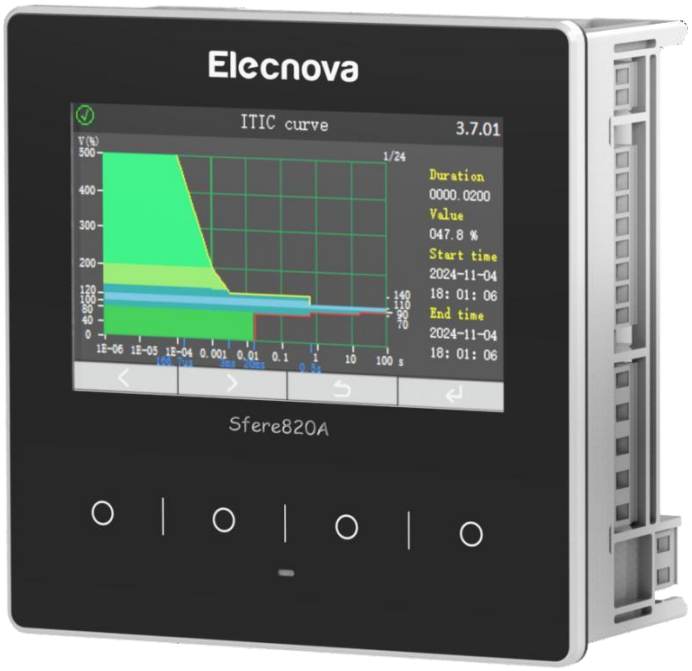
User Manual of

Power Quality Instrument

Applicable Model:

SFERE820A



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Notices for Use

Please read this manual carefully before using this device and be sure to observe the following notes while using it:

NOTE:

- This device must be operated and maintained by a professional who has read this manual.
- Before performing any internal or external operations on the device, disconnect all input signals and power supplies and make sure that the secondary terminals of the voltage transformer are not short-circuited and the secondary terminals of the current transformer are not open-circuited.
- Be sure to use an appropriate voltage measuring device to confirm that there is no voltage present in any of the device's components.
- The electric parameters supplied to the device must be within the rated range.
- Please do not touch the terminals of the device while it is working.
- To use the communication function of the device, please connect it to a secure communication network.

The following circumstances may result in the device being damaged or operating improperly:

- The operating environment is out of range.
- The voltage of the auxiliary power supply is out of range.
- The frequency of the power distribution system is out of range.
- The signal input exceeds the maximum rating.
- The polarity of the current or voltage input is incorrect.
- The connection is not as required.

Contents

1. Introduction

1.1 Overview

SFERE820A is characterized by precise power parameter measurement, energy metering, and power quality monitoring capabilities, and meets IEC 61000-4-30 A for power quality. With a rich package of I/O modules for on-site equipment state monitoring and control, it can be easily integrated with various intelligent power monitoring systems and energy management systems to share a wealth of monitoring data and power quality data.

1.2 Model function

[Note 1]: "-" - not available, "● "- available, "○" - optional.

Functions		Sfere820A
Display Mode	TFT LCD (Color display)	5"
Real-time Measurement	Three-phase voltage (Va, Vb, Vc, Uab,Ubc, Uca)	●
	Three-phase current (Ia, Ib, Ic)	●
	Neutral current (In)	●
	Active power (P, Pa, Pb, Pc)	●
	Reactive power (Q, Qa, Qb, Qc)	●
	Apparent power (S, Sa, Sb, Sc)	●
	Power factor (Pf)	●
	Frequency (F)	●
	Demand	●
	Max/Min values	●
	Phase angle	●
Energy Metering	Bi-directional active energy	●
	Bi-directional reactive energy	●
	Four-quadrant reactive electric energy	●
	Apparent energy	●
	Bi-directional tariff energy	●

Power Quality	Voltage deviation	●
	Frequency deviation	●
	Unbalance	●
	THD (Voltage, Current) Harmonic content(2^{nd}-51^{st})	●
	Inter-harmonic ratio	●
	Voltage flicker	●
	Rapid voltage change	●
	Voltage swell	●
	Voltage dip	●
	Voltage interruption	●
	Crest factor	●
	k-factor of current	●
	Transient capture	80μs
	ITIC/SEMI F47 curve	●
Alarms	Voltage	●
	Current	●
	Active power	●
	Reactive power	●
	Apparent power	●
	Power factor	●
	Frequency	●
Data Records	SOE log	1,024 events
	PQ event log	1,024 events
	Waveform record	1,024 events

	Data freeze	●
	EN50160 report	60 events
	Data Memory	2GB
Input/Output	Digital input	4
	Relay output	4
Communication	Modbus-RTU Through RS485 interface	●
Time synchronization	IRIG-B	●
	Modbus- RTU	●
Optional Modules	FM2: 4 digital inputs	○
	FM3: 2 relay outputs	○
	FM11: RS485 port, Modbus-RTU protocol	○
	FM24: Ethernet port, Modbus-TCP, Web-sever	○

2. Technical Specification

Accuracy	
Voltage (Va/Vb/Vc)	Class 0.1 (IEC 61557-12)
Voltage (Uab/Ubc/Uca)	Class 0.1 (IEC 61557-12)
Current (Ia/Ib/Ic)	Class 0.1 (IEC 61557-12)
Current (In)	Class 0.1 (IEC 61557-12)
Active Power (P/Pa/Pb/Pc)	Class 0.2 (IEC 61557-12)
Reactive Power (Q/Qa/Qb/Qc)	Class 0.2 (IEC 61557-12)
Apparent Power (S/Sa/Sb,Sc)	Class 0.2 (IEC 61557-12)
Power Factor (PF/PFa/PFb/PFc)	Class 0.2 (IEC 61557-12)
Frequency (F)	Class 0.1 (IEC 61557-12)
Active Energy (EP+)	Class 0.2S (IEC 61557-12)

Reactive Energy (EQ+)	Class 0.5S(IEC 61557-12)
Power Quality Parameters	IEC 61000-4-30 Cl. A
Environmental Characteristics	
Working Temperature	-25℃...+70℃
Storage Temperature	-25℃...+70℃
Relative Humidity	5%...95%RH, without condensation
Working Altitude	≤ 2000m (CAT III)
Pollution Degree	2
Mechanical Characteristics	
Dimension	144mm×144mm×80mm
Protection Degree	Face frame: IP54; rear housing: IP20
Safety Characteristics	
Measurement Category	300V (CAT III)
Safety	IEC 61010-1, double insulation
Auxiliary Power Supply	
Voltage	AC/DC 80V...270V
Frequency	50/60Hz ± 5Hz
Power Consumption	≤ 10VA
Voltage Measurement Input	
Rated Value	3×230/400 VAC
Measurement Range	10 – 276VAC (L - N) 17 – 480VAC (L - L)
Overload	Continuous: 1.2Vn; instantaneous: 2Vn/1min
Frequency	45Hz...65Hz
Current Measurement Input	

Rated Value	3×.../1A or .../5A
Minimum Operating value	10mA
Overload	Continuous: 2In; instantaneous: 20In/0.5s
Sampling time	
Number	256 samples/cycles at 50Hz/60Hz
Data update rate	200ms
Display update rate	1s
Digital Input	
Number	4
Type	Dry contact, built-in DC 24V
Relay Output	
Number	4
Contact Capacity	AC 250V/5A or DC30V/5A
Pulses of Electric Energy	
Number	1
Type	Photocoupler isolation
Communication Port	
Number	1
Port	RS485
Baud rate	2.4kbps ... 115.2kbps
Protocol	Modbus-RTU
Real-time Clock	
Clock Drifting	≤ 0.5s/day
Terminals	
Torque	0.5N·m

Applicable Standards	
GB/T 39853/ IEC 62586	Power Quality Measurement in Power Supply System
GB/T 18216.12/ IEC 61557-12	Power metering and monitoring devices (PMD)
GB/T 17626.2/ IEC 61000-4-2	Immunity to electrostatic discharge, Level 4
GB/T 17626.3/ IEC 61000-4-3	Immunity to radio-frequency field, Level 3
GB/T 17626.4/ IEC 61000-4-4	Immunity to electrical fast transients/bursts, Level 4
GB/T 17626.5/ IEC 61000-4-5	Surge Immunity, Level 4
GB/T 17626.8/ IEC 61000-4-8	Immunity to power frequency magnetic fields, Level 4
CE	Safety
EN50160	Power quality report

3. Installation

3.1 Dimensions

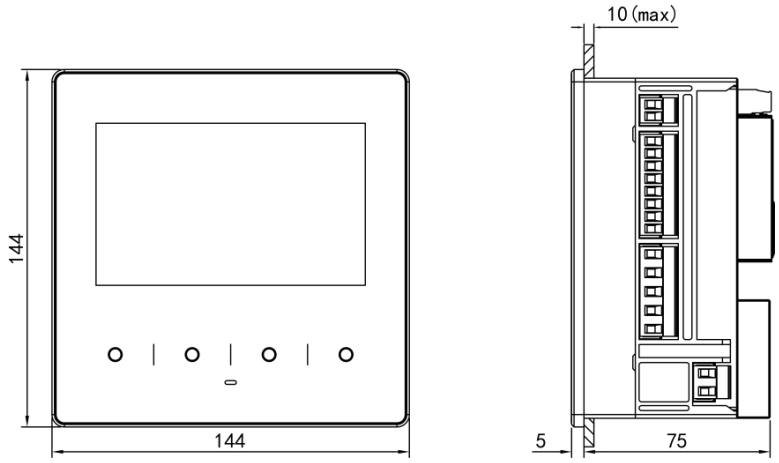
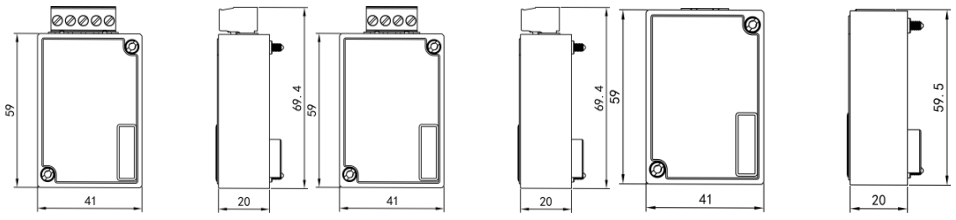


Figure 3.1.1 Sfere820A (Unit: mm)



FM2, FM3, FM11, FM24

Figure 3.1.2 Extension Module (Unit: mm)

3.2 Installation

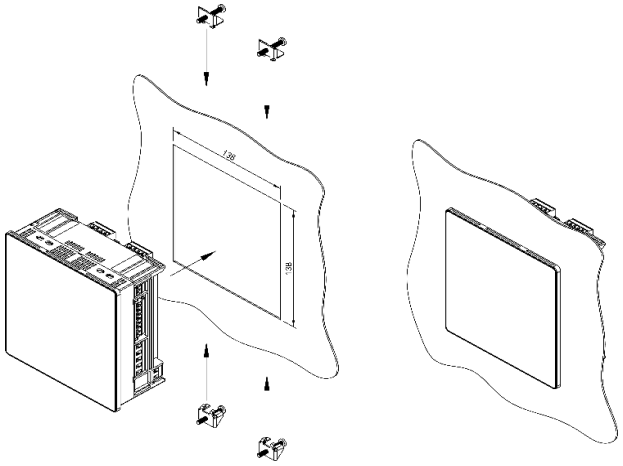


Figure 3.2.1 Installation Diagram

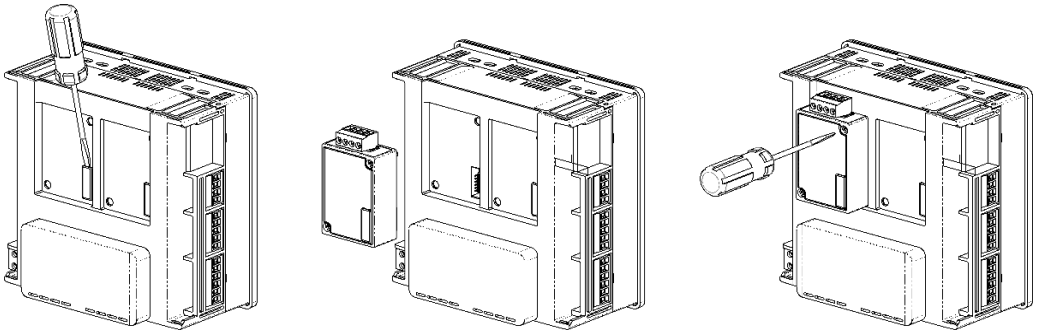


Figure 3.2.2 Module installation Diagram

Note: FM24 module can only be installed in position ① (see Figure 3.3.1.2) After the FM24 module is connected, no other modules can be installed in position ①.

