COOPER POWER SERIES

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FXD Control User Manual
V1.0

Powering Business Worldwide

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Forward

Please read this chapter carefully before using this product!

This chapter introduces the safety precautions before using this product. Please make sure the content of this chapter is fully read and understood before installation and usage. Our company will not undertake any responsibilities for any damage or injury caused by improper operations because of ignoring relevant warning in below safety items.

Before operating this device, relevant professional personnel shall read this instruction carefully and well understand the content.

Safety items

- When the primary system is live working, secondary open circuit for the current transformer connected to the device is absolutely forbidden, and the open of this circuit may cause extremely dangerous high voltage.
- Take note that during operation of the switch certain parts are subject to dangerous voltage. Mechanical parts, also remote-Controlled, can move quickly. Failure to comply may result in death, severe personal injury, or damage to equipment.
- Installation, operation, and maintenance shall only be carried out by trained and experienced personnel who are familiar with the equipment and the electrical safety requirements.
- The device is only permitted to run in atmospheric environment that specified in the technical specifications, and abnormal vibrations shall be avoided in its running environment.
- When the output terminals of the device are connected to external circuit, please carefully check the voltage of external power to prevent overheating of the circuit.
- Carefully check the cable connected to the device, preventing applying too much external force on it.
- Grounding terminals of the device shall be firmly grounded.

1. INTRODUCTION

Intelligent distribution grid is the combination of traditional power grid and technology innovation of products, the application of sensors enables distribution grid to have the ability to observe the status, the application of control and communication technology enable distribution grid to have the ability of remote control, the application of artificial intelligence technology enables distribution grid to have the ability of self-diagnosis, and most of all, Feeder Terminal Unit (FTU) is the concentrated expression of these abilities.

In distribution power grid, Feeder Terminal Unit (FTU) is the key point to realize feeder automation. Its main function is to realize Fault Detection, Isolation and Restoration (FDIR), reducing outage time, improving reliability of power supply.

With the continuously development of distribution automation worldwide, more and more Feeder Terminal Units are applied in overhead lines, while protecting feeder, implementing local or centralized fault self-recovery control, and by communication network, connecting to SCADA system, realizing remote functions.

1.1 Description

The FXD Control is a fully digitalized and microprocessor-based control device which designed to provide protective coordination and fault clearance of distribution systems for the continuous best quality of electric service.

The FXD Control provides protection, measurements, status monitoring, control, communication, data handling and distribution automation.

The FXD Control contains DT, IDMT and user defined curves according to IEC and ANSI standards to provide fully protective coordination for the continuous best quality of electric distribution. Users can select any time of current curve simply by programming and modifying.

The FXD Control can operate Close and Open and other actions with key buttons on the user interface panel: Hot line tag, Remote Enabled, Reclose Blocked, Battery test, OC Blocked, EF Blocked, SEF Blocked, Alternate-settings, Lamp test, Authorization.

The FXD Control can be managed by software through portable PC for modification of settings, acquisition of event data, and management of operation history.

The FXD Control is a weatherproof cabinet with a door that can be pad lockable, and suitable for mounting on a prestressed concrete pole. A steel channel, fixed to the Control cabinet for mounting purpose, is provided.

1.2 Safety Instructions

General hazard statements applicable to this equipment are described in this section. Statements related to specific tasks or procedures are located throughout this manual.

DANGER! Contact with hazardous voltage can cause death or severe personal injury. Contact with switching module or switch control terminals should only be undertaken when equipment is isolated from applicable sources of voltage.

WARNING! Follow all locally approved safety procedures when installing or operating this equipment. Improper handling, installation, operation, or maintenance can result in death, severe personal injury or damage to equipment.

WARNING! Power distribution equipment must be properly selected and used only for the intended purpose.

1.3 Summary of Features

Protection

- Three-phase Non-directional Over-current Protection (ANSI 50/51)
- Non-directional Earth-fault Protection (ANSI 50N/51N)
- Three-phase Directional Over-current Protection (ANSI 67)
- Directional Earth-fault Protection (ANSI 67N)
- Sensitive Earth-fault Protection (ANSI 50SEF)
- Broken Conductor Protection (ANSI 46BC)
- Inrush restraint Function (ANSI 68)
- Negative-sequence over-current Protection (ANSI 46)
- Three Phase Over-voltage Protection (ANSI 59)
- Three Phase Under-voltage Protection (ANSI 27)
- Negative-sequence Over-voltage Protection (ANSI 47)
- Residual Over-voltage Protection (ANSI 59N)
- Over-frequency Protection (ANSI 81O)
- Under-frequency Protection (ANSI 81U)
- Rate of Change of Frequency Protection (ANSI 81R)
- Circuit Breaker Failure Protection (ANSI 50BF)
- Power Direction Protection (ANSI 32)
- Fault Locator (ANSI FLOC)
- Loss of Phase Function
- Cold Load Pickup Function
- Phase Reverse Detection Function
- Hot Line Tag
- 5 Setting Groups

Measurement

- Phase, Ground and Sensitive Ground Current (Ia, Ib, Ic, Io, I0)
- Line and Phase Voltage on power and load side (Uu, Uv, Uw, Ur, Us, Ut)
- Residual Voltage on power and load side (Uo1, Uo2)
- Single and Three Phase Active Power (Pa, Pb, Pc, Pt)
- Single and Three Phase Reactive Power (Qa, Qb, Qc, Qt)
- Single and Three Phase Apparent Power (Sa, Sb, Sc, St)
- Single and Three Phase Active Energy (EPa, EPb, EPc, EPt)
- Single and Three Phase Reactive Energy (EQa, EQb, EQc, EQt)
- Single and Three Phase Apparent Energy (ESa, ESb, ESc, ESt)
- Single and Three Phase Power Factor (PFa, PFb, PFc, PFt)
- Frequency Magnitude and Rate (F)
- Synchronizing Difference Voltage
- Synchronizing Difference Frequency
- Synchronizing Difference Angle
- Sequence Components of Three Phase Voltages & Currents (I1, I2, Io, U1, U2, Uo)
- True RMS, Harmonics up to 16th and THD of Voltages & Currents
- Demand Currents, Voltages, Power, Energy, Power Factor, Frequency and Harmonics
- Power Quality, Load Profile, Disturbance Recorder Graphs for Analysis
- Battery Voltage (Vdc)

Control

- Open and Close
- Local and Remote
- Reclosing Function (ANSI 79)
- Fast/Delay Curve Selection
- Zone Sequence Coordination
- High Current Trip/Lockout
- Fast Trip Block Function
- Single Shot Function
- Synchronization Check Function (ANSI 25)

- Battery Test (Healthy Condition)
- Lamp Test
- Authorization Setting
- Duty Cycle Preset
- Clear Indications, Events, Fault Records, Disturbance Records, Power Quality, Load Profile
- Function Enable/Disable: Reclosing, Protection, Group Setting, Hot Line Tag

Monitoring

- Protection Start, Trip and Alarm
- Measurement High/Low Alarm and Warn
- Trip Counter Limit
- Duty Cycle
- Open/Close Status
- Local/Remote Status
- Reclosing Status
- Reclosing Lockout
- Reclosing Operation Fail
- Synchronism Check Status
- Synchronism Check Successful
- Synchronism Check Fail
- AC Fail & DC Fail
- Battery Low Alarm
- Battery Activation Status
- Battery Condition
- Door Open Alarm
- Device Internal Fault

Communication

- Front Panel RJ45 Ethernet Port/USB Type B Port: for maintenance
- Rear Panel RS232 & RS485/232 Serial Port: IEC101/ DNP3.0/Modbus for remote
- Rear Panel RJ45 Ethernet Port: IEC61850/IEC104/DNP3.0/ Modbus for remote

Recorder

- Trip and fault counter
- System Event Recorder - last 10,000 events
- Fault Recorder - last 1,024 faults
- Load profile recorder - last 60 days
- Disturbance Recorder - Maximum 500 cycles ×10 (128 samples/cycle)

Distribution Automation

- Loop Automation Scheme
- Auto-changeover Scheme

User Interface

- Large LCD (10 lines * 20 characters)
- Fault Indicators
- 16 Programmable LEDs
- 10 Programmable buttons
- Access Security (Passcode)
- RJ45 Ethernet Debugging Port
- USB Debugging Port

Time/Date Format

- 24H:MM: SS:MS
- 12H:MM: SS:MS
- DD.MM.YYYY
- DD/MM/YYYY
- DD-MM-YYYY
- MM.DD.YYYY
- MM/DD/YYYY
- YYYY-MM-DD
- YYYY-DD-MM
- YYYY/DD/MM

1.4 Abbreviations

ACR	Automatic Circuit Recloser
FTU	Feeder Terminal Unit
IED	Intelligent Electronic Device
FDIR	Fault Detection, Isolation and Restoration
SCADA	Supervisory Control And Data Acquisition
VT	Voltage Transformer
CT	Current Transformer
VS	Voltage Sensor
SA	Surge Arrester
OC	Over Current Protection Element
EF	Earth Fault Protection Element
DOC	Directional Over Current Protection Element
DEF	Directional Earth Fault Protection Element
SEF	Sensitive Earth Fault Protection Element
IR	Inrush Restraint Function Element
NSOC	Negative Sequence Over Current Protection Element
OV	Over Voltage Protection Element
UV	Under Voltage Protection Element
OF	Over Frequency Protection Element
UF	Under Frequency Protection Element
FR	Frequency Rate of change Protection Element
PF	Power Factor
CSM	Current Sequence Measurement
VSM	Voltage Sequence Measurement
CTHD	Current Total Harmonic Distortion
VTHD	Voltage Total Harmonic Distortion
SOE	Sequence of Event
FR	Fault Recorder
DR	Disturbance Recorder
PQM	Power Quality Management
LPD	Load Profile Display
CLP	Cold Load Pickup
HLT	Hot Line Tag
BAT	Battery
Syn-Check	Synchronism Check Function
DT	Definite Time
IDMT	Inverse Definite Minimum Time
NI	Normal Inverse curve
VI	Very Inverse curve
EI	Extremely Inverse curve
MI	Moderately Inverse curve
LEI	Long time Extremely Inverse curve
LVI	Long time Very Inverse curve
LI	Long time Inverse curve
SI	Short time Inverse curve
RMS	Root Mean Square
DFT	Discrete Fourier Transform
HMI	Human Machine Interface
LHMI	Local Human Machine Interface
WHMI	Website Human Machine Interface
OHL	Overhead Line
SBO	Select Before Operate

2. TECHNICAL SPECFICATIONS

2.1. Functional Diagram

A function block diagram of FXD Control is shown as Figure 1. In general, there are several main modules, including Switchgear Reaction Interface, Power Management module, Battery, I/O, Communications and User Interface. Current sensing is provided by three current transformers located in upper apparatus and interfaced to FXD Control via the Control cable. This cable also supplies Open/Close signal and feedbacks Apparatus status. Voltage sensing is connected to the analog inputs module which located on Mainboard.

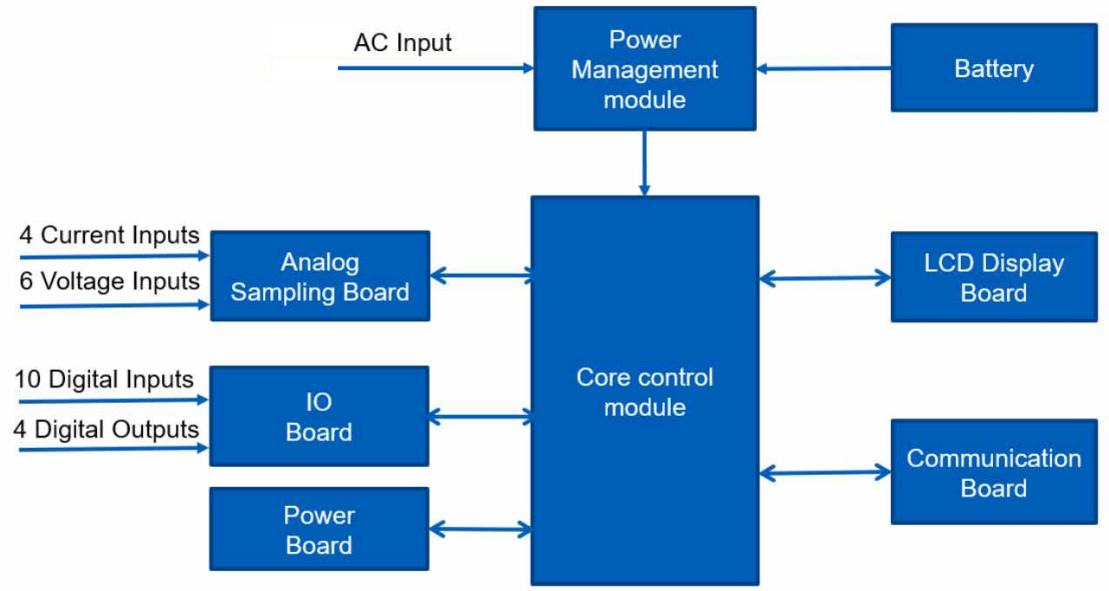


Figure 1 FXD Control Functional Diagram

2.2. Summary of Features

Table 1 FXD Control Summary of Features

Parameter	FXD Control
Power supply range	220V or 120V AC ±20%
Maximum power consumption	<50 W
Rated frequency	50/60Hz
Rechargeable battery voltage & capacity	24V/18AH
Analog input	4Is+6Us
Current transformer input ratio	1A/5A (1)
Binary input/output	10 BI/4BO (2)
Debugging port on front panel	RJ45 Ethernet port
Communication serial port on rear panel	RS232 & RS232/485 serial port
Communication ethernet port on rear panel	RJ45 Ethernet port& USB Debug port
Communication protocol	IEC101/104, DNP3.0, MODBUS, IEC61850 MMS
Temperature range	-40°C +70°C
Humidity range	0~100%
Degree of protection	IP65
Dimension	765*459*354 mm
Weight	55kg

(1) Need to select when ordering.

(2) Standard configuration, up to 20BI/8BO with expand option card if required.

2.3. Standard Compliance

Surge Immunity Test

Standard: IEC60255-26:2023;IEC 61000-4-5:2014

Severity: Level 4

Radiated Emission

Standard: IEC60255-26:2023

Severity: Class A

Electrostatic Discharge Immunity Test

Standard: IEC60255-26:2023; IEC61000-4-2:2008

Severity: Level 4, Class A

Radiated Electromagnetic Field Immunity Test

Standard: IEC60255-26:2023; IEC61000-4-3: 2020

Severity: 10 V/m, Class A

Electrical Fast Transient /Burst Immunity Test

Standard: IEC60255-26:2023; IEC61000-4-4:2012

Severity: Level 4, Class A

Conducted RF Immunity Test

Standard: IEC60255-26:2023; IEC61000-4-6:2013

Severity: Level 4, Class A

Voltage Dips&Short Interruptions Test(AC or DC)

Standard: IEC60255-26:2023; IEC61000-4-11:2020

Class X, Class A

Damped Oscillatory Wave Immunity Test

Standard: IEC60255-26:2023; IEC 61000-4-18:2019

Severity: Level 4, Class A

Cold Test

Standard: IEC60255-1:2022

Severity: -40°C, 16h

Dry Heat Test

Standard: IEC60255-1:2022

Severity: +70°C, 16h

Damp Heat Steady State Cycle

Standard: IEC60255-1:2022

Severity: (40±2)°C,Humidity (93±3)%,10 days

Cyclic Temperature With Humidity Test

Standard: IEC60255-1:2022

Severity:(25±3)°C~ (55±2)°C,Humidity (93±3)%,6 cycles of 24h(12h+12h)

Change of Temperature Test

Standard: IEC60255-1:2022

Severity: -40°C~+70°C, 5 cycles

Vibration Response and endurance

Standard: IEC62271-1: 2017, Clause 7.10.4.5; IEC 60255-21-1:1988

Severity: Class 1

Shock Response, Withstand and Bump

Standard: IEC62271-1: 2017, Clause 7.10.4.5; IEC 60255-21-2:1988

Severity: Class 1

Shock Response, Withstand and Bump

Standard: IEC62271-1: 2017, Clause 7.10.4.5; IEC 60255-21-2:1988

Severity: Class 1

Minimum Tripping Current

Standard: C37.60:2003 Section 6.6

Severity: Phase 20A, Ground 5A

3. USER INTERFACE

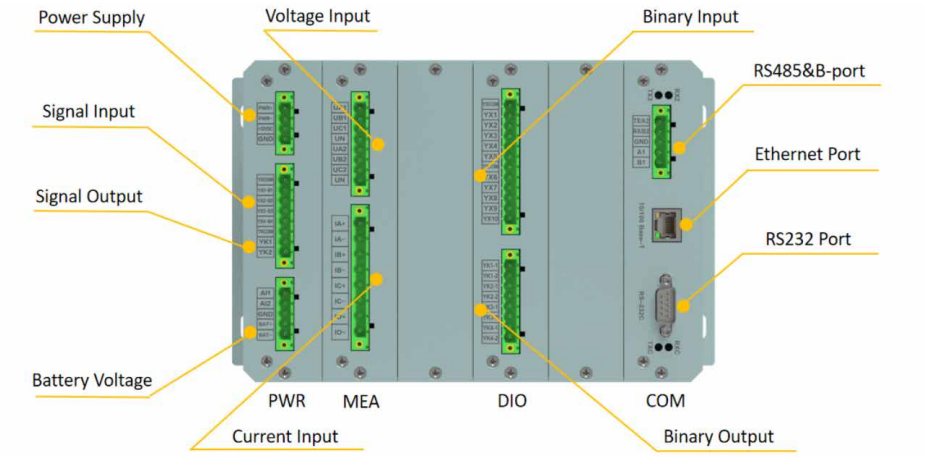


Figure 2 FXD Control layout

3.1. Front Panel

The right picture is FXD Front Panel. It offers extensive operation capabilities:

- →View fault locator results.
- →LCD display
- →Operate Function Buttons

HMI is shown as right, including LED indicators, Operating Buttons and LCD Display. The LCD screen displays ten lines. There are seven buttons in the middle of operation panel, the parameters could be modified by these buttons, and you could view the measured values.

3.2. Led Indication

The two parts are status light of FXD. They provide instant information on the control and status.

PHASE FAULT A/B/C: When a trip signal was issued, one of them was lighted up.

Earth Fault, Sensitive EF: Indicates that a Ground or Sensitive Fault emerged.

Above Min Trip: The fault current which tripped FXD is higher than the pre-programmed min trip.

Voltage Trip: Indicates that a Voltage Fault emerged.

Frequency Trip: Indicates that a Frequency Fault emerged.

Ready, Cycle, Lockout: After pre-programmed operation sequence, the LED indicates the control is in a ready or cycle or locked-out state.

Self-Check: The self-check is used to show the status of protection relay.

AC Power: Indicates the presence of AC Power.

Battery Low: Indicates the presence of Battery Power.

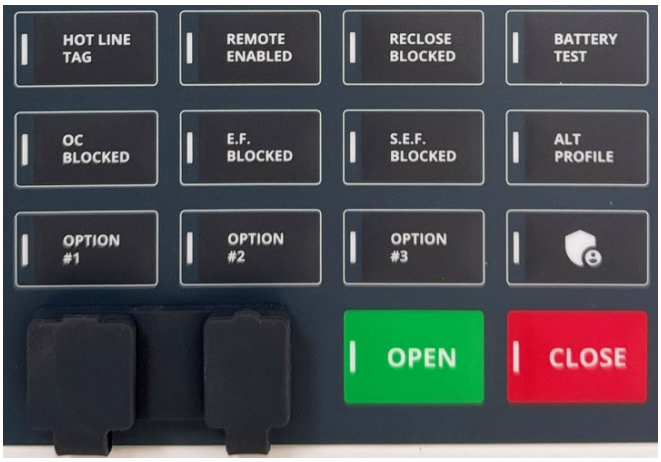
Com Status: It indicates the control is operating normally.

Phase A/B/C/X/Y/Z Voltage: Indicates the presence of voltage of Phase A/B/C/X/Y/Z.

Indicator L1/L2/L3/L4: Reserved indicator lights, which can be adjusted as needed.

3.3. Operation and Function Buttons

There are nine operation buttons on FXD front panel.



Used for Trip operation and Led indicates FXD is in the open position.

Used for Close operation and Led indicates FXD is in the closed position.

Used for protection under hot line. Prevents all closing operations and shifts protection to one trip-to-lockout on the programmed TCC definite time.

Blocks ground trip fault detection.

The FXD Control will reclose automatic when red light is lighted.

Access to operate the six operation and function buttons when the red light is off, else not.

Switch group Normal and ALT#1.

User can define the function of option#1 to option#3.

Authorization button, there are four level authorization for selection:

- Administrator
- Engineer
- Operator
- Viewer

Debugging port

- RJ45 on front panel for debugging
- USB on front panel for debugging.

3.4. LCD Menu Display

The big LCD display is 10 lines and 20 chars. Operating the above seven keys to view or modify all settings and measurements. More details about the seven keys will be explained as follows.

ENTER	It has two main functions, entering into a submenu and saving the modifications the user does.
EDIT	To modify settings, configurations, or values, such as the value of phase minimum trip, press EDIT button to enter the pages.
ESC	Leave current page to previous page.
^	This is a direction key. It moves the cursor upward or adds the value need to be changed.
v	This is also a direction key. It moves the cursor downward or decreases the value need to be changed. The other function of the key is the same as ESC key.
<	One of the functions is the same with ESC key. Another is that when need change a value, it moves the cursor to corresponding bit, then cooperate with up ^ and down v altering the value.
>	Used to move the cursor to corresponding bit, then cooperate with up ^ and down v altering the value. The other function of the key is entering into a submenu.
LAMP TEST	Lamp test button is used to test LED lights.
RESET	Reset button is used to reset the Controller.

4. PRODUCT FUNCTIONALITY

FXD Control offers a comprehensive solution for protecting, metering, and controlling outdoor primary switches, such as automatic circuit recloser. Besides the main protection functions, they include monitoring and operation features as well as distribution automation scheme, events and disturbance records providing data analysis capability in both local and remote.

4.1 Protection

4.1.1 Three-phase Over-current Protection

The three-phase over-current protection is used as one-phase, two-phase or three-phase overcurrent and short-circuit protection for feeders. It can be selected between non-direction and direction.

The function includes three types:

- Fast/Delay inverse time over-current
- Instantaneous time over-current
- Definite time over-current

Inverse time over-current has TC curves including IEC, ANSI and customized curves which can be composed using maintenance software. One of those curves can be selected for fast and delayed operation respectively with different curve adjustments. Depending on reclosing sequence and setting, fast or delayed element is applied for inverse time OC.

Inverse time over-current curve can be easily adjusted by three parameters such as time multiplier, time adder and IDMT minimum operate time.

Instantaneous/definite time over-current operates after a predefined operate time and resets when the fault current disappears.

Three-phase over-current protection can be selected between non-direction and direction. The corresponding IEC / ANSI identifications are shown in below.

Table 2-Three-phase non-directional over-current protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Non-directional OC	3I	50/51P
Directional OC	3I->	67P

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “trip”, “alarm”, “off”, and definite time curves can be “on” and “off” independently.

The operation principle of non-directional OC can be described as below.

The measured phases current is compared with preset start value, if the measured value is greater than preset

start value, the phase selection logic will detect which phase of the measured current exceeds the preset value. If the phase information matches the set value of the start phase number, the timer will activate the pickup signal output. According to the protection curve type, the time characteristics are definite time or inverse definite minimum time. When the timer has reached the value of operate delay time in DT mode or the maximum value in IDMT mode, the alarm or trip signal will be activated.

The operation principle of directional OC can be described as below.

The measured phases current is compared with preset start value, if the measured value is greater than preset start value, and directional calculation is fulfilled fault criteria, the phase selection logic will detect which phase of the measured current exceeds the preset value. If the phase information matches the set value of the start phase number, the timer will activate the pickup signal output. According to the protection curve type, the time characteristics are definite time or inverse definite minimum time. When the timer has reached the value of operate delay time in DT mode or the maximum value in IDMT mode, the alarm or trip signal will be activated.

If the fault suddenly disappears before the operate delay time is reached, the reset delay time is activated. When the definite time characteristic is selected, the timer will not be reset until it exceeds the reset delay time value; when the immediately is selected, the timer will be reset instantaneously after detecting fault disappeared; when the inverse time characteristic is selected, the reset time depends on the current during the drop-off situation. The pickup signal is deactivated when the reset time has expired.

The inverse time reset mode is only supported with ANSI or user programmable types of the IDMT protection curves. If another protection curve type is selected, an immediately reset occurs during the drop-off situation.

The function operates on DFT measurement mode.

The forward and reverse sectors are defined separately. The forward operation area is limited with the min forward angle and max forward angle settings. The reverse operation area is limited with the min reverse angle and max reverse angle settings. The Characteristic angle setting is used to turn the directional characteristic. The following picture describes the angular relationship between voltage and current.

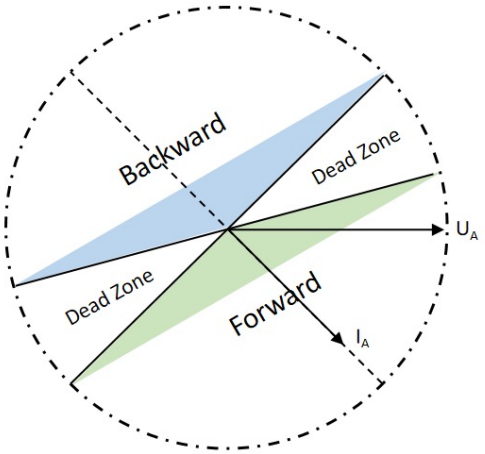


Figure 3 OC directional operating sectors

FXD Control provides 28 protection characteristic curves that including 5 IEC curves, 7 IEEE/ANSI curves, and 14 recloser curves. In addition to this, a user defined curve can be used if none of the standard curves are applicable.

The following table describes the characteristics supported by fast and delay curves.

Table 3-Characteristics supported by different stages

Curve Type	Fast curves	Delay curves
IEC Very Inverse	■	■
IEC Extremely Inverse	■	■
IEC Normal Inverse	■	■
IEC Long Time Inverse	■	■
IEC Short Time Inverse	■	■
ANSI Normal Inverse	■	■
ANSI Very Inverse	■	■
ANSI Extremely Inverse	■	■
ANSI Moderately Inverse	■	■
ANSI Long Time Extremely Inverse	■	■
ANSI Long Time Very Inverse	■	■
ANSI Long Time Inverse	■	■
RI Inverse	■	■
RD Inverse	■	■
Recloser 104 inverse	■	■
Recloser 105 inverse	■	■
Recloser 111 inverse	■	■
Recloser 113 inverse	■	■
Recloser 116 inverse	■	■
Recloser 117 inverse	■	■
Recloser 131 inverse	■	■
Recloser 132 inverse	■	■
Recloser 133 inverse	■	■
Recloser 135 inverse	■	■
Recloser 138 inverse	■	■
Recloser 140 inverse	■	■
Recloser 141 inverse	■	■
Recloser 162 inverse	■	■
User Defined	■	■

The following table shows the parameter settings among OC three stages.

Table 4-Over-current protection parameter settings

Parameter	Range	Default	Step	Unit	Description
OC Protection					
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as “alarm”, the protection will give an alarm without actual trip at fault. The protection would disable if select “off”.
Number of start phases	1 out of 3 2 out of 3 3 out of 3	1 out of 3			Number of phases required for operate activation.
IDMT user defined parameter A	0.0086~120.0000	28.2000			Parameter A for user defined curve.
IDMT user defined parameter B	0.0000~0.7120	0.1217			Parameter B for user defined curve.
IDMT user defined parameter C	0.02~2.00	2.00			Parameter C for user defined curve.
IDMT user defined parameter D	0.46~30.00	29.10			Parameter D for user defined curve.
IDMT user defined parameter E	0.0~1.0	1.0			Parameter E for user defined curve.

Parameter	Range	Default	Step	Unit	Description
Fast/Delay 51					
Start value	5~20000	1600	1	A	This parameter fast/delay starting level of the inverse OC protection.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Definite delay time	0.02~180.00	0.02	0.01	s	The definite OC protection would be alarm or trip if timer exceeded this value.
Fast time multiplier	0.05~15.00	1.00	0.01		Time multiplier in fast IDMT curves.
Fast time adder	0.00~1.00	0.00	0.01	s	Time adder in fast IDMT curves.
Fast IDMT minimum time	0.02~60.00	0.02	0.01	s	Minimum operate time for fast IDMT curves.
Fast IDMT maximum time	0.05~800.00	70.00	0.01	s	Maximum operate time for fast IDMT curves.
Fast time current curve (51)	Refer to table 3	IEC NI			Selection of time delay curve type.
Fast reset curve	Immediately Def.time Inv.time	Immediately			Selection of fast reset curve type.
Delay time multiplier	0.05~15.00	1.00	0.01		Time multiplier in delay IDMT curves.
Delay time adder	0.00~1.00	0.00	0.01	s	Time adder in delay IDMT curves.
Delay IDMT minimum time	0.02~60.00	0.02	0.01	s	Minimum operate time for delay IDMT curves.
Delay IDMT minimum time	0.05~800.00	70.00	0.01	s	Maximum operate time for delay IDMT curves.
Delay time current curve(51)	Refer to table 3	IEC EI			Selection of time delay curve type.
Delay reset curve	Immediately Def.time Inv.time	Immediately			Selection of delay reset curve type.
Instantaneous 50					
Instantaneous 50 operation	On/off	off			Enable/disable instantaneous OC protection.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Instantaneous 50 start value	2~20000	3200	1	A	This parameter Instantaneous starting level of the instantaneous OC protection.
Operate delay time	0.02~60.00	0.02	0.01	s	The Instantaneous OC protection would be alarm or trip if timer exceeded this value.
Lowset					
Lowset operation	On/off	off			Enable/disable definite OC protection.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Lowset start value	5~20000	400	1	A	This parameter defines starting level of the definite OC protection.
Operate delay time	0.02~180.00	0.04	0.01	s	The definite OC protection would be alarm or trip if timer exceeded this value.
Direction					
Allow direction	true false	false			Enable/disable directional OC protection.
Directional mode	forward reverse	forward			Select the operation area.
Characteristic angle	-179~180	60	1	deg	The angle between current and voltage.
Max forward angle	0~90	80	1	deg	Maximum phase angle in forward direction.
Min forward angle	0~90	80	1	deg	Minimum phase angle in forward direction.
Max reverse angle	0~90	80	1	deg	Maximum phase angle in reverse direction.
Min reverse angle	0~90	80	1	deg	Minimum phase angle in reverse direction.

The technical data of function shows below table.

