

GE
Grid Solutions

iSTAT I500

Enhanced 3ph Transducer

Manual

Publication reference: I500/EN/M/F



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 2.5mm², 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

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 Battery Replacement



Where internal batteries are fitted they should be replaced with the recommended type and be installed with the correct polarity, to avoid possible damage to the equipment.

3.3 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.

3.4 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: | IEC 61010-1 : 2002 Class I EN 61010-1 : 2002 Class I | This equipment requires a protective (safety) earth connection to ensure user safety. |
| Insulation Category (Over voltage): | IEC 61010-1 : 2002 600V Category III EN 61010-1 : 2002 600V Category III | |
| Environment: | IEC 61010-1 : 2002 Pollution degree 2 EN 61010-1 : 2002 Pollution degree 2 | Compliance is demonstrated by reference to generic safety standards. |
| Product Safety:  | 2006/95/EC EN 61010-1 : 2002 | Compliance with the European Commission Low Voltage Directive. Compliance is demonstrated by reference to generic safety standards. |

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6. INTRODUCTION

6.1 General

The **I500** is a multifunction transducer family aimed at the high and medium voltage and industrial market segments throughout the world. It allows the user to select the most appropriate model from the family and customise the features to suit the particular application.

The **I500** multifunction transducer family integrates a number of measurements, monitoring, recording and metering functions in the same unit for comprehensive power system management. The **I500** offers:

- High accuracy measurements
- A cost-effective solution for High, Medium Voltage and Industrial markets
- Power Quality analysis to EN50160
- Modbus protocol for integrating into energy management and control systems.
- Tariff and cost management functions for use in sub metering applications.
- Digital inputs and outputs and analogue inputs and outputs
- CE certification

6.2 KEY MESSAGES

- The iSTAT **I500** provides **Class 0.2** measurement of Volts, Current and Power and **Class 0.5S** for Energy measurement.
- The iSTAT **I500** is an economical choice for measurements, with a family that allows the user to tailor the transducer and functions to the application.
- The comprehensive Energy Cost Management Library of functions enables the **I500** to store energy readings in 4 registers and programme tariff structures and costs. This data can be recorded, communicated or read via pulse outputs
- **I500** offers multiple communication hardware options to allow integration in to a wide range of applications.
- **I500** allows communication to MODBUS based systems that are widely used by industrial and utility customers worldwide.
- **I500** is available with either Ring or Pin terminals to suit the installation requirements.

iSTAT – **THE standard** measurement platform

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

Simple to fit, **simple** to set, **simple** to connect

6.3 iSTAT I500 Family

The **I500** family consists of 3-phase and single phase transducers all of which are 0.2% multifunction instruments. **This manual details the 3-phase transducer models and the Remote Display that can be connected to them.**

6.3.1 i5MT class 0.2 multifunction communicating Transducer.

The transducer is used for monitoring and measuring electric quantities of single or three-phase electrical power distribution systems. The meter is provided with 32 program adjustable alarms, up to four input or output modules and communication. With the RS232/RS485, Ethernet or USB communication, the meter can be set and measurements can be checked.

The meter also functions as an energy counter, with the additional function of cost management by tariffs. A tariff input or a tariff clock can be set. When using tariff clock setting, four seasons and four day groups as well as energy cost for each period and a day group (16 different cost periods) are available. Additionally, the instrument can store up to 20 holidays. As an energy counter it can record energy in four tariffs in all four quadrants of the load power diagram.

The **i5MT** can be used as a

- Power Meter for monitoring and measuring electrical parameters in a power system.
- Class 0.5S Energy Meter with measurement in all 4 quadrants, suitable for secondary-metering applications (not revenue metering).

6.3.2 i5MR class 0.2 communicating Network Recorder

The transducer is used for monitoring, measuring and recording measurements of electric quantities of electrical power distribution systems. The **i5MR** measures all the same parameters as the **i5MT** and up to 64 measurements and up to 32 alarms can be recorded in the internal 8MB memory. The memory is separated into up to 4 sections for measurements and one section for recording alarms. The memory division is defined by the user via communication.

6.3.3 i5MQ class 0.2 communicating Network Analyser.

