iSTAT M3x5

Power Quality Analyser

Manual

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Power Quality Analyser

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1. SAFETY SECTION

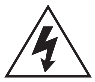
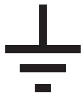
This Safety Section should be read before commencing any work on the equipment.

1.1 Health and Safety

The information in the Safety Section of the product documentation is intended to ensure that products are properly installed and handled in order to maintain them in a safe condition. It is assumed that everyone who will be associated with the equipment will be familiar with the contents of the Safety Section.

1.2 Explanation of symbols and labels

The meaning of symbols and labels may be used on the equipment or in the product documentation, is given below.

 Caution: refer to product documentation	 Caution: risk of electric shock
 Protective/safety *earth terminal	 Functional *earth terminal Note: This symbol may also be used for a protective/safety earth terminal if that terminal is part of a terminal block or sub-assembly e.g. power supply.

*NOTE: The term earth used throughout the product documentation is the direct equivalent of the North American term ground.

2. INSTALLING, COMMISSIONING AND SERVICING

Equipment connections

Personnel undertaking installation, commissioning or servicing work on this equipment should be aware of the correct working procedures to ensure safety. The product documentation should be consulted before installing, commissioning or servicing the equipment.

Terminals exposed during installation, commissioning and maintenance may present a hazardous voltage unless the equipment is electrically isolated.

If there is unlocked access to the rear of the equipment, care should be taken by all personnel to avoid electrical shock or energy hazards.

Voltage and current connections should be made using insulated crimp terminations to ensure that terminal block insulation requirements are maintained for safety. To ensure that wires are correctly terminated the correct crimp terminal and tool for the wire size should be used.

Before energising the equipment it must be earthed using the protective earth terminal, or the appropriate termination of the supply plug in the case of plug connected equipment. Omitting or disconnecting the equipment earth may cause a safety hazard.

The recommended minimum earth wire size is $2.5mm^2$, unless otherwise stated in the technical data section of the product documentation.

Before energising the equipment, the following should be checked:

– Voltage rating, frequency and polarity

– VT ratio and phase sequence

– CT circuit rating and integrity of connections;

– Protective fuse rating;

– Integrity of earth connection (where applicable)

– Supply voltage

– External switch or circuit-breaker must be included in the installation for disconnection of the devices' auxiliary power supply. It must be suitably located and properly marked for reliable disconnection of the device when needed.

3. EQUIPMENT OPERATING CONDITIONS

The equipment should be operated within the specified electrical and environmental limits.

3.1 Current transformer circuits

Do not open the secondary circuit of a live CT since the high level voltage produced may be lethal to personnel and could damage insulation.

3.2 Insulation and dielectric strength testing

Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, the voltage should be gradually reduced to zero, to discharge capacitors, before the test leads are disconnected.

3.3 Opening enclosure

There are no customer replaceable PCB cards or components within the enclosure, so the enclosure should not be opened.

4. DECOMMISSIONING AND DISPOSAL

Decommissioning: The auxiliary supply circuit in the relay may include capacitors across the supply or to earth. To avoid electric shock or energy hazards, after completely isolating the supplies to the relay (both poles of any dc supply), the capacitors should be safely discharged via the external terminals prior to decommissioning.

Disposal: It is recommended that incineration and disposal to water courses is avoided. The product should be disposed of in a safe manner. Any products containing batteries should have them removed before disposal, taking precautions to avoid short circuits. Particular regulations within the country of operation, may apply to the disposal of lithium batteries.

5. TECHNICAL SPECIFICATIONS

5.1 Protective fuse rating

The recommended maximum rating of the external protective fuse for this equipment is 6A, Red Spot type or equivalent, unless otherwise stated in the technical data section of the product documentation.

Insulation class:	EN 61010-1 : 2010 Class II	
Insulation Category (Over voltage):	EN 61010-1 : 2010 Category II (600V), III (300V)	
Environment:	EN 61010-1 : 2010 Pollution degree 2	Compliance is demonstrated by reference to generic safety standards.
Product Safety:	2006/95/EC EN 61010-1 : 2010	Compliance with the European Commission Low Voltage Directive. Compliance is demonstrated by reference to generic safety standards.

6. CONTACT ADDRESS

The supplier of the product is: **ALSTOM GRID UK LTD**

Who can be contacted via the Worldwide Contact Centre.

Email: contact.centre@alstom.com

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7. INTRODUCTION

FIGURE 7-1 : M3X5 FRONT AND REAR CASE VIEWS

7.1 General

The **M3x5** Quality Analyser is a comprehensive device intended for the permanent monitoring of power quality from its production (especially renewable), transmission, distribution to final consumers, who are most affected by insufficient quality of voltage. It is mostly applicable in medium and low voltage markets.

Lack of information about supplied quality of voltage can lead to unexplained production problems and malfunction or even damage to equipment used in production processes. Therefore, the **M3x5** can be used for utility purposes (evaluation against standards) as well as for industrial purposes (e.g. for monitoring supplied power quality).

The **M3x5** Power Quality Analyser integrates a number of measurements, monitoring, recording and metering functions in the same unit for comprehensive power system management.

The **M3x5** offers:

- Power Quality measurement to IEC 61000-4-30:2008 Class A
- Power Quality analysis to EN50160: 2011
- High accuracy measurements (0.1%, 0.2S Energy)
- 4 voltage and 4 current inputs (including neutral current)
- 31 kHz sampling (620 s/c @ 50 Hz)
- Interharmonics Measurement
- Time synchronisation (multiple methods)
- Modbus and DNP3(level 1) protocols for integrating into energy management and control systems on Serial and Ethernet communications channels.
- Up to 20 I/O channels and 32 programmable alarms
- 128 (4 x 32) channel trend recorder and alarm status recorder.
- Energy measurement, tariff and cost management functions for use in sub metering applications.
- User friendly configuration, download and analysis software (QDSP2)
- A cost-effective solution for Medium and Low voltage and Industrial markets

The **M3x5** uses a software package called **QDSP2,** v2.0 or later is required for **M3x5**. Although basic configuration can be performed via the keypad it is suggested that the **QDSP2** software is used when possible as it provides a simple interface for communicating with the product. A separate **QDSP2** manual is available.

- **QDSP2** can be used for setting and monitoring all of the iSTAT devices with communications, i400, i4Mx, i500, M2x1, M2x2, M2x3, and **M3x5**. It can also be used off line using a Memory Card to transfer data to and from the device. It is also used to provide the data logging and Power Quality download and analysis functions required by **M355** and other devices.
- **QDSP2** also offers additional features such as upgrading from a secure web site for both the **QDSP2** and the devices.

KEY MESSAGES

- The iSTAT **M3x5** family measures Power Quality parameters in compliance with IEC61000-4-30:2008 Class A. And performs Power Quality Analysis to EN50160:2011.
- The iSTAT **M3x5** family is **easy to set and test**. In the substation world, more settings increase the chance of misapplication, and the potential for incorrect settings and inaccurate measurements. The ISTAT **M3x5** minimises the chance of an incorrect setting by using a setup wizard to help the operator configure the device.
- The iSTAT **M3x5** offers **easy fitting**, by using embedded current transformers and a wrong connection warning for the current circuits. It uses a standard 144mm DIN case.
- The **comprehensive** Energy Cost Management Library of functions enables the **M3x5** to store energy readings in 4 registers and programme tariff structures and costs. This data can be recorded, communicated or transmitted via pulse outputs.
- **M3x5** allows connection to MODBUS and DNP3(level 1) based systems that are widely used by industrial and utility customers worldwide.
- The **M3x5** family also allows a Memory Card to be used for configuring the meters and extracting data for post analysis.

iSTAT – **THE standard** measurement platform

- Multiple advanced configuration features fitted as standard.
- Comprehensive choice of features for measurement applications – to satisfy all metering, measurement, data recording and power quality applications
- Flexible programmable software (**QDSP2**) allows off line and on line configuration and data interpretation
- Complete and informative documentation, **QDSP2** also includes help information.
- A choice of different input and output options.

7.2 Purpose

The **M3x5** Quality Analyser performs measurements in compliance with regulatory standard IEC 61000-4-30: 2008 and evaluates recorded parameters for analysis according to the limit values defined in European supply quality standard EN 50160:2011. The limit values can be modified to match the requirements of the customer.

Moreover the **M3x5** stores measurements and quality reports in internal memory for further analysis of recorded measurements. From multiple devices installed in different locations, the user can gain the overall picture of the system behaviour. This can be achieved with respect to its accurate internal real time clock and the wide range of time synchronization sources supported, which ensure accurate, time-stamped measurements from dispersed units.

All required measurements, weekly PQ reports and alarms can also be stored locally in the internal memory. Stored data can then be transferred to a memory card or accessed through communication for post analysis.

The internal memory capacity allows the storing of more than 170,000 variations of the measurements from the standard values, which allows the eventual reasons for the problems in the network to be found. The limits and the required quality in a monitored period can be defined for each monitored characteristic.

7.3 Family

The **iSTAT M3x5** family provides:

- **M355** is a class 0.1 communicating Power Quality Analyser that meets Class A to IEC61000-4-30:2008. The **M355** also includes a tariff structure, alarm indication, 0.2S energy measurement function and a range of communications and input/output options.
- Others to be defined.

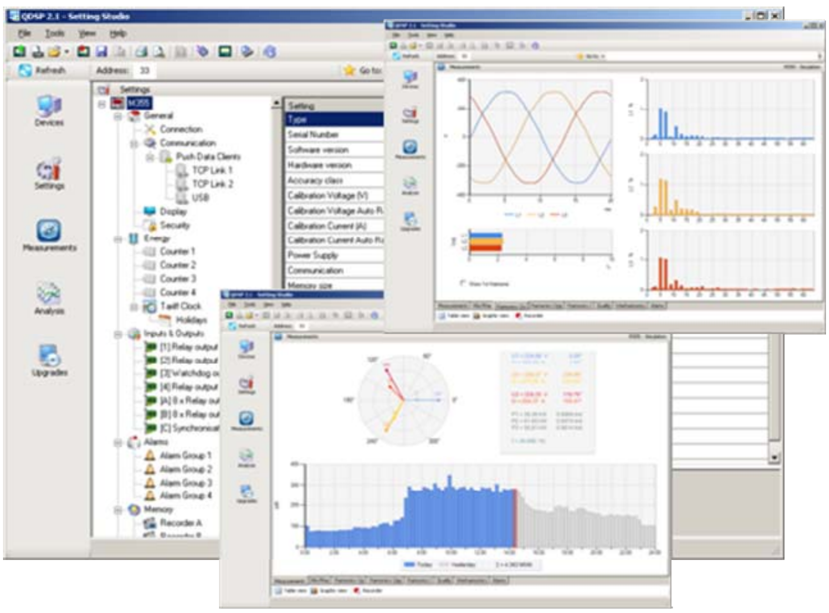
Software:

- **QDSP2** for setting, monitoring, recording and Power Quality application software.

7.4 QDSP2

The **QDSP2** software is used for configuring the **M3x5**. Additionally it can be used to obtain and display many real time measurements in graphical or tabular form. **QDSP2** also configures the data and power quality recorders and is used to download and display the recorded data.

A separate manual is available for **QDSP2** which describes its operation and all of the features.



7.5 Measurements

The **M3x5** family is ideally suited to applications where continuous Power Quality monitoring is required.

TABLE 7-1 summarises the measurements available. The **M3x5** can be user configured for either single or three phase connection.

TABLE 7-1 : MEASUREMENTS	**M3x5**
V, I, P, Q, S, PF, PA, F, φ	●
Energy kWh class 0.2S	●
Maximum demand	●
Minimum values: V, I, P, Q, S, PF, PA, F, φ	●
Maximum values: V, I, P, Q, S, PF, PA, F, φ	●
THD (actual, min, max)	●
Harmonics (up to)	63rd
Flicker, voltage fluctuations, Interharmonics	●

7.6 Hardware features

The **M3x5** family has a number of hardware features that are designed to make the installation, commissioning and use of the meters as simple as possible, see TABLE 7-2.

It has a large 128 x 64 pixel Liquid Crystal Display (LCD) that can display information in a number of different font sizes and is backlit for use in conditions with a low light level. The menu is driven locally by a 5 key function pad on the front of the meter and the **M3x5** family has the ability to customise the display and key functions to enable the user to retrieve information as quickly as possible.

The **M3x5** has 3 LED indicators that indicate the status for a number of functions; Steady RED for Memory Card activity; blinking GREEN for communications activity and blinking RED for an alarm condition.

The **M3x5** has an auto ranging current and voltage measurement inputs so that it can be used in most site conditions without the need to specify connection information at the order stage.

The **M3x5** has 8 energy counters and a real time clock so that it supports comprehensive energy management applications.

The **M3x5** has 8MB of internal memory to support the data recording and Power Quality Analysis functions.

The **M3x5** supports a Memory Card with capacity up to 2GB which is used to transfer settings and extract records from the **M3x5**. This means that the **M3x5** can download Power Quality records and have settings made off line and up/downloaded via a Memory card using the front card access port. The slot is protected by a cover to prevent humidity and dust ingress.

TABLE 7-2 : HARDWARE	**M3x5**
Time synchronisation	●
Large backlit LCD 128 x 64	●
LED alarm indication	●
5 key menu	●
Autorange V&I input	●
Power supply universal AC/DC (2 ranges High/Low)	●
Watchdog (optional)	●
8 Energy counters	●
Real time clock	●
Internal Flash Memory	8MB
Memory card	●

7.7 Communication and inputs/outputs

The **M3x5** family has a wide range of communications options that allow it to integrate with a number of different management systems, see TABLE 7-3.

The **M3x5** has the option of an RS232/RS485 wired port, USB port or an RJ45 Ethernet port that will support MODBUS or DNP3. In addition a second RS232/RS485 port is available if it is not used for communicating with a GPS modem.

The **M3x5** family has a front port supporting Memory Cards so that settings and records can be extracted locally from the meter. It can also be used to upgrade the firmware of the **M3x5**.

The **M3x5** has four hardware modules on the rear, 2 of which can support 2 inputs or outputs and 2 which can support 8 inputs or outputs as shown in table 7-3. Each module configuration is specified at the order stage and they are independent of each other.

TABLE 7-3 : COMMUNICATIONS	**M3x5**
Memory Card port	●
RS232/RS485, USB or Ethernet	●
Second RS232/RS485 for communications with GPS modem or general usage	●
Modbus RTU, TCP and DNP3	●
2x energy pulse contacts	●
2x tariff inputs	●
2x alarm contacts	●
2x analogue outputs	●
1x Watchdog & 1x alarm contact	●
2x digital inputs	●
2x analogue input	●
8x digital inputs	●
8x digital outputs	●

7.8 User features

The **M3x5** family has a wide range of user features that are designed to make the installation and commissioning simple. These features are summarised in TABLE 7-4 .

The Setup Wizard takes the user through the basic settings required to commission the **M3x5**. The benefit of the wizard is that it leads the commissioning engineer through all the basic settings required to install the **M3x5** ensuring that the **M3x5** is correctly setup. This is fully detailed in section 9.3.

The **M3x5** will monitor the voltage and current polarity and when it detects that an input has been incorrectly connected it will display a warning symbol on the display. This is useful when direction is important, such as in energy applications, to ensure that the values calculated are correct.

The **M3x5** provides over 140 different measurements that the operator can scroll through and read on the display. If the operator only wants to see a small number of measurements, they can configure the display to show up to 3 customised screens. The refresh time is programmable to allow the operator time to interpret the information on the display.

To demonstrate the different display options that are available, the **M3x5** has a demo option which will display each of the different screens available. The refresh time is programmable so that the operator is given time to interpret the information shown.

TABLE 7-4 : USER FEATURES	**M3x5**
Set up Wizard	●
Wrong connection warning	●
3 Custom screens	●
Reset default settings	●
Demonstration screens	●
Settable refresh times	●

7.9 Applications

The **M3x5** family can be used in a wide range of different applications that are summarised in TABLE 7-5.

TABLE 7-5 : APPLICATION	**M3x5**
Power measurements	●
Energy Metering	●
Cost Management	●
Programmable alarms	●
Measurement recorder	●
Quality of supply	●

Power Measurements: The **M3x5** family provide a wide range of instantaneous analogue values; voltage, current, power, phase angle, power factor and frequency. These are available locally on the **M3x5** family and remotely. The **M3x5** therefore replaces a number of separate instruments and is ideally suited to ac switchboard applications.

Energy and sub Metering: With the addition of 4 quadrant energy measurement, the **M3x5** can be used in sub metering applications were information is passed to an energy management system to monitor the performance of the ac power system. Depending on the **M3x5** I/O options selected, the **M3x5** can use a combination of pulsed energy contacts, analogue tariff inputs and communications to integrate with and provide this data to the control system.

In addition, measurements such as maximum and minimum values and maximum demand information provide valuable information on the operation of plant and system monitoring to ensure that it performing correctly.

Cost Management: The real time clock and a tariff structure means that the **M3x5** can be used in stand-alone tariff or revenue sub metering applications. This allows the energy consumed to be given a financial cost that can vary depending on the time of day and season of the year. This provides information on the cost of plant operation and can be used to ensure that equipment and processes are used in the most financially efficient manner.

Measurement Recorder: The **M3x5** has 4 independent data recorders that provide trending information on up to 128 different analogue values. The status of all 32 software alarms can also be recorded within the data recorder. This provides a comprehensive record of the status of the monitoring system and a timed record of events.

Quality of supply: The **M3x5** provides quality of supply measurement which complies with IEC 61000-4-30:2008 Class A and analysis that complies with the European standard EN50160:2011. This power quality standard is used to monitor electrical systems and ensure that it falls within a number of different limits, ensuring that the user has the required electricity supply quality. The EN50160 standard monitors the following electrical characteristics:

Phenomena	**PQ Parameters**
Frequency variations	Frequency distortion
Voltage variations	Voltage fluctuation Voltage unbalance
Voltage changes	Rapid voltage changes Flicker
Voltage events	Voltage dips Voltage interruptions Voltage swells
Harmonics & THD	THD Harmonics Inter-harmonics Signalling voltage

8. HARDWARE

8.1 Front panel

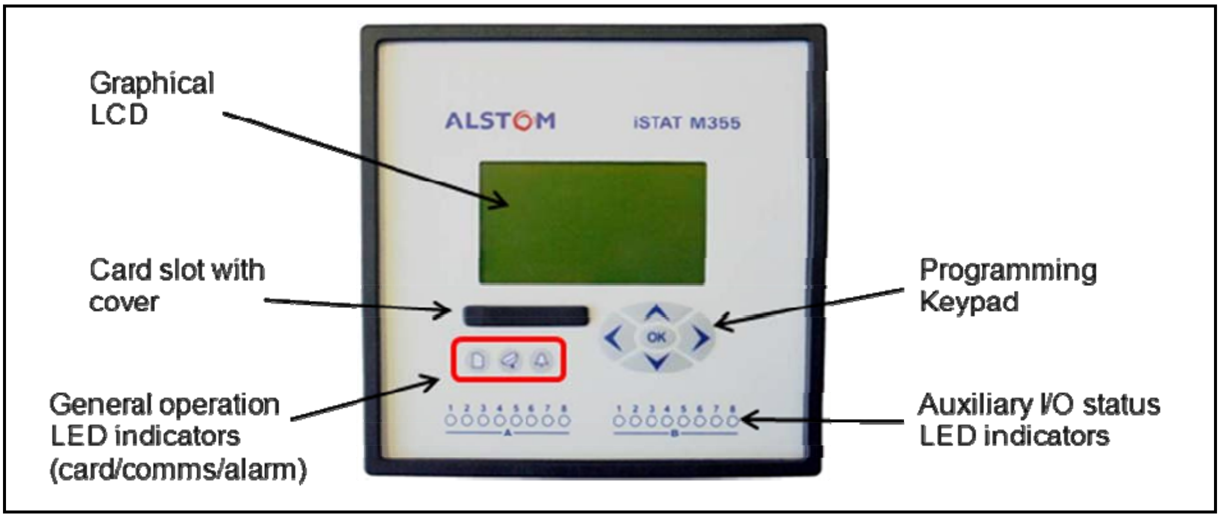


FIGURE 8-1: M3X5 FRONT PANEL FEATURES

Graphical LCD: A graphical LCD with back light is used for high resolution display of measured quantities and for the display of selected functions when configuring the device.

Programming Keypad: The "OK" key is used for confirming the settings, selecting and exiting the displays. Direction keys are used for shifting between screens and menus.

Memory card slot: A slot is provided for a full size SD (or MMC) card that is used for data transfer from the internal memory, device setting and software upgrading. A protection cover over the slot prevents the penetration of humidity and dust into the device.

LED indicators: There are two types of LED indicators positioned on the front panel. General operation LED indicators and I/O status LED indicators.

- General operation LED indicators warn of a certain state of the device. A left (red) indicator indicates the memory card activity and that it should not be pulled out. A middle (green) one is blinking when transmitting data via communications. A right (red) one is blinking when the condition for an alarm is fulfilled.
- I/O state LED indicators are in operation when additional Modules A and/or B are built in and they have functioning Digital input or Relay output. They indicate the state of a single I/O. Red LED is lit when:
  - o Relay output is activated
  - o Signal is present on Digital input

8.2 Rear connections

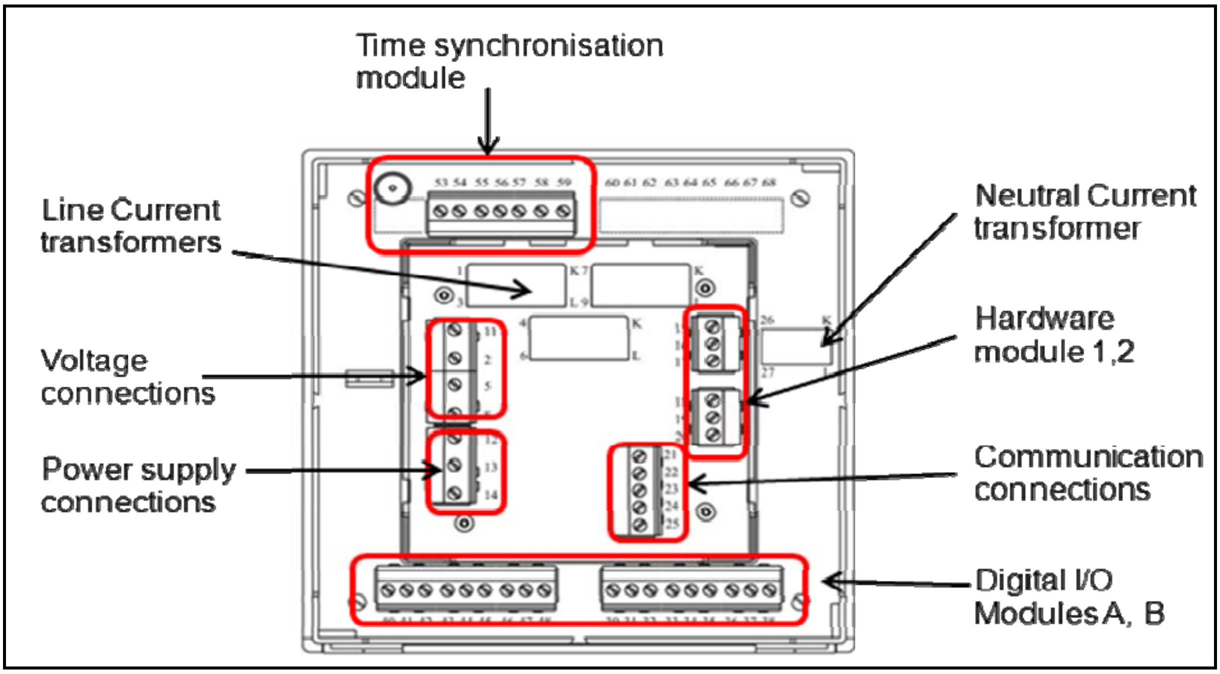


FIGURE 8-2: REAR PANEL CONNECTIONS

8.3 Mounting

The **M3x5** is only intended for mounting in a panel and is a standard 144 x 144 mm DIN enclosure. Pluggable connection terminals allow easier installation and quick replacement should that be required.

The **M3x5** is not intended to be used as portable equipment and should only be used as a fixed panel mounted device.

The required panel cut out is 138(+0.8) x 138(+0.8) mm.

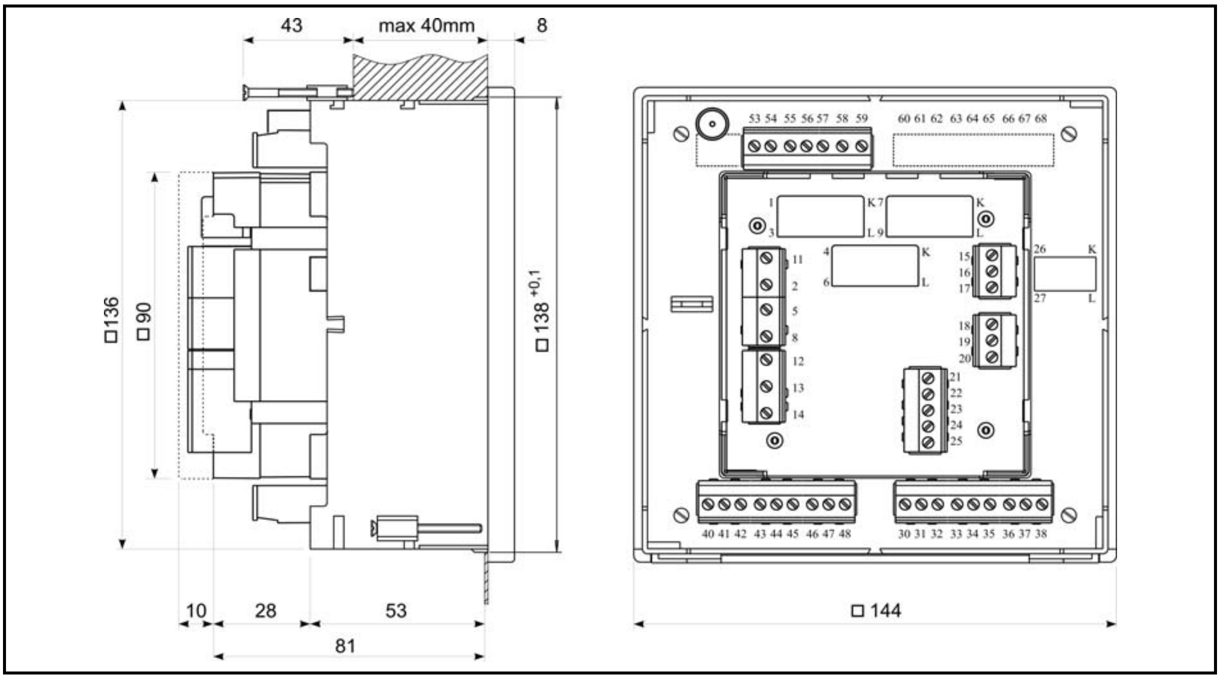


FIGURE 8-3: CASE DIMENSIONS

8.4 Auxiliary Supply

The **M3x5** family has the option of 2 Universal AC/DC auxiliary voltage supplies with different voltage ranges.

Parameter	Universal Auxiliary - LOW	Universal Auxiliary - HIGH
AC Voltage	48…..77 VAC	80…..276 VAC
Frequency	45 – 65Hz	40 – 65Hz
DC Voltage	19…..70 VDC	70 – 300 VDC
Burden	< 8 VA	< 8 VA

TABLE 8-1: AUXILIARY SUPPLY

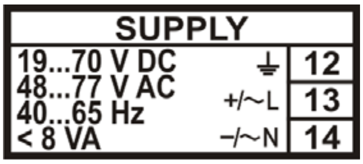


FIGURE 8-4: AUXILIARY SUPPLY - LOW

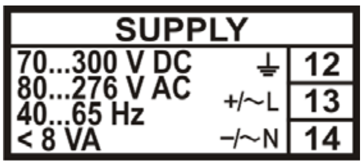


FIGURE 8-5: AUXILIARY SUPPLY – HIGH

WARNING!

Auxiliary power supply can be LOW range (19-70V_{DC}, 48-77V_{AC}). Connecting a device with LOW power supply to a higher voltage will cause device malfunction. Check the devices' specification before turning it on!

WARNING!

It is imperative that terminal 12, which represents the fourth voltage measurement channel, is connected to earth pole ONLY. This terminal should be connected to EARTH potential at all times!

CAUTION

Aux. supply inrush current can be as high as 20A for short period of time (<1 ms). Please choose an appropriate MCB for connection of aux. supply.

8.5 Voltage and Current measurement connections

Voltage inputs of the device can be connected directly to low voltage networks or via a primary voltage transformer to a high voltage network.

Current inputs of the device are fed through a hole in the current transformers to allow uninterrupted current connection. Connection to the network is performed via a corresponding primary current transformer.

The **M3x5** has the capability of measuring 4 AC voltages and 4 AC currents, and can be configured for a number of different connections.

The wiring diagrams for the different connections are shown below.

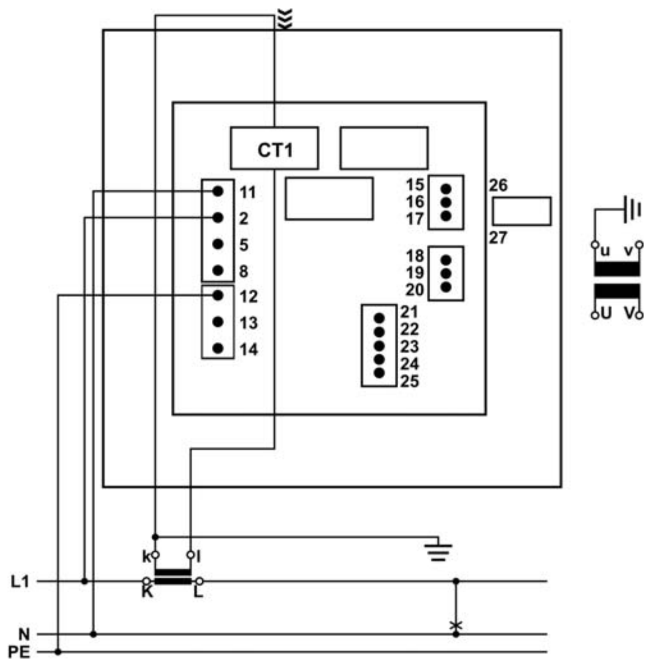


FIGURE 8-6: EXTERNAL WIRING DIAGRAM: SINGLE PHASE (1B)

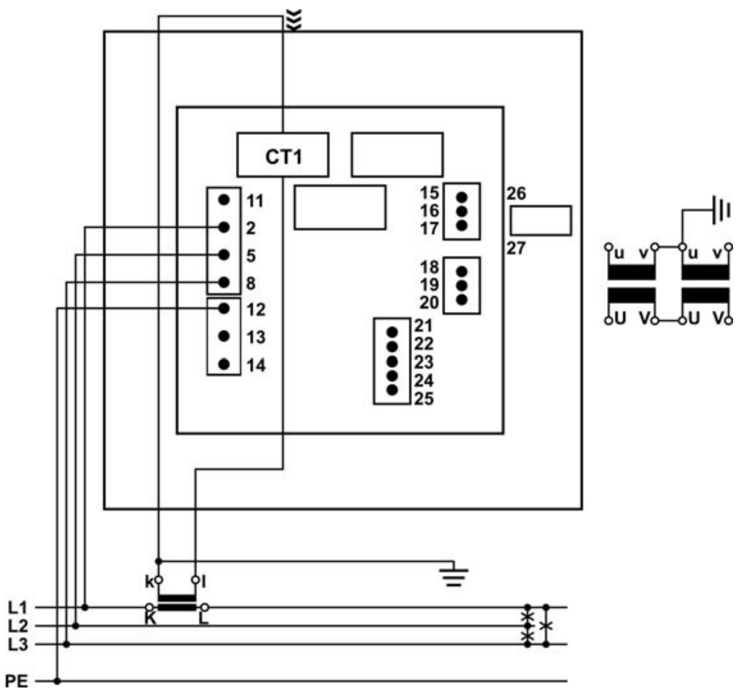


FIGURE 8-7: EXTERNAL WIRING DIAGRAM: 3-PHASE, 3-WIRE BALANCED LOAD (3B)

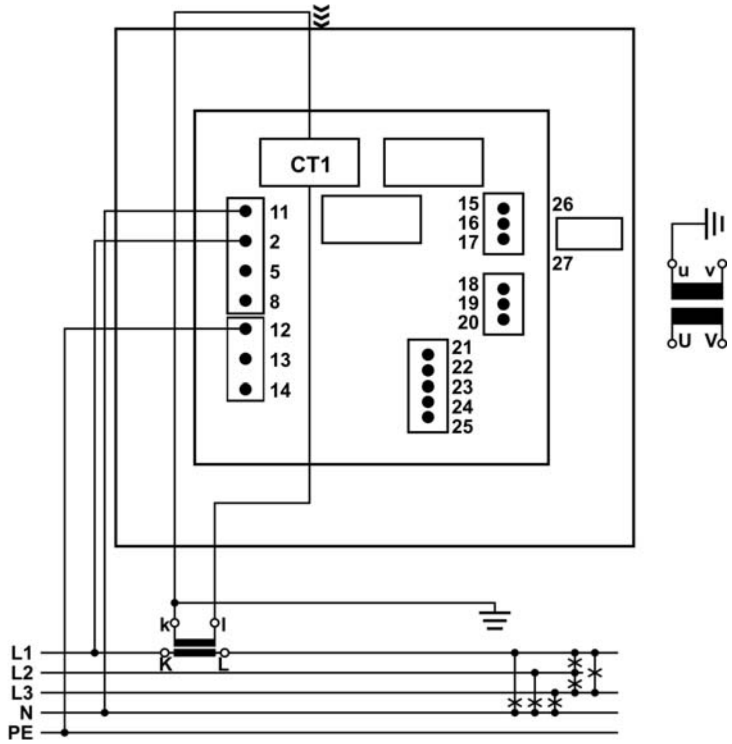


FIGURE 8-8: EXTERNAL WIRING DIAGRAM: 3-PHASE, 4-WIRE BALANCED LOAD (4B)

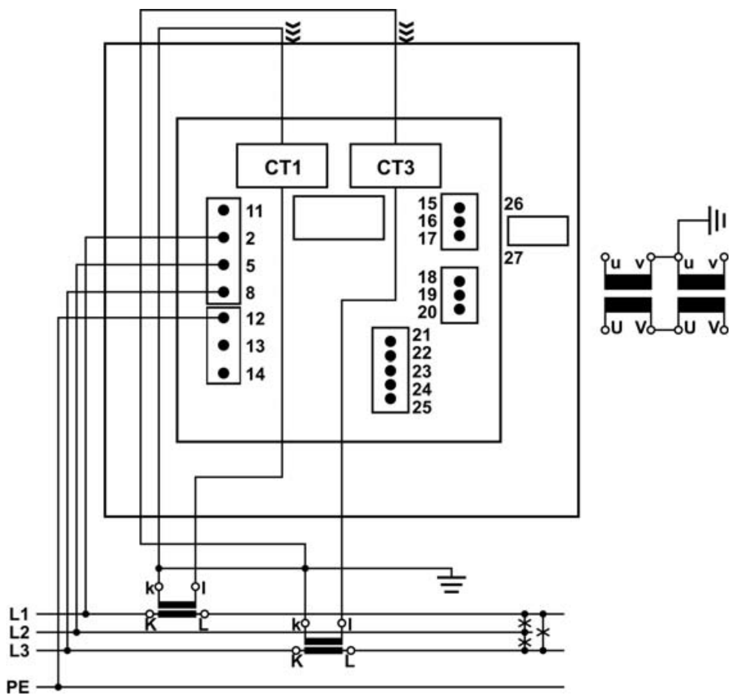


FIGURE 8-9: EXTERNAL WIRING DIAGRAM: 3-PHASE, 3-WIRE UNBALANCED LOAD (3U)

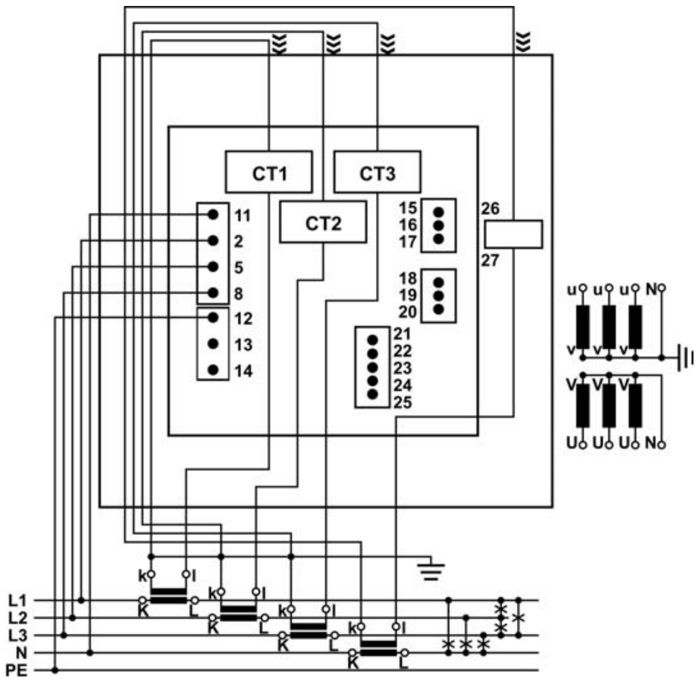


FIGURE 8-10: EXTERNAL WIRING DIAGRAM: 3-PHASE, 4-WIRE UNBALANCED LOAD (4U)

CAUTION

For accurate operation and to avoid measuring signal crosstalk it is important to avoid routing voltage measuring wires close to current measuring transformers.

PLEASE NOTE

After the physical connection is complete, settings have to be entered via the keypad that reflects the connection of the device to the voltage network (connection mode, current and voltage transformers ratio, etc). Settings can also be done via communication or a memory card.

8.6 Communications

The **M3x5** can be supplied with either RS232/RS485, USB or Ethernet electrically isolated communications that must be specified at time of ordering. The communication protocols that are available are MODBUS RTU and TCP or DNP3 (serial or Ethernet), which are detailed in the Appendices. The communications allows remote viewing of measurements and the viewing and setting of system parameters.

8.6.1 RS232 /RS485 Communications

The **M3x5** has a 5-pole terminal for RS232 or RS485 communications.

PLEASE NOTE

When connecting serial communication please note that only RS232 or RS485 should be used and not both at the same time. Connector terminals that are not used should remain unconnected otherwise the communications may not work properly.

The connection of RS232 communications has a maximum cable length of 15 metres.

Two-wire RS485 communications enables simultaneous connection to a maximum of 32 communicating devices, over a maximum distance of 1000m. For long cable distances a terminating resistor (120 ohm) may have to be connected between the 2 wires at the extreme ends of the cable network.

Connection information will be shown on the label as depicted in Figure 8-11.

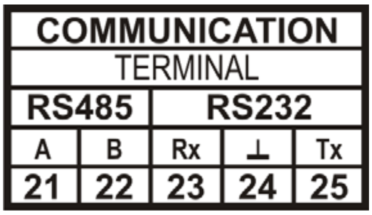


FIGURE 8-11: RS232/RS485 CONNECTIONS

A second RS232/RS485 port (COM2) may also be available depending on which RTC synchronization method is used (see section 8.9).

8.6.2 Ethernet Communications

The **M3x5** can be supplied with an Ethernet port, which is always supplied alongside an USB port. This option will have a rear mounted RJ45 Ethernet connecter, along with an USB connector.

Both of the Ethernet and USB ports can be used simultaneously allowing interrogation locally and remotely at the same time.

Note that each **M3x5** will have a unique MAC number indicated on the label that can be used when configuring for Ethernet communications.

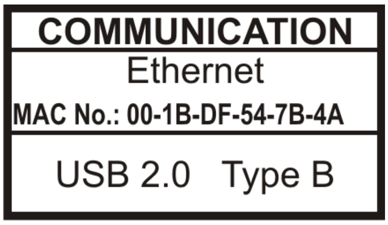


FIGURE 8-12: ETHERNET/USB

8.6.3 USB Communications

The **M3x5** can be supplied with a USB port, via a rear mounted USB type B connector.

USB communication serves as a fast peer-to-terminal data link. The instrument is detected by the host as a USB 2.0 compatible device.

If both Ethernet and USB ports are fitted they can be used simultaneously allowing interrogation locally and remotely at the same time.

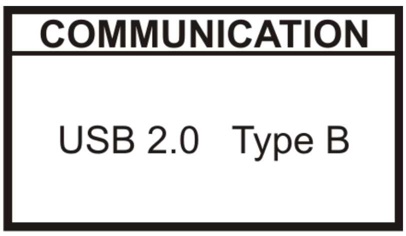


FIGURE 8-13: USB

8.7 Inputs and Outputs – Main modules 1 & 2

The **M3x5** can be supplied with two main input/output modules, designated 1 & 2, situated on the rear of the case. Each of these modules has 2 channels and can be factory configured to one of the options shown in table 8-2:

TABLE 8-2 : I/O OPTIONS	M3x5
2x energy contacts	●
2x tariff inputs	●
2x alarm contacts	●
2x analogue outputs	●
1x Watchdog & 1x alarm contact	●
2x digital inputs	●
2x analogue input	●

Since each input/output (I/O) module is independent from the other, the **M3x5** can be supplied with two different modules (for example 2 energy contacts and 2 alarm contacts) or with two similar modules (for example 4 analogue outputs or 4 tariff inputs).

The wiring diagrams for the I/O modules fitted are shown on labels attached to the product

I/O module 1 uses terminals 15/16/17 and module 2 uses 18/19/20.