Table 5-Over-current protection technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.005 x In (At currents in the range of 0.05...20.0 x In)
Reset time accuracy in DT	±1.0% or ±20ms
Reset time accuracy in IDMT	±5.0% or ±20ms
Operate time accuracy in DT	±1.0% or ±20ms
Operate time accuracy in IDMT	±5.0% or ±20ms

4.1.2 Earth-fault Protection

The earth-fault function is used as earth-fault protection for feeders. It can be selected between non-direction and direction.

The function includes three stages:

- Fast/Delay inverse time earth-fault
- Instantaneous time earth-fault
- Definite time earth-fault

Inverse time earth-fault has TC curves including IEC, ANSI and customized curves which can be composed using maintenance software. One of those curves can be selected for fast and delayed operation respectively with different curve adjustments. Depending on reclosing

sequence and setting, fast or delayed element is applied for inverse time EF.

Inverse time earth-fault curve can be easily adjusted by three parameters such as time multiplier, time adder and IDMT minimum operate time.

Instantaneous/definite time earth-fault operates after a predefined operate time and resets when the fault current disappears.

Earth-fault protection can be selected between non-direction and direction.The corresponding IEC / ANSI identifications are shown in below.

Table 6 -Earth fault protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Non-directional EF	Io	50/51N
Directional EF	Io->	67N

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “trip”, “alarm”, “off”, and definite time curves can be “on” and “off” independently.

The operation principle of non-directional EF can be described as below.

The measured or calculated residual current is compared with preset start value, if the value is greater than preset start value, the timer will activate the pickup signal output. According to the protection curve type, the time characteristics are definite time or inverse definite minimum time. When the timer has reached the value of operate delay time in DT mode or the maximum value in IDMT mode, the alarm or trip signal will be activated.

The operation principle of directional EF can be described as below.

The measured or calculated residual current is compared with preset start value, if the measured value is greater than preset start value, and directional calculation is fulfilled fault criteria, the timer will activate the pickup signal output. According to the protection curve type, the time characteristics are definite time or inverse definite minimum time. When the timer has reached the value of operate delay time in DT mode or the maximum value in IDMT mode, the alarm or trip signal will be activated.

If the fault suddenly disappears before the operate delay time is reached, the reset delay time is activated. When the definite time characteristic is selected, the timer will not be reset until it exceeds the reset delay time value; when the immediately is selected, the timer will be reset instantaneously after detecting fault disappeared; when the inverse time characteristic is selected, the reset time depends on the current during the drop-off situation. The pickup signal is deactivated when the reset time has expired.

The inverse time reset mode is only supported with ANSI or user programmable types of the IDMT protection curves. If another protection curve type is selected, an immediately reset occurs during the drop-off situation.

The function operates on DFT measurement mode.

The forward and reverse sectors are defined separately. The forward operation area is limited with the min forward angle and max forward angle settings. The reverse operation area is limited with the min reverse angle and max reverse angle settings. The Characteristic angle setting is used to turn the directional characteristic. The following picture describes the angular relationship between residual voltage and residual current.

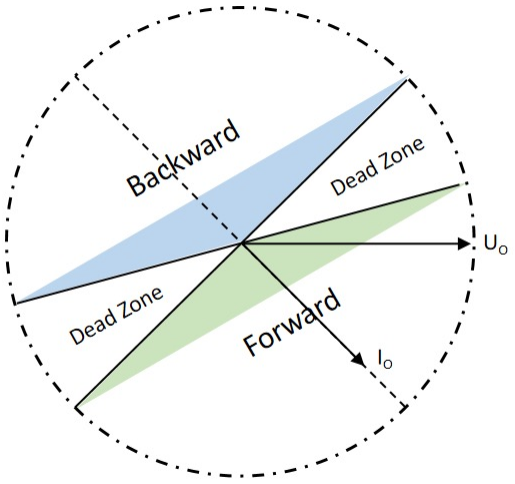


Figure 4 EF directional operating sectors

FXD Control provides 28 protection characteristic curves that including 5 IEC curves, 7 IEEE/ANSI curves, and 14 recloser curves. In addition to this, a user defined curve can be used if none of the standard curves are applicable.

The following table describes the characteristics supported by fast and delay curves.

Table 7-Characteristics supported by different Curves

Curve Type	Fast curves	Delay curves
IEC Very Inverse	■	■
IEC Extremely Inverse	■	■
IEC Normal Inverse	■	■
IEC Long Time Inverse	■	■
IEC Short Time Inverse	■	■
ANSI Normal Inverse	■	■
ANSI Very Inverse	■	■
ANSI Extremely Inverse	■	■
ANSI Moderately Inverse	■	■
ANSI Long Time Extremely Inverse	■	■
ANSI Long Time Very Inverse	■	■
ANSI Long Time Inverse	■	■
RI Inverse	■	■
RD Inverse	■	■
Recloser 104 inverse	■	■
Recloser 105 inverse	■	■
Recloser 111 inverse	■	■
Recloser 113 inverse	■	■
Recloser 116 inverse	■	■
Recloser 117 inverse	■	■
Recloser 131 inverse	■	■
Recloser 132 inverse	■	■
Recloser 133 inverse	■	■
Recloser 135 inverse	■	■
Recloser 138 inverse	■	■
Recloser 140 inverse	■	■
Recloser 141 inverse	■	■
Recloser 162 inverse	■	■
User Defined	■	■

The following table shows the parameter settings among earth-fault protection.

Table 8-Earth fault protection parameter settings

Parameter	Range	Default	Step	Unit	Description
EF protection					
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as “alarm”, the protection will give an alarm without actual trip at fault. The protection would disabled if select “off”.
IDMT user defined parameter A	0.0086~120.0000	28.2000			Parameter A for user defined curve.
IDMT user defined parameter B	0.0000~0.7120	0.1217			Parameter B for user defined curve.
IDMT user defined parameter C	0.02~2.00	2.00			Parameter C for user defined curve.
IDMT user defined parameter D	0.46~30.00	29.10			Parameter D for user defined curve.
IDMT user defined parameter E	0.0~1.0	1.0			Parameter E for user defined curve.
Fast/delay 51					
Start value	2~20000	1000	1	A	This parameter fast/delay starting level of the inverse EF protection.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.

Parameter	Range	Default	Step	Unit	Description
Definite delay time	0.02~180.00	0.02	0.01	s	The definite EF protection would be alarm or trip if timer exceeded this value.
Fast time multiplier	0.05~15.00	1.00	0.01		Time multiplier in fast IDMT curves.
Fast time adder	0.00~1.00	0.00	0.01	s	Time adder in fast IDMT curves.
Fast IDMT minimum time	0.02~60.00	0.02	0.01	s	Minimum operate time for fast IDMT curves.
Fast IDMT maximum time	0.05~800.00	70.00	0.01	s	Maximum operate time for fast IDMT curves.
Fast time current curve (51N)	Refer to table 7	IEC NI			Selection of time delay curve type.
Fast reset curve	Immediately Def.time Inv.time	Immediately			Selection of fast reset curve type.
Delay time multiplier	0.05~15.00	1.00	0.01		Time multiplier in delay IDMT curves.
Delay time adder	0.00~1.00	0.00	0.01	s	Time adder in delay IDMT curves.
Delay IDMT minimum time	0.02~60.00	0.02	0.01	s	Minimum operate time for delay IDMT curves.
Delay IDMT maximum time	0.05~800.00	70.00	0.01	s	Maximum operate time for delay IDMT curves.
Delay time current curve(51N)	Refer to table 7	IEC EI			Selection of time delay curve type.
Delay reset curve	Immediately Def.time Inv.time	Immediately			Selection of delay reset curve type.
Instantaneous 50N					
Instantaneous 50N operation	On/off	off			Enable/disable instantaneous EF protection.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Instantaneous 50N start value	2~20000	3200	1	A	This parameter Instantaneous starting level of the instantaneous EF protection.
Operate delay time	0.02~60.00	0.02	0.01	s	The Instantaneous EF protection would be alarm or trip if timer exceeded this value.
Lowset					
Lowset operation	On/off	off			Enable/disable definite EF protection.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Lowset start value	5~20000	200	1	A	This parameter defines starting level of the definite EF protection.
Operate delay time	0.02~180.00	0.04	0.01	s	The definite EF protection would be alarm or trip if timer exceeded this value.
Direction					
Voltage limit start value	0.01~1.00	0.04	0.01	xUn	This parameter defines starting level of the voltage.
Allow direction	true false	false			Enable/disable directional EF protection.
Directional mode	forward reverse	forward			Select the operation area.
Characteristic angle	-179~180	-90	1	deg	The angle between current and voltage.
Max forward angle	0~90	80	1	deg	Maximum phase angle in forward direction.
Min forward angle	0~90	80	1	deg	Minimum phase angle in forward direction.
Max reverse angle	0~90	80	1	deg	Maximum phase angle in reverse direction.
Min reverse angle	0~90	80	1	deg	Minimum phase angle in reverse direction.

The technical data of function shows below table.

Table 9-Earth fault protection technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.005 x In (At currents in the range of 0.01...20.0 x In)
Reset time accuracy in DT	±1.0% or ±20ms
Reset time accuracy in IDMT	±5.0% or ±20ms
Operate time accuracy in DT	±1.0% or ±20ms
Operate time accuracy in IDMT	±5.0% or ±20ms

4.1.3 Sensitive Earth-fault Protection

On the isolated or compensated network, it is hard to detect the earth fault current because it is too small to discriminate. In case of earth fault in the isolated network, the fault current is charged current in the stray capacitance of the line. The magnitude depends on number of feeders connected and length of the feeders. In addition, when an earth fault occurs, charged currents flow into the faulted point from all feeders.

In order to detect this kind of earth fault, the accurate residual current is needed. Generally, the core balance current transformer is used to detect residual current accurately, and then FXD Control can measure the current precisely even though it is very small. In addition, the residual current can also be detected by the way of connection of three phase CTs, but the precision will decrease, because the fault current and CT error current from load currents can't be distinguished. It means the earth fault on isolated network can't be detected securely with residual CT connection. Therefore, the core balance CT is absolutely required for this protection function SEF.

Sensitive earth-fault protection can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). In the DT mode, the function operates after a predefined operate time and resets when the fault current disappears. The IDMT mode provides current-dependent timer characteristics.

The corresponding IEC/ANSI identifications are shown in below.

Table 10-Sensitive earth-fault protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Sensitive earth-fault	I0>	50SEF

The function can be enabled and disabled with the Operation setting, corresponding parameter values are "trip", "alarm", "off".

The operation principle of SEF can be described as below.

The measured or calculated residual current is compared with preset start value, if the value is greater than preset start value, the timer will activate the pickup signal output. According to the protection curve type, the time characteristics are definite time or inverse definite minimum time. When the timer has reached the value of operate delay time in DT mode or the maximum value in IDMT mode, the alarm or trip signal will be activated.

Moreover, the zero-sequence voltage is used to give the direction for the SEF. Zero sequence voltage will be calculated internally from 3 phase voltage sensors. Thus, SEF function determines the fault direction with the phase relationship between the zero-sequence current and zero sequence voltage. If the measured value is greater than preset start value, and directional calculation is fulfilled fault criteria, the timer will activate the pickup signal output. The function will trip Recloser or just give an alarm depending on setting.

If the fault suddenly disappears before the operate delay time is reached, the reset delay time is activated. When the definite time characteristic is selected, the timer will not be reset until it exceeds the reset delay time value; when the immediately is selected, the timer will be reset instantaneously after detecting fault disappeared; when the inverse time characteristic is selected, the reset time depends on the current during the drop-off situation. The pickup signal is deactivated when the reset time has expired.

The inverse time reset mode is only supported with ANSI or user programmable types of the IDMT protection curves. If another protection curve type is selected, an immediately reset occurs during the drop-off situation.

The function operates on DFT measurement mode.

FXD Control provides 15 protection characteristic curves that including 5 IEC curves and 7 IEEE/ANSI curves. In addition to this, a user defined curve can be used if none of the standard curves are applicable.

The following table shows the parameter settings among SEF protection.

Table 11-Sensitive earth-fault protection parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as “alarm”, the protection will give an alarm without actual trip at fault. The protection would disabled if select “off”.
IDMT user defined parameter A	0.0086~120.0000	28.2000			Parameter A for user defined curve.
IDMT user defined parameter B	0.0000~0.7120	0.1217			Parameter B for user defined curve.
IDMT user defined parameter C	0.02~2.00	2.00			Parameter C for user defined curve.
IDMT user defined parameter D	0.46~30.00	29.10			Parameter D for user defined curve.
IDMT user defined parameter E	0.0~1.0	1.0			Parameter E for user defined curve.
start value	0.1~40.0	5.0	0.1	A	This parameter defines starting level of the SEF protection.
Time multiplier	0.05~15.00	1.00	0.01		Time multiplier in IDMT curves.
Time adder	0.00~1.00	0.00	0.01	s	Time adder in IDMT curves.
IDMT minimum time	0.02~60.00	0.02	0.01	s	Minimum operate time for IDMT curves.
IDMT maximum time	0.05~800.00	70	0.01	s	Maximum operate time for IDMT curves.
Definite delay time	0.04~180.00	0.04	0.01	s	The protection would be alarm or trip if timer exceeded this value.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Protection curve type	Off Def. Time IEC VI IEC EI IEC NI IEC LI IEC SI ANSI NI ANSI VI ANSI EI ANSI MI ANSI LEI ANSI LVI ANSI LNI RI Inv. RD Inv User defined	Def. Time			Selection of time delay curve type.
Reset curve type	Immediately Def.time Inv.time	Immediately			Selection of reset curve type.
Voltage limit start value	0.01~1.00	0.01	0.01	xUn	This parameter defines starting level of the voltage.
Allow direction	true false	false			Enable/disable directional SEF protection.
Directional mode	forward reverse	forward			Select the operation area.
Characteristic angle	-179~180	-90	1	deg	The angle between current and voltage.
Max forward angle	0~90	80	1	deg	Maximum phase angle in forward direction.
Min forward angle	0~90	80	1	deg	Minimum phase angle in forward direction.
Max reverse angle	0~90	80	1	deg	Maximum phase angle in reverse direction.
Min reverse angle	0~90	80	1	deg	Minimum phase angle in reverse direction.

The technical data of function shows below table.

Table 12-Sensitive earth-fault protection technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.001 x In (At currents in the range of 0.002...2.0 x In)
Reset time accuracy in DT	±1.0% or ±20ms
Reset time accuracy in IDMT	±5.0% or ±20ms
Operate time accuracy in DT	±1.0% or ±20ms
Operate time accuracy in IDMT	±5.0% or ±20ms

4.1.4 Negative-sequence Over-current Protection

The negative-sequence over-current protection is used to detect one phase, two phases faults or unbalanced loads due to broken conductor or unsymmetrical situations.

The function includes three types:

- Fast/Delay inverse time negative-sequence over-current
- Instantaneous inverse time negative-sequence over-current
- Definite time negative-sequence over-current

Inverse time negative-sequence over-current has TC curves including IEC, ANSI and customized curves which can be composed using maintenance software. One of those curves can be selected for fast and delayed operation respectively with different curve adjustments. Depending on reclosing sequence and setting, fast or delayed element is applied for inverse time NSOC.

Inverse time negative-sequence over-current curve can be easily adjusted by three parameters such as time multiplier, time adder and IDMT minimum operate time.

Instantaneous/definite time negative-sequence over-current operates after a predefined operate time and resets when the fault current disappears.

Negative-sequence over-current protection can be selected between non-direction and direction. The corresponding IEC/ANSI identifications are shown in below.

Table 13-Negative-sequence over-current protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Negative-sequence over-current	I2>	46

The function can be enabled and disabled with the The The function can be enabled and disabled with the Operation setting, corresponding parameter values are “trip”, “alarm”, “off”, and definite time curves can be “on” and “off” independently. The operation principle of non-directional NSOC can be described as below. The calculated negative current is compared with preset start value, if the value is greater than preset start value, the timer will activate the pickup signal output. According to the protection curve type, the time characteristics are definite time or inverse definite minimum time. When the timer has reached the value of operate delay time in DT mode or the maximum value in IDMT mode, the alarm or trip signal will be activated.

The operation principle of directional NSOC can be described as below. The negative-sequence voltage is used to give the direction for the NSOC. Negative-sequence voltage will be calculated internally from 3 phase voltage sensors. Thus, NSOC function determines the fault direction with the phase relationship between the negative-sequence current and negative-sequence voltage. If the measured negative current value is greater than preset start value, and directional calculation is fulfilled fault criteria, the timer will activate the pickup signal output.

If the fault suddenly disappears before the operate delay time is reached, the reset delay time is activated. When the definite time characteristic is selected, the timer will not be reset until it exceeds the reset delay time value; when the immediately is selected, the timer will be reset instantaneously after detecting fault disappeared; when the inverse time characteristic is selected, the reset time depends on the current during the drop-off situation. The pickup signal is deactivated when the reset time has expired.

The inverse time reset mode is only supported with ANSI or user programmable types of the IDMT protection curves. If another protection curve type is selected, an immediately reset occurs during the drop-off situation.

The forward and reverse sectors are defined separately. The forward operation area is limited with the min forward angle and max forward angle settings. The reverse operation area is limited with the min reverse angle and max reverse angle settings. The Characteristic angle setting is used to turn the directional characteristic. The following picture describes the angular relationship between negative-sequence voltage and negative-sequence current.

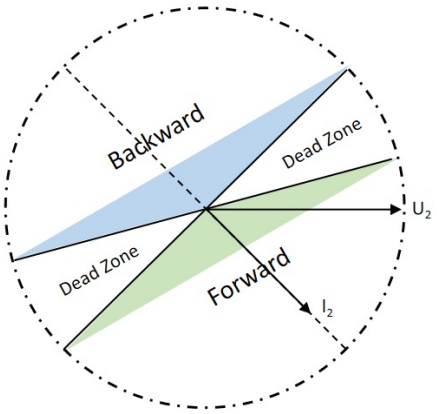


Figure 5 NSOC directional operating sectors

FXD Control provides 28 protection characteristic curves that including 5 IEC curves and 7 IEEE/ANSI curves, and 14 recloser curves. In addition to this, a user defined curve can be used if none of the standard curves are applicable.

The following table describes the characteristics supported by fast and delay curves.

Table 14-Characteristics supported by different curves.

Curve Type	Fast curves	Delay curves
IEC Very Inverse	■	■
IEC Extremely Inverse	■	■
IEC Normal Inverse	■	■
IEC Long Time Inverse	■	■
IEC Short Time Inverse	■	■
ANSI Normal Inverse	■	■
ANSI Very Inverse	■	■
ANSI Extremely Inverse	■	■
ANSI Moderately Inverse	■	■
ANSI Long Time Extremely Inverse	■	■
ANSI Long Time Very Inverse	■	■
ANSI Long Time Inverse	■	■
RI Inverse	■	■
RD Inverse	■	■
Recloser 104 inverse	■	■
Recloser 105 inverse	■	■
Recloser 111 inverse	■	■
Recloser 113 inverse	■	■
Recloser 116 inverse	■	■
Recloser 117 inverse	■	■
Recloser 131 inverse	■	■
Recloser 132 inverse	■	■
Recloser 133 inverse	■	■
Recloser 135 inverse	■	■
Recloser 138 inverse	■	■
Recloser 140 inverse	■	■
Recloser 141 inverse	■	■
Recloser 162 inverse	■	■
User Defined	■	■

The following table shows the parameter settings among NSOC protection.

Table 15-Negative-sequence over-current protection parameter settings

Parameter	Range	Default	Step	Unit	Description
NSOC protection					
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as “alarm”, the protection will give an alarm without actual trip at fault. The protection would disable if select “off”.
IDMT user defined parameter A	0.0086~120.0000	28.2000			Parameter A for user defined curve.
IDMT user defined parameter B	0.0000~0.7120	0.1217			Parameter B for user defined curve.
IDMT user defined parameter C	0.02~2.00	2.00			Parameter C for user defined curve.
IDMT user defined parameter D	0.46~30.00	29.10			Parameter D for user defined curve.
IDMT user defined parameter E	0.0~1.0	1.0			Parameter E for user defined curve.
Fast/delay 46					
Start value	5~20000	1600	1	A	This parameter fast/delay starting level of the inverse NSOC protection.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.

Parameter	Range	Default	Step	Unit	Description
Definite delay time	0.02~180.00	0.02	0.01	s	The definite NSOC protection would be alarm or trip if timer exceeded this value.
Fast time multiplier	0.05~15.00	1.00	0.01		Time multiplier in fast IDMT curves.
Fast time adder	0.00~1.00	0.00	0.01	s	Time adder in fast IDMT curves.
Fast IDMT minimum time	0.02~60.00	0.02	0.01	s	Minimum operate time for fast IDMT curves.
Fast IDMT maximum time	0.05~800.00	70.00	0.01	s	Maximum operate time for fast IDMT curves.
Fast time current curve (46)	Refer to table 14	IEC NI			Selection of time delay curve type.
Fast reset curve	Immediately Def.time Inv.time	Immediately			Selection of fast reset curve type.
Delay time multiplier	0.05~15.00	1.00	0.01		Time multiplier in delay IDMT curves.
Delay time adder	0.00~1.00	0.00	0.01	s	Time adder in delay IDMT curves.
Delay IDMT minimum time	0.02~60.00	0.02	0.01	s	Minimum operate time for delay IDMT curves.
Delay IDMT maximum time	0.05~800.00	70.00	0.01	s	Maximum operate time for delay IDMT curves.
Delay time current curve(46)	Refer to table 14	IEC EI			Selection of time delay curve type.
Delay reset curve	Immediately Def.time Inv.time	Immediately			Selection of delay reset curve type.
Fast/delay 46					
Instantaneous 46 operation	On/off	off			Enable/disable instantaneous NSOC protection.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Instantaneous 46 start value	2~20000	3200	1	A	This parameter Instantaneous starting level of the instantaneous NSOC protection.
Operate delay time	0.02~60.00	0.02	0.01	s	The Instantaneous NSOC protection would be alarm or trip if timer exceeded this value.
Lowset					
Lowset operation	On/off	off			Enable/disable definite NSOC protection.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Lowset start value	5~20000	400	1	A	This parameter defines starting level of the definite NSOC protection.
Operate delay time	0.06~180.00	0.06	0.01	s	The definite NSOC protection would be alarm or trip if timer exceeded this value.
Direction					
Allow direction	true false	false			Enable/disable directional NSOC protection.
Directional mode	forward reverse	forward			Select the operation area.
Characteristic angle	-179~180	60	1	deg	The angle between current and voltage.
Max forward angle	0~90	80	1	deg	Maximum phase angle in forward direction.
Min forward angle	0~90	80	1	deg	Minimum phase angle in forward direction.
Max reverse angle	0~90	80	1	deg	Maximum phase angle in reverse direction.
Min reverse angle	0~90	80	1	deg	Minimum phase angle in reverse direction.

The technical data of function shows below table.

Table 16-Negative-sequence over-current protection technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.005 x In (At currents in the range of 0.01...5.0 x In)
Reset time accuracy in DT	±1.0% or ±20ms
Reset time accuracy in IDMT	±5.0% or ±20ms
Operate time accuracy in DT	±1.0% or ±20ms
Operate time accuracy in IDMT	±5.0% or ±20ms

4.1.5 Inrush Restraint Function

The directional earth-fault protection is used as ground fault When a distribution feeder supplies many transformers, magnetizing inrush current may cause current protection element to trip or alarm when the line is energized. The inrush restraint function can be used to selectively block overcurrent and earth-fault protection by the way of monitoring 2nd harmonic components.

The corresponding IEC/ANSI identifications are shown in below.

Table 17-Inrush restraint function identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Inrush restraint	3I2f>	68

The function can be enabled and disabled with the The function can be enabled and disabled with the Operation setting, corresponding parameter values are “on”, “off”.

The operation principle of function can be described as below. When the transformers are energized and caused magnetizing inrush current, that contains large percentage of 2nd harmonic current relatively, if the current was larger than protection pickup value, and the ratio of second harmonic component over the fundamental component exceeds the preset value, the corresponding protection would be blocked and prevented to mis-operation.

The following table shows the parameter settings among IR function.

Table 18-Inrush restraint function parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	on/off	off			This protection element can be used as an alarm function. If this parameter is set as “on”, the protection will give an alarm. The protection would disable if select “off”.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Start value	5~100	20	1	%	This parameter defines starting level of the protection.
Operate delay time	0.02~180.00	0.02	0.01	s	The protection would be alarm if timer exceeded this value.

The technical data of function shows below table.

Table 19-Inrush restraint function technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.005 x In (At currents in the range of 0.1...10 x In) ±5.0% of set value (At ratio I2f/I1f in the range of 5.0...100.0%)
Reset time accuracy	±1.0% or ±20ms
Operate time accuracy	±1.0% or ±20ms

4.1.6 Broken Conductor Protection

On the isolated or compensated network, it is hard to The broken conductor protection is a three-phase protection with DT characteristic, designed for detecting broken conductors in distribution networks. The function is applicable for both overhead lines and underground cables.

The corresponding IEC / ANSI identifications are shown in below.

Table 20-Broken conductor protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Broken conductor	I2/I1>	46BC

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “trip”, “alarm”, “off”.

The operation principle of BC can be described as below. The function starts and operates when the unbalance current I2 /I1 exceeds the set limit. To prevent faulty operation, at least one phase current needs to be above the minimum level. The broken conductor protection operates with DT characteristic. When the timer has reached the value of operate delay time , the alarm or trip signal will be activated. If the unbalance fault suddenly disappears before the operate delay time is reached, the reset delay time is activated.

The following table shows the parameter settings among BC protection.

Table 21-Broken conductor protection parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as "alarm", the protection will give an alarm without actual trip at fault. The protection would disabled if select "off".
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Min phase current value	5~300	10	1	A	Minimum phase current.
Start value	10~100	50	1	%	This parameter defines starting level of the protection.
Operate delay time	0.10~300.00	0.10	0.01	s	The protection would be alarm or trip if timer exceeded this value.

The technical data of function shows below table.

Table 22-Broken conductor protection technical data

Parameter	Value
Operation accuracy	±2.0% of set value
Reset time accuracy	±1.0% or ±20ms
Operate time accuracy	±1.0% or ±20ms

4.1.7 Three-phase Over-voltage Protection

The three-phase over-voltage is used to protect the network from excessive voltages that could damage the insulation and cause insulation breakdown. The protection is usually applied on generators, transformers, motors, power lines, etc. It can be selected the type of operation required with any one phase, two phase and three phase. The three-phase over-voltage protection can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). In the DT mode, the function operates after a predefined operate time and resets when the fault disappears. The IDMT mode provides voltage-dependent timer characteristics.

The corresponding IEC / ANSI identifications are shown in below.

Table 23-Three-phase over-voltage protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Three-phase over-voltage	3U>	59

The function can be enabled and disabled with the Operation setting, corresponding parameter values are "trip", "alarm", "off".

The operation principle of OV can be described as below.The measured three phases voltage are compared with preset start value, if the measured value is greater than preset start value, the phase selection logic will detect which phase of the measured voltage exceeds the preset value. If the phase information matches the set value of the start phase number, the timer will activate the pickup signal output. The relative hysteresis parameter can be used for preventing unnecessary oscillations if the input signal slightly differs from the Start value setting. According to the protection curve type, the time characteristics are definite time or inverse definite minimum time. When the timer has reached the value of operate delay time in DT mode or the maximum value in IDMT mode, the alarm or trip signal will be activated. If the fault suddenly disappears before the operate delay time is reached, the reset delay time is activated. When the definite time characteristic is selected, the timer will not be reset until it exceeds the reset delay time value; when the immediately is selected, the timer will be reset instantaneously after detecting fault disappeared. The pickup signal is deactivated when the reset time has expired. The function operates on DFT measurement mode.

FXD CONTROL provides 4 protection characteristic curves that including DT curves and 3 IDMT curves. In addition to this, a user defined curve can be used if none of the standard curves are applicable.

The following table shows the parameter settings among OV protection.

Table 24-Three-phase over-voltage protection parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as "alarm", the protection will give an alarm without actual trip at fault. The protection would disabled if select "off".
Number of start phases	1 out of 3 2 out of 3 3 out of 3	1 out of 3			Number of phases required for operate activation.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
IDMT minimum operate time	0.04~60.00	0.04	0.01	s	Minimum operate time for IDMT curves.
Voltage selection	Phase to phase Phase to earth	Phase to phase			Selection of voltage type.
Relative hysteresis	1.0~5.0	4.0	0.1	%	Relative hysteresis for operation.
IDMT user defined parameter A	0.005~200.000	1.000			Parameter A for user defined curve.
IDMT user defined parameter B	0.50~100.00	1.00			Parameter B for user defined curve.
IDMT user defined parameter C	0.0~1.0	0.0			Parameter C for user defined curve.
IDMT user defined parameter D	0.000~60.000	0.000			Parameter D for user defined curve.
IDMT user defined parameter E	0.000~3.000	1.000			Parameter E for user defined curve.
Start value	0.05~2.00	1.10	0.01	xUn	This parameter defines starting level of the protection.
Time multiplier	0.05~15.00	1.00	0.01		Time multiplier in IDMT curves.
Operate delay time	0.04~300.00	0.04	0.01	s	The protection would be alarm or trip if timer exceeded this value.
Protection curve type	IEC Def. Time Inv. curve A Inv. curve B Inv. curve C User defined curve	IEC Def. Time			Selection of time delay curve type.
Reset curve type	Immediately Def.time	Immediately			Selection of reset curve type.

The technical data of function shows below table.

Table 25-Three-phase over-voltage protection technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.005 x Un (At voltages in the range of 0.05...2.00 x Un)
Reset time accuracy	±1.0% or ±20ms
Operate time accuracy in DT	±1.0% or ±20ms
Operate time accuracy in IDMT	±5.0% or ±20ms

4.1.8 Three-phase Under-voltage Protection

The three-phase under-voltage is used to disconnect from network when encountered low voltage conditions which can damage the devices. It can be selected the type of operation required with any one phase, two phase and three phase.

The three-phase under-voltage protection can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). In the DT mode, the function operates after a predefined operate time and resets when the fault disappears. The IDMT mode provides voltage-dependent timer characteristics.

The corresponding IEC/ANSI identifications are shown in below.

Table 26-Three-phase under-voltage protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Three-phase under-voltage	3U<	27

The function can be enabled and disabled with the Operation setting, corresponding parameter values are "trip", "alarm", "off".

