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LVS Digital
FC610 – Feeder monitoring and control
User Manual

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1 General

1.1 Target Group

The manual is primarily intended for those requiring information on the applications of FC610 for the purpose of understanding, engineering, wiring & operating the product.

It is assumed that the user has a basic knowledge of physical and electrical fundamentals, electrical wiring practices and electrical components.

1.2 Use of Warning, Caution, Information and Tip icon

This publication includes **Warning, Caution**, and **Information** icons where appropriate to point out safety related or other important information. It also includes **Tip** icons to point out useful hints to the reader. The corresponding symbols should be interpreted as follows:

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The caution icon indicates important information or warnings related to the concept discussed in the text. It might indicate the presence of a hazard that could result in *corruption of software or damage to equipment/property*

The information icon alerts the reader to pertinent facts and conditions

The tip icon indicates advice on, for example, how to design your project or how to use a certain function

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1.3 Terminology

List of the terms, acronyms, abbreviations, and definitions that the document uses.

Abbreviation	Term	Description
M10x	Motor controller	An intelligent motor controller for 3-phase AC induction motors combining the two classical functions of motor protection and motor management in a single device plus offering diagnostic and fieldbus communication
LVS	low-voltage switchgear	A factory-built assembly built to conform with IEC 61439-1
LVS Digital		The digital solution based on low-voltage switchgear
CMES		ABB Ability™ Condition Monitoring for electrical systems
MConfig-G		Configuration and parameterization tool for ABB LVS Digital smart devices including FC610
	MODBUS RTU	Fieldbus communication protocol based on serial communication layer
	MODBUS TCP/IP	Fieldbus communication protocol based on Ethernet
	Real time clock	Integrated clock function in devices used to generate time and date information if a remote clock system is not present
	Trip	A consequence of an alarm activated or an external trip command from another device to stop the motor or trip the circuit breaker.
	Alarm	Alarm is defined as status transition from any state to abnormal state. Status transition to abnormal state can be data crossing over the pre-defined alarm limit.
	Event	An event is a status transition from one state to another. It can be defined as alarm, if the state is defined as abnormal or as warning as a pre-alarm state.

Abbreviation	Term	Description
RS485		Communication interface standard from EIA (Electronics Industries Association, USA), operating on voltages between 0V and +5V. RS-485 is more noise resistant than RS-232C, handles data transmission over longer distances, and can drive more receivers.
THD	Total harmonic distortion	It is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.
P		Total active power of all phases
QA		Total reactive power calculated by arithmetic method
QV		Total reactive power calculated by vector method
SA		Total apparent power calculated by arithmetic method
SV		Total apparent power calculated by vector method
Ea		Total active energy
ErA		Total reactive energy arithmetic
EapV		Total apparent energy vector
EapA		Total apparent energy arithmetic
F	Frequency	Value of measured frequencies in an electrical distribution system
I	Phase current	Value of the current flowing in each phase of an electrical distribution system
I_N	Measured neutral current	Value of neutral current of an electrical distribution system
I_{NC}	Calculated neutral current	Value of neutral current of an electrical distribution system by calculate
U	Voltage	Voltage including Upg (line p to line g voltage) and Vp (line p to neutral voltage)
PF_A	Power factor Arithmetic	Under periodic conditions, ratio of the absolute value of the active power to the apparent power

Abbreviation	Term	Description
PF_V	Power factor Vector	Under periodic conditions, ratio of the vector of the active power to the apparent power
U_{dip}	Voltage dip	Temporary reduction of the voltage magnitude at a point in the electrical system below a threshold
U_{swl}	Voltage swell	Temporary increase of the voltage magnitude at a point in the electrical system above a threshold
U_{int}	Voltage interruption	Voltage Interruption including Upg int (phase to ground) and Vp int (Phase to N)
U_{nb}	Unbalanced voltage	Voltage unbalance is a condition in which the three-phase voltages differ in amplitude or are displaced from their normal 120° phase relationship, or both.
Uh	Amplitude of harmonic voltage	The amplitude of harmonic voltage applied by Fourier analysis
THD_u	Total harmonic distortion related to voltage	Total harmonic distortion voltage of all harmonic frequencies over the voltage of fundamental frequency
I_h	Amplitude of harmonic current	The amplitude of harmonic current applied by Fourier analysis
THD_i	Total harmonic distortion related to current	Total harmonic distortion current of all harmonic frequencies over the current of fundamental frequency
TN		One of the points in the generator or transformer is connected with earth, usually the star point in a three-phase system. The body of the electrical device is connected to earth via this earth connection at the transformer.
TT		The protective earth connection for the consumer is provided by a local earth electrode, and there is another independently installed at the generator. There is no 'earth wire' between the two.
IT		The electrical distribution system has no connection to earth at all, or it has only a high impedance connection.
TN-S		PE and N are separate conductors that are connected only near the power source.

1.4 Related Documentation

- 1TNC928247 FC610 Modbus Protocol Implementation
- 1TNC928243 Modbus TCP Converter MS572 User Guide
- 1TGC908020 LVS Digital Data Description FC610
- 1TGC908001 ABB Ability Condition Monitoring for Electrical System-CMES User Manual

1.5 Related System Version

The content of this document is related to FC610 products with the following hardware and firmware version release.

	HW	FW*
FC610	1.0	1.4
MP53	1.0	1.2
MP56	1.0	1.2

*FC610 firmware here refers to the application firmware (FMU).

Until further notice, this document is also applicable for future firmware versions other than those listed above.

The described functions are designed but may not be fully implemented in all details. Please refer to the release notes regarding possible restrictions.

2 Product Information

2.1 Applications

FC610 is a multifunction meter and a network analyzer used in incomer/bus coupler/feeder applications. It provides a scalable set of functions of electrical parameters which includes options for monitoring, control, power quality analysis and energy efficiency evaluations.

FC610 is applicable for TN/TT/IT networks, providing all the measurements for energy management, power quality and issues alarms for unexpected network disturbance.

FC610 is part of ABB LVS Digital smart devices family and fully integrated to LVS Digital platform via Modbus RTU directly or Modbus TCP through MS572, the digital network converter.

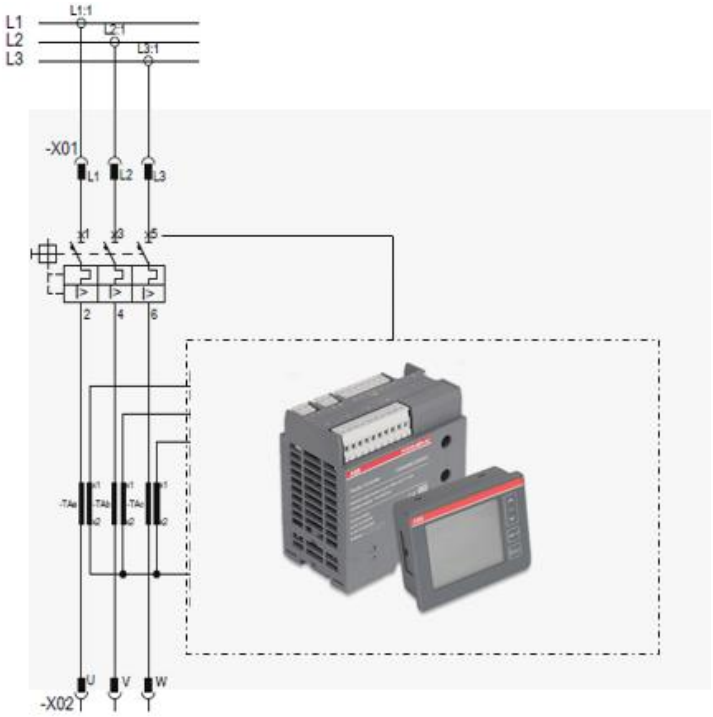


Figure 1: Example of using FC610 in a 3-phase feeder

2.2 Product Description

FC610 is the smart feeder unit designed for ABB low-voltage switchgear digital family. The product consists of two main parts, i.e. FC610 basic unit and the operator panel, also known as the HMI. The separately mounted HMI from the basic unit fits perfectly in the low-voltage switchgear modules, enabling safe operation of feeders in front of closed doors and compartments of the switchboard.

FC610 basic unit supports 3-phase 230/400V voltage measurements with a maximum phase to phase 690Vac direct measurement, applicable in IT/TN/TT networks. The basic unit comes with a built-in current transformer supporting 1A or 5A direct current measurement.

The measured and monitored parameters are displayed via an HMI. Upon the application, a MP53 (compact type) may be selected to fit on a module door of each outgoing feeders while a MP56 (full size) HMI may be selected for an incomer or a feeder fitting in a full size panel. FC610 parameters are configured through HMI panel. Alternatively, the parameter setting software MConfig-G can be used for remote parameterization.

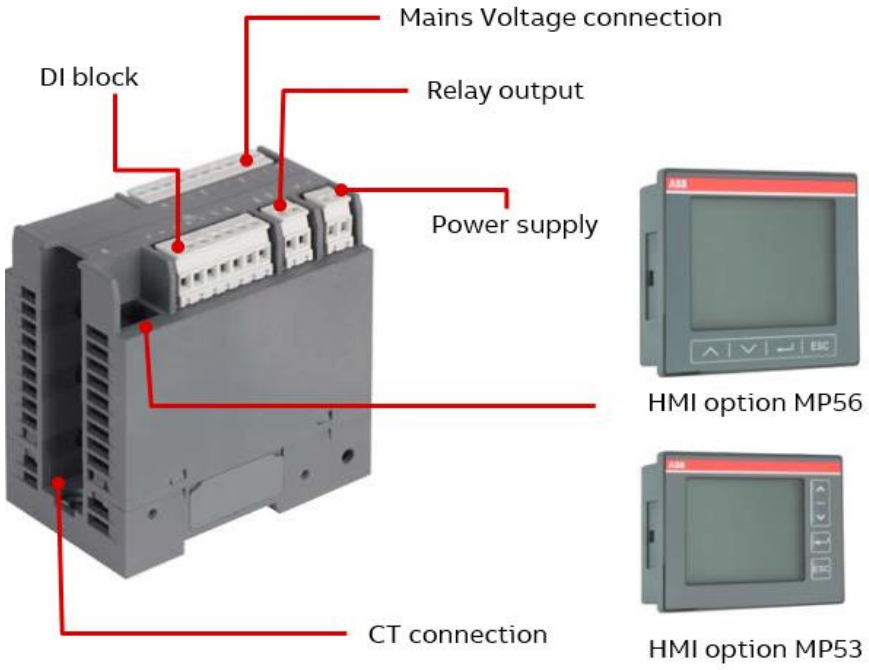


Figure 2: FC610 basic unit with HMI MP56, MP53

2.3 Ordering Types

Depend on selected HMI type, two FC610 product types and order codes are available as follows:

1TNA928612R3001 FC610 with MP53, 110-240Vac supply, Modbus RTU

1TNA928612R6001 FC610 with MP56, 110-240Vac supply, Modbus RTU

2.4 Installation

FC610 basic unit can be easily installed onto standard TS35 DIN-rail. It can also be screw mounted when necessary.

Installation and maintenance must be performed according to the technical rules, codes and relevant standards and carried out by skilled electricians only.