8.7.1 Energy Pulse Outputs

The 2 energy pulsed outputs can be used for external monitoring of energy consumption. The energy measurement value output via the pulsed outputs corresponds to the basic energy measurement on the **M3x5** display. The pulsed outputs' energy measurement can be adapted to the customer's needs using the **QDSP2** configuration software via the communications link.

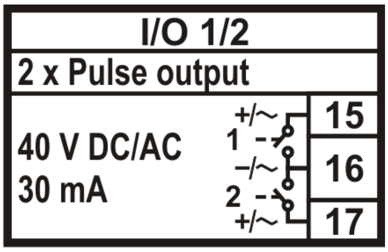


FIGURE 8-14: DUAL ENERGY CONTACTS

The pulse output module has three terminals, the energy contacts share a common connection but each contact can be individually set.

8.7.2 Tariff Inputs

The 2 tariff inputs can be used for signalling different tariff periods. The tariff period would be used in conjunction with the Cost Management feature to determine the financial value of energy being monitored. This corresponds to the energy costs on the **M3x5** display. The tariff structure can be adapted to the customer's needs using the **QDSP2** configuration software via the communications link.

The tariff input module has three terminals (see Figure 8-15) and shares a common connection but each input can be individually set.

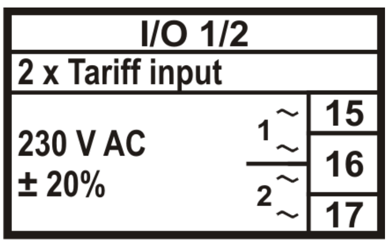


FIGURE 8-15: TARIFF INPUTS

8.7.3 Alarm Outputs

The 2 alarm contacts can be used for external monitoring of an alarm condition. The alarm contacts can be adapted to the customer's needs using the **QDSP2** configuration software via the communications link.

The alarm module has three terminals (see Figure 8-16), the alarm contacts share a common connection but each contact can be individually set.

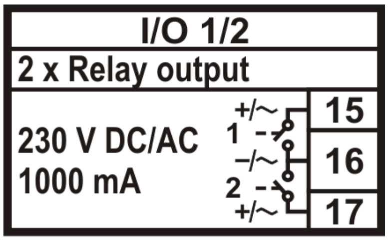


FIGURE 8-16: ALARM CONTACTS

8.7.4 Analogue Outputs

The 2 analogue outputs can be set within the range 0…20mA and can be configured to represent any of the instantaneous measured values. The analogue outputs' can be adapted to the customer's needs using the **QDSP2** configuration software via the communications link.

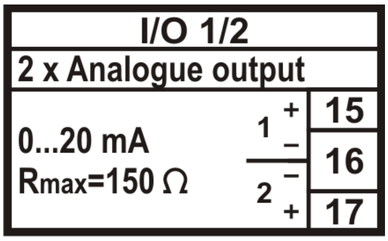


FIGURE 8-17: ANALOGUE OUTPUTS

The analogue output module has three terminals (see Figure 8-17), the analogue outputs share a common connection but each output can be individually set.

8.7.5 Digital Inputs

The 2 digital inputs are able to read the status of the input connection. Various voltage values are available, see the ordering cortec. The status of a digital input is defined as one of the 32 alarms available on the product, which can be monitored remotely via the communications.

The digital input module has 3 terminals (see Figure 8-18) sharing an input common terminal.

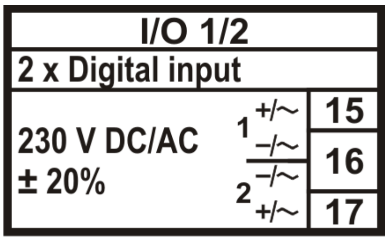


FIGURE 8-18: DIGITAL INPUTS

8.7.6 Watchdog Output and Alarm Output (Combined)

The **M3x5** can be supplied with a module that combines a Watchdog output and an Alarm Relay. The Alarm relay operates as if it is a part of an Alarm Output module.

The module has 3 terminals (see Figure 8-19) sharing an output common terminal.

When both I/O modules use this option, the **M3x5** can have 2 Watchdog outputs and 2 Alarm outputs.

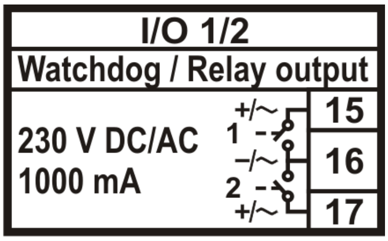


FIGURE 8-19: WATCHDOG AND ALARM OUTPUTS

8.7.7 Analogue Input

The **M3x5** can be supplied with 2 analogue inputs. Various options are available. The module has 3 terminals (see Figure 8-20), sharing an input common terminal.

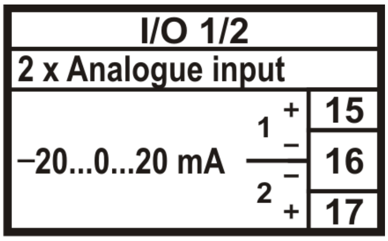


FIGURE 8-20: ANALOGUE INPUTS

WARNING!
When only one resistance-temperature analogue input is used, the other must be short-circuited.

8.8 Inputs and Outputs – Auxiliary modules A & B

The **M3x5** can be supplied with two auxiliary input/output (I/O) modules, designated A & B, situated on the rear of the case. These ports can be factory configured to one of the following options as shown in table 8-3:

TABLE 8-3 : I/O OPTIONS	**M3x5**
8x alarm contacts	●
8x digital inputs	●

Auxiliary modules A & B can be fitted in additional to modules 1 & 2, resulting in up to 20 I/O channels being available.

The status of the digital inputs or alarm outputs are shown by led's visible on the front escutcheon.

The wiring diagrams for the I/O modules fitted are shown on labels attached to the product

Auxiliary module A uses terminals 30-38 and module B uses 40-48.

8.8.1 Alarm Outputs

The 8 alarm contacts can be used for external monitoring of an alarm condition. The alarm contacts can be adapted to the customer's needs using the QDSP configuration software via the communications link.

The alarm contacts share a common connection (see Figure 8-21), but each contact can be individually set. When both I/O modules are used for the alarm contacts, the **M3x5** will provide an additional 16 independent outputs.

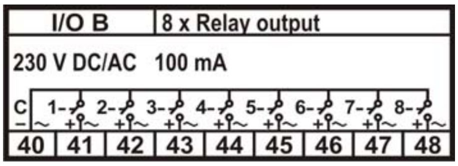


FIGURE 8-21: ALARM CONTACTS

8.8.2 Digital Inputs

The 8 digital inputs are able to read the status of the input. Various voltage values are available. The status of a digital input is defined as one of the 32 alarms available on the product, which can be monitored remotely via the communications.

The digital inputs share a common terminal connection (see figure 8-22). When both I/O modules are used as a digital input, the **M3x5** will provide an additional 16 independent inputs.

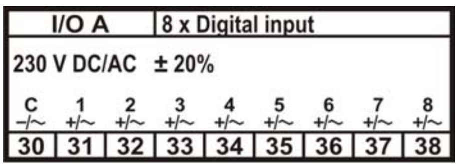


FIGURE 8-22: DIGITAL INPUTS

8.9 Real Time Synchronization module C

A Synchronized real-time clock (RTC) is an essential part of any Class A analyser for proper chronological determination of events. To differentiate cause from consequence, to follow a certain event from its origin to manifestation in other parameters it is very important that each and every event and recorded measurement on one instrument can be compared with events and measurements on other devices. Even if instruments are dispersed, which is normally the case in electro distribution networks, events have to be time-comparable with accuracy better than a single period.

The Synchronisation module is used to synchronise the RTC of the device to a standard which is also used by other related devices. This maintains its accuracy for correct aggregation intervals and time stamps of recorded events appearing in the monitored electro distribution network.

Different types of RTC synchronisation are available:

- IRIG-B modulated; 1 kHz modulation with <1ms resolution.
- IRIG-B un-modulated (level shift)
- 1PPS + RS232 Date & Time telegram (from GPS)

PLEASE NOTE

SNTP synchronisation is also possible via Ethernet communication if the Ethernet communication module is fitted.

8.9.1 GPS time synchronization

1PPS and serial RS232 communication with NMEA 0183 sentence support. GPS interface is designed as 5 pole pluggable terminal (+5V for receiver supply, 1PPS input and standard RS232 communication interface). Suggested GPS receiver is GARMIN GPS18x.

8.9.2 IRIG time code B (IRIG-B)

Un-modulated (DC 5V level shift) and modulated (1 kHz) serial coded format with support for 1PPS, day of year, current year and straight seconds of day as described in standard IRIG-200-04. Supported serial time code formats are IRIG-B007 and IRIG-B127.

Interface for modulated IRIG-B is designed as BNC-F terminal with 600Ω input impedance, and the interface for un-modulated IRIG-B is pluggable terminals.

8.9.3 Simple Network time protocol (SNTP)

Synchronization via Ethernet requires access to an NTP server.

PLEASE NOTE

SNTP can usually maintain time to within tens of milliseconds over the public Internet, but the accuracy depends on infrastructure properties - asymmetry in outgoing and incoming communication delay affects systematic bias. It is recommended that a dedicated network rather than public network is used for synchronisation purposes.

CAUTION

RTC synchronisation is an essential part of a Class A instrument. If adequate RTC synchronisation is not provided the **M3x5** will only operate as a Class S instrument.

8.9.4 Module connections

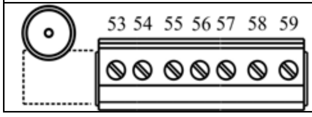
Terminals	Connector type
	BNC for modulated IRIG-B and Pluggable screw terminals for level-shift IRIG-B, GPS modem or serial RS232 or RS485

TABLE 8-4: SYNCHRONISATION MODULE CONNECTORS

Connector	Position	Data direction	Description
BNC connector	600 Ohm input impedance: standard Coaxial cable (55 Ohm) recommended		
Screw terminal	53	1PPS (GPS) or IRIG-B (level shift)	Synchronisation pulse
	54	To/From (A)	RS485
	55	To/From (B)	RS485
	56	To	Data reception (Rx)
	57	GND	Grounding
	58	From	Data transmission (Tx)
	59	+5V	AUX voltage +5V (supply for GPS modem)

TABLE 8-5: SYNCHRONISATION MODULE CONNECTIONS

When modulated IRIG-B signal is used it should be connected to the BNC terminal. When level-shift IRIG-B signal is used it should be connected to 1PPS terminal.

When using a GPS modem the 1PPS signal should be connected to 1PPS terminal and the serial RS232 signal should be connected to RS232 terminals.

More information regarding the use of the Synchronisation module C can be found in section 10.12.

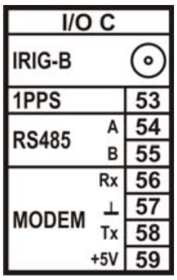


FIGURE 8-23: SYNCHRONISATION MODULE C LABEL

PLEASE NOTE

The communication port on Module C is primarily dedicated to receive serial coded date and time telegram from a GPS receiver in order to synchronise the internal real time clock (RTC). When other methods are used for synchronising the RTC this communication port can be used as a secondary general purpose communication port.
Please note that either RS232 or RS485 should be used and not both at the same time.
Connector terminals that are not used should remain unconnected otherwise the communications may not work correctly.

CAUTION

Max consumption of +5V supply terminal is 100mA. When GPS with consumption greater the 100mA is used it is advisable to use an external power supply.

8.10 Memory Card

The **M3x5** family have a Memory Card slot located on the front display where the Memory Card is inserted, see figure 8-1. Section 11 describes the operation of the Memory Card.

The Memory card slot on **M3x5** will accept a full size SD Card or MultiMediaCard (MMC) with card memory sizes up to 2GB supported.

The Memory Card is only used for transferring data; it cannot be used as an extension to the logging memory of the Meter. Therefore the Memory Card should not be left in the slot in the Meter and the slot cover should be fitted to prevent ingress of moisture and dust.

The Memory card can be used to load the **M3x5** settings and to extract records. This means that the settings can be made off line using **QDSP2** and then loaded on to the product without needing communications.

The options available for the Memory card are fully described in section 11: Memory Card Status, Save Data, Load Settings and Software Update.

Memory Card Status: the **M3x5** can check the status of the Memory card ensuring that it is correctly located in the front slot and that it can be read from and written to.

Save Data: The data from the recording functions, data logger or Power Quality recorder, can be saved to the Memory Card for off line analysis with the **QDSP2** software.

Load Settings: the settings for the **M3x5** are compiled in **QDSP2** using the .msf file suffix. This file can be saved on a computer or onto the Memory Card. The Memory card is then inserted into the **M3x5** and these settings loaded into the **M3x5**. Using the memory card many devices can be programmed quickly with identical settings. The **M3x5** will only load the appropriate .msf file so that the settings from one meter cannot be inadvertently loaded into another inappropriate meter.

Software Update: **QDSP2** has an upgrade function for the **M3x5** firmware. This firmware can be saved onto the Memory Card and then transferred to the **M3x5** so that the meter firmware can be upgraded. This can be performed fastest by using the memory card. New firmware should be transferred to a memory card from the computer once, and then multiple devices can be updated only using the memory card.

PLEASE NOTE
Measurements cannot be directly recorded to a memory card. Only data previously stored in internal memory can be transferred to a memory card.

CAUTION
During firmware update the auxiliary power supply **must not** be interrupted.

9. GETTING STARTED

Due to the complexity the **M3x5** needs to be programmed using the **QDSP2** software. There are many options on the **M3x5** that can only be programmed using the **QDSP2** software.

The basic programming of the **M3x5** can be done using the display and keypad on the device. In addition most of the measurements can be displayed on the LCD, after selection using the keypad.

9.1 Menu introduction

The settings, measurements and functions of the **M3x5** can be accessed from the front panel. The menu structure of the **M3x5** is navigated using the five keys on the front panel shown in figure 9-1:

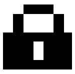
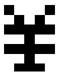
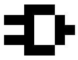
FIGURE 9-1 : M3X5 FRONT VIEW

Throughout this section the following symbols are used to relate to pressing the corresponding key on the front panel.

Key	Left	Right	Down	Up	Enter
Symbol	◀	▶	▼	▲	OK

9.2 Display Icons

During the LCD operation some icons can be displayed in the upper part of LCD. The significance of the icons (from right to left) is explained in the following table.

Icon	*Meaning*
	Device is locked with a password of the second level (L2). The first level (L1) can be unlocked.
	Device could be wrongly connected at 4u connection. Energy flow direction is different by phases.
	The auxiliary power supply of the device supply is too low.
	Clock not set.

The meaning of the icons is also explained on a product display in the Information menu.

9.3 Installation Wizard

After installation and electrical connection, basic parameters have to be set in order to ensure correct operation. The easiest way to achieve that is to use the Installation wizard.

The Installation Wizard is designed to take the user through the minimum functions necessary to install the **M3x5**. By pressing the **OK** key the following functions can be set: Language; Date: Time: Connection Mode: VT Primary: VT Secondary: CT Primary: CT Secondary: Device Address: Communications settings:

Main menu	
Measurements Settings Resets SD card Info Installation	
14.11.2012	16:53:36

When entering the Installation menu (as shown above), settings follow one another when the previous one is confirmed. All required parameters should be entered and confirmed. Exit from the wizard is possible when all required settings are confirmed or with interruption (key ⇐ several times) without changes.

The Installation wizard menu may vary, depending on the built in communication modules. In the description below are defined which menu appears for each specific option.

PLEASE NOTE

All settings that are entered through the Installation wizard can be subsequently changed by means of the Settings menu or via the **QDSP2** software using the communications or a Memory card.

When entering the installation wizard the following display is shown:

Installation
Welcome to the Installation Wizard. Press OK to continue.
⇦ Main menu

The Wizard then routes the user through the following screens.

Language

Set device language.

Date

Set device date.

Time

Set device time. If instrument is connected to one of supported time synchronisation sources, date and time are automatically set.

Connection mode

Choose connection from a list of supported connection modes.

Primary voltage

Set primary voltage of monitored system if a device is connected indirectly by means of a voltage transformer. If device is connected directly to a low voltage enter this value.

Secondary voltage

Set secondary voltage if a voltage transformer is used; set voltage of low voltage network if connection is direct.

Primary current

Set primary current of monitored system if a device is connected indirectly by means of a current transformer. Otherwise primary and secondary current should remain the same.

Secondary current

Set secondary current of current transformer or the value of nominal current if connection is direct.

Common energy counter resolution

Define Common energy counter resolution as recommended in table below, where Individual counter resolution is at default value 10. Values of primary voltage and current determine proper Common energy counter resolution. For detailed information about setting energy parameters see section 10.9.

Table 5: Suggested Common energy counter resolutions

Voltage \ Current	1 A	5 A	50 A	100 A	1000 A
110 V	100 mWh	1 Wh	10 Wh	10 Wh	100 Wh
230 V	1 Wh	1 Wh	10 Wh	100 Wh	1 kWh
1000 V	1 Wh	10 Wh	100 Wh	1 kWh	10 kWh
30 kV	100 Wh	100 Wh	1 kWh	10 kWh	10 kWh *

* − Individual counter resolution should be at least 100

Device address

Set MODBUS address for the device. Default address is 33.

Baud rate

Set communication rate. Default rate is 19200 bits/s. This setting is available only when RS232 / RS485 communication is built in.

Parity

Set communication parity. Default value is “None”. This setting is available only when RS232 / RS485 communication is built in.

Stop bit

Set communication stop bits. Default value is 2. This setting is available only when RS232 / RS485 communication is built in.

IP Address

Set correct IP address of the device. Default setting is 0.0.0.0 and represents DHCP addressing. This setting is available only when Ethernet communication is built in.

TCP Port

Set TCP communication Port. Default value is 10001. This setting is available only when Ethernet communication is built in.

Subnet mask

Set network subnet mask. Default value is 255.255.255.0. This setting is available only when Ethernet communication is built in.

9.4 Display of Device Information

The basic information about the device can be read from the display

A main menu is divided into several submenus with data and information about the device:

Welcome screen

Information

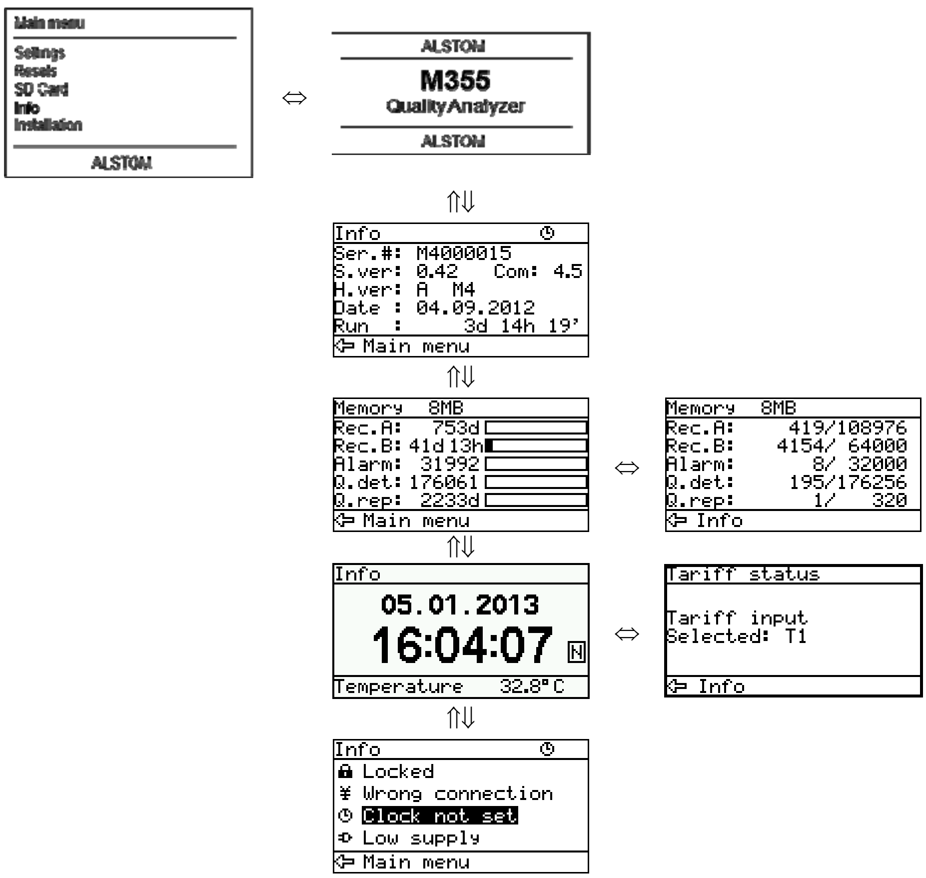
Serial number, Hardware and Firmware version, date of calibration and operational time

Memory

Availability of the internal memory storage: Memory information shows available memory since last official data transfer. If an official data transfer is performed, the device will virtually erase the entire memory. It will set memory counters to zero but it will not overwrite the existing data. This data is still available until the memory space overflows and starts overwriting older data.

Time, date, internal temperature and tariff status

Meaning of icons



10. M3X5 PROGRAMMING

10.1 Introduction

M3x5 settings can be remotely modified using the **QDSP2** software, when connected to a PC, or with the use of the keypad on the **M3x5**.

All settings in the **M3x5** can be modified using the **QDSP2** software, but only the basic settings can be programmed using the keypad and display. The settings that can be modified using the **M3x5** keypad are indicated by (KD) in the sections below.

10.2 QDSP2 Software

QDSP2 is a software tool for complete monitoring of measuring instruments, connected to a PC via serial, USB or Ethernet communication. A user-friendly interface consists of five segments: devices management, instrument settings, real-time measurements, data analysis and software upgrading.

To program the **M3x5** requires **QDSP2** version 2.0 or later.

A separate **QDSP2** manual is available that defines the operation of **QDSP2** in detail.

10.2.1 Devices Management

The communications parameters for any connected device can be modified. Also included are browsers which scan the communications networks attached to the PC and identify all of the devices connected with their addresses and communications parameters. This can be done on RS232, RS485, USB and Ethernet connections.

10.2.2 Instrument settings

The instrument settings are organized in a tree structure and they can be modified simply as required. In addition to transferring settings to the instrument, **QDSP2** can also store the data to settings files and read it back when required.

10.2.3 Real time measurements

All measurements can be displayed in real time in tabular or graphical form. Harmonics and their time-reconstruct signals are displayed graphically.

If further processing of the measurement data is required it can be copied via a clipboard and inserted into standard Windows formats.

10.2.4 Data Analysis

Analysis can be performed on the recorded data in the **M3x5**. Recorded values can be displayed in a tabular or graphical form. The events that triggered alarms can be analysed or a report on supply voltage quality can be made. All data can be exported to an Access database, Excel worksheet or a text file.

10.2.5 Software upgrading

It is suggested that the latest version of **QDSP2** should always be used and if the system is also connected to the internet if can define if an upgrade is available for download.

10.3 Setting Procedure

The Settings can be accessed on the display as shown below.

Main menu	
Measurements **Settings** Resets SD card Info Installation	
14.11.2012	16:53:36

⇨

Settings
General Date & Time Connection Communication LCD Security Energy Inputs/Outputs
⇦ Main menu

In order to modify the settings with **QDSP2** the existing settings must first be loaded. Instrument settings can be acquired via a communications link or they can be loaded off-line from a file on a local disk. The **QDSP2** contains sample settings files for each product variant that can be downloaded to show the range of settings available for the specific product. These files can be modified and then stored under a different name allowing an instrument configuration to be generated off-line without an instrument attached, and downloaded at a later date.

Settings are displayed in the **QDSP2** setting window, the left side displays a hierarchical tree structure of settings, and the right hand part displays the parameter values of the chosen setting group.

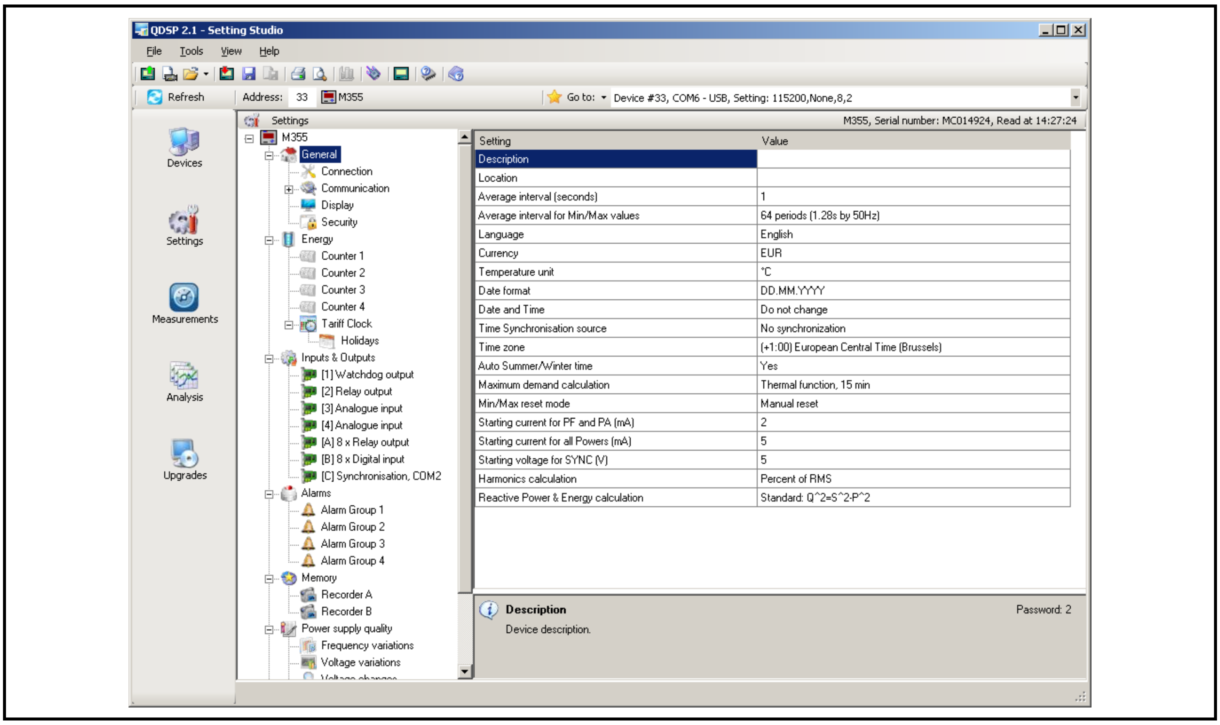


FIGURE 10-1: QDSP2 INTERFACE

10.4 General Settings

General Settings are essential for the operation of the **M3x5**. They are divided into four additional sublevels (Connection, Communication, Display and Security).

10.4.1 Description and Location

These are two parameters that are available for easier recognition of a particular instrument. They allow for the identification or location to be defined where measurements are performed.

10.4.2 Average Interval

The averaging interval defines the refresh rate of measurements on the display, communications and analogue outputs. It also defines the response time for alarms set to Normal response The Interval can be set from 0.1 to 5 s, default value is 1 s.

(KD) **Main menu ⇨ Settings ⇨ General ⇨ Average interval**

10.4.3 Average interval for Min/Max values

The averaging interval for Min/Max values defines the interval on which values will be averaged to track Minimum and Maximum values. By choosing a shorter interval very fast changes in the network will be detected. The Interval can be set form 1 to 256 periods.

PLEASE NOTE
This setting applies only for minimum and maximum values displayed on the LCD and accessible via communications. These values are not used for storing into the internal recorder.

10.4.4 Language

Set language for display. When language is changed from or to Russian, characters of the password are changed too.

(KD) **Main menu ⇨ Settings ⇨ General ⇨ Language**

10.4.5 Currency

Define currency for evaluating energy costs. A currency designation consists of up to 4 letters taken from the English or Russian alphabet and numbers and symbols stated in the table below.

English	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
Symbols		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/	0 to 9			:	;	<	=	>	?	@
Russian	А	Б	В	Г	Д	Е	Ж	З	И	Й	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ
	а	б	в	г	д	е	ж	з	и	й	к	л	м	н	о	п	р	с	т	у	ф	х	ц	ч	ш	щ

(KD) **Main menu ⇨ Settings ⇨ General ⇨ Currency**

10.4.6 Temperature unit

Choose temperature units for display, °C or °F.

(KD) **Main menu ⇨ Settings ⇨ General ⇨ Temperature unit**

10.4.7 Date Format

Set a date format for time stamped actions.

(KD) **Main menu ⇨ Settings ⇨ Date & Time ⇨ Date format**

10.4.8 Date and Time

Set the date and time of the meter; correct setting is important for data recorder operation, maximum values (MD), etc. If the **M3X5** is connected to one of the supported time synchronisation sources, the date and time are automatically set.

(KD) **Main menu ⇨ Settings ⇨ Date & Time**

10.4.9 Real Time Synchronisation source

A synchronized real-time clock (RTC) is an essential part of any Class A analyser for proper chronological determination of various events. To distinguish cause from consequence, to follow a certain event from its origin to manifestation in other parameters it is very important that each and every event and recorded measurement on one device can be compared with events and measurements on other devices. Even if devices are distributed widely, which is normally the case in an electro distribution network; events have to be time-comparable with accuracy better than a single period.

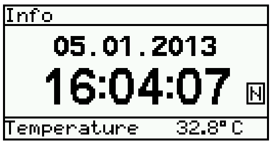
For this purpose devices normally support highly accurate internal RTC, but this is usually not enough, since temperature is location dependant and it influences the precision of the RTC. For that reason it is required to implement periodic RTC synchronization.

CAUTION
RTC synchronisation is an essential part of a Class A instrument. If no proper RTC synchronisation is provided the device operates as Class S instrument.

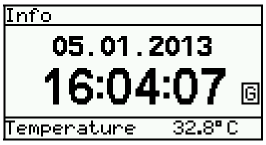
This setting is used to choose primary synchronisation source.

- NO synchronisation (not advisable, see CAUTION above)
- SNTP synchronisation
- MODULE C synchronisation

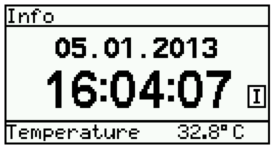
Synchronisation status can be checked on the INFO display of the Clock.



Notification icon ‘N’ shows successful SNTP synchronisation



Notification icon ‘G’ shows successful GPS synchronisation. If only 1pps signal is present (without date and time feed) notification icon ‘g’ is shown’



Notification icon ‘I’ shows successful IRIG synchronisation

10.4.10 Time Zone

Set the time zone in which the device is mounted. The Time zone influences the internal time and time stamps. When UTC time is required, time zone 0 (GMT) should be chosen.

10.4.11 Auto Summer/Winter time

If selected, the time will automatically shift to Winter or Summer time when required.

(KD) **Main menu ⇨ Settings ⇨ Date & Time**

10.4.12 Maximum Demand calculation (MD mode)

The **M3x5** provides maximum demand values from a number of different demand values.

- Thermal Function
- Fixed Window
- Sliding Windows (up to 15)

Thermal function

A thermal function assures exponent thermal characteristic based on simulation of bimetal meters.

Maximum values and time of their occurrence are stored in device. A time constant can be set from 1 to 255 minutes and is 6 times thermal time constant (t. c. = 6 × thermal time constant).

Example:

Mode:	Thermal function
Time constant:	8 min.
Running MD and maximal MD:	Reset at 0 min.

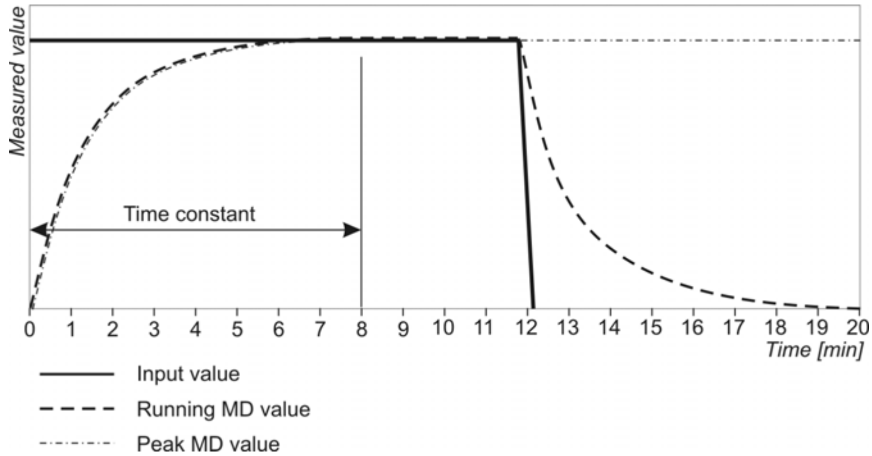


FIGURE 10-2: OPERATION OF THERMAL MD FUNCTION

Fixed window

A fixed window is a mode that calculates average value over a fixed time period. Time constant can be set from 1 to 255 min.

»*Time into period*« as displayed in **QDSP2** actively shows the remaining time until the end of the period in which current MD and maximal MD from the last reset are calculated.

When displays for Pt(+/−), Qt(L/C), St, I1, I2 and I3 are updated, a new period and measurement of new average values are started. »TIME IN A PERIOD« then shows 0 of X min.

A new period also starts after a longer interruption of power supply (more than 1 s). If time constant is set to one of the values of 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 or 60 minutes, »TIME IN A PERIOD« is set to such value that one of the following intervals will be terminated at a full hour. In other cases of time constants, »TIME IN A PERIOD« is set to 0.

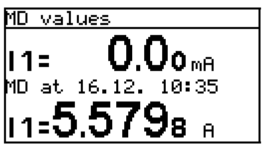


Figure above shows display of MD measurement for current I1. Running MD is displayed (0 mA), max. value of MD since last reset is displayed and its time of occurrence.

Example:

Mode:	Fixed window
Time constant:	8 min.
Running MD and maximal MD:	Reset at 0 min.

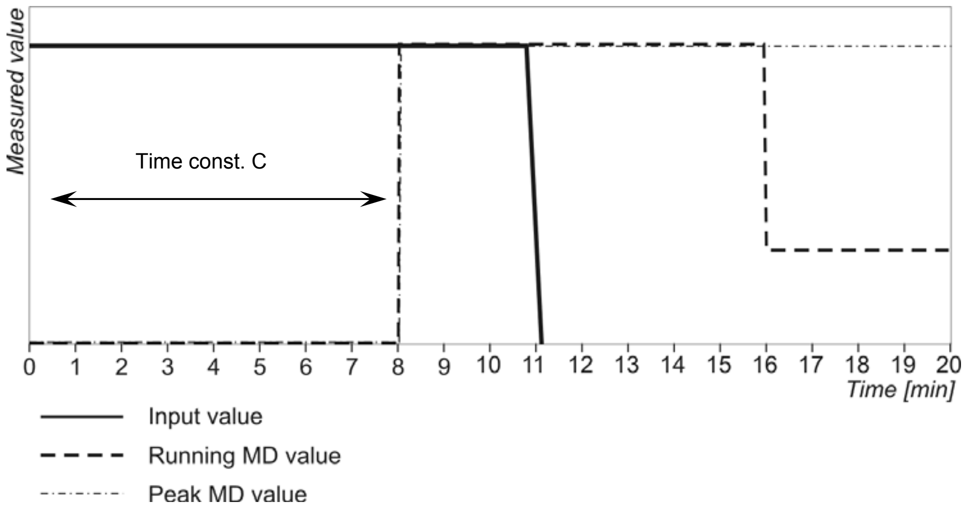


FIGURE 10-3: OPERATION OF FIXED WINDOW MD FUNCTION

Sliding windows

A mode of sliding windows enables multiple calculations of average in a period and thus more frequent refreshing of measuring results. Average value over a complete period is displayed. A running MD is updated every sub-period for average of previous sub-periods.

A number of sub-periods can be set from 2 to 15. A time constant can be set from 1 to 255 minutes.

A new period also starts after a longer interruption of power supply (more than 1 s). If time constant is set to one of the values of 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 or 60 minutes, »TIME IN A PERIOD« is set to such value that one of the following intervals will be terminated at a full hour. In other cases of time constants, »TIME IN A PERIOD« is set to 0.

Example:

Mode:	Sliding windows
Time constant:	2 min
No. of sub-periods:	4
Running MD and maximal MD:	Reset at 0 min.

A complete period lasts for 8 minutes and consists of 4 sub-periods that are 2 minutes long. A running MD and a maximal MD are reset at 0 min. "Time into period" is data for a sub period so that the values for a running MD and a maximal MD are refreshed every two minutes. After 4 sub-periods (1 complete period) the oldest sub period is eliminated when a new one is added, so that average (a window) always covers the last 4 sub-periods.

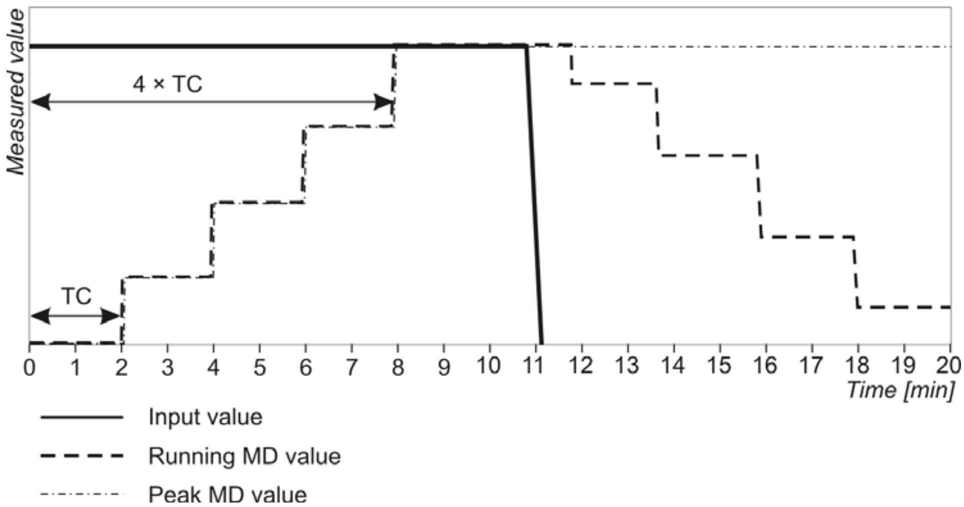


FIGURE 10-4: OPERATION OF SLIDING WINDOW MD FUNCTION

(KD) **Main menu ⇨ Settings ⇨ General ⇨ MD mode / MD time const.**

10.4.13 Maximum Demand Reset mode

Defines how and when the stored Maximum Demand values will be reset.

The reset can either be Manual (see section 10.18) or in Automatic mode (daily, weekly, monthly or yearly reset)

In Automatic mode the resets are performed at the beginning of the defined period at midnight.

- Daily – every day at 00:00
- Weekly – every Monday at 00:00
- Monthly – the first day of the month at 00:00
- Yearly – the first day of the year (1^{st} January) at 00:00

10.4.14 Min/Max Reset mode (KD)

Defines how and when the stored Min/Max values will be reset.

The reset can either be Manual (see section 10.18) or in Automatic mode (daily, weekly, monthly or yearly reset)

In Automatic mode the resets are performed at the beginning of the defined period at midnight.

- Daily – every day at 00:00
- Weekly – every Monday at 00:00
- Monthly – the first day of the month at 00:00
- Yearly – the first day of the year (1^{st} January) at 00:00

(KD) **Main menu ⇨ Settings ⇨ General ⇨ Min/Max reset mode**

10.4.15 Starting Current for PF and PA (mA)

At all measuring inputs noise is usually present. It usually has consistent amplitude and its influence on the accuracy of the measurement increases as the amplitude of the signal to be measured decreases. It is also present when measuring signals are not connected and can give false readings for all subsequent calculations.

By setting a starting current for Total Power Factor and Power Angle, a minimum level is defined where the measurements and calculations commence, reducing the effect of any input noise.

The value for starting current should be set according to conditions in the system (level of noise, random current fluctuation…).

10.4.16 Starting current for all powers (mA)

By setting a Minimum Starting Current, a level is defined where the measurements of Current and calculation of all powers commence, reducing the effect of any input noise.

The value for starting current should be set according to conditions in the system (level of noise, random current fluctuation…).

10.4.17 Starting voltage for SYNC (V)

The device needs to synchronize its sampling with the measuring signals period to accurately determine its frequency. For that purpose, the input signal has to be large enough to be distinguished from the noise.

If all phase voltages are smaller than this (noise limit) setting, the device uses the current inputs for synchronization. If all of the phase currents are also smaller than the Starting current for PF and PA setting, synchronization is not possible and frequency displayed is 0.

The value for starting voltage should be set according to conditions in the system (level of noise, random voltage fluctuation…)

10.4.18 Calculation of Harmonics

The selection of the reference for the calculation of harmonics is important for the calculation of the absolute values. It is possible to select harmonics

- As a percentage of the RMS signal value where a value is calculated for all harmonics
- Or relative to the fundamental (first harmonic) where all other harmonics are calculated relative to the 1st harmonic.

10.4.19 Reactive power and energy calculation

Two different principles of reactive power and energy calculation can be used:

Standard method:

With this method a reactive power and energy are calculated based on assumption that all power (energy) that is not active is reactive.

$Q^2 = S^2 - P^2$

This means also that all higher harmonics will be measured as reactive power (energy).

Displacement method:

With this method, reactive power (energy) is calculated by multiplication of voltage samples and delayed current samples.

$Q = U \times I|_{+90^\circ}$

With this method, reactive power (energy) represents only true reactive component of apparent power (energy).

10.5 Connection

The setting of the connection parameters must reflect the actual applications or the measurements will not be valid.

All of the settings in this section should be defined before the settings for the analogue and alarm outputs, as changes to this section may automatically change the measurements and output settings.