The operation principle of UV can be described as below. The measured three phases voltage are compared with preset start value, if the measured value is lower than preset start value, the phase selection logic will detect which phase of the measured voltage less than the preset value. If the phase information matches the set value of the start phase number, the timer will activate the pickup signal output. The relative hysteresis parameter can be used for preventing unnecessary oscillations if the input signal slightly differs from the Start value setting. According to the protection curve type, the time characteristics are definite time or inverse definite minimum time. When the timer has reached the value of operate delay time in DT mode or the maximum value in IDMT mode, the alarm or trip signal will be activated. If the fault suddenly disappears before the operate delay time is reached, the reset delay time is activated. When the definite time characteristic is selected, the timer will not be reset until it exceeds the reset delay time value; when the immediately is selected, the timer will be reset instantaneously after detecting fault disappeared. The pickup signal is deactivated when the reset time has expired.

The function operates on DFT measurement mode.

FXD Control provides 3 protection characteristic curves that including DT curves and 2 IDMT curves . In addition to this, a user defined curve can be used if none of the standard curves are applicable.

The following table shows the parameter settings among UV protection.

Table 27-Three-phase under-voltage protection parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as “alarm”, the protection will give an alarm without actual trip at fault. The protection would disabled if select “off”.
Number of start phases	1 out of 3 2 out of 3 3 out of 3	1 out of 3			Number of phases required for operate activation.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
IDMT minimum operate time	0.06~60.00	0.06	0.01	s	Minimum operate time for IDMT curves.
Voltage selection	Phase to phase Phase to earth	Phase to phase			Selection of voltage type.
Voltage block value	0.05~1.00	0.20	0.01	xUn	Blocking under-voltage protection under this value.
Enable block value	True/false	true			Enable/disable blocking under-voltage protection.
Relative hysteresis	1.0~5.0	4.0	0.1	%	Relative hysteresis for operation.
IDMT user defined parameter A	0.005~200.000	1.000			Parameter A for user defined curve.
IDMT user defined parameter B	0.50~100.00	1.00			Parameter B for user defined curve.
IDMT user defined parameter C	0.0~1.0	0.0			Parameter C for user defined curve.
IDMT user defined parameter D	0.000~60.000	0.000			Parameter D for user defined curve.
IDMT user defined parameter E	0.000~3.000	1.000			Parameter E for user defined curve.
Start value	0.05~1.20	0.90	0.01	xUn	This parameter defines starting level of the protection.
Time multiplier	0.05~15.00	1.00	0.01		Time multiplier in IDMT curves.
Operate delay time	0.06~300.00	0.06	0.01	s	The protection would be alarm or trip if timer exceeded this value.
Protection curve type	IEC Def. Time Inv. curve A Inv. curve B User defined curve	IEC Def. Time			Selection of time delay curve type.
Reset curve type	Immediately Def.time	Immediately			Selection of reset curve type.

The technical data of function shows below table.

Table 28-Three-phase under-voltage protection technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.005 x Un (At voltages in the range of 0.05...1.20 x Un)
Reset time accuracy	±1.0% or ±20ms
Operate time accuracy in DT	±1.0% or ±20ms
Operate time accuracy in IDMT	±5.0% or ±20ms
Operate time accuracy in IDMT	±5.0% or ±20ms

4.1.9 Residual Over-voltage Protection

Residual over-voltage protection is designed to be used in isolated neutral, resistance earthed or reactance earthed systems, and as a backup protection or as a release signal for the feeder earth-fault protection. In compensated and isolated neutral systems, the system neutral voltage, that is, the residual voltage, increases in case of any fault connected to earth. Depending on the type of the fault and the fault resistance, the residual voltage reaches different values. The function starts when the residual voltage exceeds the set limit. The protection operates with the definite time (DT) characteristic.

The corresponding IEC / ANSI identifications are shown in below.

Table 29-Residual over-voltage protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Residual over-voltage	Uo>	59N

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “trip”, “alarm”, “off”.

The operation principle of ROV can be described as below. The metering of residual voltage can be selected between “Measured” and “Calculated”. It is compared to the set Start value, if the value exceeds the set Start value, the timer will activate the pickup signal output. When the timer has reached the value of operate delay time, the alarm or trip signal will be activated. If the fault suddenly disappears before the operate delay time is reached, the reset delay time is activated. The pickup signal is deactivated when the reset time has expired. The function operates on DFT measurement mode.

The following table shows the parameter settings among ROV protection.

Table 30-Residual over-voltage protection parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as “alarm”, the protection will give an alarm without actual trip at fault. The protection would disabled if select “off”.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Residual voltage source	Measured Calculated	Calculated			Selection for residual voltage signal.
Start value	0.01~1.00	0.03	0.01	xUn	This parameter defines starting level of the protection.
Operate delay time	0.04~300.00	0.04	0.01	s	The protection would be alarm or trip if timer exceeded this value.

The technical data of function shows below table.

Table 31-Residual over-voltage protection technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.005 x Un (at voltages in the range of 0.01...1.00 x Un)
Reset time accuracy	±1.0% or ±20ms
Operate time accuracy	±1.0% or ±20ms

4.1.10 Negative-sequence Over-voltage Protection

The voltage unbalance mainly occurs due to broken conductors or asymmetrical loads and is characterized by the appearance of a negative-sequence component of the voltage. In rotating machines, the voltage unbalance results in a current unbalance, which heats the rotors of the machines. If the machines have an unbalance protection of their own, the negative-sequence over-voltage protection can be applied as a backup protection, or it can be used as an alarm. The function starts when the negative-sequence voltage exceeds the set limit. The protection operates with the definite time (DT) characteristic.

The corresponding IEC / ANSI identifications are shown in below.

Table 32-Negative-sequence over-voltage protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Negative-sequence over-voltage	U2>	47

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “trip”, “alarm”, “off”.

The operation principle of NSOV can be described as below. The calculated negative voltage is compared with preset start value, if the value is greater than preset start value, the timer will activate the pickup signal output. When the timer has reached the value of operate delay time, the alarm or trip signal will be activated. If the fault suddenly disappears before the operate delay time is reached, the reset delay time is activated. The pickup signal is deactivated when the reset time has expired.

The following table shows the parameter settings among NSOV protection.

Table 33-Negative-sequence over-voltage protection parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as “alarm”, the protection will give an alarm without actual trip at fault. The protection would disable if select “off”.
Reset delay time	0.00~60.00	0.02	0.01	s	The timer would be reset if had exceeded this value.
Start value	0.01~1.00	0.03	0.01	xUn	This parameter defines starting level of the protection.
Operate delay time	0.12~120.00	1.00	0.01	s	The protection would be alarm or trip if timer exceeded this value.

The technical data of function shows below table.

Table 34-Negative-sequence over-voltage protection technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.005 x Un (At voltages in the range of 0.01...1.00 x Un)
Reset time accuracy	±1.0% or ±20ms
Operate time accuracy	±1.0% or ±20ms

4.1.11 Loss of Phase

The loss of phase protection is used to detect one or two phases disconnection in the feeder. When voltages on one or two phases drop below the “Deadline value” setting, the timer will activate the pickup signal output. When the timer has reached the value of operate delay time, the alarm or trip signal will be activated. The protection operates with the definite time (DT) characteristic. If voltages on detected phases rise to the “Live line value” setting, The pickup signal is deactivated immediately. The function can be enabled and disabled with the Operation setting, corresponding parameter values are “trip”, “alarm”, “off”.

The following table shows the parameter settings among loss of phase protection.

Table 35-Loss of phase protection parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as "alarm", the protection will give an alarm without actual trip at fault. The protection would disable if select "off".
Operate delay time	0.06~15.00	4.00	0.01	s	The protection would be alarm or trip if timer exceeded this value.
Deadline value	0.1~0.8	0.5	0.1	xUn	Power line voltage off level.
Live line value	0.2~1.0	0.8	0.1	xUn	Power line voltage on level.

The technical data of function shows below table.

Table 36-Loss of phase protection technical data

Function Description	IEC 60617	ANSI/IEEE C37.2
Operation accuracy	f>	±1.5% of set value or ±0.005 x Un (At voltages in the range of 0.10...1.00 x Un)
Operate time accuracy	f<	±1.0% or ±20ms

4.1.12 Frequency Protection

The frequency protection is used to protect power equipment against abnormal frequency conditions in network. The function contains over-frequency, under-frequency, and frequency rate of change protection. The over-frequency protection is applicable in all situations where high levels of the fundamental frequency of a power system voltage must be reliably detected. The under-frequency is applicable in all situations where a reliable detection of a low fundamental power system voltage frequency is needed. The frequency rate of change protection is applicable in all the situations where the change of the fundamental power system voltage frequency should be detected reliably.

The corresponding IEC/ANSI identifications are shown in below.

Table 37-Frequency protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Over-frequency	f>	81O
Under-frequency	f<	81U
Frequency rate of change	df/dt	81R

The function can be enabled and disabled with the Operation setting, corresponding parameter values are "trip", "alarm", "off".

The operation principle of function can be described as below.

a. Over-frequency protection:

The measured frequency is compared with preset start value, if the measured value exceeds preset start value, the timer will activate the pickup signal output. When the timer has reached the value of operate delay time in DT mode, the alarm or trip signal will be activated. If the frequency returned to normal before the operate delay time is reached, the reset delay time is activated. The pickup signal is deactivated when the reset time has expired.

b. Under-frequency protection:

The measured frequency is compared with preset start value, if the measured value is lower than preset start value, the timer will activate the pickup signal output. When the timer has reached the value of operate delay time in DT mode, the alarm or trip signal will be activated. If the frequency returned to normal before the operate delay time is reached, the reset delay time is activated. The pickup signal is deactivated when the reset time has expired.

c. Frequency rate of change protection

The calculated frequency rate is compared with preset start value, if the measured value exceeds preset start value, the timer will activate the pickup signal output. When the timer has reached the value of operate delay time in DT mode, the

alarm or trip signal will be activated. If the frequency rate returned to normal before the operate delay time is reached, the reset delay time is activated. The pickup signal is deactivated when the reset time has expired.

The following table shows the parameter settings among OF, UF, FR protection.

Table 38-Frequency protection parameter settings

Parameter	Range	Default	Step	Unit	Description
Over-frequency					
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as "alarm", the protection will give an alarm without actual trip at fault. The protection would disabled if select "off".
Reset delay time	0.00~60.00	0.00	0.01	s	The timer would be reset if had exceeded this value.
Start value	0.90~1.20	1.05	0.01	xFn	This parameter defines starting level of the protection.
Operate delay time	0.08~200.00	0.20	0.01	s	The protection would be alarm or trip if timer exceeded this value.
Under-frequency					
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as "alarm", the protection will give an alarm without actual trip at fault. The protection would disabled if select "off".
Reset delay time	0.00~60.00	0.00	0.01	s	The timer would be reset if had exceeded this value.
Start value	0.80~1.10	0.95	0.01	xFn	This parameter defines starting level of the protection.
Operate delay time	0.08~200.00	0.20	0.01	s	The protection would be alarm or trip if timer exceeded this value.
Frequency rate of change					
Operation	trip/alarm/off	off			This protection element can be used as an alarm or trip function. If this parameter is set as "alarm", the protection will give an alarm without actual trip at fault. The protection would disabled if select "off".
Reset delay time	0.00~60.00	0.00	0.01	s	The timer would be reset if had exceeded this value.
Start value	-0.20~0.20	0.05	0.01	xFn/s	This parameter defines starting level of the protection.
Operate delay time	0.12~200.00	0.40	0.01	s	The protection would be alarm or trip if timer exceeded this value.

The technical data of function shows below table.

Table 39-Frequency protection technical data

Parameter	Value
Operation accuracy	±20 mHz (At frequency in the range of 0.80...1.20 x Fn) ±1Hz/s (In the range of 2Hz/s~10Hz/s, -2Hz/s~-10Hz/s)
Reset time accuracy	±1.0% or ±30ms
Operate time accuracy	±1.0% or ±30ms

4.1.13 Cold Load Pickup Function

In some cases, when power supply is restored after prolonged outage, will result in greater than normal power demand, that because the large number of the thermostat-controlled devices such as heaters, refrigeration, air conditioners etc. will turn on. The longer the period without supply the greater the loss of diversity and the higher the load current will be when supply is restored. The increase in load current after a prolonged outage could cause current protection to operate unnecessarily. The purpose of the cold load pickup function is to automatically compensate for the loss of diversity by adjusting the current protection pickup thresholds until the load regains its diversity and steady state load conditions return. It works by measuring the time that supply was lost and then temporarily raising the current protection settings for the selected elements according to the time the load has been without supply. The function can be enabled and disabled with the Operation setting, corresponding parameter values are "on", "off".

The operation principle of function can be described as below.

Whenever the cold load timer is running, the actual multiplier being applied is known as the “Operational cold load multiplier”. The operational cold load multiplier is calculated using the following equation:

Operational Multiplier=1+(operational cold load time/user set cold load time) *(user set multiplier-1)

Equation 1
Operational cold load multiplier

Where the operational cold load time is the time the supply has been lost minus any time it’s been back on. So, when the supply is off, the operational cold load time is increasing and when the supply is on, the operational cold load time is decreasing. This means the operational cold load multiplier will have a minimum value of 1, and a maximum value equal to the parameter cold load multiplier setting.

There is an example as below figure.

(Cold load multiplier and cold load time following default value: cold load multiplier=2.0; cold load time=120 mins. The protection element=100A).

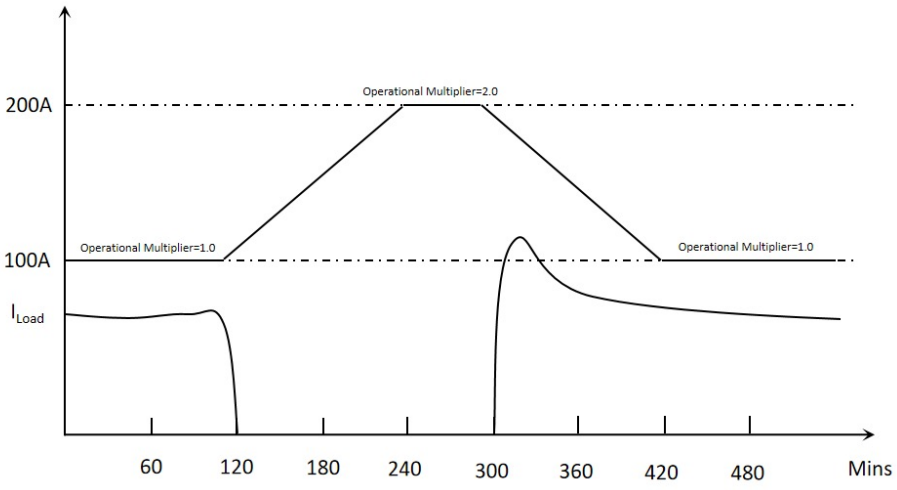


Figure 6 Cold load pickup function example

In this example the supply goes off for four hours. Over the first two hours, the operational cold load multiplier (OCLM) increases from x1 to x2. The supply stays off for another two hours, but the operational cold load multiplier doesn’t increase any further because it’s reached its maximum setting. When the supply comes back on, the load current is significantly higher than usual but doesn’t cause a protection pickup because it doesn’t exceed the “Setting Current x the Operational Cold Load Multiplier”. Over the next two hours the operational cold load multiplier ramps down from x2 to x1 and is always above the load current which also tapers off over that time.

The cold load pickup can be selected On or Off for the OC, EF, SEF and NSOC protection independently.

The following table shows the parameter settings among CLP function.

Table 40-Cold load pickup function parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	on/off	off			This protection element can be used as an alarm function. If this parameter is set as “on”, the protection will give an alarm. The protection would disable if select “off”.
OC enable	on/off	off			Over-current protection active or inactive in cold load pickup function.
EF enable	on/off	off			Earth-fault protection active or inactive in cold load pickup function.
SEF enable	on/off	off			Sensitive earth fault protection active or inactive in cold load pickup function.
NSOC enable	on/off	off			Negative-sequence over-current protection active or inactive in cold load pickup function.

Parameter	Range	Default	Step	Unit	Description
Cold load multiplier	1.0~10.0	2.0	0.1		The multiple of protection element.
Cold load time	1~480	120	1	min	The time that multiplier reach to maximum setting value.

The technical data of function shows below table.

Table 41-Cold load pickup function technical data

Parameter	Value
Cold load time	+/- 1 min

4.1.14 Circuit Breaker Failure Protection

The circuit breaker failure protection is activated by trip commands from the protection functions, which includes a three-phase re-trip function, and also a three-phase back-up trip function. The function uses the same levels of current detection for both re-trip and back-up trip. There are two independently timers for trip purposes: a re-trip timer for the repeated tripping of its own breaker and a back-up timer for the trip logic operation for upstream breakers. The trip pulse length can be set for the re-trip and back-up trip.

The corresponding IEC/ANSI identifications are shown in below.

Table 42-Circuit breaker failure protection identifications

Function Description	IEC 60617	ANSI/IEEE C37.2	Step	Unit	Description
Circuit breaker failure	3I>/Io>BF	50BF	1		Currently active group

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “on”, “off”.

The operation principle of function can be described as below.

The monitoring mode has three types: current/breaker status/both. If failure mode is set to the “current”, protection is activated when the value of any phase current exceeds the Current value setting, which includes A/B/C phases and residual depend on the trip mode selection; If failure mode is set to the “breaker status”, protection is activated when the circuit breaker is in the closed position; If failure mode is set to the “both”, protection is activated when either of the “Breaker status” or “Current” mode condition is satisfied. Once time exceeds “CB fault delay time”, CB failure will be alarm. The trip mode also has three types: 1 out of 3/1 out of 4/2 out of 4. If failure mode is set to the “1 out of 3”, the failure detection is based on any of the A/B/C phase current exceeding the “phase current value” setting; If failure mode is set to the “1 out of 4”, the failure detection is based on either a phase current or a residual current exceeding the “phase current value” or “residual current value” setting; If failure mode is set to the “2 out of 4”, the failure detection requires that

a phase current and a residual current both exceed the “phase current value” or “residual current value” setting respectively. In most applications, “1 out of 3” is sufficient. The re-trip logic can be used to give a re-trip signal for the main circuit breaker. The re-trip logic is inactive if “re-trip mode” setting is set to “off”. If “re-trip mode” is set to the “Current check” mode, the activation of the re-trip output depends on the “monitoring mode” setting. If “re-trip mode” is set to the “without check”, re-trip is activated without checking the current level.

The backup trip logic can be used to trip the upstream backup circuit breaker when the main circuit breaker fails to clear the fault.

During the re-trip and backup trip delay time, they will be reset immediately once not fulfill condition. CB failure alarm should generate if the first protection trip was not successful, and signal will output after CB fault delay time.

The following table shows the parameter settings among CBF function.

Table 43-Circuit breaker failure protection parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	on/off	off			This protection element can be used as an alarm and trip function. If this parameter is set as “on”, the protection will give an alarm and trip. The protection would disable if select “off”.
Monitoring Mode	Current Breaker status both	current			Operating mode of function.

Parameter	Range	Default	Step	Unit	Description
Trip mode	1 out of 3 1 out of 4 2 out of 4	1 out of 3			Current check mode.
Phase current value	0.05~2.00	0.30	0.01	xIn	Operating phase current.
Residual current value	0.05~1.00	0.30	0.01	xIn	Operating residual current.
Re-trip mode	Off Without check Current check	off			Operating mode of re-trip logic.
Re-trip operate delay time	0.25~60.00	0.25	0.01	s	Delay timer for re-trip.
Backup-trip operate delay time	0.25~60.00	0.50	0.01	s	Delay timer for backup trip.
CB fault delay time	0.00~60.00	5.00	0.01	s	Delay time for CB fail alarm.
Re-trip&Backup-trip Pulse Width	0.00~60.00	0.15	0.01	s	Pulse length of retrip and backup trip outputs.

The technical data of function shows below table.

Table 44-Circuit breaker failure protection technical data

Parameter	Value
Operation accuracy	±1.5% of set value or ±0.005 x In (At currents in the range of 0.01...20.0 x In)
Operate time accuracy	±1.0% or ±20ms

4.1.15 Fault Locator Function

Fault locator function reduces operating costs by avoiding lengthy and expensive patrols. Fault locator function expedites repairs and restoration of lines, ultimately reducing revenue loss caused by outages.

One-ended impedance methods of fault location are a standard feature in most numerical relays. One-ended impedance methods use a simple algorithm, and communication channels and remote data are not required. One-ended impedance-based fault locators calculate the fault location from the apparent impedance seen by looking into the line from one end.

An example system one-line is shown in Figure 6. To locate all fault types, the phase-to-ground voltages and currents in each phase must be measured. If the fault resistance is assumed to be zero, we can use one of the impedance calculations in Table 45 to estimate the fault location.

Table 45-Fault location estimate equation

Fault Type	Positive-sequence Impedance Equation (m_{z1L}=)
AG Fault	$V_a/(I_a+k\cdot 3\cdot I_0)$
BG Fault	$V_b/(I_b+k\cdot 3\cdot I_0)$
CG Fault	$V_c/(I_c+k\cdot 3\cdot I_0)$
ABG Fault	V_{ab}/I_{ab}
BCG Fault	V_{bc}/I_{bc}
CAG Fault	V_{ca}/I_{ca}
ABCG Fault	Any of the following: V_{ab}/I_{ab}, V_{bc}/I_{bc}, V_{ca}/I_{ca}
AB Fault	V_{ab}/I_{ab}
BC Fault	V_{bc}/I_{bc}
CA Fault	V_{ca}/I_{ca}
ABC Fault	Any of the following: V_{ab}/I_{ab}, V_{bc}/I_{bc}, V_{ca}/I_{ca}

where

k is (Z_{0L} – Z_{1L}) / $3Z_{1L}$,

Z_{0L} is the zero-sequence line impedance,

Z_{1L} is the positive-sequence line impedance,

m is the per unit distance to fault (for example: distance to fault in kilometers divided by the total line length in kilometers),

I_0 is the zero-sequence current.

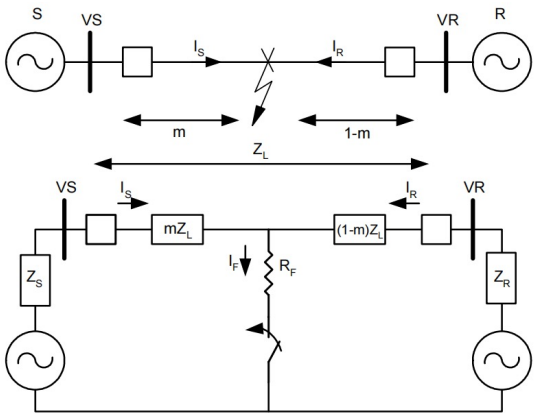


Figure 7 One-line diagram

The following conditions can cause errors for one ended impedance-based fault location methods:

- The effort of fault resistance and load.
- Zero-sequence modeling errors.
- Inaccurate relay measurement, instrument transformer or line parameters.

According to the equivalent circuit (Figure 6), the formula can be derived as follows:

$$V_S = m \bullet Z_{1L} \bullet I_S + R_F \bullet I_F$$

Equation 2
Equivalent circuit formula

One-ended impedance method requires pre-fault and fault data. Introducing a current parameter: Isup*=I-Ipre, where I is the fault current and Ipre is the pre-fault current, multiply this parameter by the equivalent circuit formula on both sides to obtain the following formula for calculating the fault distance m:

$$I_m[V_S \bullet I_{sup*}] = m \bullet I_m(Z_{1L} \bullet I_S \bullet I_{sup*}) + R_F \bullet I_m(I_F \bullet I_{sup*})$$

$$m = \frac{I_m(V_S \bullet I_{sup*})}{I_m(Z_{1L} \bullet I_S \bullet I_{sup*})}$$

The closer the phase angle between Is and IF, the more accurate the distance calculation.

The following table shows the parameter settings among FLOC function.

Table 46-Fault locator function parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	on/off	off			This protection element can be used as a fault recorder. If this parameter is set as “on”, the protection will give a fault recorder. The protection would disable if select “off”.
Line length	0.00~300.00	100.00	0.01	km	Line length parameter.
R0	0.00~20.00	0.01	0.01	ohm/km	Zero-sequence resistance.
X0	0.00~30.00	1.00	0.01	ohm/km	Zero-sequence reactance.
R1	0.00~20.00	1.00	0.01	ohm/km	Positive-sequence resistance.
X1	0.00~30.00	2.00	0.01	ohm/km	Positive-sequence reactance.

4.1.16 Power Flow Direction

The correct sign for the power measurement is dependent on the correct power flow direction setting. When power flows through the primary switch from source to load, it is deemed to be

positive power flow. When power flows through the primary switch from load to source, it is deemed to be negative power flow. As the primary switch can be installed on a pole with either side connected to the source of supply, this setting should be checked as part of the commissioning procedure.

When the power flow direction is enabled, if the actual power flow direction of the power system is opposite to the parameter setting, it will automatically switch to the alternative setting group.

The following table shows the parameter settings among power flow direction function.

Table 47-Power flow direction settings

Parameter	Range	Default	Step	Unit	Description
Power direction opt	on/off	off			Enable and disable the function.
Power direction	UVW->RST RST->UVW	UVW->RST			Power direction selection.

4.1.17 Hot Line Tag

The hot line tag enables to go to maintenance mode, the FXD Control can trip at fault but not initiate closing, either by local, remote or automatic. Therefore, hot line tag affords protection for operators working on live lines.

The function can be enabled and disabled with the button on front panel.

4.1.18 Protection Setting Groups

FXD Control supports up to 5 setting groups, each setting group can be configured with completely separate characteristics and parameters. The customer can change the active setting group at run time.

The following table shows the parameter settings among CLP function.

Table 48-Protection setting groups parameter settings

Parameter	Range	Default	Step	Unit	Description
Active group	1~5	1	1		Currently active group
Alternative setting group	1~5	2	1		Alternative group.

4.2 Measurement

The FXD Control gets analog signals from automatic circuit switch current transformers and voltage sensors, convert them into digital format. The following values are contained in the measurement element.

Table 49-The measurement element applicability

Parameter	Range	Applicability	
		Protection	Indication
Three-phase Current (Ia/Ib/Ic)	0.00~20.00In	√	√
Residual Current (Io)	0.00~20.00In	√	√
Three-phase Voltage (Ua/Ub/Uc)	0.00~2.00Un	√	√
Three-phase Voltage (Ur/Us/Ut)	0.00~2.00Un	√	√
Residual Voltage (Uo1/Uo2)	0.00~2.00Un	√	√
Active Power (Pa/Pb/Pc/Pt)	0~999999999kW		√
Reactive Power (Qa/Qb/Qc/Qt)	0~999999999kvar		√
Apparent Power(Sa/Sb/Sc/St)	0~999999999kva		√
Active Energy (EPa/EPb/EPc/EPt)	0~999999999kwh		√
Reactive Energy (EQa/EQb/EQc/EQt)	0~999999999kvarh		√
Apparent Energy (ESa/ESb/ESc/ESt)	0~999999999kvah		√
Power Factor (PFa/PFb/PFc/PFt)	-1.00~1.00		√
Frequency (F)	30Hz~90Hz	√	√
Current Sequence Measurement (I1/I2)	0.00~20.00In	√	√
Voltage Sequence Measurement (U1/U2)	0.00~2.00Un		√
Battery Voltage (Vbat)	18~26 Vdc		√

4.2.1 Fundamental Measurement

The FXD Control performs current, voltage, power and energy metering using the fundamental signals. These values are measured on account of system frequency, which is usually near 50 Hz or 60 Hz. Frequency tracking ensures that frequency variations do not adversely affect metering accuracy. The FXD Control also presents phasor quantities calculated through fundamental power frequency components extracted by FFT (Fast Fourier Transform) algorithm.

Moreover, the calibration is performed in the factory before delivery using precise current and voltage signal generator. The calibration compensates the measurements error caused by the components in the circuit of input.

The corresponding IEC/ANSI identifications are shown in below.

Table 50-The fundamental measurement identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Three-phase current	3I	3I
Residual current	Io	Io
Three-phase voltage	3U	3U
Residual voltage	Uo	Uo
Power	P	P
Energy	E	E
Power factor	PF	PF
Frequency	F	F

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “on”, “off”.

Current and voltage measurement functions operate on two alternative measurement modes: DFT and RMS, other measurement functions mode is DFT.

The demand values are calculated separately for each measurement function and per phase when applicable.

The limit value supervision function indicates whether the measured value exceeds or falls below the set limits.

The deadband supervision function reports the measured value according to integrated changes over a time period. The reporting delay of the integral algorithms in seconds is calculated with the following equation:

T=(max-min) *deadband/|△Y|*100

Equation 2

Reporting delay time

The following table shows the parameter settings among fundamental measurement function.

Table 51-The fundamental measurement function parameter settings

Parameter	Range	Default	Step	Unit	Description
Three-phase Current					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Measurement Mode	DFT/RMS	RMS			measurement mode selection.
Demand Interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The average value during interval time.
Current high alarm limit	0.00~40.00	1.40	0.01	xIn	High alarm current limit.
Current high warn limit	0.00~40.00	1.20	0.01	xIn	High warn current limit.
A deadband	0.1~100.0	2.5	0.1	%	Deadband configuration value.
Residual Current					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Measurement Mode	DFT/RMS	RMS			measurement mode selection.
Demand Interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The average value during interval time.
Current high alarm limit	0.00~40.00	0.20	0.01	xIn	High alarm current limit.
Current high warn limit	0.00~40.00	0.05	0.01	xIn	High warn current limit.
A deadband	0.1~100.0	2.5	0.1	%	Deadband configuration value.
Three-phase Voltage					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Measurement Mode	DFT/RMS	RMS			measurement mode selection.
Demand Interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The average value during interval time.
Voltage high alarm limit	0.00~2.00	1.40	0.01	xUn	High alarm voltage limit.
Voltage high warn limit	0.00~2.00	1.20	0.01	xUn	High warn voltage limit.
V deadband	0.1~100.0	10.0	0.1	%	Deadband configuration value.
Residual Voltage					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Measurement Mode	DFT/RMS	RMS			measurement mode selection.

Parameter	Range	Default	Step	Unit	Description
Demand Interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The average value during interval time.
Voltage high alarm limit	0.00~2.00	0.20	0.01	xUn	High alarm voltage limit.
Voltage high warn limit	0.00~2.00	0.05	0.01	xUn	High warn voltage limit.
V deadband	0.1~100.0	10.0	0.1	%	Deadband configuration value.
Power					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Measurement mode	total & each phase, Total, each phase	total & each phase			Measurement mode selection.
Demand Interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The average value during interval time.
Energy					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Measurement mode	total & each phase, Tota, each phase	total & each phase			Measurement mode selection.
Demand Interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The maximum value during interval time.
Power Factor					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Measurement mode	total & each phase; Total; each phase	total & each phase			Measurement mode selection.
Demand Interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The average value during interval time.
Frequency					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Demand Interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The average value during interval time.
Freq. high alarm limit	40.00~72.00	54.00	0.01	Hz	High alarm frequency limit.
Freq. high warn limit	40.00~72.00	52.00	0.01	Hz	High warn frequency limit.
Freq. low warn limit	40.00~72.00	48.00	0.01	Hz	Low warn frequency limit.
Freq. low alarm limit	40.00~72.00	46.00	0.01	Hz	Low alarm frequency limit.
F deadband	0.1~100.0	1.0	0.1	%	Deadband configuration value.