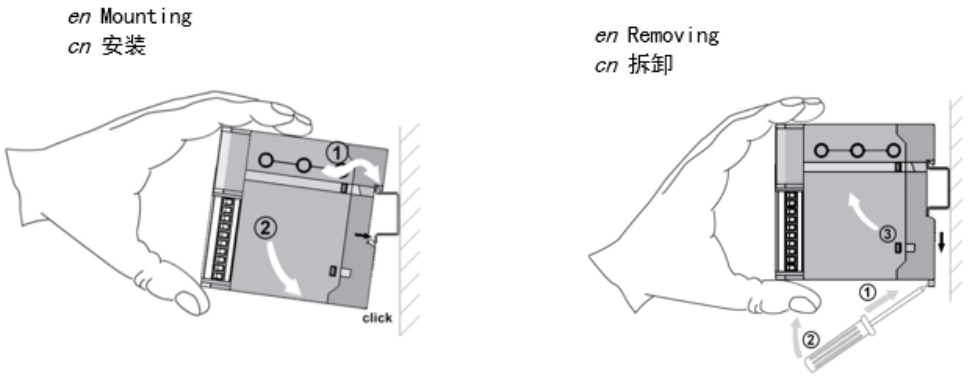


Figure 3: DIN-rail mounting and removing of FC610 basic unit

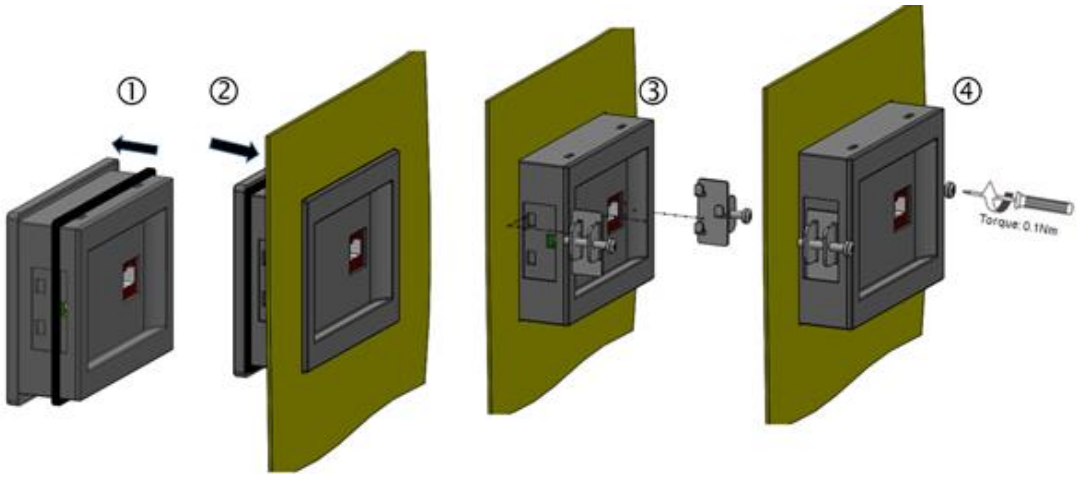


Figure 4: Installation of HMI MP53/56

Installation dimension (W X H X D):

Basic unit	60 mm x 98 mm x 103 mm
HMI unit MP53 (front)	91 mm x 75 mm x 29.3 mm
(cut-out)	84 mm x 68 mm x 29.3 mm
HMI unit MP56 (front)	98 mm x 98 mm x 29.3 mm
(cut-out)	91 mm x 91 mm x 29.3 mm

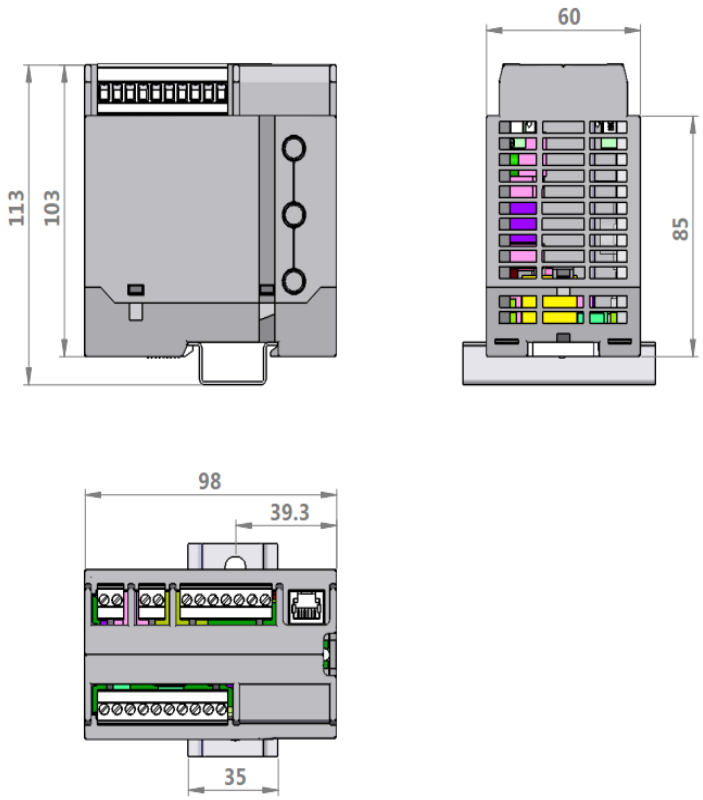
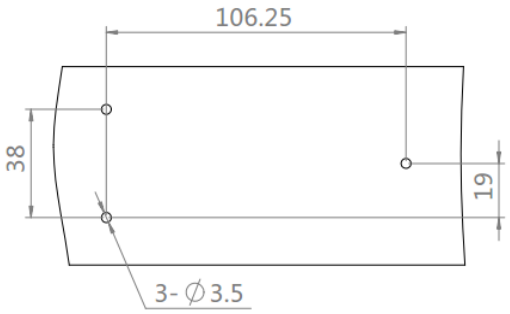


Figure 5: Installation dimension and DIN-rail mounting



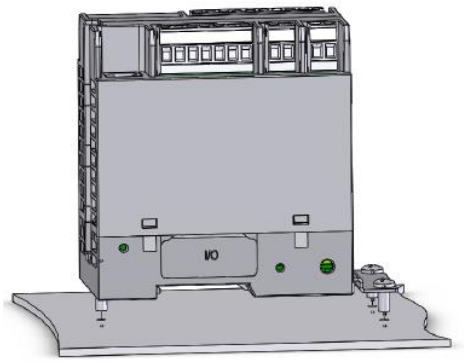


Figure 6: Screw mounting of FC610 basic unit

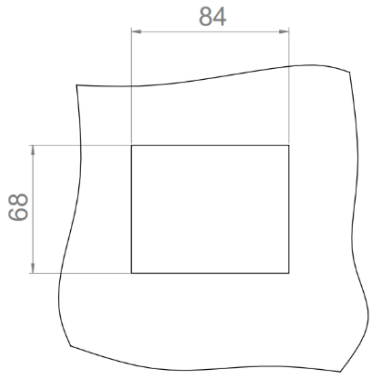


Figure 7: Front panel cut-out dimension of MP53

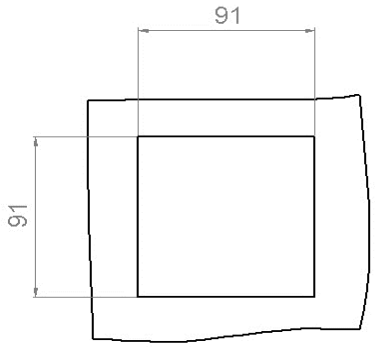


Figure 8: Front panel cut-out dimension of MP56

2.5 Wiring connections

2.5.1 Terminal blocks

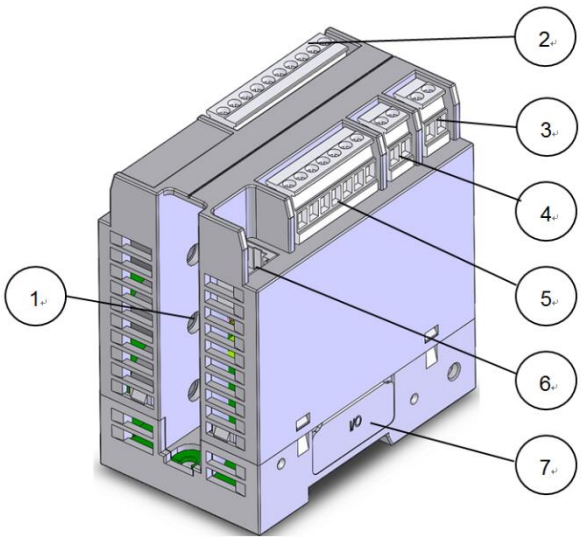


Figure 9: FC610 basic unit terminals description

Number	Block function	Description
1	CT inputs (lead through)	Current input by lead through the CT
2	Voltage input	Voltage supply
3	Auxiliary power supply	Auxiliary power supply
4	Relay output	Output contact, 230 VAC – 1 A
5	Signal terminal	Terminal for digital inputs, RS485 communication and 24 VDC power output
6	MP	Interface for HMI MP53/56
7	Expansion interface	Interface for extension module*

*) The interface to connect possible expansion module is reserved only in this product version.

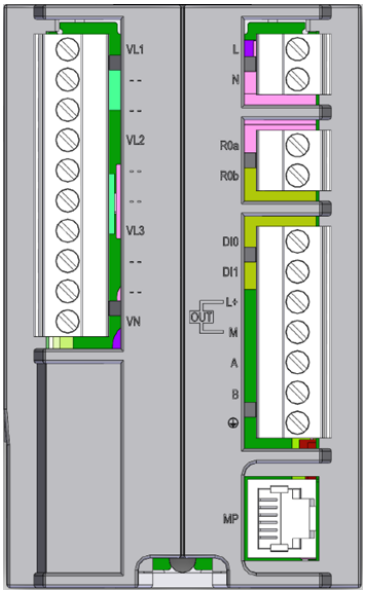


Figure 10: FC610 basic unit top view terminal layout

Terminal name	Function	Description
L, N	Power supply	110-240 VAC
R0a, R0b	Relay output	24 to 110 VDC, 110 to 240 VAC
DI0...DI1	Digital inputs	24 VDC
OUT/L+, OUT/M	DC power output	24 VDC*
A, B, FE	RS485 interface	For Modbus RTU connection; FE shield terminal
VL1, VL2, VL3, VN	Voltage inputs	
L1, L2, L3	Current Measurement	
MP	Interface of MP53/56	RJ12 socket

*) FC610 provides 24 VDC output with a max load of 100 mA @ 240 VAC of power supply or 50 mA @ 110 VAC of power supply.

2.5.2 Wiring connections

FC610 generates a 24 VDC output internally for digital inputs. The maximum load of the internal supply is 100mA@240 VAC input or 50mA @ 110 VAC input of power supply.

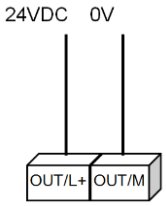


Figure 11: 24 VDC power output

One relay output is available for general fault indication by default. The relay is rated 2A@240VAC AC-15. Please refer to “Appendix A Technical data” for more details.

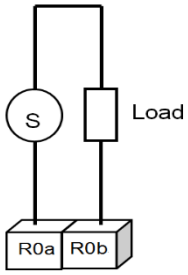


Figure 12: Relay output connection

The R0 relay output is pre-configured as ‘common warning’ function.

There are two sets of digital inputs available and pre-configured as main switching device status (DI0) and fault (DI1) indication with ‘NO’ input characteristics.

The digital inputs can be supplied directly from internal 24 VDC power output.