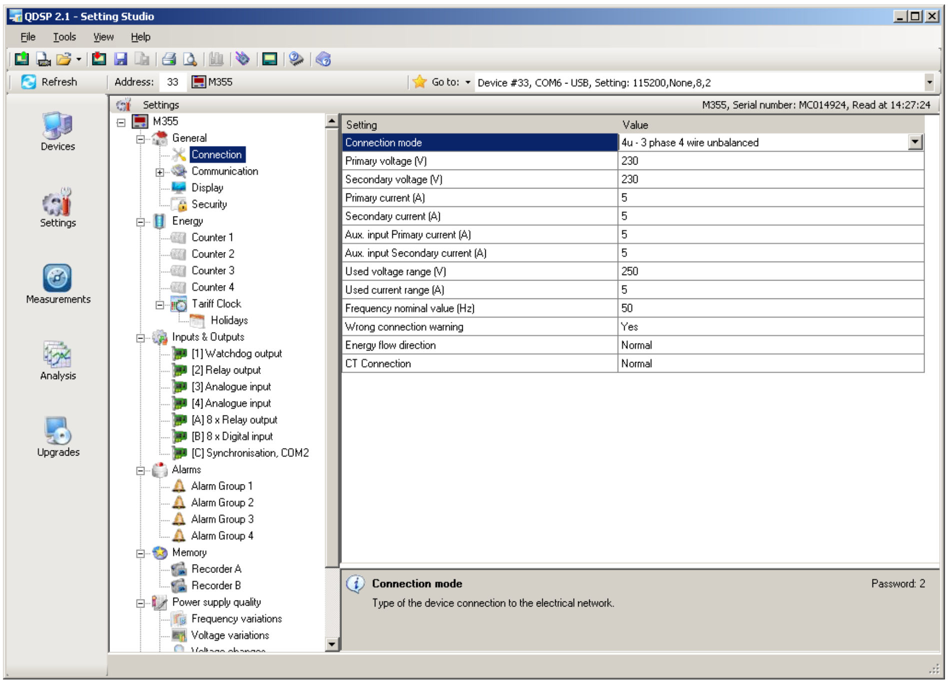


FIGURE 10-5: CONNECTION

10.5.1 Connection

When the connection is selected, the load connection and the supported measurements are defined (see section 12.2).

When the Connection is modified all other settings must be reviewed to ensure that they are still valid for the new Connection selected.

(KD) **Main menu ⇨ Settings ⇨ Connection ⇨ Connection mode**

10.5.2 Setting of current and voltage ratios

The details of the application must be known to define these settings; all other measurements depend on them. Values with up to 5 numerical digits and a maximum of 3 decimal places can be input.

Auxiliary CT transformer ratios can be set separately from phase CT ratios since Auxiliary CT could differ from phase CTs.

Range of CT and VT ratios	VT primary	VT secondary	CT primary	CT secondary
Maximum value	1638,3 kV	13383 V	1638,3 kA	13383 A
Minimum value	0,1 V	1 mV	0,1 A	1 mA

(KD) **Main menu ⇨ Settings ⇨ Connection ⇨ VT/CT/Aux CT**

10.5.3 Used Voltage and Current Range

The setting of this range is connected with the setting of all alarms, analogue outputs and the display (calculation) of energy and measurement recording. Using a value that matches the expected measurement range (with overload) will achieve the highest quality of measurements.

If the ‘Used’ ranges are changed after the analogue or alarm settings have been defined, then the analogue and alarm settings will be modified automatically, as defined below. It may be necessary to modify the settings for the analogue and alarm outputs.

The ‘Used’ ranges are used to set the default scaling for the analogue output, which can be subsequently changed to meet the application requirements. Internally the analogue settings are also stored as a percentage of the ‘Used’ ranges. If the ‘Used’ ranges are subsequently changed the analogue output settings will be correspondingly changed to maintain the settings as the same percentage of the ‘Used’ range.

Although the alarm settings are defined in real values on **QDSP2**, the alarms are also calculated as a percentage of the ‘Used’ range. If the ‘Used’ ranges are subsequently changed the alarm settings will be correspondingly changed to maintain the settings as the same percentage of the ‘Used’ range.

10.5.4 Nominal Frequency

The Nominal frequency can be selected from a list of predefined values. A valid frequency measurement is within ± 30Hz of the nominal frequency.

This setting is only used for alarms and recorders.

10.5.5 Maximum Demand current for TDD

Select maximum current (CT or fuse rating) at a point of instrument connection for proper TDD calculation. Unlike THD, TDD is a measure of harmonics relative to a fixed value of max demand current. Therefore TDD is a demand independent measure of current harmonics.

10.5.6 Wrong connection warning

If all phase currents (active powers) do not have the same sign (some are positive and some negative) and/or if phase voltages and phase currents have mixed signs, the warning will be activated if this setting is set to YES. An icon will appear on the display.

10.5.7 Energy flow direction

This setting allows a manual change of energy flow direction (IMPORT to EXPORT or vice versa) in readings tab.

It has no influence on readings sent to communications or to memory!

10.5.8 CT connection

If this setting is set to REVERSED it has the same influence as if the CT’s were connected in reverse. All power readings will change their sign.

This setting is useful to correct wrongly wired CT connections.

10.6 Communication

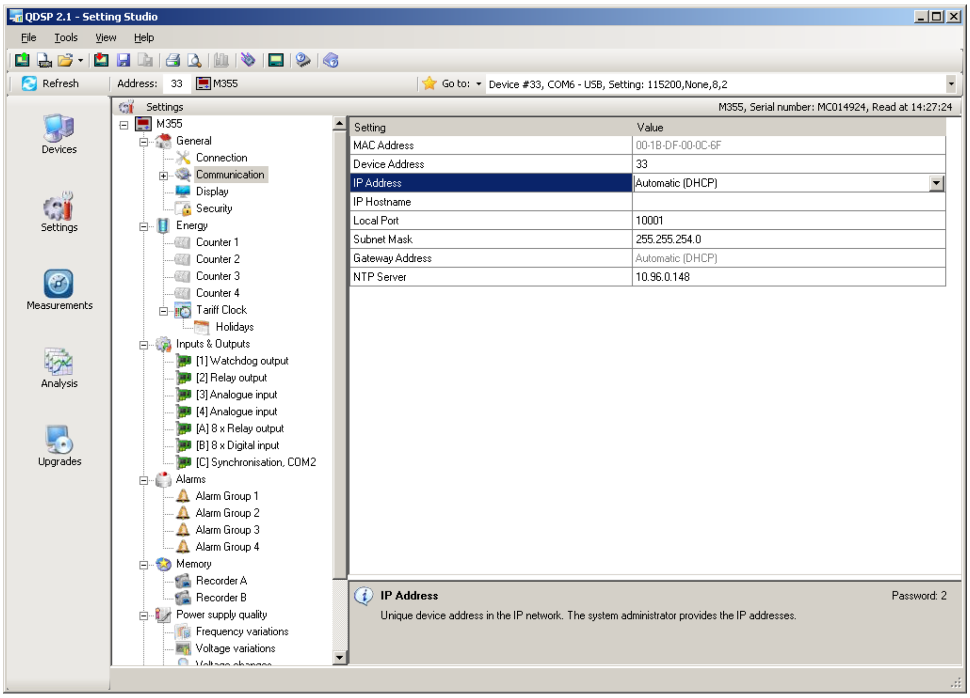


FIGURE 10-6: COMMUNICATION

The settings displayed depend on the communications options on the specific instrument connected or the settings in the specific settings file that is being worked on off-line.

10.6.1 Serial Communication parameters (COM1)

These parameters are important for the correct operation in RS485 networks or connections with PC via RS232 communications.

Factory settings for serial communication are

Device Address	#33	address range is 1 to 247
Comm. speed	19200	speed range is 2400 to 115200
Parity	none	
data bits	8	
stop bits	2	

PLEASE NOTE

Additional settings referring to secondary communication port COM2 via synchronisation module C (in **QDSP2** software) can be found in section 10.12.

(KD) **Main menu** ⇨ **Settings** ⇨ **Communication** ⇨

10.6.2 Ethernet Communication

(KD) **Main menu** ⇨ **Settings** ⇨ **Communication** ⇨ (all settings are not supported on keypad)

10.6.2.1 Device Address (KD)

Device Modbus address is important when the user is trying to connect to the device via **QDSP2** software. Usable range of addresses is from 1 to 247. Default address number is 33.

10.6.2.2 IP address (KD)

The communication interface should have a unique IP address in the Ethernet network. Two modes for assigning IP are available:

- Fixed IP address: In most installations a fixed IP address is required. A system provider usually defines IP addresses. An IP address should be within a valid IP range, unique for your network and in the same sub-network as your PC.
- DHCP: An automatic method of assigning IP addresses (DHCP) is used in most networks. If you are not sure if DHCP is used on your network, check it with your system provider.

10.6.2.3 IP HostName

This is the nickname that is given to the device and it is used in automatic (DHCP) mode only.

10.6.2.4 Local Port (KD)

When using Ethernet communications the device has two open local ports.

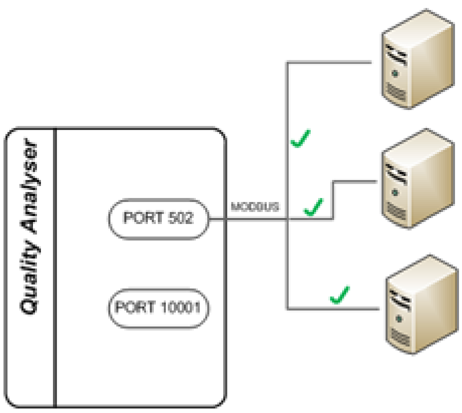
- Fixed port number 502, which is a standard MODBUS port. The device allows multiple connections to this port.
- User defined port. Any port number is allowed except reserved ports (see table below). Only a single connection is allowed to this port. When this port is used all other connections (including connection to port 502) are disabled. This is a terminal type of connection.

Terminal type of connection is used when due to a performed function other connections are not allowed. This is the case when a firmware update is performed. In other cases it is advised to use port 502.

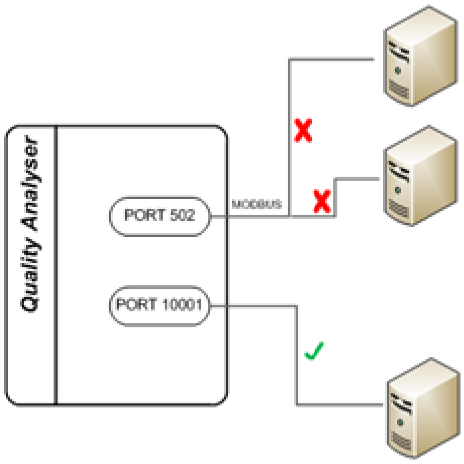
When port 502 is used a remote application(s) can access the device regardless of the setting for Local Port in the device. The Local port setting is applicable only when terminal access is required

For Local port use a non-reserved port number from 1025 to 65535.

Reserved Port numbers	Function
1 – 1024, 9999, 30718, 33333	Reserved numbers
502	Standard MODBUS port - fixed
33333	UDP port used for Device Discovery Service



Multiple connections to a device are possible when port 502 (special MODBUS port) is used.



When any other allowed port is used only a single connection is possible

Port 502

Is the standardized port to communicate with the device via MODBUS/TCP communication protocol and is fixed. Communication via this port allows multiple connections to the device. Communication over this port does not block any other traffic.

Port 33333

This UDP port is reserved for Discovery Service, a service run by the **QDSP2** software, to discover which devices are connected to the local Ethernet communication network.

Other available Ports

Other, allowed TCP ports, act as a terminal port and when connected to it, all other connections (including port 502) are disabled until it is released.

10.6.2.5 Subnet Mask (KD)

It is used to determine what subnet an IP address belongs to.

10.6.2.6 Gateway Address

It is a gateway that connects separate network segments (LAN, WAN or internet).

10.6.2.7 NTP Server

This is the IP address of an NTP server that can be used for time synchronisation of the device.

SNTP can usually maintain time to within tens of milliseconds over the public Internet, but the accuracy depends on infrastructure properties - asymmetry in outgoing and incoming communication delay affects systematic bias.

PLEASE NOTE

It is recommended that a dedicated network rather than public network is used for synchronisation purposes using SNTP.

Factory settings for Ethernet Communications are:

IP Address	DHCP (automatically)
TCP Port	10001
Subnet Mask	255.255.255.0

10.6.3 USB

The **M3x5** will be identified as a USB device when connected to a USB port on the PC. There are no settings for the USB port.

When the device is connected to a PC through USB communication for the first time, the user is prompted to install a driver, refer to the separate **QDSP2** manual for details of the driver installation.

PLEASE NOTE

The **M3x5** supports only a single communication input (USB or Ethernet) at a time when using primary communication port COM1. Priority is USB communication. If communication using Ethernet is in progress, do not connect USB since it will terminate the Ethernet connection. When the USB cable is unplugged from the device the Ethernet communication will be available again.

10.7 Display

10.7.1 Display settings

A combination of the settings of the contrast and back light defines the visibility and legibility of a display. The display settings should be defined depending on the conditions in which it will be monitored. The back light is turned off according to the value of the inactivity timer.

(KD) **Main menu ⇨ Settings ⇨ LCD ⇨ Contrast / Back light / Back light time off**

10.7.2 Demo cycling period

For demonstration purposes it is useful for the device to automatically switch between different measurements displays.

This setting defines the dwell time in seconds for each displayed screen of measurements.

(KD) **Main menu ⇨ Settings ⇨ LCD ⇨ Demo cycling period**

10.7.3 Settings of customized screens

For easier and faster reading of measurements that are important to the user, three different customized screens are available; each customized screen displays three measurements. When setting customized screens the designations are displayed in short form, with up to 4 characters.

Example:

Customized screen 1	Customized screen 2	Customized screen 3	Combined customized screen 4
U1	I_{TOT}	φ_{1-3_RMS}	U1
U_{P-P_avg}	I_{NM}	f	U_{P-P_avg}
$U_{UNBALANCE}$	I_{AVG}	THD-I1	$U_{UNBALANCE}$
-	-	-	I_{TOT}
-	-	-	I_{NM}

PLEASE NOTE

Customized screens defined here are selected in menu

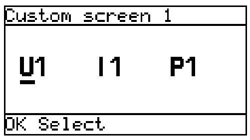
(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Custom**

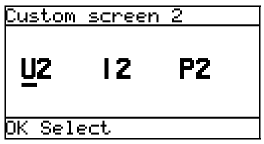
Setting can be made only for 3 customized screens. 4th customized screen shows 5 parameters, three from Customized screen 1 and the first two from Customized screen 2. See example above.

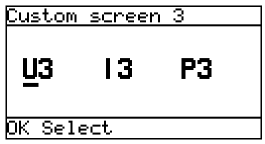
Setting:

(KD) **Main menu ⇨ Settings ⇨ LCD ⇨ Custom screen 1 / 2 / 3 / (4)**

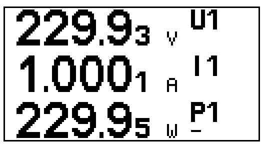
Customized screen 1 Customized screen 2 Customized screen 3



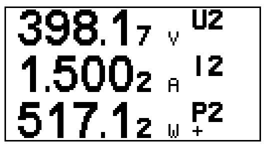




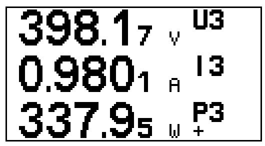
(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Custom**



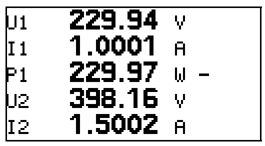
⇔



⇔



⇔



10.8 Security

Parameter settings are divided into 2 groups regarding security level:

1. If the passwords are set to 'AAAA' (default) there is no restriction to the access of parameter settings.
2. Password level 0 (PL0), no password is required and the settings for LCD backlight, contrast and display language can be modified.
3. Password level 1 (PL1), the settings for the real time clock and the reset of the energy registers and MD can be accessed.
4. Password level 2 (PL2), access is given to all parameter settings.
5. Change to the language setting is possible without inputting a password. When language is changed to or from Russian, character transformation has to be taken in to account, see section 10.4.5.
6. A Backup password (BP) is used if the passwords at level 1 (PL1) and level2 (PL2) have been forgotten, and it is different for each device depending on the serial number of the instrument. The BP password is available from the customer support department of Alstom Grid, and is entered instead of password PL1 and/or PL2. The serial number must be supplied when requesting the BP and is defined on the product label, is available via the display or can be read with **QDSP2**.

10.8.1 Password setting

A password consists of four capital letters taken from the British alphabet from A to Z. When setting a password, only the letter being set is visible, while the others are covered with an asterisk.

Two passwords (PL1, PL2) and the time of automatic activation can be set.

(KD) **Main menu ⇨ Settings ⇨ Security ⇨ Password level 1 / Password level 2 / Password lock time**

10.8.2 Password modification (KD)

A password can be modified; however only the password whose access has been unlocked (password entered) can be modified.

10.8.3 Password disabling (KD)

To disable a password previously set, modify the password back to ‘AAAA’.

PLEASE NOTE

A factory set password is "AAAA" at both access levels (L1 and L2). This password does not limit access.

Password and language

Language change is possible without password input. When language is changed from or to Russian, character transformation has to be taken in to account. Character transformation table (English or Russian alphabet) is stated below.

English	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Russian	А	Б	В	Г	Д	Е	Ж	З	И	Й	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ

10.9 Energy

The parameters defining the energy measurement and totalising can be modified. After modifications have been made the energy meters must be reset or all subsequent energy measurements will be incorrect.

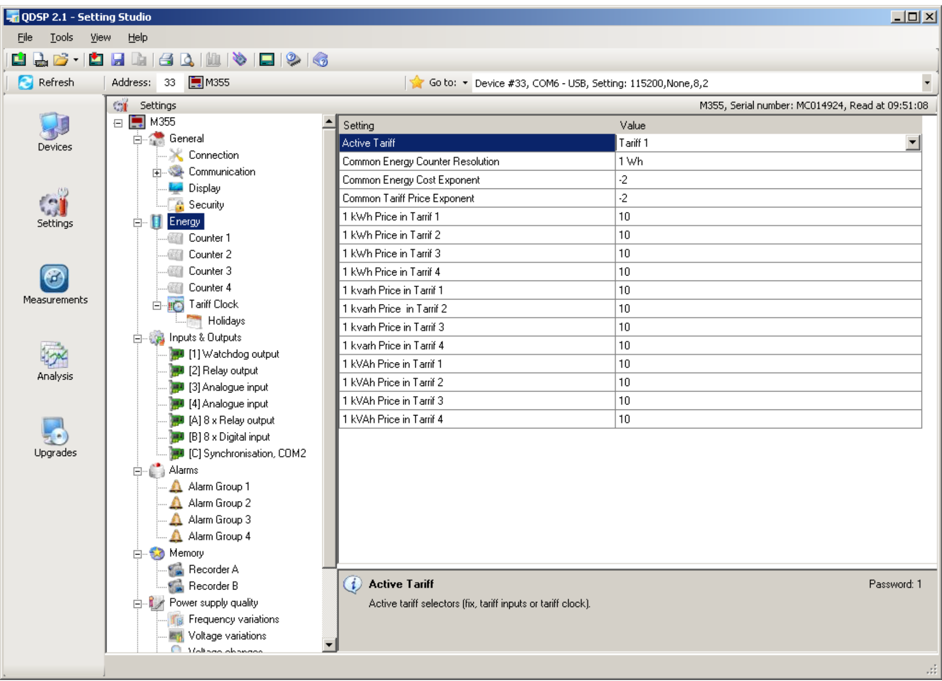


FIGURE 10-7: ENERGY

WARNING

Before modification, all energy counters should be read or if energy values are stored in recorders, recorder should be read with **QDSP2** software or stored on Memory card to ensure data consistency for the old data.

After modification of the energy parameters, the energy meters (counters) should be reset. All recorded measurements from this point back might have incorrect values so they should not be transferred to any system for data acquisition and analysis. Data read before any modification should be used for this purpose.

10.9.1 Active Tariff (KD)

When active tariff is set, one of the tariffs is defined as active, switching between tariffs is done with a tariff clock or a tariff input. For the operation of the tariff clock other parameters of the tariff clock that are accessible only via the communications must be set correctly.

10.9.2 Common Energy Counter Resolution (KD)

The Common Energy Counter Resolution defines the minimum energy value that can be displayed on the energy counter. On the basis of this and a counter divider, a basic calculation factor for energy is defined (-3 is 10^{-3}Wh=mWh, 4 is 10^4Wh = 10 kWh). The Common energy counter resolution also affects the setting of pulse outputs and alarm outputs when the instrument is being used as an energy meter.

The Table below defines recommended values for the Common Energy counter resolution, where the Individual Counter Resolution is at its default value of 10.

Current / Voltage	1 A	5 A	50 A	100 A	1000 A
110 V	100 mWh	1 Wh	10 Wh	10 Wh	100 Wh
230 V	1 Wh	1 Wh	10 Wh	100 Wh	1 kWh
1000 V	1 Wh	10 Wh	100 Wh	1 kWh	10 kWh
30 kV	100 Wh	100 Wh	1 kWh	10 kWh	10 kWh *

* - Individual Counter Resolution should be at least 100

10.9.3 Common energy cost exponent

Defines the number of decimal places used for the energy cost calculation and storage. The cost exponent is used for recording the cost without decimal places.

10.9.4 Common Tarif Price Exponent and Energy Price in Tariffs

The exponent and price represent the energy price (active, reactive, common) in a tariff. The price exponent is used for recording the price without decimal places.

For example, to set a price for tariff 1 to 0.1567 €/kWh, the number in Price for energy in tariff 1 field should be 1567 and Common tariff price exponent should be -4 (1567 x 1E-4 = 0.1567)

10.9.5 Measured Energy

For each of the eight (8) counters different measured quantities can be selected. User can select from a range of predefined options referring to measured total energy or energy on single phase. Or the user can select their own option by selecting appropriate quantity, quadrant, absolute or inverse function.

The Energy counters can operate in all four quadrants; this is chosen using a graphical interface as shown in Figure 10.8.

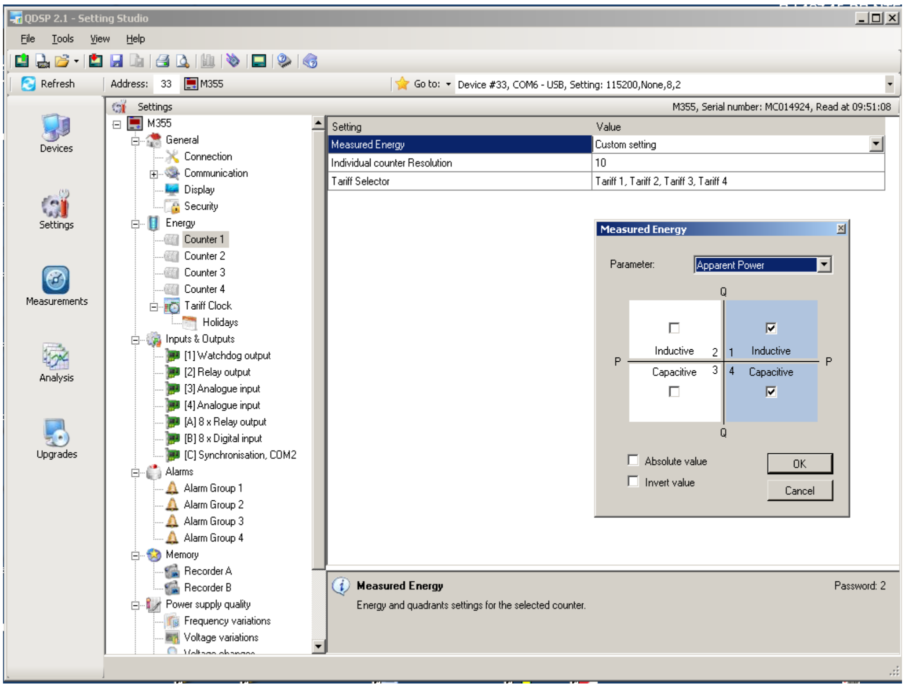


FIGURE 10-8: MEASURED ENERGY

10.9.6 Individual Counter Resolution

The counter divider defines the precision of a specific counter, according to settings of the Common Energy counter Resolution.

An example for 12.345kW of consumed active energy in the first tariff (price 0.1567 €/kWh):

Common Energy Counter Resolution	0	2	2
Individual Energy Counter Resolution	1	1	100
Common energy cost exponent	−2	−3	0
Common tariff price exponent	−4	−4	−4
Price for energy in tariff 1	1567	1567	1567
Unit	EUR	EUR	EUR
Example of result, display	12.345 kWh 1.93 EUR	12.3 kWh 1.934 EUR	0.01 MWh 1 EUR

10.9.7 Tariff selector

The tariffs selected to be applicable to the specified counter can be defined.

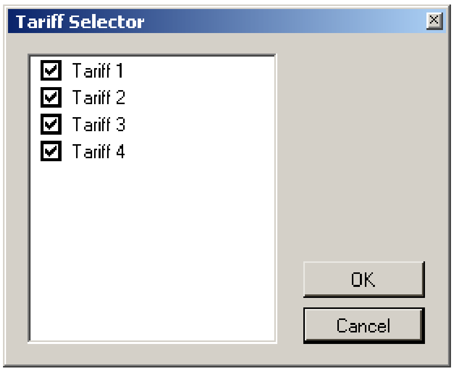


FIGURE 10-9: TARIFF SELECTION

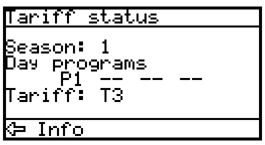
10.9.8 Tariff Clock

Basic Characteristics of the program tariff clock:

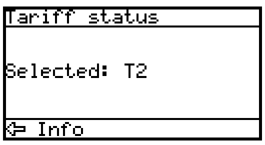
- 4 tariffs (T1 to T4)
- Up to 4 specific times in each day for tariff switching
- A combination of valid days in a week or holidays for each program
- Combining of day groups (use of more than 4 specific times for certain days in a week)
- Separate settings for 4 seasons a year
- Up to 20 settable dates for holidays

Tariff status is displayed in the Info menu.

(KD) **Main menu ⇨ Info**



or



or

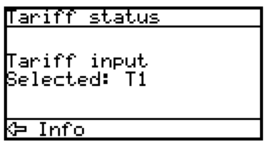


Figure 10-10 shows the **QDSP2** Tariff menu. This enables a full tariff structure with 4 seasons and 4 day groups that are configurable. Within each day or season times can also be specified to show rates within the period. The Holiday sub menu is used to specify tariff holidays.

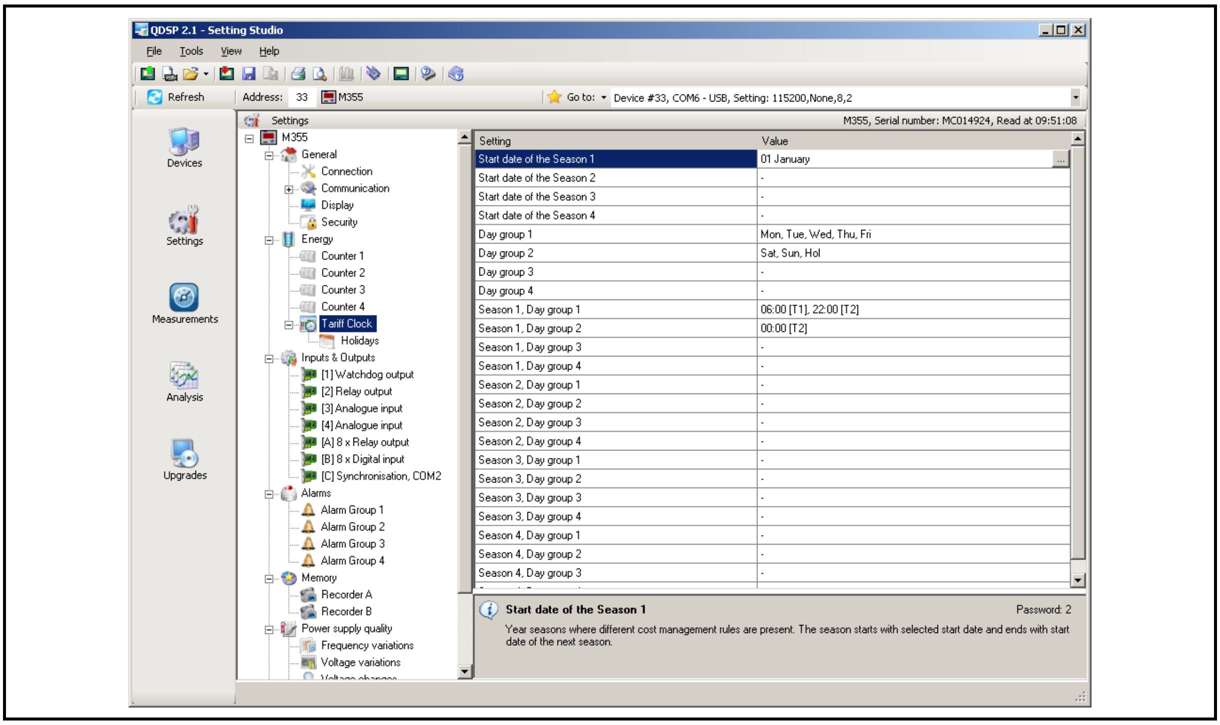


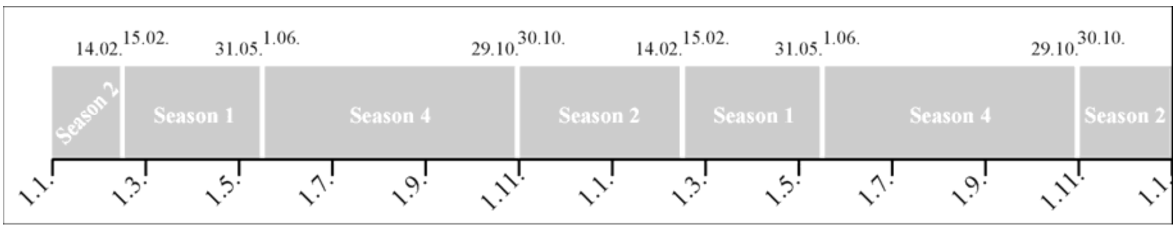
FIGURE 10-10: TARIFF STRUCTURE

The order of seasons and starting dates is not important, except when 2 dates are the same. In that case the season with the highest number will have priority, while the season with a lower number will never be active.

If the actual date is before the first starting date defined for any period, the period with the last starting date becomes active.

Example of settings

Season	Season start day
Season 1:	15.02
Season 2:	30.10
Season 3:	–
Season 4:	01.06
Date	Active season
01.01. – 14.02.	2 (last in the year)
15.02. – 31.05.	1
01.06. – 29.10.	4
30.10. – 31.12.	2



Several daily groups can be active simultaneously, which enables more than 4 time slots in one day (Combination of day programs)

10.10 Inputs and Outputs (Main Modules 1 & 2)

I/O functionality is a powerful tool of the **M3x5** Quality Analyser. Using various I/O modules the device can be used not only for monitoring main electrical quantities but also for monitoring process quantities (temp., pressure, wind speed…) and for various control purposes.

The module settings displayed will depend on the I/O modules built in to the instrument or defined in the settings file if working off-line.

PLEASE NOTE

All modules have double input or output functionality, except the Watchdog output module. All modules with a double input or output are represented as two separate modules in **QDSP2.**

10.10.1 Analogue output module

The analogue output module is useful for control and measurement visualisation purposes. It can be connected to analogue meters, PLC controller, etc. It has the defined output range of 20mA DC. Output parameter and shape (up to 5 break points) of an analogue output can be configured using the **QDSP2** software.

10.10.1.1 Output parameter

Output parameter can be any measured value that is required for monitoring, recording, visualisation or control. The parameter is chosen from a drop-down menu.

10.10.1.2 Output range

The analogue output has a fixed range of 0 – 20mA.

10.10.1.3 Output Signal

This defines the actual range and output curve shape of the required analogue signal. Up to 5 break points can be programmed to achieve the required curve.

Output signal can be adjusted to meet all required purposes.

- Shape of output signal (linear, Quadratic)
- Number of break points for zoom function (up to 5)
- Start and End output value

For improved visualisation of output signal parameters that have been set a graphical representation of the transfer function is displayed.

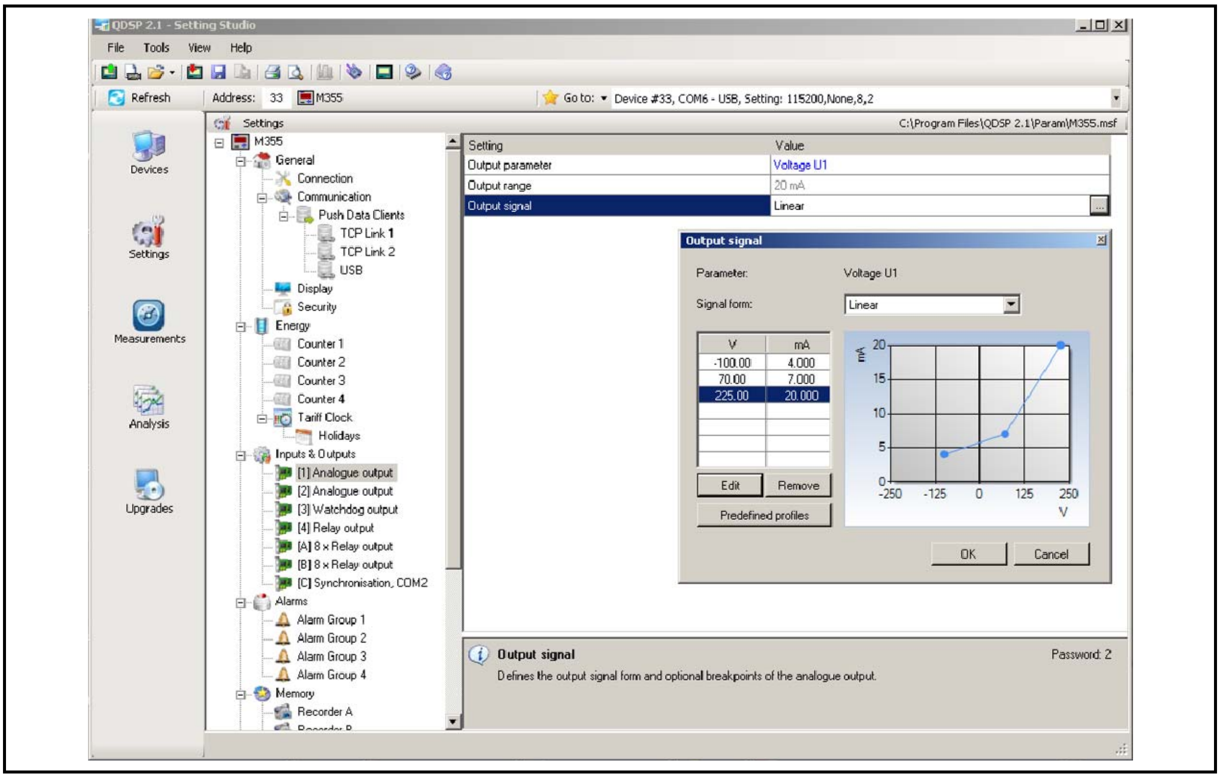


FIGURE 10-11: ANALOGUE OUTPUT SETTINGS

If the Analogue output signal is modified from the full linear range, the accuracy of the output may be reduced due to the reduction in the overall output range.

Note: If the 'Used' voltage and current ranges are changed after the analogue settings have been defined, then the analogue settings will be modified automatically, see section 10.5.3. It may be necessary to subsequently modify the settings for the analogue outputs.

10.10.2 Alarm/Digital Output Module (KD)

If a Digital output is defined as an Alarm output, its activity (trigger) is connected to the Alarm groups. Multiple alarm groups can be attached to it and different signal shapes can be defined.

An alarm module can also function as a pulse output with limited pulse length (min 10ms) or a general purpose digital output. The settings for the pulse option are defined in the same way as for the pulse module. A parallel RC filter with a time constant of at least 150 µs (R*C ≥ 250 µs) should be fitted when connected to a sensitive pulse counter, to attenuate the relay transient signals.

10.10.2.1 Output signal

The alarm/digital output can be configured for a number of different signal shapes:

- Normal − A relay is closed as long as condition for the alarm is fulfilled.
- Normal inverse − A relay is open as long as condition for the alarm is fulfilled. After that relay goes to closed state
- Latched − A relay is closed when condition for the alarm is fulfilled, and remains closed until it is manually reset.
- Latched inverse − A relay is open when condition for the alarm is fulfilled, and remains open until it is manually reset.
- Pulsed − an impulse of the user set length is activated always when condition for the alarm is fulfilled.
- Pulsed inversed – Normally relay is activated. An impulse of the user set length deactivates it always when condition for the alarm is fulfilled.

- Always switched on / off (permanent) – A relay is permanently switched on or off irrespective of the condition for the alarm (general purpose digital output functionality).

For more information on Alarms see section 10.13.

10.10.3 Pulse Output Module (KD)

The pulse output module is either defined to an Energy counter or it can be used as an alarm output with limited current load (max 20mA).

When used as a pulse output the number of pulses per energy unit, pulse length and the tariffs in which the output is active are set.

Pulse parameters are defined in EN 62053-31, and the following is a simplified rule that satisfies the specification, where ‘e’ is multiplier.

$$1{,}5\ldots15\ \mathrm{eW} \rightarrow 100\ \mathrm{p}/1\ \mathrm{eWh}$$

Examples

Expected power	→	Pulse output settings
150 − 1500 kW	→	1 p/1kWh
1,5 − 15 MW	→	100 p/1MWh
15 − 150 MW	→	10 p/1MWh
150 − 1500 MW	→	1 p/1MWh

10.10.4 Tariff input module

There are no settings for the tariff input; they operate by setting the active tariff. With two tariff inputs available a maximum of 4 tariffs can be selected.

Active tariff	Signal presence on tariff input	
	Input T1/T2	Input T3/T4
Tariff 1	0	0
Tariff 2	1	0
Tariff 3	0	1
Tariff 4	1	1

10.10.5 Digital Input module

Purpose is to collect digital signals from various devices, such as intrusion detection relay, different digital signals in transformer station, industry etc.

There are no settings for the digital input; they operate by acting as an input to the Alarms 1 to 32. The input therefore can be used to trigger a software alarm and is available via the communications and can be stored in the alarm data recorder.

10.10.6 Watchdog Output (and Relay output) module

The Watchdog and relay module is a combination of two functionalities. One output is used for Watchdog functionality, the other acts as a Relay output module.

The Watchdog detects potential malfunction of the **M3x5** or auxiliary power supply failure. This module can be set for normal operation (relay in closed position) or for test purposes to open position (manual activation). After test the module should be set back to normal operation.

10.10.7 Analogue Input module

Three analogue input options are available for acquisition of low voltage DC signals from external sensors. According to the application requirements it is possible to choose current, voltage or resistance (temperature) analogue input options. They all use the same input terminals.

QDSP2 allows setting of an appropriate calculation factor, exponent and required unit for representation of primary measured value (temperature, pressure, flux, etc.)

DC current range:

Range setting allows bipolar ±20 mA input value

DC voltage range:

Range setting allows bipolar ±10 V input value

Resistance / temperature range:

Range setting allows 2000Ω or 200 Ω maximum input value.

It is also possible to choose temperature sensor (PT100 or PT1000) with direct translation into temperature (-200°C to +850°C). Since only two-wire connection is possible it is recommended that the wire resistance is also set, when long leads are used.

The measured input can be used to set alarms, as value for analogue output, is available via communications and can be stored in the data recorder.

10.11 Inputs and Outputs (Auxiliary Modules A & B)

The **M3x5** is also equipped with two auxiliary I/O slots. The main difference in functionality between the main and auxiliary I/O modules is in response time. Digital inputs and outputs in the auxiliary I/O modules do not have as fast a response time as those in the main I/O modules.

The module settings displayed will depend on the I/O modules built in to the instrument or defined in the settings file if working off-line.

The status of the built in I/O modules can be monitored also via the LEDs on the front panel of the device.

10.11.1 Digital input module (8 channels)

The module has no settings. The purpose of the module is to collect digital signals from various devices, such as (intrusion detection relay, different digital signals in transformer station, industry…).

The digital inputs can also trigger a software alarm. For more information on Alarms see section 10.13.

The state of the digital inputs can also be monitored for control purposes by reading the appropriate MODBUS registers.

10.11.2 Relay output module (8 channels)

The Relay output module is a relay switch. Its main purpose is to be used as an alarm output.

For the Relay output module in Auxiliary I/O modules A & B, only a single alarm can be connected to each output, whereas with the Relay output module in Main I/O module 1 or 2, a combination of alarm groups can be connected to each output to trigger it.

For more information on Alarms see section 10.13.

10.12 RTC Synchronization module C

In order to use Module C for synchronisation purposes it has to be defined as a synchronisation source.

CAUTION

RTC synchronisation is an essential part of a Class A instrument. If no proper RTC synchronisation is provided the device operates as a Class S instrument.

Quality Analyzer **M3x5** supports three types of RTC synchronization:

- GPS time synchronisation (via Synchronisation module C)
- IRIG-B time synchronisation (via Synchronisation module C)
- SNTP time synchronisation (via Ethernet)

Instructions regarding connection of Synchronisation module C can be found in section 8.9.

PLEASE NOTE

Serial communication built into Synchronisation module C can, under certain conditions, be used as an independent secondary communication.

10.12.1 GPS time synchronization

For proper GPS synchronisation two signals are required.

- 1PPS with TTL voltage level and
- NMEA 0183 coded serial RS232 communication sentence

GPS interface is designed as 5 pole pluggable terminal (+5V for receiver supply, 1PPS input and standard RS232 communication interface).

Proposed GPS receiver is GARMIN GPS18x

PLEASE NOTE

When connecting a GPS modem to the serial RS232 communication interface please take into consideration the required communication parameters. For the proposed GPS receiver the default communication speed is 4800 b/s.