The technical data of function shows below table.

Table 52-The fundamental measurement technical data

Parameter	Value
Current operation accuracy	±0.5% (At currents in the range of 0.01...4.00 In)
Voltage operation accuracy	±0.5% (At voltages in the range of 0.05...1.20Un)

4.2.2 Sequence Components

The FXD Control provides the sequence components of three-phase currents and voltages. They are positive sequence current (I1) and voltage (U1), negative sequence current (I2) and voltage (U2), and zero sequence current (I0) and voltage (U0) which are calculated by three-phase phasor quantities. This information can be used to monitor unbalance of distribution line.

The corresponding IEC/ANSI identifications are shown in below.

Table 53-The sequence components identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Current sequence	I1, I2, I0	I1, I2, I0
Voltage sequence	U1, U2, U0	U1, U2, U0

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “on”, “off”.

The limit value supervision function indicates whether the measured value exceeds or falls below the set limits.

The deadband supervision function reports the measured value according to integrated changes over a time period.

The following table shows the parameter settings among sequence components function.

Table 54-The sequence components function parameter settings

Parameter	Range	Default	Step	Unit	Description
Current Sequence Measurement					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Positive sequence current high alarm limit	0.00~40.00	1.40	0.01	xIn	High alarm positive sequence current limit.
Positive sequence current high warn limit	0.00~40.00	1.20	0.01	xIn	High warn positive sequence current limit.
Positive sequence A deadband	0.1~100.0	2.5	0.1	%	Deadband configuration value.
Negative sequence current high alarm limit	0.00~40.00	0.20	0.01	xIn	High alarm negative sequence current limit.
Negative sequence current high warn limit	0.00~40.00	0.05	0.01	xIn	High warn negative sequence current limit.
Negative sequence A deadband	0.1~100.0	2.5	0.1	%	Deadband configuration value.
Zero sequence current high alarm limit	0.00~40.00	0.20	0.01	xIn	High alarm zero sequence current limit.
Zero sequence current high warn limit	0.00~40.00	0.05	0.01	xIn	High warn zero sequence current limit.
Zero sequence A deadband	0.1~100.0	2.5	0.1	%	Deadband configuration value.
Voltage Sequence Measurement					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Positive sequence voltage high alarm limit	0.00~2.00	1.40	0.01	xUn	High alarm positive sequence voltage limit.
Positive sequence voltage high warn limit	0.00~2.00	1.20	0.01	xUn	High warn positive sequence voltage limit.
Positive sequence V deadband	0.1~100.0	10.0	0.1	%	Deadband configuration value.
Negative sequence voltage high alarm limit	0.00~2.00	0.20	0.01	xUn	High alarm negative sequence voltage limit.
Negative sequence voltage high warn limit	0.00~2.00	0.05	0.01	xUn	High warn negative sequence voltage limit.
Negative sequence V deadband	0.1~100.0	10.0	0.1	%	Deadband configuration value.
Zero sequence voltage high alarm limit	0.00~2.00	0.20	0.01	xUn	High alarm zero sequence voltage limit.

Parameter	Range	Default	Step	Unit	Description
Zero sequence voltage high warn limit	0.00~2.00	0.05	0.01	xUn	High warn zero sequence voltage limit.
Zero sequence V deadband	0.1~100.0	10.0	0.1	%	Deadband configuration value.

The technical data of function shows below table.

Table 55-The sequence components technical data

Parameter	Value
CSM accuracy	±1.0% (At currents in the range of 0.01...20.00 In)
VSM accuracy	±1.0% (At voltages in the range of 0.05...2.00Un)

4.2.3 Harmonics

The FXD Control provides 2nd to 16th harmonic magnitudes and THDs (Total Harmonic Distortion) for each phase. THD is the total harmonic percentage to the fundamental frequency component. These values may be used to monitor the power quality of distribution line.

The corresponding IEC/ANSI identifications are shown in below.

Table 56-The total harmonic distortion identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Current total harmonic distortion	PQM3I	PQM3I
Voltage total harmonic distortion	PQM3U	PQM3U

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “on”, “off”.

The demand values are calculated separately for each measurement function and per phase when applicable.

The limit value supervision function indicates whether the measured value exceeds below the set limits.

The following table shows the parameter settings among harmonics function.

Table 57-The harmonics function parameter settings

Parameter	Range	Default	Step	Unit	Description
Current Total Harmonic Distortion					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Demand interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The maximum value during interval time.
Total demand distortion alarm limit	1.0~100.0	50.0	0.1	%	Current THD alarm limit.
Voltage Total Harmonic Distortion					
Operation	on/off	on			This measurement element can be enabled or disabled by on/off selection.
Demand interval	1 min 5 mins 15 mins 30 mins 60 mins 180 mins	1 min			The maximum value during interval time.
Total demand distortion alarm limit	1.0~100.0	50.0	0.1	%	Voltage THD alarm limit.

4.3 Control

In the field of distribution automation, reliable control, and status indication of primary switching components both locally and remotely is in a significant role. The FXD Control provides control functions, including open/close operation, local/remote operation, reclosing and synchronization check.

4.3.1 Opening and Closing Operations

The corresponding opening and closing operations are available via local or remote commands. There are open and close button on the front of FXD Control panel and need to be confirmed before execute which named SBO operation.

4.3.2 Local and Remote Operations

Local/Remote Control is by default realized through the REMOTE ENABLED button on the front panel. Switch can be controlled from local and remote status. Local mode allows opening and closing from control button on front panel, remote mode allows opening and closing from SCADA, and automation scheme as well.

4.3.3 Reclosing Function

Almost 80% ~ 85% of faults in medium voltage overhead lines are instantaneous faults, which can be automatically cleared by reclosing function. In case of permanent fault, the switch will trip finally after auto reclosing. The location of the permanent fault must be determined and cleared before the fault location is re-energized.

Any switch suitable for automatic reclosing can use this function. The switch generally adopts spring operating mechanism. If the switch is matched with a permanent magnet operating mechanism, a high-power current generator is required.

The corresponding IEC/ANSI identifications are shown in below.

Table 58-Reclosing function identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Reclosing	O-->I	79

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “on”, “off”.

This function can provide up to four reclosing times, and each trip can be selected among the OC/EF/NSOC/SEF. The reclosing times and interval time, including reclaim time, can be set by the user.

This function can provide OC/EF/NSOC fast and delay reclosing sequence, for example, in the below figure, the reclosing sequence is organized in 2F2D, which means the recloser protection function operates as fast element during first 2 reclosing shots and operates as delay element during last 2 reclosing shots. This composition also can be configured.

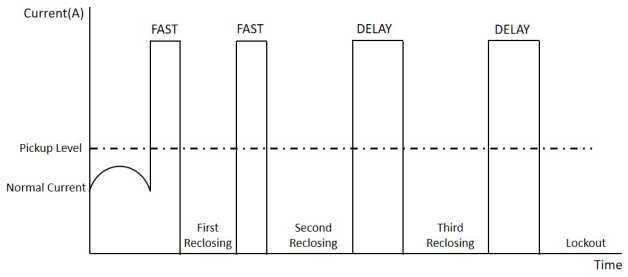


Figure 8 Reclosing sequence

This function can provide OC/EF/NSOC high current trip and lockout, which to lockout the recloser after a certain trip that according to setting as the fault current is high enough.

This function can provide single shot function, which used to provide an appropriate protection when non-reclosing operation such as closing onto a fault is required. In single shot operation the controller goes directly to lockout after a trip and will not reclose.

This function can provide fast trip blocked which change the reclosing sequence to delay curve if enabled.

Zone sequence coordination function can be used in the case which more than one recloser is used in series in the same distribution line. The purpose of the function is to synchronize to use the fast and delay element for recloser in series during reclosing sequence.

For example, assume that two reclosers are installed in the line as the following figure:

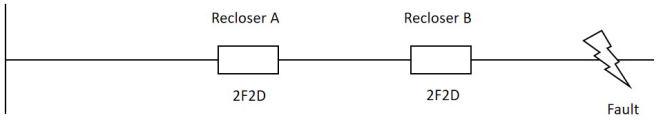


Figure 9 One more reclosers in line

When a fault is occurred in the load-side of recloser B, the fast element of A and B sees the fault simultaneously. But normally B trips first before A reaches the trip point according to protection setting. After B trips the fault, B waits reclosing time and prepare 2nd trip element before first reclosing. In this situation, A also detects the fault. But A didn’t trip the line. Instead of tripping, A detected the de-energized line before tripping. In this case B also prepares the protection element

as the 2nd trip element. If the fault is sustained, the same sequence is repeated. Thus, A and B goes to the 3rd trip element together. The third tripping can be done by B if the delay elements of A and B are coordinated. If the sequence coordination of A is not enabled, A will trip by fast element before B trips by delay element because the fast element is set faster than the delay element normally. That’s not desired situation.

In conclusion, the zone sequence coordination function is that source-side recloser monitors load-side reclosing sequence and follows the same protection element as load-side recloser.

The following table shows the parameter settings among AR function.

Table 59-Reclosing function parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Reclose cycle	1~4	3	1		Reclosing cycle.
OC/EF/NSOC					
First reclose time	0.1~1000.0	0.6	0.1	s	First interval time.
Second reclose time	0.1~1000.0	2.0	0.1	s	Second interval time.
Third reclose time	0.1~1000.0	15.0	0.1	s	Third interval time.
Fourth reclose time	0.1~1000.0	15.0	0.1	s	Fourth interval time.
Reclaim time	0.10~1800.00	30.00	0.01	s	Reclosing reclaim time.
OC TCC Selection					
First trip	Fast curve Delay curve	Fast curve			Fast/delay selection.
Second trip	Fast curve Delay curve	Fast curve			Fast/delay selection.
Third trip	Fast curve Delay curve	Delay curve			Fast/delay selection.
Fourth trip	Fast curve Delay curve	Delay curve			Fast/delay selection.
Fifth trip	Fast curve Delay curve	Delay curve			Fast/delay selection.
EF TCC Selection					
First trip	Fast curve Delay curve Def	Fast curve			Fast/delay selection.
Second trip	Fast curve Delay curve Def	Fast curve			Fast/delay selection.
Third trip	Fast curve Delay curve Def	Delay curve			Fast/delay selection.
Fourth trip	Fast curve Delay curve Def	Delay curve			Fast/delay selection.
Fifth trip	Fast curve Delay curve Def	Def			Fast/delay selection.
NSOC TCC Selection					
First trip	Fast curve Delay curve Def	Fast curve			Fast/delay/def. curve selection.
Second trip	Fast curve Delay curve Def	Fast curve			Fast/delay/def. curve selection.
Third trip	Fast curve Delay curve Def	Delay curve			Fast/delay/def. curve selection.
Fourth trip	Fast curve Delay curve Def	Delay curve			Fast/delay/def. curve selection.
Fifth trip	Fast curve Delay curve Def	Def			Fast/delay/def. curve selection.

Parameter	Range	Default	Step	Unit	Description
OC High Current Lockout(HCL)					
OC HCL operation	on/off	off			This function element can be enabled or disabled by on/off selection.
OC lockout value	10~20000	3200	1	A	This parameter defines lockout level of the OC HCL function.
OC HCL first trip	True/False	True			Enable or disable lockout after first trip.
OC HCL second trip	True/False	False			Enable or disable lockout after second trip.
OC HCL third trip	True/False	False			Enable or disable lockout after third trip.
OC HCL fourth trip	True/False	False			Enable or disable lockout after fourth trip.
OC HCL fifth trip	True/False	False			Enable or disable lockout after fifth trip.
EF High Current Lockout(HCL)					
EF HCL operation	on/off	off			This function element can be enabled or disabled by on/off selection.
EF lockout value	2~20000	1600	1	A	This parameter defines lockout level of the NSOC HCL function.
EF HCL first trip	True/False	True			Enable or disable lockout after first trip.
EF HCL second trip	True/False	False			Enable or disable lockout after second trip.
EF HCL third trip	True/False	False			Enable or disable lockout after third trip.
EF HCL fourth trip	True/False	False			Enable or disable lockout after fourth trip.
EF HCL fifth trip	True/False	False			Enable or disable lockout after fifth trip.
SEF					
Operation mode	On/off	off			This function element can be enabled or disabled by on/off selection.
First reclosing time	0.1~1000.0	0.6	0.1	s	First interval time.
Second reclosing time	0.1~1000.0	2.0	0.1	s	Second interval time.
Third reclosing time	0.1~1000.0	15.0	0.1	s	Third interval time.
Fourth reclosing time	0.1~1000.0	15.0	0.1	s	Fourth interval time.
Reclaim time	0.10~1800.00	30.00	0.01	s	Reclosing reclaim time.
SEF TCC Selection					
First trip	True/False	True			SEF selection on first trip.
Second trip	True/False	True			SEF selection on second trip.
Third trip	True/False	True			SEF selection on third trip.
Fourth trip	True/False	True			SEF selection on fourth trip.
Fifth trip	True/False	False			SEF selection on fifth trip.
Single Shot					
Single shot time	0~180	0	1	s	After this time the function has been already.
Zone sequence coordination					
ZSC operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Fast trip blocked					
Fast trip blocked	on/off	off			This function element can be enabled or disabled by on/off selection.

The technical data of function shows below table.

Table 60-Reclosing function technical data

Parameter	Value
Operation time accuracy	±1.0% or ±20ms

4.3.4 Synchronization Check Function

The synchro check function checks the condition across the switch (circuit breaker or automatic circuit recloser) from separate power system parts and gives the permission to close the switch. The synchro check function includes the functionality of synchro check and energizing check.

The corresponding IEC/ANSI identifications are shown in below.

Table 61-Synchronization check function identifications

Function Description	IEC 60617	ANSI/IEEE C37.2
Synchro check	SYNC	25

The function can be enabled and disabled with the Operation setting, corresponding parameter values are “on”, “off”.

The operation principle of function can be described as below.

The synchronization check function checks that the voltages on both sides of the switch are perfectly synchronized. It is used to perform a controlled reconnection of two systems which are divided after islanding and it is also used to perform a controlled reconnection of the system after reclosing. The energizing check function checks that at least one side is dead to ensure that closing can be done safely.

There are two modes in synchronization check function: continuous and command.

In the continuous mode, synchronization check is continuously checking the synchronism. When synchronism is detected, gives the permission to the control block that executes the CB closing.

In the command mode, the control function block delivers the command signal to close the synchronization check function for the releasing of a closing signal pulse to the switch. If the closing conditions are fulfilled during a permitted check time, the synchronization check function delivers a closing signal to the switch after the command signal is delivered for closing.

The following table shows the parameter settings among Synchronization Check function.

Table 62-Synchronization check function parameter settings

Parameter	Range	Default	Step	Unit	Description
Synchronism Check					
Synchronism check mode	on/off	off			This function element can be enabled or disabled by on/off selection.
Synchronism check control	Continuous	0.05	0.01	xUn	Maximum voltage difference limit.
Command	Continuous			Synchronism check mode selection.	Maximum frequency difference limit.
Difference voltage	0.01~0.50	0.05	0.01	xUn	Maximum voltage difference limit.
Difference frequency	0.001~0.100	0.001	0.001	xFn	Maximum frequency difference limit.
Difference angle	5~90	5	1	deg	Maximum angle difference limit.
Energizing Check					
Energizing check mode	Off; both side dead; live line & busbar dead; line dead & busbar live; busbar dead & line any; line dead & busbar any; one live & dead; not both live	off			Energizing check mode.
Dead line value	0.1~0.8	0.2	0.1	xUn	Voltage low-limit line for energizing check.
Live line value	0.2~1.0	0.5	0.1	xUn	Voltage high-limit line for energizing check.
Energizing check time	0.1~60.0	0.1	0.1	s	Energizing delay time.

The technical data of function shows below table.

Table 63-Synchronization check function technical data

Parameter	Value
Operation accuracy	VVoltage: ±3.0% Frequency: ±50 mHz Phase angle: ±3°
Reset time accuracy	±1.0% or ±20ms
Operate time accuracy	±1.0% or ±20ms

4.4 Communication

In the local mode, the recloser is controlled via the front panel on FXD Control, in the remote mode the recloser is controlled via communication. The FXD Control supports a variety of communication protocols, so as to realize the connection with SCADA or DMS station. Available communication protocols are IEC61850,IEC 60870-5-101/104, DNP3 and Modbus.

The supported remote communication interfaces and protocols are as below table.

Table 64-Interfaces and protocols

Protocol	Ethernet	Serial	
	RJ45	RS232/RS485	RS232 (DB9)
IEC 60870-5-101	-	√	√
IEC 60870-5-104	√	-	-
DNP3.0	√	√	√
MODBUS(RTU/ASCII)	-	√	√
MODBUS(TCP/IP)	√	-	-
	√	-	-

The following table shows the parameter settings among communication port.

Table 65-Communication port parameter settings

Parameter	Range	Default	Step	Unit	Description
Ethernet					
Ethernet (Rear)					
Local IP address		192.168.1.100			IP address for remote communication.
Subnet mask		255.255.255.0			Subnet mask for rear port.
Default gateway		192.168.1.1			Default gateway for rear port.
MAC address		8c-00-00-00-00-00			MAC address for rear port.
DNS1		192.168.1.1			DNS1
DNS2		192.168.1.1			DNS2
Keep Alive Time	1~60	5	1	sec	Keep alive time.
Lost Detection Time	10~255	120	1	sec	Lost detection time.
Redundancy Protocol	HSR/PRP	HSR			Redundancy Protocol
Ethernet (Front)					
IP Address		192.168.4.100			IP address for commissioning.
Subnet mask		255.255.255.0			Subnet mask for front port.
Default gateway		192.168.4.1			Default gateway for front port.
MAC address		8c-00-00-00-00-00			MAC address for front port.
DNS1		192.168.1.1			DNS1
DNS2		192.168.1.1			DNS2

Parameter	Range	Default	Step	Unit	Description
RS232					
Baud rate	1200 2400 4800 9600 19200 38400 57600 115200	9600			Baud rate for RS232 port.
Data bits		8			Data bits for RS232 port.
Parity	None Even Odd	None			Parity for RS232 port.
Stop bit		1			Stop bit for RS232 port.
Frame timeout	1~60000	20	1	ms	Frame timeout for RS232 port.
RS232					
Baudrate	1200 2400 4800 9600 19200 38400 57600 115200	9600			Baudrate for RS232 port.
Data bits		8			Data bits for RS232 port.
Parity	None Even Odd	None			Parity for RS232 port.
Stop bit		1			Stop bit for RS232 port.
Frame timeout	1~60000	20	1	ms	Frame timeout for RS232 port.
RS232/485 (default is RS485)					
Baudrate	1200 2400 4800 9600 19200 38400 57600 115200	9600			Baudrate for RS232/485 port.
Data bits		8			Data bits for RS232/485 port.
Parity	None Even Odd	None			Parity for RS232/485 port.
Stop bit		1			Stop bit for RS232/485 port.
Frame timeout	1~60000	20	1	ms	Frame timeout for RS232/485 port.

The following table shows the parameter settings among communication protocol.

Table 66-Communication protocol parameter settings

Parameter	Range	Default	Step	Unit	Description
IEC 60870-5-101/104					
IEC 60870 General					
Max Data Link Frame Size	35~261	261			Max Data Link Frame Size
C_SE General Interrogation	Disable Enable	Disable			C_SE General Interrogation.
Analog Value Type	Normalized Scaled Float	Scaled			M_ME type identification.
Analog Event Mode	SOE Most recent	SOE			Determine to transmit analog event with all or only with most recent events.
Select/Operate Timeout	1~255	15	1	sec	This parameter will be used for SBO (Select before Operate) operation.
Cyclic Period	0~60	0	1	sec	Data update for transmission can be triggered periodically through this parameter.
M_SP Cyclic	Disable Enable	Disable			It selects if the cyclic update will be done or not for each type identification.
M_DP Cyclic	Disable Enable	Disable			It selects if the cyclic update will be done or not for each type identification.
M_ME Cyclic	Disable Enable	Enable			It selects if the cyclic update will be done or not for each type identification.
M_SP Start Address	1~65535	100	1		It defines the base address of information points for each type identification.
C_SC Start Address	1~65535	200	1		It defines the base address of information points for each type identification.
M_DP Start Address	1~65535	300	1		It defines the base address of information points for each type identification.
C_DC Start Address	1~65535	400	1		It defines the base address of information points for each type identification.
M_ME Start Address	1~65535	1000	1		It defines the base address of information points for each type identification.
C_SE Start Address	1~65535	2000	1		It defines the base address of information points for each type identification.
M_IT Start Address	1~65535	4000	1		It defines the base address of information points for each type identification.
IEC 60870-5-101					
Operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Type	IEC101-RS232 IEC101-RS232/485	IEC101-RS232			Serial mode selection.
Link Address	1~65535	1	1		Link address for IEC101.
Link Address Size	1~2	1	1		Link address size for IEC101.
Common Address Size	1~2	1	1		Common address size for IEC101.
Object Address Size	1~3	2	1		Object address size for IEC101.
COT Size	1~2	1	1		The size of"Cause Of Transmission".
Time Marker	None CP24 CP56	CP56			The time tag can be selected as 24-bit or 56-bit.
Single NACK Control	Yes No	Yes			This function element can be enabled or disabled by yes/no selection.
Link Mode	Unbalanced Balanced	Balanced			Link mode setting for IEC101.
IEC 60870-5-104					
Operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Type	IEC104-Eth-TCPClient, IEC104-Eth-TCPServer	IEC104-Eth-TCPServer			Ethernet mode selection.
Remote IP Address		0.0.0.0			Remote IP address for IEC104.

Parameter	Range	Default	Step	Unit	Description
Port	1~65535	2404	1		Server TCP port.
Common Address	1~65535	1	1		Common address for IEC1014.
Common Address Size	1~2	1	1		Common address size for IEC104.
Object Address Size	1~3	2	1		Object address size for IEC104.
COT Size	1~2	1	1		The size of"Cause Of Transmission".
T0 Connection Timeout	1~255	30	1	sec	Time-out of connection establishment.
T1 Response Timeout	1~255	15	1	sec	Time-out of send or test APDUs.
T2 S-Frame Period	1~255	10	1	sec	Time-out for acknowledges in case of no data messages t2 < t1.
T3 Test Period	1~255	20	1	sec	Time-out for sending test frames in case of a long idle state.
K Value	0~12	12		APD	K Value
W Value	0~8	8		APD	W Value
Time Marker	None CP24 CP56	CP56			The time tag can be selected as 24-bit or 56-bit.
Initialize end frame	on/off	on			Initialize end frame
Modbus					
Operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Type	Eth-TCPServer, RS232, RS232/485	Eth-TCPServer			Mode selection.
IP address		0.0.0.0			IP address for Modbus.
TCP port	1~65535	502	1		TCP port for Modbus.
Slave address	1~65535	1	1		Modbus unit address.
Link mode	ASCII RTU	RTU			Link mode selection.
CRC order	Hi-Lo Lo-Hi	Hi-Lo			CRC order for Modbus.
Write authority	Read only Full access	Read only			Write authority selection.
Time format	Local UTC	Local			Time format for Modbus.
Event ID selection	Address UID	Address			Event ID selection.
Event buffering	Keep oldest Keep newest	Keep newest			Event buffering mode selection.
Event backoff	1~1000	100			Event backoff for Modbus.
DNP3.0					
Slave address	1~65531	1	1		DNP unit address.
DNP3.0 Serial					
Operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Type	DNP3_RS232,DNP3_ RS232/485	DNP3_RS232			Serial port selection.
Index Table Number	1~3	1	1		Index table number for DNP serial.
Analog Event Mode	SOE Most recent	SOE			Determine to transmit analog event with all or only with most recent events.
Analog Input Object Type	16BIT 32BIT FLOAT	16BIT			Analog Input Object Type.
Counter Object Size	16BIT 32BIT	16BIT			Counter Object Size.
Select/Operate Timeout	1~255	15	1	sec	This parameter will be used for SBO (Select before Operate) operation.
Interval to Request Link Status	0~60000	0	1	sec	Indicates how often Data Link Layer status request is sent while the communication is idle.
Interval to Set IIN1.4 (Need Time)	0~60000	0	1	sec	For requesting time synchronization to master station this every interval.
Data Link Layer Frame Size	64~292	292	1		It defines the maximum size of data link frame.

Parameter	Range	Default	Step	Unit	Description
Data Link Layer Frame Interval	10~500	100	10	ms	Data Link Layer Frame Interval time.
Data Link Layer Retries	0~2	0	1		Number of data link layer retries when the data link the confirm timeout take places.
Data Link Layer Timeout	1~255	30	1	sec	Data link timeout for waiting the data link layer confirm from master station.
Data Link Layer Confirm	No Yes Sometimes	Sometimes			This parameter controls data link confirm for sending frames.
Application Layer Fragment Size	256 512 1024 2048	2048			Maximum size of each application fragment.
Application Layer Retries	0~100	1	1		Application Layer Retries.
Application Layer Timeout	1~255	40	1	sec	Application Layer Timeout.
Unsolicited Mode	on/off	off			This function element can be enabled or disabled by on/off selection.
Unsolicited Address (Master Address)	1~65531	65531	1		The address of the master station which the unsolicited response will be sent.
Unsolicited class 1 Number	1~512	5	1		The maximum number of events in the corresponding class to bellowed before an unsolicited response is generated.
Unsolicited class 2 Number	1~512	5	1		The maximum number of events in the corresponding class to bellowed before an unsolicited response is generated.
Unsolicited class 3 Number	1~512	5	1		The maximum number of events in the corresponding class to bellowed before an unsolicited response is generated.
Unsolicited class 1 Delay Time	0~60	5	1	sec	The waiting time to send an unsolicited response after a first event occurred.
Unsolicited class 2 Delay Time	0~60	5	1	sec	The waiting time to send an unsolicited response after a first event occurred.
Unsolicited class 3 Delay Time	0~60	5	1	sec	The waiting time to send an unsolicited response after a first event occurred.
Unsolicited Offline Retry Delay	0~255	15	1	min	Unsolicited Offline Retry Delay.
Unsolicited class 1	Disable Enable	Disable			Unsolicited setting for Class 1, 2, 3.
Unsolicited class 2	Disable Enable	Disable			Unsolicited setting for Class 1, 2, 3.
Unsolicited class 3	Disable Enable	Disable			Unsolicited setting for Class 1, 2, 3.
DNP3.0 TCP/IP					
Operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Type	DNP3-TCPServer, DNP3-TCPClient	DNP3-TCPServer			Ethernet port selection.
Remote IP		0.0.0.0			IP address for DNP.
Port	1~65534	20000	1		TCP port for DNP.
Index Table Number	1~3	1	1		Index table number for DNP TCP/IP.
Analog Event Mode	SOE Most recent	SOE			Determine to transmit analog event with all or only with most recent events.
Analog Input Object Type	16BIT 32BIT FLOAT	16BIT			Analog Input Object Type.
Counter Object Size	16BIT 32BIT	16BIT			Counter Object Size.
Select/Operate Timeout	1~255	15	1	sec	This parameter will be used for SBO (Select before Operate) operation.
Interval to Request Link Status	0~60000	0	1	sec	Indicates how often Data Link Layer status request is sent while the communication is idle.
Interval to Set IIN1.4 (Need Time)	0~60000	0	1	sec	For requesting time synchronization to master station this every interval.
Data Link Layer Frame Size	64~292	292	1		It defines the maximum size of data link frame.
Data Link Layer Frame Interval	10~500	100	10	ms	Data Link Layer Frame Interval time.

