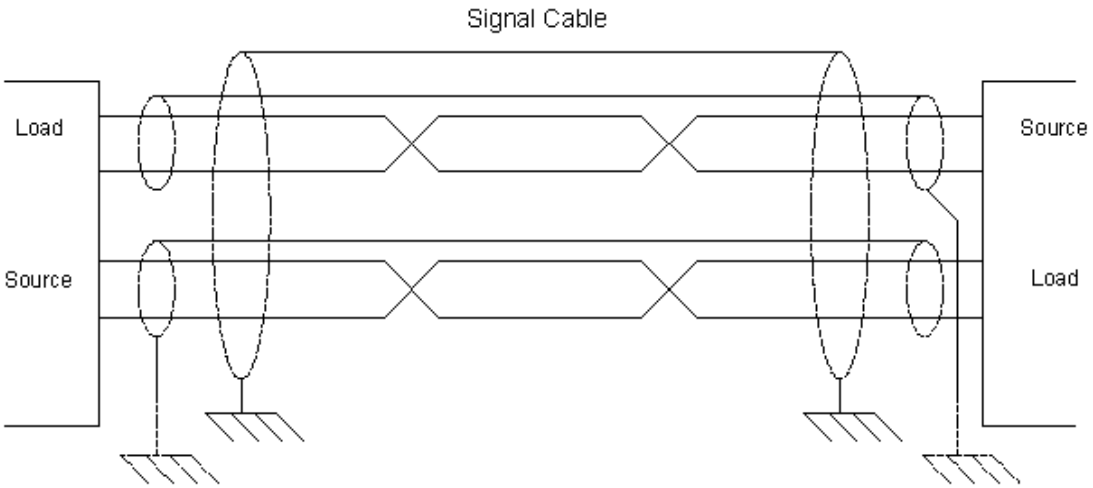


Figure 11.7.1 Shielded cable connection

11.7.5 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.

11.7.6 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.

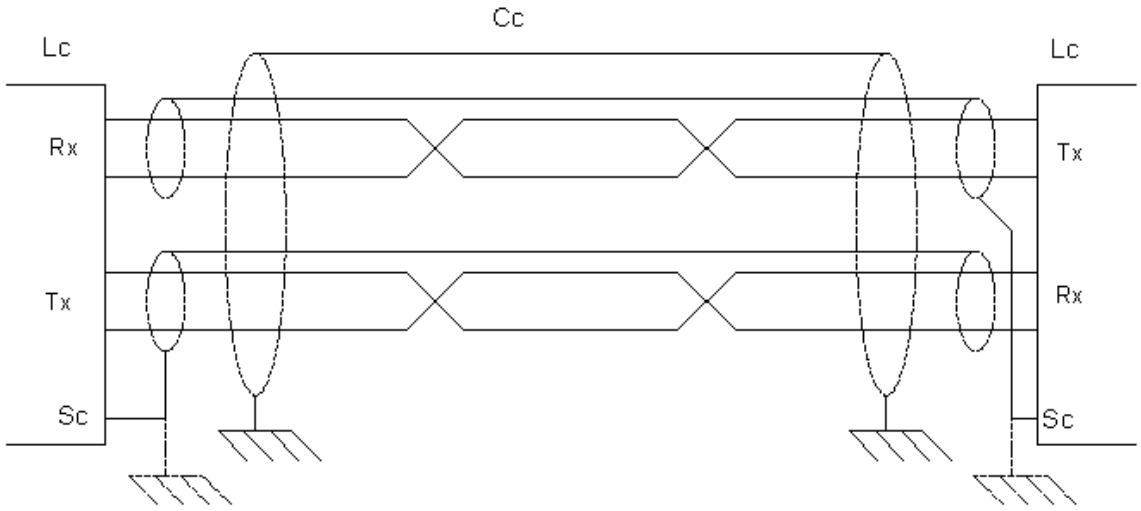


Figure 11.7.1 Communication cable connection

Cc: communication cable

Lc: line connector

Rx: receive signal input

Tx: transmit signal output

Sc: shielded (grounding) 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.

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 year, 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 equipments, 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 oftenly 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 a 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 Structure drawing of BP-2C (Digital)