3.3 Wirings

3.3.1 Typical Wiring Diagram

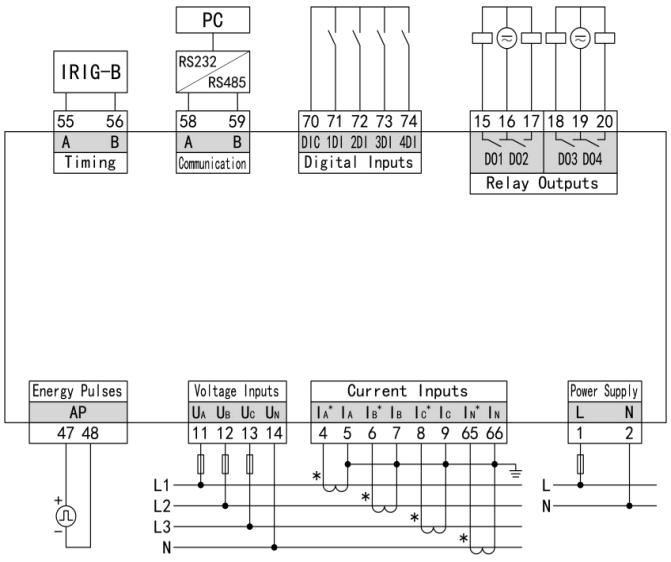


Figure 3.3.1.1 Typical wiring diagram

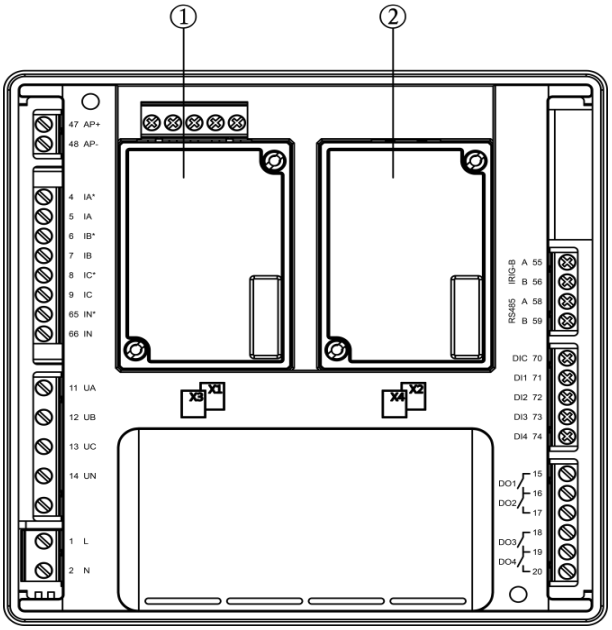


Figure 3.3.1.2 Back-end Diagram

3.3.2 Voltage/Current Input Connection

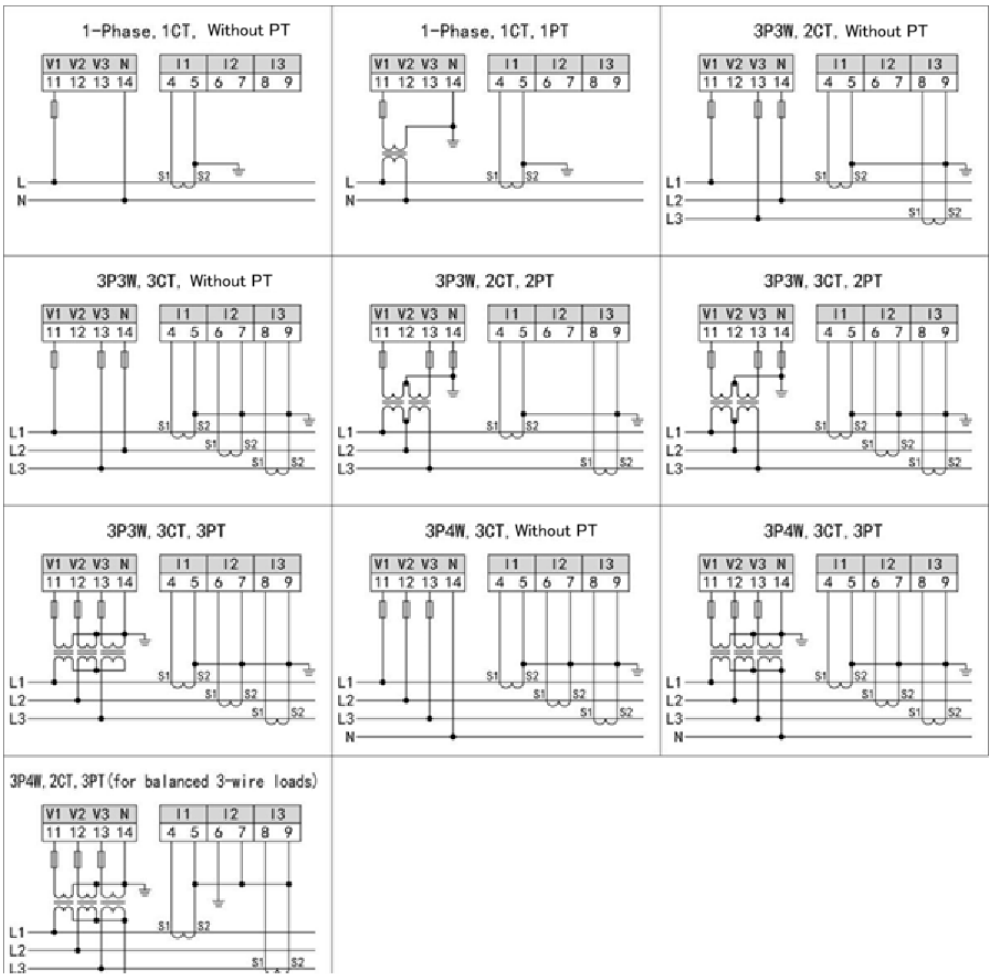
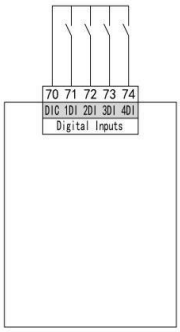
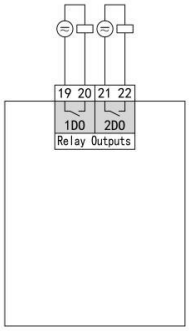


Figure 3.3.2.1 Voltage/Current Input Connection Diagram

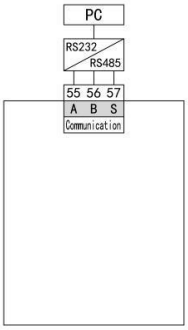
3.3.3 Module Wiring



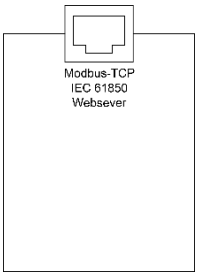
Module-FM2



Module-FM3



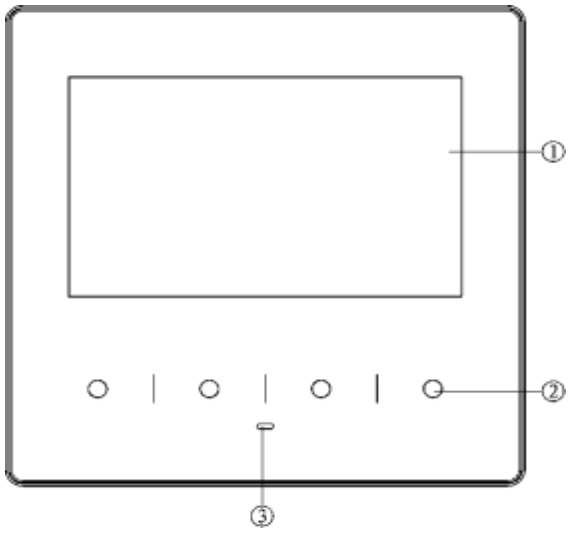
Module-FM11



Module-FM24

4. Operation

4.1 Panel



① Display window

Content Prompt: The currently displayed content will be prompted in the center of each interface;

Page Number: Each interface has a unique number, which is displayed in the upper right corner of the interface;

Data Window: It displays various data contents;

② Button

There are four prompt areas for button function icons at the bottom of each interface, indicating the present function of each physical button.

Users can set the device parameters with those buttons.

③ Indicator led

Button functions

Icons	Description
	Increase the selected data bits.
	Move down the options/page down/change parameters.
	Move in a circular way to the left to change or display data.
	Move in a circular way to the right to change or display data.
	Return directly to the “Main Menu” page, return to the previous menu or discard modifications.
	Enter the selected option.
	Confirm.
	Zoom in or out to display the image.
	Edit the options.
	Turn to next page.
	Invalidate the present button.

Modification methods for values:

Press “  ” to move and modify the data bit, and then press “  ” to cyclically increase the present data bit.

Entering and exiting of programming state:

Entering of programming state: On the main interface, press “  ” and “  ” to change the selected item into “System Setup”, and then press “  ” to enter the interface of programming setup. Generally, users can enter by selecting “User Setup”. After entering the correct programming protection password, they will enter the programming Setup and start setting parameters (the default programming password is 0001, and users can modify it as necessary).

Exiting of programming state: When you have already returned to the first-tier menu of programming interface, Press the button “ Back ”. Now, the device will prompt whether to save the modifications. Select “Yes” to save the modifications and return to the main menu, or select “No” to abandon saving the modifications and return to the main menu.