Parameter	Range	Default	Step	Unit	Description
Data Link Layer Retries	0~2	0	1		Number of data link layer retries when the data link the confirm timeout take places.
Data Link Layer Timeout	1~255	30	1	sec	Data link timeout for waiting the data link layer confirm from master station.
Data Link Layer Confirm	No Yes Sometimes	Sometimes			This parameter controls data link confirm for sending frames.
Application Layer Fragment Size	256 512 1024 2048	2048			Maximum size of each application fragment.
Application Layer Retries	0~100	1	1		Application Layer Retries.
Application Layer Timeout	1~255	40	1	sec	Application Layer Timeout.
Unsolicited Mode	on/off	off			This function element can be enabled or disabled by on/off selection.
Unsolicited Address (Master Address)	1~65531	65531	1		The address of the master station which the unsolicited response will be sent.
Unsolicited class 1 Number	1~512	5	1		The maximum number of events in the corresponding class to bellowed before an unsolicited response is generated.
Unsolicited class 2 Number	1~512	5	1		The maximum number of events in the corresponding class to bellowed before an unsolicited response is generated.
Unsolicited class 3 Number	1~512	5	1		The maximum number of events in the corresponding class to bellowed before an unsolicited response is generated.
Unsolicited class 1 Delay Time	0~60	5	1	sec	The waiting time to send an unsolicited response after a first event occurred.
Unsolicited class 2 Delay Time	0~60	5	1	sec	The waiting time to send an unsolicited response after a first event occurred.
Unsolicited class 3 Delay Time	0~60	5	1	sec	The waiting time to send an unsolicited response after a first event occurred.
Unsolicited Offline Retry Delay	0~255	15	1	min	Unsolicited Offline Retry Delay.
Unsolicited class 1	Disable Enable	Disable			Unsolicited setting for Class 1, 2, 3.
Unsolicited class 2	Disable Enable	Disable			Unsolicited setting for Class 1, 2, 3.
Unsolicited class 3	Disable Enable	Disable			Unsolicited setting for Class 1, 2, 3.
DNP3.0 SECURE AUTHENTICATION					
Secure Authentication	Disable Enable	Disable			Secure Authentication
Secure Authentication Version	2/5	2			Secure Authentication Version
Outstation Name		outstation			Outstation Name
Aggressive Mode		enable			Aggressive Mode
Security Message Response Timeout	0~120	2	1	s	Security Message Response Timeout
Session Key Change Interval	0~7200	1800	1	s	Session Key Change Interval
Session Key Change Message Count	1~10000	2000	1		Session Key Change Message Count
Maximum Session Key Status Count	0~255	5	1		Maximum Session Key Status Count
Maximum Error Count	0~10	2	1		Maximum Error Count
MAC Algorithm	not used/SHA-1 4 octets(serial)/SHA-1 10 octets(net)/SHA-256 8 octets(serial)/SHA-256 16 octets(net)	not used			MAC Algorithm
Key Wrap Algorithm	AES-128/AES-256	AES-128			Key Wrap Algorithm
wLinkFailTimeout	0~120	0	1	s	wLinkFailTimeout
Opt. Critical Functions-Confirm	Disable Enable	disable			Opt. Critical Functions-Confirm

Parameter	Range	Default	Step	Unit	Description
Opt. Critical Functions-Read	Disable Enable	disable			Opt. Critical Functions-Read
Opt. Critical Functions-Immediate Freeze	Disable Enable	disable			Opt. Critical Functions-Immediate Freeze
Opt. Critical Functions-Immediate Freeze(no Ack)	Disable Enable	disable			Opt. Critical Functions-Immediate Freeze(no Ack)
Opt. Critical Functions-Freeze and Clear	Disable Enable	disable			Opt. Critical Functions-Freeze and Clear
Opt. Critical Functions-Freeze and Clear(no Ack)	Disable Enable	disable			Opt. Critical Functions-Freeze and Clear(no Ack)
Opt. Critical Functions-Freeze with Time	Disable Enable	disable			Opt. Critical Functions-Freeze with Time
Opt. Critical Functions-Freeze with Time(no Ack)	Disable Enable	disable			Opt. Critical Functions-Freeze with Time(no Ack)
Opt. Critical Functions-Intitalize Data to Defaults	Disable Enable	disable			Opt. Critical Functions-Intitalize Data to Defaults
Opt. Critical Functions-Assign Class	Disable Enable	disable			Opt. Critical Functions-Assign Class
Opt. Critical Functions-Delay Measurement	Disable Enable	disable			Opt. Critical Functions-Delay Measurement
Opt. Critical Functions-Response	Disable Enable	disable			Opt. Critical Functions-Response
Opt. Critical Functions-Unsolicited Message	Disable Enable	disable			Opt. Critical Functions-Unsolicited Message
UserNum		1			UserNum
Secure Authentication User Number #1	64 character				Secure Authentication User Number #1
Secure Authentication User Number #2	64 character				Secure Authentication User Number #2
Secure Authentication User Number #3	64 character				Secure Authentication User Number #3
Secure Authentication User Number #4	64 character				Secure Authentication User Number #4
Secure Authentication User Number #5	64 character				Secure Authentication User Number #5
Secure Authentication User Number #6	64 character				Secure Authentication User Number #6
Secure Authentication User Number #7	64 character				Secure Authentication User Number #7
Secure Authentication User Number #8	64 character				Secure Authentication User Number #8
Secure Authentication User Number #9	64 character				Secure Authentication User Number #9
Secure Authentication User Number #10	64 character				Secure Authentication User Number #10
Secure Authentication User Number #11	64 character				Secure Authentication User Number #11
Secure Authentication User Number #12	64 character				Secure Authentication User Number #12
Secure Authentication User Number #13	64 character				Secure Authentication User Number #13
Secure Authentication User Number #14	64 character				Secure Authentication User Number #14
Secure Authentication User Number #15	64 character				Secure Authentication User Number #15
Secure Authentication User Number #16	64 character				Secure Authentication User Number #16

Parameter	Range	Default	Step	Unit	Description
DNP3.0 SECURE AUTHENTICATION					
Unexpected Messages	0~65535	3	1		Unexpected Messages
Authorization Failures	0~65535	5	1		Authorization Failures
Authentication Failures	0~65535	5	1	s	Authentication Failures
Reply Timeouts	0~65535	3	1		Reply Timeouts
Rekey Due to Authentication Failure	0~65535	3	1		Rekey Due to Authentication Failure
Total Messages Sent	0~65535	100	1		Total Messages Sent
Total Messages Received	0~65535	100	1		Total Messages Received
Critical Messages Sent	0~65535	100	1		Critical Messages Sent
Critical Messages Received	0~65535	100	1		Critical Messages Received
Discarded Messages	0~65535	10	1		Discarded Messages
Error Messages Sent	0~65535	2	1		Error Messages Sent
Error Messages Received	0~65535	10	1		Error Messages Received
Successful Authentications	0~65535	100	1		Successful Authentications
Session Key Changes	0~65535	10	1		Session Key Changes
Failed Session Key Changes	0~65535	5	1		Failed Session Key Changes
Update Key Changes	0~65535	1	1		Update Key Changes
Failed Update Key Changes	0~65535	1	1		Failed Update Key Changes
Rekey Due to Restart	0~65535	3	1		Rekey Due to Restart

4.5 Data Handling

The FXD Control has data handling function for following items:

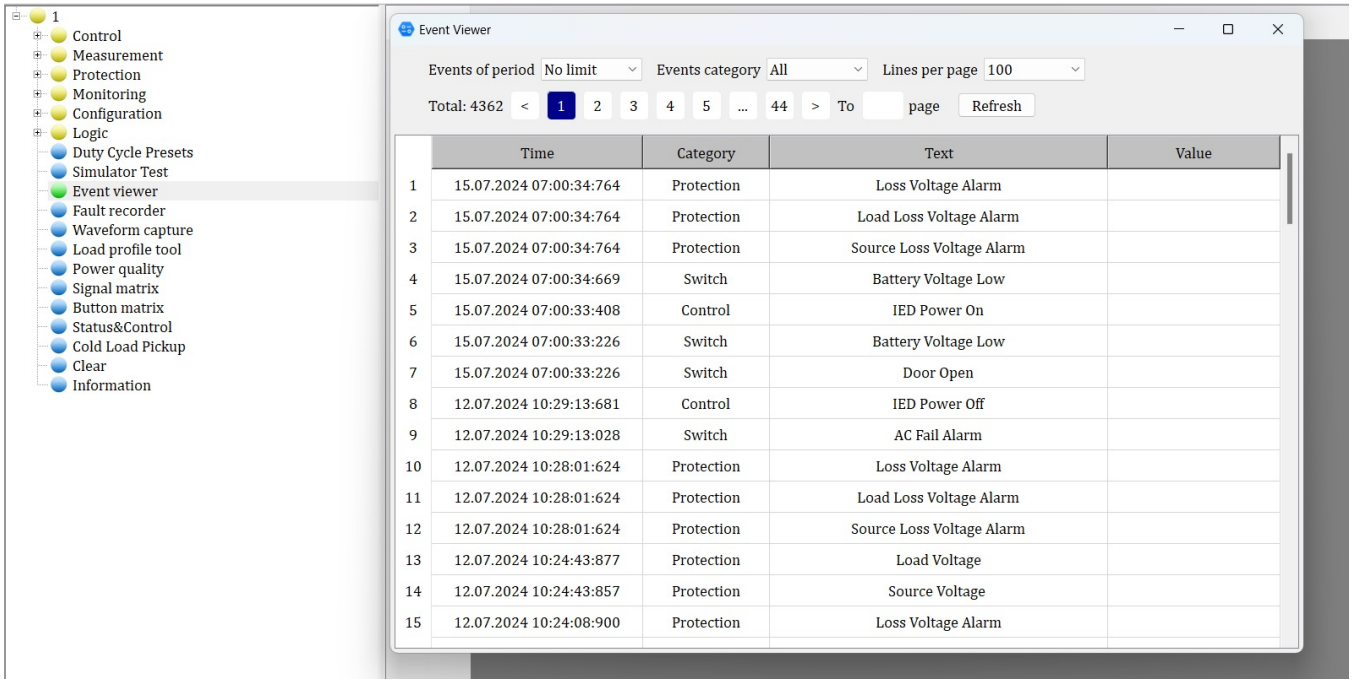
- Sequence of event recorder
- Fault recorder
- Disturbance recorder
- Power quality analysis
- Load profile

4.5.1 SOE and Fault recorder

This function is used to verify shortly the operated history of FXD Control in normal operation and fault situation. Sequence of event is triggered by control, set value change, operation of protection, communication, measurement alarm, system error or self-diagnosis, etc. The FXD Control can store 10,000 events in a nonvolatile memory including occurred time/date, type, values of current/voltage alarm and warn. All events can view through LCD screen. The capacity of fault recorder is 1,024 pieces, which contains all protection occurred time/date, type and values of fault current, voltage and frequency. The SOE and fault recorder follows FIFO (First In First Out) principle.

The types of SOE include “protection”, “measurement”, “control”, “settings”, “switch”, “communication” and “internal fault”; the types of FR includes “start”, “alarm” and “trip”.

Stored events and faults can be uploaded and listed on Maintenance Software and webserver through commissioning port on front panel. The event and fault list are shown in software as below picture.



	Time	Category	Text	Value
1	15.07.2024 07:00:34:764	Protection	Loss Voltage Alarm	
2	15.07.2024 07:00:34:764	Protection	Load Loss Voltage Alarm	
3	15.07.2024 07:00:34:764	Protection	Source Loss Voltage Alarm	
4	15.07.2024 07:00:34:669	Switch	Battery Voltage Low	
5	15.07.2024 07:00:33:408	Control	IED Power On	
6	15.07.2024 07:00:33:226	Switch	Battery Voltage Low	
7	15.07.2024 07:00:33:226	Switch	Door Open	
8	12.07.2024 10:29:13:681	Control	IED Power Off	
9	12.07.2024 10:29:13:028	Switch	AC Fail Alarm	
10	12.07.2024 10:28:01:624	Protection	Loss Voltage Alarm	
11	12.07.2024 10:28:01:624	Protection	Load Loss Voltage Alarm	
12	12.07.2024 10:28:01:624	Protection	Source Loss Voltage Alarm	
13	12.07.2024 10:24:43:877	Protection	Load Voltage	
14	12.07.2024 10:24:43:857	Protection	Source Voltage	
15	12.07.2024 10:24:08:900	Protection	Loss Voltage Alarm	

Figure 10 Event list

4.5.2 Disturbance Recorder

The FXD Control supports disturbance recorder function including 12 analog and 64 binary signal channels, which can store 10 records with a maximum of 10 seconds at the storage rate of 128 sampling points in each fundamental frequency period and store up to 100 records to help customers comprehensively analyze the reason of the fault, tracing the rooting cause to solve the problem. The record length and storage rate are adjustable.

The function can be enabled and disabled with the operation setting, corresponding parameter values are “on”, “off”.

Disturbance recorder can be triggered by the following methods:

A. Triggered according to the state change of any or more binary channels, triggering on the rising edge of the binary input signal indicates that the recording sequence is enabled when the input signal is activated. Correspondingly, triggering on the falling edge indicates that the recording sequence is enabled when the effective input signal is reset. It can also be triggered from both edges at the same time. In addition, it can also not trigger the monitoring signal if necessary.

B. Trigger according to the limit value of analog channel (high limit value or low limit value), the filtering time of all analog channels are the same, about 50ms.

C. Manually trigger by disturbance recorder parameters on LCD menu.

D. Regularly triggered, which means that the disturbance recorder will be recorded automatically at a specific time interval. The user can adjust this interval time through the periodic trigger time parameter. If the parameter value is changed, the new setting will be adopted at the next periodic trigger.

Disturbance recorder has two operation modes: saturation mode and overwrite mode.

The user can change the operation mode through the parameter. In saturation mode, the records cannot be overwritten by new one. When the recording memory is full (reaching the maximum number of records), the waveforms will be stopped to capture. When the operation mode is overwrite and the recording memory is full, the records will be updated by new one. If you want to get the latest record in the memory, it is recommended to adopt the overwrite mode, if the old record is more important, the saturation mode is adopted.

The disturbance recorder is also uploaded to software, and current/voltage waveforms at fault and protection elements operation can be analyzed with report. This disturbance recorder function follows the COMTRADE file format rule. The waveforms picture is shown in software as below:

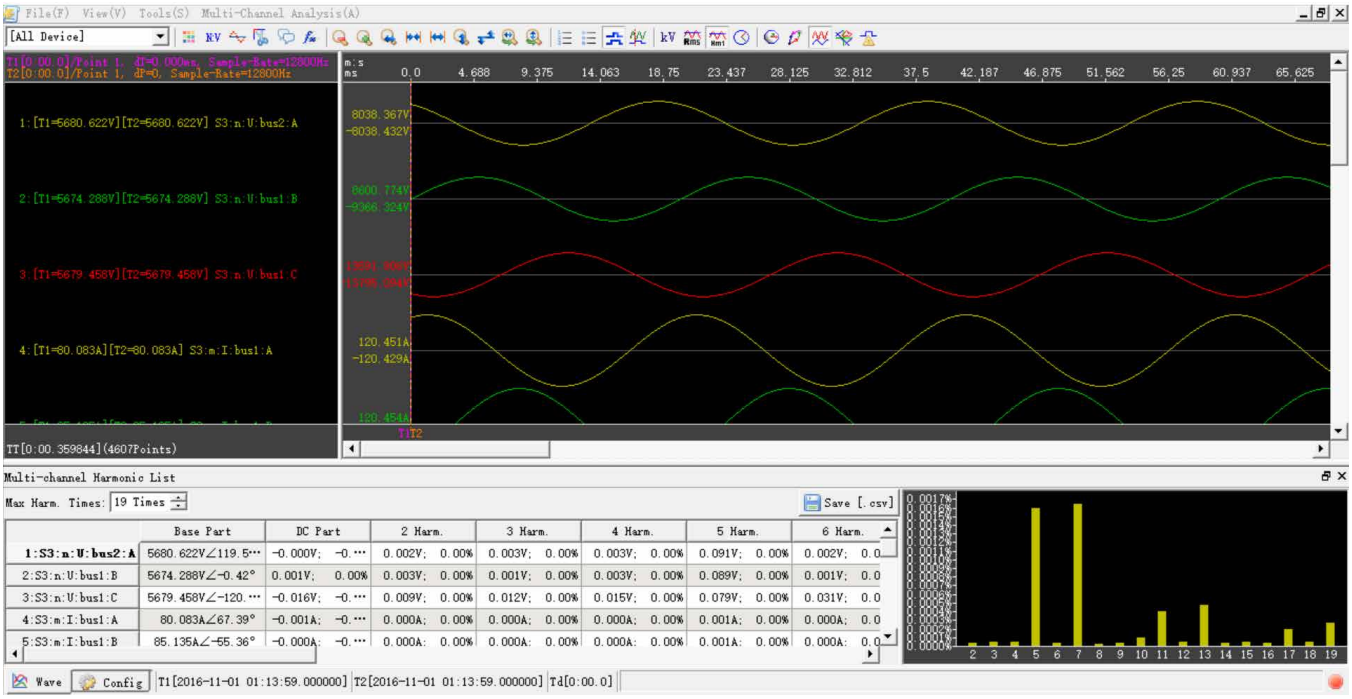


Figure 11 Disturbance recorder

The following table shows the parameter settings among disturbance recorder function.

Table 67-Disturbance recorder function parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Record length	10~500	50	1	cycles	Size of the recording in fundamental cycles.
Pre-trg length	0~10	5	1	cycles	Length of the recording preceding the triggering.
Operation mode	Overwrite Saturation	Overwrite			Operation mode of the recorder.
Exclusion time	0~100000	0	1	ms	The time during which triggerings of same type are ignored.
Storage rate	128 64 32 16 8	128			Storage rate of the waveform recording.
Periodic triger time	0~600000	0	1	sec	Time between periodic triggerings.
Analog ch1 operation	on/off	on			This function element can be enabled or disabled by on/off selection.
Ch1 selection	Ia/Ib/Ic/Io/Ua/Ub/Uc/Uo1/ Ur/Us/Ut/Uo2/Uab/Ubc/Uca/ Urs/Ust/Utr/none	Ia			Select the analog to be recorded by this channel.
Analog high triger level	0.00~60.00	10.00	0.01	pu	High trigger level for the analog channel. (0.00 means disable this function)
Analog low triger level	0.00~2.00	0.00	0.01	pu	Low trigger level for the analog channel. (0.00 means disable this function)
OC ch1 operation	on/off	on			This function element can be enabled or disabled by on/off selection.
OC ch1 selection	A-Fast OC start/B-Fast OC start/C-Fast OC start/Fast OC start/Fast OC trip/A-Delay OC start/B-Delay OC start/C-Delay OC start/Delay OC start/Delay OC trip/A-Def OC start/B-Def OC start/C-Def OC start/Def OC start/Def OC trip/OC trip/A-OC start/B-OC start/C-OC start/OC start/none	Fast OC start			Select the binary to be recorded by this channel.
Binary triger mode	rising edge falling edge Both trigger off	rising edge			Level trigger mode for the binary channel.

4.5.3 Power Quality Analysis

The FXD CONTROL Supports power quality analysis, which can check the proportion of harmonic components of up to 9 analog quantities in real time, including three phase currents and three phase voltages, and up to 16 harmonics can be calculated to meet Customers' high-quality electricity demands. The power quality data is uploaded to software and shown in power quality analysis tool as below picture. The power quality data can be deleted by webserver and software.

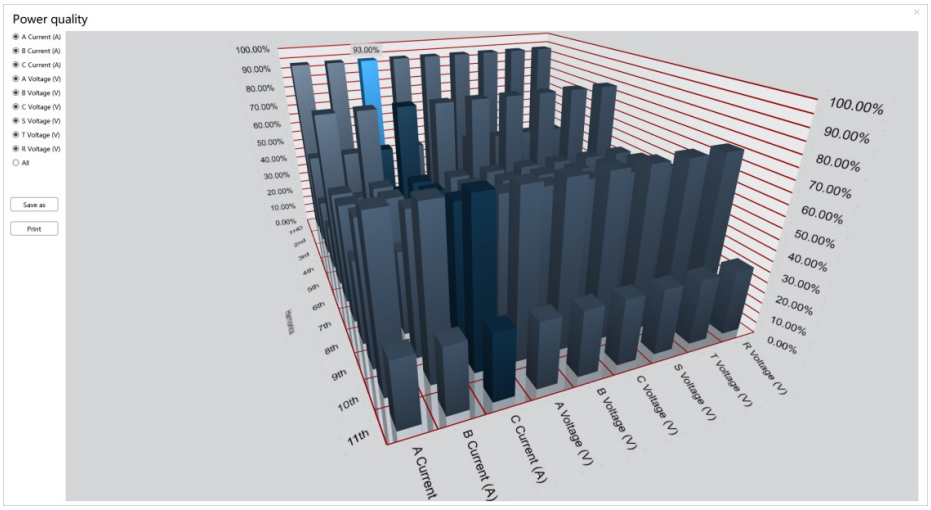


Figure 12 Power quality analysis

4.5.4 Load Profile

Record the selected analog values at the programmable intervals (1, 5, 15, 30, 60, 180 minutes). Load profile can store values for 60 days at the interval of 60 minutes and could check the historical data curve of 29 analog quantities, including current, voltage, power,energy, power factor, frequency, and harmonic, to be convenient for customers to track and save the data.

The load profile data is uploaded to software and shown in load profile tool as below picture. The load profile data can be deleted by LCD menu, webserver, and software.

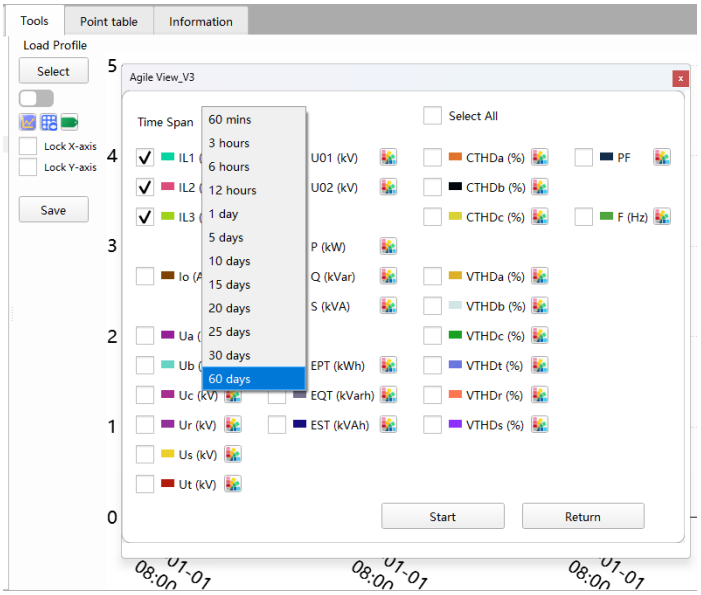


Figure 13 Load profile

4.6 Distribution Automation Scheme

Distribution automation schemes enable rapid detection, isolation, and restoration of feeder faults through the cooperation between reclosers, or between circuit breakers and load break switches.

The schemes are mainly divided into local and centralized types: the local type does not depend on the communication and SCADA systems. It can realize various logical actions through the local FXD CONTROL; the centralized type needs to establish communication and SCADA, the master station sends control commands to the intelligent terminal, so as to realize the distribution network automation functions.

The overhead line automation solutions, mainly local and partly centralized, with the innovative combination of both types, will meet the needs of customers for automation with different grid topologies. The solutions are mainly: loop automation scheme and auto-changeover scheme.

4.6.1 Loop Automation Scheme

The loop automation scheme is applied in a ring network, and completed by the recloser and FXD Control it is equipped with. Depending on where the recloser is installed on the overhead line, it can be divided into: Feeder ACR, Mid-point ACR and Tie ACR.

When over-current and ground fault occur on the line, if the Feeder ACR detects the fault current and reaches the trip time, it trips for line protection, and filters the instantaneous fault through the first reclosing. It will trip again for reclosing lock out when it is a permanent fault; if no voltage is detected on both sides, it trips directly and locks out the closing after a set delay time. If the Mid-point ACR detects a fault current, it will trip before the Feeder ACR, and if it is a permanent fault, it will open and locks out; if it detects the absence of voltage on the power side, the current protection direction is reversed, and at the same time, the reclosing function is not activated, and it becomes a single trip mode. When the Tie ACR detects voltage on one side and no voltage on the other side, it closes after a set delay time to complete the transfer of power; after the Tie ACR has closed, it plays the role of the Mid-point ACR. If the fault current is detected, it directly opens and locks out reclosing.

Through the above logic process, the recloser finally achieves faulty section isolation and restoration of power supply in the non-faulty sections within seconds.

Users may, according to their need, choose to establish communication and SCADA system for remote monitoring and control.

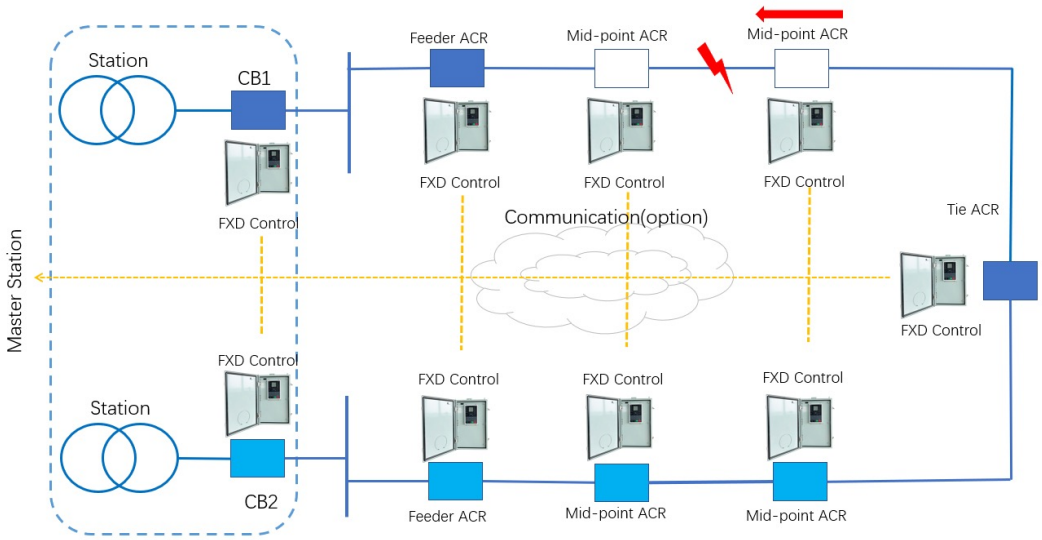


Figure 14 Loop automation scheme

The following table shows the parameter settings among loop automation scheme.

Table 68-Loop automation scheme parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Device type	Feeder Midpoint Tie	Feeder			The type of logic for automatic circuit recloser.
Open delay time	0.1~180.0	5.0	0.1	s	Delay time for operation (Feeder ACR).
Close delay time	1~600	30	1	s	Delay time for closing (Tie ACR).
Auto change	on/off	off			This function element can be enabled or disabled by on/off selection.
Auto change time	1.0~180.0	10.0	0.1	s	Delay time for auto change (Mid ACR).
Deadline value	0.1~0.8	0.2	0.1	xUn	Voltage low-limit line for solution.
Live line value	0.2~1.0	0.5	0.1	xUn	Voltage high-limit line for solution.

4.6.2 Auto-changeover Scheme

uto-changeover scheme is used in dual power supply system, usually the object of power supply is an important load, such as hospitals, factories, etc. The function logic is realized by the recloser and its own FXD Control. Depending on where the recloser is installed in the dual power supply system, it can be divided into: Feeder ACR and Tie ACR.

Normally it is powered by the main power supply. The Feeder ACR is installed on the terminal of the main power supply and is normally closed; the backup power supply is disconnected by the Tie ACR to prevent a closed loop.

When an over-current or ground fault occurs on the main power side, the circuit breaker in station trips, and the main circuit loses voltage. The Feeder ACR detects the absence of voltage on both sides, and after a set delay time, it trips and lock out the closing action directly; when the Tie ACR detects the absence of voltage on the load side, it closes after a set delay time to switch to the backup power supply and restore the power supply to the important load.

Through the above logic process, the recloser achieves automatic power transfer function within seconds.

Users may, according to their need, choose to establish communication and SCADA system for background monitoring and control.

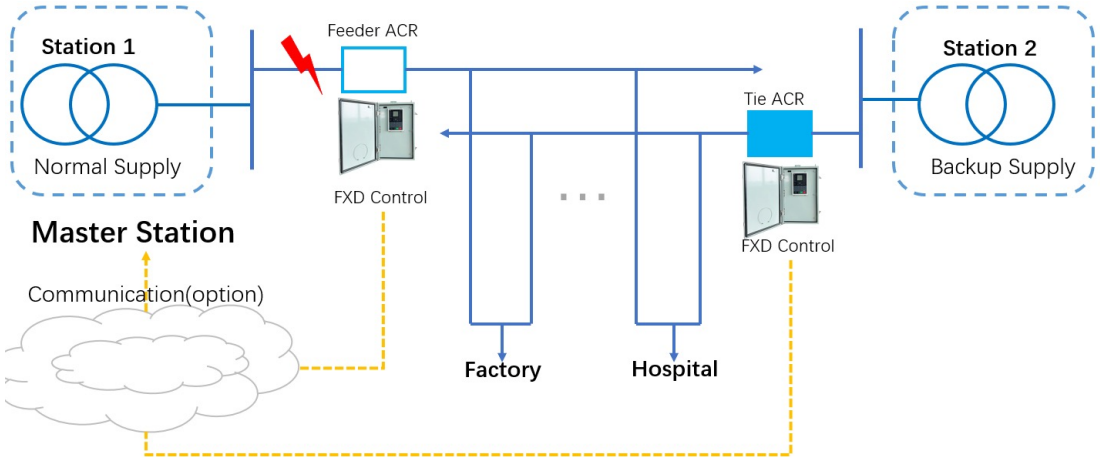


Figure 15 Auto-changeover scheme

The following table shows the parameter settings among auto-changeover scheme.

Table 69-Auto-changeover scheme parameter settings

Parameter	Range	Default	Step	Unit	Description
Operation	on/off	off			This function element can be enabled or disabled by on/off selection.
Device type	Feeder Tie	Feeder			The type of logic for automatic circuit recloser.
Open delay time	0.1~180.0	5.0	0.1	s	Delay time for operation (Feeder ACR).
Close delay time	1~600	30	1	s	Delay time for closing (Tie ACR).
Deadline value	0.1~0.8	0.2	0.1	xUn	Voltage low-limit line for solution.
Live line value	0.2~1.0	0.5	0.1	xUn	Voltage high-limit line for solution.

4.7 Authorization Function

There are four roles of user which predefined for LCD and webserver with different rights and default password.

- Administrator
- Engineer
- Operator
- Viewer

The default password of all roles can be changed with administrator rights.

The following table shows rights for four roles.

Table 70-Predifined authorization

User	LCD Authorization	Web-server Authorization
Viewer	Read only	Read only
Operator	R/L selection (only local operation)	Setting Group selection
	Local Open/Close	LEDs alarm clear
	Local buttons operation	
	Setting Group selection	
	LEDs alarm clear	
Engineer	Control parameter setting change	Control parameter setting change
	Protection parameter setting change	Protection parameter setting change
	Configuration setting change (except for authorization)	Configuration setting change (except for authorization)
	Logic parameter setting change	Logic parameter setting change
	Clear operation	Event Viewer delete/save as/print
	Cold Load Pickup setting change	Fault Records delete/save as/print
	Language setting change	Disturbance Records operation
		Load Profile Records operation
		Cold Load Pickup setting change
		Parameter List download/print
		Clear operation
		Language setting change
		File import/export
Administrator	All list above	All list above
	Changing password	Changing password

The following table shows the parameter settings among authorization function.

Table 71-Authorization function parameter settings

Parameter	Range	Default	Step	Unit	Description
Remote update	Enable Disable	Enable			Allow or not allow the remote maintenance by enable/disable
Remote override	True False	False			Show the below menu if selected true. (Only administrator have permission)
Viewer password		0000			Viewer password. (Only administrator have permission)
Operator password		0000			Operator password. (Only administrator have permission)
Engineer password		0000			Engineer password. (Only administrator have permission)
Administrator password		0000			Administrator password. (Only administrator have permission)

4.8 Internal Fault

When an internal fault is detected, protection operation will be disabled, the self-check LED change from green to red. Internal fault indications have the highest priority on the LCD. When the internal faut is found to be permanent, all other output contacts are released and locked for the internal fault, the internal fault information is shown as a SOE on the event list. When the internal fault disappears, the self-check LED will recovery to green LED flashing and the FXD Control returns to the normal service state, The fault information remains on the SOE event list.

The following table shows types of internal fault.

Table 72-Internal fault type

Internal Fault Type	Fault code
Internal Fault File error	1
Internal Fault PWR CAN Comm. error	2
Internal Fault MEA CAN Comm. error	3
Internal Fault LCD CAN Comm. error	4
Internal Fault COM CAN Comm. error	5
Internal Fault DIO1 CAN Comm. error	6
Internal Fault DIO2 CAN Comm. error	7
Internal Fault LCD and COM Comm. error	8
Internal Fault LHMI Module error	9
Internal Fault MEA Flash error	10
Internal Fault LCD Flash error	11
Internal Fault COM Flash error	12
Internal Fault RTC error	13
Internal Fault LCD RJ45 error	14
Internal Fault COM RJ45 error	15
Internal Fault ADC Sample error	16
Internal Fault Frequency error	17
Internal Fault MEA Timer error	18
Internal Fault PWR Timer error	19
Internal Fault DIO1 Timer error	20
Internal Fault DIO2 Timer error	21
Internal Fault MEA Buffer error	22
Internal Fault MEA Config error	23

4.9 Programmable Logic Controller

Programmable logic builds up functions by using input, output, protection, and control block diagram, and is used to perform logic desired by users. Through programmable logic tool, various functions such as signal input, command output, DA solution, inter-lock, programmable LED can be accomplished. Programmable logic is according to IEC 61131-3 standard.