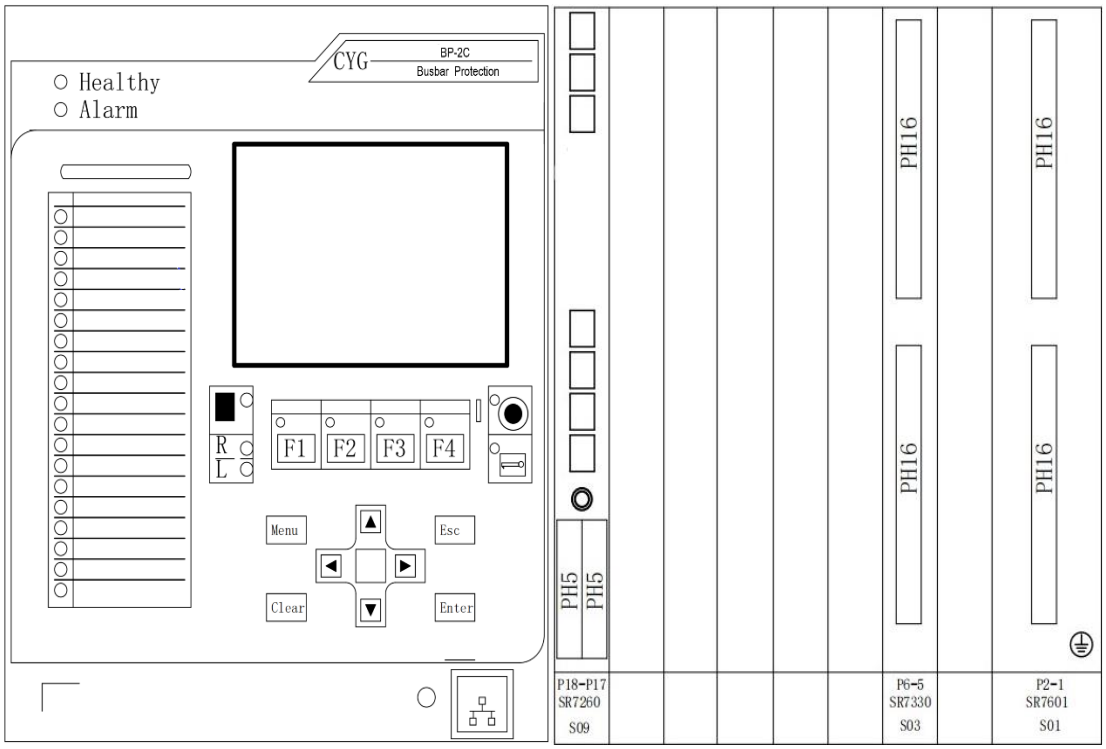


Figure 14.1.1 Drawing of structure

14.2 Modules drawing of BP-2C (Digital)

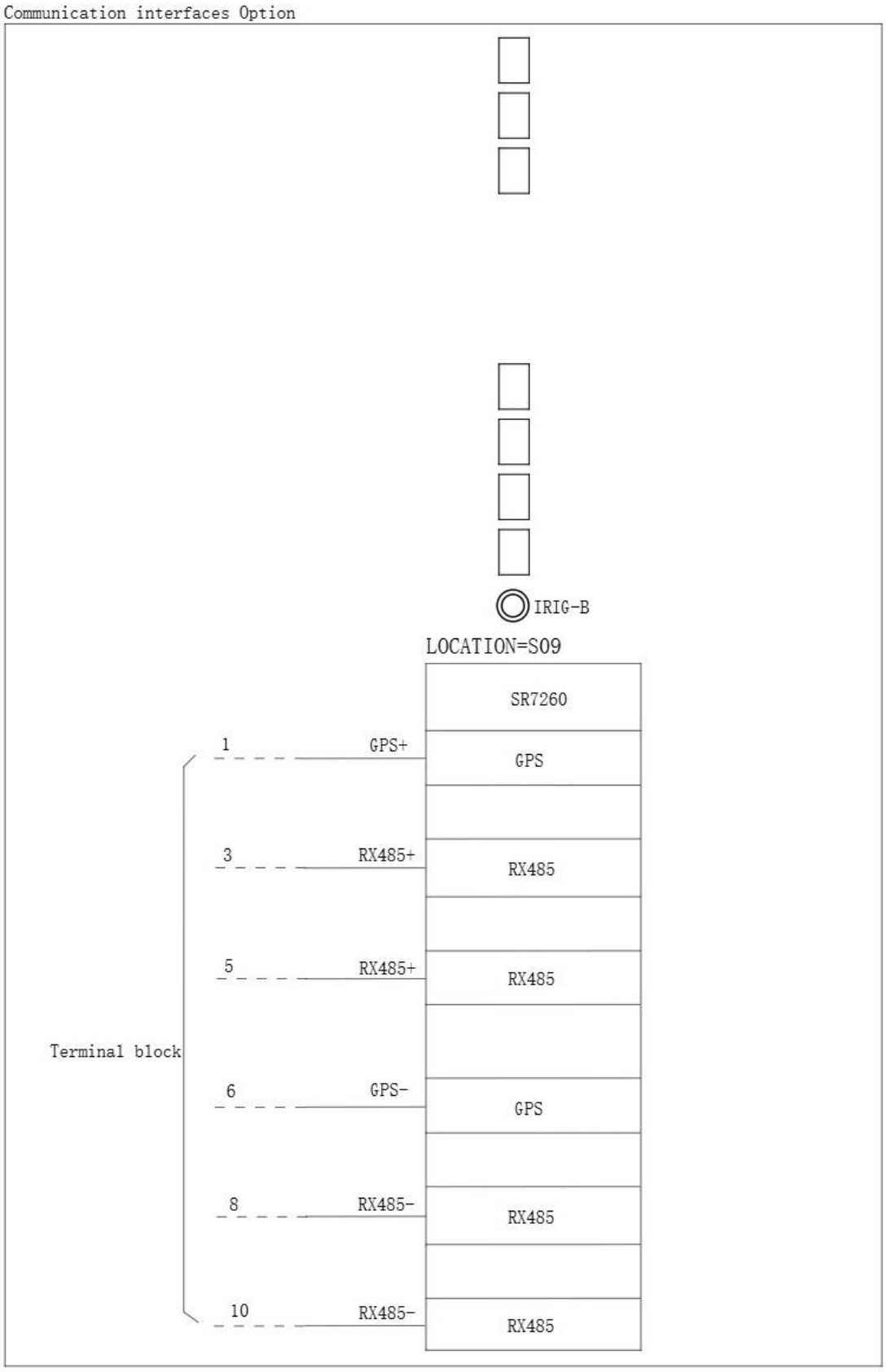