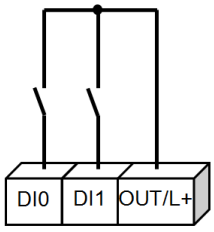
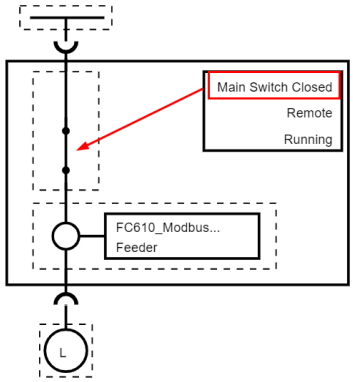


Figure 13: DIs supplied by internal 24 VDC

For LVS Digital feeder applications FC610 is typically used to indicate the status and the common fault of the main switching device in addition to the measurement values.

To ensure a correct indication of the status in the single line representations of e.g. CMES condition monitoring system it is mandatory to connect these signals to the FC610 DI0/DI1 as described before!



When the digital inputs are powered by external supply, OUT/M terminal must be connected as follows.

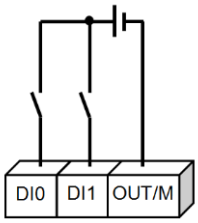


Figure 14: DIs supplied by external 24 VDC

1) The common terminal of digital inputs is internally connected with the negative terminal of the power output.

2) Each digital input consumes approximately 15 mA.

FC610 supports Modbus RTU directly via a RS485 interface. The connection is as follows,

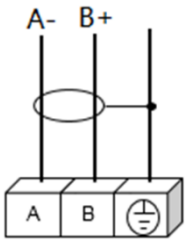


Figure 15: RS485 connection

Please refer to document “1TNC928247 FC610 Modbus Protocol Implementation” for communication related information.

Voltage measurement of FC610 is through the voltage input connections. The maximum direct input system voltage is 690 VAC (phase to phase) with 15 % fluctuation. External PT should be used for higher voltage measurement. 0.5 A fuse protection is recommended for the voltage input connections.

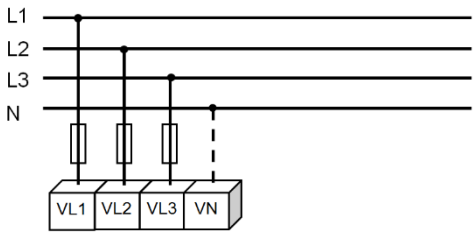


Figure 16: Voltage measurement direct connection

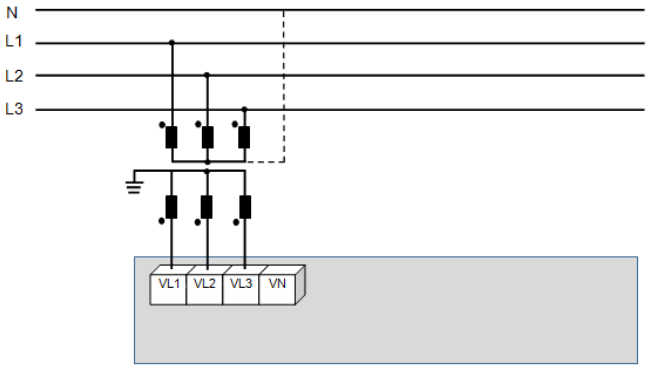


Figure 17: Voltage measurement connection via PT

Current measurement of FC610 is via a built-in 3-phase CT which is rated at 1 A or 5 A selectable through configuration. An external CT with a secondary rated 1 A or 5 A which is wired through FC610 CT inputs, is usually required in an application.

1) Always check the phase of the measured voltage and current to ensure the matching phase sequence and avoid error reading.
2) The current measurement accuracy also depends on the accuracy of selected external CTs.

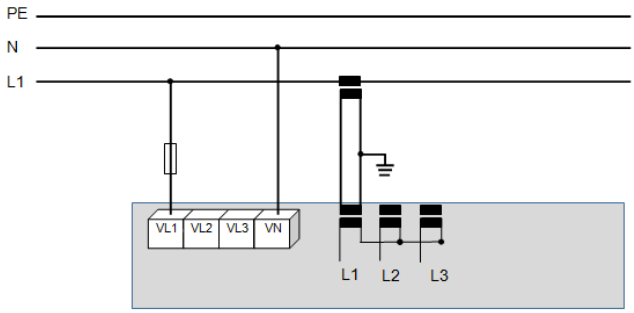


Figure 18: Current measurement single phase connection

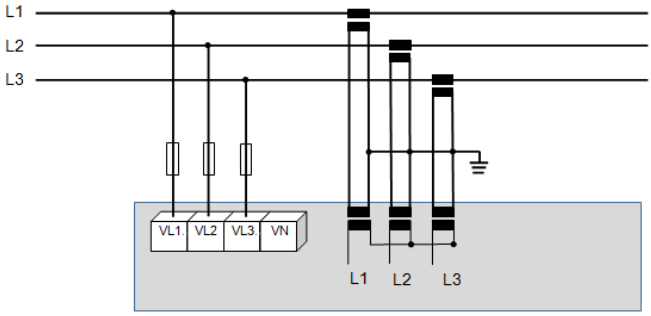


Figure 19: Current measurement 3phase, IT network connection

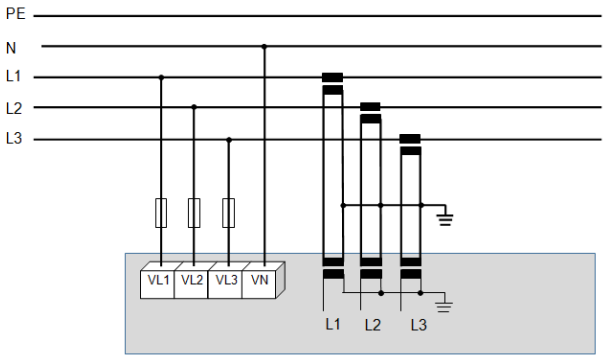


Figure 20: Current measurement 3phase+N, TN/TT network connection

3 Product Functions

From real-time electrical measurement, energy analysis, power quality monitoring to diagnostic and data logging features, FC610 provides a complete set of measurement and monitoring data for the plant operators. With the connectivity to the communication network and the leverage of ABB Ability™ CMES Condition Monitoring, it assists the plant operator further to set up energy management and asset management strategies.

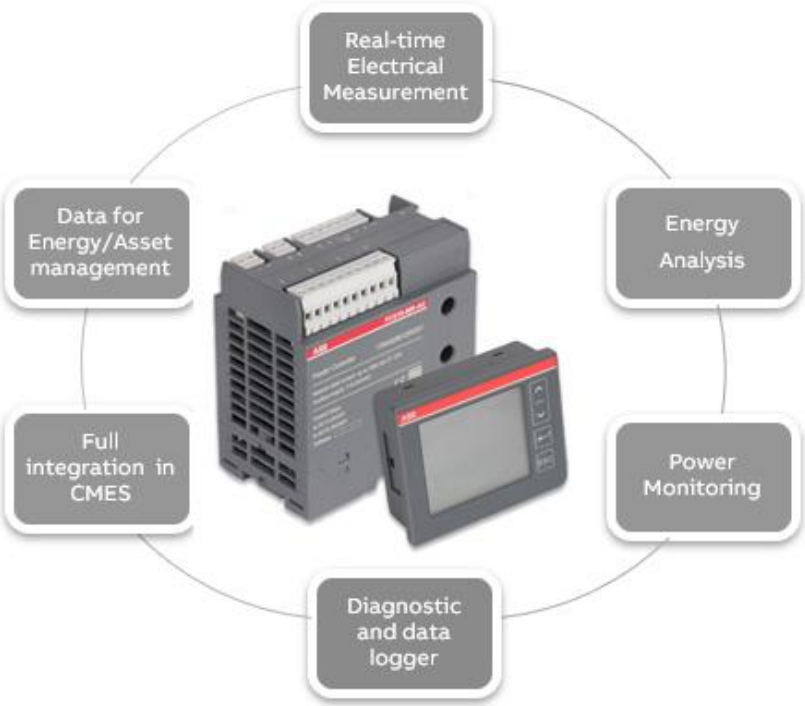


Figure 21: FC610 product features

3.1 Measurements

Description	Range	Accuracy (accord. to IEC 61557-12)
Voltage U1	30 to 400 VAC ph/n	0.2
Voltage U2	30 to 400 VAC ph/n	0.2
Voltage U3	30 to 400 VAC ph/n	0.2
Voltage U12	50 to 690 VAC ph/ph	0.2
Voltage U23	50 to 690 VAC ph/ph	0.2
Voltage U31	50 to 690 VAC ph/ph	0.2
Current I1	5 % to 120 % In	0.2
Current I2	5 % to 120 % In	0.2
Current I3	5 % to 120 % In	0.2
Current Neutral I_N	5 % to 120 % In	1
Current Unbalance I_{unb}	%	na
Voltage Unbalance u_{unb}	%	na
Power factor PF	0.5 ind to 0.8 cap	0.5
Frequency F	45 to 65 Hz	0.1
Active power L1- P1	2 % to 120 % In	0.5
Active power L2-P2	2 % to 120 % In	0.5
Active power L3-P3	2 % to 120 % In	0.5
Total active power P	2 % to 120 % In	0.5
Reactive power L1-Q1	2 % to 120 % In	0.5
Reactive power L2-Q2	2 % to 120 % In	0.5
Reactive power L3-Q3	2 % to 120 % In	0.5
Total reactive power Q	2 % to 120 % In	0.5
Apparent power L1-S1	2 % to 120 % In	1
Apparent power L2-S2	2 % to 120 % In	1
Apparent power L3-S3	2 % to 120 % In	1
Total apparent power S	2 % to 120 % In	1

* All listed values above are displayed through HMI MP53/MP56 and accessible via communication.

3.2 Energy analysis

3.2.1 Energy

Description	Range	Accuracy (accord. to IEC 61557-12)
Active energy import Ea +	0 to 99999999 kWh	0.5
Active energy export Ea -	0 to 99999999 kWh	0.5
Reactive energy import ErV +	0 to 99999999 kvarh	2
Reactive energy export ErV -	0 to 99999999 kvarh	2
Apparent energy EapA	0 to 99999999 kVAh	1

The type of load can be represented geometrically by four quadrants.

In the first quadrant the load is inductive. Both active and reactive energy are imported, i.e. energy is imported from the utility to the consumer load.

In the second quadrant the load is capacitive in which active energy is exported and reactive energy is imported.

In the third quadrant the load is inductive. Both active and reactive energy are exported to the network.

In the last quadrant the load is capacitive in which active energy is imported while reactive energy is exported.

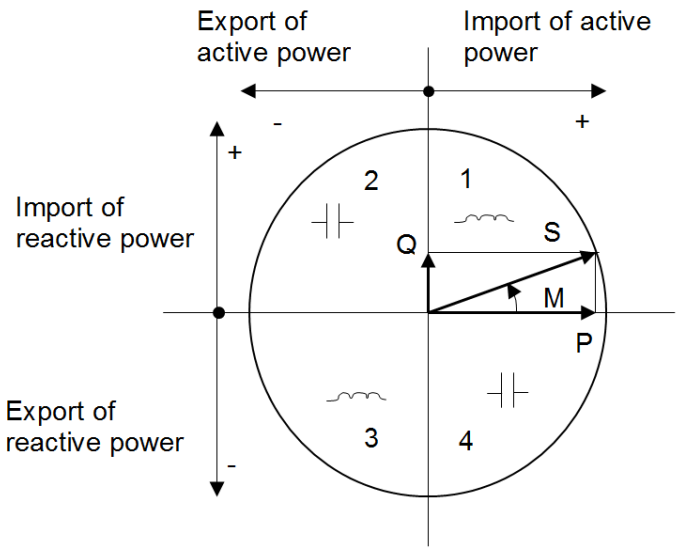


Figure 22: Four-quadrant representation of active and reactive power and energy

3.2.2 Maximum and average demand values

In addition to the measured values listed above, FC610 provides demand values to assist the operator to carry out energy consumption analysis and achieve increase in energy efficiency.