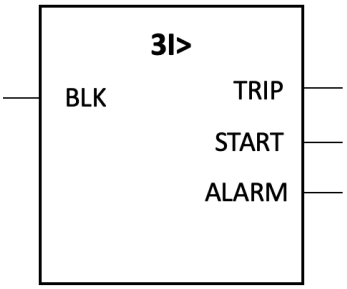
Programmable logic controller can support various functions as below table.

Table 73-PLC function list

Function	Block name	Block Qty
Protection	Non-directional OC (3I>)	1PC
	Directional OC (3I>->)	1PC
	Non-directional EF (Io>)	1PC
	Directional EF (Io>->)	1PC
	Non-directional SEF (SEF>)	1PC
	Directional SEF (DSEF>)	1PC
	Inrush Restraint (3I2f>)	1PC
	Non-directional NSOC (I2>)	1PC
	Directional NSOC (I2>->)	1PC
	Broken Conductor (I2/I1>)	1PC
	Over-voltage (3U>)	1PC (Only on source)
	Under-voltage (3U<)	1PC (Only on source)
	Negative-sequence OV (U2>)	1PC (Only on source)
	Residual OV (Uo>)	1PC (Only on source)
	Frequency Protection (f>/f<, df/dt)	1PC
	Breaker Failure (3I>/Io>BF)	1PC
Measurement	Three-phase Current (3I)	1PC
	Neutral Current (IO)	1PC
	Three-phase voltage (3U)	2PCS (Source and load sides)
	Neutral Voltage (UO)	2PCS (Source and load sides)
	Frequency (F)	1PC
	Current Sequence (I1,I2,I0)	1PC
	Voltage Sequence (U1,U2,U0)	2PCS (Source and load sides)
	Energy (E)	1PC
Power Quality	Current Harmonic (PQM3I)	1PC
	Voltage Harmonic (PQM3U)	1PC
Control	Open/Close Control (I<->0 CB)	1PC
	Local/Remote Control (LOC/REM/OFF)	1PC
	Reclosing (O-->I)	1PC
	Synchro check (SYNC)	1PC
General	Operation Counter (OPTS)	1PC
I/O	Input (→I)	10PCS
	Output (O→)	4PCS
LED	LED	16PCS

4.9.1 Non-directional OC (3I>)

The Function block diagram is described as below:



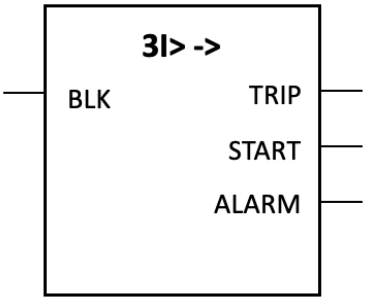
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 74-Input/output signals (3I>)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.2 Directional OC (3I>->)

The Function block diagram is described as below:



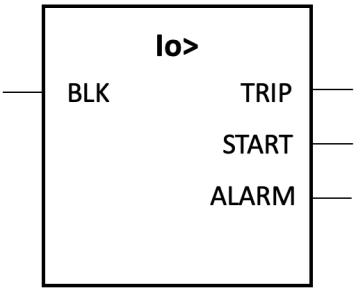
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 75-Input/output signals (3I>->)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.3 Non-directional EF (Io>)

The Function block diagram is described as below:



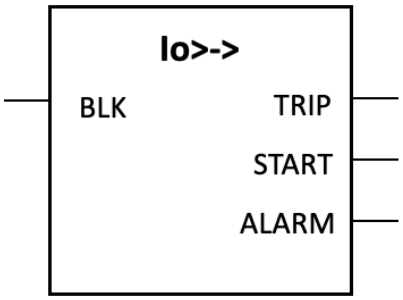
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 76-Input/output signals (Io>)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.4 Directional EF (Io>->)

The Function block diagram is described as below:



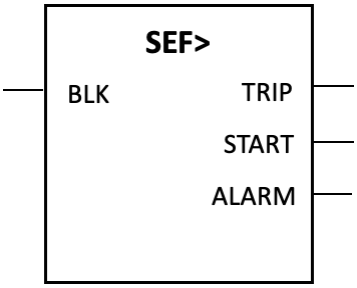
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 77-Input/output signals (Io>->)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.5 Non-directional SEF (SEF>)

The Function block diagram is described as below:



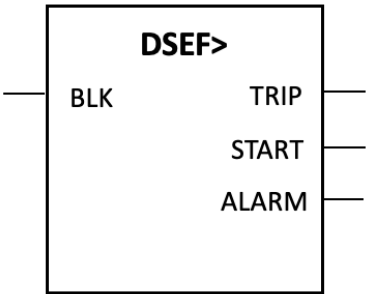
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 78-Input/output signals (SEF>)

Name	Type	Default
Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.6 Directional SEF (DSEF>)

The Function block diagram is described as below:



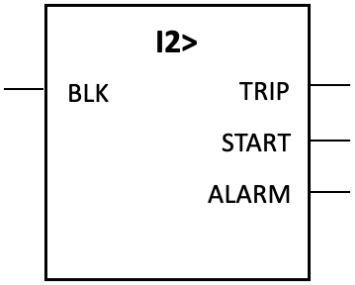
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 79-Input/output signals (DSEF>)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.7 Non-directional NSOC (I2>)

The Function block diagram is described as below:



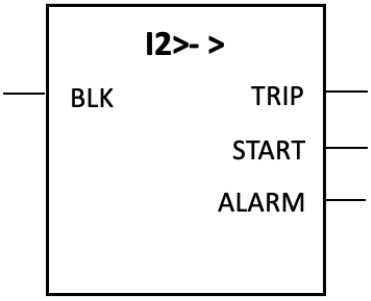
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 80-Input/output signals (I2>)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	
ALARM	BOOLEAN	

4.9.8 Directional NSOC (I2>->)

The Function block diagram is described as below:



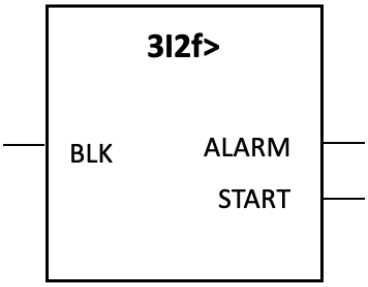
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 81-Input/output signals (I2>->)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.9 Inrush Restraint (3I2f>)

The Function block diagram is described as below:



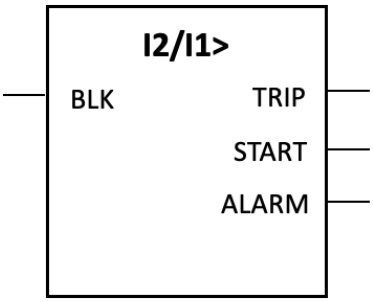
Once the blocking signal BLK is at a high level, the START and ALARM signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 82-Input/output signals (3I2f>)

Name	Type	Default
BLK	BOOLEAN	0=False
START	BOOLEAN	
ALARM	BOOLEAN	
ALARM	BOOLEAN	

4.9.10 Broken Conductor (I2/I1>)

The Function block diagram is described as below:



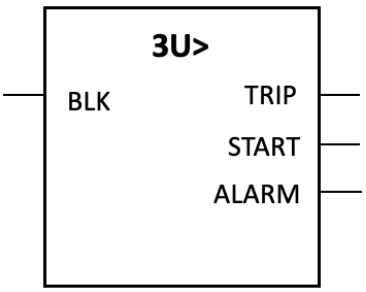
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 83-Input/output signals (I2/I1>)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.11 Over-voltage (3U>)

The Function block diagram is described as below:



Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 84-Input/output signals (3U>)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.12 Under-voltage (3U<)

The Function block diagram is described as below:

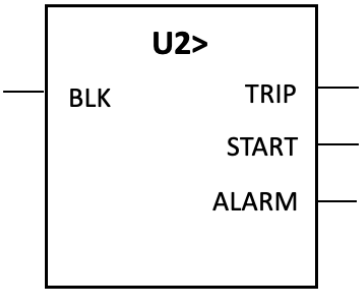
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 85-Input/output signals (3U<)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.13 Negative-sequence OV (U2>)

The Function block diagram is described as below:



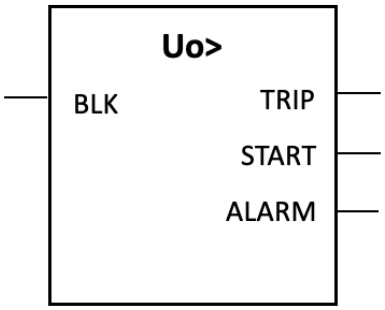
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 86-Input/output signals (U2>)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.14 Residual OV (Uo>)

The Function block diagram is described as below:



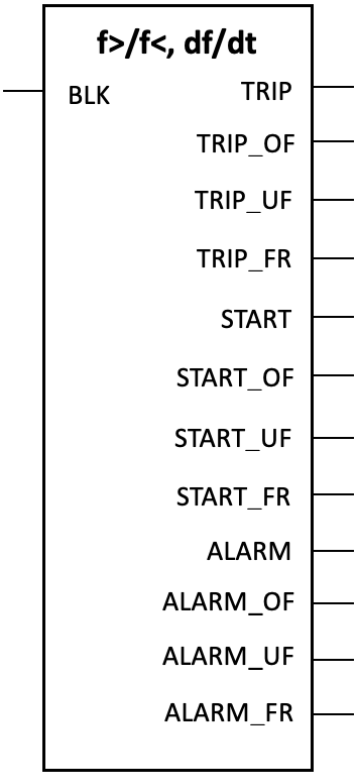
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 87-Input/output signals (Uo>)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.15 Frequency Protection (f>/f<, df/dt)

The Function block diagram is described as below:



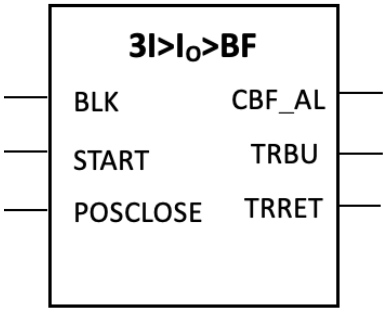
Once the blocking signal BLK is at a high level, the START, ALARM, and TRIP signals will be blocked. When the condition is fulfilled, the corresponding output signals will be activated.

Table 88-Input/output signals (f>/f<, df/dt)

Name	Type	Default
BLK	BOOLEAN	0=False
TRIP	BOOLEAN	
START	BOOLEAN	
ALARM	BOOLEAN	

4.9.16 Breaker Failure (3I>/Io>BF)

The Function block diagram is described as below:



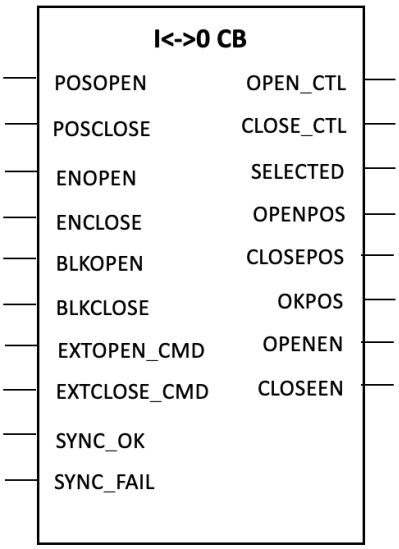
Once the blocking signal BLK is at a high level, the CBF_AL, TRBU, and TRRET signals will be blocked. Input signal START usually connects to protection trip, POSCLOSE is close position. CBF_AL is circuit breaker failure alarm signal, TRBU is backup trip signal, TRRET is re-trip signal, when the condition is fulfilled, the corresponding output signals will be activated.

Table 89-Input/output signals (3I>/Io>BF)

Name	Type	Default
BLK	BOOLEAN	0=False
START	BOOLEAN	0=False
POSCLOSE	BOOLEAN	0=False
CBF_AL	BOOLEAN	
TRBU	BOOLEAN	
TRRET	BOOLEAN	

4.9.17 CB Control (I<->0 CB)

The Function block diagram is described as below:



POSOPEN and POSCLOSE are switch open and close position input signals, it's necessary to determine the status of switch before control. ENOPEN and ENCLOSE are used to input the signals which enabled open and close actions. BLKOPEN and BLKCLOSE are used to input the signals which disabled open and close actions. EXTOPEN_CMD and EXTCLOSE_CMD are used to input the external command to control the open and close. SYNC_OK and SYNC_FAIL is used to input the SYNC signal from SYNC block diagram. OPEN_CTL and CLOSE_CTL are used to output open and close command. SELECTED, OPENPOS, CLOSEPOS are used to output the status of control. OKPOS is used to output the signal if open or close was successful. OPENEN and CLOSEEN are used to output the signal that allow open and close.

Table 90-Input/output signals (I<->0 CB)

Name	Type	Default
POSOPEN	BOOLEAN	0=False
POSCLOSE	BOOLEAN	0=False
ENOPEN	BOOLEAN	1=TRUE
ENCLOSE	BOOLEAN	1=TRUE
BLKOPEN	BOOLEAN	0=False
BLKCLOSE	BOOLEAN	0=False
EXTOPEN_CMD	BOOLEAN	0=False
EXTCLOSE_CMD	BOOLEAN	0=False
SYNC_OK	BOOLEAN	0=False
SYNC_FAIL	BOOLEAN	0=False
OPEN_CTL	BOOLEAN	
CLOSE_CTL	BOOLEAN	
SELECTED	BOOLEAN	
OPENPOS	BOOLEAN	
CLOSEPOS	BOOLEAN	
OKPOS	BOOLEAN	
OPENEN	BOOLEAN	
CLOSEEN	BOOLEAN	

4.9.18 Local/Remote Control (LOC/REM/OFF)

The Function block diagram is described as below:

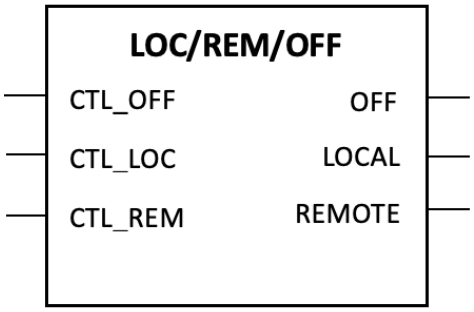


Table 91- Logic between input and output

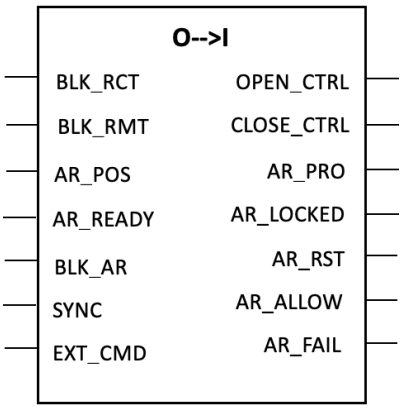
INPUT			OUTPUT
CTL_OFF	CTL_LOC	CTL_REM	
TRUE	ANY	ANY	OFF=TRUE
FALSE	TRUE	ANY	LOCAL=TRUE
FALSE	FALSE	TRUE	REMOTE=TRUE
FALSE	FALSE	FALSE	OFF=TRUE

Table 92-Input/output signals (LOC/REM/OFF)

Name	Type	Default
CTL_OFF	BOOLEAN	0=False
CTL_LOC	BOOLEAN	0=False
CTL_REM	BOOLEAN	0=False
OFF	BOOLEAN	
LOCAL	BOOLEAN	
REMOTE	BOOLEAN	

4.9.19 Reclosing (O-->I)

The Function block diagram is described as below:



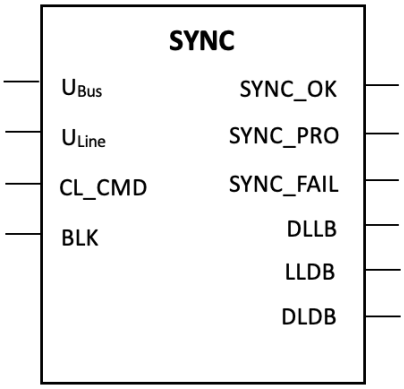
POSOPEN and POSCLOSE are switch open and close posiBLK_RCT is used to reset the reclosing time, BLK_RMT is used to reset the reclaim time. AR_POS is used to input the switch position, AR_READY is used to put the switch into ready status. BLK_AR is used to disable reclosing function. SYNC is used to input SYNC status. EXT_CMD is used to receive external command. OPEN_CTRL and CLOSE_CTRL are control the switch open and close. AR_PRO is activated when switch in cycle status, AR_LOCKED is activate when switch in lockout status, AR_RST is activated when switch in reset status, AR_ALLOW is activate when switch in ready status. AR_FAIL is activated when switch not control successful.

Table 93-Input/output signals (O-->I)

Name	Type	Default
BLK_RCT	BOOLEAN	0=False
BLK_RMT	BOOLEAN	0=False
AR_POS	BOOLEAN	0=False
AR_READY	BOOLEAN	1=TRUE
BLK_AR	BOOLEAN	0=False
SYNC	BOOLEAN	0=False
EXT_CMD	BOOLEAN	0=False
OPEN_CTRL	BOOLEAN	
CLOSE_CTRL	BOOLEAN	
AR_PRO	BOOLEAN	
AR_LOCKED	BOOLEAN	
AR_RST	BOOLEAN	
AR_ALLOW	BOOLEAN	
AR_FAIL	BOOLEAN	

4.9.20 Synchro check (SYNC)

The Function block diagram is described as below:



For the input end, UBus is the bus side voltage (near the power supply side), Uline is the voltage on the line side (near the load side), CL_CMD is the input terminal of the closing command. Once the blocking signal BLK is at a high level, the function will be blocked. For the output end, SYNC_OK is activate when the synchronization meets the requirements, SYNC_PRO is activate during the synchronization process, SYNC_FAIL is activate when the synchronization detection fails, DLLB is activate when no voltage on the line side and voltage on the bus side, LLDB is activate that there is voltage on the line side and no voltage on the bus side, DLDB is activate when no voltage on the line side and no voltage on the bus side.

Table 94-Input/output signals (SYNC)

Name	Type	Default
UBus	SIGNAL	0
ULine	SIGNAL	0
CL_CMD	BOOLEAN	0=False
BLK	BOOLEAN	0=False
SYNC_OK	BOOLEAN	
SYNC_PRO	BOOLEAN	
SYNC_FAIL	BOOLEAN	
DLLB	BOOLEAN	
LLDB	BOOLEAN	
DLDB	BOOLEAN	

5. PRODUCT OPERATION

Safety information: All the operations must be carried out by qualified personnel from Eaton or customer, with in depth knowledge of the power equipment and distribution network. If the operations would be prevented, please check the operation sequence that whether correct or not, do not forcedly and fiercely operate the mechanical or else personnel or equipment safety can be jeoparded.

Totally three ways to operate and configurate: LCD menu, Web-server, Configuration tool.

The maintenance content please find as below table:

Table 95-Maintenance content

Content	LCD Menu	Web-server	Configuration Tool
Parameter View	■	■	■
Parameter setting	■	■	■
Parameter saving	■	■	■
Parameter Import/Export		■	■
Project Import/Export			■
Event list	■	■	■
Fault recorder		■	■
Disturbance recorder		■	■
Load Profile Tool			■
Power Quality Management			■
Authorization	■	■	■
Signal Matrix			■
Button Matrix			■
Communication management			■
IED Update			■
Programmable Logic			■

5.1 Authorization Login

When power on the FXD Control, need to select authorization and login on menu. There are four roles and default passwords with different authority which mentioned in chapter 4.7. The user can change the role during operation through authorization button (Figure 16).

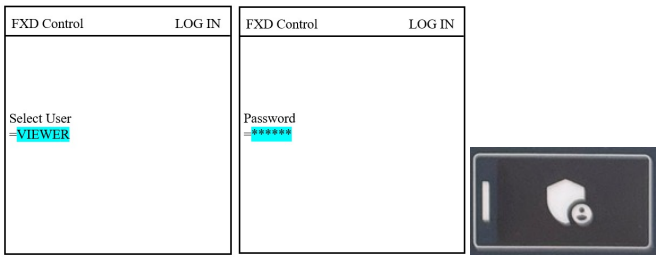


Figure 16 Login system on LCD

The user can login system through web-server as well, select properly role and put into password to get permission (Figure 17).

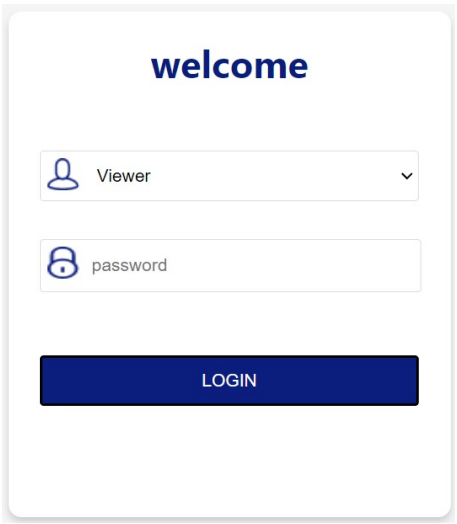


Figure 17 Login system on web-server

5.2 Closing and Opening

The closing and opening operations including two modes as below:

- Local operations
- Remote operationse

Figure 29 shows the recommended grounding diagram for the FXD Control installed with relevant voltage transformer.

5.2.1 Local Operations

To operate the device via the front panel, change the mode to “local” by pressing the REMOTE ENABLED button. If the Led is on, it means remote mode; if the Led is off ,it means local mode (Figure 18).

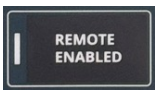


Figure 18 Local position

To open the primary switch via front panel, push the green button and confirm the selection on menu (Figure 19).

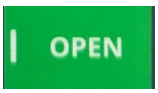


Figure 19 Local Open

To close the primary switch via front panel, push the red button and confirm the selection on menu (Figure 20).

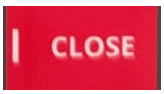


Figure 20 Local close

5.2.2 Remote operations

Opening and closing are available in Remote mode as well.

5.3 Protection Settingsg

Protection settings can be edited locally via three ways:

- LCD menu on front panel
- Web-server on PC
- Configuration tool on PC

If using the LCD menu on front panel to change protection settings:

Main Menu -> Protection -> Current Protection

Protection settings can be changed in each group independently (Figure 21)

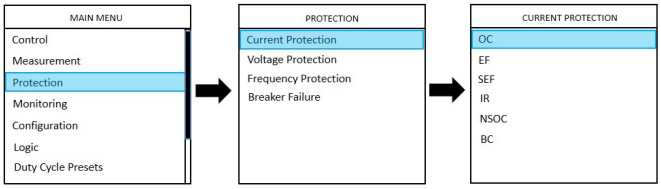


Figure 21 Protection settings on LCD menu

If using web-server on PC to change protection settings:

1. Connect the PC with the FXD Control through front ethernet port (RJ45);
2. Visit 192.168.4.100 address in website and find login button;
3. Select properly role (Engineer or administrator) and put into correctly password;
4. Find the “Protection” button in the menu tree;
5. Click the “Protection” and parameter settings window will popup where it is possible to edit. (Figure 22)

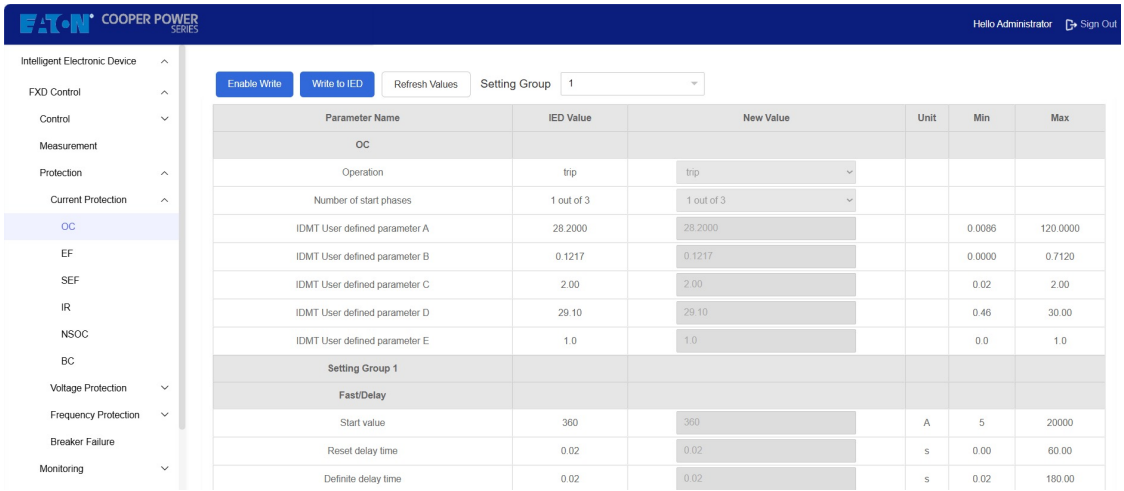


Figure 22 Protection settings on web-server

If using configuration tool on PC to change protection settings:

1. Connect the PC with the FXD Control through front ethernet port (RJ45);
2. Change the communication status from offline to online;
3. Find the “Protection” button in the menu tree;
4. Click the “Protection” and parameter settings window will popup where it is possible to edit. (Figure 23)

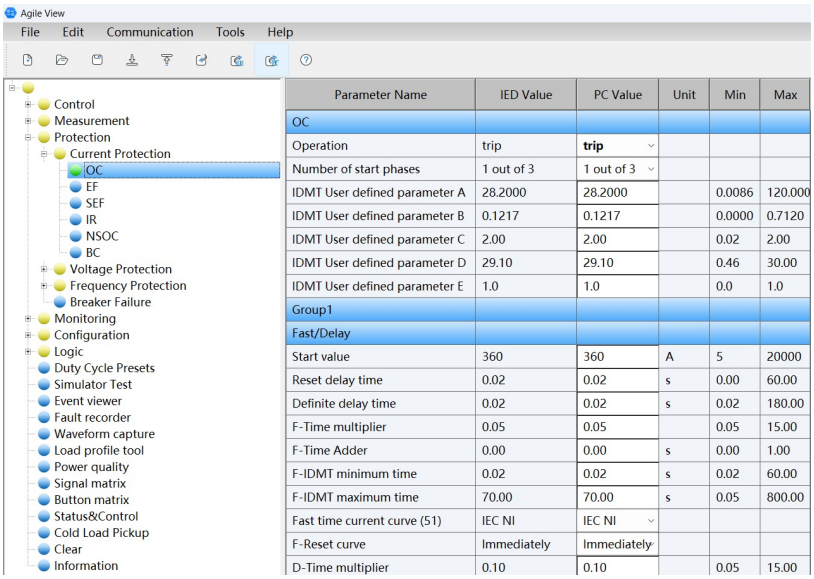


Figure 23 Protection settings on configuration tool

5.4 Measurement Settings

Measurement values can be viewed locally via three ways:

- LCD menu on front panel
- Web-server on PC
- Configuration tool on PC

If using the LCD menu on front panel to view measurement values:

Main Menu -> Measurement -> values#

Shown as figure 24 below

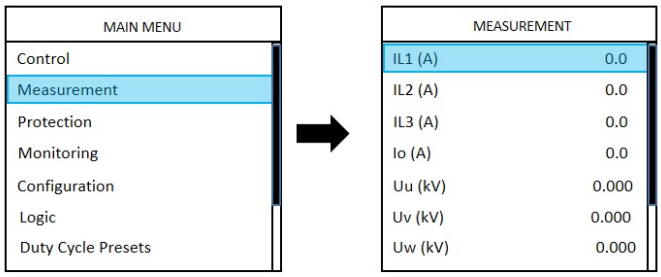


Figure 24 Measurement values on LCD menu

Tips: If the current value is less than 5A ,the current value IL1, IL2, IL3 Will be displayed as 0.0 .

If using web-server on PC to view measurement values:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Visit 192.168.4.100 address in website and find login button;
3. Select properly role (any) and put into correctly password;
4. Find the “Measurement” button in the menu tree;
5. Click the “Measurement” and values window will popup. (Figure 25)

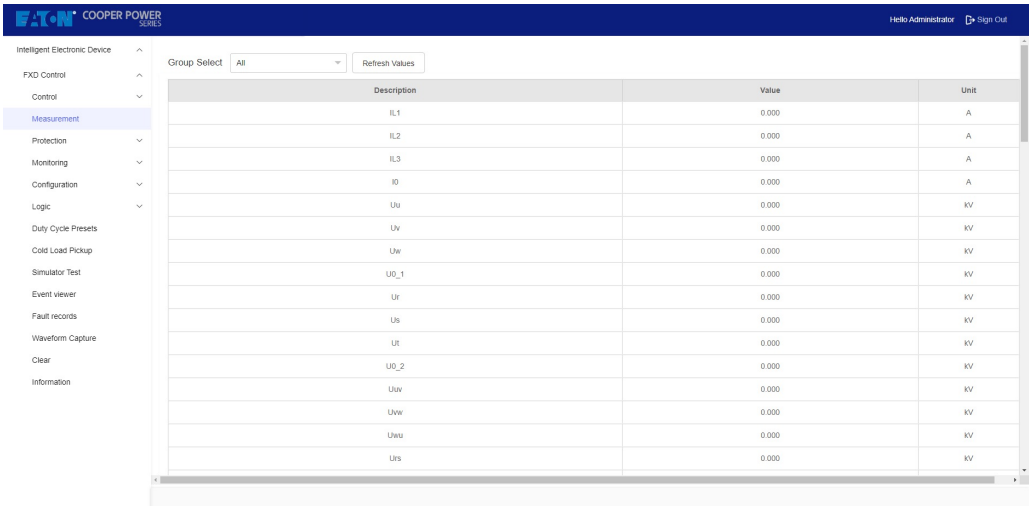


Figure 25 Measurement values on web-server

If using configuration tool on PC to view measurement values:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Change the communication status from offline to online;
3. Find the “Measurement” button in the menu tree;
4. Click the “Measurement” and values window will popup. (Figure 26)

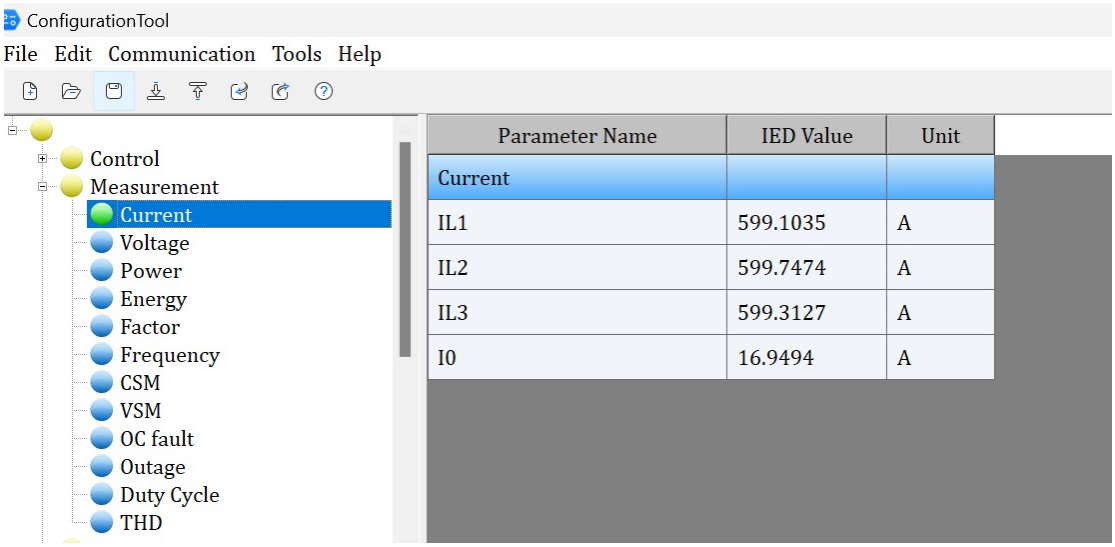


Figure 26 Measurement values on configuration tool

There are current and voltage analog input configuration which defined “In”(Primary current) and “Un”(Primary voltage) values.