The transducer measures all the same parameters and includes the data logger as in the **i5MR**, and is used also for permanent analysis of electricity supply quality in compliance with the EN 50160 standard. A partition in the internal memory is reserved for storing reports for a period of the last seven years. The internal memory capacity enables storing of more than 170,000 variations of the measurements from the standard values, which enables fault analysis for problems in the network. Limits and required quality in a monitored period can be defined for each monitored characteristic. The following characteristics are measured and recorded:

- Frequency variations
- Voltage variations
- Voltage unbalances
- Voltage dips
- Voltage interruptions
- Rapid voltage changes
- Flickers Pst & Plt
- Temporary overvoltage's
- THD's
- Harmonics

6.3.4 Remote display **i5RD**

The transducers can be connected to the **i5RD** Remote display, with up to 31 transducers connected to a single display. The Remote display is very useful for a quick look-up to all measured parameters or to set up the **I500** measuring transducers without the PC. A graphical display with the resolution of 128x64 enables graphical representation of signals and parameters. With five select buttons it is possible to browse through the user-friendly menu.

6.3.5 Software:

The same QDSP software is used for configuring the devices as on all iSTAT communicating products.

The QDSP software is used for configuration and to browse the measurement values. In addition it is used to configure the data recorders and Power Quality analyser and to download and analyse the data stored.

6.4 Measurements

The **I500** family is ideally suited to applications where continuous monitoring of a single or three-phase system is required:

- **i5MT**: local and remote indication for ac switchboard power measurements, energy metering into a remote energy management system
- **i5MR**: System monitoring and alarm recording, local and remote indication for ac switchboard power measurements, energy metering into a remote energy management system,
- **i5MQ**: Quality of supply compliance monitoring, system monitoring and alarm recording, local and remote indication for ac switchboard power measurements, energy metering into a remote energy management system.

TABLE 7-1 has a summary of the measurements available. The I500 can be user configured for either single or three phase connection.

| TABLE 7-1: MEASUREMENTS | i5MT | i5MR | i5MQ |
|--|---|---|------------------|
| V, I, P, Q, S, PF, PA, F, ϕ | ● | ● | ● |
| Energy kWh class 0.5S | ● | ● | ● |
| 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) | 31 st or 63 rd | 31 st or 63 rd | 63 rd |

6.5 Hardware features

The **I500** 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.

The **I500** has 2 LED indicators, Red for power on and Green for communications activity.

The **I500** has 2 ranges of universal auxiliary supply available and an auto ranging current and voltage measurement input so that it can be used in most site conditions without the need to specify this information at the order stage.

The **I500** has 4 energy counters and a real time clock so that it supports the comprehensive energy management applications.

The **i5MR** has 8MB of internal memory to support the data recording functions and the **i5MQ** has 8MB of internal memory to support the data recording and Power Quality recorder functions.

| | i5MT | i5MR | i5MQ |
|------------------------|----------|----------|----------|
| Auto range V&I input | ● | ● | ● |
| Watchdog (optional) | ● | ● | ● |
| Universal Power supply | HI or LO | HI or LO | HI or LO |
| 4 Energy counters | ● | ● | ● |
| Real time clock | ● | ● | ● |
| Internal Flash Memory | | 8MB | 8MB |

6.6 Communications

The **I500** family has a wide range of communications options that allow it to integrate with a number of different management systems, see TABLE 7-3.

| COM | Port | Connector |
|-----|-------------|--|
| 1 | RS232/RS485 | Both options on one DB9 connector, in addition the RS485 connections are available via terminals |
| 1 | Ethernet | RJ-45 connector |
| 1 | USB | USB-B connector |
| 2 | RS485 | Terminals |

The **I500** have 2 communications ports, COM1 has the option of an RS232/RS485 wired port, a USB port or a combined Ethernet and USB port that will support MODBUS (RTU or TCP). The optional COM2 is a wired RS485 port that is fitted in the I/O 4 position.

If the optional Remote Display port option is selected an additional RJ11 connector is fitted for the RS485 communications between a single transducer and the display. If the Remote Display communications option is fitted then COM2 cannot be fitted.