4.2 Display

4.2.1 Display Menu

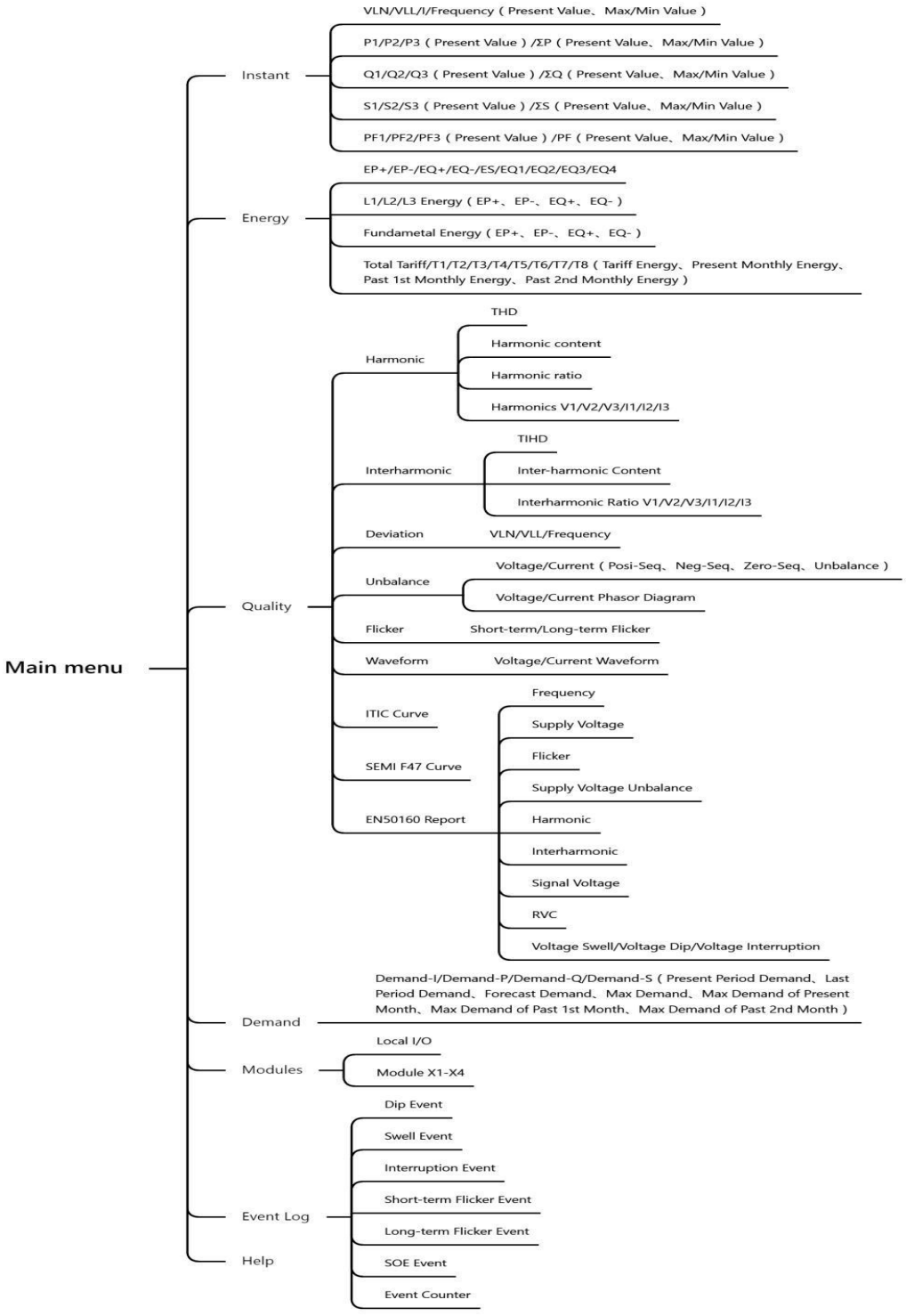
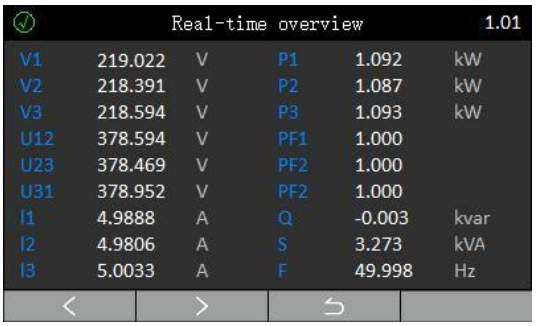
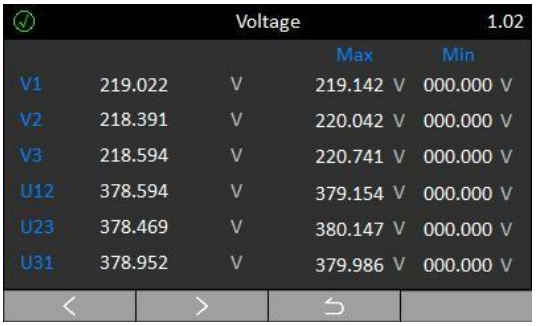
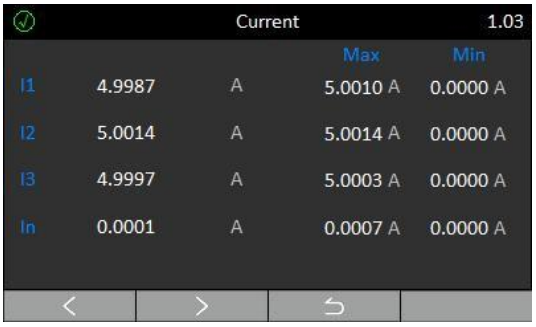
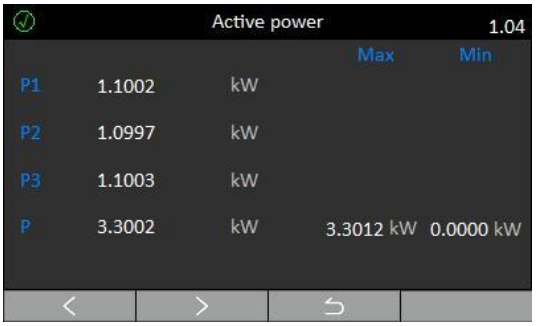
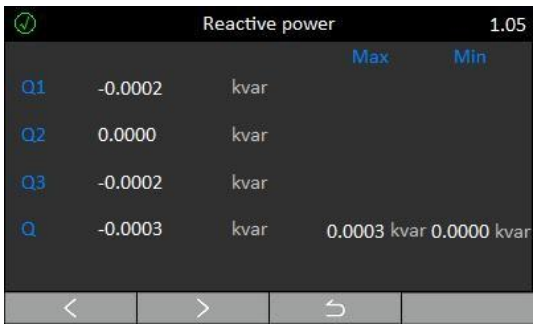
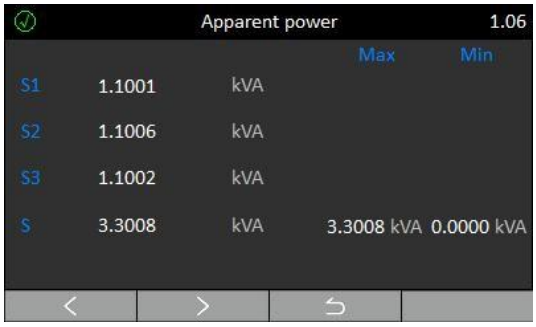
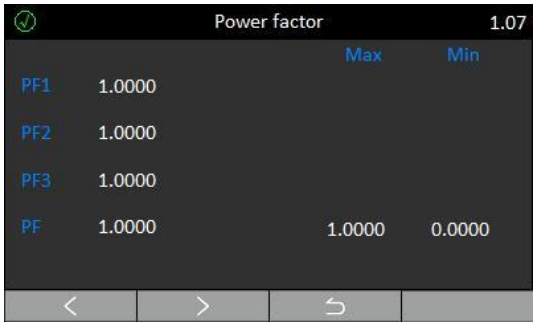
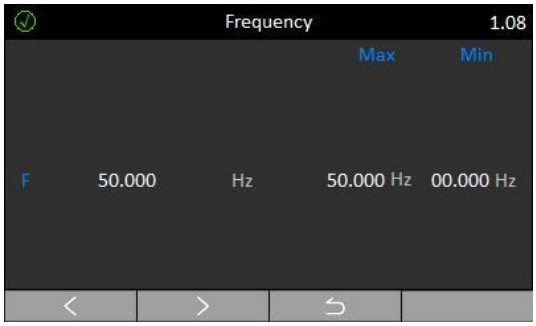


Figure 4.2.1 Overview of Display Menu

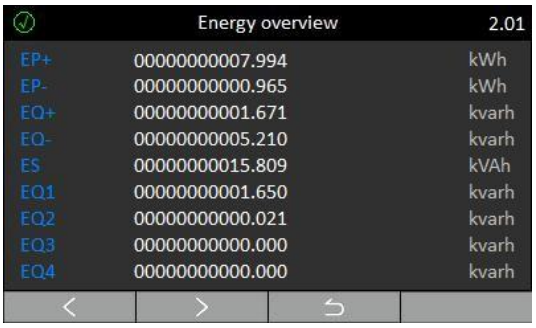
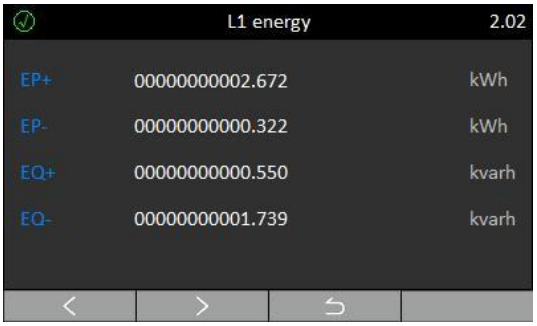
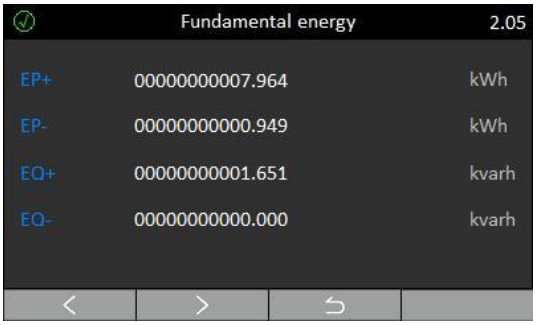
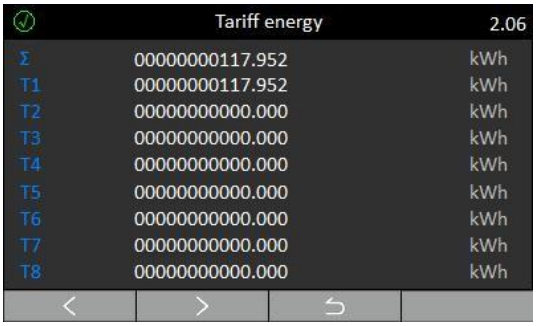
4.2.2 Display Features

4.2.2.1 Real-time measurement

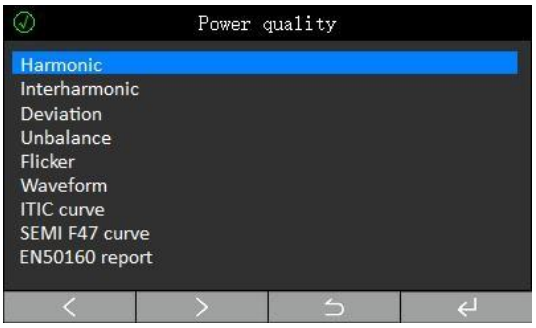
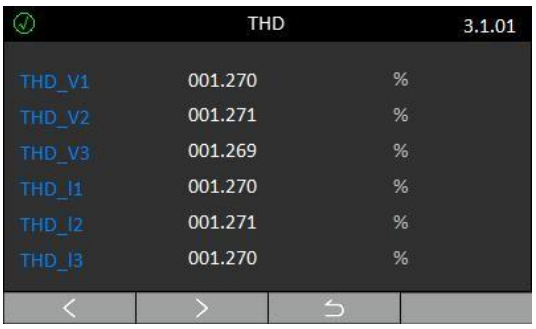
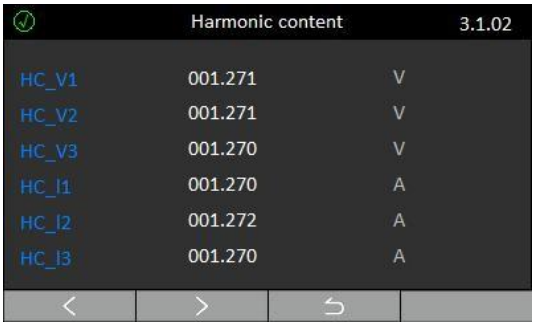
No.	Display	Description
1		Real-time measurement overview
2		Voltage Phase to neutral voltage V1=219.022V V2=218.391V V3=218.594V Phase to phase voltage U12=378.594V U23=378.469V U31=378.952V
3		Current I1=4.9987A I2=5.0014A I3=4.9997A Neutral current In=0.0001A
4		Active power P1 =1.1002kW P2=1.0997kW P3=1.1003kW P= 3.3002kW

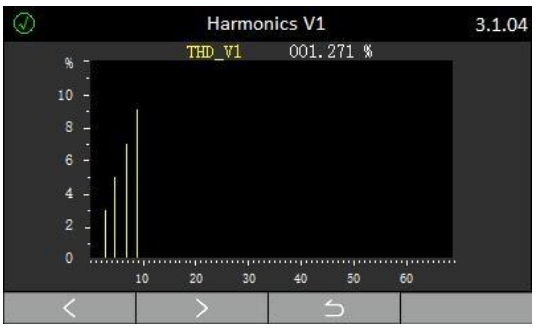
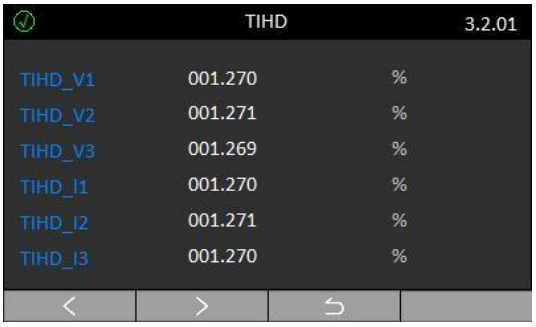
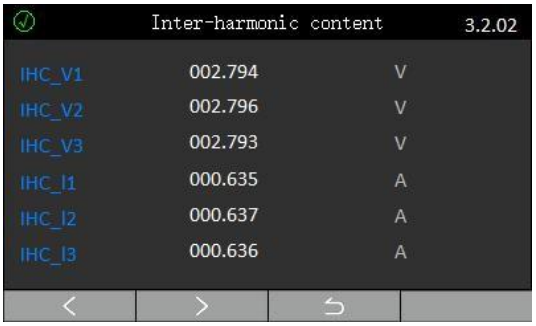
5		Reactive power Q1=-0.002kvar Q2=0.000kvar Q3=-0.002kvar Q =-0.003kvar
6		Apparent power S1=1.1001kVA S2=1.1006kVA S3=1.1002kVA S=3.3008kVA
7		Power factor PF1=1.000 PF2=1.000 PF3=1.000 PF=1.000
8		Frequency F=50.000Hz