Figure 14.2.1 Communication interfaces

14.3 Structure drawing of BP-2C

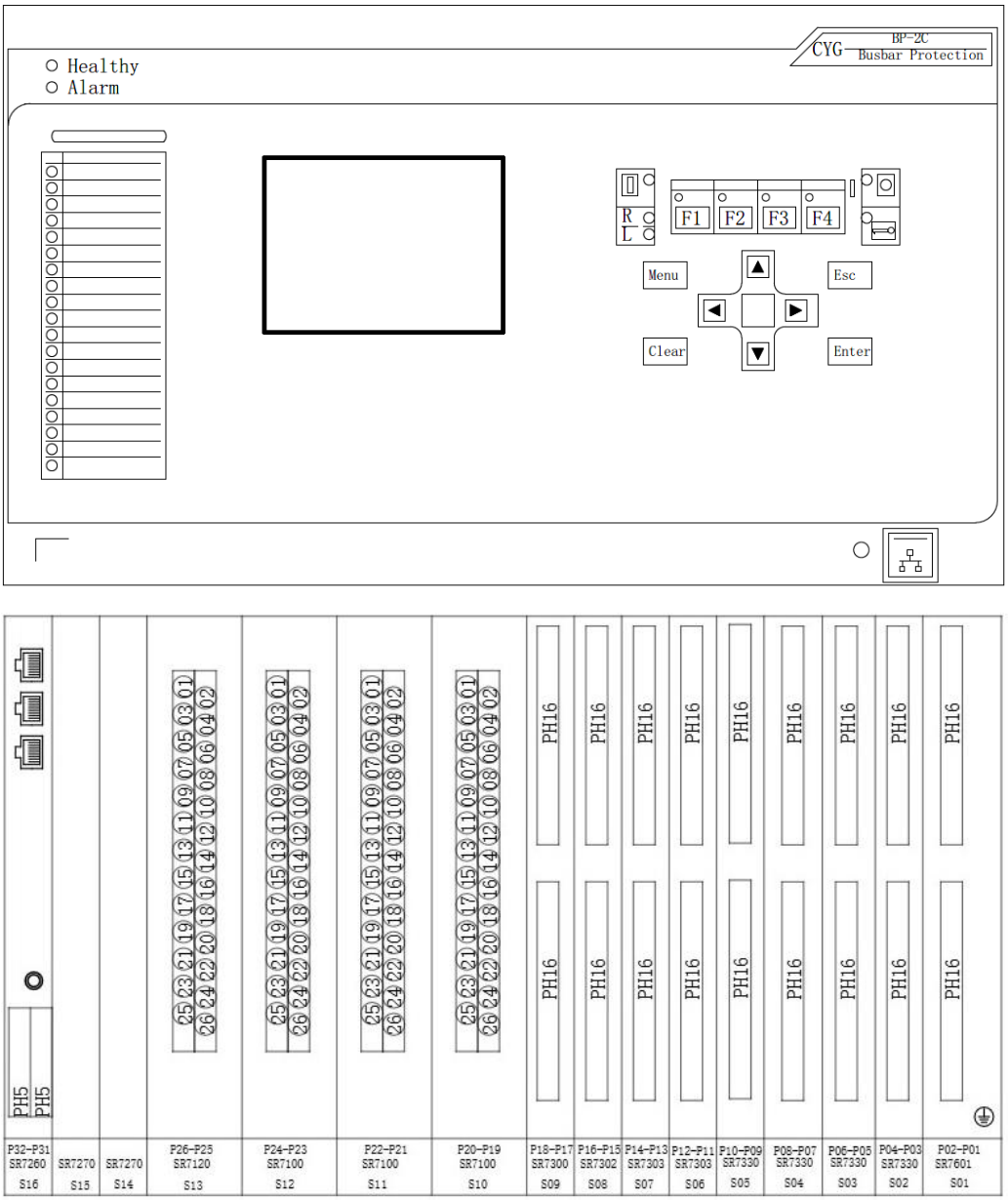
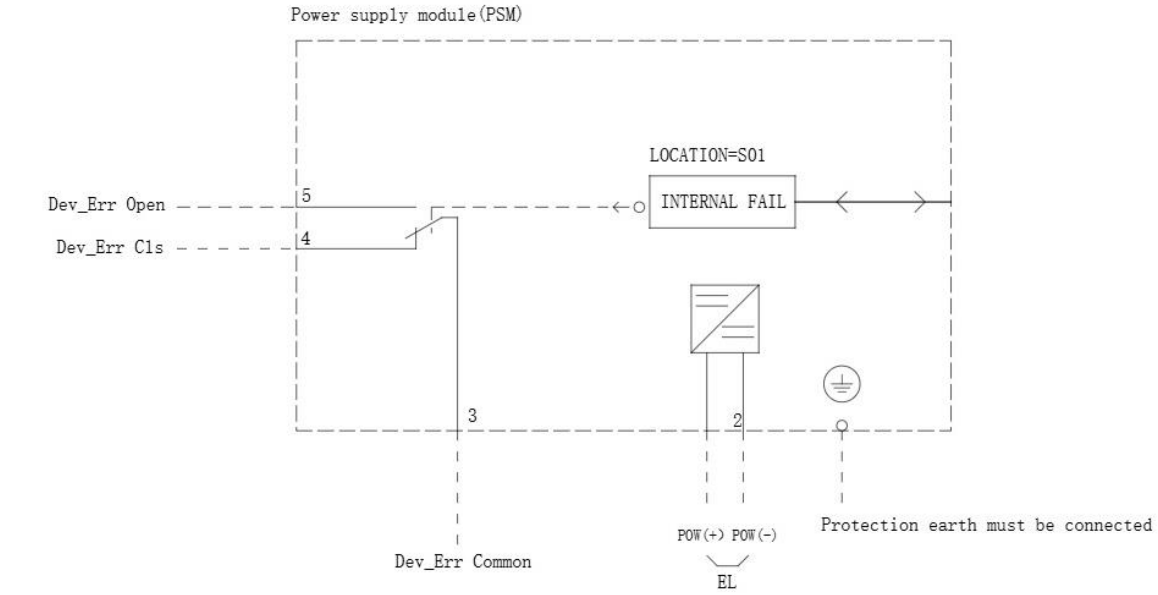