If using the LCD menu on front panel to change the analog input settings:

Main Menu -> Configuration -> Analog Input

Shown as figure 27 below

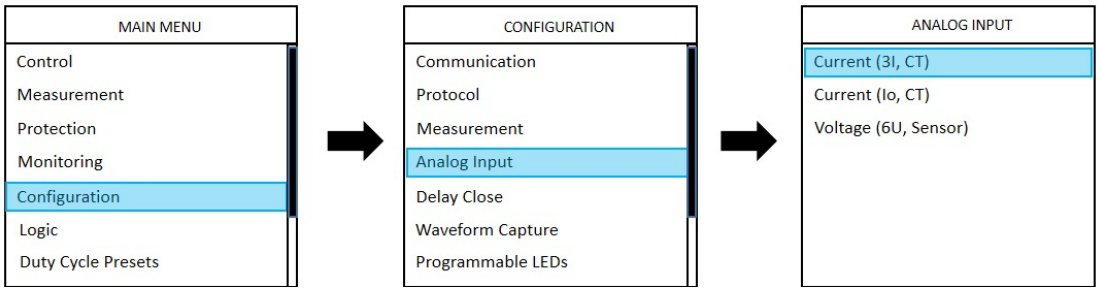


Figure 27 Analog input on LCD menu

If using web-server on PC to change the analog input settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Visit 192.168.4.100 address in website and find login button;
3. Select properly role (Engineer or administrator) and put into correctly password;
4. Find the “Configuration” button in the menu tree;
5. Click the “Analog Input” and parameter settings window will popup where it is possible to edit. (Figure 28)

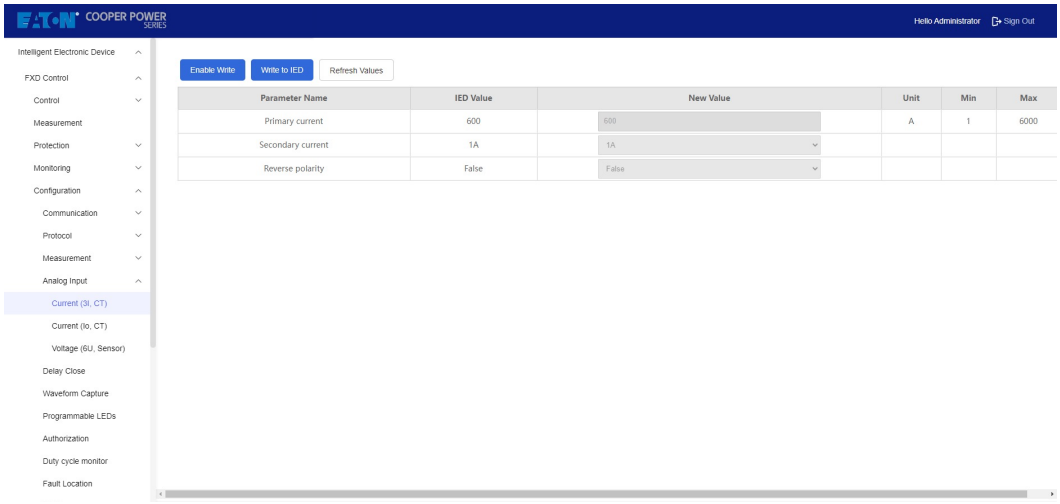


Figure 28 Analog input on web-server

If using configuration tool on PC to change the analog input settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Change the communication status from offline to online;
3. Find the “Configuration” button in the menu tree;
4. Click the “Analog input” and parameter settings window will popup where it is possible to edit. (Figure 29)

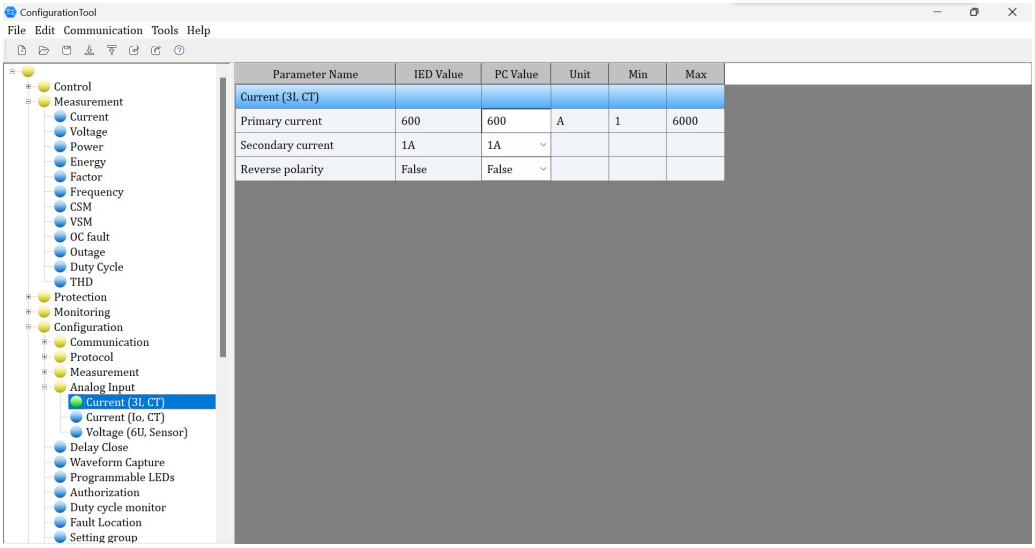


Figure 29 Analog input on configuration tool

5.5 Communication settings

Communication settings can be edited locally via three ways:

- LCD menu on front panel
- Web-server on PC
- Configuration tool on PC

If using the LCD menu on front panel to edit communication settings:

Main Menu -> Configuration -> Communication ->Ethernet/RS232/485

Shown as figure 30 below

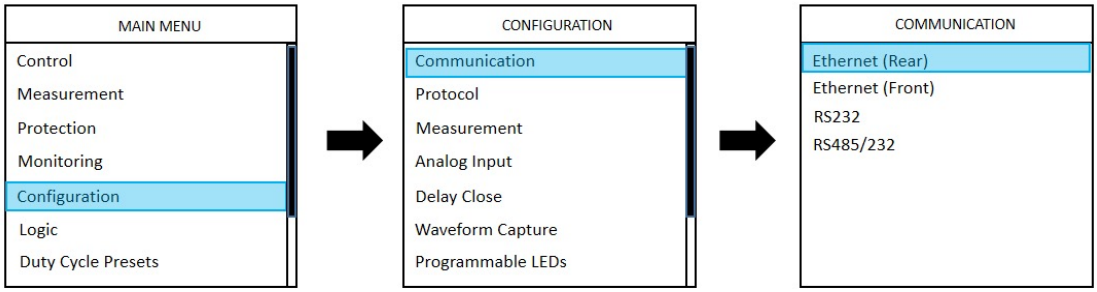


Figure 30 Communication settings on LCD menu

If using web-server on PC to edit communication settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Visit 192.168.4.100 address in website and find login button;
3. Select properly role (Engineer or administrator) and put into correctly password;
4. Find the “Configuration” button in the menu tree;
5. Click the “Communication” and parameter settings window will popup where it is possible to edit. (Figure 31)

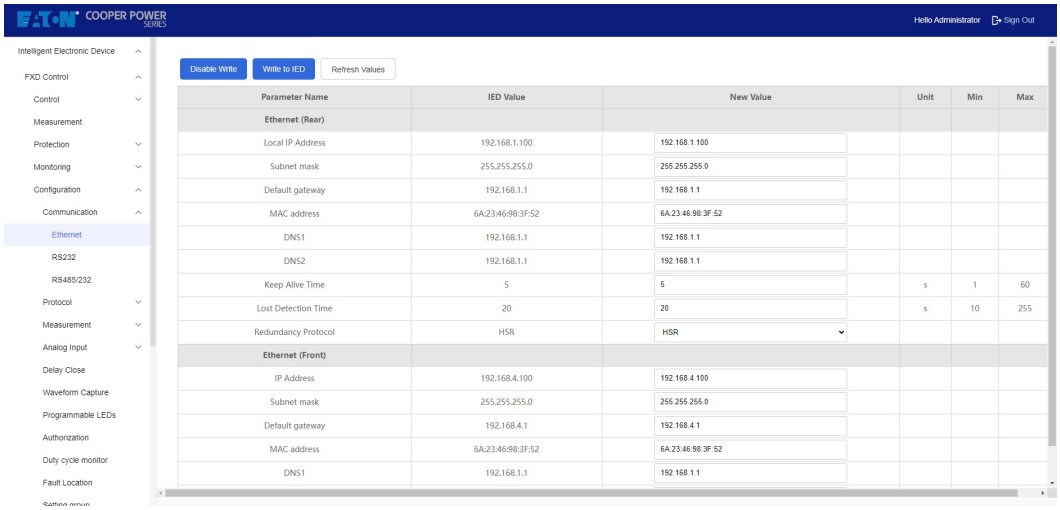
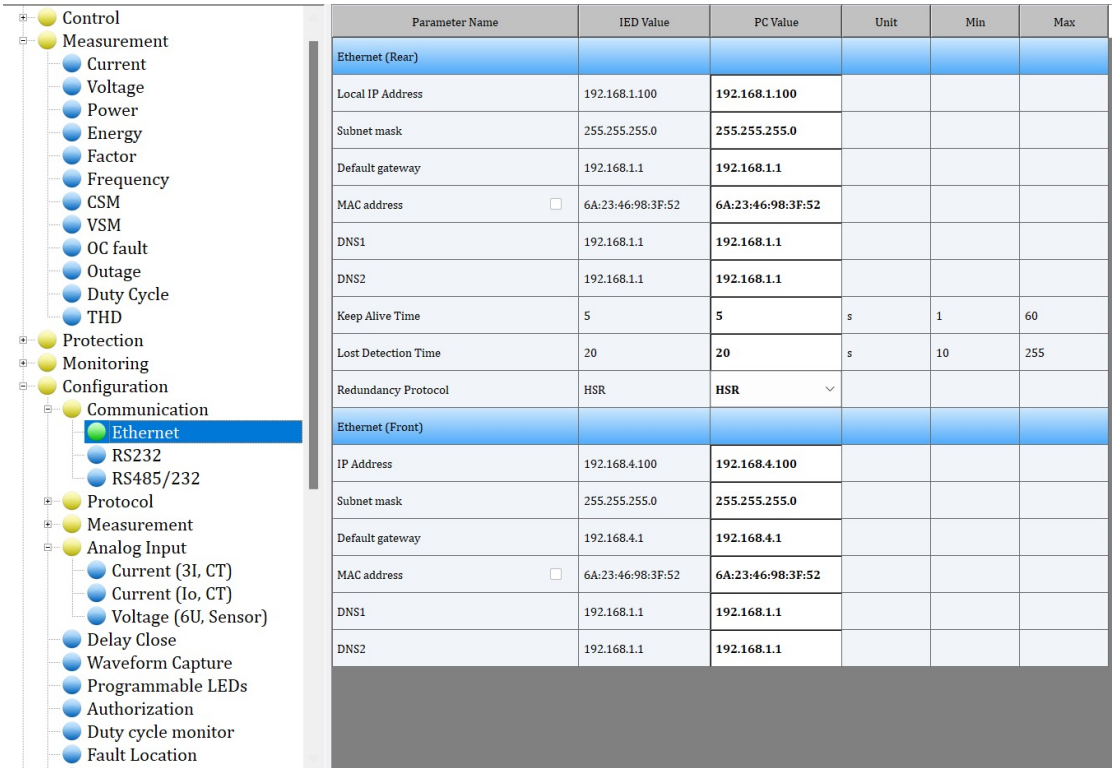


Figure 31 Communication settings on web-server

If using configuration tool on PC to edit communication settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Change the communication status from offline to online;
3. Find the “Configuration” button in the menu tree;
4. Click the “Communication” and parameter settings window will popup where it is possible to edit. (Figure 32)



Parameter Name	IED Value	PC Value	Unit	Min	Max
Ethernet (Rear)					
Local IP Address	192.168.1.100	**192.168.1.100**			
Subnet mask	255.255.255.0	**255.255.255.0**			
Default gateway	192.168.1.1	**192.168.1.1**			
MAC address	6A:23:46:98:3F:52	**6A:23:46:98:3F:52**			
DNS1	192.168.1.1	**192.168.1.1**			
DNS2	192.168.1.1	**192.168.1.1**			
Keep Alive Time	5	**5**	s	1	60
Lost Detection Time	20	**20**	s	10	255
Redundancy Protocol	HSR	**HSR**			
Ethernet (Front)					
IP Address	192.168.4.100	**192.168.4.100**			
Subnet mask	255.255.255.0	**255.255.255.0**			
Default gateway	192.168.4.1	**192.168.4.1**			
MAC address	6A:23:46:98:3F:52	**6A:23:46:98:3F:52**			
DNS1	192.168.1.1	**192.168.1.1**			
DNS2	192.168.1.1	**192.168.1.1**			

Figure 32 Communication settings on configuration tool

5.6 Monitoring Settings

Monitor settings can be viewed locally via three ways:

- LCD menu on front panel
- Web-server on PC
- Configuration tool on PC

If using the LCD menu on front panel to view monitoring settings:

Main Menu -> Monitoring-> Current Protection

Shown as figure 33 below

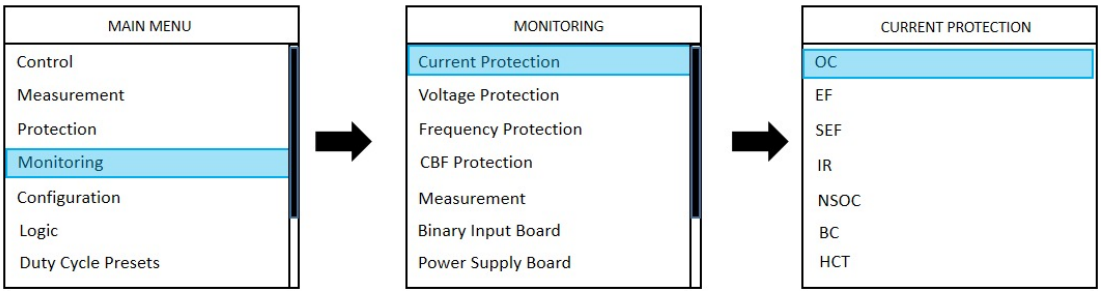


Figure 33 Monitoring settings on LCD menu

If using web-server on PC to view monitoring settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Visit 192.168.4.100 address in website and find login button;
3. Select properly role (any) and put into correctly password;
4. Find the “Monitoring” button in the menu tree;
5. Click the “Monitoring” and status window will popup. (Figure 34)

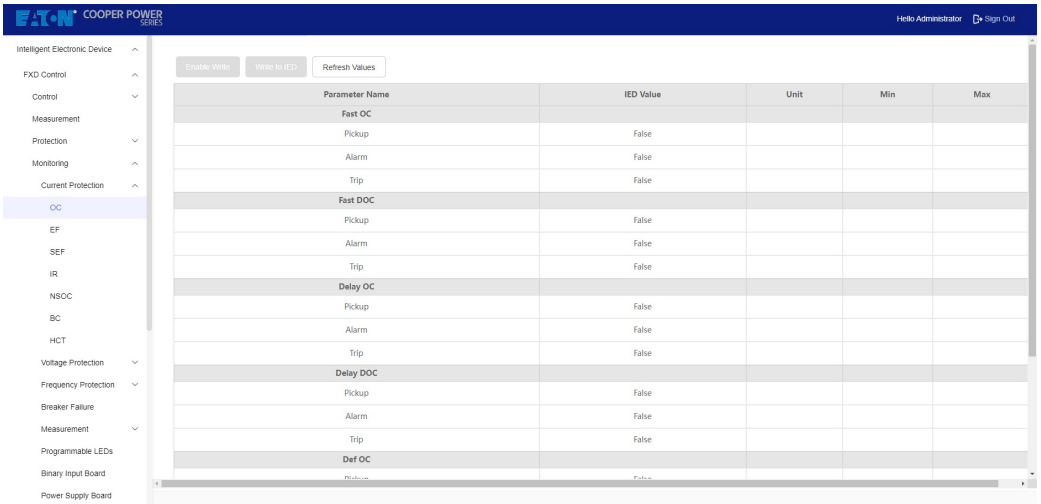


Figure 34 Monitoring settings on web-server

If using configuration tool on PC to view monitoring settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Change the communication status from offline to online;
3. Find the “Monitoring” button in the menu tree;
4. Click the “Monitoring” and status window will popup. (Figure 35)

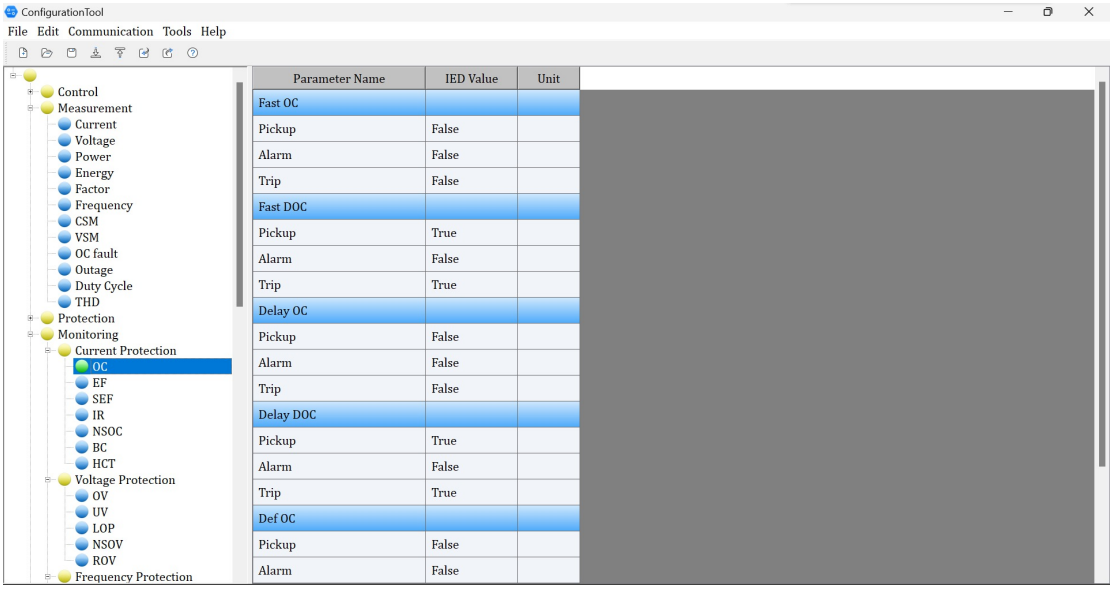


Figure 35 Monitoring settings on configuration tool

The status (True or false) of monitoring settings includes protection (pickup/alarm/trip), measurement (alarm/warn), control (local/remote/off), input, output, programmable led, internal fault.

5.7 Logging

From the front panel the following logs can be read:

- Sequence of event (SOE)

* includes internal fault messages.

Main Menu -> Event

Shown as figure 36 below

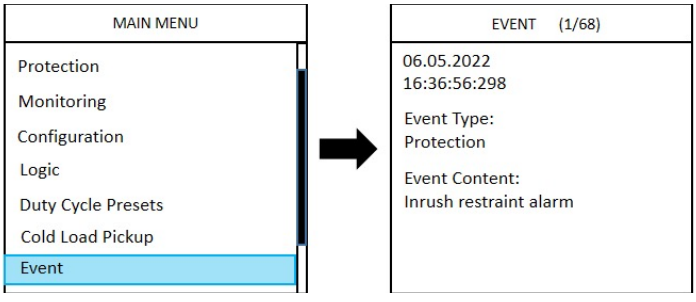


Figure 36 Sequence of event on LCD men

Regarding the delete SOE operation on LCD, click the “RESET” button , and change the “events” setting from “remain” to “clear”, and all of events will be deleted after confirmation.

From the web-server the following logs can be read:

- Sequence of event (SOE)
- Fault recorder (FR)
- Disturbance recorder (DR)

*DR only support file download from web-server.

From the configuration tool the following logs can be read:

- Sequence of event (SOE)
- Fault recorder (FR)
- Disturbance recorder (DR)
- Load profile recorder (LP)
- Power quality management (PQM)

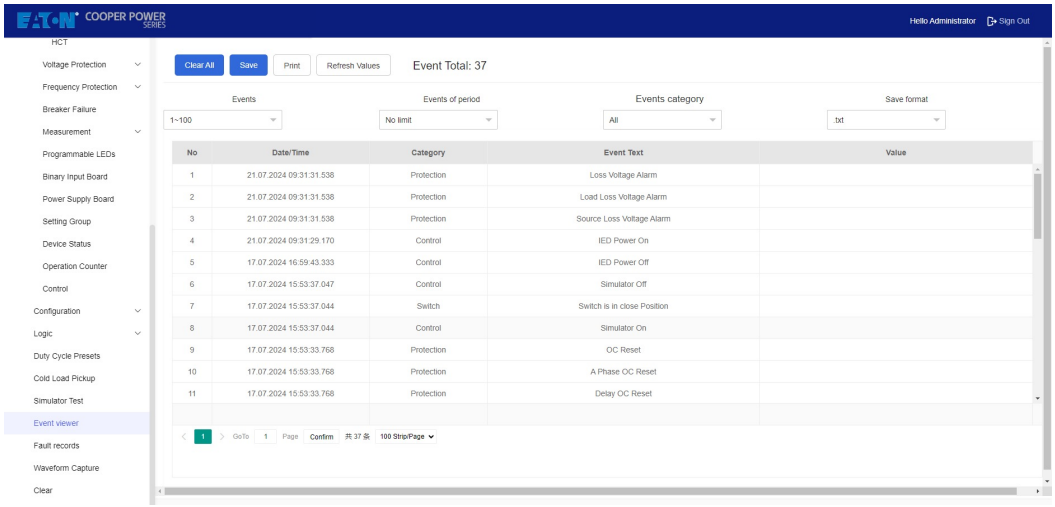


Figure 37 Sequence of event on web-server

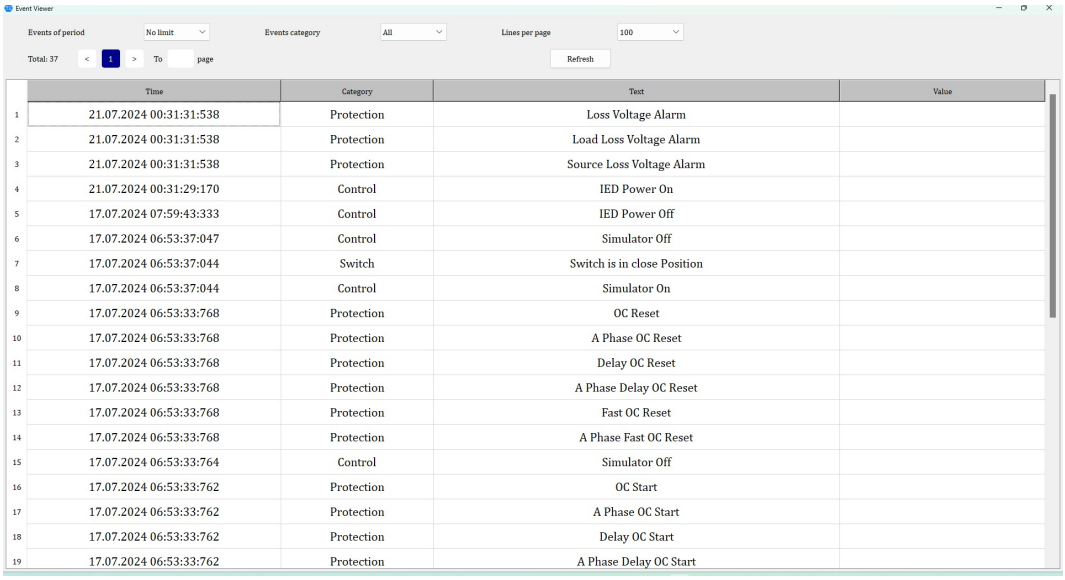


Figure 38 Sequence of event on configuration tool

The latest SOE is placed at the top of the list. Time and date of the SOE is displayed on the table.

There are many options for event scope: “1~100; 101~200; 201~300; 301~400; 401~500; 501~600; 601~700; 701~800; 801~900; 901~1000; all”.

There are many options for event period: “1 min; 15 mins; 30 mins; 1 hour; 2 hours; 4 hours; 8 hours; 12 hours; 1 day; 1 week; 1 month; 1 year; all”.

The types of SOE include “protection”, “measurement”, “control”, “settings”, “switch”, “communication” and “internal fault”.

The user can save SOE file as .txt and .csv format, and print as well.

The user can delete all SOE information by “Clear All” button under “engineer” and “administrator” authorization.

The fault recorder on the web-server and configuration tool are as below:

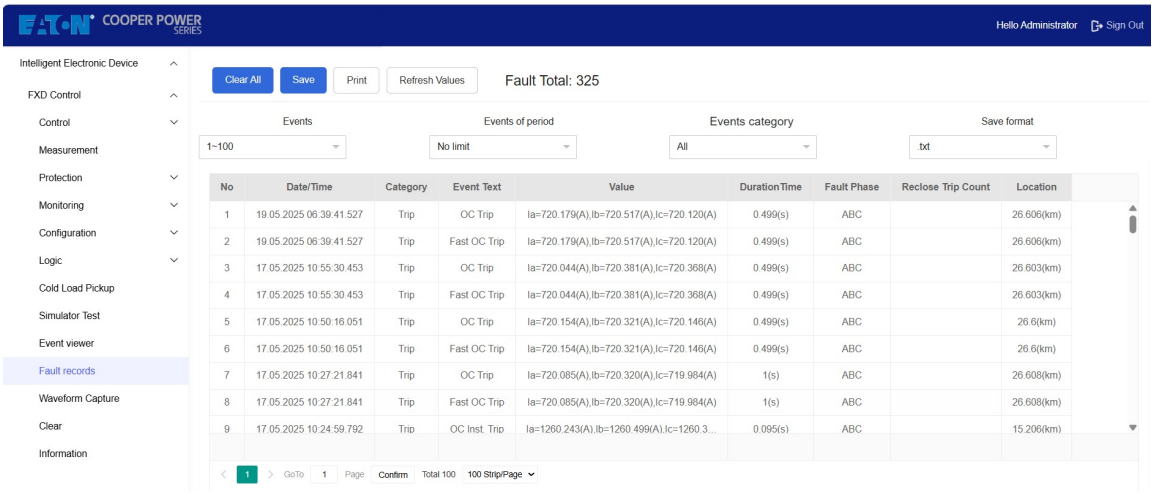


Figure 39 Fault recorder on web-server

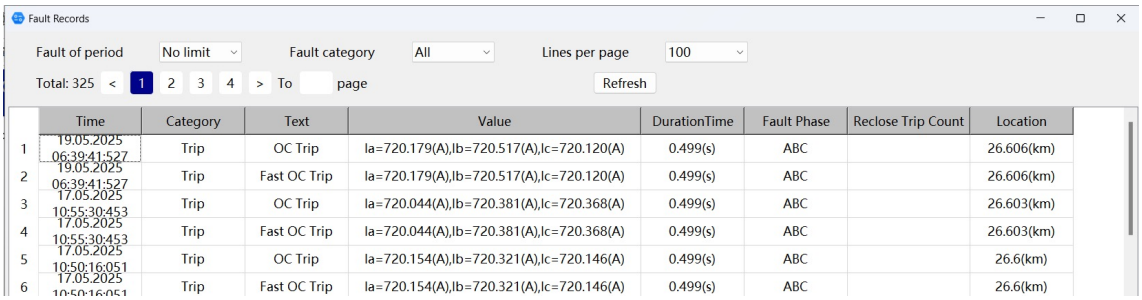


Figure 40 Fault recorder on configuration tool

The latest FR is placed at the top of the list. Time and date of the FR is displayed on the table.

There are many options for event scope: “10; 50; 100; 200; 300; all”.

The types of FR include “start”, “alarm” and “trip”.

The user can save FR file as .txt and .csv format, and print as well.

The user can delete all FR information by “Clear All” button under “engineer” and “administrator” authorization.