6.7 Inputs and Outputs

The **I500** has four I/O module positions, each of which can support an I/O module as shown in TABLE 7-4. Each module configuration is specified at the order stage and there are dependences between them.

| TABLE 7-4: I/O OPTIONS | Quantity | Position | Specification |
|------------------------------------|-----------|----------|--|
| Alarm output | 4 outputs | any I/O | 48 V AC/ VDC (+40% max), 1000 mA max |
| Alarm output – High voltage | 2 outputs | I/O 1,2 | 150 VDC max, 1000 mA max 110 VAC (+30% max), 1000 mA max |
| Analogue output | 4 outputs | any I/O | Fully programmable +/- 20mA, +/- 10V |
| Watchdog output | 4 outputs | any I/O | 48 V AC/ VDC (+40% max), 1000 mA max |
| Watchdog output - High voltage | 2 outputs | I/O 1,2 | 150 VDC max, 1000 mA max 110 VAC (+30% max), 1000 mA max |
| Pulse output | 4 outputs | any I/O | 40 VAC/DC 30mA max 1...999ms |
| Tariff input | 2 inputs | I/O 1,2 | 110 or 230 VAC, 45...65Hz |
| Digital input | 4 inputs | any I/O | 48 V AC/DC (+40% max) |
| Analogue input | 4 inputs | any I/O | -20...0...20mA -10...0...10V Pt100, Pt1000, Resistance |
| Pulse input | 4 inputs | any I/O | 5 – 48 VDC |
| Additional RS485 comm. port (COM2) | 1 I/O | I/O 4 | |

6.8 Applications

The **I500** family can be used in a wide range of different applications depending on the model, the applications are summarised in Table 7-5.

| TABLE 7-5: APPLICATION | i5MT | i5MR | i5MQ |
|------------------------|------|------|------|
| Power measurements | ● | ● | ● |
| Energy Metering | ● | ● | ● |
| Cost Management | ● | ● | ● |
| Programmable alarms | ● | ● | ● |
| Measurement recorder | | ● | ● |
| Quality of supply | | | ● |

Power Measurements: All the **I500** family provide a wide range of instantaneous analogue values; Voltage, current, Power, phase angle, power factor and frequency. These are available remotely on all the **I500** family and locally if the Remote display is specified. The **I500** therefore replaces a number of separate transducers and instruments and is ideally suited to ac switchboard applications.

Energy and sub Metering: With addition of 4 quadrant energy measurement, the **I500** can be used in sub metering applications where information is passed to an energy management system to monitor the performance of the ac power system. Depending on the **I500** model and options selected, the **I500** can use a combination of pulsed energy contacts, 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 is performing correctly.

Cost Management: The addition of a real time clock and a tariff structure means that the **I500** 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 **i5MR** and **i5MQ** have up to 4 independent data recorders that provide trending information on up to 64 different analogue values. The type of value can be defined for each parameter, i.e. minimum, maximum, or average. Maximum demand and maximum and minimum instantaneous (every cycle) values can also be recorded. The status of all of the 32 software alarms can also be recorded within a separate alarm recorder. This provides a comprehensive record of the status of the monitoring system and a timed record of events.

Quality of supply: The **i5MQ** provides a quality of supply monitor that complies with the European standard EN50160. 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 a consistent and correct supply of electricity.

7. HARDWARE

7.1 Communications

The **I500** can be supplied with various communications options: RS232/RS485, Ethernet, USB or Ethernet and USB, which must be specified when ordering. The communication protocols that are available are Modbus RTU and Modbus TCP, which are detailed in a separate manual. The communications enables the remote viewing of measurements and viewing and setting of system parameters.



FIGURE 8-1: I5MT

The **I500** has a communications port (COM1) mounted under a transparent cover on the front. Under the same cover is an optional RJ11 connector which can be used for connection to the **i5RD** remote display.

In addition a second communications port (COM2) can be fitted as an option in the position usually used for the 4th hardware I/O module.

7.1.1 RS232 /RS485 communications

The **I500** transducers can be supplied with a combined RS232/RS485 port (COM1) via a front mounted DB9 9 pin. The RS485 communications are also available via terminals for field wiring. The RS232/RS485 port can be used for either RS232 or RS485, but not both since the port cannot support both options at the same time. All RS232 wiring must be removed before the RS485 communications on COM1 will operate correctly

WARNING: DO NOT ATTEMPT TO CONNECT USING RS232 AND RS485 COMMUNICATIONS AT THE SAME TIME AS DAMAGE CAN OCCUR. LEAVE UNUSED PINS UNCONNECTED.

The **I500** transducers can also be supplied with a second RS485 communications port (COM2) which is fitted in the position for the 4th hardware I/O module and is connected to terminals.