10.12.2 IRIG time code B (IRIG-B)

Un-modulated (DC 5V level shift) and modulated (1 kHz) serial coded format with support for 1PPS, day of year, current year and straight seconds of day as described in standard IRIG-200-04.

Supported serial time code formats are IRIG-B007 and IRIG-B127.

10.12.3 Serial communication (COM2)

If the **M3x5** uses RTC synchronisation over SNTP server (via Ethernet module), IRIG-B or only 1PPS without date synchronisation, the serial communication port of RTC Synchronisation module C is free to be used as a secondary communication port COM2.

Either RS232 or RS485 communication can be used, but not both at the same time. COM1 and COM2 are completely independent and can be used for the same purpose and at the same time.

Module settings define parameters, which are important for the operation in RS485 network or connections with PC via RS232 communication.

Factory settings for serial communication COM2 are

- Device Address#33 (address range is 1 to 247)
- Comm. speed 4800 (speed range is 2400 to 115200)
- Parity none
- Data bits 8
- Stop bits 2

PLEASE NOTE

By default, addresses of COM1 and COM2 are the same (#33). When COM1 and COM2 have the same address any change of COM1 address sets COM2 to the same address. When COM1 and COM2 have different addresses, change of COM1 address has no influence on COM2 address. A change of the COM2 address never has an influence on COM1 address.

10.13 Alarms

There are 32 software alarms available split into 4 alarm groups.

Alarm condition can be set for any measured quantity, also for quantities measured on analogue inputs or signals from digital inputs.

Alarms can trigger different actions according to their settings:

- Visual (alarms cause alarm LED to light)
- Sound (alarms can cause audible indication)
- Relay switch (alarms can switch digital outputs on main and aux. I/O modules)

The alarm status can also be stored in the Recorder.

CAUTION

New values of alarm settings are calculated as a percentage. Whenever any of the connection settings are changed ensure that the alarm values set are still correct.

10.13.1 Alarm statistics reset

This setting is only for the online alarms statistics displayed in the **QDSP2** software which can show graphically the frequency that alarms occur.

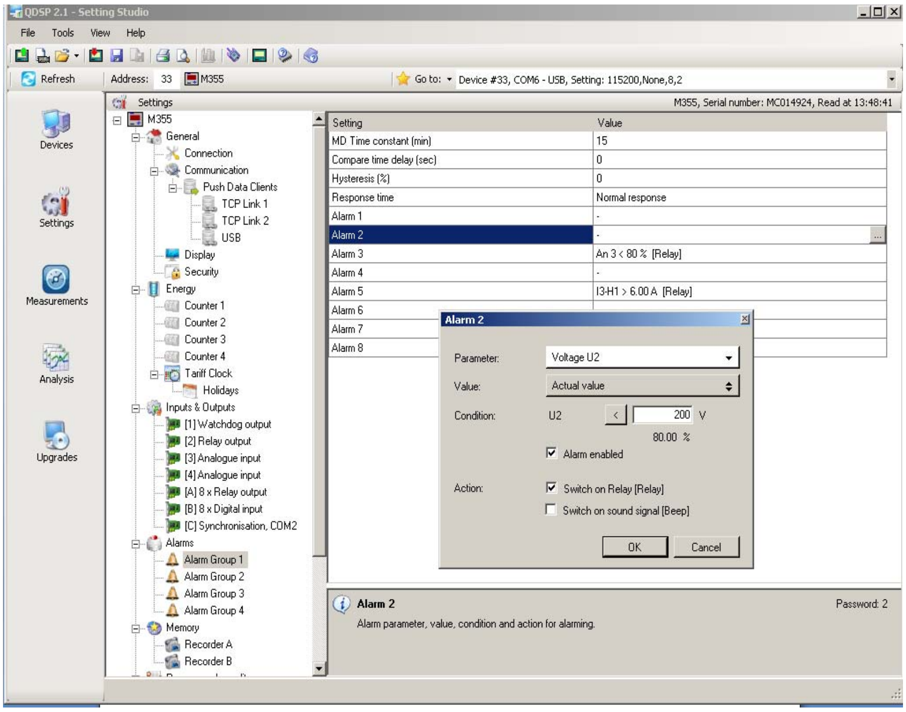


FIGURE 10-12: QDSP2 ALARM SETTINGS

10.13.2 Alarm Group settings

M3x5 supports recording and storing of 32 alarms that are divided into 4 groups of 8 alarms. Each group of alarms has some common settings applicable for all alarms within the group.

10.13.2.1 MD Time constant

Sets a thermal mode maximum demands time constant for the alarm group.

When monitoring a quantity it is possible to monitor its actual value or its maximum demand value. If the latter is chosen then a time constant for calculation of the thermal mode maximum demand value should be set.

This setting is for alarm purposes only and is independent of maximum demand calculation settings for monitoring and recording purposes.

10.13.2.2 Compare time delay

This setting defines the delay time (if required) between satisfying the alarm condition and alarm activation. If the alarm condition exists or a shorter time than the delay defined, the alarm will not be triggered.

This setting is used to remove sporadic and very short duration events.

10.13.2.3 Hysteresis

This setting defines the alarm deactivation hysteresis.

When a monitored quantity is close to the defined alarm value small variations can generate numerous alarms. Hysteresis should be set according to the expected variation of the monitored quantity.

10.13.2.4 Response time

This setting defines the alarm response on measured quantity.

- Normal response: In this case the monitored quantity is averaged according to display averaging settings (0.1 to 5s).
- Fast response: In this case the alarms react on non-averaged measurements (1 signal period).
    - o This setting should be used according to the required functionality. Fast response is more prone to glitches and transient effects in a system but reaction time is fast.

10.13.3 Individual Alarm settings

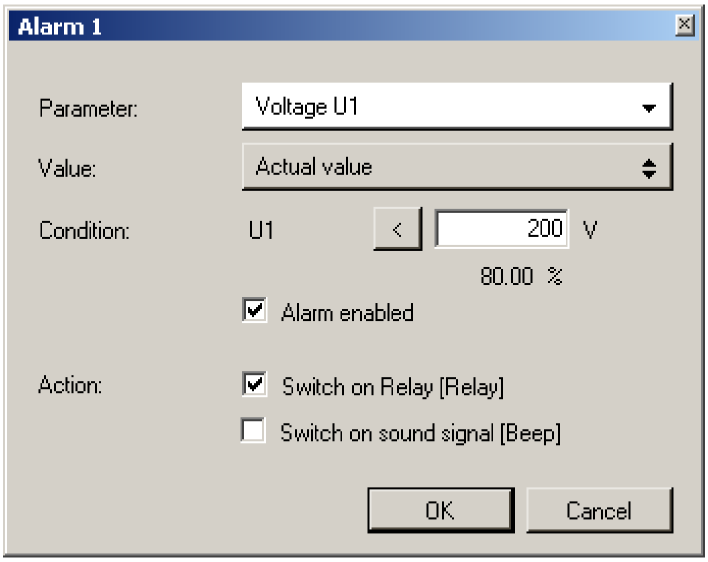


FIGURE 10-13: ALARM SETTINGS

For each individual alarm a parameter, value (actual value or MD thermal) and the condition for alarm switching are defined. In addition it is defined if a relay is to be switched and a beep on alarm.

Note: If the 'Used' ranges are changed after the alarm settings have been defined, then the alarm settings will be modified automatically, see section 10.5.3. It may be necessary to subsequently modify the settings for the alarm outputs.

If a digital input module is fitted to the unit, then the status of the input can be defined as the parameter.

10.13.3.1 Parameter

This setting defines a quantity that should be monitored. It is also possible to select process quantities from I/O modules.

10.13.3.2 Value

For chosen monitoring parameter an actual value or MD value should be set.

10.13.3.3 Condition

It is a combination of a logical operator “Higher than” or “Lower than” and a limit value of the condition. For digital input it is possible to set condition as “Is high” or “Is low”.

10.13.3.4 Action

This section consists of checkboxes that apply different functions to individual alarms.

Switch on Relay checkbox can be selected if user wants this alarm to trigger output(s) that are connected to its group of alarms (pulse or relay output module). This action only applies to I/O modules 1 and 2. To relay outputs of I/O module A or B only a single alarm can be attached. In this case Switch on Relay setting has no influence.

Switch on sound signal checkbox activates the built in beeper if this alarm is active.

Alarm enabled checkbox, activates alarm setting.

10.13.3.5 Types of alarms

Visual alarm: When alarm is switched on, a red LED on the device front side blinks.

Audible alarm: When alarm is switched on, an audible alarm is given by the device (a beep). It can be switched off by pressing any key on the front plate

Alarm output (pulse) – setting made for I/O module 1 and 2: According to the alarm signal shape the output relay will behave as shown below.

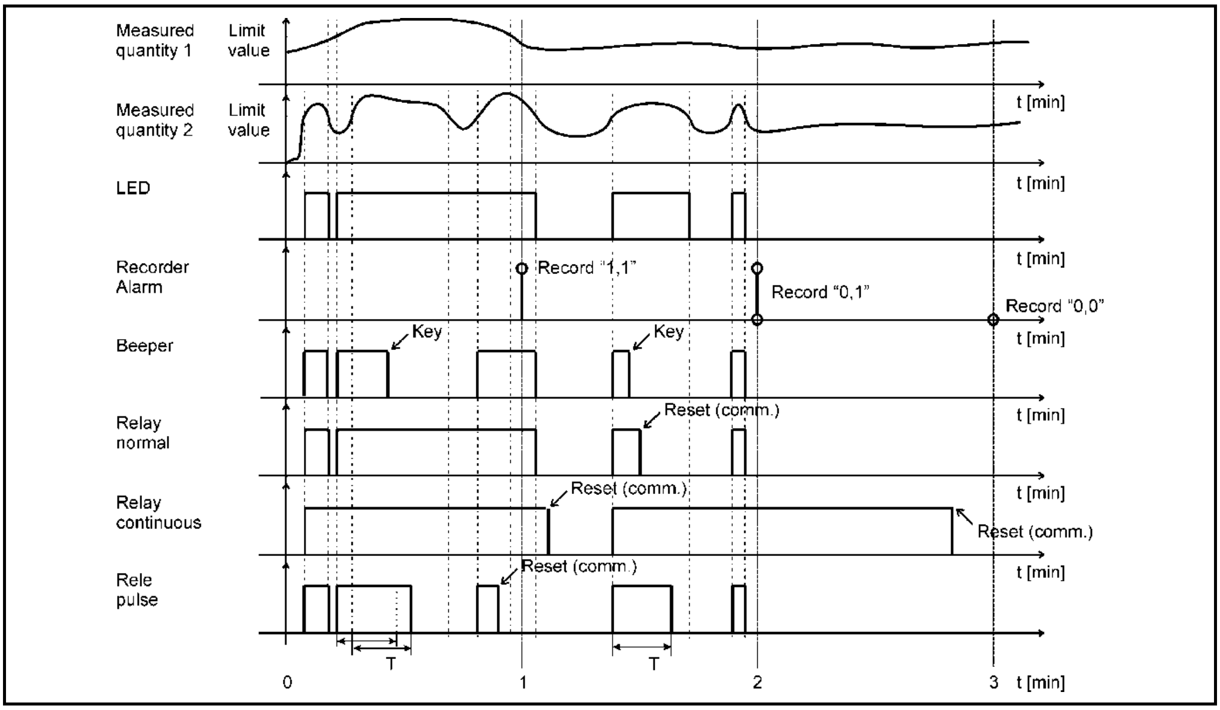


FIGURE 10-14: ALARM OUTPUTS

10.14 Internal Memory

Measurements, alarms, reports and details of supply voltage quality can be stored in the 8MB of internal memory on the **M3x5**. 2MB of the memory is reserved for the storing of EN 50160 compliant PQ reports with details, with capacity to store records for a period greater than 12 months. All records stored in memory are accessible by communication or memory card and can be displayed with the **QDSP2** software.

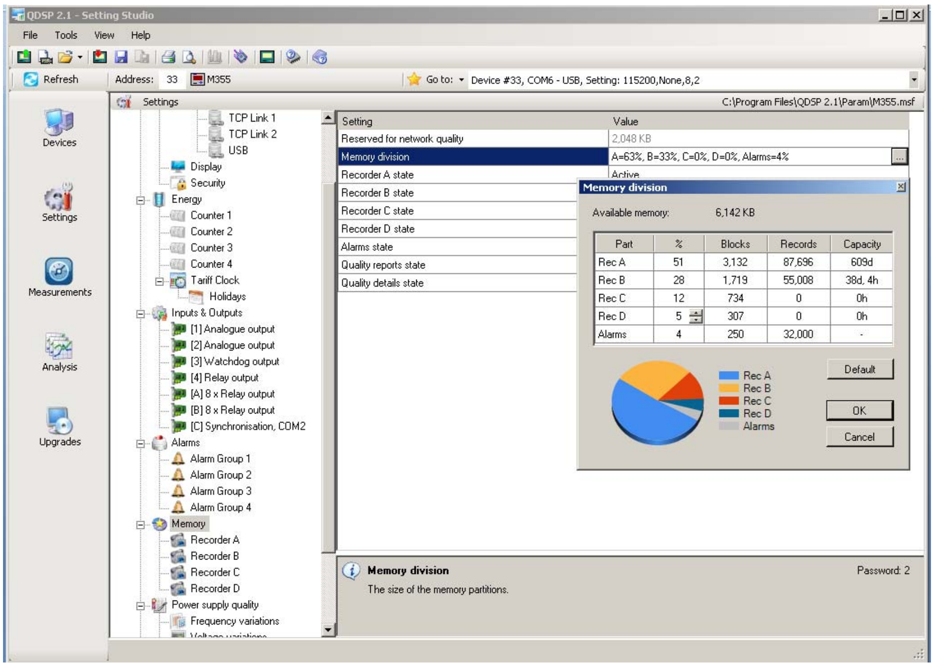


FIGURE 10-15: MEMORY SETTINGS

10.14.1 Memory division

The **M3x5** internal memory has 8MB of total memory space. It is divided into 5 partitions whose size is defined by the user and 2 fixed partitions.

User defined partitions are A, B, C and D recorders that are intended for recording of measurements (each recorder can store up to 32 parameters), while all alarms that occur are recorded in an alarm partition. The size of the user defined partitions can be changed as shown in Figure 10-15.

The 2 fixed partitions are dedicated for recording PQ reports and details.

10.14.2 Memory operation

The memory functions in a cyclic mode in compliance with the FIFO method. This means that if necessary the oldest records will be deleted to allow the latest records to be stored.

The length of time that data can be stored in each of the recorders depends on the amount of memory allocated, the storage period and the number of channels enabled in the recorder.

The storage available in the recorders can be viewed (Memory Info button) as below.

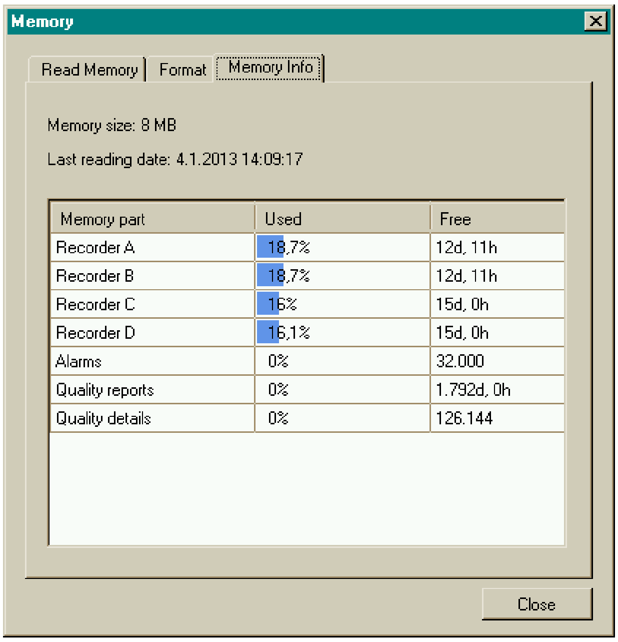


FIGURE 10-16: MEMORY INFO FORM

10.14.3 Memory clearing

There is usually no need to clear the memory as it works in cyclic mode in FIFO method with the oldest records being overwritten when new records are stored. If the memory needs to be cleared follow the steps below:

- Read the instrument readings with **QDSP2** and set "Recorder state" in Memory to 'stopped' for all recorders to be cleared and download the settings to the meter.

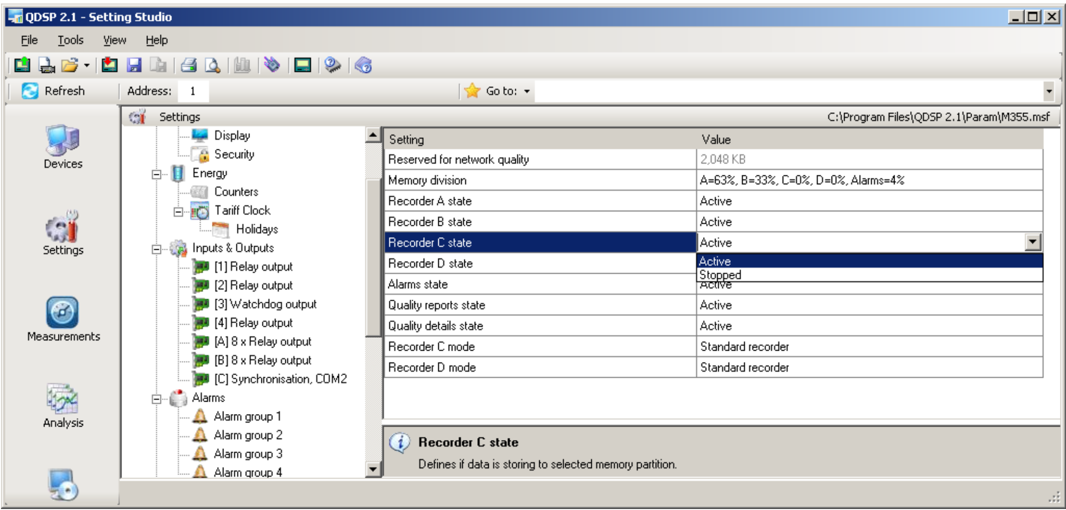


FIGURE 10-17: ENABLING OR DISABLING DATA STORAGE

- Open the Memory info form and click on the Format tab.
- Select the memory partitions to be cleared and click Format.
- Set "Recorder state" setting back to 'Active' for each of the recorders.

CAUTION

It is strongly advised to download recorder data before applying any changes to recorder settings or changes of settings for energy, type of connection, current and voltage transformer settings and used current and voltage ranges. These changes might have an impact on the recorded history so the data might no longer be valid.

10.15 General Purpose Recorder

The general purpose recorder consists of 4 partitions (A, B, C and D). The general purpose recorder does not include the alarm recorder or the PQ reports and details recorder.

These four recorder partitions are independent from each other and each can be configured to record up to 32 different values in each partition.

Recorders C and D can be user defined as a standard trend recorders (like recorders A and B) or can be defined as dedicated harmonic recorders. As such they will record all 63 harmonics, voltage or current depends on user setting for each of those two recorders. Settings are available in general tab of Standard recorders section (see figure 10-17).

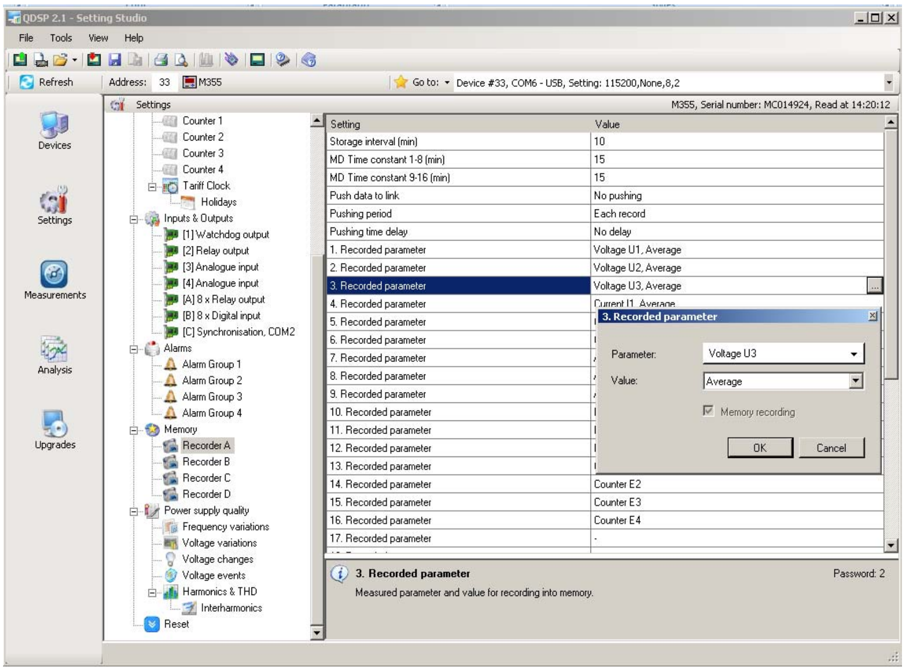


FIGURE 10-18: DATA RECORDER

10.15.1 Storage interval

The storage interval sets a time interval for readings to be recorded. This can be different for each recorder partition.

10.15.2 MD Time constant

When maximum demand values are to be recorded, this setting sets a period for calculation of maximum and minimum value in thermal mode (Minimum (MD) or Maximum (MD)). Different parameters can be set for Recorded parameters 1-8, 17-24 and 9-16, 25-32. This setting is only available for recorders A and B.

10.15.3 Recorded quantities

For each measurement to be recorded it is possible to set the required quantity and its type.

Parameter
The required monitoring quantity can be selected from a list of supported measurements. Besides the primary electrical quantities, auxiliary quantities from the input modules can also be selected.

Value
The type of the selected quantity to be recorded can be defined.

- **Minimum and Maximum** value represents minimum or maximum of the recorded averaged values within the selected storage interval. Note that the minimum and maximum values are not single period values but an average (0.1 s to 5 s).

- **Minimum (MD) and Maximum (MD)** value represents the calculation of a MD value with applied thermal function. This only applies to recorders A and B
- **Average** value represents the calculated average value within the selected storage interval
- **Actual** value represents the first momentary value within the selected storage interval. Note that momentary values are not a single period value but an average (0.1 s to 5 s). This only applies to recorders C and D.
- **Minimum and Maximum (Period)** values represent the minimum or maximum values within the selected storage interval calculated in a single period. This function allows recording of very fast changes. It only applies to recorders C and D.

10.16 Power Quality Recorder Report

The **M3x5** has a power quality measurement function that monitors compliance to the European standard EN50160. The power quality features can be set on the **M3x5** and this then determines when data reports are ready to be communicated. **QDSP2** is then used to extract and display the reports.

10.16.1 Conformity of Voltage with EN 50160 Standard

The EN 50160 standard deals with the voltage characteristics of electricity supplied by public distribution systems. It specifies the limits of values of voltage characteristics in normal operation within public low or medium voltage distribution networks. Following this definition the **M3x5** Power Quality Analyzer is designed for monitoring voltage characteristics of a distribution system according to the EN 50160 standard. Together with setting and monitoring software **QDSP2** voltage characteristics can be monitored and weekly reports about power quality can be issued.

Based on the requirements stated in the standard, default parameters are set in the **M3x5** according to which supervision of all the required characteristics is performed.

Individual parameter settings can also be changed to suit customer requirements.

CAUTION

Factory default settings for Power Quality characteristics are in compliance with standard EN 50160. By changing individual parameters conformity of weekly reports with this standard is no longer valid.

10.16.2 Power Supply Quality

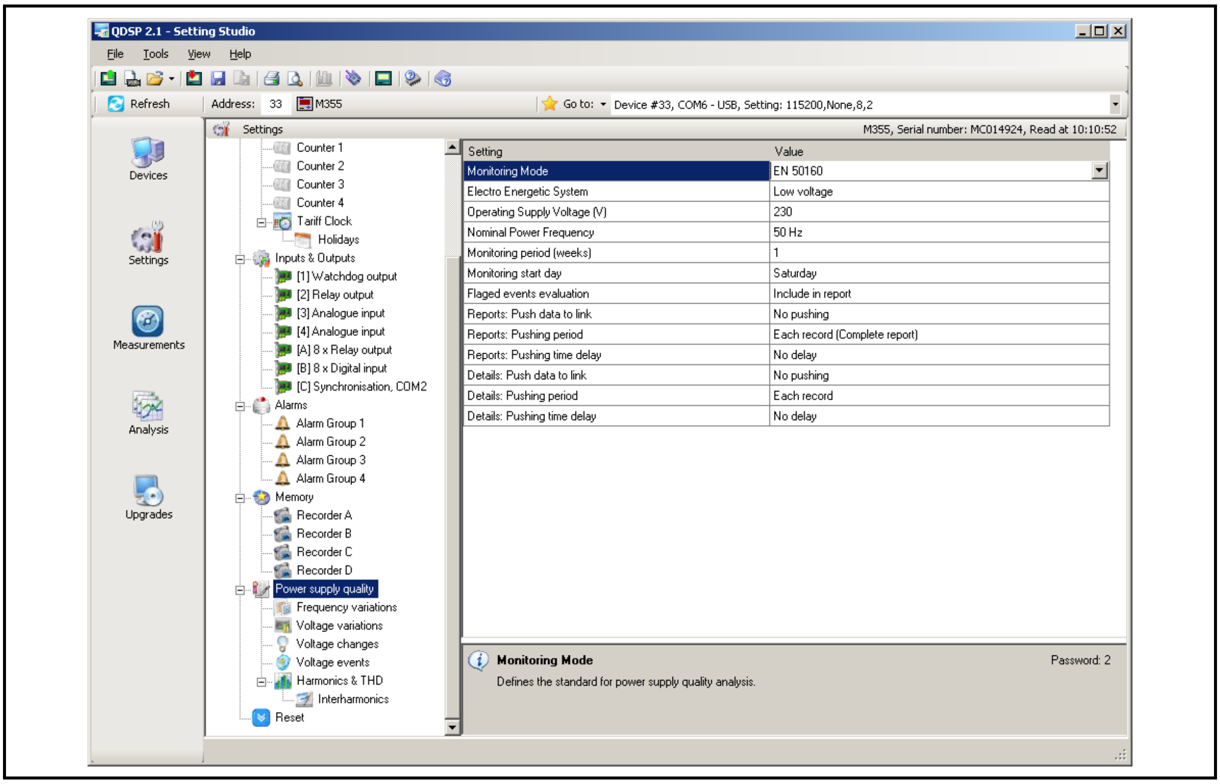


FIGURE 10-19: GENERAL POWER QUALITY SETTINGS

Basic parameters are defined that influence other settings

10.16.2.1 Monitoring mode

Monitoring mode can be set to:

- EN50160: Monitoring according to EN 50160 enabled. Weekly reports are issued according to set parameters
- No monitoring: Weekly reports for network compliance with the standard are disabled

10.16.2.2 Electric energetic system

The requirements for PQ monitoring differ according to the type of public distribution system being monitored. Therefore it is essential to choose the proper type. This setting influences some of the predefined limit lines according to EN 50160.

M3x5 can monitor PQ within the following systems:

- Low Voltage grid connected system
- Medium Voltage grid connected system
- Low Voltage islanded system
- Medium Voltage islanded system

PLEASE NOTE

Choosing one of the listed distribution systems automatically sets PQ characteristics according to requirements in EN 50160 for that particular system.

10.16.2.3 Nominal supply voltage

Sets the voltage level of the monitored system and is used as a reference for the calculation of power quality indices and is usually equal to the nominal network voltage (also marked as Udin in various standards). Factory default value is EU standard low voltage value 230 V.

10.16.2.4 Nominal power frequency

Nominal frequency of monitored supply voltage is selected. Factory default value is the EU standard frequency 50Hz. It is also possible to choose 60 Hz.

10.16.2.5 Flicker calculation function

The low voltage level for residential lamps can be either 230V or 110V. The function for the detection of flicker differs depending on this voltage. Since the actual low voltage level can be different from the secondary voltage of the used VT (nominal measuring voltage) this setting must be set to the voltage level which is used to supply residential lamps.

10.16.2.6 Monitoring period (weeks)

This setting defines how often Power Quality reports should be issued. When Monitoring Mode is set to EN 50160, monitoring is performed continuously.

10.16.2.7 Monitoring start day

A starting day in the week is selected. It starts at 00:00 (midnight). The selected day will be the first day in a report.

After the Monitoring period and Monitoring start day are defined, PQ reports will be continuously issued at the end of each monitoring period. All reports and associated anomalies within the monitored period are stored in the internal memory and can be analysed by the **QDSP2** software.

10.16.2.8 Flagged events setting

Flagged events setting specifies whether data (recorded events) that have been flagged (marked) according to flagging concept in IEC 61000-4-30 should be included in the reports.

Flagged data are power quality records, which have been influenced by one or more voltage events (interruptions, dips, swells).

The purpose of flagging data is to mark recorded parameters when certain disturbances might influence measurements and caused corrupted data. For example, voltage dip can also trigger occurrence of flicker, interharmonics, etc. In this case all parameters which were recorded at the same time as a voltage event are marked (flagged). In later evaluation the flagged records can be omitted from the final report by choosing the appropriate setting.

PLEASE NOTE

Regardless of this setting, the readings will be always be stored in the recorder and available for analysis. Flagging only affects PQ reports.

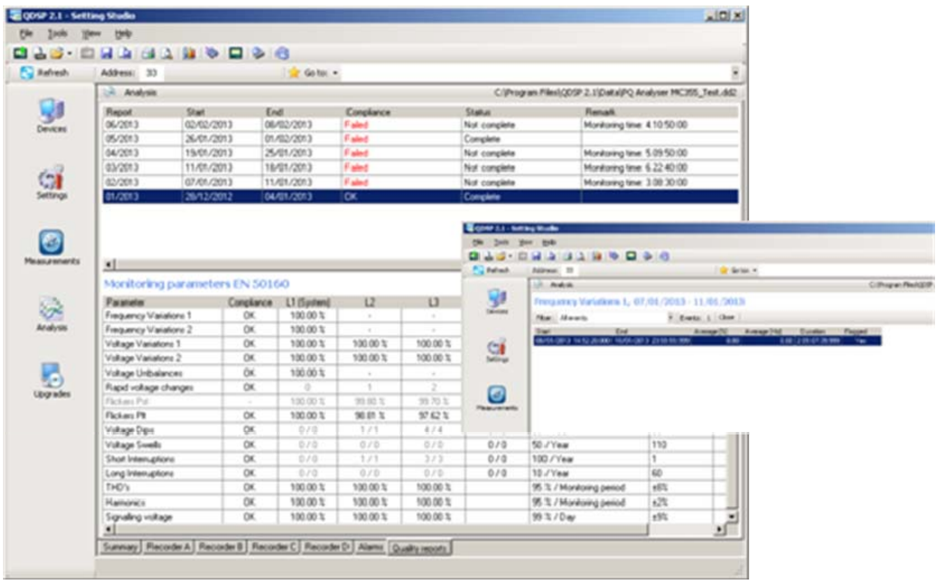


FIGURE 10-20: FLAGGED DATA CAN BE INCLUDED OR EXCLUDED FROM A PQ REPORT

10.17 EN 50160 parameter settings

Phenomena	PQ Parameters
Frequency variations	Frequency distortion
Voltage variations	Voltage fluctuation Voltage unbalance
Voltage changes	Rapid voltage changes Flicker
Voltage events	Voltage dips Voltage interruptions Voltage swells
Harmonics & THD	THD Harmonics Inter-harmonics Signalling voltage

TABLE 10-21: POWER QUALITY INDICES AS DEFINED BY EN 50160

The EN 50160 standard describes in detail the PQ parameters and corresponding limit lines for monitoring whether the distribution system voltage operates in accordance with standard.

Settings of limit lines and the required percentage of appropriate indices within **M3x5** matches the requirements of EN 50160. Therefore when monitoring according to EN 50160 is required there is no need to make changes to the PQ parameters settings.

More detailed description of certain parameter monitoring procedures is defined in chapter 12 - Measurements.

There are some PQ parameters which are interesting for monitoring but are not required as part of PQ reports. These parameters do not have standardised limit values and can be set according to distribution network requirements.

– Short term flicker (limit Pst = 1)
– Interharmonics (10 values of user defined frequencies)

QDSP2 "information" descriptions clearly indicate the PQ parameters that are not required as a part of EN 50160 PQ report.

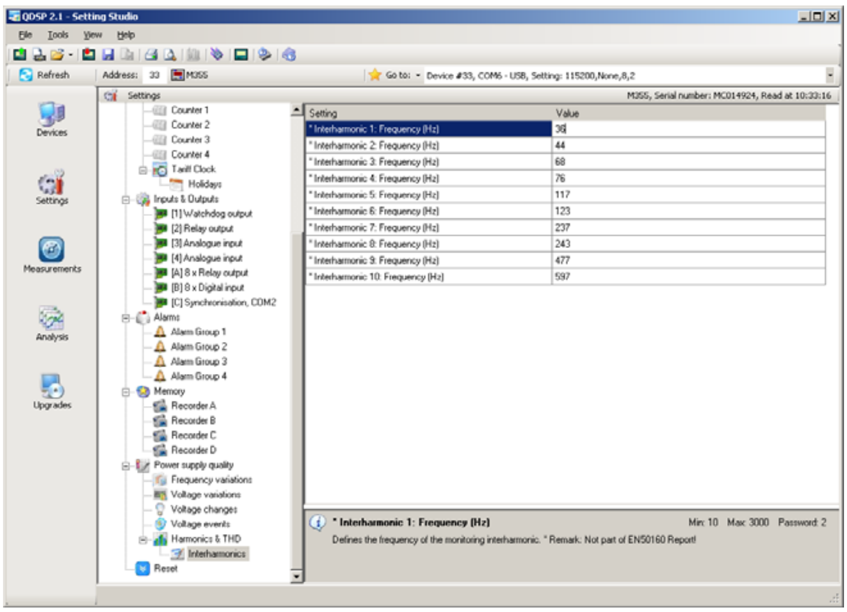


FIGURE 10-21: SETTINGS FOR 10 USER DEFINED INTERHARMONIC FREQUENCIES

10.18 Reset Operations

During normal operation of the device different counter values and statuses may need to be reset from time to time.

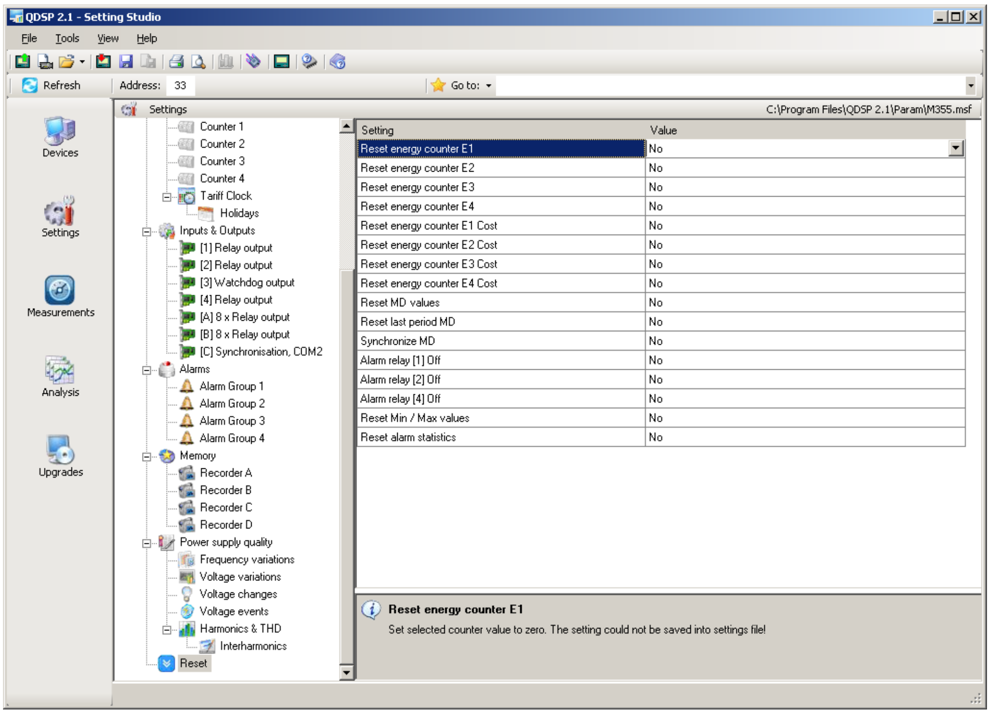


FIGURE 10-22: RESETS PAGE IN **QDSP2**

10.18.1 Set energy counters (E1, E2, E3, E4)

All or individual energy meters (counters) are reset.

(KD) **Main menu** ⇨ **Resets** ⇨ **Energy counters** ⇨ **All Energy counters / Energy counter E1 / E2 / E3 / E4**

10.18.2 Reset Energy counter costs (E1, E2, E3, E4)

All or individual energy costs are reset.

(KD) **Main menu** ⇨ **Resets** ⇨ **Energy counters** ⇨ **All Cost counters / Cost counter E1 / E2 / E3 / E4**

10.18.3 Reset maximal MD values

10.18.3.1 Thermal mode

Current and stored MD's are reset.

10.18.3.2 Fixed Interval / Sliding Window

The values in the current time interval, in all sub-windows and stored MD are reset. At the same time, synchronization of the time interval to the beginning of the first sub-window is also performed.

(KD) **Main menu** ⇨ **Resets** ⇨ **MD values**

10.18.4 Reset the last MD period

10.18.4.1 Thermal mode

Current MD value is reset.

10.18.4.2 Fixed interval / Sliding windows

Values in the current time interval and in all sub-windows for sliding windows are reset. In the same time, synchronization of the time interval is also performed.

(KD) **Main menu ⇨ Resets ⇨ Last period MD**

10.18.5 MD synchronization

10.18.5.1 Thermal mode

In this mode, synchronization does not have any influence.

10.18.5.2 Fixed interval / Sliding Windows

Synchronisation sets time in a period or a sub-period for sliding windows to 0 (zero). If the interval is set to 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 or 60 minutes, time set in a period is set to such a value that some intervals will be terminated at completed hour.

Example:

(KD) **Main menu ⇨ Resets ⇨ Synchronize MD**

Time constant (interval)	15 min	10 min	7 min
Synchronization start time	10:42	10:42	10:42
Time in a period	12 min	2 min	0 min
First final interval	10:45	10:50	10:49

10.18.6 Alarm relay – modules 1 & 2, Off

All alarm (relay) outputs on modules 1 & 2 are turned off.

(KD) **Main menu ⇨ Resets ⇨ Reset alarm status**

10.18.7 Reset Min/Max values

All Min/Max values are reset.

(KD) **Main menu ⇨ Resets ⇨ Reset Min. Max. values**

10.18.8 Reset Alarm statistics

The **QDSP2** software can clear the alarm statistics, when set to Manual under Alarm settings. This setting is only for resetting online alarms statistics displayed in **QDSP2** software.

11. SETTINGS AND MEMORY CARD

The **M3x5** is provided with a built in slot for a full size SD memory card (also MMC) that is used for transfer of records from the internal memory, device settings download and software upgrading. The memory card needs to be formatted with the FAT16 file system.

Directory structure on a memory card

A structure of directories is defined and enables correct data handling via a memory card. The memory card shall contain the following directories and files:

- DATA
- SETTING
- UPGRADE
- File: Automenu.txt (option)

DATA

Records from the products internal memory are stored in the DATA directory. To upload data from several devices to the memory card, each device checks and, if necessary, creates its own subdirectory before data transfer. Each subdirectory uses the device serial number as its name and stores files with data in it. Each file name contains date (year, month and day) and a record sequence number of that day.

WARNING

When uploading data file to the memory card and there is a file with sequence number 99 of that day, a file with sequence number 00 is generated. Files with identical sequence numbers of that day, will be overwritten if any further data uploads are done that day.

Settings

Settings are stored in the directory using two recording modes:

- With a type designation and a sequence number from 1 to 9
- With an device serial number

Upgrade

A file with upgrades is available for upload with the **QDSP2** software. The file has the name of the corresponding device type designation and suffix FL2 (e.g. M355.FL2).

Automenu.txt

For faster and easier upgrading of the firmware there is the »Automenu.txt« file in the root directory. When a memory card with this file is inserted and if the upgrade version is later than that installed in the product the display automatically jumps into the memory card menu and suggests the Software upgrade menu, otherwise it automatically jumps into the Save data menu.

When upgrading is finished and the OK key is pressed and the memory card is removed, the menu that was displayed before inserting the memory card is displayed.

Automenu.txt file can be created by the user by means of a text editor. A new file has to be opened and saved under the correct name (Automenu.txt) and without content.

Example:

DATA		
↳	MC003973	
	↳	06050301.MMC
	MC003974	
	↳	06050301.MMC
		06070301.MMC
	MC009424	
	↳	06060301.MMC
		06070301.MMC
SETTING		
↳	MC003973.MSF	
	M355−1.MSF	
	M355−2.MSF	
	M243−1.MSF	
UPGRADE		
↳	M355.FL2	
Automenu.txt		

Handling the memory card

The **M3x5** is equipped with a slot on the front panel for a Memory card. The slot has a protection cover that can be simply removed before inserting the memory card. The protection cover should be fitted back in place when the card is removed.

CAUTION

While memory card activity LED is blinking the memory card should not be pulled out of the slot.

Memory card information

The device checks the file system and capacity of the inserted memory card.

(KD) **Main menu ⇨ SD card ⇨ SD info**

Save data

Recorder Sections

For each recorder section define whether it is to be included in a file to be downloaded.

Date

Define how much data is to be included for the sections defined.

Since the last transfer: all available data from the last official reading with a password is included.

Last week and Last month: all data of the last complete period (a week, a month) with the beginning on the first day at 00:00 is included.