Demand value is the time-integrated value of the measured values. It is the average value calculated over the demand integration time.

The demand integration time in FC610 are selectable from 2 s, 10 s, 5 min, 8 min, 10 min, 15 min, 20 min, 30 min and 60 mins. The integration time is calculated by the sliding method. The sliding time interval is 1 second when the integration time is selected as 2 or 10 seconds. When the integration time is 5,8,10,20,30, 60 minutes, the sliding time interval is 1 minute.

For example, when 2s integration time is selected, the measured values are integrated for a 2 second time window. The sliding time interval is 1 second which means that the demand value is calculated and updated every second.

Similarly, when 10min integration time is selected, the demand value is calculated for a 10mins period time window. The sliding time interval is 1minute which means that the demand value is calculated and updated every minute.

Maximum demand value is the maximum average value since FC610 is powered up or last reset. The maximum demand value is resettable through fieldbus only.

Maximum demand values	**Demand values**
Max average neutral current	Ave neutral current
Max average current L1	Ave current L1
Max average current L2[1]	Ave current L2
Max average current L3	Ave current L3
Max average voltage L1	Ave voltage L1
Max average voltage L2	Ave voltage L2
Max average voltage L3	Ave voltage L3
Max average voltage U12	Ave voltage U12
Max average voltage U23	Ave voltage U23
Max average voltage U31	Ave voltage U31
Max average active power	Ave active power
Max average reactive power	Ave reactive power
	Ave apparent power

3.3 Power quality

3.3.1 Harmonics measurement

Harmonics refers to the amount of electricity contained in the current that is an integral multiple of the fundamental (i.e., 50 Hz or 60 Hz). FC610 measures total harmonic distortions as well as individual harmonics up to 31st harmonic.

Total Harmonics	Individual Harmonic
THD of current L1	Harmonic I1 3rd to 31st
THD of current L2	Harmonic I2 3rd to 31st
THD of current L3	Harmonic I3 3rd to 31st
THD of voltage L1	Harmonic U1 3rd to 31st
THD of voltage L2	Harmonic U2 3rd to 31st
THD of voltage L3	Harmonic U3 3rd to 31st
THD of voltage U12	Harmonic U12 3rd to 31st
THD of voltage U23	Harmonic U23 3rd to 31st
THD of voltage U31	Harmonic U31 3rd to 31st

3.3.2 Current unbalance supervision

FC610 monitors unbalanced current and current unbalanced condition.

Unbalanced current is presented as a percentage value following below calculation and displayed directly through HMI.

$$\mathrm{I}_{nba} = \frac{\max\{|I_1 - I_{avg}|, |I_2 - I_{avg}|, |I_3 - I_{avg}|\}}{I_{avg}}$$

where

$$\mathrm{I}_{avg} = \frac{I_1 + I_2 + I_3}{3}$$

The current unbalance threshold and hysteresis is a percentage value. A current unbalance event is detected when current unbalance value I_{nba} is above the threshold. The event ends when the I_{nba} is equal to or below the value of the threshold minus the hysteresis.

Current unbalance supervision settings	
Value range	0=Disable 1=Enable
Default value	0
Threshold	
Value range	50-90 %
Defaults value	50 %
Step value	1 %
Hysteresis	
Value range	0-10 %
Default value	2 %
Step value	1 %

3.3.3 Voltage unbalance supervision

FC610 monitors unbalanced voltage and voltage unbalanced condition.

Unbalanced voltage is presented as a percentage value following below calculation and displayed directly through HMI.

$$\mathrm{U}_{nba} = \frac{\max\{|U_{12} - U_{avg}|, |U_{23} - U_{avg}|, |U_{31} - U_{avg}|\}}{U_{avg}}$$

Where

$$\mathrm{U}_{avg} = \frac{U_{12} + U_{23} + U_{31}}{3}$$

The voltage unbalance threshold and hysteresis are both presented as percentage value. A voltage unbalance event is detected when voltage unbalance value U_{nba} is above the threshold. The event ends when the U_{nba} is equal to or below the threshold minus the hysteresis.

Voltage unbalance supervision settings	
Value range	0=Disable 1=Enable
Default value	0
Threshold	
Value range	50-90 %
Default value	50 %
Step value	1 %
Hysteresis	
Value range	0-10 %
Default value	2 %
Step value	1 %

3.3.4 Voltage dip supervision

Voltage dip is the condition of voltage dropping temporarily under the threshold level due to an unexpected electrical system network disturbance. The dip threshold and hysteresis voltage settings are a percentage of the system rated voltage Un.

In single-phase system, when U_{dip} falls below the threshold, an alarm is triggered; when U_{dip} is equal to or above the dip threshold plus the hysteresis, the alarm is reset.

In three-phase system, when U_{dip} of any phase falls below the threshold, an alarm is triggered. The alarm is reset when the U_{dip} of three-phase are recovered to or above the threshold plus the hysteresis value.

Voltage dip supervision settings	
Value range	0=Disable 1=Enable
Default value	0
Threshold	
Value range	5-100 %
Default value	10 %
Step value	1 %
Hysteresis	
Value range	0-10 %
Default value	2 %
Step value	1 %

Do not set the voltage dip threshold below the lowest measurable limit. i.e. minimum 29 VAC (Phase to N) or 50 VAC (Phase to Phase).
For example, in a 240 VAC single phase system, the minimum setting should not be lower than 12 % (29 VAC/240 VAC). While in a 400 VAC 3-phase system, the minimum setting should not be lower than 13 % (50 VAC/400 VAC).

3.3.5 Voltage swell supervision

Voltage swell is the condition when the voltage in the electrical system temporarily increase above a threshold.
The swell threshold and hysteresis voltage settings are a percentage of the system rated voltage Un.

In single-phase system, when U_{swl} rise above the threshold, an alarm is triggered; when U_{swl} returns to or below the swell threshold minus the hysteresis, the alarm is reset.

In three-phase system, when U_{swl} of any phase rise above the threshold, an alarm is triggered; The alarm is reset when U_{swl} of three-phase is returned to or below the threshold minus the hysteresis value.

Voltage swell supervision settings	
Value range	0=Disable 1=Enable
Default value	0
Threshold	
Value range	5-20 %
Default value	10 %
Step value	1 %
Hysteresis	
Value range	0-10 %
Default value	2 %
Step value	1 %

3.3.6 Voltage interruption supervision

Voltage interruption is a special case of voltage dip. It provides a second level setting in addition to voltage dip supervision to assist the operator in network analysis.

The interruption threshold and hysteresis voltage settings are a percentage of the system rated voltage Un.

In single-phase system, when U_{int} falls below the threshold, an alarm is triggered; when U_{int} is equal to or above the dip threshold plus the hysteresis, the alarm is reset.

In three-phase system, when U_{int} of any phase falls below the threshold, an alarm is triggered; The alarm is reset when U_{int} of three-phase are recovered to or above the threshold plus the hysteresis value, the alarm is reset.

Voltage interruption supervision settings	
Value range	0=Disable 1=Enable
Default value	0
Threshold	
Value range	95-100 %
Default value	95 %
Step value	1 %
Hysteresis	
Value range	0-10 %
Default value	2 %
Step value	1 %

3.4 Load supervision

3.4.1 Over current supervision

FC610 monitors over current condition of the connected load by issuing an alarm message.

The over current function in FC610 is designed for supervision purpose only and should not be used to replace any over current protection device.

The over current threshold and hysteresis settings are a percentage value of the I_n. An over current event is detected when any of the measured phase current is above the threshold. An alarm is triggered.
The alarm is cleared when the phase current returns to or below the value of threshold setting minus the hysteresis.
Example.
The threshold is set as 110 % with the hysteresis 10 %.
An over current alarm is triggered in FC610 when phase A current rise to/above 110 % I_n. When phase A current returns below 110 %, the alarm continues. Only when current phase A drops below 100 %, i.e. 110 % (threshold) minus 10 % (hysteresis), the alarm is reset.

Over current supervision settings	
Value range	0=Disable 1=Enable
Default value	0
Threshold	
Value range	100-120 %
Default value	110 %
Step value	1 %
Hysteresis	
Value range	0-10 %
Default value	2 %
Step value	1 %

3.4.2 Phase sequence supervision

FC610 monitors phase sequence of the voltage or current to prevent loss due to wiring errors of the connected load. Before FC610 detects the current, the phase sequence protection is based on voltage. When FC610 detects the current, the phase sequence protection is based on current.
The correct phase sequence for this protection function is specified as follows:

- Voltage: L1，L2，L3
- Current: Ia，Ib，Ic

If this function is enabled, an alarm will be issued when the voltage or current phase sequence detected by FC610 does not match the above specifications.

Function enable/disable	
Value range	0=Disable 1=Enable
Default value	0

3.4.3 Status and condition monitoring

FC610 provides status monitoring of the connected devices through digital IOs in addition to electrical measurements.

FC610 also provide condition data of the connected load and switching device for service and maintenance purpose.

All condition data including alarm and trip messages are displayed on local HMI MP53/56 directly and accessible via the communication interface.

Main switch status monitoring	
Main switch status (ON/OFF)*	√
Main switch fault*	√
Main switch condition monitoring	
Main switch operation counter*	√
Main switch fault counter*	√
Load condition monitoring	
Running time	√
Stopped time	√
Last alarm	√
Last trip	√
Last operation	√
Other condition monitoring	
FC610 parameters change counter	√
Feeder module insertion cycles	√

*Main switch status (ON/OFF) is monitored through ‘feedback’ function.

There are two options available in feedback, i.e. “current feedback” and “main switch feedback” (via DI). When “current feedback” option is selected, main switch status is monitored through current measurement. i.e. main switch status will be indicated as ‘ON’ when a current is measured. Similarly, when “main switch feedback” option is selected, main switch status will be only updated through monitoring the DI0 which is pre-configured as main switch function.

Main switch fault is monitored via DI1 which is pre-configured as main switch function.

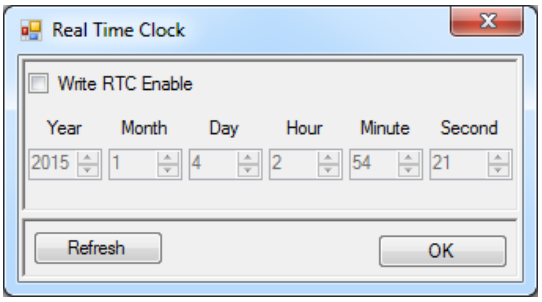
Feedback delay time is fixed as 100ms.

3.5 Data recording and logs

Data recording and logs in FC610	
Single last alarm with time stamp	√
Single last operation with time stamp	√
Sequence of events (SOE)up to 256 events	√
Load curves	√
Event curves	√
Real-time clock (RTC)	√
Time synchronization	√

Real-time clock (RTC)
FC610 keeps an internal real-time clock to record alarms, operations, events with time stamps. The RTC operates to a timing accuracy of 10ms.

The setting of the internal clock may be manually from the front HMI panel or via dedicated configuration software MConfig-G with the setting accuracy to 1 second.



For higher timing accuracy, the RTC setting is expected from fieldbus, e.g. through Modbus RTU. A time setting to an accuracy of 10ms may be broadcasted to FC610 from a Modbus main station. More details of writing RTC from Modbus network are available in separate document '1TNC928247 FC610 Modbus Protocol Implementation'.