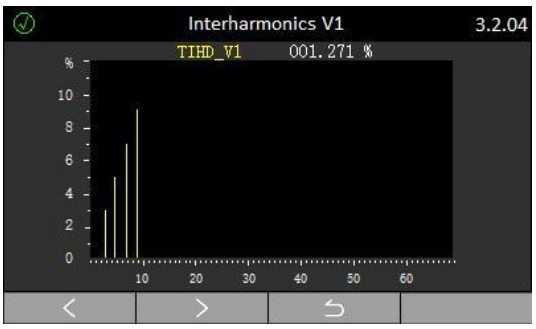
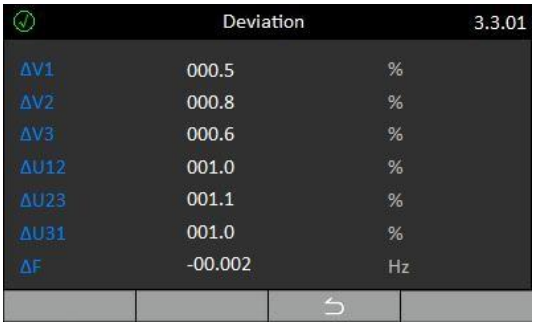
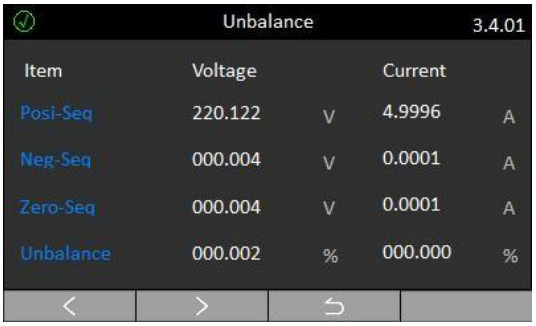
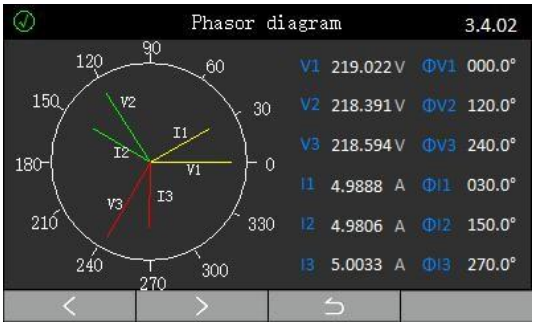
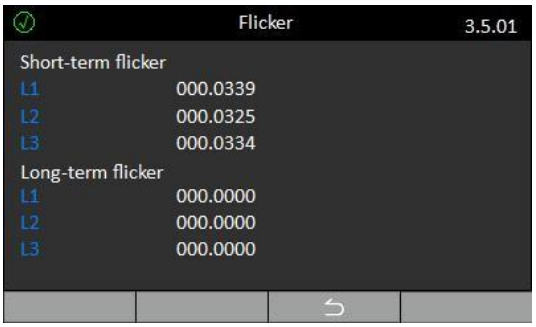
4.2.2.2 Energy metering

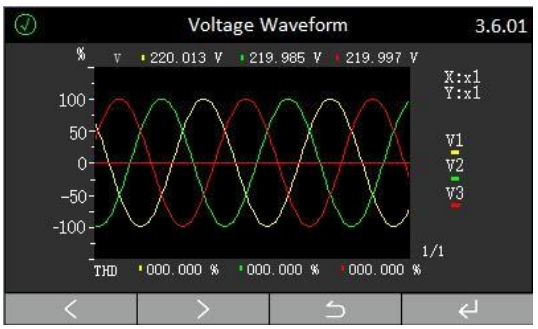
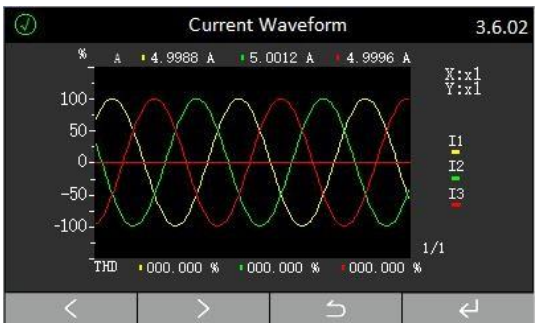
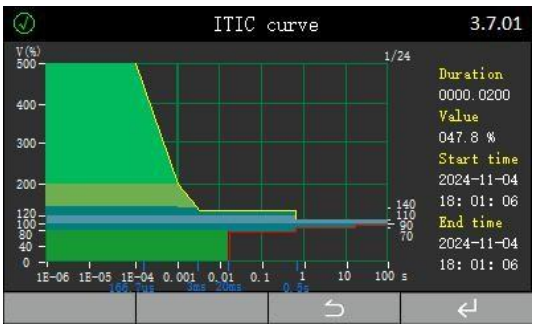
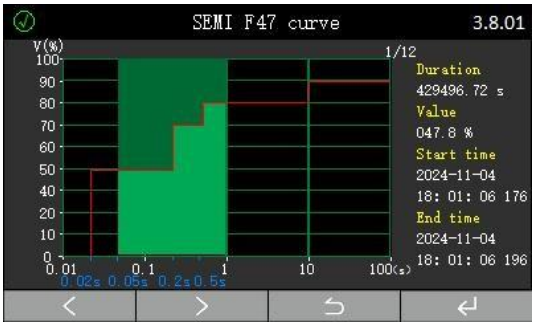
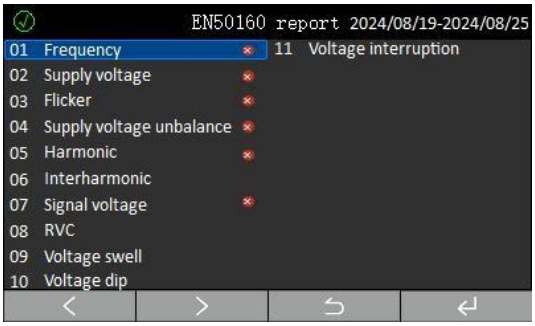
No.	Display	Description
1		Energy overview
2		L1 energy Import active energy EP+ = 2.672kWh Export active energy EP- = 0.322kWh Import reactive energy EP+ = 4.284kvarh Export reactive energy EP- = 1.814kvarh
3		Fundamental energy Fundamental import active energy EP+ =7.964kWh Fundamental export active energy EP- = 0.949kWh Fundamental import reactive energy EQ+ = 1.651kvarh Fundamental export reactive energy EQ- = 0.000kvarh
4		Tariff energy 8 tariffs energy

4.2.2.3 Power quality Metering

No.	Display	Description
1		Power quality overview
2		Total harmonic distortion (THD)
3		Harmonic content
4		Harmonic ratio
5		Harmonic ratio

6		Harmonic bar graph
7		Total Inter-harmonic distortion
8		Inter-harmonic content
9		Inter-harmonic ratio
10		Inter-harmonic ratio

11		Inter-harmonic bar
12		Voltage deviation Frequency deviation
13		Unbalance
14		Phasor diagram
15		Flicker

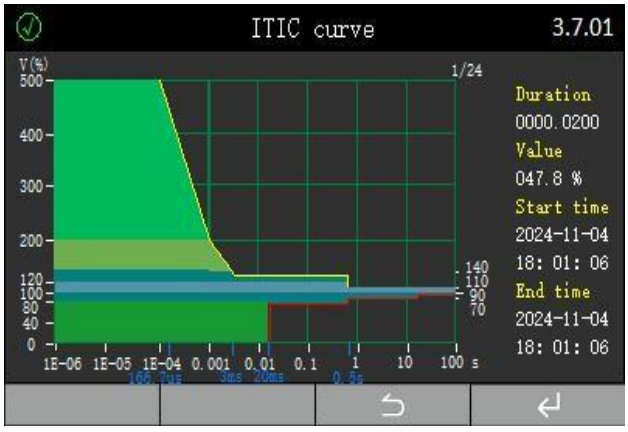
16		Voltage waveform
17		Current waveform
18		ITIC curve
19		SEMI F47 curve
20		EN50160 report

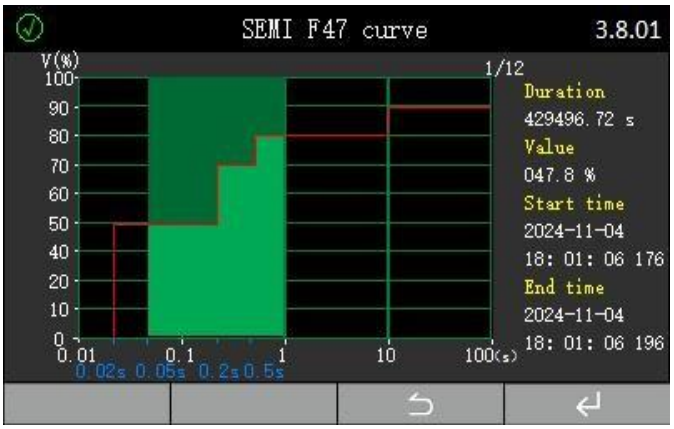
ITIC/SEMI F47 Curves

The ITIC and SEMI F47 curves specify the ability of equipment to withstand power supply's voltage disturbances. Their significance lies in being the benchmarks for assessing the tolerance of power equipment

to voltage interference and voltage disturbances in power supply systems.

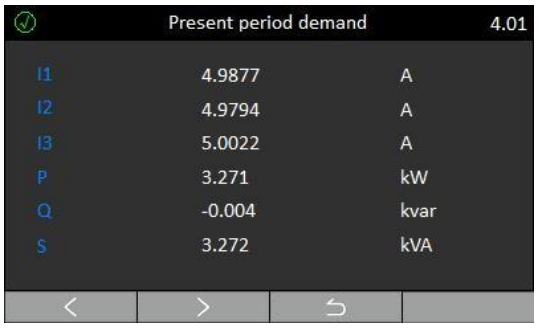
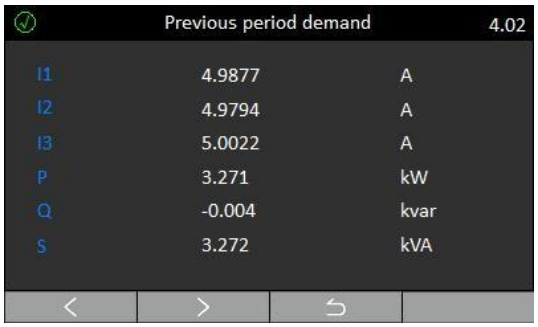
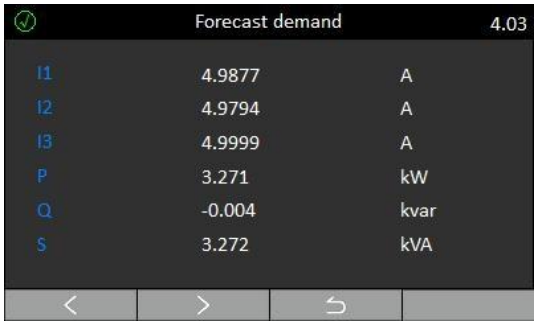
For the ITIC curve interface displayed by the device, the horizontal axis represents the duration of transient voltage event, and the vertical axis represents the voltage percentage (relative to nominal voltage). The upper curve represents the tolerance of equipment to voltage swells, and the lower curve represents the tolerance of equipment to voltage dips. The area between them represents the normal running range. As shown in the figure below, this interface shows the amplitude-duration distribution of a single transient event.



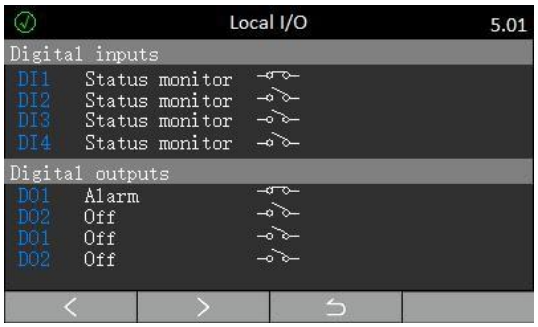
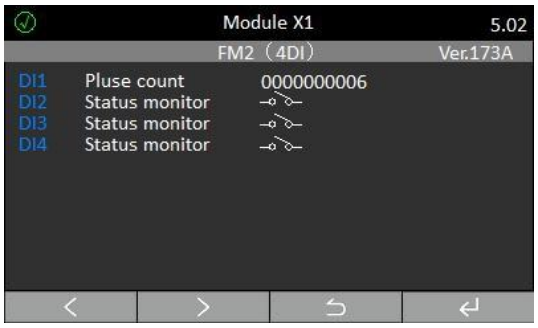
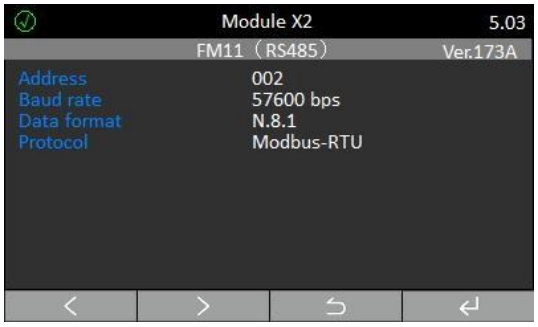
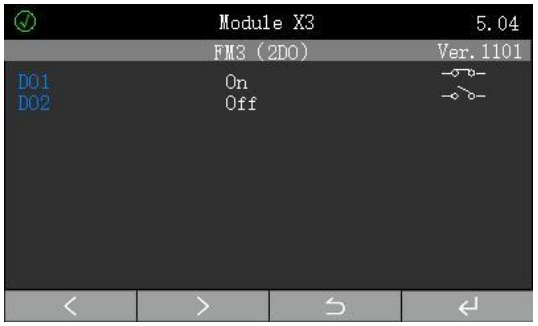


For the SEMI F47 curve interface displayed by the device, the horizontal axis represents the duration of transient voltage event, and the vertical axis represents the voltage percentage (relative to nominal voltage). The specification stipulates the tolerance time of equipment to voltage dips. The area above red solid line represents that the equipment must ensure normal continuous running under such interference. The equipment can run continuously for 0.02s at 0% of the nominal value, 0.2s at 50% of the nominal value, 0.5s at 70% of the nominal value, 1s at 80% of the nominal value, and 10s at 90% of the nominal value. As shown in the figure below, this interface shows the amplitude-duration distribution of a single transient event.