Figure 14.3.1 Drawing of structure

14.4 Modules drawing of BP-2C



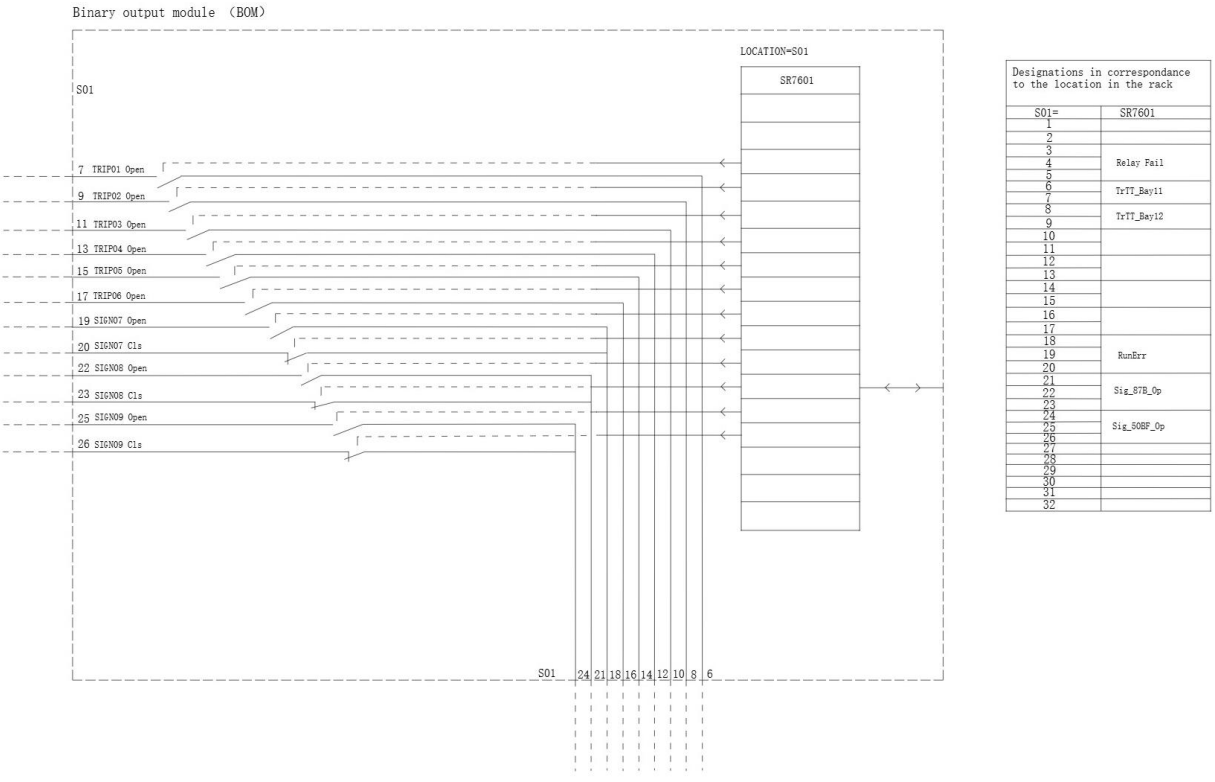


Figure 14.4.1 Power supply module

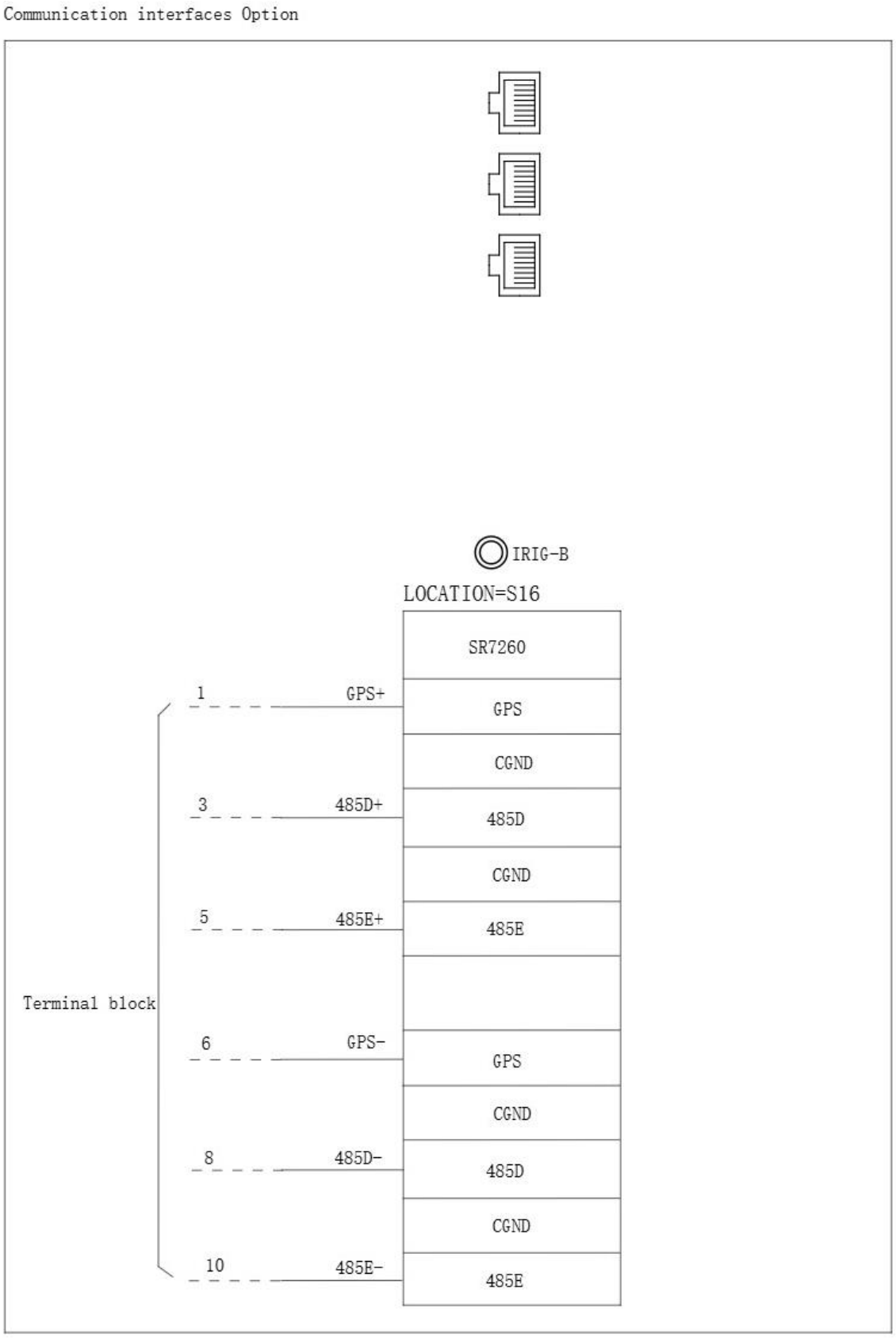


Figure 14.4.2 Communication interfaces

Note: The diagram of all CPU modules are same.