When FC610 is used with a MS572, the digital converter, in a Modbus TCP network (fig25), it is also possible to synchronize time from external SNTP server to MS572 before further broadcasting to FC610.

SOE
Other than recording single alarm, trip and operation, FC610 records up to 256 events with time stamp.

Event curve

FC610 records events triggered by voltage dip, voltage swell, Interruption, over current through event curves. Current and voltages curves including I1, I2, I3, U1, U2, U3, U12, U23, and U31 of each triggered event are recorded in FC610. Only the last 10 records are saved in FC610 for each event type.

Each event curve is recorded from event pre-trigger point until event recovery stage through 120 samples or 240 samples. The sampling frequency is every half cycle. For example, in a 50Hz system, the sampling frequency is every 10ms.

When an event, from detection to recovery, completes within 120 samples time, the event will still be recorded with 120 samples (Figure 23). If an event is longer than 120 samples time, the event will be recorded through 240 samples instead, with 120 samples recorded during event detected period and the other 120 samples during event recovery period. (Figure 24)

The pre-trigger point of an event is configurable from 30% -70% of the sampling range before the event is detected. For example, if 30% is configured as pre-trigger level in a 50Hz system, 36 samples are recorded before the event is triggered while 84 samples are recorded after the event is detected. Similarly, another 36 samples are recorded before the event is recovered and 84 samples after recovery.

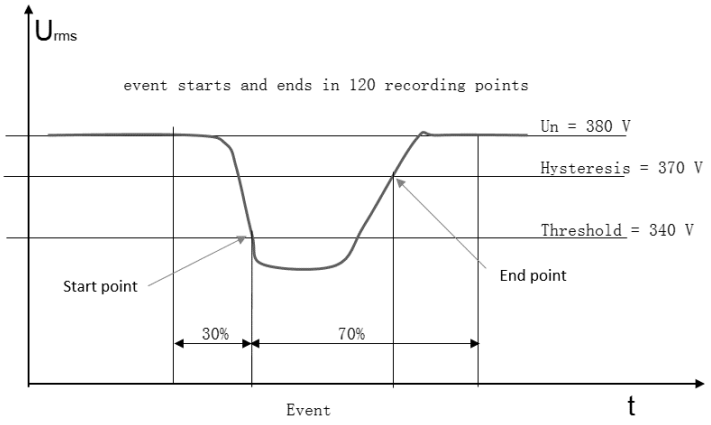


Figure 23: Example of voltage dip curve U1- the event completes within 120 samples time

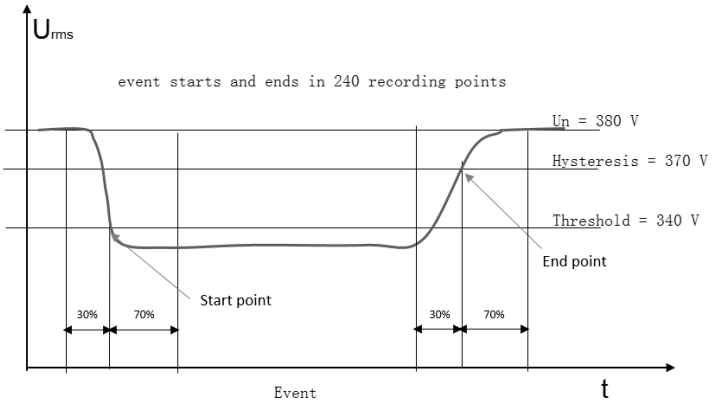


Figure 24: Example of voltage dip curve U1 - the event longer than 120 samples time

Event curves and load curves are only accessible and displayed via configuration software MConfig-G. They are not accessible by upper system via communication network.

Load curve

FC610 records load profile curves for P1, P2, P3, Q1, Q2, Q3, S1, S2, S3 and P, Q, S, PF for a fixed period.

FC610 logs power related values every 10 minutes and offers latest 60 days' record through MConfig-G software.

Event curves and load curves are only accessible and displayed via configuration software MConfig-G. They are not accessible by upper system via communication network.

3.6 Connectivity

FC610 supports Modbus RTU protocol. The communication speed is up to 115.2 kbps. Parameterization and monitoring can be done via the integrated RS485 port.
To integrate FC610 into a Modbus TCP network the generic ABB Modbus RTU/TCP converter MS572 can be used.

FC610 is fully integrated to ABB LVS Digital network via Modbus RTU as well as Modbus TCP.

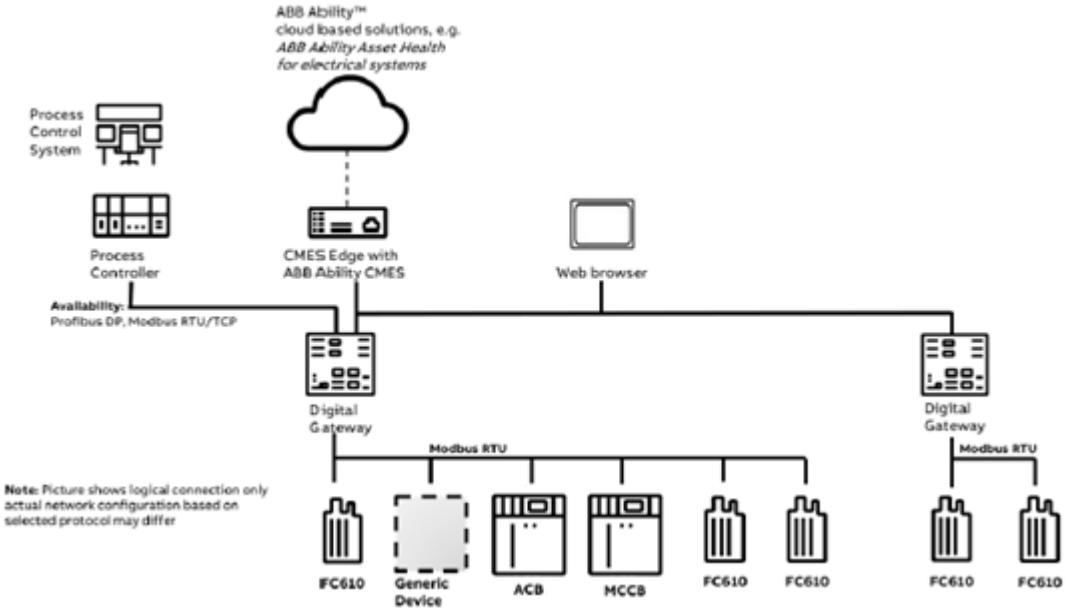


Figure 25: Example for LVS Digital integration with FC610 via Modbus RTU

Figure 26: Example for LVS Digital integration with FC610 via Modbus TCP (MS572)

4 HMI MP53/MP56

FC610 provides HMI panel MP53/56 for local monitoring, operation and configuration.

MP53 is designed to be fit to the compact module front door of ABB LVS switchgear. MP56 provides a bigger LCD screen with a better visual option.

There is no functional difference between MP53 and MP56.

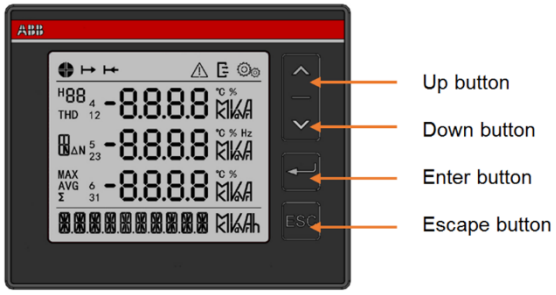


Figure 27: MP53 Operator Panel

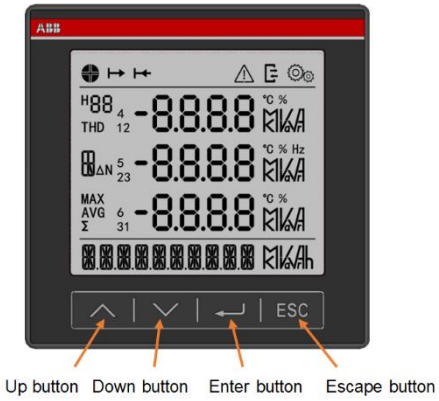


Figure 28: MP56 Operator Panel

4.1 Navigation Buttons

Button	Function
	Enter button, to enter selected menu
	Down button, to show next messages or menus or changing the data. Long press the button (>1s) changes the main group page under display state or changes the parameter under configuration state
	Up button, to show previous messages or menus or changing the data. Long press the button (>1s) changes the main group page under display state or changes the parameter under configuration state
	Escape button, to exit selected menu or go back to last step.

4.2 Notification icons

Icon	Description
	Indication of 1st,2nd ,3rd ,4th quadrant
	Energy Import, Energy Export
	Alarm is active
	MP Communication active
	Parameter configuration in progress

4.3 Main display pages

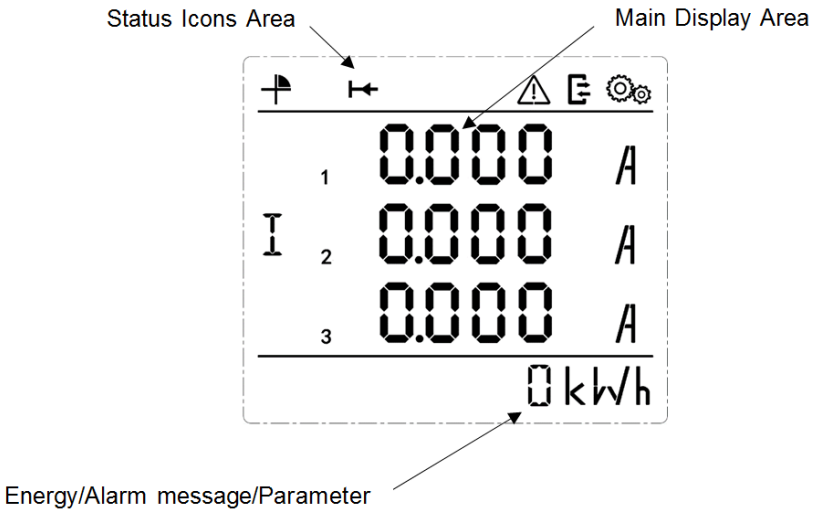


Figure 29: Main display page

4.3.1 Navigate through display groups

Parameters are grouped into 9 main display groups for easy navigation. Long pressing the scroll button up or down changes the display group.

The display of which parameter groups are customizable in HMI panel. How to select the parameter groups to display is explained in configuration section.