Custom date: defines a day beginning at 00:00 that is the start of the required transfer, ending with the current time of the data transfer.

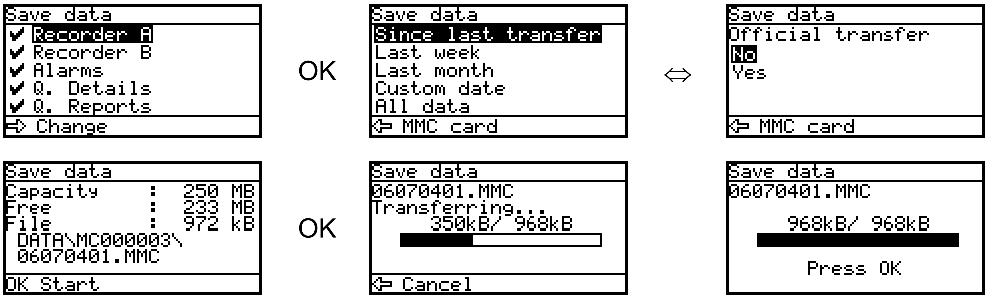
All data: all data for each individual section, that is stored in the memory up to the moment when the reading is started, is transferred.

Official reading

If official reading is selected the date of data reading is stored in the device, and is applied at the next official reading.

Example:

(KD) **Main menu ⇨ SD card ⇨ Save data**



Save settings (KD)

The file of the current device settings is stored in SETTING directory. The file name consists of the device serial number and MSF extension. In the case of a file already stored on the memory card with the same name, the device asks if file should be overwritten.

Load settings

For loading settings, the files that correspond to the device type are displayed on the LCD. When a file is selected, it is necessary to choose the segments of the settings that will be overwritten. A number of registers that will be modified is written next to each segment. After transfer of the settings, a warning about errors could be displayed. Errors occur when the module settings and the memory capacity differ from the ones used in the device. A number of settings (registers) that do not match and have not been modified are displayed after the warning.

Basic settings

At transfer of basic settings, settings of connections, ratios, used voltage and current ranges as well as nominal frequency are not changed. New settings can influence energy counters if recorded in a memory.

Alarms

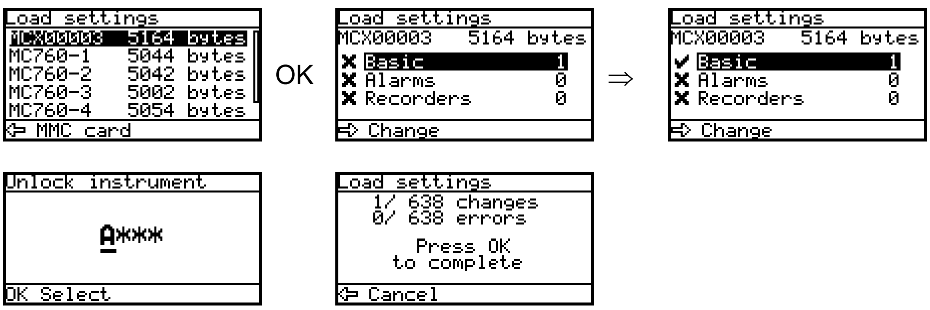
Settings of all alarms are changed, but old alarms with previous settings remain in the recorder memory.

Recorders

Recorder overwriting enables modified setting of connection, ratio, used voltage and current ranges as well as nominal frequency. All other data in memory is lost.

Example of a display on LCD for **M3x5**:

(KD) **Main menu ⇨ SD card ⇨ Load settings**



Firmware upgrading (KD)

Before upgrading the firmware on the device the files on the memory card are checked first, this can last some time (approx. 1 minute). When both versions are displayed, upgrade can be performed if the device firmware version is lower or equal to the version on the memory card.

WARNING

When upgrading the firmware removal of the memory card or interruption of the auxiliary power supply, could cause the device to become inoperative!
Repair of the device in this case can only be done by return to factory

Upgrade error codes:

Error 1: memory card not inserted

Error 2: Error on FAT16 file system

Error 3: File not exist (.fl2)

Error 4: Error in .fl2 file

Error 5: File too long (.fl2)

Error 6: Invalid file (.fl2)

Error 7: Incorrect upgrade version (.fl2)

12. MEASUREMENTS

The **M3x5** performs measurements with a constant sampling frequency of 31 kHz. Measurement methods differ for normal operation quantities, where values are averaged and aggregated according to the aggregation requirements of IEC 61000-4-30 standard (Class A) and voltage events where half-period values are evaluated again according to IEC 61000-4-30 (Class A).

12.1 Online Measurements

Online measurements are available on the device display or they can be monitored with the setting and monitoring software **QDSP2**.

The readings on the display are performed continuously with a refresh time dependent on the defined average interval whereas the rate that **QDSP2** monitors the readings is fixed at approximately every two seconds.

For a better overview over numerous readings, the measurements are divided into several groups, which contain basic measurements, minimum and maximum values, harmonics, PQ parameters and alarms.

Each group can represent the data in graphical form or in detailed tabular form. When in tabular form the readings can be frozen to allow the data to be copied into various report generation software tools.

A record can be made on the PC of the online data in .csv format for later analysis.

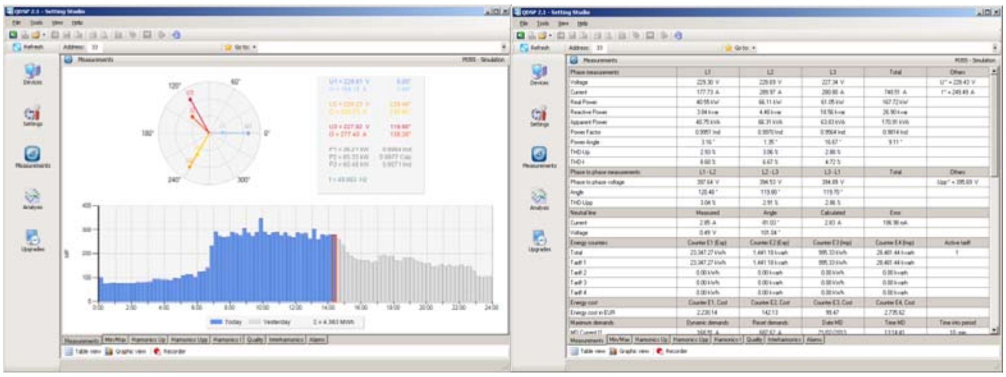


FIGURE 12-1: SAMPLE OF ONLINE MEASUREMENT DISPLAYS

12.2 Selection of available measurements

The available online measuring quantities and their appearance can vary according to the settings for the type of power network and other settings such as; average interval, maximum demand mode, reactive power calculation method, etc.

PLEASE NOTE

The Measurements supported depends on the connection mode configured. Calculated measurements (for example voltages U_1 *and* U_2 when 3-phase, 4-wire connection with a balanced load is used) are only informative.

PLEASE NOTE

For 3b and 3u connection modes, only the phase to phase voltages are measured. Because of this, a factor √3 is applied to the calculation of qualities requiring nominal phase voltage. For the 4b connection mode measurements support is the same as for 1b.

Meas. type	***Measurement***	***3-phase 4-wire***	***3-phase 3-wire***	***1-phase***	***comments***
Phase measurements	*Voltage*				
	U_{1-3_RMS}	☑	☑	☑1ph	
	U_{AVG_RMS}	☑	☑	☑	
	$U_{unbalance\_neg\_RMS}$	☑🕮	☑🕮		
	$U_{unbalance\_zero\_RMS}$	☑🕮			
	U_{1-3_DC}	☑	☑	☑1ph	*DC component of phase voltages*
	Current				
	I_{1-3_RMS}	☑	☑	☑1ph	
	I_{TOT_RMS}	☑	☑	☑	
	I_{AVG_RMS}	☑	☑	☑	
	Power				
	P_{1-3_RMS}	☑	☑	☑1ph	
	P_{TOT_RMS}	☑	☑	☑	
	Q_{1-3_RMS}	☑🕮	☑🕮	☑1ph🕮	*reactive power can be calculated as a squared difference between S and P or as delayed sample*
	Q_{TOT_RMS}	☑	☑	☑	
	S_{1-3_RMS}	☑	☑	☑1ph	
	S_{TOT_RMS}	☑	☑	☑	
	PF_{1-3_RMS}	☑	☑	☑1ph	
	φ_{1-3_RMS}	☑	☑	☑1ph	PA – Power angle
	Harmonic analysis				
	$THD\text{-}U_{1-3}$	☑	☑	☑1ph	
	$THD\text{-}I_{1-3}$	☑	☑	☑1ph	
	$TDD\text{-}I_{1-3}$	☑	☑	☑1ph	
	$U_{1-3\_harmonic\_1-63\_\%}$	☑🕮	☑🕮	☑1ph🕮	*% of RMS or % of base*
	$U_{1-3\_harmonic\_1-63\_ABS}$	☑	☑	☑1ph	
	$U_{1-3\_harmonic\_1-63\_\varphi}$	☑	☑	☑1ph	
	$U_{1-3\_inter-harmonic\_\%}$	☑🕮	☑🕮	☑1ph🕮	*monitoring up to 10 different fixed frequencies. % of RMS or % of base*
	$U_{1-3\_inter-harmonic\_ABS}$	☑	☑	☑1ph	
	$U_{1-3\_signaling\_\%}$	☑🕮	☑🕮	☑1ph🕮	*monitoring of signaling (ripple) voltage of set frequency. % of RMS or % of base*
	$U_{1-3\_signaling\_ABS}$	☑	☑	☑1ph	
	$I_{1-3\_harmonic\_1-63\_\%}$	☑🕮	☑🕮	☑1ph🕮	*% of RMS or % of base*
	$I_{1-3\_harmonic\_1-63\_ABS}$	☑	☑	☑1ph	
	$I_{1-3\_harmonic\_1-63\_\varphi}$	☑	☑	☑1ph	
	Flickers				
	Pi_{1-3}	☑	☑	☑1ph	*Instantaneous flicker sensation measured with 150 samples / sec (original sampling is 1200 smpl/sec)*
	Pst_{1-3}	☑	☑	☑1ph	*10 min statistical evaluation (128 classes of CPF)*
	Plt_{1-3}	☑	☑	☑1ph	*derived from 12 Pst acc. to EN 61000-4-15*
	Miscellaneous				
	$K\text{-}factor_{1-3}$	☑	☑	☑1ph	
	$Current\ Crest\ factor_{1-3}$	☑	☑	☑1ph	

🕮 Further description is available in following subchapters

TABLE 12-1: SELECTION OF AVAILABLE MEASUREMENT QUANTITIES

Meas. type	**Measurement**	**3-phase 4-wire**	**3-phase 3-wire**	**1-phase**	**comments**
Phase to phase measurements	*Voltage*				
	$Upp_{1\text{-}3\_RMS}$	☑	☑		
	Upp_{AVG_RMS}	☑	☑		
	$THD\text{-}Upp_{1\text{-}3}$	☑	☑		
	$\varphi_{x\text{-}y\_RMS}$	☑			*Phase-to-phase angle*
	$Upp_{1\text{-}3\_harmonic\_1\text{-}63\_\%}$	☑🕮	☑🕮	☑1ph🕮	*% of RMS or % of base*
	$Upp_{1\text{-}3\_harmonic\_1\text{-}63\_ABS}$	☑	☑	☑1ph	
	$Upp_{1\text{-}3\_harmonic\_1\text{-}63\_\varphi}$	☑	☑	☑1ph	
	$U_{underdeviation}$	☑	☑	☑1ph	U_{under}. and U_{over}. are calculated for phase or phase-to-phase voltages regarding connection mode.
	$U_{overdeviation}$	☑	☑	☑1ph	
Metering	*Energy*	☑	☑	☑	
	Counter $E_{1\text{-}8}$	☑	☑	☑	*Each counter can be dedicated to any of four quadrants (P-Q, import-export, L-C). Total energy is a sum of one counter for all tariffs. Tariffs can be fixed, date/time dependent or tariff input dependent*
	$E\_{}_{TOT\_1\text{-}8}$	☑	☑	☑	
	Active tariff	☑	☑	☑	
Auxiliary channel measurements	*Aux. line*				
	$U_{NEUTRAL\text{-}EARTH}$	☑	☑	☑	*aux. voltage is dedicated for neutral-earth meas. only*
	$I_{NEUTRAL\_meas}$	☑	☑	☑	*measured neutral current with 4th current input*
	$I_{NEUTRAL\_calc}$	☑	☑	☑	*calculated neutral current*
	$I_{NEUTRAL\_err}$	☑	☑	☑	*error neutral current (difference between measured and calculated)*
Maximum demand measurements	*Maximum demand*				
	$MD\_I_{1\text{-}3}$	☑	☑	☑1ph	
	MD_P_{import}	☑	☑	☑	
	MD_P_{export}	☑	☑	☑	
	MD_Q_{ind}	☑	☑	☑	
	MD_Q_{cap}	☑	☑	☑	
	MD_S	☑	☑	☑	

🕮 *Further description is available in following subchapters*

TABLE 12-1: SELECTION OF AVAILABLE MEASUREMENT QUANTITIES

Meas. type	***Measurement***	***3-phase 4-wire***	***3-phase 3-wire***	***1-phase***	***comments***
Min and max measurements	*Min and max*				
	$U_{1-3\_RMS\_MIN}$	☑	☑	☑1ph	
	$U_{1-3\_RMS\_MAX}$	☑	☑	☑1ph	
	$Upp_{1-3\_RMS\_MIN}$	☑	☑	☑	
	$Upp_{1-3\_RMS\_MAX}$	☑	☑	☑	
	$I_{1-3\_RMS\_MIN}$	☑	☑	☑1ph	
	$I_{1-3\_RMS\_MAX}$	☑	☑	☑1ph	
	$P_{1-3\_RMS\_MIN}$	☑	☑	☑1ph	
	$P_{1-3\_RMS\_MAX}$	☑	☑	☑1ph	
	$P_{TOT\_RMS\_MIN}$	☑	☑	☑1ph	
	$P_{TOT\_RMS\_MAX}$	☑	☑	☑1ph	
	$S_{1-3\_RMS\_MIN}$	☑	☑	☑1ph	
	$S_{1-3\_RMS\_MAX}$	☑	☑	☑1ph	
	$S_{TOT\_RMS\_MIN}$	☑	☑	☑1ph	
	$S_{TOT\_RMS\_MAX}$	☑	☑	☑1ph	
	$freq_{MIN}$	☑	☑	☑	
	$freq_{MAX}$	☑	☑	☑	
Other measurements	*Miscellaneous*				
	$freq_{MEAN}$	☑	☑	☑	
	Internal temp.	☑	☑	☑	
	Date, Time	☑	☑	☑	
	Last Sync. time	☑🕮	☑🕮	☑🕮	*UTC*
	GPS Time	☑🕮	☑🕮	☑🕮	*If GPS receiver is connected to dedicated RTC time synchronization input*
	GPS Longitude	☑🕮	☑🕮	☑🕮	
	GPS Latitude	☑🕮	☑🕮	☑🕮	
	GPS Altitude	☑🕮	☑🕮	☑🕮	

🕮 *Further description is available in following subchapters*

TABLE 12-1: SELECTION OF AVAILABLE MEASUREMENT QUANTITIES

12.3 Basic Concepts

12.3.1 Sample frequency

The **M3x5** measures all primary quantities with a constant sampling rate of 31 kHz (620 samples/cycle at 50 Hz).

12.3.2 Average interval

Operation of the **M3x5** depends on several Average intervals, which all need to be understood and set to proper values.

Average interval for measurements and display

To ensure readability of measurements on the display and from communications, an Average interval can be selected from a range of predefined values (from 0.1s to 5 s). The Average interval also defines the refresh rate of displayed measurements.

Alarm response time is influenced by the general Average interval if their response time setting is set to “Normal response”. If it is set to “Fast response” alarms depend on a single period measurement.

This average interval has no influence on PQ measurements.

Average interval for minimum and maximum values

Minimum and maximum values often require a special averaging period, which enables or disables the detection of short measuring spikes. It is possible to set an averaging time from 1 period to 256 periods.

Average (storage) interval for recorders

This storage interval defines the period for writing data into internal recorder memory. It can be set from 1 min to 60 min. At the end of every interval different types of measured data can be stored into the recorder.

Average (aggregation) interval for PQ parameters

The PQ standard IEC61000-4-30 defines different aggregation intervals and procedures for aggregation of the measured PQ parameters.

For each PQ parameter it is possible to set the required aggregation interval. Standard aggregation intervals are:

- 10 periods (12 for 60 Hz system)
- 150 periods (180 for 60 Hz system)
- 10 sec
- 10 min (also basic time synchronisation tick interval)
- 2 h

It is also possible to set other aggregation intervals according to customer requirements. The **M3x5** supports additional aggregation intervals of 30 sec, 1 min, 15 min, and 1 hr.

12.3.3 Power and Energy Flow

The power mode is used for the signing of power measurements. The user cannot set the **M3x5** power mode. It is defined as follows:

- When displaying active power, a positive sign indicates export power (a consumer) whilst a negative sign indicates import power (a generator).
- When displaying reactive power, a coil symbol indicates an inductive load (a consumer) whilst a capacitor symbol indicates a capacitive load (a generator).

12.3.4 Operating energy quadrants

The operating energy quadrants are used to determine which types of energy are added to the energy counters. The user may modify the operating energy quadrants via the remote communications interface.

Figure 12-2 shows a flow of active power, reactive power and energy for 4u connection.

Display of energy flow direction can be adjusted to connection and operation requirements by changing the Energy flow direction setting (within Connection).

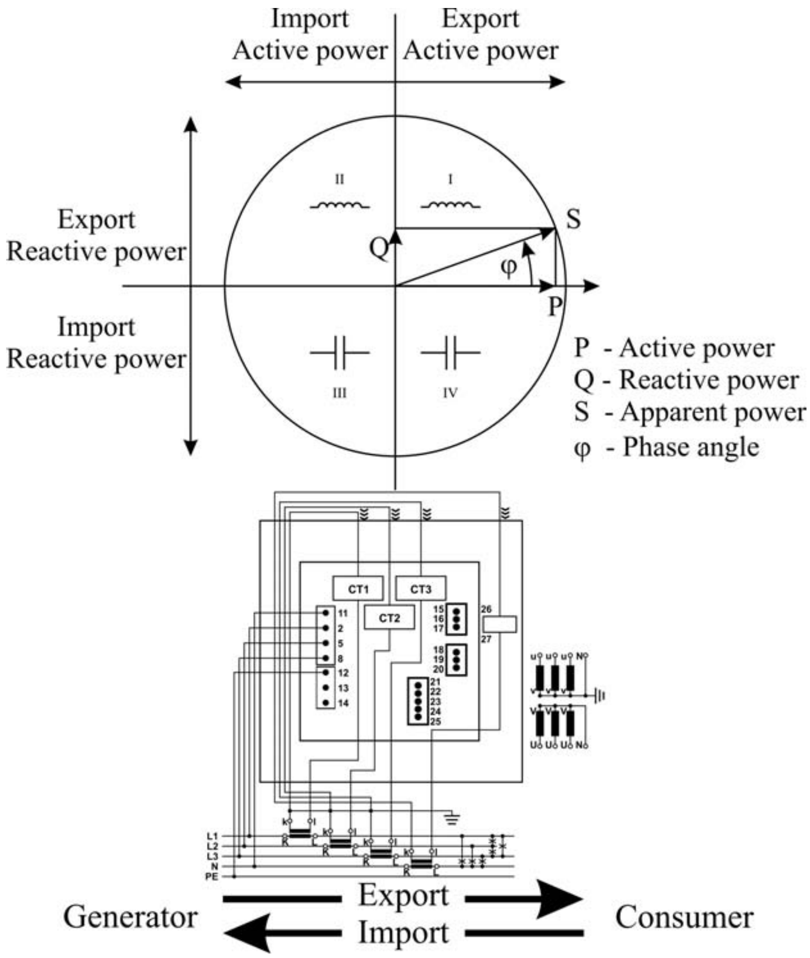


FIGURE 12-2: POWER AND ENERGY FLOW

12.4 Calculation and Display of Measurements

This chapter deals with the measurement, calculation and display of all supported quantities of measurement. Only the most important equations are described; however all of them are shown in Appendix D, with additional descriptions and explanations.

PLEASE NOTE

Calculation and display of measurements depend on the connection used. For more detailed information see section 12.2.

Keyboard and display presentation

For entry and quitting measurements display menu, the **OK** key is used. Direction keys (⇦⇨⇧⇩) are used for passing between displays as show in example below.

Example for 4u connection mode:

(KD) **Main menu** ⇨ **Measurements** ⇨ **Present values** ⇨ **Voltage**

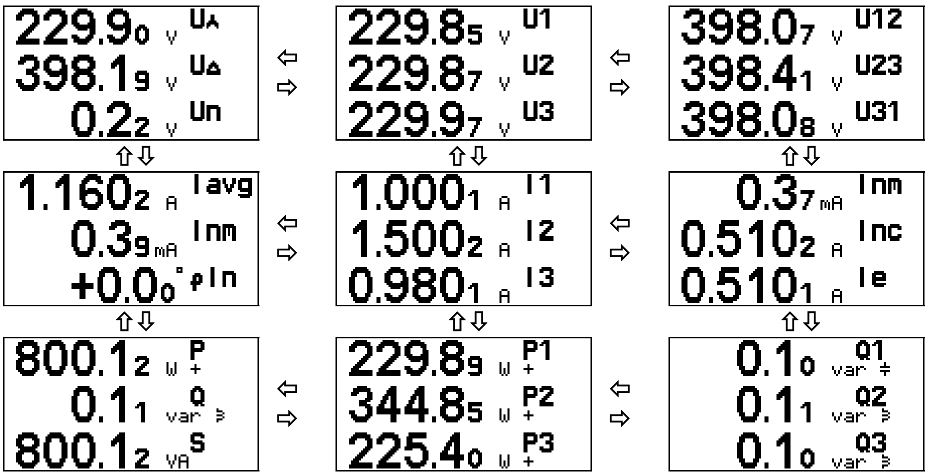
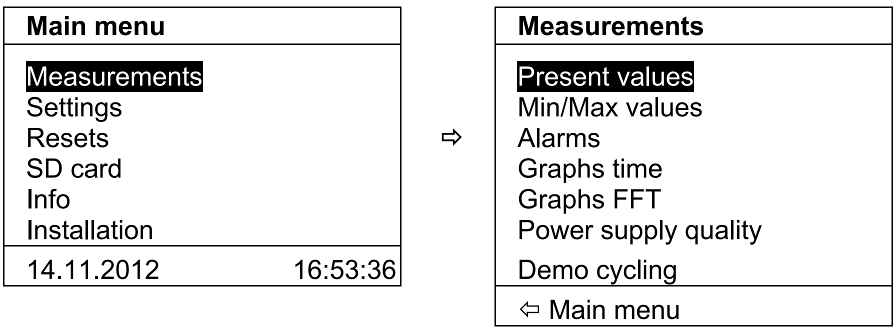


FIGURE 12-3: PRESENT VALUE VOLTAGE DISPLAYS

12.4.1 Present Values



12.4.1.1 Voltage

The device measures:

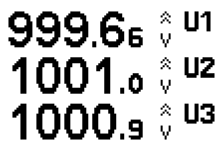
- Real effective (rms) value of all phase voltages (U1, U2, U3), phase-to-phase voltages (U12, U23, U31) and neutral to earth voltage (Un).
- Average phase voltage ($U_{⅄}$) and average phase-to-phase voltage ($U_{\triangle}$)
- Negative and zero sequence unbalance ratio (Uu, U_0)
- Phase and phase-to-phase voltage angles (φ1-3, φ12, φ13, φ23)

- Signalling phase and phase-to-phase voltages (Us1-3, Us12, Us13, Us23)
- DC component of phase and phase-to-phase voltages including neutral line

$$U_f = \sqrt{\frac{\sum_{n=1}^{N} u_n^2}{N}} \qquad U_{xy} = \sqrt{\frac{\sum_{n=1}^{N} \left(u_{xn} - u_{yn}\right)^2}{N}}$$

All voltage measurements are available on communications and on standard or customized displays on the LCD.

The device warns if the input signal is too large. Indicator ︽ is shown above the parameter unit:



(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Voltage**

12.4.1.2 Current

The device measures:

- Real effective (rms) value of phase currents and neutral measured current (Inm), connected to current inputs
- Neutral calculated current (Inc), Neutral error current (Ie = |Inm – Inc|),
- Phase angle between Neutral voltage and Neutral Current (φIn), Average current (Ia) and a sum of all phase currents (It)
- Crest factor of phase currents (CRI1-3)

$$I_{RMS} = \sqrt{\frac{\sum_{n=1}^{N} i_n^2}{N}}$$

All current measurements are available on communications and on standard and customized displays on the LCD.

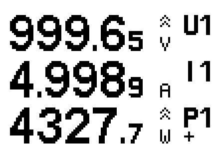
(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Current**

12.4.1.3 Active, Reactive and Apparent Power

Active power is calculated from the instantaneous phase voltages and currents. All measurements are available on communications or are displayed on LCD. For more detailed information about calculation see Appendix D.

There are two different methods of calculating reactive power, see Appendix D.

The device warns if the input signal is too large. Indicator ︽ is shown above parameter unit:



(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Power**

12.4.1.4 Power factor and power angle

Power angle is calculated as quotient of active and apparent power for each phase separately (cosφ1, cosφ2, cosφ3) and total power angle (cosφt).

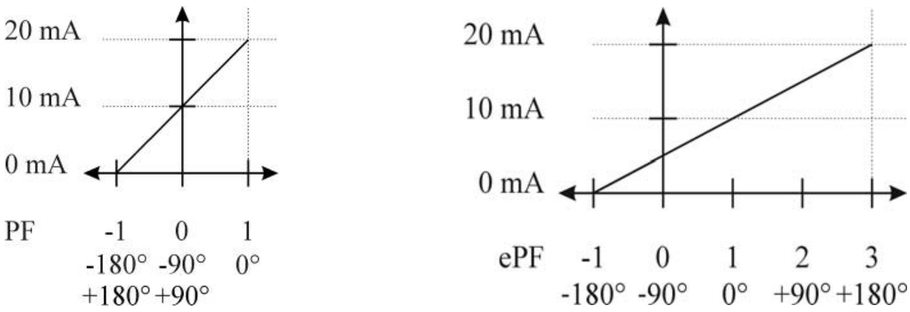
On the display a symbol for a coil represents inductive load and a symbol for a capacitor represents capacitive load.

For correct display of PF via analogue output and application of the alarm, ePF (extended power factor) is applied. It illustrates power factor with one value as described in the table below. For display on the LCD both of them have equal display function: between −1 and −1 with the icon for inductive or capacitive load.

Table 15: *Presentation of extended PF (ePF)*

Load	**C**	→		←	L
Angle [°]	**−180**	**−90**	**0**	**+90**	**+180 (179.99)**
PF	**−1**	**0**	**1**	**0**	**−1**
ePF	**−1**	**0**	**1**	**2**	**3**

Example of analogue output for PF and ePF:



(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ PF & Power angle**

12.4.1.5 Frequency

Network frequency is calculated from time periods of measured voltage. The device uses a synchronisation method, which is highly immune to harmonic disturbances.

The device usually synchronises to phase voltage *U1*. If the signal on that phase is too low it (re)synchronises to next phase. If all phase voltages are low (e.g. short circuit) the device synchronises to the phase currents. If there is no signal present on any voltage or current channel, the device shows frequency as 0 Hz.

Additionally frequency with 10 second averaging interval is displayed.

(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Frequency**.

12.4.1.6 Energy - counters

Three types of Energy counter display are available:

- by individual counter,
- by tariffs for each counter separately and
- energy cost by counter

On the display of measured counter by tariffs, the sum on the upper line depends on the tariffs set in the device.

There are two different methods of calculating reactive energy, see Appendix D.

(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Energy**

12.4.1.7 MD values

MD values and their time stamp of occurrence are shown for:

- Three phase currents
- Active powers (import and export)
- Reactive power (inductive and capacitive)
- Apparent power

(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ MD values**

Dynamic demands are continuously calculated according to set time constants and other parameters.

Reset demands are maximum values of Dynamic demands since last reset.

12.4.1.8 Harmonic distortion

Device calculates different harmonic distortion parameters:

- THD is calculated for phase currents, phase voltages and phase−to−phase voltages and is expressed as percentage of high harmonic components regarding to fundamental harmonic
- TDD is calculated for phase currents
- K-factor is calculated for phase currents

The device uses the measuring technique of real effective (rms) value that ensures exact measurements with the presence of high harmonics up to 63rd harmonic.

(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ THD**

12.4.1.9 Flickers

Flickers are one of most important PQ parameters directly (through light flickering) influencing human feeling.

Flickers are measured and statistically evaluated according to standard IEC 61000-4-15.

For basic flicker measurements on all three voltage phases 1200 readings per second are taken. Instantaneous flicker sensation reduces this sampling rate 8 times (150 instantaneous flicker calculations per second) and uses approximately 3s averaging time.

With further statistical evaluation short term and long term flickers are calculated.

$Pi_{1\text{-}3}$ represents instantaneous flicker and is averaged and refreshed every 3 sec. *Pi* is averaged from 500 instantaneous flicker calculations.

$Pim_{1\text{-}3}$ represents maximum value of instantaneous flicker *Pi* within 3 sec flicker averaging interval and is refreshed every 3 sec. This value is displayed only on display. It is not available on communication.

$Pst_{1\text{-}3}$ represents 10 min statistical evaluation of instantaneous flicker and is refresh every 10 minutes (x:00, x:10, x:20…)

$Plt_{1\text{-}3}$ represents 2 h statistical evaluation of short-time flicker *Pst* and is refreshed every even 2 hours (0:00, 2:00, 4:00…)

Until the flicker value is calculated the symbol ‘−‘ is displayed.

(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Flickers**

12.4.1.10 Customized screens

Here 4 different customised screens are shown. The first three screens show 3 different user defined values. The fourth screen displays 5 different values as a combination of 3 values of first screen and first 2 values of second screen.

(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Custom**

12.4.1.11 Overview screens

Combine several measurements on each display as shown below:

Screen 1:

	Current phase measurements			Current phase measurements	
U⅄	Average voltage $U^{\sim}$	V	P	Total active power P_t	W
1	Phase voltage U_1	V	P1	Active power P_1	W
2	Phase voltage U_2	V	P2	Active power P_2	W
3	Phase voltage U_3	V	P3	Active power P_3	W
I⅄	Average current $I^{\sim}$	A	Q	Total reactive power Q_t	var
1	Current I_1	A	Q1	Reactive power Q_1	var
2	Current I_2	A	Q2	Reactive power Q_1	var
3	Current I_3	A	Q3	Reactive power Q_1	var

Screen 2:

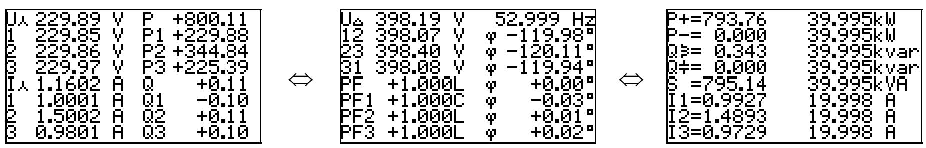
	Current phase-to-phase measurements			Current phase-to-phase measurements	
U∆	Average phase-to-phase $U^{\sim}$	V		Frequency f	Hz
12	Phase-to-phase voltage U_{12}	V	φ	Power angle φ_1	°
23	Phase-to-phase voltage U_{23}	V	φ	Power angle φ_2	°
31	Phase-to-phase voltage U_{31}	V	φ	Power angle φ_3	°
PF	Total power factor		φ	Average phase-to-phase angle $\varphi^{\sim}$	°
PF1	Power factor PF_1		φ	Power angle φ_{12}	°
PF2	Power factor PF_2		φ	Power angle φ_{23}	°
PF3	Power factor PF_3		φ	Power angle φ_1	°

Screen 3:

	Dynamic MD values			Maximal MD values	
P+	MD active power P (positive)	W		MD active power P (positive)	W
P−	MD active power P (negative)	W	φ	MD active power P (negative)	W
Q≡	MD reactive power Q−L	var	φ	MD reactive power Q−L	var
Q∔	MD reactive power Q−C	var	φ	MD reactive power Q−C	var
S	MD apparent power S	VA	φ	MD apparent power S	VA
I1	MD current I1	A	φ	MD current I1	A
I2	MD current I2	A	φ	MD current I2	A
I3	MD current I3	A	φ	MD current I3	A

Example for **M3x5** at connection 4u:

(KD) **Main menu ⇨ Measurements ⇨ Present values ⇨ Overview**



12.4.2 Minimum and Maximum values

Main menu
Measurements
Settings
Resets
SD card
Info
Installation
14.11.2012 16:53:36

⇨

Measurements
Present values
Min/Max values
Alarms
Graphs time
Graphs FFT
Power supply quality
Demo cycling
⇦ Main menu

All Min/Max values are displayed in a similar way to Present values.

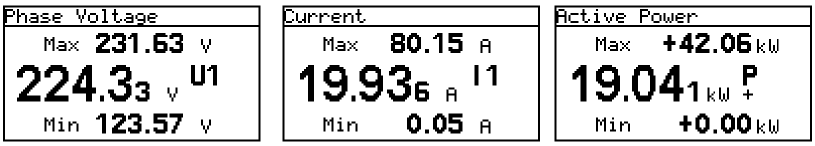
12.4.2.1 Average interval for minimum and maximum values

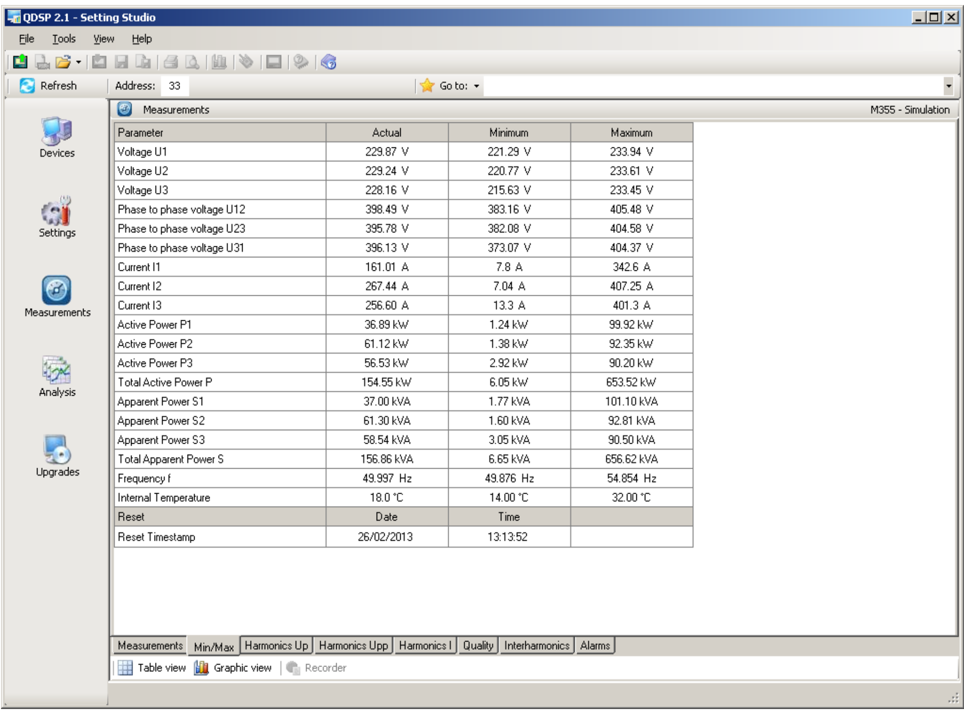
Minimum and maximum values often require a special averaging period, which enables or disables detection of short measuring spikes. With this setting it is possible to set averaging from 1 period to 256 periods.

12.4.2.2 Display of Min/Max. values

Present values are displayed with larger font in the middle of the screen, while minimum and maximum values are displayed in smaller font above and below the present values.

Example of Min/Max screens on display.





Parameter	Actual	Minimum	Maximum
Voltage U1	229.87 V	221.29 V	233.94 V
Voltage U2	229.24 V	220.77 V	233.61 V
Voltage U3	228.16 V	215.63 V	233.45 V
Phase to phase voltage U12	398.49 V	383.16 V	405.48 V
Phase to phase voltage U23	395.78 V	382.08 V	404.58 V
Phase to phase voltage U31	396.13 V	373.07 V	404.37 V
Current I1	161.01 A	7.8 A	342.6 A
Current I2	267.44 A	7.04 A	407.25 A
Current I3	256.60 A	13.3 A	401.3 A
Active Power P1	36.89 kW	1.24 kW	99.92 kW
Active Power P2	61.12 kW	1.38 kW	92.35 kW
Active Power P3	56.53 kW	2.92 kW	90.20 kW
Total Active Power P	154.55 kW	6.05 kW	653.52 kW
Apparent Power S1	37.00 kVA	1.77 kVA	101.10 kVA
Apparent Power S2	61.30 kVA	1.60 kVA	92.81 kVA
Apparent Power S3	58.54 kVA	3.05 kVA	90.50 kVA
Total Apparent Power S	156.86 kVA	6.65 kVA	656.62 kVA
Frequency f	49.997 Hz	49.876 Hz	54.854 Hz
Internal Temperature	18.0 °C	14.00 °C	32.00 °C
Reset	Date	Time	
Reset Timestamp	26/02/2013	13:13:52	

FIGURE 12-4: TABULAR PRESENTATION OF MIN/MAX. VALUES

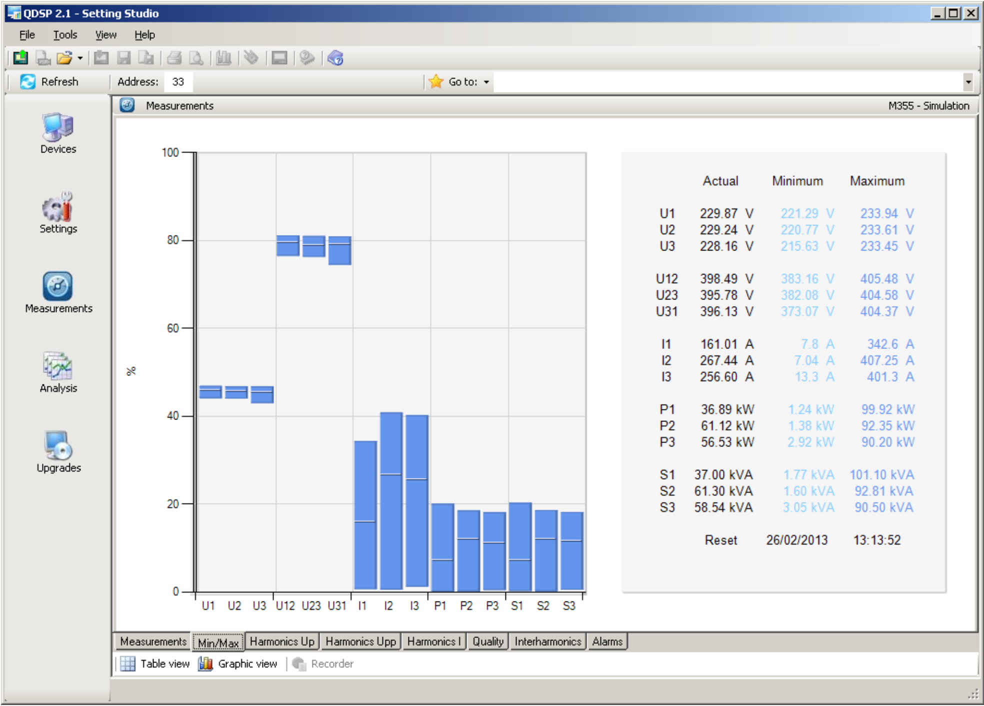


FIGURE 12-5: GRAPHICAL PRESENTATION OF MIN/MAX. VALUES

In the graphical presentation Min/Max values relative values are depicted. Base value for relative representation is defined in **general settings/Connection mode/used voltage, current range.**

For phase voltages and for phase-to-phase voltages the same value is used.

12.4.3 Alarms

Main menu
Measurements
Settings
Resets
SD card
Info
Installation
14.11.2012 16:53:36

⇨

Measurements
Present values
Min/Max values
Alarms
Graphs time
Graphs FFT
Power supply quality
Demo cycling
⇦ Main menu

Alarms are important for notifying when parameters exceed user defined values and for visualisation and recording certain events with an exact time stamp. Alarms can be connected to digital/alarm outputs to trigger different processes (switch closures, line breaking, motors start or stop...).

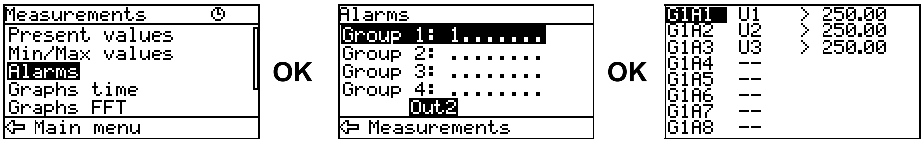
It is also useful to be able to monitor the alarms history. This is available on the display and in more detail on communications using the monitoring and setting software **QDSP2**.

12.4.3.1 Summary of alarms

The Alarm menu on the device allows the status of ongoing alarms to be monitored on the display.

In the Alarm menu, groups of alarms with the state of individual alarms are displayed. Also the connected alarm outputs are displayed on the bottom line. If the displayed alarm output is highlighted then the output is active (relay closed). For each active alarm the number of the alarm is written in the applicable group: Group 1: 1 ■ ■ 45 ■ ■ 8. A dot stands for alarm not active.