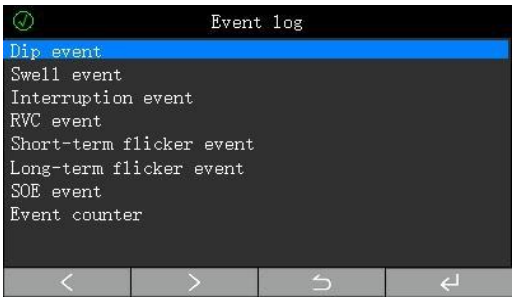
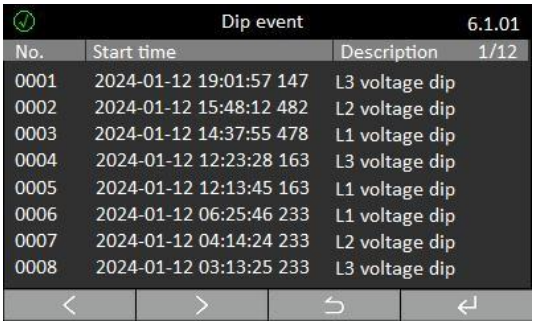
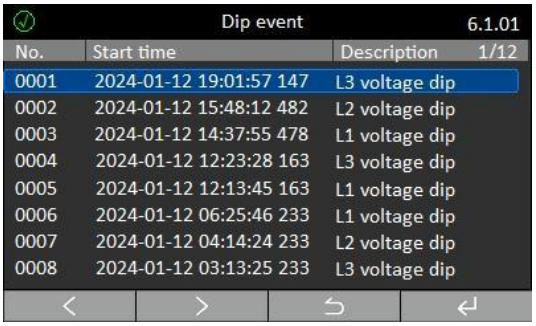
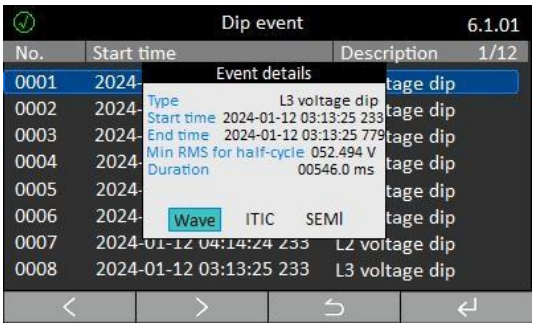
4.2.2.4 Demand

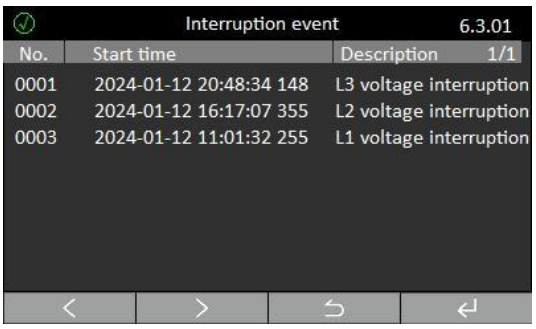
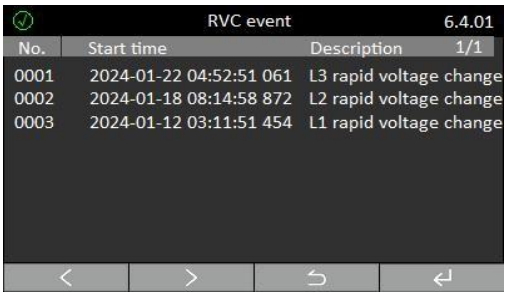
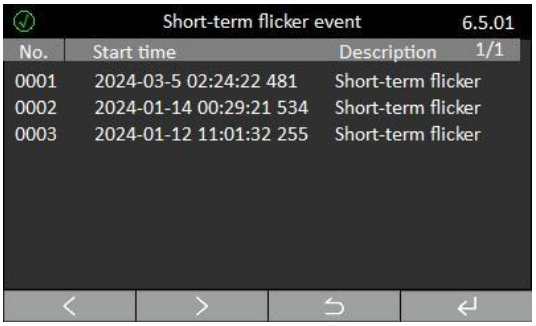
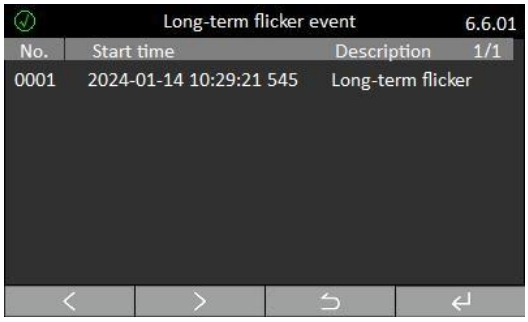
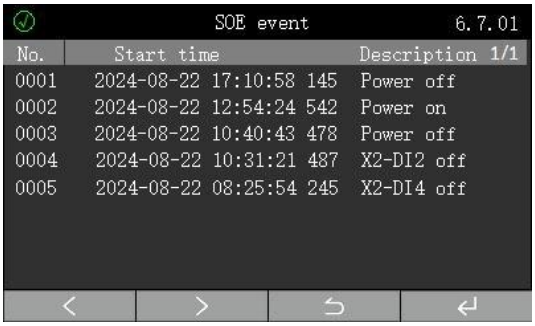
No.	Display	Description
1		Present period demand I1=4.9877A I2=4.9794A I3=5.0022A P=3.271kW Q=-0.004kvar S=3.272kVA
2		Previous period demand I1=4.9877A I2=4.9794A I3=5.0022A P=3.271kW Q=-0.004kvar S=3.272kVA
3		Forecast demand I1=4.9877A I2=4.9794A I3=4.9999A P=3.271kW Q=-0.004kvar S=3.272kVA
4		Max demand I1=4.9895A I2=4.9815A I3=5.0049A P=3.273kW Q=-0.024kvar S=3.273kVA

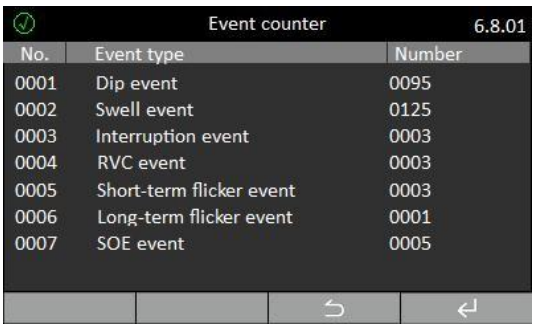
4.2.2.5 Module

No.	Display	Description
1		Local I/O
2		Expand module FM2
3		Expand module FM3
4		Expand module FM11

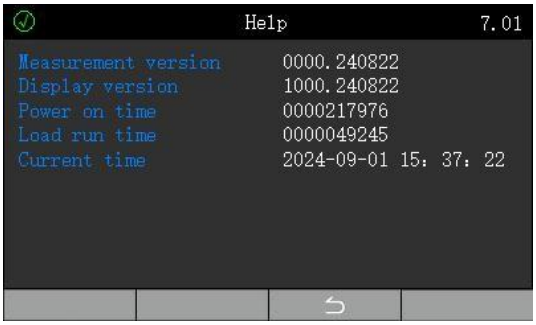
4.2.2.6 SOE logs

No.	Display	Description
1		SOE logs overview
2		Dip event logs
3		Dip event logs
4		Dip event logs
5		Swell event logs