No	Display group	The first page of each group
1	Current	I (A)
2	Voltage and frequency	U Phase (V)
3	P,Q,S,PF and energy	P1, P2, P3 (KW)
4	MAX and AVG value	I MAX (A)
5	Harmonic current	THD I (%)
6	Harmonic voltage	THD U Phase (%)
7	Reserved	Reserved
8	Device status	Main switch status
9	Maintenance	Run time/stop time/insert times/parameters changed times

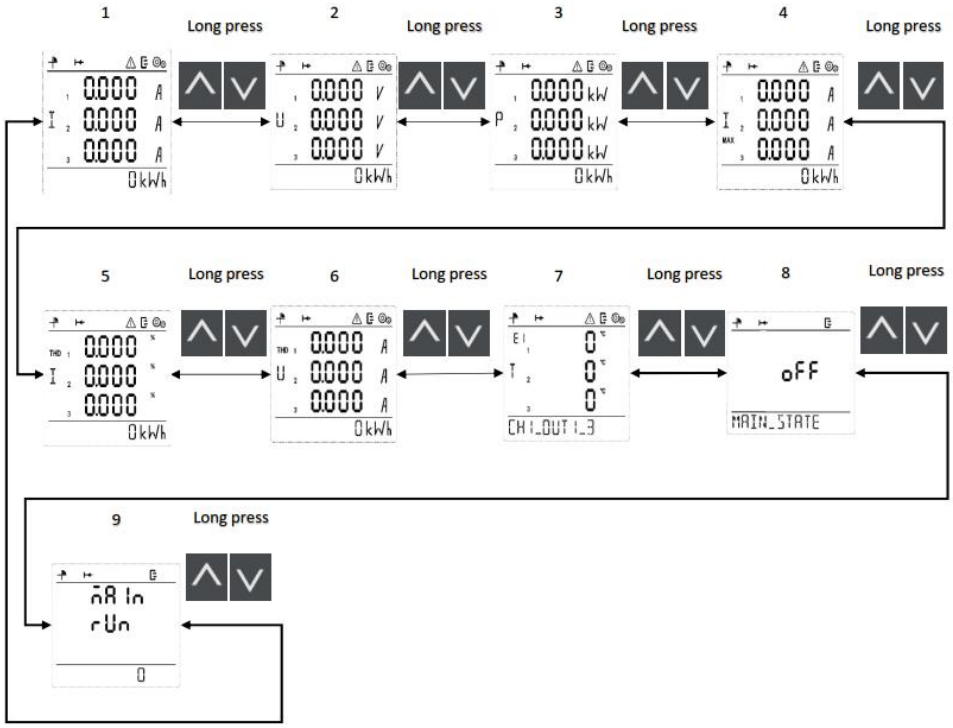


Figure 30: Navigate through display groups

4.3.2 Navigate through each display page

Under each display group, parameters are displayed in separate pages. Short press the scroll buttons to navigate through each display page.

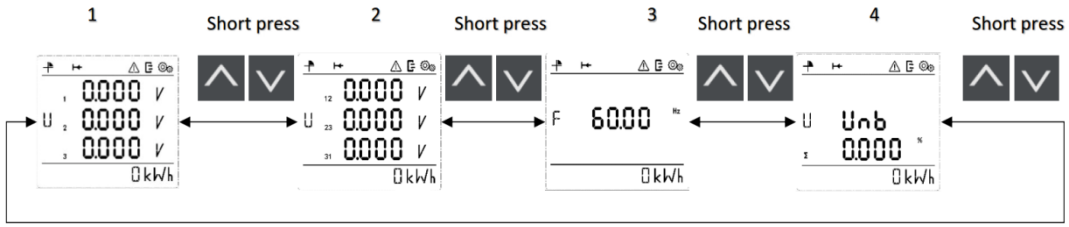


Figure 31: Navigate through display pages under each group

Display group	Page no.	Description
Current	1	I (A)
	2	I (%) = I/In*100%
	3	$I_{\Delta N}$- Earth Fault Current (A)
	4	Current unbalance (%)
Voltage and frequency*	1	U Phase (V)
	2	U Line (V)
	3	Frequency (Hz)
	4	U unbalance (%)
P,Q,S,PF and energy*	1	P1, P2, P3 (KW)
	2	Q1, Q2, Q3 (Kvar)
	3	S1, S2, S3 (KVA)
	4	P_{Σ}(KW)
	5	Q_{Σ} (Kvar)
	6	S_{Σ} (KVA)
	7	PF
	8	Energy used (kWh)—It is displayed in the last line

MAX and AVG value	1	Max current I_{Ave} (A)
	2	Max current I_{Ave} (%) =Max I_{Ave} /In*100 %
	3	Max Earth Fault Current $I_{Ave\Delta N}$ (A)
	4	Max phase voltage U_{Ave} (V)
	5	Max line voltage U_{Ave} (V)
	6	Max Frequency F_{Ave}(Hz)
	7	Max P_{Ave}(KW)
	8	Max Q_{Ave} (Kvar)
	9	Max S_{Ave} (KVA)
	10	Average current I_{Ave} (A)
	11	Average current I_{Ave} (%) = Ave.I/In*100 %
	12	Average Earth Fault Current $I_{Ave\Delta N}$ (A)
	13	Average phase voltage U_{Ave} (V)
	14	Average line voltage U_{Ave} (V)
	15	Average Frequency F_{Ave} (Hz)
	16	Average P_{Ave} (KW)
	17	Average Q_{Ave} (Kvar)
	18	Average S_{Ave} (KVA)
Harmonic of current*	1	THD I (%)
	2-32	H3-H31 I1 (%)
		H3-H31 I2 (%)
		H3-H31 I3 (%)
Harmonic of voltage*	1	THD U Phase (%)
	2	THD U Line (%)
	3-33	H3-H31 U1 (%)
		H3-H31 U2 (%)
		H3-H31 U3 (%)
	34-64	H3-H31 U12 (%)
		H3-H31 U23 (%)
		H3-H31 U31 (%)

Device status	1	Main switch status off/on/fault
	2	Digital input 1 status: on/off Digital input 2 status: on/off
Maintenance*	1	Run time
	2	Stop time
	3	Insert times
	4	parameters changed times

4.3.3 Alarm messages

Alarm message is displayed on the bottom of the display page with an alarm indication icon whenever there is an active alarm active.

Alarm message	Alarm description	Alarm condition
OVER_I	Over current	Current reach the preset threshold level.
DIPS_U	Voltage dips	Voltage reach the preset threshold level.
SWELL_U	Voltage swell	Voltage reach the preset threshold level.
INTERRUPT	Voltage interruption	Voltage reach the preset threshold level.
I_UNB	Current unbalance	Current unbalance value reaches the preset threshold level.
U_UNB	Voltage unbalance	Voltage unbalance value reaches the preset threshold level.
RUN_TIME	Running Time	Running time reaches the preset threshold level.
INSERTION	Insertion cycles	Insertion cycles reaches the preset threshold level.
P_SEQUENCE	Phase Sequence	Phase sequence of current or voltage is wrong.
IO_BUS_COM	IO bus Communication	Communication failed between Basic Unit and external module
WATHDOG	FMU Watchdog	Hardware or software watchdog
	Serial communication	RS485 communication failed
Protection bypass	Protection bypass	Protection bypass is active

Table 1 Alarm messages and description

More detail alarm information, please refer to 1TNC928247 FC610 Modbus Protocol Implementation.

4.4 Configuration pages

Parameters are configurable through HMI panel.

Long press ESC button to go into configuration menu. A password is required before the configuration can be activated.

Factory default password is 1111. For security reason, please change the password after the first log in.

4.4.1 FC610 device setting

This is the setting related to FC610 device which includes:

- Communication parameters (baud rate, slave address etc.)
- Display panel (LCD setting and password)
- Real-time clock (RTC) time setting

Level 1	Level 2	Level 3	Value range
PArA (PARA: Parameters)	Conn (Conn: Communication setting)	bAUd (bAUd: Modbus Baud Rate)	1200,2400, 4800,9600, 19200,38400, 57600,115200
		PAr I (PArI: Parity Check)	None,ODD,EVEN
		CFd (CFd: Communication Failure Delay)	1-25 or 255
		Addr (Addr: Device Address)	1-127
oPt (OPT: Display Panel)	CodE (CODE: Password Setup)	The old password	0000-9999
		NEW (NEW: Input the new code the first time)	0000-9999
		AGAIN (AGAIN: Input the new code the second time)	0000-9999
	LCd (CODE: LCD Setting)	CURRENT (Current display group)	ON/OFF
		U_F (Voltage and F display group)	
		(3-9 display group)	
tSEt (TSET: Time Setting)	rtC (RTC: RTC TIME)	NEW (NEW: Input the new code the first time)	0000-9999
		AGAIN (AGAIN: Input the new code the second time)	0000-9999
		dATE (dATE)	1-31
		HOUR (HOUR)	0-23
		MINUTE (MINUTE)	0-59
		SECONd (SECONd)	0-59

An example is given below to change password from 1111 to 0000.

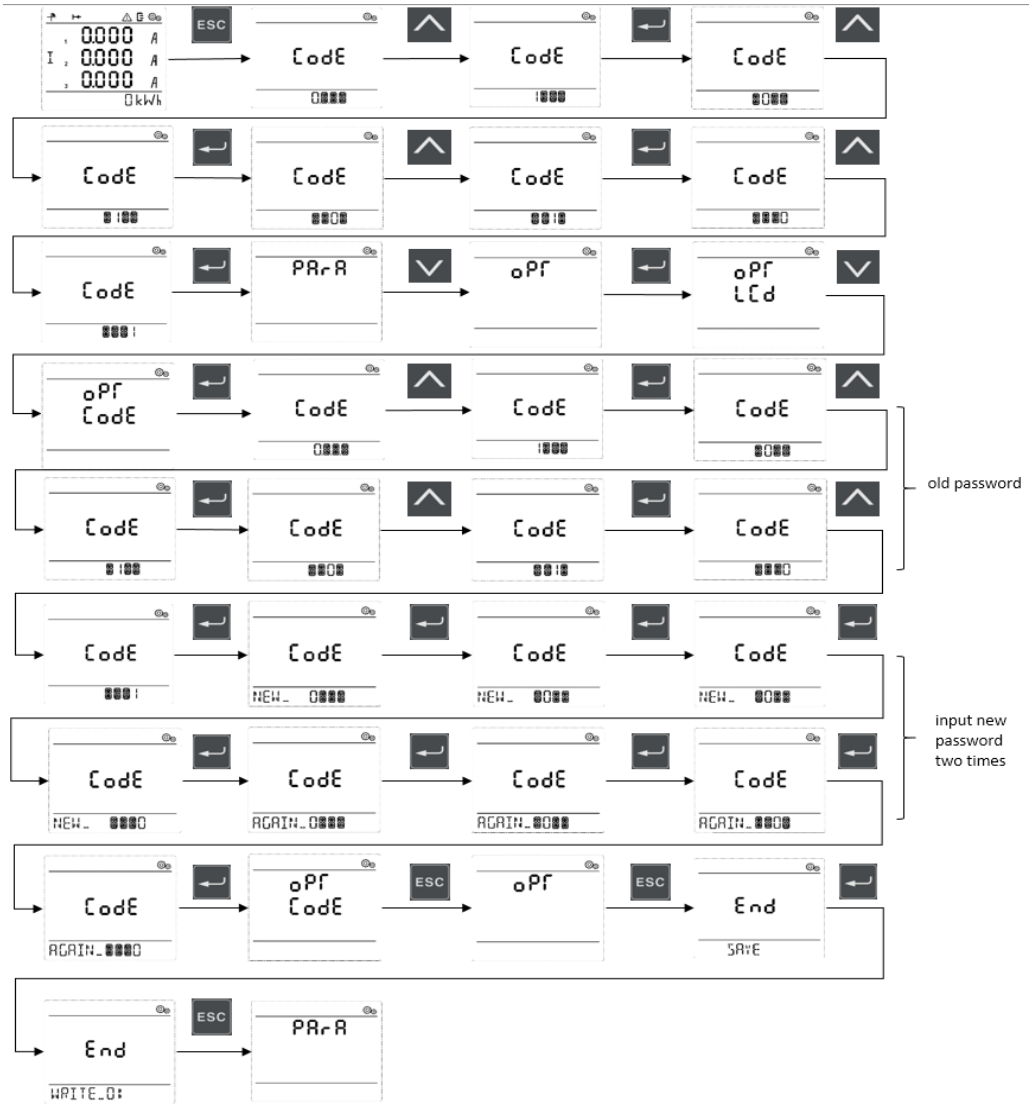


Figure 32: How to change default password

The example below shows how to turn on/off the display groups of parameters :