Communications with the Remote Display can be implemented using the RS485 on either COM1 or COM2 allowing the Remote Display to be connected to a maximum of 31 Transducers. In addition a dedicated Remote Display port option can be selected which allows the connection of a single Transducer to a Remote Display using a dedicated RS485 port via a RJ11 connector. The **I500** cannot support both COM2 and the Remote display port being fitted on the same transducer.

Connection information for COM1 and COM2 will be shown on a label as depicted in table 8-1.

The connection of RS232 communications is usually between the **I500** and a PC, the maximum connection length is 15 metres.

RS485 communications enables simultaneous connection to a maximum of 32 communicating devices; two-wire RS485 only is used. For RS485 communications, the PC will require either an internal RS485 communications port or an external RS232/RS485 or USB/RS485 interface. In both cases the device must provide automatic RS485 data flow control. The maximum connection length is 1000 metres. Conductors A and B should be terminated with a 120Ω terminating resistor on the units at each end of the RS485 network.

| Connection Label | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|----|--------------|---|---|----------------------|--|---|----|----|--------------|---|----|--|--|--------------|--|--------------|--|--|----|----|---|---|---|---|---|---|---|---|
| <table border="1" style="margin: auto;"> <tr><td colspan="5" style="text-align: center;">COMMUNICATION</td></tr> <tr><td colspan="5" style="text-align: center;">DB9 - FEMALE</td></tr> <tr><td colspan="2" style="text-align: center;">RS232</td><td colspan="3" style="text-align: center;">RS485</td></tr> <tr><td style="text-align: center;">Tx</td><td style="text-align: center;">Rx</td><td style="text-align: center;">⊥</td><td style="text-align: center;">B</td><td style="text-align: center;">A</td></tr> <tr><td style="text-align: center;">2</td><td style="text-align: center;">3</td><td style="text-align: center;">5</td><td style="text-align: center;">7</td><td style="text-align: center;">8</td></tr> </table> | | | | | COMMUNICATION | | | | | DB9 - FEMALE | | | | | RS232 | | RS485 | | | Tx | Rx | ⊥ | B | A | 2 | 3 | 5 | 7 | 8 |
| COMMUNICATION | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DB9 - FEMALE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RS232 | | RS485 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tx | Rx | ⊥ | B | A | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | 3 | 5 | 7 | 8 | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1" style="margin: auto;"> <tr><td colspan="2" style="text-align: center;">COM</td></tr> <tr><td style="text-align: center;">A</td><td style="text-align: center;">23</td></tr> <tr><td style="text-align: center;">NC</td><td style="text-align: center;">24</td></tr> <tr><td style="text-align: center;">B</td><td style="text-align: center;">25</td></tr> </table> | | | | | COM | | A | 23 | NC | 24 | B | 25 | | | | | | | | | | | | | | | | | |
| COM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| A | 23 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NC | 24 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| B | 25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

TABLE 8-1A: RS232.RS485 CONNECTIONS

| Connection Label | |
|------------------|------|
| I/O 4 | |
| COM 2 | |
| RS485 | B 21 |
| | A 22 |

TABLE 8-2B: RS485 COM2 CONNECTIONS

7.1.2 Ethernet and USB communications

The **I500** transducers can be supplied with a USB port, or a combined USB and Ethernet port via front mounted RJ45 and USB type B connectors. If both Ethernet and USB are fitted they can be used simultaneously allowing interrogation locally and remotely at the same time.

Ethernet communication allows for integration of the device into global Ethernet-based networks. The device supports fast Ethernet (10/100 Mbps). For proper operation, standard IEEE 802.3 compliant 100BASE-T CAT5 Ethernet cable is recommended. The device is supplied with a unique MAC address for identification. The MAC address is printed on the label, positioned on the upper side of the instrument.

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.