6		Interruption event logs
7		RVC event logs
8		Short term flick event logs
9		Long term flick event logs
10		SOE logs

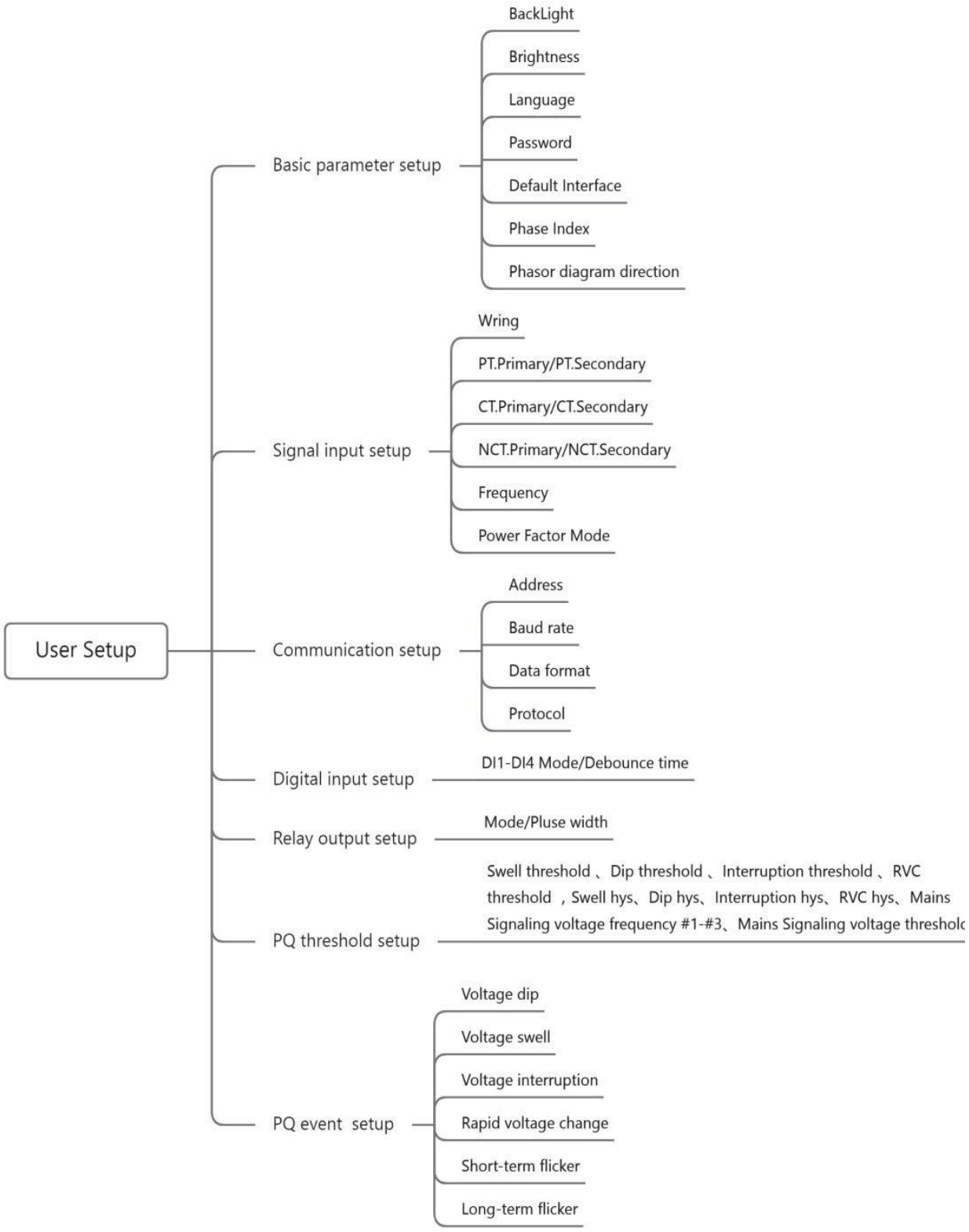
11		Event counter

4.2.2.7 Help

No.	Display	Description
1		Help page

4.3 Setup

4.3.1 Setup Menu



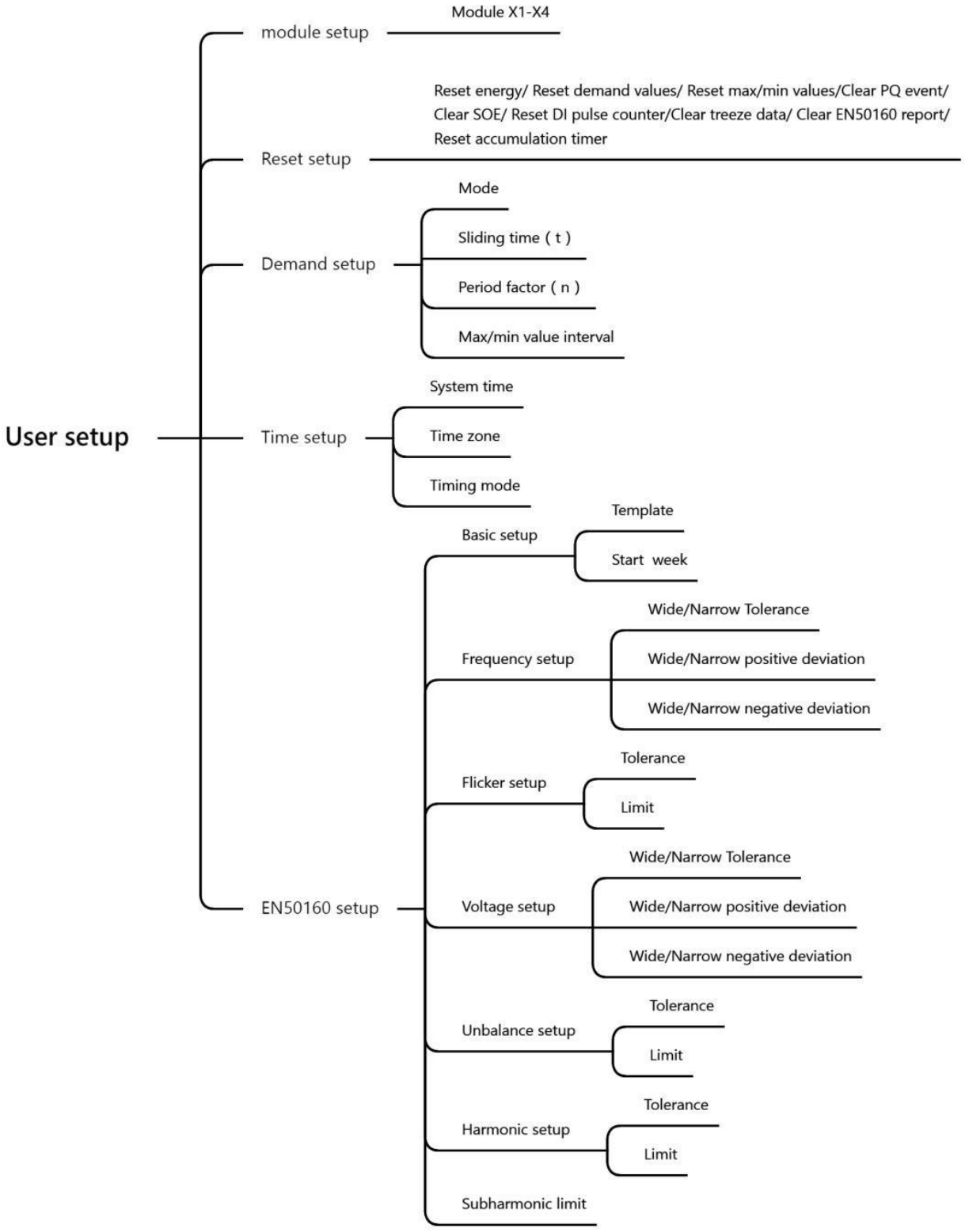
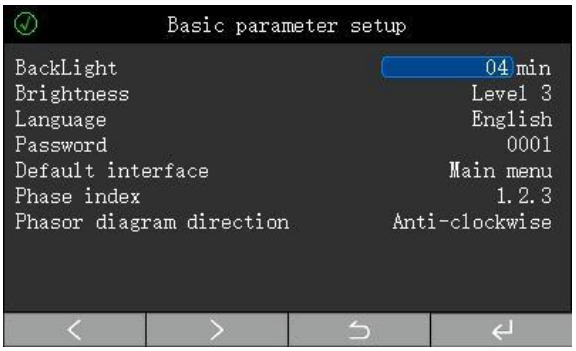


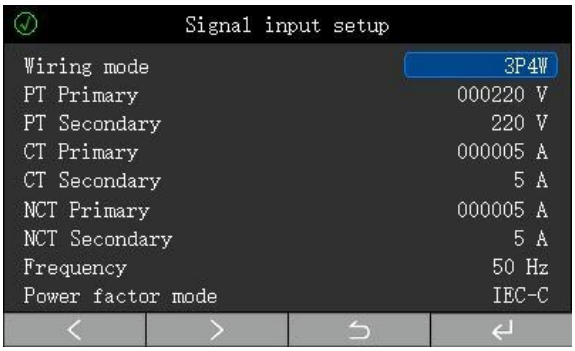
Figure 4.3.1.1 Overview of Setup Menu

4.3.2 Basic Parameter Setup

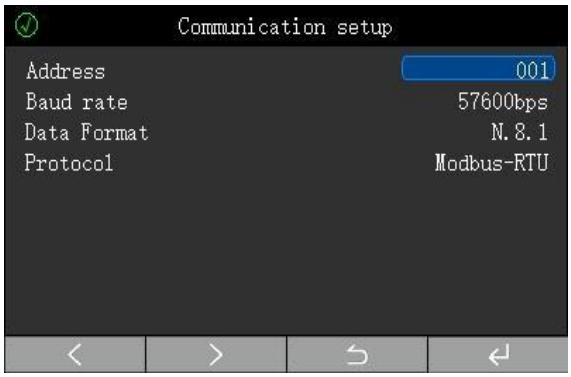
Display	Menu1	Menu2
	Back Light	01... 99min 00 - always on
	Brightness	Level 1...Level5
	Language	English
	Password	0000...9999
	Default interface	Main menu Instant overview Voltage Current Active power Reactive power Apparent power Power factor frequency Energy overview L1/L2/L3 energy Fundamental energy Tariff energy Present monthly energy THD Harmonic content Harmonic ratio Inter-harmonic content Inter-harmonic ratio Deviation Unbalance Phasor diagram Flicker Voltage Waveform Current Waveform Present Demand Last demand

		Predicted demand Max demand Max demand of present month Digital I/O Module X1...X4 About
	Phase index	a, b, c
	Phasor diagram direction	Clock wise/Anti-clock wise

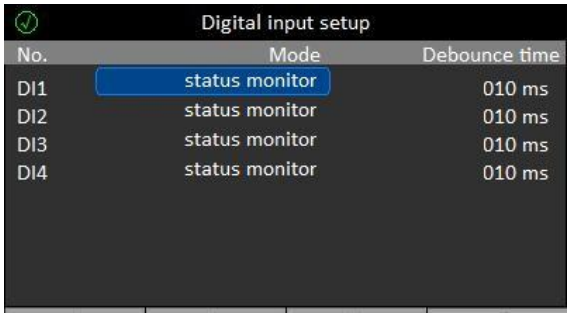
4.3.3 Signal Input Setup

Display	Menu1	Menu2
	Wiring mode	3P3W/3P4W
	PT Primary	1...999999V
	PT Secondary	1...600V
	CT Primary	1...999999A
	CT Secondary	1...6A
	NCT Primary	1...999999A
	NCT Secondary	1...6A
	Frequency	50Hz/60Hz
	Power factor mode	IEC-C/IEEE-C/IEC-P

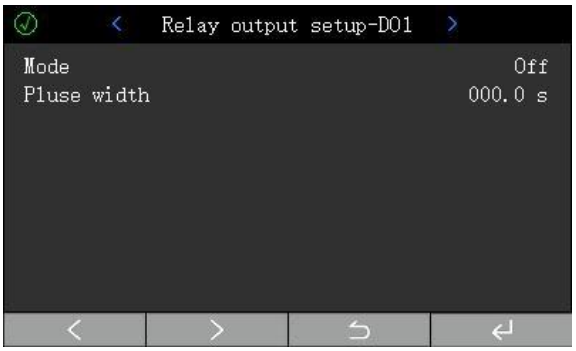
4.3.4 Communication Setup

Display	Menu1	Menu2
	Slave Address	1...247
	Baud rate	2400bps...115200bps
	Data format	E81, O81, N81, N82
	Protocol	Modbus-RTU

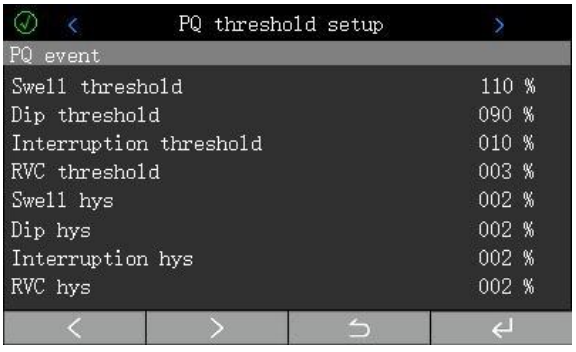
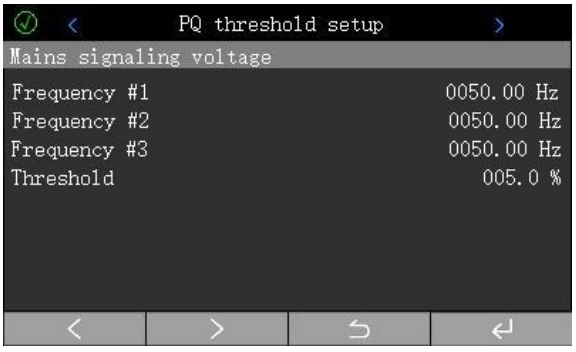
4.3.5 Digital Input Setup

Display	Menu1	Menu2
	Mode	Status monitor/ Pulse counting
	Debounce time	10...1000ms

4.3.6 Relay Output Setup

Display	**Menu1**	**Menu2**
	Mode	Off/On/Alarm
	Pulse width	0.1 .. 999.9s

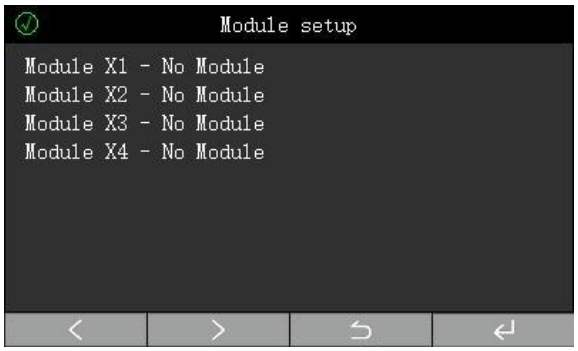
4.3.7 Power quality threshold setup

Display	Menu1	Menu2
	Swell threshold	100...180%
	Dip threshold	0...-100%
	Interruption threshold	0...100%
	RVC threshold	1...6%
	Swell hysteresis	0...10%
	Dip hysteresis	0...10%
	Interruption hysteresis	0...10%
	RVC hysteresis	0...3%
	Mains signaling voltage frequency	50.0... 2575.0Hz
	Mains signaling voltage threshold	0.3...1 00%

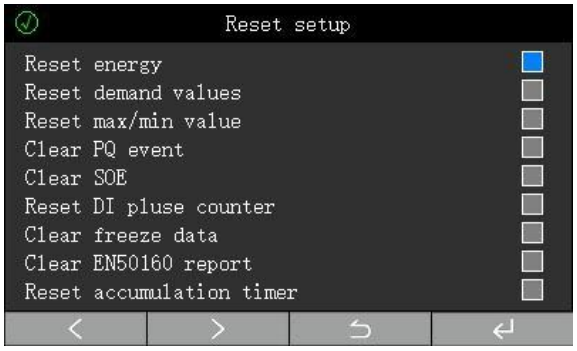
4.3.8 PQ event setup

Display	Menu1	Menu2
	Swell	Enable/Disable
	Dip	Enable/Disable
	Interrupt	Enable/Disable
	RVC	Enable/Disable
	Short term flick	Enable/Disable
	Long term flick	Enable/Disable