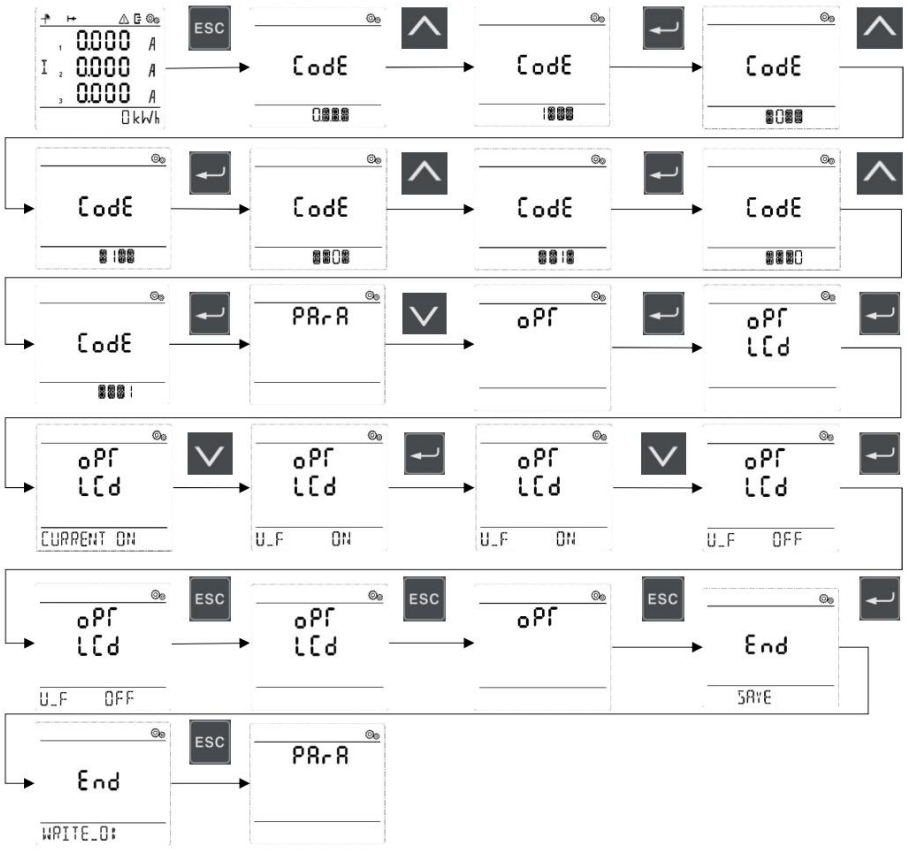


Figure 33: Turn off the voltage, frequency display group

4.4.2 Feeder information setting

This is the fundamental information of the feeder which include,

- Feeder control
- Feeder Information

Level 1	Level 2	Level 3	Value range
PArA (PARA: Parameters)	FCon (FCON: Feeder control)	ECTP (ECTP: External CT Primary)	1-10000 A
		ECTS (ECTS: External CT Secondary)	1A/5 A
		FEEd (FEEd: Feedback)*	Current: current feedback, Switch: main switch feedback
		EPU (EPU: External PT Used)	DISABLE/ ENABLE (Disable/Enable)
		EPP (EPP: External PT Primary)	600-50000
		EPS (EPS: External PT Secondary)	100-690
	InFo (InFo: Feeder Info.)	PHAS (PHAS: Number of Phases)	1/3/3+N
		U (U: Voltage)	110-690
		F (F: Frequency)	50/60
		P (P: Feeder Power Rating)	0.001-4000000.000 KW
		In (In: Feeder Nominal Current)	0.01-10000 A

*Feedback is part of the monitoring function of main switch device status on/off. There are two options available, i.e. via current measurement or main switch feedback (via DI0).

4.4.3 Supervision functions setting

Supervision functions including power quality supervision and load supervision are,

Over current supervision, current unbalance supervision, voltage unbalance supervision, voltage dip supervision, voltage swell supervision, voltage interruption supervision and phase sequence supervision.

Level 1	Level 2	Level 3	Value range
PArA (PARA: Parameters)	I-oS (I-OS: Over Current Supervision)	FUnC (FUNC: Function)	dISABLE/ ENABLE (Disable/Enable)
		tHSH (THSH: Threshold)	100 %-120 %
		HYSt (HYST: Hysteresis)	0 %-10 %
	I-US (I-US: Current Unbalance Supervision)	FUnC (FUNC: Function)	dISABLE/ ENABLE (Disable/Enable)
		tHSH (THSH: Threshold)	50 %-90 %
		HYSt (HYST: Hysteresis)	0 %-10 %
	U-US (U-US: Voltage Unbalance Supervision)	FUnC (FUNC: Function)	dISABLE/ ENABLE (Disable/Enable)
		tHSH (THSH: Threshold)	50%-90%
		HYSt (HYST: Hysteresis)	0%-10%
	U-dS (U-DS: Voltage Dip Supervision)	FUnC (FUNC: Function)	dISABLE/ ENABLE (Disable/Enable)
		tHSH (THSH: Threshold)	5 %-100 %
		HYSt (HYST: Hysteresis)	0 %-10 %
	U-SS (U-SS: Voltage Swell Supervision)	FUnC (FUNC: Function)	dISABLE/ ENABLE (Disable/Enable)
		tHSH (THSH: Threshold)	5 %-20 %
		HYSt (HYST: Hysteresis)	0 %-10 %

	U-IS (U-IS: Voltage Interruption Supervision)	FUnC (FUNC: Function)	dISABLE/ ENABLE (Disable/Enable)
		THSH (THSH: Threshold)	95 %-100 %
		HYSt (HYST: Hysteresis)	0 %-10 %
	PSS (PSS: Phase Sequence supervision)	FUnC (FUNC: Function)	dISABLE/ ENABLE (Disable/Enable)

The example below shows how to change the value from 1 % to 4 % of the “Hysteresis” (HYSt) under “Voltage Unbalance Supervision” (U-US).

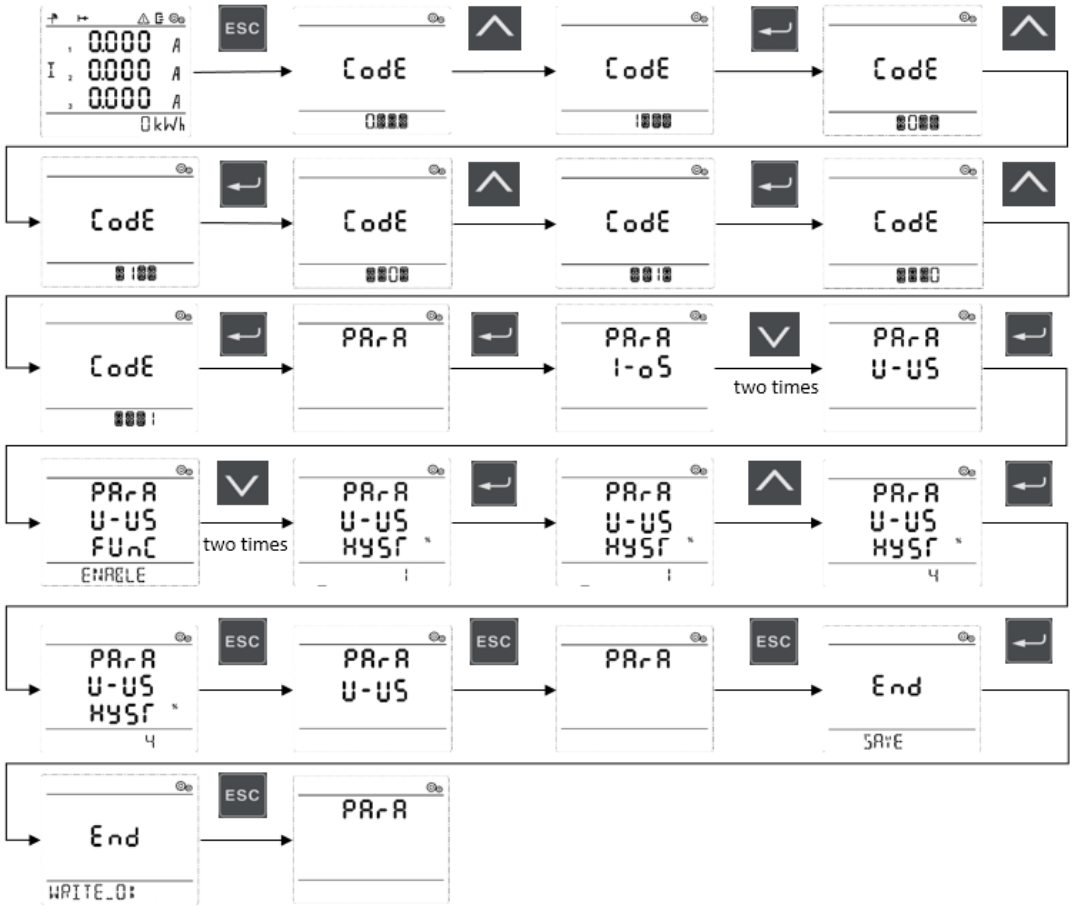


Figure 34: Change the hysteresis value

4.4.4 Demand integration time setting

The demand integration time in FC610 are selectable from 2 s, 10 s, 5 min, 8 min, 10 min, 15 min, 20 min, 30 min and 60 mins. The integration time is calculated by the sliding method. The sliding time interval is 1 second when the integration time is selected as 2 or10 seconds. When the integration time is 5, 8, 10, 20, 30, 60 minutes, the sliding time interval is 1 minute

Level 1	Level 2	Level 3	Value range
PArA (PARA: Parameters)	IPAo (IPAM: Integration period of average and maximum)	I IT (I_IT: Integration time of current)	2 seconds, 10 seconds, 5 minutes, 8 minutes, 10 minutes, 15 minutes, 20 minutes, 30 minutes, 60 minutes
		U IT (U_IT: Integration time of voltage)	
		F IT (F_IT: Integration time of frequency)	
		P IT (P_IT: Integration time of power)	

4.4.5 Maintenance setting

Level 1	Level 2	Level 3	Value range
	oAIn (MAIN: Maintenance)	PCrP (PCRP: 1/2 period curves record point *)	30 %-70 %
		run (RUN: Running time)	1-65534 Off:65535 (65535)
		InSE (INSE: Insertion cycle)	1-65534 Off:65535 (65535)

*) The event curve record position refers to the position of the record point where the event occurs in the entire event record, such as 30 %, which means that the record at the time of the event is located at 30 % of a record.

4.4.6 Read production version

The user can view the firmware version of the products including the bootloader of FC610, the application of FC610, MP53/56 and external modules if connected.

The firmware of FC610 usually refers to the application firmware, i.e., which may be required to be updated or upgraded due to bug fixing or feature improvements.

Prod (PROD: Production)	PVS (PVS: Product version)	BOOT (BOOT: Bootloader firmware of FC610)	0.1-9.9
		FC610 (FC610: Application firmware of FC610)	0.1-9.9
		MP (MP53/56: Operator Panel firmware)	0.1-9.9

Following example is used to show how to read the firmware version of FC610.