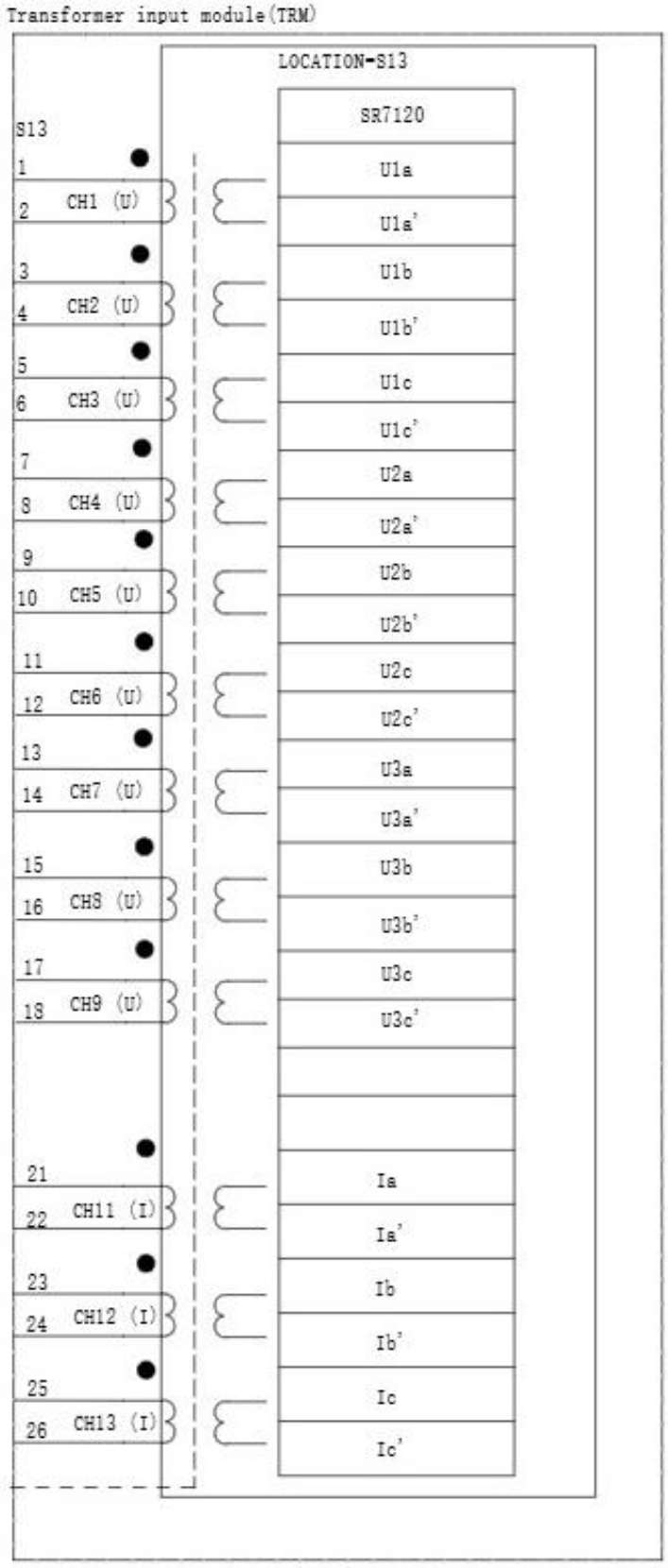


Figure 14.4.3 Transformer input module: SR7120

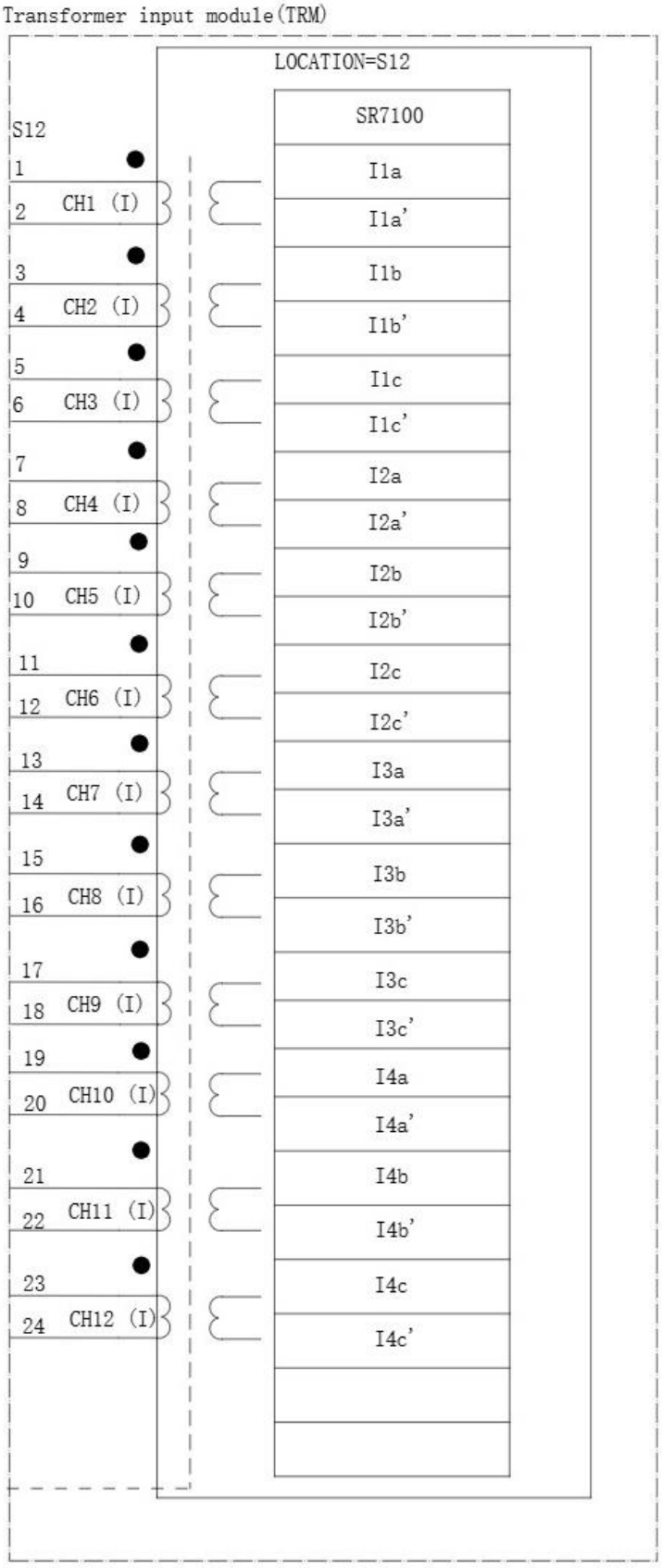
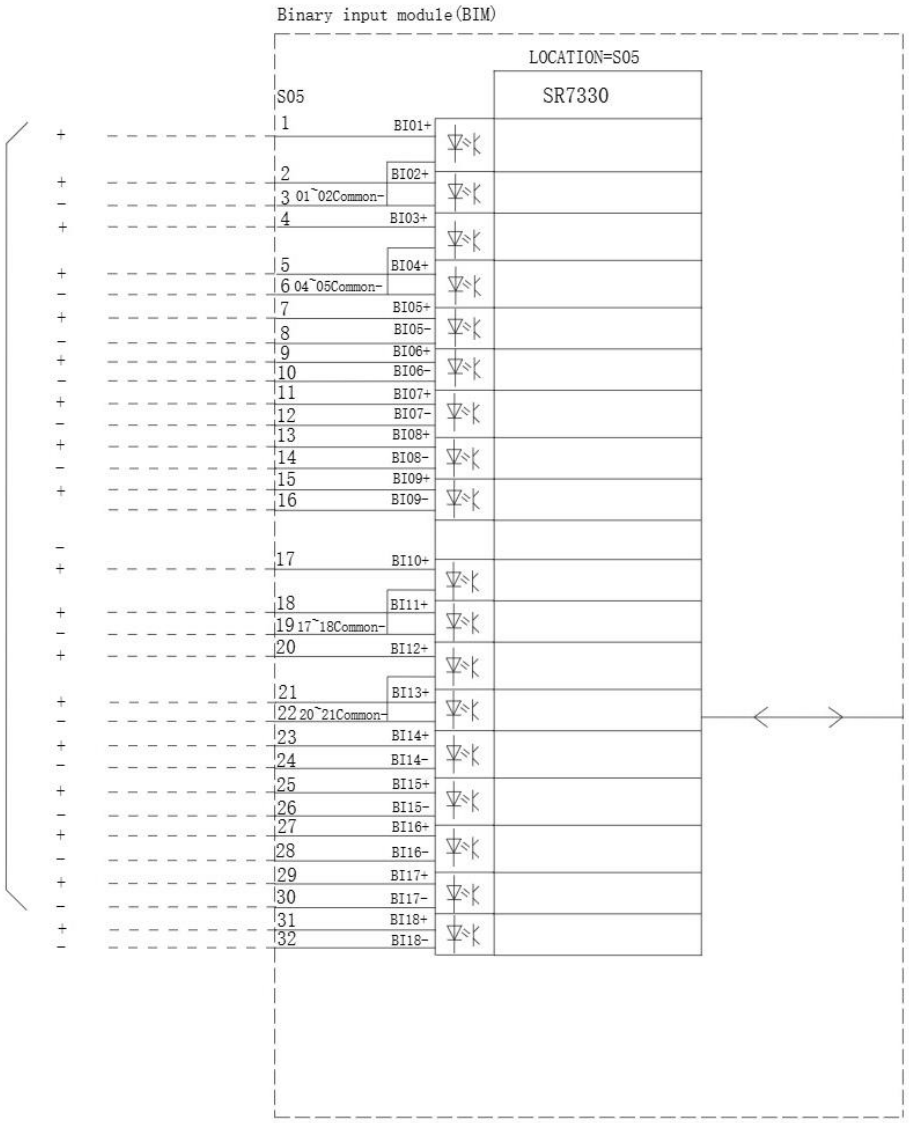


Figure 14.4.4 Transformer input module: SR7100



Designations in correspondance to the location in the rack

S05=	SR7330
1	50BF_BFI_Bay01
2	50BF_BFI_Bay02
3	
4	50BF_BFI_Bay03
5	50BF_BFI_Bay04
6	
7	50BF_BFI_Bay05
8	
9	50BF_BFI_Bay06
10	
11	50BF_BFI_Bay07
12	
13	50BF_BFI_Bay08
14	
15	50BF_BFI_Bay09
16	
17	50BF_BFI_Bay10
18	50BF_BFI_Bay11
19	
20	50BF_BFI_Bay12
21	50BF_BI_R1sVBE
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	