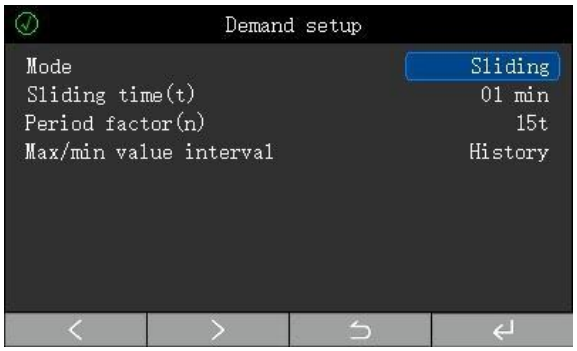
4.3.9 Module setup

Display	Menu1
	Module setup

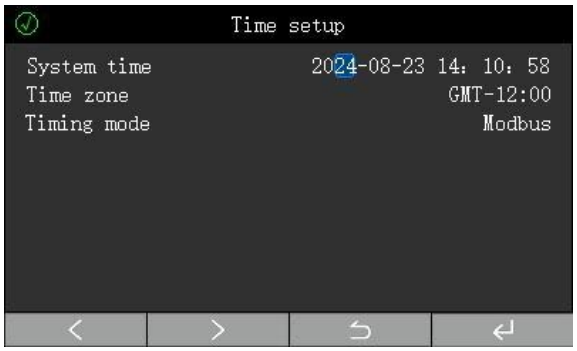
4.3.10 Reset setup

Display	Menu1	Menu2
	Reset energy values	Enable/ Disable
	Reset demand values	Enable/ Disable
	Reset max/min values	Enable/ Disable
	Clear PQ event logs	Enable/ Disable
	Clear SOE logs	Enable/ Disable
	Reset DI pulse counter	Enable/ Disable
	Clear freeze data	Enable/ Disable
	Clear EN50160 report	Enable/ Disable
	Reset accumulation timer	Enable/Disable

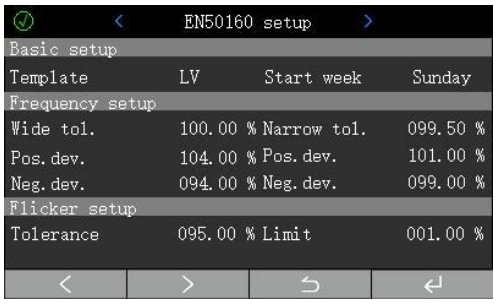
4.3.11 Demand setup

Display	Menu1	Menu2
	Mode	Sliding block/Fixed block
	Sliding time	1min...60 min
	Period factor	1t...30 t
	Max/min interval	Historical /1/5/15/30/60/1440 min

4.3.12 Time setup

Display	Menu1	Menu2
	System time	Year/Month/day/hour/ minute/second
	Time zone	GMT-12:00 ...GMT+13
	Timing mode	Modbus/IRIG-B/Web /NTP

4.3.13 EN50160 Setup

Display	Menu1	Menu2	Menu3
	Basic update	Template	LV/MV/HV
		Start week	Monday...Sunda y
	Frequency setup	Wide/Narrow Tolerance	0...100%
		Wide/Narrow positive deviation	0...200%
		Wide/Narrow negative deviation	0...100%
	Flick setup	Tolerance	0...100%
		Limit	0...100

5. Functions

5.1 Real-time measurements

The device can measure the full electric parameters of power grid.

Measurement		Phase	Total	max	Min	Average	Demand
Voltage	Phase voltage	●	—	●	●	●	—
	Line voltage	●	—			●	—
	Fundamental voltage	●	—			—	—
Current	Current	●	—	●	●	●	●
	Neutral current	—	●	●	●	—	—
	Fundamental current	●	—			—	—
Power	Active power	●	●	●	●	●	●
	Reactive power	●	●	●	●	●	●
	Apparent power	●	●	●	●	●	●
Power factor		●	●	●	●	—	—
Frequency		—	●	●	●	—	—

5.2 Energy metering

The device can meter energies, which are specifically as follows:

- Bidirectional active energy/reactive energy
- Fundamental active energy/reactive energy
- Four-quadrant reactive energy
- Apparent energy
- Tariff energy

The energy values displayed by the device are all primary values, which are obtained by multiplying the secondary value by magnification ratios of voltage and current transformers. All electric energy values are based on secondary values. The minimum resolution for accumulation of secondary electric energy values is 1Wh or 1varh, and the minimum display resolution of electric energy values is 0.001kWh or 0.001kvarh.

The maximum energy that can be retained is 4,294,967,295Wh on the secondary side. The display range of electric energy is initially 99,999,999,999kWh (99.9 billion kWh). There will be no overflow during normal service life of the device. Users can manually reset and clear the electric energy data according to their own needs (user password is required).

The device provides 6 sets of daily tariffs that can be set, weekly tariffs or 12 time zone tariffs that are optional, and 90 variable holidays that can be set. When the switching time is reached or the year/month

registers of switching time are directly written with 0xFFFF, the present rate setting will be directly overwritten by backup rate setting, and the switching time register will be cleared (the device will always run under the present rate setting).

The following tariff energy will be recorded:

- Present total/T1/T2/T3/T4/T5/T6/T7/T8 energy
- Total/T1/T2/T3/T4/T5/T6/T7/T8 energy for this month
- Historical total/T1/T2/T3/T4/T5/T6/T7/T8 energy for past 1 month to past 12 months.

5.3 Demand

The device can provide present period demand, previous period demand, maximum demand, maximum demand of present month, maximum demand of previous month and maximum demand of past 2 months, and two calculation methods, i.e., sliding block and fixed block, and the relevant setup can be made through communication.

The device can measure basic demand values, including 6 fixed demand values (I1, I2, I3, P, Q,S) and 10 optional demand values (see communication manual).

The demand can be measured with 2 methods: sliding block and fixed block. The time parameter setup involved include t (sliding time, unit: minute) and T (sliding cycle/interval time, unit: minute).

Sliding block: Every t minutes, it calculates the average demand value in the most recent T minutes, makes judgments and records, and conducts automatic meter reading for the monthly demand.

Fixed block: Every T minutes, it calculates the average demand value in the most recent T minutes, makes judgments and records, and conducts automatic meter reading for the monthly demand.

5.3.1 Sliding Block Demand

The setup related to sliding calculation are as follows:

- ✧ Mode: Sliding Block.
- ✧ Sliding Time (t): “1” minute.
- ✧ Period Factor (n): Set to “15”.

The calculation method is shown in Figure 5.2.1.1:

- ➢ Previous period Demand = $(dmd_{t1}+dmd_{t2}+ \dots + dmd_{t14}+ dmd_{t15})/15$
- ➢ Present period Demand = $(dmd_{t2}+ dmd_{t3}+ \dots + dmd_{t15}+dmd_{t16})/15$

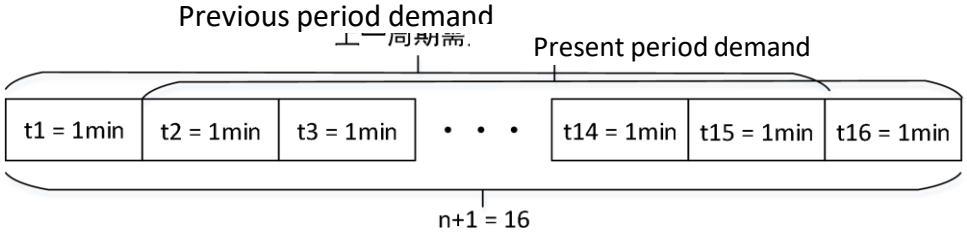


Figure 5.2.1.1 Sliding Demand Calculation

5.3.2 Fixed Block Demand

The setup related to fixed block calculation are as follows:

✧ Mode: Fixed block.

✧ Sliding Time (t): “1” minute.

✧ Period Factor (n): “15”.

The calculation method is shown in Figure 5.2.2.1:

➢ Previous period demand = $(dmd_{t1}+ dmd_{t2}+ \dots + dmd_{t14}+ dmd_{t15})/15$

➢ Present period demand = $(dmd_{t16}+ dmd_{t17}+ \dots + dmd_{t29}+ dmd_{t30})/15$

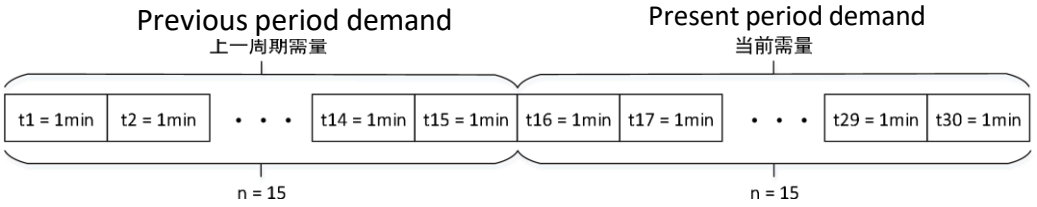


Figure 5.2.2.1 Fixed Block Demand Calculation

5.4 Max/Min Values

The device provides two types of max/min values i.e., interval values or historical values. When the interval time is set to “0”, it is the historical value; when it is not set to “0”, it is the interval value. When the interval time is set to 15min and the current time is 12:20, the values displayed by the device is the values within 12:00-12:15.

The device provides basic max/min data, including 15 fixed max data,15 fixed min data and 34 programmed data.

5.5 Power Quality

5.5.1 Power Quality

The device can monitor and analyze the power quality of grid, including the following measurement parameters:

Voltage deviation, frequency deviation, harmonics, inter-harmonics, unbalance, flicker, swell, dip, interruption and voltage rapid change.

5.5.2 Fundamental Wave Analysis

The device can provide the following fundamental data:

- Split-phase fundamental phase/line voltage
- Split-phase fundamental current
- Split-phase/total fundamental active power
- Split-phase/total fundamental reactive power

- Split-phase/total fundamental apparent power
- Split-phase/total fundamental power factor

5.5.3 Crest Factor

The device calculates the crest factor by analyzing a complete voltage and current cycle to provide crest factors of three-phase voltage and current:

Crest factor = Peak value / r.m.s value

5.5.4 k-Factor

The device calculates the k-factor based on the calculated harmonic data of current to provide k-factor of three-phase current:

$$k = \frac{\sum_{h=2}^{h=h_{max}} I_h{}^2 h^2}{I_{th}{}^2}$$

In which, h refers to the harmonic order, I_h refers to the value of harmonic distortion for the h^{th} current harmonic, and I_{th} refers to the value of total harmonic distortion. the device is capable of measuring 2^{nd} - 51^{st} harmonics. Therefore, h_{max} is equal to 51.

5.5.5 Voltage Deviation

Changes in the running mode of power supply and distribution system and slow variations in load will cause the voltage at various points of the system to change accordingly. The difference between voltage at each point and rated voltage is known as voltage deviation, which is usually expressed as a percentage. The calculation method is as follows:

$$\Delta U = \frac{U - U_N}{U_N} \times 100\%$$

In which

ΔU is Voltage deviation

U is Real Voltage

UN is rated voltage.

5.5.6 Frequency Deviation

Frequency deviation refers to the difference between actual value and nominal value of system frequency under normal running conditions in the power system. The calculation method is as follows:

Frequency deviation = Actual frequency - Nominal frequency

5.5.7 Harmonic and Inter-harmonic

Harmonics: Perform Fourier series decomposition on the periodic alternating quantity to obtain components with frequencies that are integer multiples of the fundamental frequency higher than 1;

Inter-harmonics: Perform Fourier series decomposition on the periodic alternating quantity to obtain components with frequencies that are not equal to integer multiples of the fundamental frequency higher

than 1;

The device provides the following harmonic data:

- Split-phase 2nd ... 51st voltage/current harmonic ratio
- voltage/current THD
- voltage/current harmonics content
- Split-phase harmonic active power
- Split-phase harmonic reactive power
- Split-phase 2nd ... 51st inter-harmonic ratio of voltage/current
- Voltage/current inter-harmonics content

5.5.8 Unbalance

For 3-phase 4-wire system, the device calculates voltage and current unbalance according to the calculated positive and negative sequence components of voltage and current; for 3-phase 4-wire system, the device calculates voltage and current unbalance according to the calculated maximum and average voltage and current values.

For 3-phase 4-wire System:

$$\mathrm{Unb2} = \frac{\mathrm{U2}}{\mathrm{U1}} \times 100$$

$$\mathrm{Unb0} = \frac{\mathrm{U0}}{\mathrm{U1}} \times 100$$

$$\mathrm{Inb2} = \frac{\mathrm{I2}}{\mathrm{I1}} \times 100$$

$$\mathrm{Inb0} = \frac{\mathrm{I0}}{\mathrm{I1}} \times 100$$

For 3-phase 3-wire System:

$$Unb = \frac{\max(U - Uavg)}{Uavg} \times 100$$

$$Inb = \frac{\max(I - Iavg)}{Iavg} \times 100$$

The device simultaneously provides the real and imaginary parts of fundamental wave of voltage and current.

5.5.9 Voltage Flicker

The human visual response to unstable illumination caused by voltage fluctuations (lamp flickering) is known as flicker. In other words, flicker reflects the impact of lamp flickering caused by voltage fluctuations on human visual perception.

The device provides short-term and long-term flicker values along with time stamps. Specifically, the short-term flicker update cycle is 10min, while the long-term flicker update cycle is 2h.