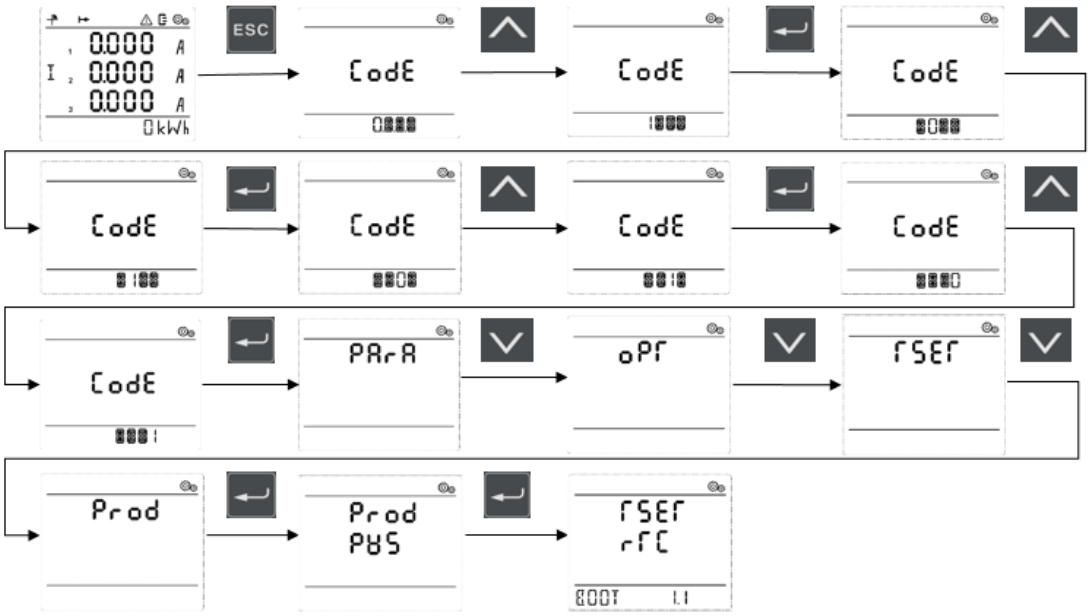


Figure 35: Read firmware version

5 Configuration

5.1 Configuration of FC610

Parameters of FC610 are expected to be configured via HMI panel MP53 or MP56 which is described in section 4.

In case of firmware updating or reading event curves, MConfig-G software must be used.

MConfig-G establish communication with FC610 via RS485 communication which is shown below. A dedicated parameterization cable TK202 is required to connect FC610 and the configuration computer with the MConfig-G software installed.

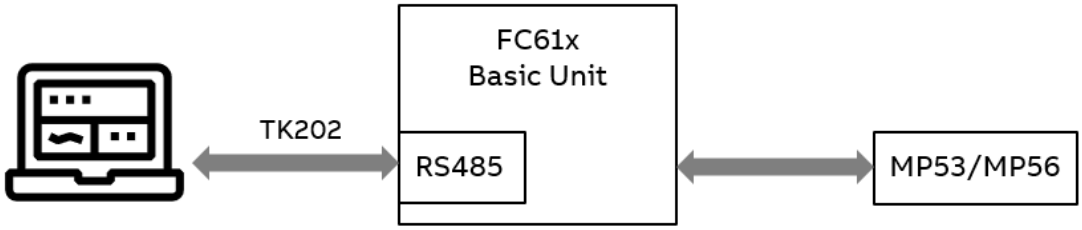


Figure 36: Configuration of FC610

It is also possible to configure FC610 via communication. Please refer to “1TNC928247 FC610 Modbus Protocol Implementation” for more information.

5.2 Factory default setting

For an easy startup of FC610, the following factory settings are preloaded in the device.

Parameters	Range	Factory setting
Feeder Information		
Feeder ID		na
System supply voltage	110-50000 V	380 V
Frequency	50/60 Hz	50 Hz
Feeder type	Single phase/3- phase /3-phase+N	3-phase+N
Feeder power rating		1.5 kW
Feeder nominal current		5 A
Feeder Control		
Feedback Function	Current feedback/main switch feedback*	Current Feedback
External CT Primary		1
External CT Secondary		1

Parameters	Range	Factory setting
External PT Used**		Disable
Demand integration time (I, U,F,P)	2s,5s,5m,8m,10m,15m,20m,30m,60m	10 mins
Event curves record point***	30-70 %	30 %
DI/DOs		
DI0		Main switch status
DI1		Main switch fault
DO		Common warning
Maintenance		
Running time alarm function	Enable/Disable	Disable
Insertion cycle alarm function	Enable/Disable	Disable

*Feedback is part of the monitoring function of main switch device status on/off. There are two options available, i.e. via current measurement or main switch feedback (via DI0).

** If external PT is used, the PT primary range is 600-50,000VAC while secondary range is 100-690VAC.

*** Event curves record point is to define the pre-trigger point and the pre-recovery point. For example, on a 240-samples event curve with 30% setting means 36 samples are recorded before the event is triggered while 84 samples are recorded after the event is detected. Another 36 samples are recorded before the event is recovered and 84 samples after recovery. More details refer to event curve section.

5.3 User definable reading data

FC610 contains a user definable area in the memory map. This area allows re-mapping of the addresses of any actual values or parameters registers. This makes it possible to reorganize the reading data according to the project requirements and minimize the reading effort by organize the required data in the registers next to each other.

Parameters have also been pre-loaded in user definable area which is in line with LVS digital data integration requirements. For the details of parameters preloaded in FC610, please refer to “1TNC928247 FC610 Modbus Protocol Implementation”.

Changing of the default mapping requires MConfig-G configuration tool locally if not updating through fieldbus.

In case FC610 is integrated into a LVS Digital system the pre-loaded data mapping shall not be changed as else the displayed information in e.g. CMES condition monitoring system will become mixed up.

Appendix A Technical Data

A.1 Technical specifications

Main circuit	
Nominal voltage	3 X 230/400 VAC (Ph/N)
Voltage range	3 X 30 – 400 VAC (Ph/N)
Rated insulation voltage	800 VAC
Frequency	50 or 60 Hz (45 – 65 Hz)
Voltage inputs	
Voltage between phases	50 – 690 VAC
Voltage between phase and neutral	30 – 400 VAC
Input consumption	0.3VA max.
Updating duration	1s (on MP53/56 HMI) 0.1s (via bus)
Terminal wire area	0.2 .. 2.5 mm^2
Recommended tightening torque	0.5 .. 0.6 Nm
Current inputs	
Primary current via CT	Up to 10000 A
Rated current In	1 A / 5 A
Maximum linear current I_{max}	6 A
Minimum current I_{min}	10 mA with U(Ph/N) > 29 VAC
Updating duration	1s (on MP53/56 HMI) 0.1s (via bus)
General data	
PMD classification	PMD SD K55
Housing color- FC610 basic unit	RAL7012
Housing color- HMI	RAL7012
HMI Display	LCD
Material- FC610 basic unit	PA6 GF20
	Halogen-free
	Flammability rating UL94V2
Pollution degree	2

Auxiliary power supply	
Rated operational voltage (Ue)	110-240 VAC
Voltage operation range	85 %-110 % Ue
Rated frequency	50 / 60 Hz
Power consumption	16 VA max. @ 240 VAC 8 VA max. @ 110 VAC
Power output	
Current	100 mA @ 240 VAC supply input 50 mA @ 110 VAC supply input
Voltage	24 VDC
Terminal wire area	0.2 .. 2.5 mm^2
Recommended tightening torque	0.5 .. 0.6 Nm
Relay output	
Rated operation voltage (Ue)	24 or 110 VDC, 110 or 240 VAC
Rated operation current (Ie)	2A /24 VDC(DC-13) 0.1A/110 VDC(DC-13) 4A/120 VAC(AC-15) 2A/240 VAC(AC-15)
Digital inputs	
Voltage	24 VDC
On	Voltage: 15 V < V < 30 V, current: 2 mA < I < 15 mA
Off	Voltage: 0 V < V < 5 V, current: 15 mA max
Terminal wire area	0.2 .. 2.5 mm^2
Recommended tightening torque	0.5 .. 0.6 Nm
Communication	
Terminal wire area	0.2 .. 2.5 mm^2
Recommended tightening torque	0.5 .. 0.6 Nm
Modbus-RTU	Up to 115.2 kbps
Environmental	
Operating temperature	-5 ℃ - 55 ℃
Storage temperature	-40 ℃ - 85 ℃
Humidity	15 % up to 95 % without dew
Derating accepted operating altitude	4500 m
Without derating operating altitude	2000 m
Resistance to water and dust	HMI MP53/56: IP54 Main unit: IP20
Mechanical environment	Vibration 10 Hz-150 Hz, 1 g Shock 11 ms, 15 g

Electromagnetic environment	1) Equipment in the system comply with EMC requirement of CE / CCC certificate. 2) Power supply system complies with IEC61000-2-1, IEC61000-2-2, especially the system in which VSD / Frequency Converters are used.
Pollution degree	2
EMC compatibility	
Electrostatic discharge	4.0 kV contact discharge 8.0 kV air discharge (IEC61000-4-2)
Electromagnetic field immunity	10 V/m (80-1000 MHz), 3 V/m (1.4-2 GHz), 1 V/m (2-2.7 GHz) (IEC61000-4-3)
Conducted disturbance immunity	3V (150 kHz to 80 MHz) (IEC61000-4-6)
Burst immunity	2 kV(5/50 ns, 5 kHz) for AC power and DC power 1 kV(5/50 ns, 5 kHz) for I/O signal control (IEC 61000-4-4)
Surge immunity	1 kV/2 kV (IEC 61000-4-5)
Voltage dip	0 % during 1 cycles 40 % during 10/12 cycles 70 % during 25/30 cycles (IEC61000-4-11)
Short interruption	0 % during 250/300 cycles (IEC61000-4-11)
Power frequency magnetic field	30 A/m (50 Hz, 60 Hz) (IEC61000-4-8)
Radiated disturbance	EN55011/CISPR 11, Class A
Standards	IEC 61557-12: class 0.5 GB/T 18216.12: class 0.5

A.2 Characteristics of functions

Function symbols	Measuring range	Function performance class according to IEC 61557-12	Other complementary characteristics
P	2 % to 120 % In	0.5	
QV	2 % to 120 % In	0.5	
SA	2 % to 120 % In	1	
Ea	0 to 99999999 kWh	0.5	
ErV	0 to 99999999 kVarh	2	
EapA	0 to 99999999 kVah	1	
F	45 to 65 Hz	0.1	
I	5 % to 120 % In	0.2	
IN, INc	5 % to 120 % In	1	
U	50 to 690 VAC ph/ph	0.2	30 to 400 VAC ph/n
PFA	0.5 ind to 0.8 cap	0.5	
Udip	5 % to 100 % Un	0.5	
Uswl	100 % to 120 % Un	0.5	
Uint	0 to 5 % Un	0.5	
Uh	3^{rd} to 17^{th}	2	
	19^{th} to 31^{st}	5	
THDu		2	
Ih	3^{st} to 31^{st}	2	
THDi		2	

A.3 Characteristics of the evaluation function of the quality of supply

Function symbols	Measuring range	Function performance class according to IEC 61557-12	Other complementary characteristics	Class acc. to IEC 61000-4-30 if any
f	45 to 65 Hz	0.1		
I	5 % to 120 % In	0.2		
IN, INc	5 % to 120 % In	1		
U	50 to 690 VAC ph/ph	0.2	30 to 400 VAC ph/n	
Udip	5 % to 100 % Un	0.5		
Uswl	100 % to 120 % Un	0.5		
Uint	0 to 5 % Un	0.5		
Uh	3^{rd} to 17^{th}	2		
	19^{th} to 31^{st}	5		
Ih	3^{rd} to 31^{st}	2		

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