Connection information will be shown on a label as depicted in table 8-3.

| Connection Label | | | | | | | | | |
|---|--|----------------------|--|----------|--|----------|--|----------------|--|
| <table border="1" style="margin: auto;"> <tr><td colspan="2" style="text-align: center;">COMMUNICATION</td></tr> <tr><td colspan="2" style="text-align: center;">Ethernet</td></tr> <tr><td colspan="2" style="text-align: center;">MAC No.:</td></tr> <tr><td colspan="2" style="text-align: center;">USB 2.0 Type B</td></tr> </table> | | COMMUNICATION | | Ethernet | | MAC No.: | | USB 2.0 Type B | |
| COMMUNICATION | | | | | | | | | |
| Ethernet | | | | | | | | | |
| MAC No.: | | | | | | | | | |
| USB 2.0 Type B | | | | | | | | | |

TABLE 8-3: ETHERNET, USB CONNECTIONS

COM1 RS485 via Terminals 23-25 is not available when Ethernet and/or USB have been selected.

7.1.3 Communication connection details

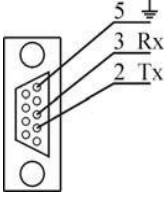
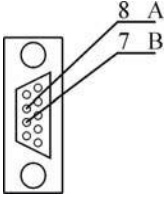



| | Connector | Terminals | | Data direction | Description |
|----------|-----------|---|---|----------------|------------------------|
| RS232 | DB9 |  | 1 | Not connected | - |
| | | | 2 | From | Data transmission (Tx) |
| | | | 3 | To | Data reception (Rx) |
| | | | 4 | Not connected | - |
| | | | 5 | - | Ground |
| | | | 6 | Not connected | - |
| | | | 7 | - | Do not connect! |
| | | | 8 | - | Do not connect! |
| | | | 9 | Not connected | - |
| RS485 | DB9 |  | 1 | Not connected | - |
| | | | 2 | - | Do not connect! |
| | | | 3 | - | Do not connect! |
| | | | 4 | Not connected | - |
| | | | 5 | - | Do not connect! |
| | | | 6 | Not connected | - |
| | | | 7 | To/From | B |
| | | | 8 | To/From | A |
| | | | 9 | Not connected | - |
| | SCREW-IN |  | 23 | To/From | A |
| | | | 24 | Not connected | C |
| | | | 25 | To/From | B |
| Ethernet | RJ-45 |  | 100BASE-T CAT5 cable recommended | | |
| USB | USB-B |  | Standard USB 2.0 compatible cable recommended (Type B plug) | | |

TABLE 8-3: PRIMARY COMMUNICATIONS

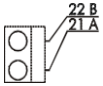
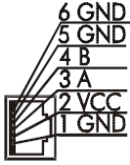
| | Connector | Terminals | | Data direction | Description |
|--|-----------|---|----|----------------|-------------|
| RS485 COM2 | SCREW-IN |  | 21 | To/From | A |
| | | | 22 | To/From | B |
| RS485 Remote Display Port | RJ-11 |  | 1 | - | Ground |
| | | | 2 | - | Vcc |
| | | | 3 | To/From | A |
| | | | 4 | To/From | B |
| | | | 5 | - | Ground |
| | | | 6 | - | Ground |

TABLE 8-4: SECONDARY COMMUNICATIONS

7.2 Inputs and Outputs

The **I500** can be supplied with up to four hardware I/O modules which are fitted internally during manufacture and need to be specified when ordering. These modules can be factory configured to one of the options shown in TABLE 8-5.



| TABLE 8-5: I/O OPTIONS | Quantity | Position |
|------------------------------------|-----------|----------|
| Alarm output | 4 outputs | any I/O |
| Alarm output – High voltage | 2 outputs | I/O 1,2 |
| Analogue output | 4 outputs | any I/O |
| Watchdog output | 4 outputs | any I/O |
| Watchdog output – High voltage | 2 outputs | I/O 1,2 |
| Pulse output | 4 outputs | any I/O |
| Tariff input | 2 inputs | I/O 1,2 |
| Digital input | 4 inputs | any I/O |
| Analogue input | 4 inputs | any I/O |
| Pulse input | 4 inputs | any I/O |
| Additional RS485 comm. port (COM2) | 1 I/O | I/O 4 |

Since each hardware module is independent and isolated from any other, the **I500** can be supplied with any combination of modules, but there are limitations to where the Tariff inputs, High voltage Alarm, High voltage Watchdog and COM2 ports can be fitted.

The terminal connections for the 4 I/O modules are shown in Figure 16-1.