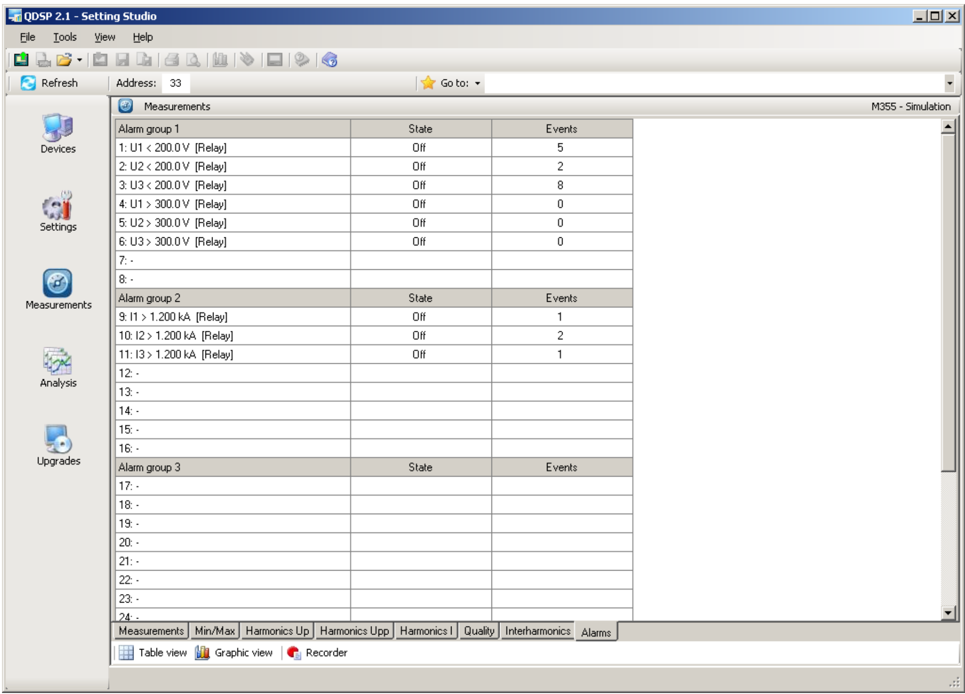
In the example below there was 1 alarm, which happened under condition defined in Group1/Alarm1 (middle picture). Condition for that alarm was *U1 > 250.00 V* (right picture). Alarm activated Relay output 2 (middle picture, highlighted Out2).



(KD) **Main menu ⇨ Measurements ⇨ Alarms**

In the **QDSP2** software all alarms can be presented in tabular and graphical form as shown in the figures below. For each alarm is shown:

- Group association
- Individual Alarm conditions
- Momentary alarm state
- Number of alarm events since last reset



Alarm group 1	State	Events
1: U1 < 200.0 V [Relay]	Off	5
2: U2 < 200.0 V [Relay]	Off	2
3: U3 < 200.0 V [Relay]	Off	8
4: U1 > 300.0 V [Relay]	Off	0
5: U2 > 300.0 V [Relay]	Off	0
6: U3 > 300.0 V [Relay]	Off	0
7: -		
8: -		
Alarm group 2	State	Events
9: I1 > 1.200 kA [Relay]	Off	1
10: I2 > 1.200 kA [Relay]	Off	2
11: I3 > 1.200 kA [Relay]	Off	1
12: -		
13: -		
14: -		
15: -		
16: -		
Alarm group 3	State	Events
17: -		
18: -		
19: -		
20: -		
21: -		
22: -		
23: -		
24: -		

FIGURE 12-6: TABULAR PRESENTATION OF ALARMS

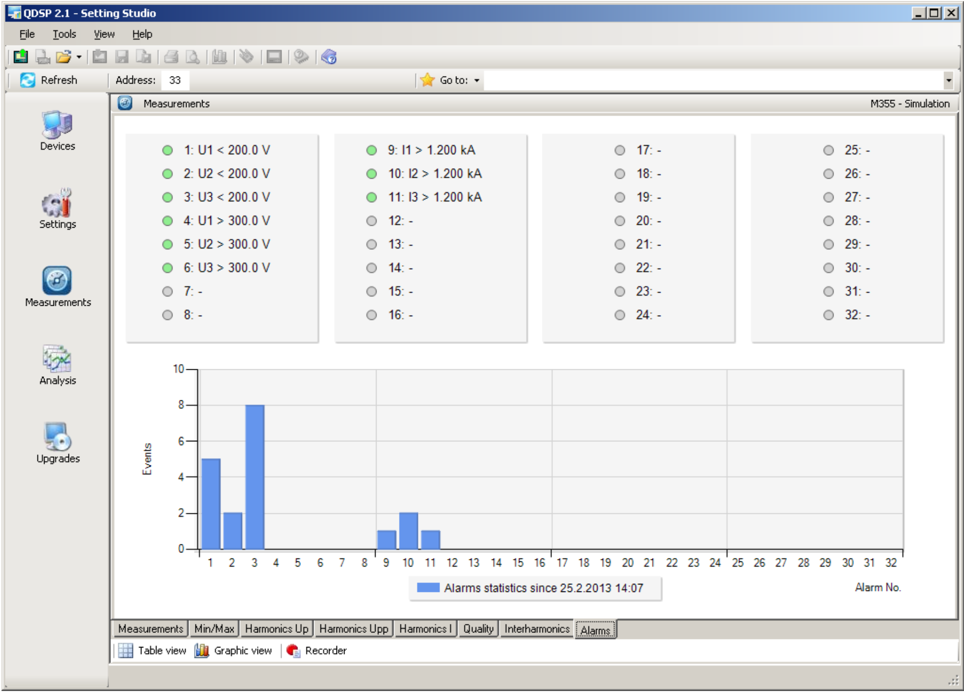


FIGURE 12-7: GRAPHICAL PRESENTATION OF ALARMS

12.4.4 Harmonic Analysis

Main menu	
Measurements	
Settings	
Resets	
SD card	
Info	
Installation	
14.11.2012	16:53:36

⇨

Measurements
Present values
Min/Max values
Alarms
Graphs time
Graphs FFT
Power supply quality
Demo cycling
⇦ Main menu

Harmonic analysis is an important part of PQ monitoring. Frequency converters, inverters, electronic motor drives, LED, halogen and other modern lamps, all cause harmonic distortion of the supply voltage and can cause other sensitive equipment to malfunction or even fail.

Particularly vulnerable are distribution level compensation devices whose capacitor banks act like a drain for higher harmonics and amplify their influence. Higher harmonic currents flowing through capacitors can cause overheating resulting in a shortening of their lifetime or possibly causing catastrophic failure.

Monitoring harmonic distortion is therefore important not only to prevent malfunction of household equipment and to prolong operation of motors but also to prevent serious damage to distribution equipment and harm to people working close to compensation devices.

Due to the importance of harmonic analysis special standard IEC 61000-4-7 defines methods for measurement and calculation of harmonic parameters.

The **M3x5** Quality Analyser measures harmonics up to 63rd and evaluates the following harmonic parameters:

- Phase Voltage harmonic signals
- THD U_{P-N}
- Phase-to-phase Voltage harmonic signals
- THD U_{P-P}
- Current harmonic signals
- THD I
- Interharmonics (10 user defined interharmonic frequencies)
- Signalling voltage (monitoring ripple control signal)

PLEASE NOTE

Interharmonics are available only on communication.

All of the listed harmonic parameters can be monitored online, stored in internal memory (not all at a time) and compared against alarm condition threshold limits.

The latter is in combination with alarm relay output suitable for notification and/or automatic disconnection of compensation devices, when too high harmonics present could endanger the capacitors.

12.4.4.1 Display of harmonic parameters

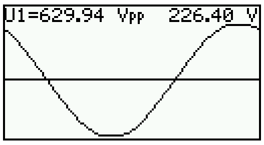
Harmonic parameters can be displayed on the devices LCD in graphical form and as data.

Representation of individual harmonics consists of:

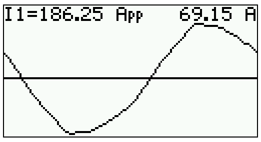
- Absolute value
- Relative value
- Phase angle between fundamental and observed harmonic

PLEASE NOTE

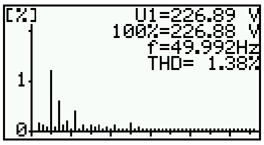
Relative value can be calculated as a percentage of fundamental or as a percentage of RMS value. Setting for choice of this relative factor is under General settings.



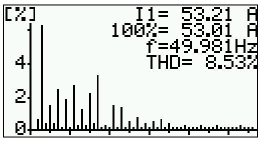
Display of Phase Voltage in time space diagram. Displayed are also peak value of monitored phase voltage and its RMS value. Similar display also for phase-to-phase voltages.



Display of Current in time space diagram. Displayed are also peak value of monitored current and its RMS value



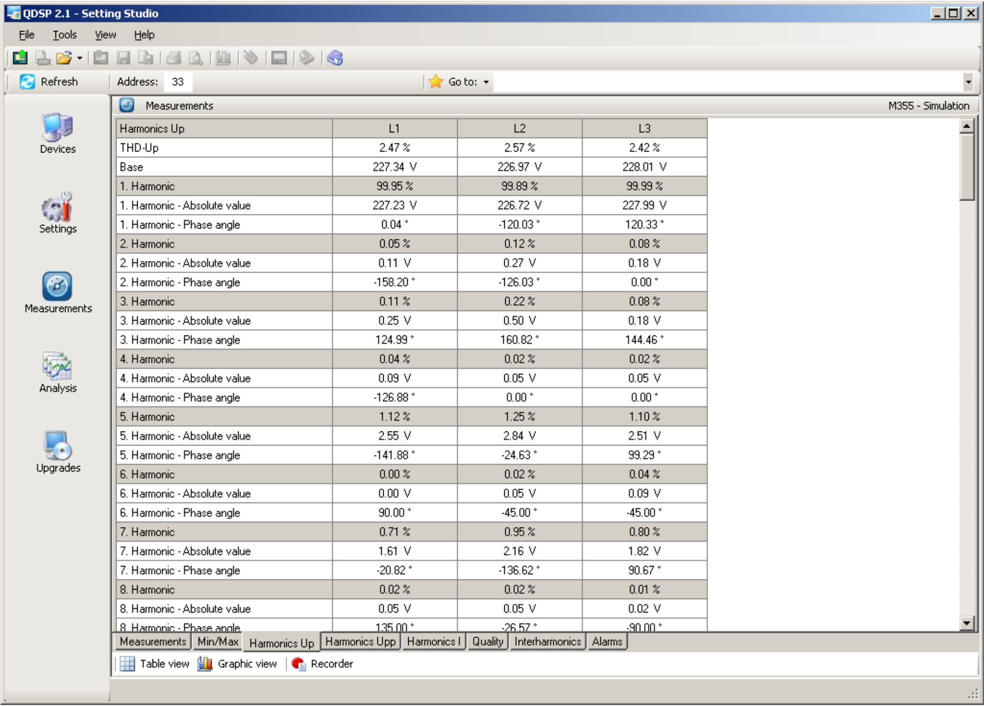
Display of Phase Voltage in frequency space diagram. Displayed are also RMS value, unit value (100%), system frequency and THD value. Similar display is also for phase-to-phase voltages.



Display of Current in frequency space diagram. Displayed are also RMS value, unit value (100%), system frequency and THD value.

More information about harmonic parameters, especially individual harmonic values, can be obtained when the device is connected via communications to the monitoring and setting software **QDSP2**.

FIGURE 12-8: GRAPHICAL PRESENTATION OF PHASE VOLTAGE HARMONIC COMPONENTS

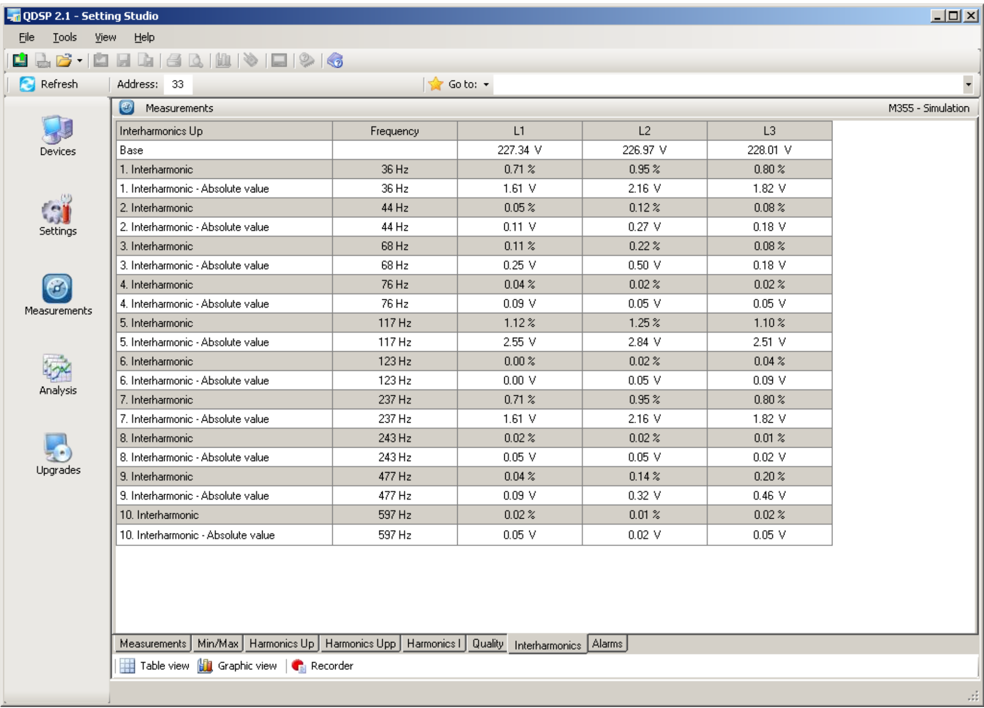


Harmonics Up	L1	L2	L3
THD-Up	2.47 %	2.57 %	2.42 %
Base	227.34 V	226.97 V	228.01 V
1. Harmonic	99.95 %	99.89 %	99.99 %
1. Harmonic - Absolute value	227.23 V	226.72 V	227.99 V
1. Harmonic - Phase angle	0.04 °	-120.03 °	120.33 °
2. Harmonic	0.05 %	0.12 %	0.08 %
2. Harmonic - Absolute value	0.11 V	0.27 V	0.18 V
2. Harmonic - Phase angle	-158.20 °	-126.03 °	0.00 °
3. Harmonic	0.11 %	0.22 %	0.08 %
3. Harmonic - Absolute value	0.25 V	0.50 V	0.18 V
3. Harmonic - Phase angle	124.99 °	160.82 °	144.46 °
4. Harmonic	0.04 %	0.02 %	0.02 %
4. Harmonic - Absolute value	0.09 V	0.05 V	0.05 V
4. Harmonic - Phase angle	-126.88 °	0.00 °	0.00 °
5. Harmonic	1.12 %	1.25 %	1.10 %
5. Harmonic - Absolute value	2.55 V	2.84 V	2.51 V
5. Harmonic - Phase angle	-141.88 °	-24.63 °	99.29 °
6. Harmonic	0.00 %	0.02 %	0.04 %
6. Harmonic - Absolute value	0.00 V	0.05 V	0.09 V
6. Harmonic - Phase angle	90.00 °	-45.00 °	-45.00 °
7. Harmonic	0.71 %	0.95 %	0.80 %
7. Harmonic - Absolute value	1.61 V	2.16 V	1.82 V
7. Harmonic - Phase angle	-20.82 °	-136.62 °	90.67 °
8. Harmonic	0.02 %	0.02 %	0.01 %
8. Harmonic - Absolute value	0.05 V	0.05 V	0.02 V
8. Harmonic - Phase angle	135.00 °	-26.57 °	-90.00 °

FIGURE 12-9: TABULAR PRESENTATION OF PHASE VOLTAGE HARMONIC COMPONENTS

PLEASE NOTE

According to standard IEC 61000-4-7 that defines methods for calculation of harmonic parameters, harmonic values and interharmonic values do not represent signal magnitude at exact harmonic frequency but weighted sum of centred (harmonic) value and its sidebands. More information can be found in the standard.



Interharmonics Up	Frequency	L1	L2	L3
Base		227.34 V	226.97 V	228.01 V
1. Interharmonic	36 Hz	0.71 %	0.95 %	0.80 %
1. Interharmonic - Absolute value	36 Hz	1.61 V	2.16 V	1.82 V
2. Interharmonic	44 Hz	0.05 %	0.12 %	0.08 %
2. Interharmonic - Absolute value	44 Hz	0.11 V	0.27 V	0.18 V
3. Interharmonic	68 Hz	0.11 %	0.22 %	0.08 %
3. Interharmonic - Absolute value	68 Hz	0.25 V	0.50 V	0.18 V
4. Interharmonic	76 Hz	0.04 %	0.02 %	0.02 %
4. Interharmonic - Absolute value	76 Hz	0.09 V	0.05 V	0.05 V
5. Interharmonic	117 Hz	1.12 %	1.25 %	1.10 %
5. Interharmonic - Absolute value	117 Hz	2.55 V	2.84 V	2.51 V
6. Interharmonic	123 Hz	0.00 %	0.02 %	0.04 %
6. Interharmonic - Absolute value	123 Hz	0.00 V	0.05 V	0.09 V
7. Interharmonic	237 Hz	0.71 %	0.95 %	0.80 %
7. Interharmonic - Absolute value	237 Hz	1.61 V	2.16 V	1.82 V
8. Interharmonic	243 Hz	0.02 %	0.02 %	0.01 %
8. Interharmonic - Absolute value	243 Hz	0.05 V	0.05 V	0.02 V
9. Interharmonic	477 Hz	0.04 %	0.14 %	0.20 %
9. Interharmonic - Absolute value	477 Hz	0.09 V	0.32 V	0.46 V
10. Interharmonic	597 Hz	0.02 %	0.01 %	0.02 %
10. Interharmonic - Absolute value	597 Hz	0.05 V	0.02 V	0.05 V

FIGURE 12-10: TABULAR PRESENTATION OF 10 PHASE VOLTAGE INTERHARMONIC COMPONENTS

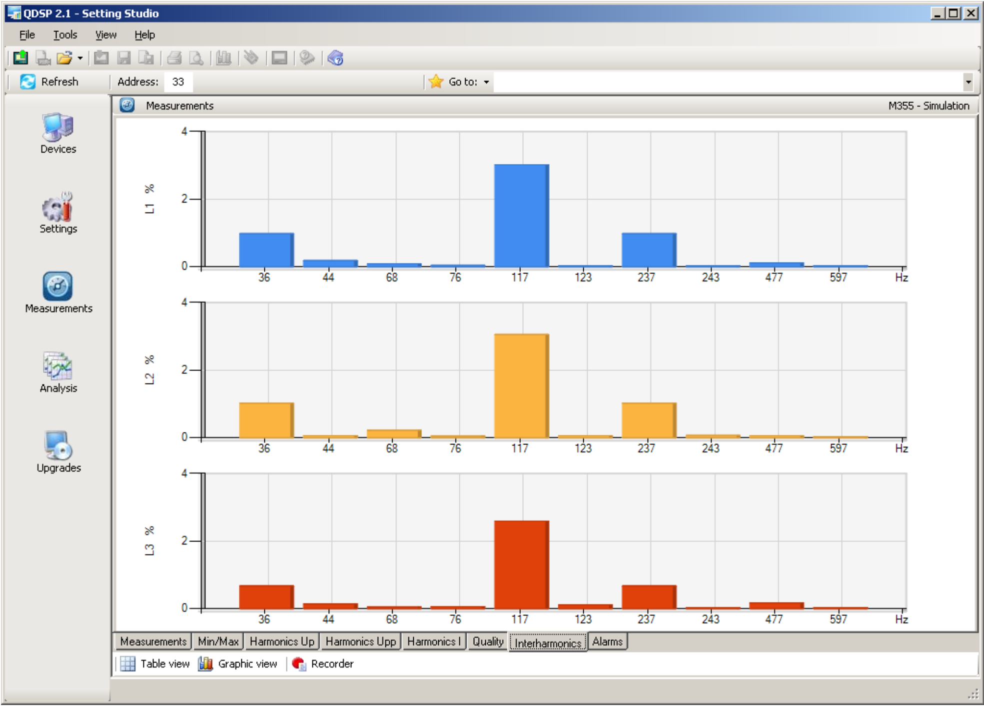


FIGURE 12-11: GRAPHICAL PRESENTATION OF 10 PHASE VOLTAGE INTERHARMONIC COMPONENTS

12.4.5 Power Quality Analysis

Main menu	
Measurements	
Settings	
Resets	
SD card	
Info	
Installation	
14.11.2012	16:53:36

⇨

Measurements
Present values
Min/Max values
Alarms
Graphs time
Graphs FFT
Power supply quality
Demo cycling
⇦ Main menu

PQ (Power Quality) analysis is the core functionality of the **M3x5** Quality Analyser. PQ is a very common and well understood expression; however it is not exactly in accordance with its actual meaning.

PQ analysis actually deals with the quality of the Supply Voltage which is the responsibility of the utility companies. It influences the behaviour of connected apparatus and devices.

Fluctuations in current and power on the other hand are the consequence of varying loads and hence the responsibility of consumers. With proper filtering the load influence can be restricted to the consumer internal network or at most within the single feeder, while poor supply voltage quality influences much wider areas.

Therefore indications of the quality of the supply voltage (alias PQ) are limited to anomalies connected only to supply voltage.

Phenomena	**PQ Parameters**
Frequency variations	Frequency distortion
Voltage variations	Voltage fluctuation Voltage unbalance
Voltage changes	Rapid voltage changes Flicker
Voltage events	Voltage dips Voltage interruptions Voltage swells
Harmonics & THD	THD Harmonics Inter-harmonics Signalling voltage

TABLE 12-2: POWER QUALITY INDICES AS DEFINED BY EN50160

For evaluation of voltage quality, the **M3x5** stores the measurements of the main voltage characteristics in to internal memory. The reports are made on the basis of this stored data. Data for the last 300 weeks and up to 170,000 variations of the measured quantities from the standard values are stored in the report, which enables detection of anomalies in the network.

QDSP2 software offers a complete review of the reports with a detailed review of individual measured quantities and anomalies. A review of compliance of individual measured quantities in previous and actual monitored periods is possible.

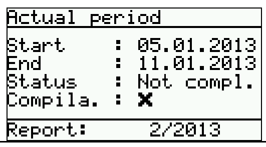
12.4.5.1 Online monitoring

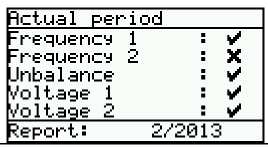
When all PQ parameters are set and analysis is enabled, PQ starts on the defined date and starts issuing weekly reports (if monitoring period setting is set to one week).

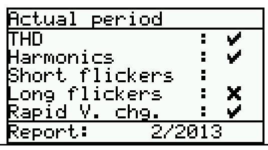
QDSP2 software allows the monitoring of the state of the actual period and of the previous monitoring period. Both periods can be overviewed on the devices display as well.

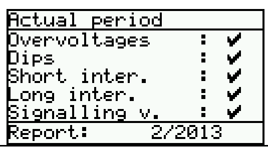
(KD) **Main menu ⇨ Measurements ⇨ Power supply quality ⇨ Actual period/Previous period**

Below is an example of PQ report for actual period generated on the device display. More detailed information about PQ is available via communication.

<table>
<tr><td>


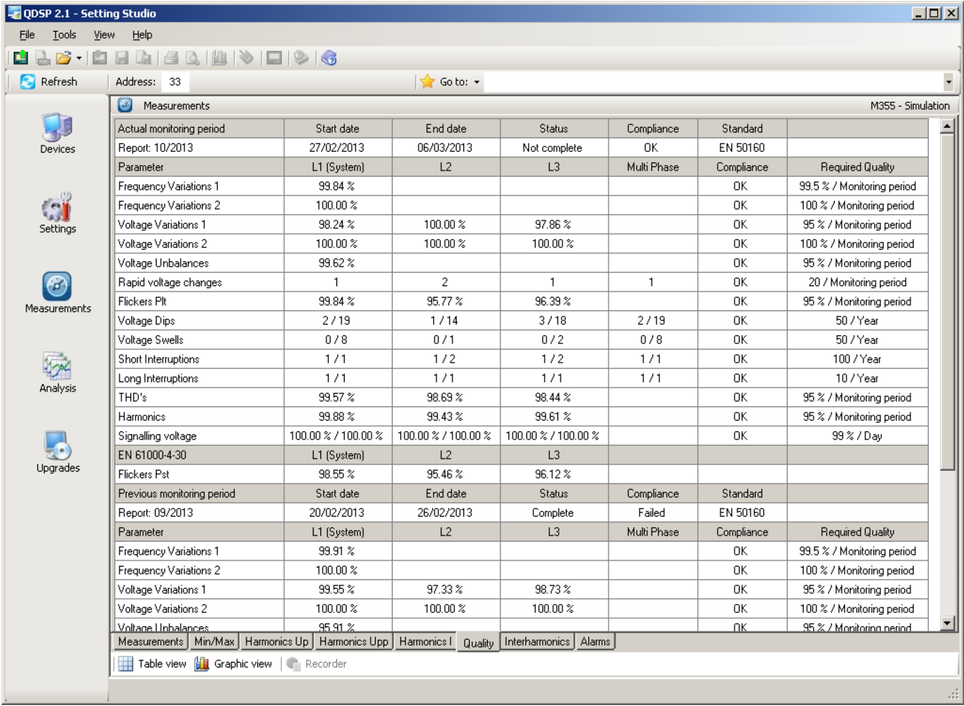
</td><td>Basic information about actual monitoring period. Period is not completed and currently not in compliance with EN 50160</td></tr>
<tr><td>


</td><td>Display of current status of PQ parameters. Some are currently not in compliance with EN 50160</td></tr>
<tr><td>


</td><td>Display of current status of PQ parameters. Some are currently not in compliance with EN 50160</td></tr>
<tr><td>


</td><td>Display of current status of PQ parameters. All are currently in compliance with EN 50160</td></tr>
</table>

Online monitoring of the PQ parameters and viewing of reports is easier with **QDSP2**.



Actual monitoring period	Start date	End date	Status	Compliance	Standard	
Report: 10/2013	27/02/2013	06/03/2013	Not complete	OK	EN 50160	
Parameter	L1 (System)	L2	L3	Multi Phase	Compliance	Required Quality
Frequency Variations 1	99.84 %				OK	99.5 % / Monitoring period
Frequency Variations 2	100.00 %				OK	100 % / Monitoring period
Voltage Variations 1	98.24 %	100.00 %	97.86 %		OK	95 % / Monitoring period
Voltage Variations 2	100.00 %	100.00 %	100.00 %		OK	100 % / Monitoring period
Voltage Unbalances	99.62 %				OK	95 % / Monitoring period
Rapid voltage changes	1	2	1	1	OK	20 / Monitoring period
Flickers Plt	99.84 %	95.77 %	96.39 %		OK	95 % / Monitoring period
Voltage Dips	2 / 19	1 / 14	3 / 18	2 / 19	OK	50 / Year
Voltage Swells	0 / 8	0 / 1	0 / 2	0 / 8	OK	50 / Year
Short Interruptions	1 / 1	1 / 2	1 / 2	1 / 1	OK	100 / Year
Long Interruptions	1 / 1	1 / 1	1 / 1	1 / 1	OK	10 / Year
THD's	99.57 %	98.69 %	98.44 %		OK	95 % / Monitoring period
Harmonics	99.88 %	99.43 %	99.61 %		OK	95 % / Monitoring period
Signalling voltage	100.00 % / 100.00 %	100.00 % / 100.00 %	100.00 % / 100.00 %		OK	99 % / Day
EN 61000-4-30	L1 (System)	L2	L3			
Flickers Pst	98.55 %	95.46 %	96.12 %			
Previous monitoring period	Start date	End date	Status	Compliance	Standard	
Report: 09/2013	20/02/2013	26/02/2013	Complete	Failed	EN 50160	
Parameter	L1 (System)	L2	L3	Multi Phase	Compliance	Required Quality
Frequency Variations 1	99.91 %				OK	99.5 % / Monitoring period
Frequency Variations 2	100.00 %				OK	100 % / Monitoring period
Voltage Variations 1	99.55 %	97.33 %	98.73 %		OK	95 % / Monitoring period
Voltage Variations 2	100.00 %	100.00 %	100.00 %		OK	100 % / Monitoring period
Voltage Unbalances	95.91 %				OK	95 % / Monitoring period

FIGURE 12-12: TABULAR PRESENTATION OF PQ PARAMETERS AND OVERALL COMPLIANCE STATUS FOR ACTUAL AND PREVIOUS MONITORING PERIOD

For all parameters basic information is shown:

Actual quality

Actual quality is for some parameters expressed as a percentage of time, when parameters were inside limit lines and for others (events) is expressed as a number of events within monitored period.

Actual quality is for some parameters measured in all three phases and for some only in a single phase (frequency). Events can also occur as Multi-Phase events (more about multiphase events is described in following sections)

Events are according to EN 50160 evaluated on a yearly basis. Actual quality information is therefore combined from two numbers (x / y) as shown in a figure 12-12, where:

x…number of events in monitored period

y…total number of events in current year

Required quality

Required quality is limit for compliance with standard EN 50160 and is directly compared with actual quality. Result of comparison is actual status of compliance.

More information about required quality limits can be found in standard EN 50160.

PLEASE NOTE

To make the complete quality report the auxiliary power supply for the device should not be interrupted during the whole period for which the report is requested. If firmware is updated or power supply is interrupted within a monitoring period, quality report is incomplete – Status: Not complete.

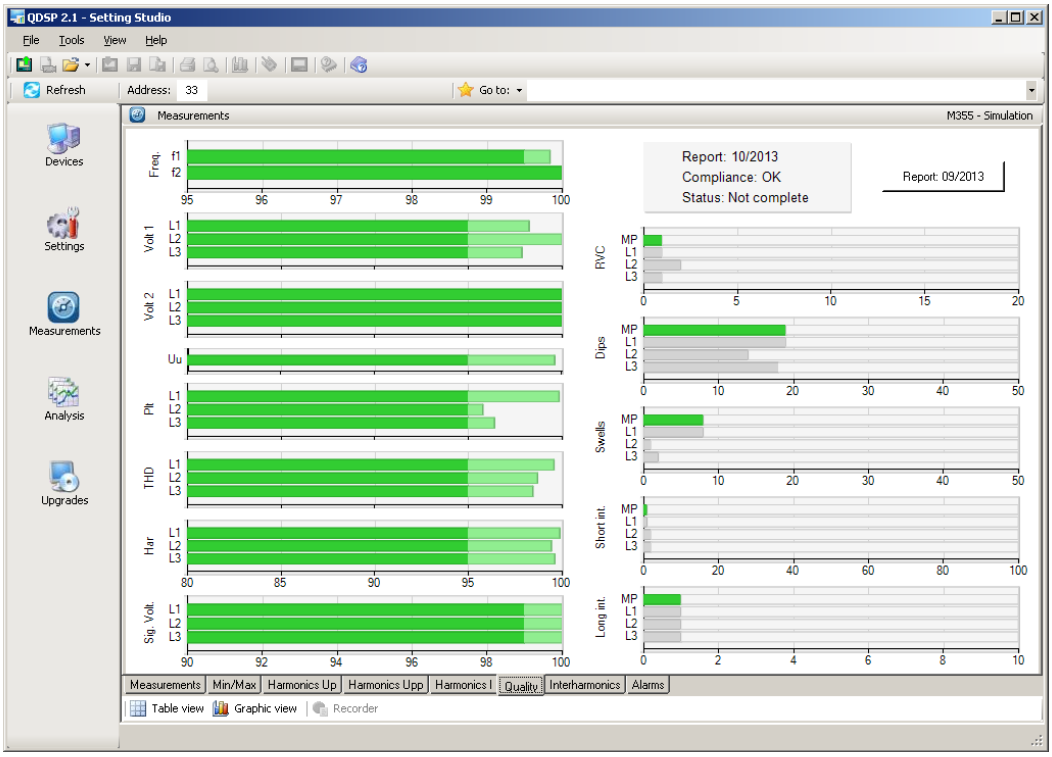


FIGURE 12-13: GRAPHICAL PRESENTATION OF PQ PARAMETERS AND OVERALL COMPLIANCE

- Darker green colour marks required quality
- Light green colour marks actual quality
- Red colour marks non-compliance with standard EN 50160
- Grey colour at events marks number of events
- MP at events marks Multi phase events

12.4.6 PQ records

Even more detailed description about PQ can be obtained by accessing PQ reports with details about anomalies in internal memory.

After memory has been read using **QDSP2**, information about the downloaded data is shown.

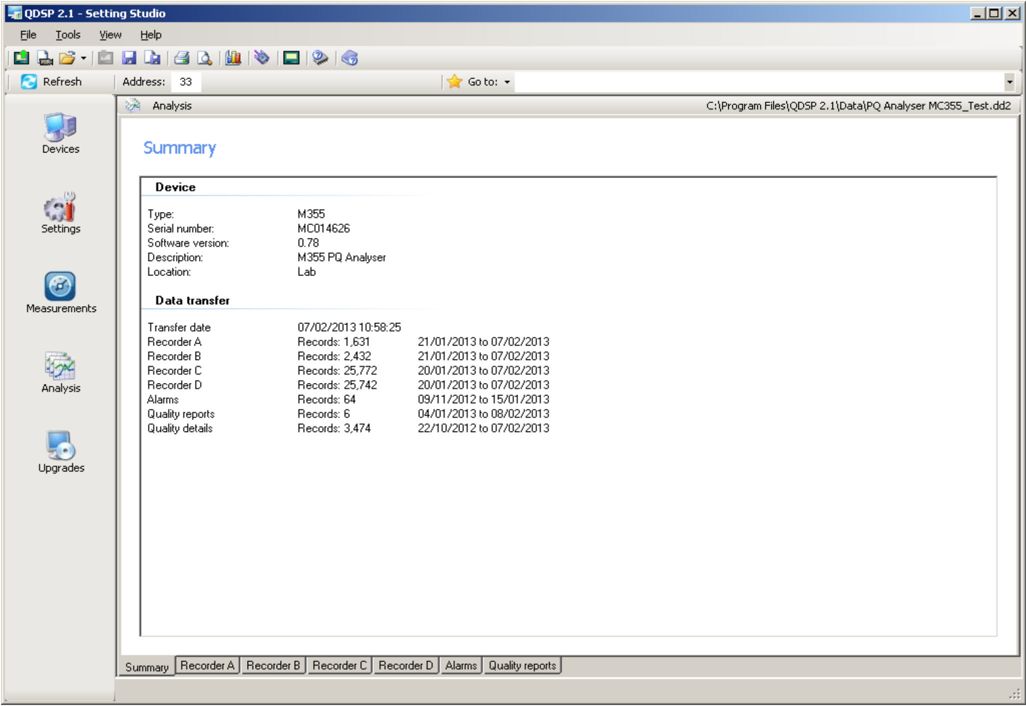


FIGURE 12-14: INFORMATION ABOUT DOWNLOADED DATA WITH TABS FOR DIFFERENT MEMORY PARTITIONS

All information about PQ is stored in **Quality reports** tab.

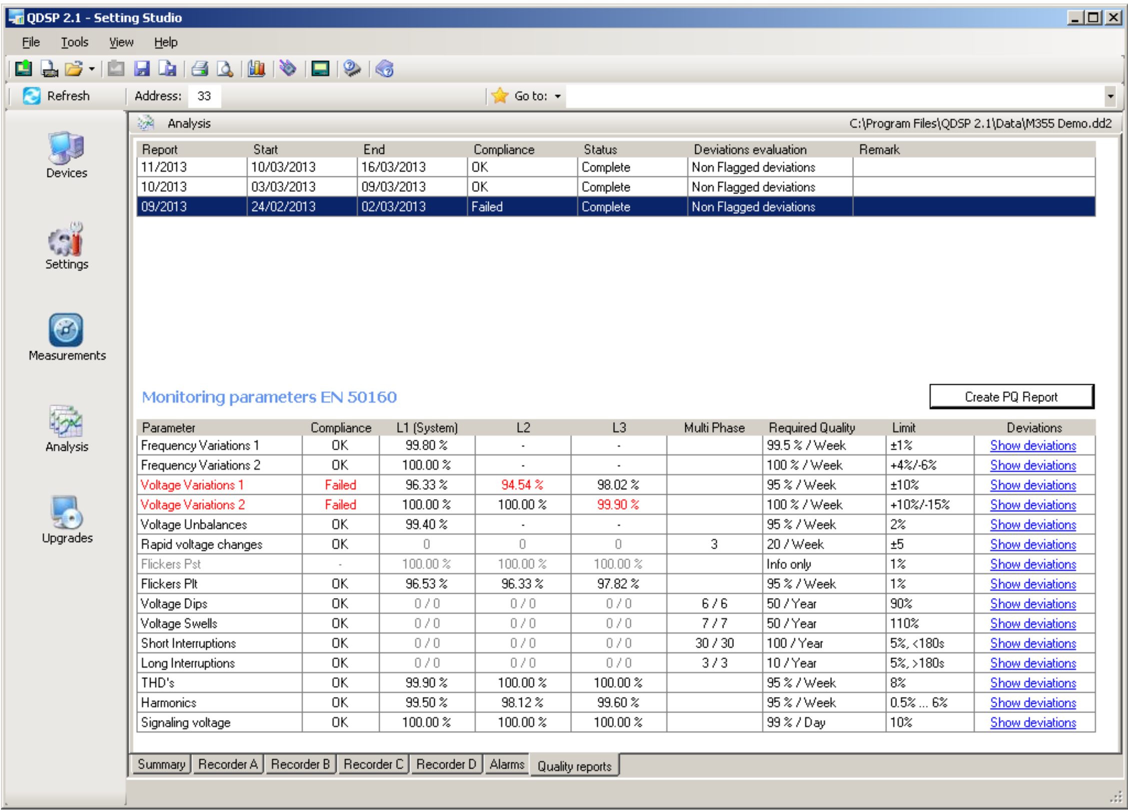


FIGURE 12-15: MAIN WINDOW OF RECORDED PQ REPORTS.

The main window is divided into two parts. Upper part shows information about recorded periodic PQ reports and lower part shows detailed information about the selected PQ report.

For each of the monitored parameters it is possible to display an anomaly report. This represents a complete list of accurately time stamped measurements that were outside the PQ limit lines.

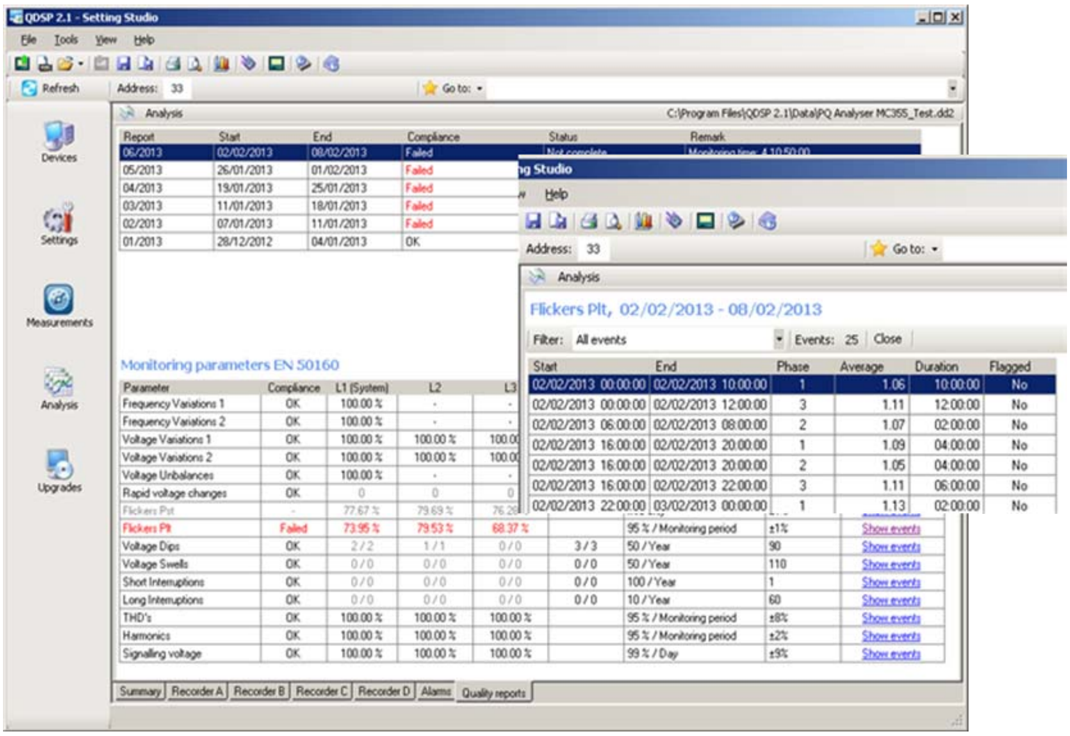


FIGURE 12-16: DETAILS OF ANOMALIES FOR MONITORED PARAMETER

12.4.7 Flagged data evaluation

Flagged data represent data (recorded events) that have been flagged (marked) according to the flagging concept defined in IEC 61000-4-30.

Flagged data are power quality records, which has been influenced by one or more voltage events (interruptions, dips, swells).

The purpose of flagging data is to mark recorded parameters when certain disturbances might influence measurements and cause corrupted data. For example, voltage dip can also trigger occurrence of flicker, interharmonics, etc. In this case all parameters which were recorded at the same time as the voltage dip event are marked (flagged).