Figure 14.4.5 Binary input module: SR7330

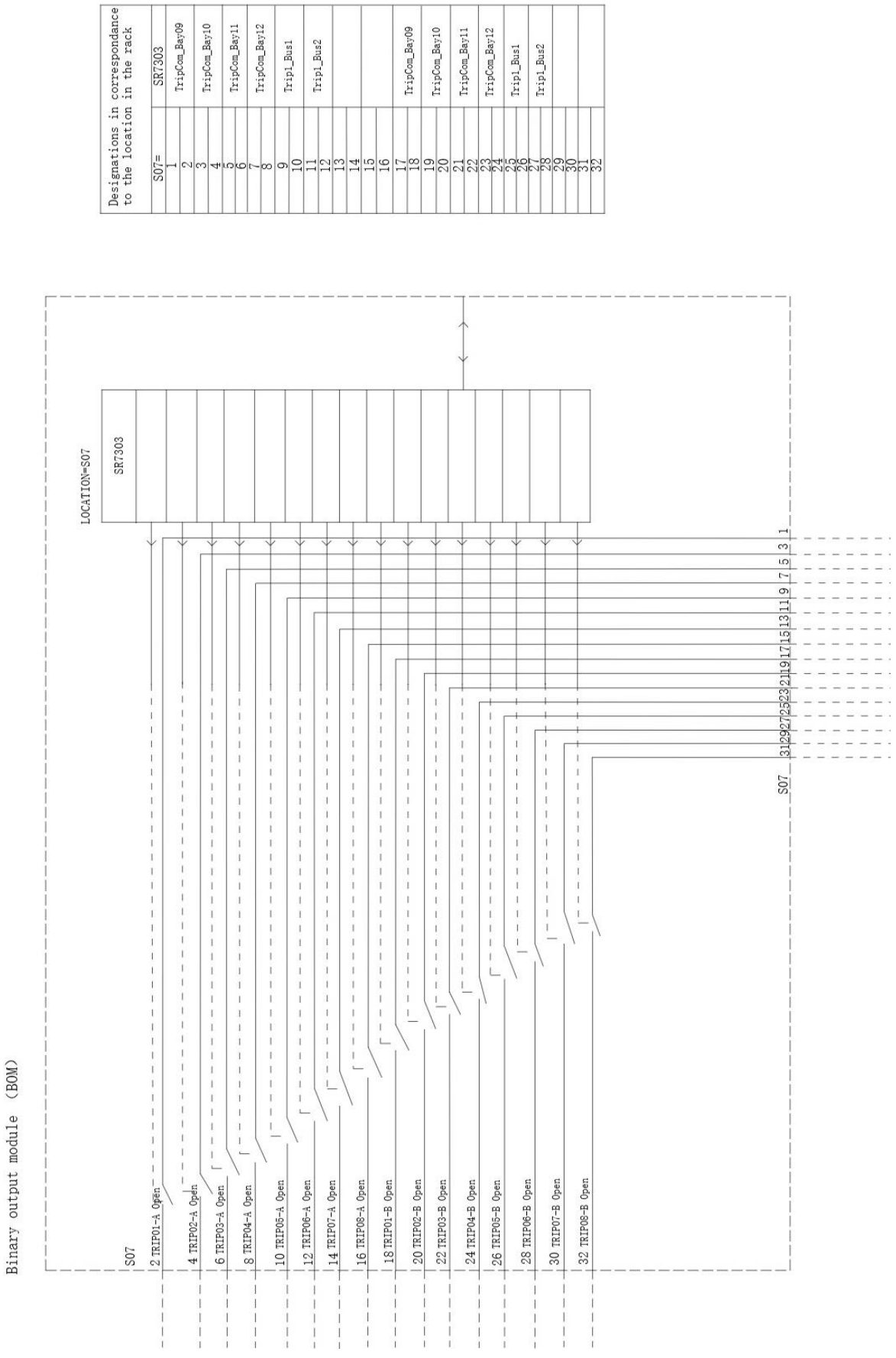


Figure 14.4.6 Binary output module: SR7303

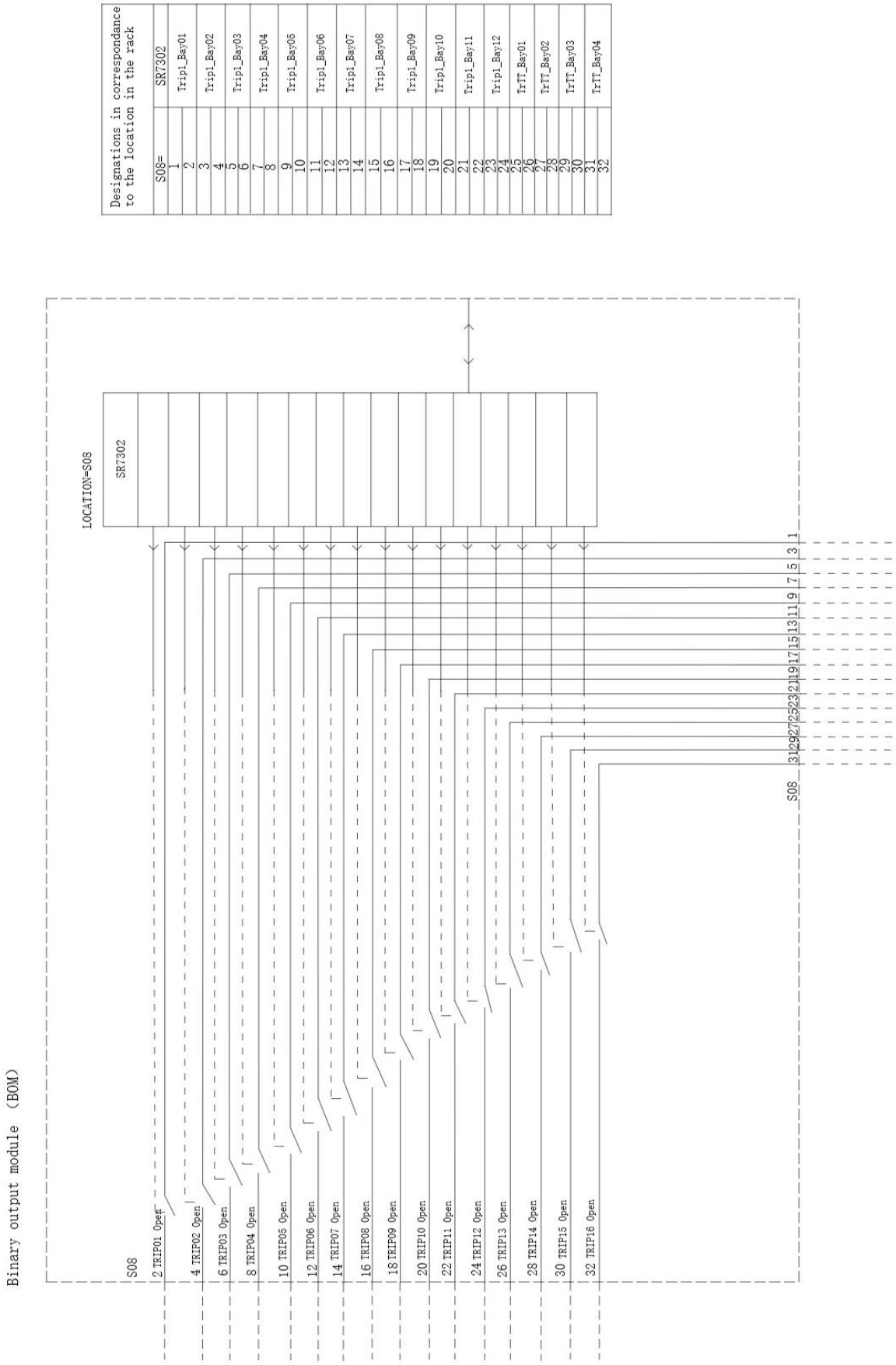


Figure 14.4.7 Binary output module: SR7302

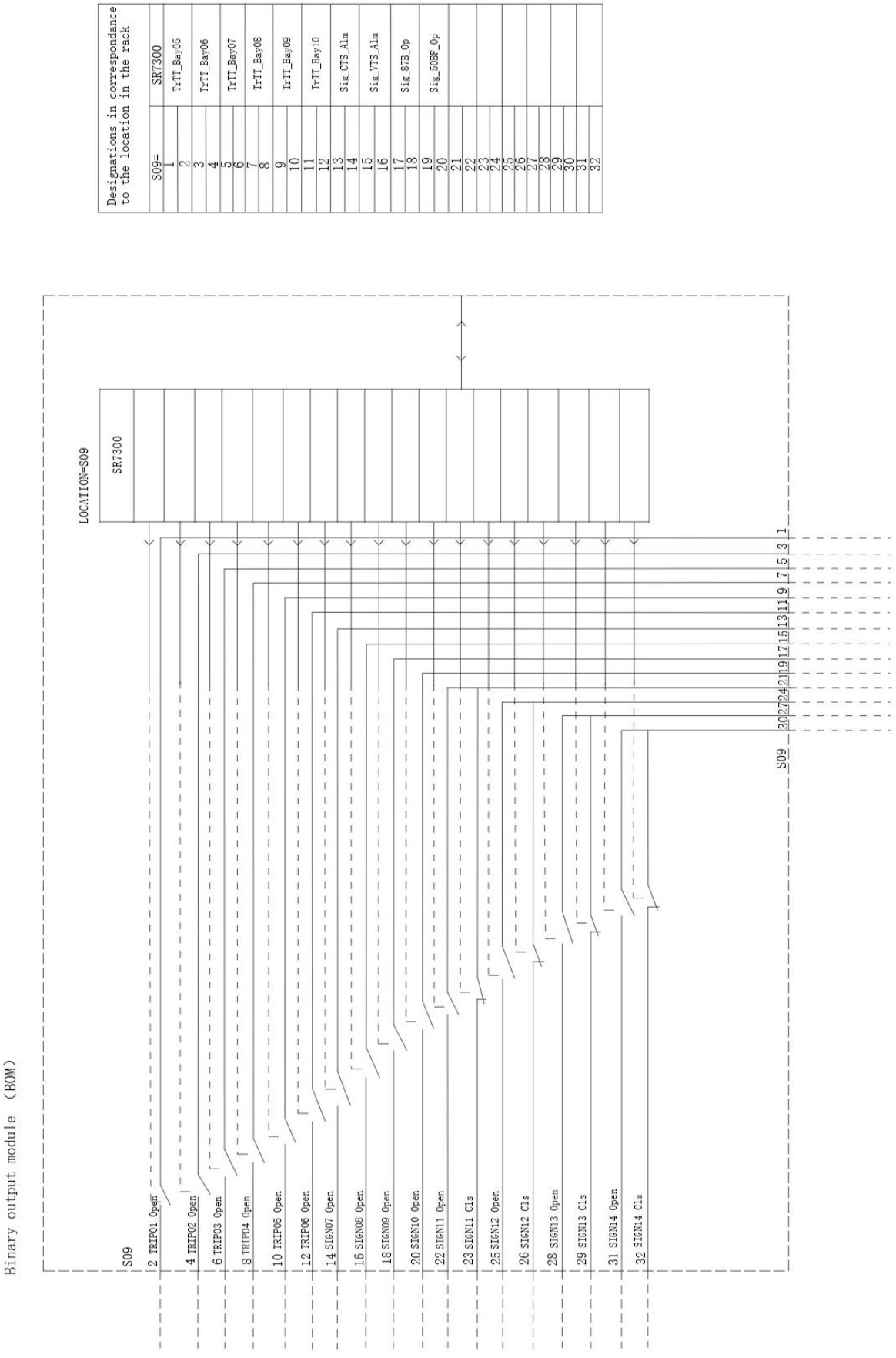


Figure 14.4.8 Binary output module: SR7300

15 Manual Version History

In the current version of the instruction manual, several descriptions on existing features have been modified.

Table 15-1 Manual version and modification history records

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 number of the binary inputs and binary outputs.. Add the binary input hardware demo diagrams in the binary input tables. Update the description of IEC61850 dual-MMS Ethernet.
1.01	1.02	1.02	2016-01-24	Add parameters of fault location function. Output TEMP_RL is added Internal improvements. Update the configurable signals.
1.02	1.03	1.10	2016-08-16	Update the communication description. Update the mechanical specifications. Update the main CPU module picture. Update the setting list.
1.03	2.01	1.20	2017-12-16	Update all the protection functions. Add the “4.2 Supervision Alarm and Block” chapter Increase the amount of the terminal of BI module. Update the logic diagram of the Three-phase thermal overload protection. Update the content of the “9 Communication Protocol” chapter.
2.01	2.02	2.00	2018-2-28	Modify the description of the protection functions. Add programmable IDMT function
2.02	2.03	2.03	2018-9-21	Modify the description of the protection function blocks. Add Chapter 9.6.
2.03	2.04	2.03	2019-10-26	Add the tirp time parameters of busbar differential protection Add the description of overvoltage protection and undervoltage protection. Modify the description of the protection functions. Modify parameters of electrical specifications.
2.04	2.041	2.03	2020-03-26	Modify protection functions and supervision function.
2.04	2.042	2.03	2024-03-14	Modify protection functions.

Manual Version		Software Version	Date	Description of change
Source	New			
				Modify the description of hardware. Add Chapter 8.4. Add Chapter 14.
2.04	2.043	2.03	2024-03-25	Modify the description of hardware. Modify Chapter 14.
2.04	2.045	2.03	2024-08-16	Modify the description of hardware and protection functions and supervision function Modify Chapter 13、14.