7.2.1 Energy Contacts (Pulse outputs)

The energy pulsed outputs that can be used for the external monitoring of energy consumption that is measured by the **I500**. The pulsed outputs' energy measurement can be adapted to the customer's needs via the communications link. The energy measuring via the pulsed outputs corresponds to the basic energy measurement on the **i5RD** Remote display.

| | |
|---|-----------|
| I/O 1 | |
| Pulse output | |
| 40 V DC/AC  | 15 |
| 30 mA  | 16 |

Pulse output (solid state) module for energy counters. (Example of pulse module as I/O module 1)

TABLE 8-6: ENERGY PULSE OUTPUTS

When all hardware modules are used for energy contacts, the **I500** will provide a maximum of 4 independent pulse outputs.

7.2.2 Tariff (inputs)

The 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. The tariff structure can be adapted to the customers' needs via the communications link.

The hardware module has two terminals (see TABLE 8-7), the tariff voltage input is 115 or 230Vac ± 20%. When 2 hardware modules, in I/O slots 1 and 2, are used for tariff applications, the **I500** will provide 2 independent inputs, defining 4 tariffs.

| | |
|---------------------|------|
| I/O 1 | |
| Tariff input | |
| 230 V AC | ~ 15 |
| ± 20% | ~ 16 |

Tariff input module for changeover between up to four tariffs. (Example of tariff module as I/O module 1)

TABLE 8-7: TARIFF INPUTS

7.2.3 Alarm (outputs)

The alarm contacts can be used for external reporting of any alarm condition.

The I500 offers 2 Alarm output options a unit capable of switching 48 Vac/dc (+40% max) and a High voltage unit capable of switching 150 VDC max or 110 Vac (+30%max), but the high voltage option is only available in I/O slots 1 and 2.

The alarm modules have two terminals (see TABLE 8-8), and the **I500** can provide a maximum of 4 independent outputs.

| | |
|---------------------|--------|
| I/O 1 | |
| Relay output | |
| 48 V DC/AC | +/~ 15 |
| 1000 mA | -/~ 16 |

Alarm (relay) module. (Example of alarm module as I/O module 1)

| | |
|------------------------|--------|
| I/O 1 | |
| Relay output HV | |
| 150 V DC max | +/~ 15 |
| 110 V AC (+30%) | |
| 1000 mA | -/~ 16 |

High voltage Alarm (relay) module. (Example of alarm module as I/O module 1)

TABLE 8-8: ALARM CONTACTS

7.2.4 Analogue (outputs)

The **I500** can be supplied with up to four independent analogue outputs, each of which can be set within the range $\pm 20\text{mA}$ or $\pm 10\text{V}$. The analogue output can be configured to represent any of the instantaneous measured values.

The analogue module has two terminals (see TABLE 8-9).

| | |
|------------------------|---|
| I/O 1 | Analogue output module with analogue output, proportional to measured quantities. The outputs may be either short or open-circuited. They are electrically insulated from each other and from all other circuits. (Example of analogue output module as I/O module 1) |
| Analogue output | |
| 0...-/+20 mA +~ 15 | |
| 0...-/+10 V -~ 16 | |

TABLE 8-9: ANALOGUE OUTPUTS

7.2.5 Digital Input

The **I500** can be supplied with up to 4 independent digital inputs

| | |
|----------------------|---|
| I/O 1 | Digital input module enables reception of impulse signal. (Example of digital module as I/O module 1) |
| Digital input | |
| 48 V DC/AC +~ 15 | |
| + 40% max -~ 16 | |

TABLE 8-10: DIGITAL INPUTS

7.2.6 Watchdog Output

The **i500** can be supplied with up to 4 independent Watchdog outputs

The I500 offers 2 Watchdog output options a unit capable of switching 48 Vac/dc (+40% max) and a High voltage unit capable of switching 150 VDC max or 110 Vac (+30%max), but the high voltage option is only available in I/O slots 1 and 2

The Watchdog module has two terminals (see TABLE 8-11).

| | |
|---------------------------|--|
| I/O 1 | Watchdog (relay) module. (Example of Watchdog module as I/O module 1) |
| Watchdog output | |
| 48 V DC/AC +~ 15 | |
| 1000 mA -~ 16 | |
| I/O 1 | High voltage Watchdog (relay) module. (Example of Watchdog module as I/O module 1) |
| Watchdog output HV | |
| 150 V DC max +~ 15 | |
| 110 V AC (+30%) -~ 16 | |