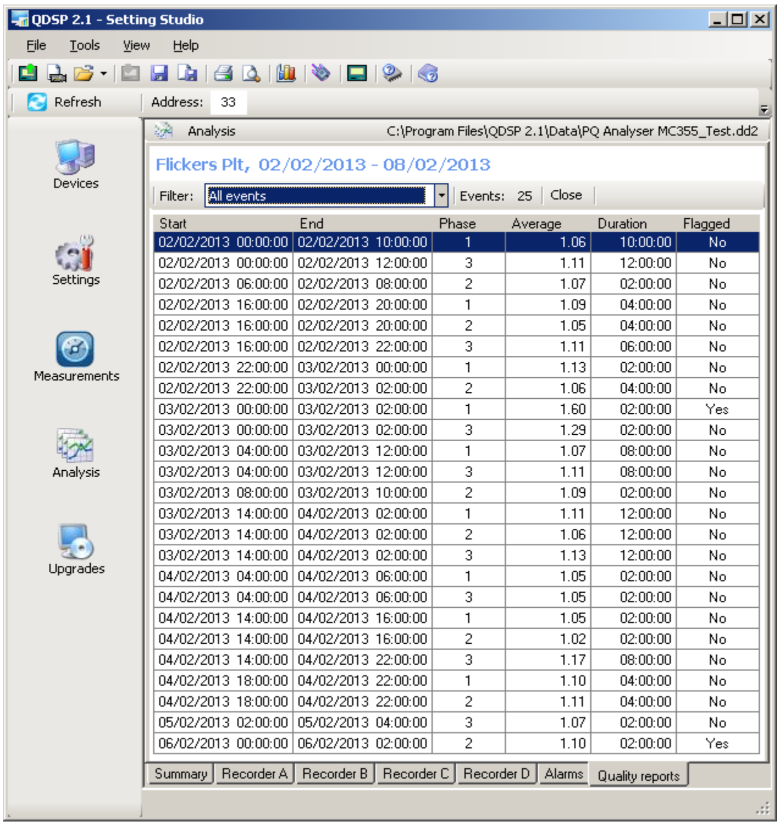
PQ report will omit or include flagged data according to appropriate setting.

PLEASE NOTE

Regardless of the Flag setting, readings will always be stored in the recorder and available for analysis. Flagging only influences PQ reports as a whole.

In evaluation of PQ parameter details it is possible to show:

- All events
- Non-flagged events



Start	End	Phase	Average	Duration	Flagged
02/02/2013 00:00:00	02/02/2013 10:00:00	1	1.06	10:00:00	No
02/02/2013 00:00:00	02/02/2013 12:00:00	3	1.11	12:00:00	No
02/02/2013 06:00:00	02/02/2013 08:00:00	2	1.07	02:00:00	No
02/02/2013 16:00:00	02/02/2013 20:00:00	1	1.09	04:00:00	No
02/02/2013 16:00:00	02/02/2013 20:00:00	2	1.05	04:00:00	No
02/02/2013 16:00:00	02/02/2013 22:00:00	3	1.11	06:00:00	No
02/02/2013 22:00:00	03/02/2013 00:00:00	1	1.13	02:00:00	No
02/02/2013 22:00:00	03/02/2013 02:00:00	2	1.06	04:00:00	No
03/02/2013 00:00:00	03/02/2013 02:00:00	1	1.60	02:00:00	Yes
03/02/2013 00:00:00	03/02/2013 02:00:00	3	1.29	02:00:00	No
03/02/2013 04:00:00	03/02/2013 12:00:00	1	1.07	08:00:00	No
03/02/2013 04:00:00	03/02/2013 12:00:00	3	1.11	08:00:00	No
03/02/2013 08:00:00	03/02/2013 10:00:00	2	1.09	02:00:00	No
03/02/2013 14:00:00	04/02/2013 02:00:00	1	1.11	12:00:00	No
03/02/2013 14:00:00	04/02/2013 02:00:00	2	1.06	12:00:00	No
03/02/2013 14:00:00	04/02/2013 02:00:00	3	1.13	12:00:00	No
04/02/2013 04:00:00	04/02/2013 06:00:00	1	1.05	02:00:00	No
04/02/2013 04:00:00	04/02/2013 06:00:00	3	1.05	02:00:00	No
04/02/2013 14:00:00	04/02/2013 16:00:00	1	1.05	02:00:00	No
04/02/2013 14:00:00	04/02/2013 16:00:00	2	1.02	02:00:00	No
04/02/2013 14:00:00	04/02/2013 22:00:00	3	1.17	08:00:00	No
04/02/2013 18:00:00	04/02/2013 22:00:00	1	1.10	04:00:00	No
04/02/2013 18:00:00	04/02/2013 22:00:00	2	1.11	04:00:00	No
05/02/2013 02:00:00	05/02/2013 04:00:00	3	1.07	02:00:00	No
06/02/2013 00:00:00	06/02/2013 02:00:00	2	1.10	02:00:00	Yes

FIGURE 12-17: DISPLAY OF ALL OR NON-FLAGGED EVENTS

12.4.8 Multiphase events

According to standard EN 50160 events (interruptions, dips, swells) should be multiphase aggregated.

Multiphase aggregation is a method where events, which occur on all phases at the same time, are substituted with a single multiphase event since they were most likely triggered by a single anomaly in the network.

However, to eliminate the possibility of loss of information all events are recorded. Therefore during a multiphase anomaly four events are recorded, three events for each phase and an additional multiphase event.

Start	End	Phase	Minimum [%]	Minimum [V]	Duration
03/02/2013 00:24:53.748	03/02/2013 00:24:53.778	-	88.78	204.19	00:00:00.030
03/02/2013 00:24:53.748	03/02/2013 00:24:53.778	1	88.78	204.19	00:00:00.030
03/02/2013 00:24:54.876	03/02/2013 00:24:54.946	-	87.35	200.91	00:00:00.070
03/02/2013 00:24:54.876	03/02/2013 00:24:54.946	1	87.35	200.91	00:00:00.070
06/02/2013 01:07:22.611	06/02/2013 01:07:22.731	-	86.11	198.05	00:00:00.120
06/02/2013 01:07:22.611	06/02/2013 01:07:22.731	2	86.11	198.05	00:00:00.120

FIGURE 12-18: “PHASE” COLUMN IN A LIST OF EVENTS MARKS MULTIPHASE EVENT WITH “-“

Definition for multiphase dip and swell is:

"*Multiphase event starts when voltage on one or more phases crosses threshold line for event detection and ends when voltage on all phases is restored to normal value"*

Definition for multiphase interruption is:

"*Multiphase interruption starts when voltage on all three phases crosses threshold line for interruption detection and ends when voltage on at least one phase is restored to normal value"*

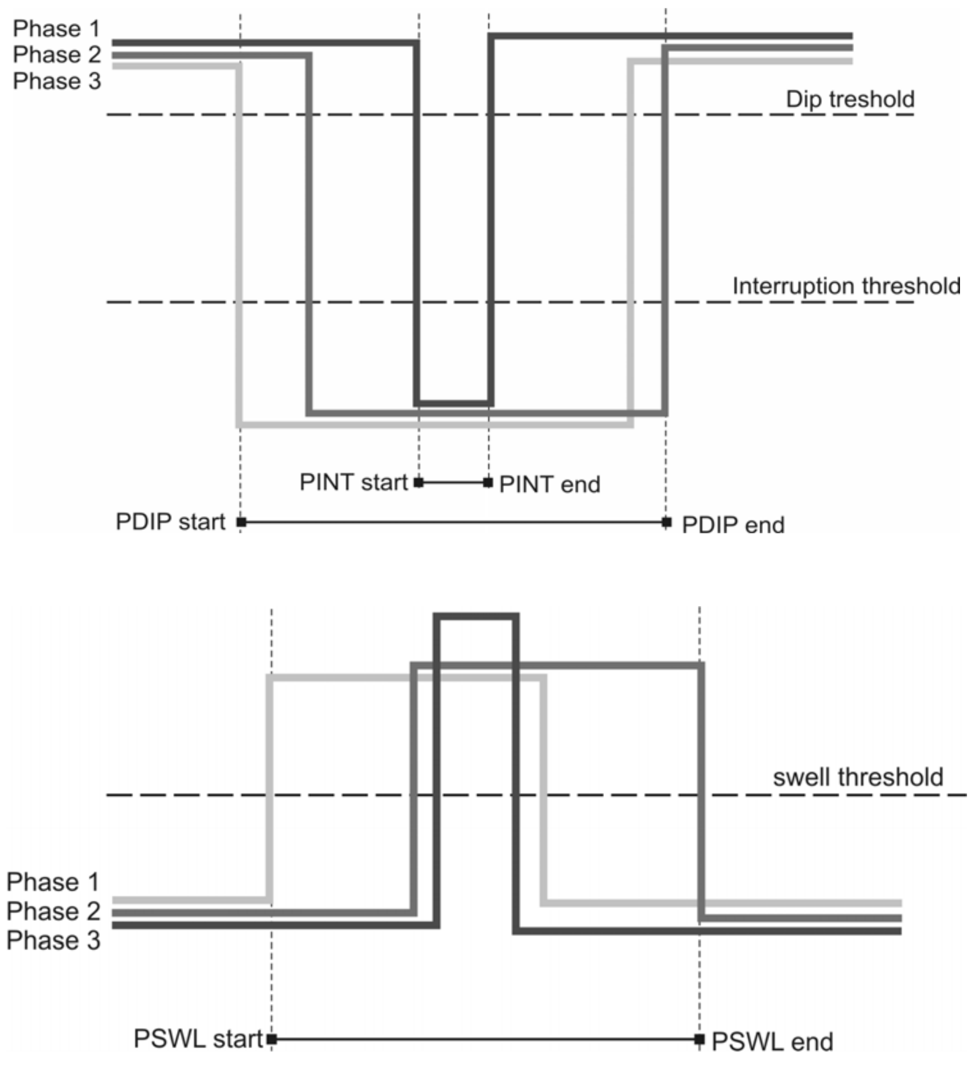


FIGURE 12-19: GRAPHICAL PRESENTATION OF MULTIPHASE (PDIP, PINT, PSWL) EVENT DETECTION

Voltage event details are displayed in two ways. Firstly as a list of events with all details and secondly in a table according to the UNIPEDE DISDIP specification.

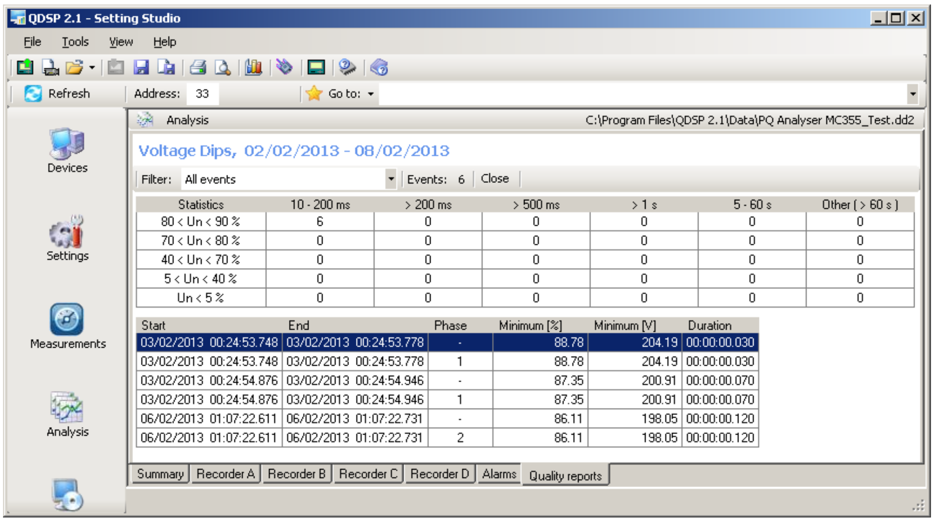
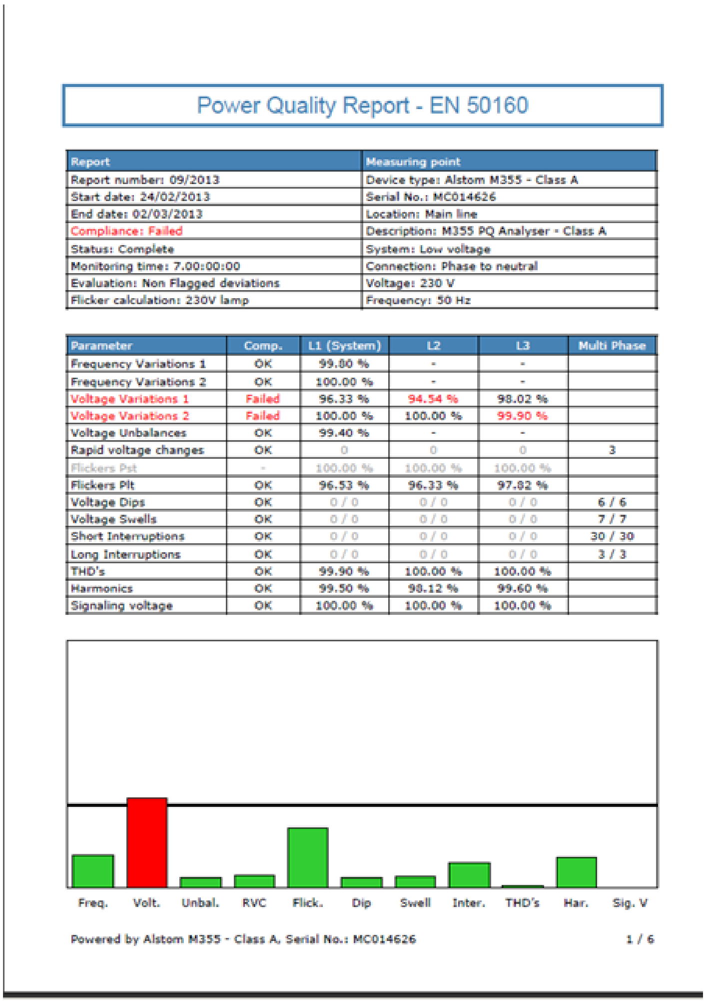


FIGURE 12-20: PRESENTATION OF DIPS AND INTERRUPTIONS IN A LIST AND IN A STATISTICS TABLE

12.4.9 EN50160 Quality Report in PDF format

By clicking 'Create PQ Report' from the Quality Report window, a full EN50160 report can be generated, including full details for all parameters, as a pdf file.



Power Quality Report - EN 50160

Report	Measuring point
Report number: 09/2013	Device type: Alstom M355 - Class A
Start date: 24/02/2013	Serial No.: MC014626
End date: 02/03/2013	Location: Main line
Compliance: Failed	Description: M355 PQ Analyser - Class A
Status: Complete	System: Low voltage
Monitoring time: 7.00:00:00	Connection: Phase to neutral
Evaluation: Non Flagged deviations	Voltage: 230 V
Flicker calculation: 230V lamp	Frequency: 50 Hz

Parameter	Comp.	L1 (System)	L2	L3	Multi Phase
Frequency Variations 1	OK	99.80 %	-	-	
Frequency Variations 2	OK	100.00 %	-	-	
Voltage Variations 1	Failed	96.33 %	94.54 %	98.02 %	
Voltage Variations 2	Failed	100.00 %	100.00 %	99.90 %	
Voltage Unbalances	OK	99.40 %	-	-	
Rapid voltage changes	OK	0	0	0	3
Flickers Pst	-	100.00 %	100.00 %	100.00 %	
Flickers Plt	OK	96.53 %	96.33 %	97.82 %	
Voltage Dips	OK	0 / 0	0 / 0	0 / 0	6 / 6
Voltage Swells	OK	0 / 0	0 / 0	0 / 0	7 / 7
Short Interruptions	OK	0 / 0	0 / 0	0 / 0	30 / 30
Long Interruptions	OK	0 / 0	0 / 0	0 / 0	3 / 3
THD's	OK	99.90 %	100.00 %	100.00 %	
Harmonics	OK	99.50 %	98.12 %	99.60 %	
Signaling voltage	OK	100.00 %	100.00 %	100.00 %	

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13. SUPPORT POWER FOR REAL TIME CLOCK OPERATION

To maintain the operation of the Real Time Clock during periods when the Auxiliary power supply is not connected an internal power source is required.

In **M3x5** a Super Capacitor is fitted. A Super Capacitor has the advantage that it should never need to be replaced during the life of the product it is fitted in, unlike a battery.

But, unlike a battery which could support the operation of the clock for a long time period, the Super Capacitor, when fully charged, can only support the clock for a period in excess of 48 hours when auxiliary power is not connected, after which the clock will stop working. When power is re-connected the clock will need to be reprogrammed, this will be done automatically if time synchronization is implemented or it can be achieved easily using the product keypad or the **QDSP2** setting software.

When powering up an **M3x5** after the clock has stopped working, the clock setting will be displayed with an Icon showing that it needs to be set. A message will be displayed on **QDSP2**, if connected, defining that the clock needs to be set. And the status of the clock can be checked by an external SCADA to confirm if the clock needs to be set.

Only the clock operation will be affected as all settings and data are maintained in non-volatile memory, which does not require any power to maintain the data.

The **M3x5** will continue to operate correctly when the clock has stopped, except that any measurements which are stored with a time stamp will have an incorrect time stamp and Energy Tariffs based on time and date will not give the correct results.

14. TECHNICAL DATA

INPUTS AND SUPPLY		
Voltage Input	Number of channels	4 4th channel is used for measuring $U_{EARTH-NEUTRAL}$
	Sampling rate	31 kHz
	Min. voltage for sync.	1 V_{rms}
	Nominal value (U_N)	230 V_{LN}, 415 V_{LL}
	Max. allowed value	277 V_{LN}, 480 V_{LL} permanently 2 x Un for 10 seconds
	Consumption	< U^2 / 4.2 MΩ per phase
	Input impedance	4.2 MΩ per phase
Current Input	Number of channels	4
	Sampling rate	31 kHz
	Nominal current (I_N)	1A, 5A
	Maximum measured value	12.5A sinusoidal
	Overload	15A continuously ≤ 300A for 1 second
	Consumption	< I^2 x 0.01Ω per phase
Frequency	Nominal Frequency (f_n)	50, 60Hz
	Measuring range	16 to 400Hz
Supply: HIGH		CAT III 300V
	Nominal voltage AC	80….276 V
	Nominal frequency	40….65Hz
	Nominal voltage DC	70….300V
	Consumption (max. all I/O)	< 8 VA
	Power-on transient current	< 20A: 1 ms
Supply: LOW		CAT III 300V
	Nominal voltage AC	48….77 V
	Nominal frequency	40….65Hz
	Nominal voltage DC	19….70V
	Consumption (max. all I/O)	< 8 VA
	Power-on transient current	< 20A: 1 ms

CONNECTIONS	
Permitted conducer cross sections	Maximum conductor cross section
Voltage terminals (4)	2.5 mm^2 ferruled or 4 mm^2 solid wire
Current terminals (4)	≤ 6mm diameter conductor with insulation(1)
Supply (3)	2.5 mm^2 ferruled or 4 mm^2 solid wire
Modules 1,2 (2 x 3)	2.5 mm^2 ferruled or 4 mm^2 solid wire
Modules A,B (2 x 9)	2.5 mm^2 ferruled or 4 mm^2 solid wire
Module C (1 x 7)	2.5 mm^2 ferruled or 4 mm^2 solid wire

(1) Insulation for current connection wire should be at least PVC with 4kV dielectric strength and at least +75 °C working temperature (+100°C short time; <1 min)

WARNING

It is imperative that terminal 12 which represents fourth voltage measurement channel is connected to earth pole ONLY. This terminal should be connected to EARTH potential at all times!

Measured values	Measuring Range (Direct connection)	Accuracy class	
		Standard	**Class**
Active power	1.8 – 18 kW (In = 5 A)	IEC61557-12	0.2
	0 – 1.8 kW (In = 1 A)	IEC61557-12	0.5
Reactive power	0 – 18 kvar	IEC61557-12	1
Apparent power	0 – 18 kVA	IEC61557-12	0.2
Active energy	9 digit	IEC61557-12	0.2S
Reactive energy	9 digit	IEC61557-12	2
Apparent energy	9 digit	IEC61557-12	0.2
Rms current (I_1, I_2, I_3, Iavg) (I_{n_meas}) (I_{n_calc})	0,001 to 12.5 Arms In = 1 A or 5A In = 1 A or 5A(1) In = 1 A or 5A	IEC61557-12	 0.1 0.2 0.5
Rms phase voltage (U_1, U_2, U_3, U_{n-g}, U_{avg})	U_{meas}:10 - 600 V $_{L-N}$ U_{din} = 120/230V	IEC61557-12 IEC61000-4-30	0.1 Class A
Rms phase-to-phase voltage (U_{12}, U_{23}, U_{31}, U_{avg})	18 - 1000 V $_{L-L}$	IEC61557-12 IEC61000-4-30	0.1 Class A
Voltage negative sequence unbalance (2) (u_2)	10 - 600 V $_{L-N}$	IEC61557-12 IEC61000-4-30	0.2 Class A
Voltage zero sequence unbalance (2) (u_0)	10 - 600 V $_{L-N}$	IEC61557-12 IEC61000-4-30	0.2 Class A
Voltage flicker (Pst, Plt)	0.2 Pst – 10 Pst	IEC61000-4-15 IEC61000-4-30	Class F1 (3) Class A
Frequency – actual (f)	50 / 60Hz	IEC61557-12 IEC61000-4-30	0.02 Class A
Frequency - (10 s average) (f_{10s})	50 / 60 Hz	IEC61557-12 IEC61000-4-30	0.02 Class A
Nominal frequency range	16…400 Hz	IEC61557-12	0.02

Measured values	Measuring Range (Direct connection)	Accuracy class	
		Standard	**Class**
Power factor (PF_A)	−1(C)…0…+1(L)	IEC61557-12	0.5
Voltage swells (U_{swl})	100 – 120 % U_{din}	IEC61557-12 IEC61000-4-30	0.2, ±1 cyc Class A
Volatge dips (U_{dip})	5 – 100 % U_{din}	IEC61557-12 IEC61000-4-30	0.2, ±1 cyc Class A
Voltage interruptions (U_{int})	0 – 5 % U_{din}	IEC61557-12 IEC61000-4-30	±1 cyc Class A
THDU(4)	10 – 200% of IEC61000-4-2 Class 3 Up to 4kHz	IEC61557-12 IEC61000-4-7 IEC61000-4-30	0.3 Class I Class A
Voltage harmonics (U_{h_l-n}, U_{h_l-l})	10 – 200% of IEC61000-4-2 Class 3 Up to 4kHz (63rd)	IEC61557-12 IEC61000-4-7 IEC61000-4-30	0.15 Class I Class A
Voltage interharmonics (U_{Ih})	10 – 200% of IEC61000-4-2 Class 3	IEC61000-4-7 IEC61000-4-30	Class I Class A
THDI(3)	Up to 4kHz	IEC61557-12	0.3
Current harmonics (I_h)	Up to 4kHz (63rd)	IEC61557-12	0.5
Signalling voltage (U_{msv})	Up to 3kHz	IEC61000-4-30	Class A
Real time clock (RTC)	–	IEC61000-4-30	< ±1 sec/day Class A

(1) Accurate measurements of neutral current (I_{n_meas}) at lower frequencies (16Hz – 30Hz) are possible up to 6Arms
(2) Voltage unbalance is measured as amplitude and phase unbalance U_{nb}
(3) Test specifications for flickermeter according to standard IEC61000-4-15:2010
(4) When measuring THD, user can set how it is calculated (as a % of fundamental or as a % from RMS value)

MODULES		
Alarm module	Type	Relay output
	Purpose	Alarm output, General purpose digital output
	No. of outputs	2 (Modules 1, 2) or 8 (Modules A, B)
	Rated Voltage	230 $V_{AC/DC}$ ± 20% max.
	Max switching current	1000 mA (Module 1, 2) 100 mA (Module A, B)
	Contact resistance	≤ 100 mΩ (100 mA, 24V)
	Pulse (Module 1, 2 only)	Max 4000 imp/hour, Min length 100ms
Status (Watchdog) module	Type	Relay output
	Number or outputs	1 x watchdog + 1 x relay output
	Normal operation	Relays is ON position
	Failure detection delay	≈ 1.5 s
	Rated Voltage	230 $V_{AC/DC}$ ± 20% max.
	Max switching current	1000 mA
	Contact resistance	≤ 100 mΩ (100 mA, 24V)
Energy Pulse module	Type	Optocoupler open collector
	Purpose	2 x Pulse output
	Maximum voltage	40 $V_{AC/DC}$
	Maximum Current	30 mA (R_{ONmax} = 8Ω)
	Contact resistance	Programmable (2….999 ms)
Analogue Output module	Output range	0 … 20mA
	Accuracy	0.5% of range
	Maximum burden	150Ω
	Linearization	Linear, Quadratic
	No, of breakpoints	5
	Output value limits	± 120% of nominal output
	Response time (measurement and analogue output)	Depends on setting of general average interval 0.1s – 5.0 s
	Residual ripple	< 1% peak to peak
Tariff Input Module	No of inputs	2
	Voltage	5….48 V AC/DC * 110V ± 20% AC/DC * 230V ± 20% AC/DC * * Depends on built in hardware
Digital Input Module	No of inputs	2 (Modules 1, 2) or 8 (Modules A, B)
	Voltage	5….48 V AC/DC * 110V ± 20% AC/DC * 230V ± 20% AC/DC * * Depends on built in hardware

MODULES		
Analogue Input module	Number of Inputs	2
DC current input	Nominal input range 1 input resistance accuracy temperature drift conversion resolution Analogue input mode	–20…0…20 mA (±20%) 20 Ω 0.5 % of range 0.1% / °C 16 bit (sigma-delta) internally referenced Single-ended
DC voltage input	Nominal input range1 input resistance accuracy temperature drift conversion resolution Analogue input mode	–10…0…10 V (±20%) 100 kΩ 0.5 % of range 0.1% / °C 16 bit (sigma-delta) internally referenced Single-ended
Resistance/temperature input	Nominal input range (low)* Nominal input range (high)* connection accuracy conversion resolution Analogue input mode	0 - 200 Ω (max. 400 Ω) PT100 (-200°C–850°C) 0 – 2 kΩ (max. 4 kΩ) PT1000 (-200°C–850°C) 2-wire 0.5 % of range 16 bit (sigma-delta) internally referenced Single-ended
	* Low or high input range and primary input value (resistance or temperature) are set by the **QDSP2** setting software	
Time synchronisation input module (C)	Digital input	GPS or IRIG-B TTL
	1pps voltage level	TTL level (+5V)
	Max. consumption on +5V terminal	100 mA
	Time code telegram	RS232 (GPS) DC level shift (IRIG-B)
	AM analogue input	IRIG-B AM modulated
	Carrier frequency	1 kHz
	Input impedance	600 Ohms
	Amplitude	2.5V p-p min, 8Vp-p max
	Modulation ratio	3:1 – 6:1

COMMUNICATION				
	Ethernet	USB	RS232	RS485
Type of Connection	Network	Direct	Direct	Network
Max connection length	30m	2m	3m	1000m
Terminals	RJ45	USB-B	Screw terminals	
Transmission mode	Asynchronous			
Protocol	MODBUS TCP / RTU & DNP3 (autodetect)	MODBUS RTU / DNP3 (autodetect)		
Insulation	In accordance with EN61010-1:2010 standard			
Transfer rate	10/100Mb/s (autodetect)	USB 2.0	2400 to 115200b/s	

SAFETY FEATURES		
Safety	Protection class II In compliance with EN61010-1:2010 600Vrms, installation category II 300Vrms, installation category III Pollution degree 2	
Test voltage	Uaux against SELV circuits - 3.51 kV rms Other circuits to functional earth – 2.21 kV rms	
EMC	Directive on electromagnetic compatibility 2004/108/EC In compliance with EN 61326-1: 2006 for industrial environment	
Protection	In compliance with EN60529:1997 / A1:2000 Front with protection cover for Memory Card slot fitted: IP40 Rear with protection cover: IP20	
Ambient conditions	Ambient temperature	K55 temperature class Acc to EN 61557 – 12 -10….55ºC
	Storage temperature	-40 to +70 ºC
	Max. storage and transport humidity	≤ 90% r.h. (no condensation)
Enclosure	Dimensions	144 x 144 x 100 mm
	Mounting	Panel mounting 144 x 144 mm
	Required mounting hole	137 x 137mm
	Enclosure material	PC/ABC
	Flammability	Acc. To UL 94 V-0
	Mass	Approx 600g

15. APPENDIX A: COMMUNICATIONS

15.1 Communications ports

The **M3x5** is fitted with a primary communications (COM1) port and a secondary port (COM2).

COM1 can be RS232/RS485, USB or Ethernet and USB

COM2 is an RS232/RS485 port which is available if not used for connection to a GPS receiver for time synchronisation.

Both communications ports can be used for settings and the monitoring of data, they operate completely independently of each other.

15.2 Communications Protocols

Modbus and DNP3 protocol are enabled via RS232 and RS485 or Ethernet communication. Both communication protocols are supported on all communication ports of the device. The response is the same type as the request. See appendix B and C for details of the Modbus and DNP3 protocols.

15.3 Communications setup

The Setup of the communications on the **M3x5** is achieved using the **QDSP2** configuration software which is detailed in the separate **QDSP2** manual. **QDSP2** can communicate with the iSTAT products via RS232, RS485, USB and Ethernet. The option used will depend on which communication port is fitted to the product.

The **QDSP2** software always uses Modbus protocol to communicate with the product.

It is suggested that the communications channel for the product required by the application is initially set up using **QDSP2** running on a PC. Then when that is working correctly the product can be connected to the required intelligent device.

15.4 Ethernet

When using the Ethernet communications the set-up will depend on how the PC and the **M3x5** are connected. The Communication interface must have a unique IP address in the Ethernet network. Two modes for assigning IP are available:

Fixed IP address: In most installations a fixed IP address is required. A system provider usually defines IP addresses. An IP address should be within a valid IP range, unique for your network and in the same Subnet mask as your PC.

DHCP: Automatic method of assigning IP addressed (DHCP) is used in most networks. If you are not sure if DHPC is used in your network, check it with your system provider.

15.4.1 Using Fixed IP address

When the PC is directly connected to the Instrument a Fixed IP address will have to be used with the PC configured in the local area connection. If the connection is made without a Hub or Switch, the connection has to be made with a Crossover Ethernet cable.

The fixed IP address can be assigned to the device using **QDSP2**.

15.4.2 Local Port

The local port is the physical connector on a device enabling the connection to be made. Use a non reserved port number from 1025 to 65535. If using Redirector software, the port number should be between 14000 and 14009.

16. APPENDIX B1: MODBUS COMMUNICATIONS

The Modbus protocol is a widely supported open interconnect protocol originally designed by Modicon that can be enabled on the **M3x5** via RS232, RS485, USB or Ethernet communication.

There are two Modbus protocol types: Modbus RTU for serial communication (and USB) and Modbus TCP for Ethernet communication. It is also possible to pass Modbus RTU communications over Ethernet.

On Serial Communication, Modbus is a single master multiple slave protocol suitable for a multi-drop configuration as provided by the RS485 connection. Up to 32 devices can be connected in this way. Single - drop RS232 or USB connection is also possible.

16.1 Transactions

Communication operates on a master-slave basis where only one device (the master) can initiate transactions called 'Requests'. The other devices (slaves) respond by supplying the requested data to the master. This is called the 'Request - Response Cycle'.

Master to slave request:

Device address	Function Code	nx8 bit data bytes	Error check

Slave to master response:

Device address	Function Code	nx8 bit data bytes	Error check

16.2 Request

This Master to Slave transaction takes the form:

Device address:	Master addressing a slave (Address 0 is used for the broadcast address, which all slave devices recognise.).
Function code:	E.g. 04 ask the slave to read its Input Registers and respond with their contents.
Data bytes:	Tells the slave which register to start at and how many registers to read.

16.3 Response

This Slave to Master transaction takes the form:

Device address:	To let the master know which slave is responding.
Function code:	This is an echo of the request function code.
Data bytes:	Contains the data collected from the slave.

16.4 Request - response cycle example

Ia	160.00 A = 16000* 10^{-2} A
Data type “T3” 32 bit unsigned	FE 00 3E $80_{(16)}$
Data held in Modbus addresses	$30036_{(10)}$ & $30037_{(10)}$ $30036_{(10)}$ - $30000_{(10)}$ = $36_{(10)}$ □ 00 $24_{(16)}$

16.4.1 Request Frame

		Starting Register	Register Count	CRC
Slave Address HI LO	Function code		HI LO	LO HI
21	04	00 24	00 02	

16.4.2 Response Frame

			Register Data	CRC
Slave Address LO HI	Function code		Byte Count	HI LO HI LO
21	04	04	FE 00 3E 80	

16.5 Framing

There are two types of message framing for the serial communications, ASCII or RTU. iSTAT products supports RTU framing.

16.6 RTU framing

In RTU mode, messages start and end with a silent interval of at least 3.5 character times (t1-t2-t3-t4 as shown below).

The advantage of this mode of framing is that it enables a greater character density and a better data throughput. However, each message must be transmitted in a continuous stream. If a silent interval of more than 1.5 character times occurs before completion of the frame, the device flushes the incomplete message and assumes that the next byte will be the address field of a new message.

Start	Address	Function	Data	CRC Check	End
t1-t2-t3-t4	8 bits	8 bits	n x 8 bits	16 bits	t1-t2-t3-t4

The Cyclic Redundancy Check (CRC) field is two bytes, containing a 16 bit binary value. The CRC value is calculated by the transmitting device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message, and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal an error results. The CRC-16 calculation is an industry standard method used for error detection.

One frame is transmitted as 1 start bit, 8 data bits and 2 stop bit. If parity is selected then the frame is transmitted as 1 start bit, 8 data bits, and 1 stop bit.

Where n > 1 data is transmitted most significant byte first.

The CRC check is transmitted least significant byte first.

17. APPENDIX B2: MODBUS SUPPORTED FUNCTIONS AND USAGE

Code	Code	Function	References
DEC	HEX		
3	03	to read from holding registers	(4XXXX memory references)
4	04	to read from input registers	(3XXXX memory references)
6	06	to write to a single holding register	(4XXXX memory references)
16	10	to write to one or more holding registers	(4XXXX memory references)
17	11	report slave ID	6 characters
77	4D	read measurement string	1 byte value code (request)
82	52	re-read output buffer	Use after broadcast request

17.1 03 read from holding registers

Reads the binary content of holding registers (4X references) in the slave. Broadcast is also supported.

17.1.1 Request Frame

The query message specifies the starting register and quantity of registers (1 to 28) to be read. Registers are addressed starting at zero.

Here is an example of a request to read registers 40009 ... 40010 from slave device 33:

		Starting Register	Register Count	CRC
Slave Address	Function Code	HI LO	HI LO	LO HI
21	03	00 09	00 02	

17.1.2 Response Frame

The register data in the response message is packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

Data is scanned in the slave at the rate of 28 registers per scan. The response is returned when the data is completely assembled.

Here is an example of a response to the query:

			Register Data	CRC
Slave Address	Function Code	Byte Count	HI LO HI LO	LO HI
21	03	04	75 03 42 15	

The contents of registers 40009 ... 40010 are 75 03 and 42 15 hex.

17.2 04 read from input registers

Reads the binary content of input registers (3X references) in the slave. Broadcast is also supported

17.2.1 Request Frame

The query message specifies the starting register and quantity (1 to 28) of registers to be read. Registers are addressed starting at zero.

Here is an example of a request to read registers 30036 ... 30037 from slave device 33:

		Starting Register	Register Count	CRC
Slave Address	Function Code	HI LO	HI LO	LO HI

21	04	00 24	00 02	

17.2.2 Response Frame

The register data in the response message is packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

Data is scanned in the slave at the rate of 28 registers per scan. The response is returned when the data is completely assembled.

Here is an example of a response to the query:

			Register Data	CRC
Slave Address	Function Code	Byte Count	HI LO HI LO	LO HI
21	04	04	FE 00 3E 80	

The contents of registers 30036 ... 30037 are FE 00 and 3E 80 hex.

17.3 06 write to a single holding register

Pre-sets a value into a single holding register (4X reference). When broadcast, the function writes the same register values in all attached slaves.

17.3.1 Request Frame

The query message specifies the register reference to be pre-set. Registers are addressed starting at zero; register 1 is addressed as 0.

Here is an example of a request to pre-set register 40010 to 4215 hex in slave device 33:

		Register Address	Register Data	CRC
Slave Address	Function Code	HI LO	HI LO	LO HI
21	06	00 0A	42 15	

17.3.2 Response Frame

The normal response is an echo of the query, returned after the register contents have been pre-set. Here is an example of a response to the query:

		Register Address	Register Data	CRC
Slave Address	Function Code	HI LO	HI LO	LO HI
21	06	00 0A	42 15	

17.4 16 (10 HEX) write to one or more registers

Writes defined values into a sequence of holding registers (4x references). When broadcast the function writes the same register values in all attached slaves.

17.4.1 Request Frame

The query message specifies the register references to be pre-set. Registers are addressed starting at zero; register 1 is addressed as 0. Here is an example of a request to pre-set two registers starting at 40000 to 41 42 and 43 44 hex (Enter Password ABCD), in slave device 33:

Slave Address	Function Code	Starting Register	Register Count	Byte Count	Register Data	CRC
		HI LO	HI LO		HI LO HI LO	LO HI
21	16	00 00	00 02	04	41 42 4344	

17.4.2 Response Frame

The normal response returns the slave address, function code, starting address, and quantity of registers pre-set. Here is an example of a response to the query shown above.

Slave Address	Function Code	Starting Register	Register Count	CRC
		HI LO	HI LO	LO HI
21	16	00 00	00 02	

If the password is not correct (L1 or L2 or BP), the response to the query is:

Slave Address	Function Code	Starting Register	Register Count	CRC
		HI LO	HI LO	LO HI
21	16	00 00	00 02	

17.5 17 (11HEX) report slave id

Returns a description of the type of controller present at the slave address.

17.5.1 Request Frame

Here is an example of a request to report the ID of slave device 33:

		CRC
Slave Address	Function Code	LO HI
21	11	

17.5.2 Response Frame

The format of a normal response is shown below:

Slave Address	Function Code	Byte Count	Register Data	CRC
			HI LO HI LO HI LO	LO HI
21	11	06	20 4D 30 32 32 30	

18. APPENDIX B3: MODBUS ERROR RESPONSES

When a slave detects an error other than a CRC error, a response will be sent to the master. The most significant bit of the function code byte will be set to 1 (i.e. the function code sent from the slave will be equal to the function code sent from the master plus 128). The following byte will be an exception code indicating the type of error that occurred.

The slave will ignore transmissions received from the master with CRC errors.

An example of an illegal request and the corresponding exception response is shown below. The request in this example is to read registers 0201H to 0209H. If these addresses are not supported in the slave then the following occurs:

Request Message				
		Starting Register	Register Count	
Address	Function Code	HI LO	HI LO	CRC
01	01	02 01	00 08	6D B4

Exception Response Message

Address	Function Code	Exception Code	CRC
01	81	02	C1 91

18.1 Exception codes

Code	Name	Meaning
01	ILLEGAL FUNCTION	The function code transmitted is not one of the functions supported by the slave.
02	ILLEGAL DATA ADDRESSES	The data address received in the request is not an allowable value for the slave. Write to password protected registers.
03	ILLEGAL DATA VALUE	The value referenced in the data field transmitted by the master is not within family for the selected data address. The register count is greater than 28 (functions 03 and 04).
06	SLAVE DEVICE BUSY	The slave is engaged in processing a long duration program command. The master should re-transmit the message later when the slave is free.