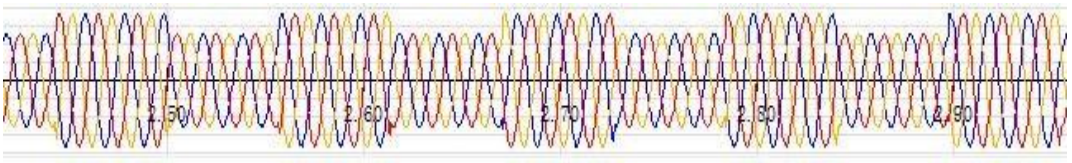


Figure 4.2.2.3.8.1 Waveform Screenshot of Voltage Flicker

5.5.10 Voltage Swell, dip and Interruption

Voltage Swell: Under power-frequency conditions, the root-mean-square value of voltage rises to 1.1-1.8 times of rated voltage.

Voltage dip: Under power-frequency conditions, the root-mean-square value of voltage drops to 0.1 0.9 times of rated voltage.

Voltage Interruption: Under power-frequency conditions, the root-mean-square value of voltage drops below 0.1 times of rated voltage for not more than 1min.

The device provides the following functions:

- Split-phase voltage swell, dip and interruption events
- Occurrence and end time, duration and extreme values during voltage swell, dip and interruption events
- Waveform recordings of voltage swell, dip and interruption events

The device provides the following relevant parameter Setup:

- Event enable setting
- Selection and setting of data sources for event
- Setup for event threshold, hysteresis and determination of occurrence duration

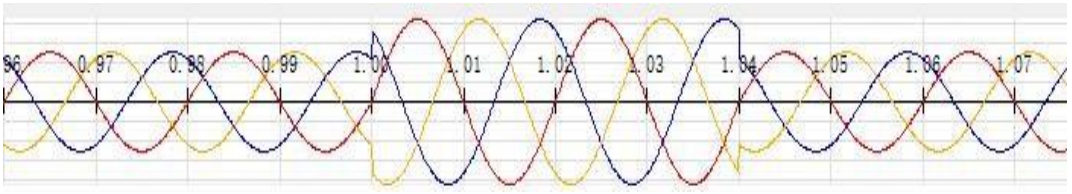


Figure 4.2.2.3.9.1 Waveform Screenshot of Voltage Swell

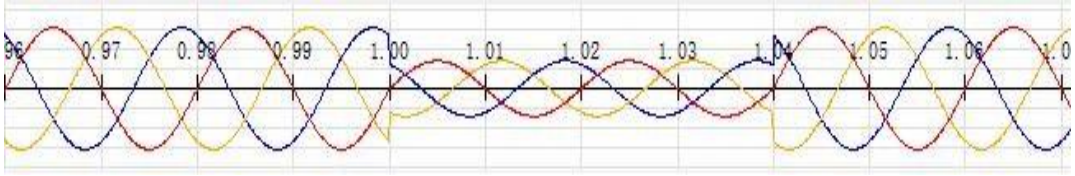


Figure 4.2.2.3.9.2 Waveform Screenshot of Voltage dip

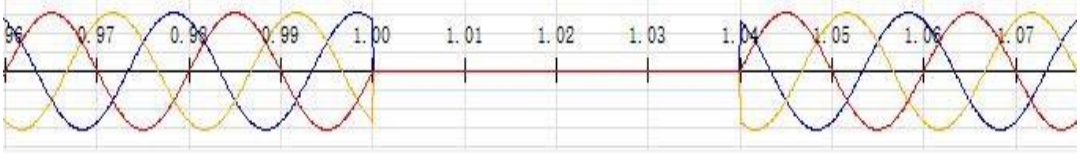


Figure 4.2.2.3.9.3 Waveform Screenshot of Voltage Interruption

5.5.11 Rapid Voltage Change

Rapid voltage change refers to a rapid transition in the effective value of voltage between two stable voltage states, with the maximum change in effective voltage value not exceeding the threshold for voltage swell or dip. the device provides the following functions:

- Rapid change events of split-phase/total voltage
- Occurrence and end time, duration, △**Umax** and △**Uss** of rapid voltage change event
- Waveform recordings during a rapid voltage change event the device provides the following relevant parameter Setup:
- Event judgment enable setting
- Event judgment threshold and hysteresis setting

△Umax: It refers to the maximum absolute value of difference between the last Uavg before an RVC event starts and any Urms during the event. For a multiphase system, it refers to maximum value among △Umax of all phases.

△Uss: It refers to the absolute value of difference between the last Uavg before an event starts and the first Uavg after the event ends. For a multiphase system, the maximum value among all phases is taken.

Uavg: It refers to the arithmetic mean of 100 consecutive Urms. Urms: It refers to the effective value of voltage half-wave.

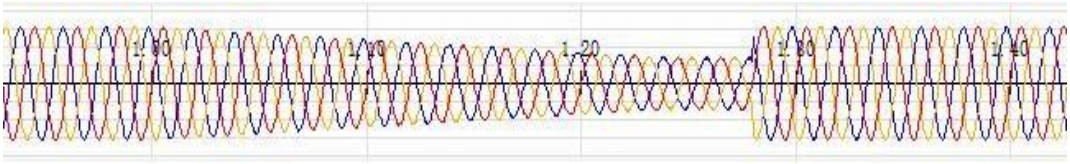


Figure 4.2.5 Waveform Screenshot of Rapid Voltage Change

5.6 Alarm

The device can provide independent alarms with enable, limit, hysteresis, and delay time. When an alarm is triggered, the register value of the alarm state of the communication address table will be updated accordingly.

The alarm item includes voltage, current, power, THD etc. Triggering Conditions of Alarm:

1) The corresponding alarm is enabled.

2) The value is more than the threshold in case of upper limit alarms; the value is less than the threshold in case of lower limit alarms.

3) The duration exceeds the delay time Release Conditions of Alarm:

The value is less than the threshold - hysteresis in case of upper limit alarms; the value is more than the value of threshold + hysteresis in case of lower limit alarms.

Alarm item:

LN-Voltage	N-phase Current

LL-Voltage	Total Active Power
Current	Total Reactive Power
Total Apparent Power	1st ... 50th current inter-harmonic content
Total Power Factor	1st ... 50th voltage inter-harmonic content
Zero-sequence voltage unbalance	1st ... 50th current inter-harmonic content
Negative-sequence voltage unbalance	DI1 ON
Zero-sequence current unbalance	DI1 OFF
Negative-sequence current unbalance	DI2 ON
Fundamental Voltage	DI2 OFF
Fundamental Current	DI3 ON
Voltage Deviation	DI3 OFF
Frequency	DI4 ON
Frequency Deviation	DI4 OFF
THD-V	X1-DI1 ON
TOHD-V	X1-DI1 OFF
TEHD-V	X1-DI2 ON
THD-I	X1-DI2 OFF
TOHD-I	X1-DI3 ON
TEHD-I	X1-DI3 OFF
TIHD-V	X1-DI4 ON
TOIHD-V	X1-DI4 OFF
TEIHD-V	X2-DI1 ON
TIHD-I	X2-DI1 OFF

TOIHD-I	X2-DI2 ON
TEIHD-I	X2-DI2 OFF
HC_V	X2-DI3 ON
HC_I	X2-DI3 OFF
IHC_V	X2-DI4 ON
IHC_I	X2-DI4 OFF
Present demand-P	X3-DI1 ON
Present demand-Q	X3-DI1 OFF
Present demand-S	X3-DI2 ON
Present demand-PF	X3-DI2 OFF
Forecast demand-P	X3-DI3 ON
Forecast demand-Q	X3-DI3 OFF
Forecast demand-S	X3-DI4 ON
Forecast demand-PF	X3-DI4 OFF
Short-term flicker	X4-DI1 ON
Long-term flicker	X4-DI1 OFF
Rapid voltage change	X4-DI2 ON
2^{nd} ... 51^{st} voltage harmonic ratio	X4-DI2 OFF
2^{nd} ... 51^{st} current harmonic ratio	X4-DI3 ON
2^{nd} ... 51^{st} voltage harmonic content	X4-DI3 OFF
2^{nd} ... 51^{st} current harmonic content	X4-DI4 ON
1^{st} ... 50^{th} voltage inter-harmonic content	X4-DI4 OFF

5.7 Event Log

The device provides 1,024 data records for querying, where each record can be divided into two parts i.e., event + occurrence time. The event is divided into a high byte (event classification) and a low byte (specific event), as shown in the following table:

High byte	Event Classification	Low byte	Specific Events
0x00	No event	—	—
0x01	Power on/off event	0x00	Power off
		0x01	Power on
0x02	Over-limit start event	—	see communication manual
0x03	Over-limit end event	—	
0x04	DI event	0x00	DI1 ON
		0x01	DI1 OFF
		0x02	DI2 ON
		0x03	DI2 OFF
		0x04	DI3 ON
		0x05	DI3 OFF
		0x06	DI4 ON
		0x07	DI4 OFF
		0x08	X1-DI1 ON
		0x09	X1-DI1 OFF
		0x0A	X1-DI2 ON
		0x0B	X1-DI2 OFF
		0x0C	X1-DI3 ON
		0x0D	X1-DI3 OFF
		0x0E	X1-DI4 ON
		0x0F	X1-DI4 OFF
		0x10	X2-DI1 ON
		0x11	X2-DI1 OFF
		0x12	X2-DI2 ON
		0x13	X2-DI2 OFF
		0x14	X2-DI3 ON
		0x15	X2-DI3 OFF
		0x16	X2-DI4 ON
		0x17	X2-DI4 OFF
		0x18	X3-DI1 ON

		0x19	X3-DI1 OFF
		0x1A	X3-DI2 ON
		0x1B	X3-DI2 OFF
0x05	DO event	0x1C	X3-DI3 ON
		0x1D	X3-DI3 OFF
		0x1E	X3-DI4 ON
		0x1F	X3-DI4 OFF
		0x20	X4-DI1 ON
		0x21	X4-DI1 OFF
		0x22	X4-DI2 ON
		0x23	X4-DI2 OFF
		0x24	X4-DI3 ON
		0x25	X4-DI3 OFF
		0x26	X4-DI4 ON
		0x27	X4-DI4 OFF
		0x00	DO1 ON
		0x01	DO1 OFF
		0x02	DO2 ON
		0x03	DO2 OFF
		0x04	DO3 ON
		0x05	DO3 OFF
		0x06	DO4 ON
		0x07	DO4 OFF
		0x08	X1- DO1 ON
		0x09	X1- DO1 OFF
		0x0A	X1- DO2 ON
		0x0B	X1- DO2 OFF
		0x0C	X2- DO1 ON
		0x0D	X2- DO1 OFF
		0x0E	X2- DO2 ON
		0x0F	X2- DO2 OFF
		0x10	X3- DO1 ON

		0x11	X3- DO1 OFF
		0x12	X3- DO2 ON
		0x13	X3- DO2 OFF
		0x14	X4- DO1 ON
		0x15	X4- DO1 OFF
		0x16	X4- DO2 ON
		0x17	X4- DO2 OFF
0x06	Meter operation event	0x00	Setup change
		0x01	Reset energy values
		0x02	Reset demand values
		0x03	Reset max/min values
		0x05	Clear SOE logs
		0x07	Reset DI pulse counter
		0x09	Reset running timer
		0x0A	Clear PQ event
		0x0B	Clear EN50160 report
		0x0C	Clear freeze data
		0xFF	Clear all records

5.8 Data Freezing

The device can freeze data, including 5 fixed data (import active energy, export active energy, import reactive energy, export reactive energy and apparent energy) and 20 optional data. Freeze interval can select 1min,5min,15min,30min,60min or 1440min.

5.9 Address Mapping

The device has 60 registers that its address can be programmed.

For example, if the host computer wants to read “phase voltage-V1”, “phase voltage-V2”, “phase voltage-V3”, and “average phase voltage” in one frame, you can set as follows:

- Custom data setting 1/2 set to “0x0006”/ “0x0007” (address of phase voltage-V1)
- Custom data setting 3/4 set to “0x0008”/ “0x0009” (address of phase voltage-V2)
- Custom data setting 5/6 set to “0x000A”/ “0x000B” (address of phase voltage-V3)
- Custom data setting 7/8 set to “0x0310”/ “0x0311” (Address of average phase voltage)

After the setting is completed, the host computer can read 8 addresses directly from the 0x1000 to complete a frame reading the above data.

5.10 Digital Input

The digital input module adopts the dry contact mode. Since it is equipped with an built-in power source, the device can be used to monitor the state of the circuit breaker, accumulate the pulses of energy without external power source.

5.11 Relay Output

Relay output can select three modes, including OFF mode, alarm mode and remote-control mode.

5.12 Expand Module

- FM2: 4 digital inputs
- FM3: 2 relay outputs
- FM11: RS485, Modbus-RTU
- FM24: Ethernet port, Modbus-TCP, Websever

The device supports expand module, including FM2, FM3, FM11 and FM24.

Revision History

Version Number	Content	Revision Date
V1.0A	EN Updated	May, 2024
V1.2A	EN Finalized	April, 2025

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