The disturbance recorder on the web-server is as below:

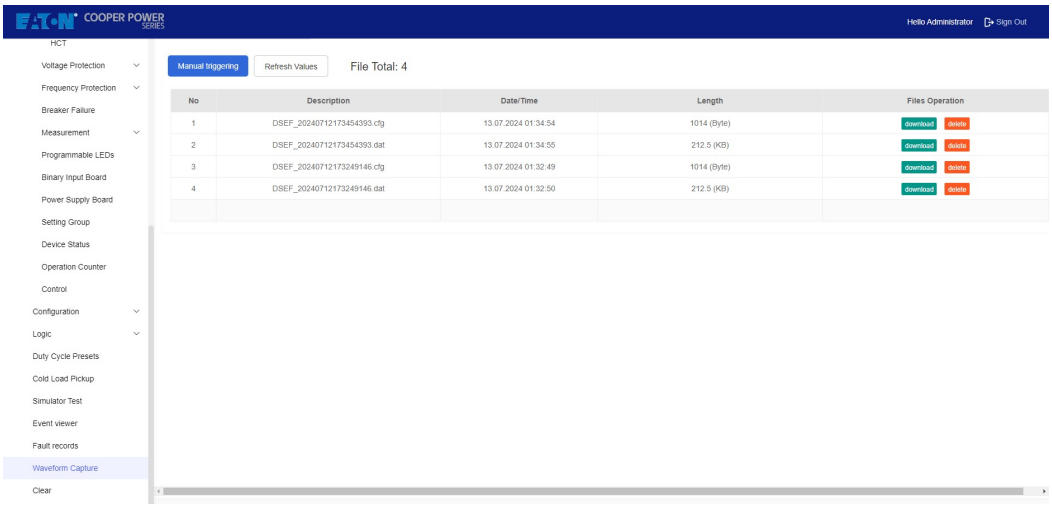


Figure 41 Disturbance recorder on web-server

The user can read all the DR file from web-server after download and delete corresponding or all disturbance records by “Delete” or “ Delete All” buttons.

The disturbance recorder on the configuration tool is as below:

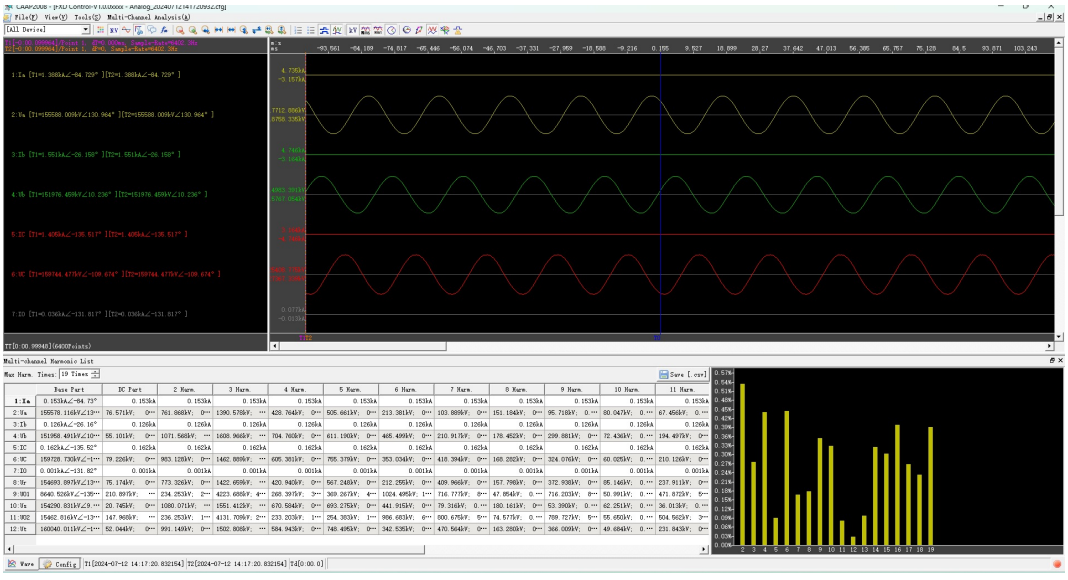


Figure 42 Disturbance recorder on configuration tool

The user can save DR file as .csv format and print as well. The file includes waveforms and report.

5.8 Date and Time Settings

Date and time settings can be edited locally via three ways:

- LCD menu on front panel
- Web-server on PC
- Configuration tool on PC

If using the LCD menu on front panel to edit date and time settings:

Main Menu -> Configuration-> Time

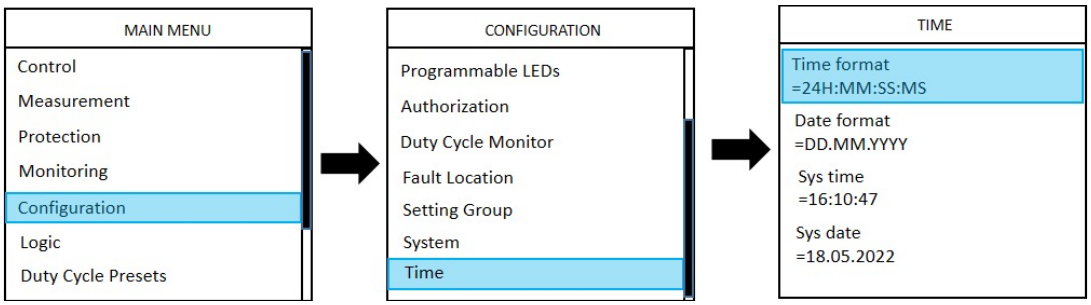


Figure 43 Date and time settings on LCD menu

If using web-server on PC to edit date and time settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Visit 192.168.4.100 address in website and find login button;
3. Select properly role (Engineer or administrator) and put into correctly password;
4. Find the "Configuration" button in the menu tree;
5. Click the "time" and parameter settings window will popup where it is possible to edit. (Figure 44)

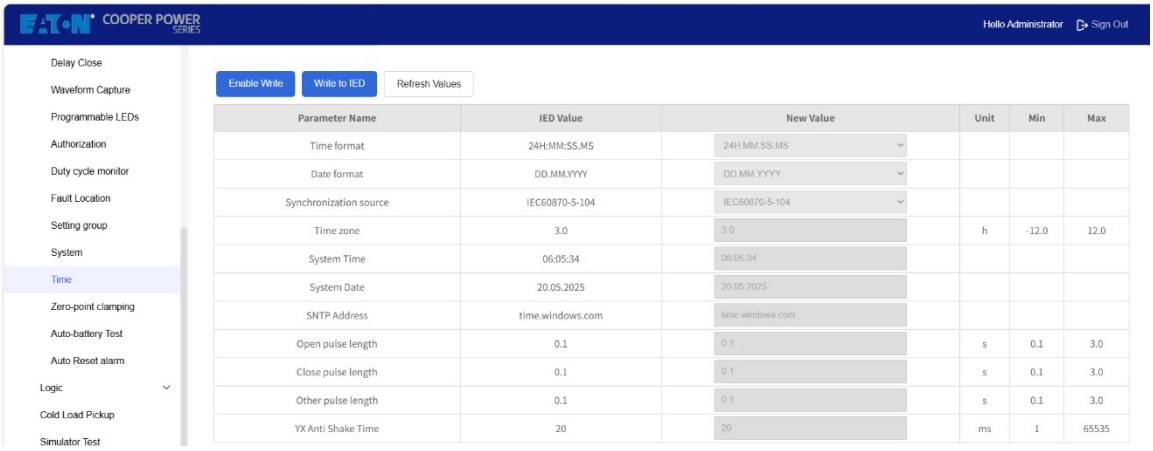
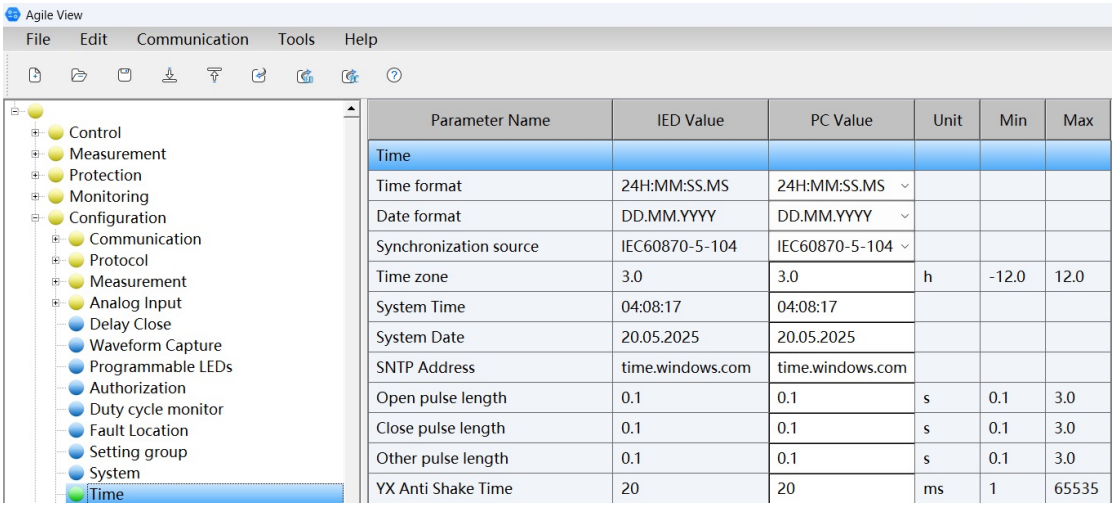


Figure 44 Date and time settings on web-server

If using configuration tool on PC to edit date and time settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Change the communication status from offline to online;
3. Find the “Configuration” button in the menu tree;
4. Click the “Time” and parameter settings window will popup where it is possible to edit. (Figure 45)



Parameter Name	IED Value	PC Value	Unit	Min	Max
Time					
Time format	24H:MM:SS.MS	24H:MM:SS.MS			
Date format	DD.MM.YYYY	DD.MM.YYYY			
Synchronization source	IEC60870-5-104	IEC60870-5-104			
Time zone	3.0	3.0	h	-12.0	12.0
System Time	04:08:17	04:08:17			
System Date	20.05.2025	20.05.2025			
SNTP Address	time.windows.com	time.windows.com			
Open pulse length	0.1	0.1	s	0.1	3.0
Close pulse length	0.1	0.1	s	0.1	3.0
Other pulse length	0.1	0.1	s	0.1	3.0
YX Anti Shake Time	20	20	ms	1	65535

Figure 45 Date and time settings on configuration tool

The user can select time and date format which shows on logs. And synchronization source can be selected between protocol and B code.

5.9 System Settings

System settings can be edited locally via three ways:

- LCD menu on front panel
- Web-server on PC
- Configuration tool on PC

If using the LCD menu on front panel to edit system settings:

Main Menu -> Configuration-> System

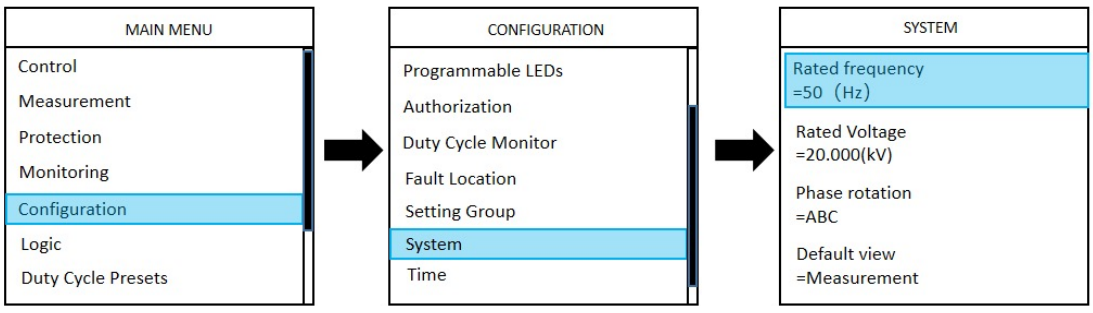


Figure 46 System settings on LCD menu

If using web-server on PC to edit system settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Visit 192.168.4.100 address in website and find login button;
3. Select properly role (Engineer or administrator) and put into correctly password;
4. Find the “Configuration” button in the menu tree;
5. Click the “system” and parameter settings window will popup where it is possible to edit. (Figure 47)

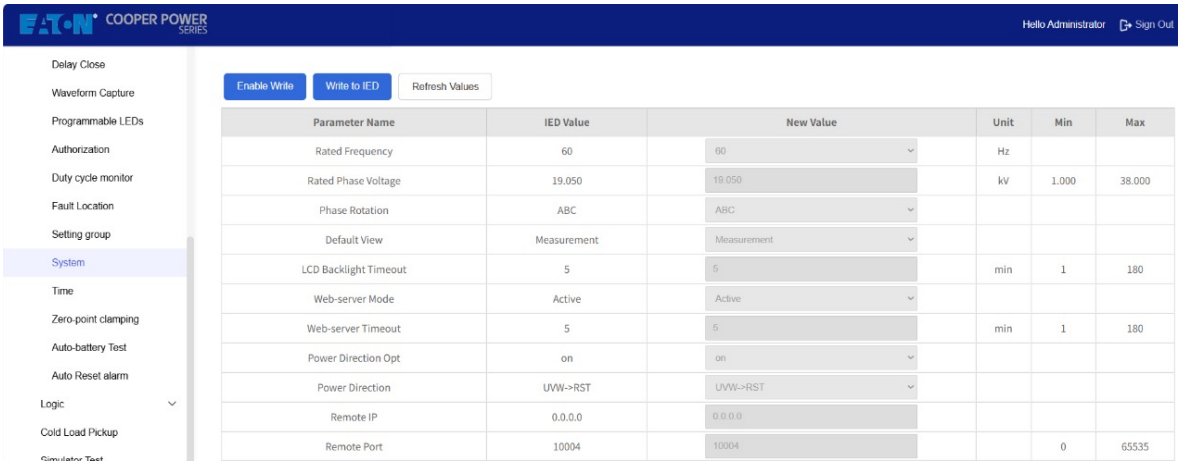


Figure 47 System settings on web-server

If using configuration tool on PC to edit system settings:

1. Connect the PC with the feeder protection relay through front ethernet port (RJ45);
2. Change the communication status from offline to online;
3. Find the “Configuration” button in the menu tree;
4. Click the “system” and parameter settings window will popup where it is possible to edit. (Figure 48)

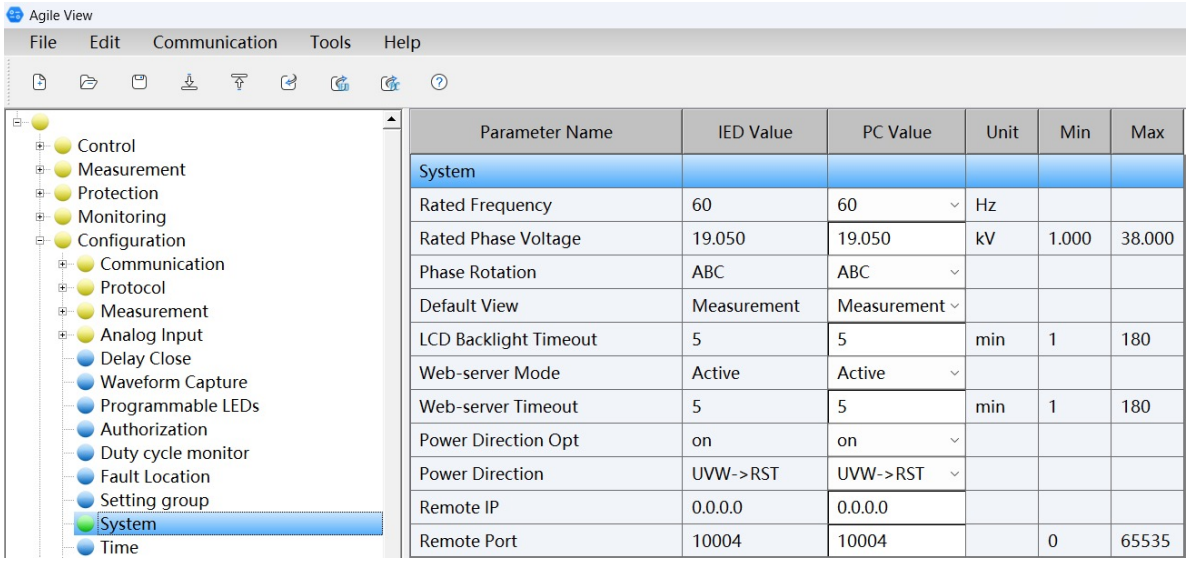


Figure 48 System settings on configuration tool

There is rated frequency selection (50Hz or 60Hz) which defined “Fn” values.

The user can change phase rotation from ABC to ACB if required.

Default menu is used to defined the LCD menu on the front of panel.

There are two times on system settings, one is “LCD backlight timeout” which defined the duration of backlight if not used; another is “Web-server timeout” which defined duration of connection between PC and IED if not used.

If user want to operate through web-server mode, should be changed “Web-server mode” to active at first (default setting is inactive).

5.10 Download and Upload Settings

In conclusion, there are three ways to configure FXD Control:

- LCD menu on front panel
- Web-server on PC
- Configuration tool on PC

If using LCD menu, please click “left” button (back to previous page) and confirm the settings after configuration.

If using web-server, please click “Enable write” at first, and then “write to IED” after configuration, and click “refresh values” to confirm the settings is successful or not.

Figure 49 Download and upload settings on web-server

The user can download and upload all parameter as file through “Export/Import” button.

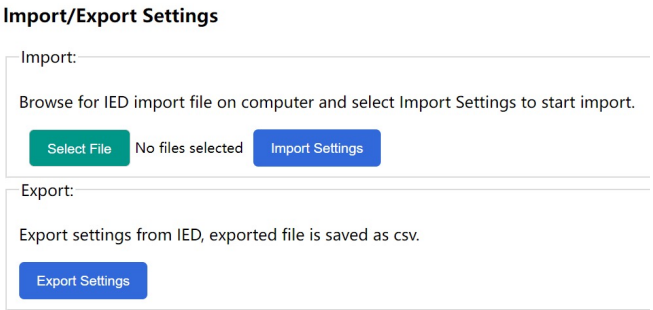


Figure 50 Parameter download and upload

If using configuration tool, please click “write to IED” after configuration, and click “read from IED” to confirm the settings is successful or not.

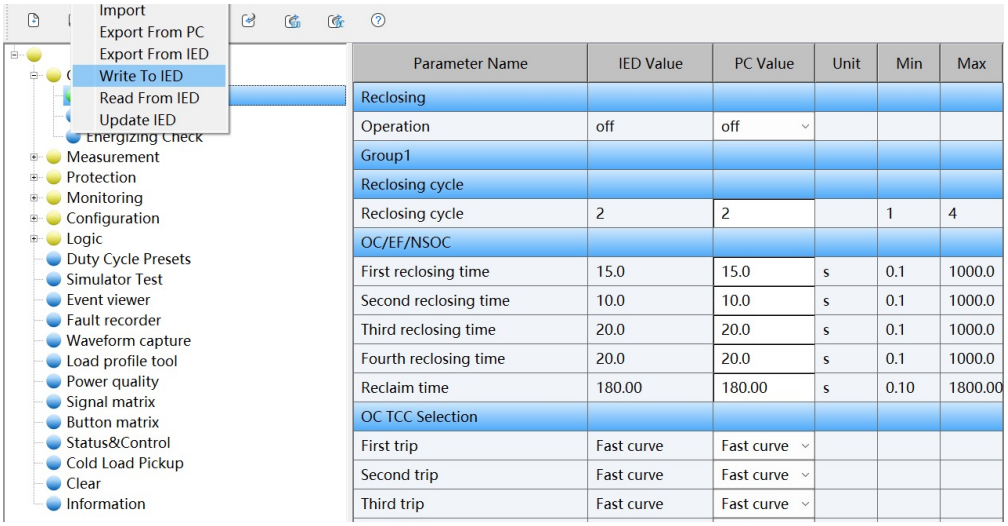


Figure 51 Download and upload settings on configuration tool

There are two kinds of files in configuration tool, one is parameter file, another is project file.

For parameter file, the user can select current page or all parameter to download and upload by click “Export” and “Import” buttons.

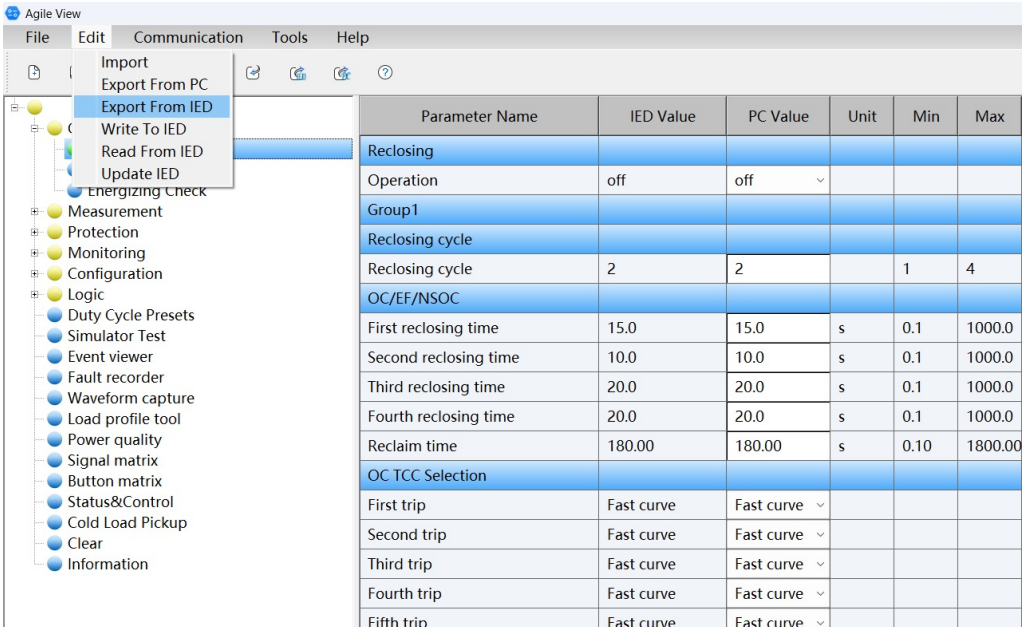


Figure 52 Parameter file download and upload

For project file, the user can download and upload by click “save as” and “open project” buttons.

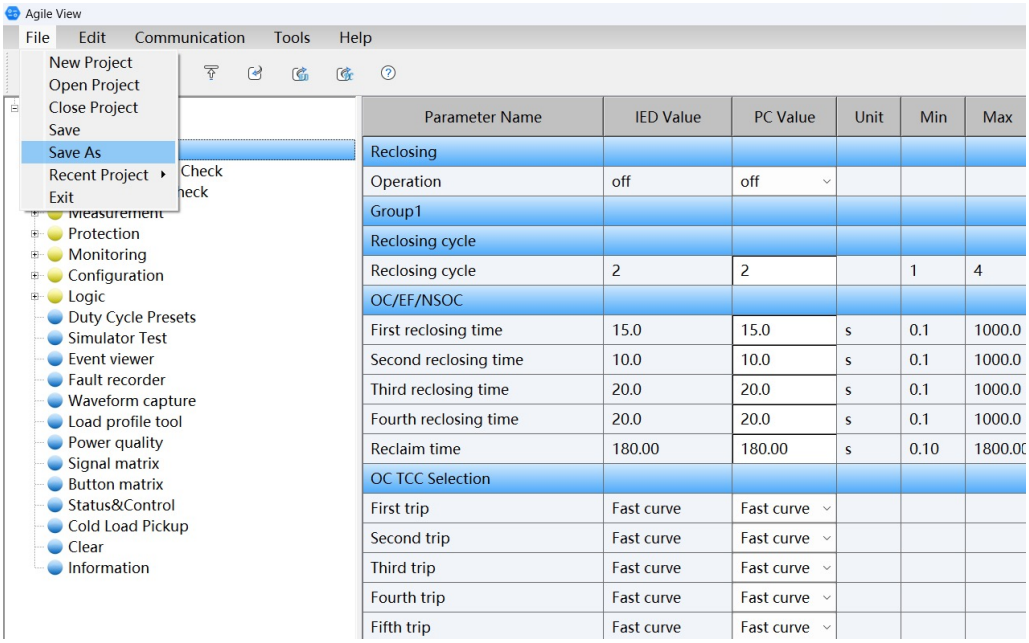


Figure 53 Project download and upload

The user can update feeder protection relay through configuration tool only by click “Update IED” button on file menu.

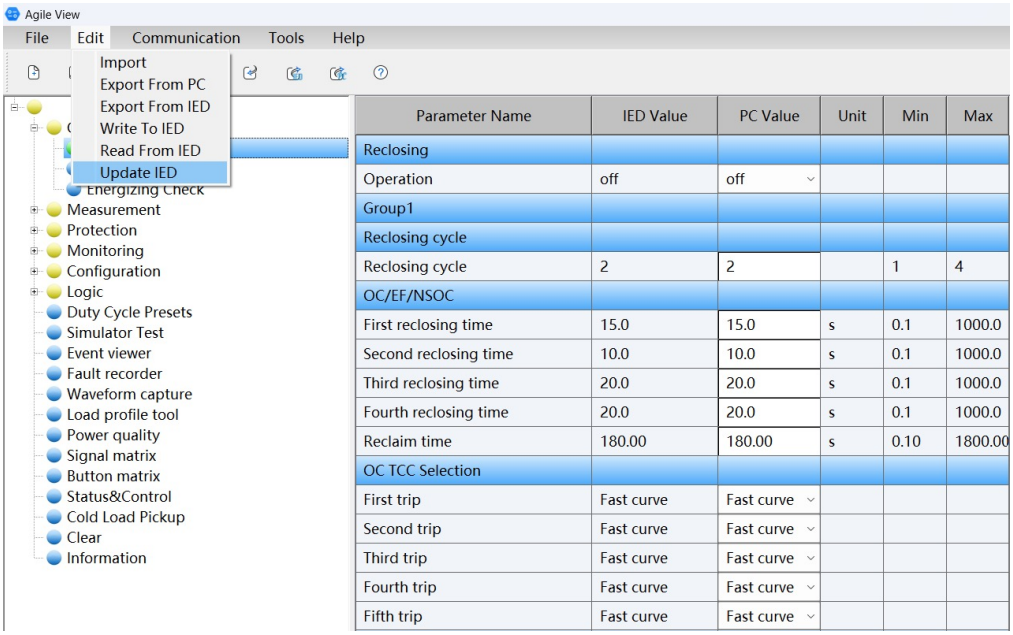


Figure 54 Update IED on configuration tool

6. PRODUCT COMMISSIONING

Eaton performs a complete function check and calibration of each control cubicle before it is shipped. This helps ensure that user receive a recloser control operates correctly and accurately. Before powering the feeder line, the recloser should be in the open position.

6.1 Power Supply Check

After switching on the DC power, the FXD Control should be powered on. Please make sure that local date/time settings are correct. If not, you can rectify date/time through LCD menu: **Main Menu -> Configuration-> Time**. You can also synchronize date and time by protocol and B code from station. Date and time are visible at the LCD screen.

Besides date/time settings, please make sure the LCD menu navigation, LED indication and button function are OK.

6.2 System and Analog Input Check

After checking power supply, please find the system settings on LCD menu:

Main Menu -> Configuration-> System

Make sure the rated frequency (default=50Hz) and phase rotation (default=ABC) are OK for you.

Then turn to analog input configuration on LCD menu:

Main Menu -> Configuration-> Analog Input

Checking the primary and secondary value of current and voltage are consistent with the actual situation or not, the primary value determines the value of In and Un in protection and measurement.

6.3 Protection Settings Check

There are five protection setting groups (default active group=1) with the same default values, please check and change if need that according to your actual situation. The path on LCD menu:

Main Menu -> Protection -> Current Protection

Main Menu -> Protection -> Voltage Protection

Main Menu -> Protection -> Frequency Protection

Main Menu -> Configuration-> Setting Group

6.4 Measurement Values Check

After powering the feeder line and closing the recloser via button on front panel, please check those measurements of phase currents, voltages, power, energy, power factors and frequency are correct.

The path on LCD menu:

Main Menu -> Measurement -> Values#

7. INSTALLATION

7.1 Enclosure Dimension

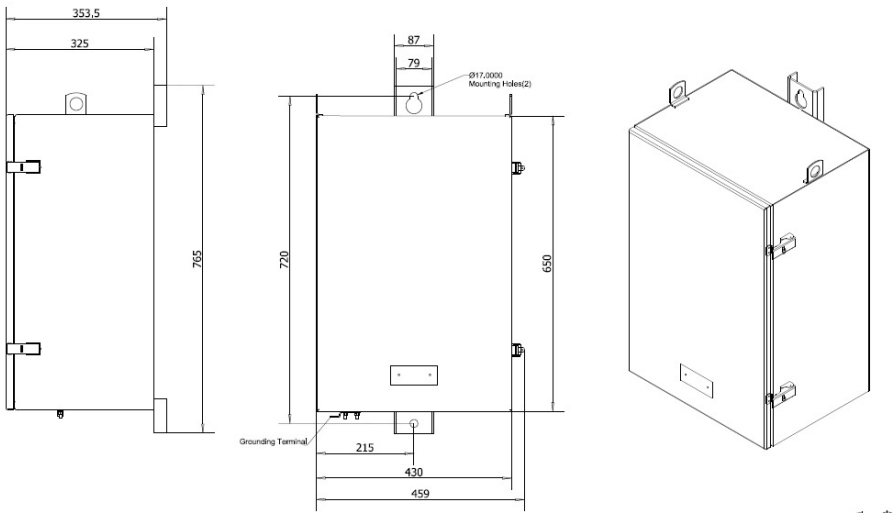


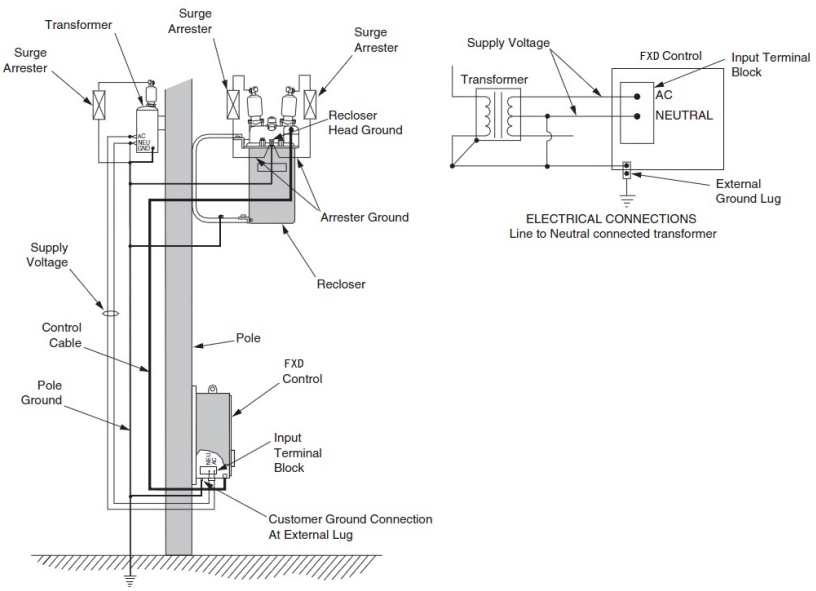
Figure 55 FXD Control Enclosure Dimension

7.3 Earthing

Installation of a FXD Control with a local supply voltage transformer must include the following:

Protection of the bushings and the supplying transformer with lightning arresters.

- Grounding of the head and tank
- Grounding of the transformer tank
- Grounding of the Control enclosure
- Grounding of the SCADA equipment
- All the grounding must be connected together



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