19. APPENDIX B4: MODBUS REGISTER MAPS

The Modbus register map consists of the following columns:

<table>
<tr><td>Address</td><td colspan="2">16 bit register address starting from zero.
Please Note:
Most Modbus master devices assume that 30001 or 40001 are subtracted from the defined address for the registers. The M3x5 subtract 30000 and 40000, meaning that the addresses may have to be offset by 1.</td></tr>
<tr><td>Contents</td><td colspan="2">Description of parameters assigned to registers.</td></tr>
<tr><td rowspan="5">Data type</td><td colspan="2">MODBUS data types T1 etc. are described in section 20.4.</td></tr>
<tr><td>UNSIGNED INTEGER</td><td>family 0 ... 65535
one 16-bit register</td></tr>
<tr><td>SIGNED INTEGER</td><td>family 32768 ... 32767
one 16-bit register</td></tr>
<tr><td>ASCII</td><td>Family 32…159
16 bit registers (two ASCII codes per register)</td></tr>
<tr><td>BINARY FLAGS</td><td>Each bit of a 16 bit register can be used as a binary flag</td></tr>
<tr><td>Indicator</td><td colspan="2">Each bit of a 16-bit register can be either assigned as flags or filled with binary data.</td></tr>
<tr><td>Values</td><td colspan="2">Definitions of settings, data values and any dependencies that exist between settings.</td></tr>
<tr><td>Register type</td><td colspan="2">Declares whether a register is to be read/write register (setting) or a read register (data).</td></tr>
<tr><td>Min, max step</td><td colspan="2">The minimum and maximum numerical family and the incremental step size.</td></tr>
<tr><td>Password</td><td colspan="2">There is a numerical password that allows save/abort settings and a factory accessible password constructed from the serial number that allows entry/exit to and from the calibration and configuration settings.</td></tr>
</table>

20. APPENDIX B5: MODBUS DATA

20.1 MEASUREMENTS

Parameter	MODBUS		
	Register		Type
	Start	End	
Actual time	30101	30104	T_Time
Frequency	30105	30106	T5
Voltage U_1	30107	30108	T5
Voltage U_2	30109	30110	T5
Voltage U_3	30111	30112	T5
Average phase Voltage $U^{\sim}$	30113	30114	T5
Phase to phase voltage U_{12}	30118	30119	T5
Phase to phase voltage U_{23}	30120	30121	T5
Phase to phase voltage U_{31}	30122	30123	T5
Average phase to phase Voltage $U_{pp\sim}$	30124	30125	T5
Voltage neutral to ground $Uno_{\sim}$	30485	30486	T5
Current I_1	30126	30127	T5
Current I_2	30128	30129	T5
Current I_3	30130	30131	T5
Neutral Current Inc (calculated)	30132	30133	T5
Neutral Current Inm (measured)	30134	30135	T5
Average Current	30136	30137	T5
Total Current I	30138	30139	T5
Real Power P_1	30142	30143	T6
Real Power P_2	30144	30145	T6
Real Power P_3	30146	30147	T6
Total Real Power P	30140	30141	T6
Reactive Power Q1	30150	30151	T6
Reactive Power Q2	30152	30153	T6
Reactive Power Q3	30154	30155	T6
Total Reactive Power Q	30148	30149	T6
Apparent Power S1	30158	30159	T5
Apparent Power S2	30160	30161	T5
Apparent Power S3	30162	30163	T5
Total Apparent Power S	30156	30157	T5

Parameter	MODBUS		
	Register		Type
	Start	End	
Power Factor PF1	30166	30167	T7
Power Factor PF2	30168	30169	T7
Power Factor PF3	30170	30171	T7
Total Power Factor PF	30164	30165	T7
Power Angle U1−I1	30173		T17
Power Angle U2−I2	30174		T17
Power Angle U3−I3	30175		T17
Angle between In and U1	30488		T17
Power Angle atan2(Pt, Qt)	30172		T17
Angle U1−U2	30115		T17
Angle U2−U3	30116		T17
Angle U3−U1	30117		T17
Angle Un−U1	30487		T17
Voltage unbalance Uu	30176		T16
Voltage unb. zero sequence Uo	30177		T16
U1 Signal voltage Abs	30592	30593	T5
U2 Signal voltage Abs	30594	30595	T5
U2 Signal voltage Abs	30596	30597	T5
THD I1	30188		T16
THD I2	30189		T16
THD I3	30190		T16
THD U1	30182		T16
THD U2	30183		T16
THD U3	30184		T16
THD U12	30185		T16
THD U23	30186		T16
THD U31	30187		T16
Internal Temperature	30181		T2

Parameter	MODBUS		
	Register		Type
	Start	End	
Max Demand Since Last RESET			
MD Real Power P (positive)	30542	30543	T6
MD Real Power P (negative)	30548	30549	T6
MD Reactive Power Q – L	30554	30555	T6
MD Reactive Power Q – C	30560	30561	T6
MD Apparent Power S	30536	30537	T5
MD Current I1	30518	30519	T5
MD Current I2	30524	30525	T5
MD Current I3	30530	30531	T5
Dynamic Demand Values			
MD Real Power P (positive)	30510	30511	T6
MD Real Power P (negative)	30512	30513	T6
MD Reactive Power Q – L	30514	30515	T6
MD Reactive Power Q – C	30516	30517	T6
MD Apparent Power S	30508	30509	T5
MD Current I1	30502	30503	T5
MD Current I2	30504	30505	T5
MD Current I3	30506	30507	T5

Parameter	MODBUS		
	Register		Type
	Start	End	
Energy			
Energy Counter 1 Exponent	30401		T2
Energy Counter 2 Exponent	30402		T2
Energy Counter 3 Exponent	30403		T2
Energy Counter 4 Exponent	30404		T2
Counter E1	30406	30407	T3
Counter E2	30408	30409	T3
Counter E3	30410	30411	T3
Counter E4	30412	30413	T3
Counter E1 Tariff 1	30414	30415	T3
Counter E2 Tariff 1	30416	30417	T3
Counter E3 Tariff 1	30418	30419	T3
Counter E4 Tariff 1	30420	30421	T3
Counter E1 Tariff 2	30422	30423	T3
Counter E2 Tariff 2	30424	30425	T3
Counter E3 Tariff 2	30426	30427	T3
Counter E4 Tariff 2	30428	30429	T3
Counter E1 Tariff 3	30430	30431	T3
Counter E2 Tariff 3	30432	30433	T3
Counter E3 Tariff 3	30434	30435	T3
Counter E4 Tariff 3	30436	30437	T3
Counter E1 Tariff 4	30438	30439	T3
Counter E2 Tariff 4	30440	30441	T3
Counter E3 Tariff 4	30442	30443	T3
Counter E4 Tariff 4	30444	30445	T3
Counter E1 Cost	30446	30447	T3
Counter E2 Cost	30448	30449	T3
Counter E3 Cost	30450	30451	T3
Counter E4 Cost	30452	30453	T3
Total Energy Counter Cost	30454	30455	T3
Energy Counter 5	30456	30457	T3
Energy Counter 6	30458	30459	T3
Energy Counter 7	30460	30461	T3
Energy Counter 8	30462	30463	T3
Energy Counter 5 Exponent	30464		T2
Energy Counter 6 Exponent	30465		T2
Energy Counter 7 Exponent	30466		T2
Energy Counter 8 Exponent	30467		T2
Active tariff	30405		T1

Actual counters E1 – E4 are calculated as: $Cnt. \times 10^{exponent}$

Parameter	MODBUS		
	Register		Type
	Start	End	
DC Voltages			
DC Voltage U1	30471	30472	T6
DC Voltage U2	30473	30474	T6
DC Voltage U3	30475	30476	T6
DC Voltage U12	30477	30478	T6
DC Voltage U23	30479	30480	T6
DC Voltage U31	30481	30482	T6
DC Voltage Un	30483	30484	T6
Current Factors			
TDD I1	30491		T16
TDD I2	30492		T16
TDD I3	30493		T16
K factor I1	30494		T16
K factor I2	30495		T16
K factor I3	30496		T16
CREST factor I1	30497		T1 10 for 1.0%
CREST factor I2	30498		T1 10 for 1.0%
CREST factor I3	30499		T1 10 for 1.0%

Parameter	MODBUS		
	Register		Type
	Start	End	
Under/Over-deviations			
U1 underdeviation	30574		T17
U2 underdeviation	30575		T17
U3 underdeviation	30576		T17
U1 overdeviation	30577		T17
U2 overdeviation	30578		T17
U3 overdeviation	30579		T17
			<0 until the first measurement
Flickers			
Flicker Pst1	30580		T17
Flicker Pst2	30581		T17
Flicker Pst3	30582		T17
Flicker Plt1	30583		T17
Flicker Plt2	30584		T17
Flicker Plt3	30585		T17
Flicker Pf5 - L1	30586	30587	T5
Flicker Pf5 - L2	30588	30589	T5
Flicker Pf5 - L3	30590	30591	T5
Phase voltage harmonic data			
U1 Harmonic Data			
Base for % calculation	31001	31002	T5
U1 1 Harmonic Abs %	31003		T16
U1 1 Harmonic Phase Angle	31004		T17
U1 Harmonics from 2 to 62			
U1 63 Harmonic Abs %	31127		T16
U1 63 Harmonic Phase Angle	31128		T17
U2 Harmonic Data			
Base for % calculation	31129	31130	T5
U2 1 Harmonic Abs %	31131		T16
U2 1 Harmonic Phase Angle	31132		T17
U2 Harmonics from 2 to 62			
U2 63 Harmonic Abs %	31255		T16
U2 63 Harmonic Phase Angle	31256		T17
U3 Harmonic Data			
Base for % calculation	31257	31258	T5
U3 1 Harmonic Abs %	31259		T16
U3 1 Harmonic Phase Angle	31260		T17
U3 Harmonics from 2 to 62			
U3 63 Harmonic Abs %	31383		T16
U3 63 Harmonic Phase Angle	31384		T17

Parameter	MODBUS		
	Register		Type
	Start	End	
Line voltage harmonic data			
U12 Harmonic Data			
Base for % calculation	31385	31386	T5
U12 1 Harmonic Abs %	31387		T16
U12 1 Harmonic Phase Angle	31388		T17
U12 Harmonics from 2 to 62			
U12 63 Harmonic Abs %	31511		T16
U12 63 Harmonic Phase Angle	31512		T17
U23 Harmonic Data			
Base for % calculation	31513	31514	T5
U23 1 Harmonic Abs %	31515		T16
U23 1 Harmonic Phase Angle	31516		T17
U23 Harmonics from 2 to 62			
U23 63 Harmonic Abs %	31639		T16
U23 63 Harmonic Phase Angle	31640		T17
U31 Harmonic Data			
Base for % calculation	31641	31642	T5
U31 1 Harmonic Abs %	31643		T16
U31 1 Harmonic Phase Angle	31644		T17
U31 Harmonics from 2 to 62			
U31 63 Harmonic Abs %	31767		T16
U31 63 Harmonic Phase Angle	31768		T17

Parameter	MODBUS		
	Register		Type
	Start	End	
Phase current harmonic data			
I1 Harmonic Data			
Base for % calculation	31769	31770	T5
I1 1 Harmonic Abs %	31771		T16
I1 1 Harmonic Phase Angle	31772		T17
I1 Harmonics from 2 to 62			
I1 63 Harmonic Abs %	31895		T16
I1 63 Harmonic Phase Angle	31896		T17
I2 Harmonic Data			
Base for % calculation	31897	31898	T5
I2 1 Harmonic Abs %	31899		T16
I2 1 Harmonic Phase Angle	31900		T17
I2 Harmonics from 2 to 62			
I2 63 Harmonic Abs %	32023		T16
I2 63 Harmonic Phase Angle	32024		T17
I3 Harmonic Data			
Base for % calculation	32025	32026	T5
I3 1 Harmonic Abs %	32027		T16
I3 1 Harmonic Phase Angle	32028		T17
I3 Harmonics from 2 to 62			
I3 63 Harmonic Abs %	32151		T16
I3 63 Harmonic Phase Angle	32152		T17
Phase voltage interharmonic data			
U1 Interharmonic Data			
Base for % calculation	32153	32154	T5
1. Interharmonic Abs %	32155		T16
2. Interharmonic Abs %	32156		T16
3. - 10 Interharmonic	32157	32164	T16
U2 Interharmonic Data			
Base for % calculation	32171	32172	T5
1. Interharmonic Abs %	32173		T16
2. Interharmonic Abs %	32174		T16
3. - 10 Interharmonic	32175	32182	T16
U3 Interharmonic Data			
Base for % calculation	32189	32190	T5
1. Interharmonic Abs %	32191		T16
2. Interharmonic Abs %	32192		T16
3. - 10 Interharmonic	32193	32200	T16

Parameter	MODBUS		
	Register		Type
	Start	End	
Line voltage interharmonic data			
U12 Interharmonic Data			
Base for % calculation	32417	32418	T5
1. Interharmonic Abs %	32419		T16
2. Interharmonic Abs %	32420		T16
3. - 10 Interharmonic	32421	32428	T16
U23 Interharmonic Data			
Base for % calculation	32435	32436	T5
1. Interharmonic Abs %	32437		T16
2. Interharmonic Abs %	32438		T16
3. - 10 Interharmonic	32439	32446	T16
U31 Interharmonic Data			
Base for % calculation	32453	32454	T5
1. Interharmonic Abs %	32455		T16
2. Interharmonic Abs %	32456		T16
3. - 10 Interharmonic	32457	32464	T16

20.2 MEASUREMENTS (IEEE 754)

Code	Address		Contents	Data	Ind	Values and Dependencies
MEASUREMENTS (IEEE 754)						
	32484	32485	Uavg (phase to neutral)	T_float		
	32486	32487	Uavg (phase to phase)	T_float		
	32488	32489	Σ I	T_float		
	32490	32491	Active Power Total (Pt)	T_float		
	32492	32493	Reactive Power Total (Qt)	T_float		
	32494	32495	Apparent Power Total (St)	T_float		
	32496	32497	Power Factor Total (PFt)	T_float		
	32498	32499	Frequency	T_float		
	32500	32501	U1	T_float		
	32502	32503	U2	T_float		
	32504	32505	U3	T_float		
	32506	32507	Uavg (phase to neutral)	T_float		
	32508	32509	U12	T_float		
	32510	32511	U23	T_float		
	32512	32513	U31	T_float		
	32514	32515	Uavg (phase to phase)	T_float		
	32516	32517	I1	T_float		
	32518	32519	I2	T_float		
	32520	32521	I3	T_float		
	32522	32523	Σ I	T_float		
	32524	32525	I neutral (calculated)	T_float		
	32526	32527	I neutral (measured)	T_float		
	32528	32529	Iavg	T_float		
	32530	32531	Active Power Phase L1 (P1)	T_float		
	32532	32533	Active Power Phase L2 (P2)	T_float		
	32534	32535	Active Power Phase L3 (P3)	T_float		
	32536	32537	Active Power Total (Pt)	T_float		
	32538	32539	Reactive Power Phase L1 (Q1)	T_float		
	32540	32541	Reactive Power Phase L2 (Q2)	T_float		
	32542	32543	Reactive Power Phase L3 (Q3)	T_float		
	32544	32545	Reactive Power Total (Qt)	T_float		
	32546	32547	Apparent Power Phase L1 (S1)	T_float		
	32548	32549	Apparent Power Phase L2 (S2)	T_float		
	32550	32551	Apparent Power Phase L3 (S3)	T_float		
	32552	32553	Apparent Power Total (St)	T_float		
	32554	32555	Power Factor Phase 1 (PF1)	T_float		
	32556	32557	Power Factor Phase 2 (PF2)	T_float		
	32558	32559	Power Factor Phase 3 (PF3)	T_float		
	32560	32561	Power Factor Total (PFt)	T_float		

Code	Address		Contents	Data	Ind	Values and Dependencies
	32562	32563	CAP/IND P. F. Phase 1 (PF1)	T_float		
	32564	32565	CAP/IND P. F. Phase 2 (PF2)	T_float		
	32566	32567	CAP/IND P. F. Phase 3 (PF3)	T_float		
	32568	32569	CAP/IND P. F. Total (PFt)	T_float		
	32570	32571	φ1 (angle between U1 and I1)	T_float		
	32572	32573	φ2 (angle between U2 and I2)	T_float		
	32574	32575	φ3 (angle between U3 and I3)	T_float		
	32576	32577	Power Angle Total (atan2(Pt,Qt))	T_float		
	32578	32579	φ12 (angle between U1 and U2)	T_float		
	32580	32581	φ23 (angle between U2 and U3)	T_float		
	32582	32583	φ31 (angle between U3 and U1)	T_float		
	32584	32585	Frequency	T_float		
	32586	32587	U unbalance	T_float		
	32588	32589	I1 THD%	T_float		
	32590	32591	I2 THD%	T_float		
	32592	32593	I3 THD%	T_float		
	32594	32595	U1 THD%	T_float		
	32596	32597	U2 THD%	T_float		
	32598	32599	U3 THD%	T_float		
	32600	32601	U12 THD%	T_float		
	32602	32603	U23 THD%	T_float		
	32604	32605	U31 THD%	T_float		
			MAX DEMAND SINCE LAST RESET			
	32606	32607	Active Power Total (Pt) - (positive)	T_float		
	32608	32609	Active Power Total (Pt) - (negative)	T_float		
	32610	32611	Reactive Power Total (Qt) - L	T_float		
	32612	32613	Reactive Power Total (Qt) - C	T_float		
	32614	32615	Apparent Power Total (St)	T_float		
	32616	32617	I1	T_float		
	32618	32619	I2	T_float		
	32620	32621	I3	T_float		
			DYNAMIC DEMAND VALUES			
	32622	32623	Active Power Total (Pt) - (positive)	T_float		
	32624	32625	Active Power Total (Pt) - (negative)	T_float		
	32626	32627	Reactive Power Total (Qt) - L	T_float		
	32628	32629	Reactive Power Total (Qt) - C	T_float		
	32630	32631	Apparent Power Total (St)	T_float		
	32632	32633	I1	T_float		
	32634	32635	I2	T_float		
	32636	32637	I3	T_float		

Code	Address		Contents	Data	Ind	Values and Dependencies
			ENERGY			
	32638	32639	Energy Counter 1	T_float		
	32640	32641	Energy Counter 2	T_float		
	32642	32643	Energy Counter 3	T_float		
	32644	32645	Energy Counter 4	T_float		
	32646	32647	Energy Counter 1 Cost	T_float		
	32648	32649	Energy Counter 2 Cost	T_float		
	32650	32651	Energy Counter 3 Cost	T_float		
	32652	32653	Energy Counter 4 Cost	T_float		
	32654	32655	Total Energy Counter Cost	T_float		
	32656	32657	Active Tariff	T_float		
	32658	32659	Internal Temperature	T_float		
			ANALOGUE INPUTS			
	32660	32661	Analogue input 1	T_float		
	32662	32663	Analogue input 2	T_float		
	32664	32665	Analogue input 3	T_float		
	32666	32667	Analogue input 4	T_float		
			DIRECTIONAL CURRENTS (=Ix * sign(Px))			
	32668	32669	Directional Iavg	T_float		
	32670	32671	Directional I1	T_float		
	32672	32673	Directional I2	T_float		
	32674	32675	Directional I3	T_float		
			DC VOLTAGES			
	32676	32677	DC Voltage U1	T_float		
	32678	32679	DC Voltage U2	T_float		
	32680	32681	DC Voltage U3	T_float		
	32682	32683	DC Voltage U12	T_float		
	32684	32685	DC Voltage U23	T_float		
	32686	32687	DC Voltage U31	T_float		
	32688	32689	DC Voltage Un	T_float		
	32690	32691	Voltage neutral to ground Uno~	T_float		
	32682	32693	Angle Un−U1	T_float		
	32694	32695	Angle between In and U1	T_float		
	32696	33000	Reserved			

20.3 BASIC PRODUCT SETTINGS

Address		Contents	Data	Ind	Values/Dependencies	Min	Max	P.level
GENERAL SETTINGS								
40143		Connection Mode	T1	0	No mode	1	5	2
				1	1b - Single Phase			
				2	3b - 3 phase 3 wire balanced			
				3	4b - 3 phase 4 wire balanced			
				4	3u - 3 phase 3 wire unbalanced			
				5	4u - 3 phase 4 wire unbalanced			
40144		CT Secondary	T4		mA			2
40145		CT Primary	T4		A/10			2
40146		VT Secondary	T4		mV			2
40147		VT Primary	T4		V/10			2
40148		Current input range (%)	T16		10000 for 100%	5.00	260.00	2
40149		Voltage input range (%)	T16		10000 for 100%	2.50	100.00	2
40150		Frequency nominal value	T1		Hz	10	1000	2

20.4 MODBUS DATA TYPES

Registers defined in the Modbus database will define data as one of the data types described in the following table:

Type	Bit mask	Description
T1		Unsigned Value (16 bit) Example: 12345 = 3039(16)
T2		Signed Value (16 bit) Example: -12345 = CFC7(16)
T3		Signed Long Value (32 bit) Example: 123456789 = 075B CD 15(16)
T4	bits # 15…14 bits # 13…00	Short Unsigned float (16 bit) Decade Exponent(Unsigned 2 bit) Binary Unsigned Value (14 bit) Example: 10000*102 = A710(16)
T5	bits # 31…24 bits # 23…00	Unsigned Measurement (32 bit) Decade Exponent(Signed 8 bit) Binary Unsigned Value (24 bit) Example: 123456*10-3 = FD01 E240(16)
T6	bits # 31…24 bits # 23…00	Signed Measurement (32 bit) Decade Exponent (Signed 8 bit) Binary Signed value (24 bit) Example: - 123456*10-3 = FDFE 1DC0(16)
T7	bits # 31…24 bits # 23…16 bits # 15…00	Power Factor (32 bit) Sign: Import/Export (00/FF) Sign: Inductive/Capacitive (00/FF) Unsigned Value (16 bit), 4 decimal places Example: 0.9876 CAP = 00FF 2694(16)
T9	bits # 31…24 bits # 23…16 bits # 15…08 bits # 07…00	Time (32 bit) 1/100s 00 - 99 (BCD) Seconds 00 - 59 (BCD) Minutes 00 - 59 (BCD) Hours 00 - 24 (BCD) Example: 15:42:03.75 = 7503 4215(16)

Type	Bit mask	Description
T10	 bits # 31…24 bits # 23…16 bits # 15…00	Date (32 bit) Day of month 01 - 31 (BCD) Month of year 01 - 12 (BCD) Year (unsigned integer) 1998..4095 Example: 10, SEP 2000 = 1009 07D0(16)
T16		Unsigned Value (16 bit), 2 decimal places Example: 123.45 = 3039(16)
T17		Signed Value (16 bit), 2 decimal places Example: -123.45 = CFC7(16)
T_float	 bits # 31 bits # 30…23 bits # 22…0	IEEE 754 Floating-Point Single Precision Value (32bit) Sign Bit (1 bit) Exponent Field (8 bit) Significand (23 bit) Example: 123.45 stored as 123.45000 = 42F6 E666(16)

21. APPENDIX C: DNP3.0 PROGRAMMING

DNP3 protocol enables operation of Measurement Centre on DNP3 networks. **M3x5** can communicate using DNP3 over Serial or Ethernet networks. For devices with serial communication the DNP3 protocol enables point to point (for example device to PC) communication via RS232 communication and multi drop communication via RS485.

21.1 DNP 3.0 DEVICE PROFILE DOCUMENT

<table>
<tr><td>DNP 3.0
Device Profile Document</td><td>Issue: E
Date: 8 Jan 2013</td></tr>
<tr><td colspan="2">Device Name: Measurement centre
Vendor Name: Alstom
Models Covered: M3x5</td></tr>
<tr><td>Highest DNP Level Supported:
For Requests: 2
For Responses: 2</td><td>Device Function:
❒ Master
☑ Slave</td></tr>
<tr><td colspan="2">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the DNP V3.0 Implementation table):</td></tr>
<tr><td>Maximum Data Link Frame Size (octets):
Transmitted: 292
Received: 249
Maximum Data Link Re-tries:
☑ None
❒ Configurable</td><td>Maximum Application Fragment Size (octets):
Transmitted: 2048
Received: 249
Maximum Application Layer Re-tries:
☑ None
❒ Configurable</td></tr>
<tr><td colspan="2">Requires Data Link Layer Confirmation:
☑ Never
❒ Always
❒ Sometimes
❒ Configurable</td></tr>
<tr><td colspan="2">Requires Application Layer Confirmation:
☑ Never
❒ Always
❒ Sometimes
❒ Configurable</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Timeouts while waiting for: Data Link Confirm: ☑ **None** ❒ Fixed at ____ ❒ Variable ❒ Configurable Complete Appl. Fragment: ☑ **None** ❒ Fixed at ____ ❒ Variable ❒ Configurable Application Confirm: ☑ **None** ❒ Fixed at ____ ❒ Variable ❒ Configurable Complete Appl. Response: ☑ **None** ❒ Fixed at ____ ❒ Variable ❒ Configurable Others:	
Sends/Executes Control Operations: WRITE Binary Outputs ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable SELECT/OPERATE ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable DIRECT OPERATE ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable DIRECT OPERATE – NO ACK ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable Count > 1 ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable Pulse On ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable Pulse Off ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable Latch On ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable Latch Off ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable Queue ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable Clear Queue ☑ **Never** ❒ Always ❒ Sometimes ❒ Configurable	
Reports Binary Input Change Events when no specific variation requested: ☑ **Never** ❒ Only non-time-tagged ❒ Configurable	Reports time-tagged Binary Input Change Events when no specific variation requested: ☑ **Never** ❒ Binary Input Change With Relative Time ❒ Configurable
Sends Unsolicited Responses: ☑ **Never** ❒ Configurable ❒ Only certain Objects ❒ Sometimes ❒ ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☑ **Never** ❒ When Device Restarts ❒ When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ❒ No Counters Reported ❒ Configurable ☑ **Default Object: 30** ☑ **Default Variation: 4** **Point-by-point list attached**	Counters Roll Over at: ❒ No Counters Reported ❒ Configurable ❒ 16 Bits ❒ 32 Bits ☑ **Other Value: 20000** **Point-by-point list attached**
Sends Multi-Fragment Responses: ❒ Yes ☑ **No**	

Object			Request		Response	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
0	242	Device Attributes - software version	1	00	129	00, 17
0	243	Device Attributes – hardware version	1	00	129	00, 17
0	246	Device Attributes – user assigned ID	1	00	129	00, 17
0	248	Device Attributes – serial number	1	00	129	00, 17
0	250	Device Attributes – product name	1	00	129	00, 17
0	252	Device Attributes – manufacture name	1	00	129	00, 17
0	254	Device Attributes – nonspecific all attributes request	1	00, 06		
0	255	Device Attributes – list of attribute variation	1	00, 06	129	00, 5B

Points for object 0

0	Software version	T_Str3		Data	var	242	
0	Hardware version	T_Str2		Data	var	243	
0	user assigned ID	T_Str2		Data	var	246	
0	serial number	T_Str8		Data	var	248	
0	product name	T_Str16		Data	var	250	
0	manufacture name	T_Str20		Data	var	252	

Object			Request		Response	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
10	0	Binary output status	1	00, 01, 06		
10	2	Binary output status	1	00, 01, 06	129	00, 01

Points for object 10

0	Relay 1	T1		Data	0	1	
1	Relay 2	T1		Data	0	1	
2	Relay 3	T1		Data	0	1	
3	Relay 4	T1		Data	0	1	
4	Slot A - Relay 1	T1		Data	0	1	
5	Slot A - Relay 2	T1		Data	0	1	
6	Slot A - Relay 3	T1		Data	0	1	
7	Slot A - Relay 4	T1		Data	0	1	
8	Slot A - Relay 5	T1		Data	0	1	
9	Slot A - Relay 6	T1		Data	0	1	
10	Slot A - Relay 7	T1		Data	0	1	
11	Slot A - Relay 8	T1		Data	0	1	
12	Slot B - Relay 1	T1		Data	0	1	
13	Slot B - Relay 2	T1		Data	0	1	
14	Slot B - Relay 3	T1		Data	0	1	
15	Slot B - Relay 4	T1		Data	0	1	
16	Slot B - Relay 5	T1		Data	0	1	
17	Slot B - Relay 6	T1		Data	0	1	
18	Slot B - Relay 7	T1		Data	0	1	
19	Slot B - Relay 8	T1		Data	0	1	

Object			Request		Response	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
30	0	16-Bit Analog Input without flag	1	00, 01, 06		
30	2	16-Bit Analog Input with flag	1	00, 01, 06	129	00, 01
30	4	16-Bit Analog Input without flag	1	00, 01, 06	129	00, 01

Points for object 30

0	U1	T16		Data	-Un	+Un	
1	U2	T16		Data	-Un	+Un	
2	U3	T16		Data	-Un	+Un	
3	Uavg (phase to neutral)	T16		Data	-Un	+Un	
4	U12	T16		Data	-Un	+Un	
5	U23	T16		Data	-Un	+Un	
6	U31	T16		Data	-Un	+Un	
7	Uavg (phase to phase)	T16		Data	-Un	+Un	
8	I1	T16		Data	-In	+In	
9	I2	T16		Data	-In	+In	
10	I3	T16		Data	-In	+In	
11	I total	T16		Data	-In	+In	
12	I neutral (calculated)	T16		Data	-In	+In	
13	I neutral (measured)	T16		Data	-In	+In	
14	Iavg	T16		Data	-In	+In	
15	Active Power Phase L1 (P1)	T17		Data	-Pn	+Pn	
16	Active Power Phase L2 (P2)	T17		Data	-Pn	+Pn	
17	Active Power Phase L3 (P3)	T17		Data	-Pn	+Pn	
18	Active Power Total (Pt)	T17		Data	-Pt	+Pt	
19	Reactive Power Phase L1 (Q1)	T17		Data	-Pn	+Pn	
20	Reactive Power Phase L2 (Q2)	T17		Data	-Pn	+Pn	
21	Reactive Power Phase L3 (Q3)	T17		Data	-Pn	+Pn	
22	Reactive Power Total (Qt)	T17		Data	-Pt	+Pt	
23	Apparent Power Phase L1 (S1)	T16		Data	-Pn	+Pn	
24	Apparent Power Phase L2 (S2)	T16		Data	-Pn	+Pn	
25	Apparent Power Phase L3 (S3)	T16		Data	-Pn	+Pn	
26	Apparent Power Total (St)	T16		Data	-Pt	+Pt	
27	Power Factor Phase 1 (PF1)	T17		Data	-1	+1	
28	Power Factor Phase 2 (PF2)	T17		Data	-1	+1	
29	Power Factor Phase 3 (PF3)	T17		Data	-1	+1	

Points for object 30 cont.							
30	Power Factor Total (PFt)	T17		Data	-1	+1	
31	CAP/IND P. F. Phase 1 (PF1)	T17		Data	-1 CAP	+1	300% for -1 IND
32	CAP/IND P. F. Phase 2 (PF2)	T17		Data	-1 CAP	+1	300% for -1 IND
33	CAP/IND P. F. Phase 3 (PF3)	T17		Data	-1 CAP	+1	300% for -1 IND
34	CAP/IND P. F. Total (PFt)	T17		Data	-1 CAP	+1	300% for -1 IND
35	j1 (angle between U1 and I1)	T17		Data	-100°	+100°	
36	j2 (angle between U2 and I2)	T17		Data	-100°	+100°	
37	j3 (angle between U3 and I3)	T17		Data	-100°	+100°	
38	Power Angle Total (atan2(Pt,Qt))	T17		Data	-100°	+100°	
39	j12 (angle between U1 and U2)	T17		Data	-100°	+100°	
40	j23 (angle between U2 and U3)	T17		Data	-100°	+100°	
41	j31 (angle between U3 and U1)	T17		Data	-100°	+100°	
42	Frequency	T17		Data	Fn-10Hz	Fn+10Hz	
43	U unbalace	T16		Data	-100%	+100%	
44	I1 THD%	T16		Data	-100%	+100%	
45	I2 THD%	T16		Data	-100%	+100%	
46	I3 THD%	T16		Data	-100%	+100%	
47	U1 THD%	T16		Data	-100%	+100%	
48	U2 THD%	T16		Data	-100%	+100%	
49	U3 THD%	T16		Data	-100%	+100%	
50	U12 THD%	T16		Data	-100%	+100%	
51	U23 THD%	T16		Data	-100%	+100%	
52	U31 THD%	T16		Data	-100%	+100%	
	MAX DEMAND SINCE LAST RESET						
53	Active Power Total (Pt) - (positive)	T16		Data	-Pt	+Pt	
54	Active Power Total (Pt) - (negative)	T16		Data	-Pt	+Pt	
55	Reactive Power Total (Qt) - L	T16		Data	-Pt	+Pt	
56	Reactive Power Total (Qt) - C	T16		Data	-Pt	+Pt	
57	Apparent Power Total (St)	T16		Data	-Pt	+Pt	
58	I1	T16		Data	-In	+In	
59	I2	T16		Data	-In	+In	
60	I3	T16		Data	-In	+In	
	DYNAMIC DEMAND VALUES						
61	Active Power Total (Pt) - (positive)	T16		Data	-Pt	+Pt	

Points for object 30 cont.							
62	Active Power Total (Pt) - (negative)	T16		Data	-Pt	+Pt	
63	Reactive Power Total (Qt) - L	T16		Data	-Pt	+Pt	
64	Reactive Power Total (Qt) - C	T16		Data	-Pt	+Pt	
65	Apparent Power Total (St)	T16		Data	-Pt	+Pt	
66	I1	T16		Data	-In	+In	
67	I2	T16		Data	-In	+In	
68	I3	T16		Data	-In	+In	
	ENERGY						
69	Energy Counter 1	T17		Data			(32-bit value) MOD 20000
70	Energy Counter 2	T17		Data			(32-bit value) MOD 20000
71	Energy Counter 3	T17		Data			(32-bit value) MOD 20000
72	Energy Counter 4	T17		Data			(32-bit value) MOD 20000
73	Energy Counter 1 Cost	T17		Data			(32-bit value) MOD 20000
74	Energy Counter 2 Cost	T17		Data			(32-bit value) MOD 20000
75	Energy Counter 3 Cost	T17		Data			(32-bit value) MOD 20000
76	Energy Counter 4 Cost	T17		Data			(32-bit value) MOD 20000
77	Total Energy Counter Cost	T17		Data			(32-bit value) MOD 20000
78	Aktiv Tariff	T1		Data			
79	Internal Temperature	T17		Data	-100°	+100°	

Object			Request		Response	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
40	0	16-bit Analog output status	1	00, 01, 06		
40	2	16-bit Analog output status	1	00, 01, 06	129	00, 01

Points for object 40							
0	Analog output 1	T1		Data	0		
1	Analog output 2	T1		Data	0		
2	Analog output 3	T1		Data	0		
3	Analog output 4	T1		Data	0		
4	Slot A - Analog output 1	T1		Data	0		
5	Slot A - Analog output 2	T1		Data	0		
6	Slot A - Analog output 3	T1		Data	0		
7	Slot A - Analog output 4	T1		Data	0		
8	Slot B - Analog output 1	T1		Data	0		
9	Slot B - Analog output 2	T1		Data	0		
10	Slot B - Analog output 3	T1		Data	0		
11	Slot B - Analog output 4	T1		Data	0		

Object			Request		Response	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
50	0	Time and Date – absolute time	2	7		
50	1	Time and Date – absolute time	2	7	129	7

Points for object 50

0	Time and Date	T_Time		Data			

Object			Request		Response	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
60	1	CLASS 0 DATA	1	06		
60	2	CLASS 1 DATA	1,22*	06		
60	3	CLASS 2 DATA	1,22*	06		
60	4	CLASS 3 DATA	1,22*	06		

*only object 30

21.2 DATA TYPES – DECODING

Type	Value / Bit Mask	Description
T1		Unsigned Value (16 bit) Example: 12345 stored as 12345 = $3039_{(16)}$
T16		Unsigned Value (16 bit), 2 decimal places Example: 123.45 stored as 123.45 = $3039_{(16)}$
T17		Signed Value (16 bit), 2 decimal places Example: -123.45 stored as -123.45 = $CFC7_{(16)}$
T_Str8		Text String 8 characters Two characters per 16 bit register.
T_Str16		Text String 16 characters Two characters per 16 bit register.
T_Str20		Text String 20 characters Two characters per 16 bit register.

21.3 100% VALUE CALCULATIONS

Un =	(R40147 / R40146) * R30015 * R40149
In =	(R40145 / R40144) * R30017 * R40148
Pn =	Un*In
It =	In ; for Connection Mode: 1b
It =	3*In ; for Connection Modes: 3b, 4b, 3u, 4u
Pt =	Pn ; for Connection Mode: 1b
Pt =	3*Pn ; for Connection Modes: 3b, 4b, 3u, 4u
Fn =	R40150

Register	Content
30015	Calibration voltage
30017	Calibration current

Register	Content	Data	Ind	Values / Dependencies	Min	Max	P. Level
40143	Connection Mode	T1	0	No mode	1	5	2
			1	1b - Single Phase			
			2	3b - 3 phase 3 wire balanced			
			3	4b - 3 phase 4 wire balanced			
			4	3u - 3 phase 3 wire unbalanced			
			5	4u - 3 phase 4 wire unbalanced			
40144	CT Secondary	T4		mA			2
40145	CT Primary	T4		A/10			2
40146	VT Secondary	T4		mV			2
40147	VT Primary	T4		V/10			2
40148	Current input range (%)	T16		10000 for 100%	5,00	200,00	2
40149	Voltage input range (%)	T16		10000 for 100%	2,50	100,00	2
40150	Frequency nominal value	T1		Hz	10	1000	2

22. APPENDIX D: EQUATIONS

Definitions of symbols

No	Symbol	Definition
1	M_P	Average interval
2	U_f	Phase voltage (U_1, U_2 or U_3)
3	U_{ff}	Phase-to-phase voltage (U_{12}, U_{23} or U_{31})
4	N	Total number of samples in a period
5	n	Sample number (0 ≤ n ≤ N)
6	x, y	Phase number (1, 2 or 3)
7	i_n	Current sample n
8	u_{fn}	Phase voltage sample n
9	u_{fFn}	Phase-to-phase voltage sample n
10	φ_f	Power angle between current and phase voltage f (φ_1, φ_2 or φ_3)
11	U_u	Voltage unbalance
12	U_c	Agreed supply voltage

Voltage

$U_f = \sqrt{\frac{\sum_{n=1}^{N} u_n^2}{N}}$	***Phase voltage*** N − samples in averaging interval (up to 65 Hz)
$U_{xy} = \sqrt{\frac{\sum_{n=1}^{N} (u_{xn} - u_{yn})^2}{N}}$	***Phase-to-phase voltage*** u_x, u_y − phase voltages (U_f) N − a number of samples in averaging interval
$U_u = \sqrt{\frac{1-\sqrt{3-6\beta}}{1+\sqrt{3-6\beta}}} \cdot 100\%$ $\beta = \frac{U_{12fund}^4 + U_{23fund}^4 + U_{31fund}^4}{(U_{12fund}^2 + U_{23fund}^2 + U_{31fund}^2)^2}$	***Voltage unbalance*** U_{fund} − first harmonic of phase-to-phase voltage

Current

$I_{RMS} = \sqrt{\frac{\sum_{n=1}^{N} i_n^2}{N}}$	***Phase current*** N − samples in averaging interval (up to 65 Hz)
$I_n = \sqrt{\frac{\sum_{n=1}^{N} (i_{1n} + i_{2n} + i_{3n})^2}{N}}$	***Neutral current*** i − n sample of phase current (1, 2 or 3) N − samples in averaging interval (up to 65 Hz)

Power

$P_f = \frac{1}{N} \cdot \sum_{n=1}^{N} (u_{fn} \cdot i_{fn})$	***Active power by phases*** N − a number of periods n − index of sample in a period f − phase designation
$P_t = P_1 + P_2 + P_3$	***Total active power*** t − total power 1, 2, 3 − phase designation
$\mathrm{SignQ}_f(\varphi)$ $\varphi \in [0° - 180°] \Rightarrow \mathrm{SignQ}_f(\varphi) = +1$ $\varphi \in [180° - 360°] \Rightarrow \mathrm{SignQ}_f(\varphi) = -1$	***Reactive power sign*** Q_f − reactive power (by phases) φ − power angle
$S_f = U_f \cdot I_f$	***Apparent power by phases*** U_f − phase voltage I_f − phase current
$S_t = S_1 + S_2 + S_3$	***Total apparent power*** S_f − apparent power by phases
$Q_f = \mathrm{SignQ}_f(\varphi) \cdot \sqrt{S_f^2 - P_f^2}$	***Reactive power by phases*** S_f − apparent power by phases P_f − active power by phases
$Q_f = \frac{1}{N} \cdot \sum_{n=1}^{N} \left(u_{f\,n} \times i_{f\,[n+N/4]}\right)$	***Reactive power by phases (displacement method)*** N − a number of samples in a period n − sample number (0 ≤ n ≤ N) f − phase designation
$Q_t = Q_1 + Q_2 + Q_3$	***Total reactive power*** Q_f − reactive power by phases
$\varphi_s = \arctan2(P_t, Q_t)$ $\varphi_s = [-180°, 179{,}99°]$	***Total power angle*** P_t − total active power S_t − total apparent power
$PF_t = \frac{P_t}{S_t}$	***Distortion* factor** P − total active power S − total apparent power
$PF_f = \frac{P_f}{S_f}$	***Distortion factor*** P_t − phase active power S_t − phase apparent power

THD, TDD

$I_f THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} I_n^2}}{I_1} \cdot 100$	***Current THD*** I_1 − value of first harmonic n − number of harmonic
$I_f TDD(\%) = \frac{\sqrt{\sum_{n=2}^{63} I_n^2}}{I_L} \cdot 100$	***Current TDD*** I_L − value of max. load current (fixed, user defined value) n − number of harmonic
$U_f THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} U_{fn}^2}}{U_{f1}} \cdot 100$	***Phase voltage THD*** U_1 − value of first harmonic n − number of harmonic
$U_{ff} THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} U_{ffn}^2}}{U_{ff1}} \cdot 100$	***Phase-to-phase voltage THD*** U_1 − value of first harmonic n − number of harmonic

Current factors

$CFI(\%) = \frac{I_{PEAK}}{I_{RMS}} \cdot 100$	***CREST factor*** I_{RMS} – RMS value of phase current I_{PEAK} – Peak value of current within cycle
$K_i = \frac{\sum_{n=1}^{63} (I_n \times n)^2}{\sum_{n=1}^{63} I_n^2}$	***K factor*** I_L − value of max. load current (fixed, user defined value) n − number of harmonic

Flickers

$P_{50S} = (P_{30} + P_{50} + P_{80})/3$ $P_{10S} = (P_6 + P_8 + P_{10} + P_{13} + P_{17})/5$ $P_{3S} = (P_{2,2} + P_3 + P_4)/3$ $P_{1S} = (P_{1,7} + P_1 + P_{1,5})/3$ $P_{st} = \sqrt{0{,}0314P_{0,1} + 00525P_{1S} + 0{,}0657P_{3S} + 0{,}28P_{10S} + 0{,}08P_{50S}}$	***Pst − Short-term flicker intensity*** Short-term flicker intensity is measured in 10 minute periods. P_x − flicker levels that are exceeded by x% in a 10-minute period (e.g. $P_{0,1}$ represents a flicker level that is exceeded by 0.1% samples)
$P_{lt} = \sqrt[3]{\sum_{i=1}^{12} \frac{P_{sti}^3}{12}}$	***Plt − Long-term flicker intensity*** Calculated from twelve successive values of short-term flicker intensity in a two-hour period

Energy

$\text{Pricein tariff} = \text{Price} \cdot 10^{\text{Tarif priceexponent}}$	Total exponent of tariff price and energy price in all tariffs

23. RELATED DOCUMENTS

Ref	Document	Title
1	PI-MBUS-300 Rev. E	Modicon Modbus Protocol Reference Guide
2	QDSP EN/M	iSTAT Configuration and Analysis Software Manual

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