TABLE 8-11: WATCHDOG OUTPUTS

7.2.7 Analogue Input

The **i500** can be supplied with up to 4 independent Analogue Inputs

The Analogue Input module has two terminals (see TABLE 8-12).

| | | | | | | | |
|-----------------------|---|-----------|---|-----------|---|---|-----------|
| I/O 1 | | | | | | | |
| Analogue input | | | | | | | |
| 0...-/±20 mA | <table border="1"> <tr> <td style="text-align: center;">+</td> <td style="text-align: center;">⊕</td> <td style="text-align: center;">15</td> </tr> <tr> <td style="text-align: center;">-</td> <td style="text-align: center;">⊖</td> <td style="text-align: center;">16</td> </tr> </table> | + | ⊕ | 15 | - | ⊖ | 16 |
| + | ⊕ | 15 | | | | | |
| - | ⊖ | 16 | | | | | |

Analogue Input module. (Example of Analogue Input module as I/O module 1)

TABLE 8-12: ANALOGUE INPUTS

7.2.8 Pulse Input

The **i500** can be supplied with up to 4 independent Pulse Inputs

The Pulse input module has two terminals (see TABLE 8-13).

| | | | | | | | |
|--------------------|---|-----------|---|-----------|---|---|-----------|
| I/O 1 | | | | | | | |
| Pulse input | | | | | | | |
| 5...48 V DC | <table border="1"> <tr> <td style="text-align: center;">+</td> <td style="text-align: center;">⊕</td> <td style="text-align: center;">15</td> </tr> <tr> <td style="text-align: center;">-</td> <td style="text-align: center;">⊖</td> <td style="text-align: center;">16</td> </tr> </table> | + | ⊕ | 15 | - | ⊖ | 16 |
| + | ⊕ | 15 | | | | | |
| - | ⊖ | 16 | | | | | |

Pulse Input module. (Example of Pulse Input module as I/O module 1)

TABLE 8-13: PULSE INPUTS

7.2.9 COM2 RS485 port

The I500 can be fitted with a secondary RS485 communications port that is fitted in I/O module slot 4.

| | | | | | | | |
|--------------|---|-----------|---|-----------|---|---|-----------|
| I/O 4 | | | | | | | |
| COM 2 | | | | | | | |
| RS485 | <table border="1"> <tr> <td style="text-align: center;">B</td> <td style="text-align: center;">⊖</td> <td style="text-align: center;">21</td> </tr> <tr> <td style="text-align: center;">A</td> <td style="text-align: center;">⊕</td> <td style="text-align: center;">22</td> </tr> </table> | B | ⊖ | 21 | A | ⊕ | 22 |
| B | ⊖ | 21 | | | | | |
| A | ⊕ | 22 | | | | | |

2nd communication module, for connection of RS485 communication (COM2).

TABLE 8-14: COM2

7.3 Auxiliary Supply

The **I500** Measuring transducer has a universal (AC/DC) auxiliary power supply. It is supplied in two versions, either LOW (20 VDC – 70 VDC; 48 VAC – 77 VAC) or HIGH (70 VDC – 300 VDC; 80 VAC – 276 VAC), which must be defined at time the order.

Connection details and ratings are shown on a label as detailed in TABLE 8-15.









| | |
|--|--|
| AUX | |
| 19...70 V DC  12 | Connection of universal power supply (LOW) to terminals 13, 14 and 12 |
| 48...77 V AC  13 | |
| 40...65 Hz  14 | |
| < 8 VA  | |
| AUX | |
| 70...300 V DC  12 | Connection of universal power supply (HIGH) to terminals 13, 14 and 12 |
| 80...276 V AC  13 | |
| 40...65 Hz  14 | |
| < 8 VA  | |

TABLE 8-15: AUXILAIRY SUPPLY

NOTE: FOR SAFETY PURPOSES IT IS IMPORTANT THAT ALL THREE WIRES ARE FIRMLY CONNECTED. THEY SHOULD BE CONNECTED ONLY TO THE DESIGNATED TERMINALS AS SHOWN ON THE LABEL ABOVE AS WELL AS ON THE FRONT LABEL OF THE TRANSDUCER. AN EARTH CONNECTION IS ALWAYS REQUIRED FOR SAFETY AS THERE ARE ACCESSIBLE METAL COMPONENTS.

7.4 Measurement Inputs

The **I500** has an auto-ranging voltage and current input with nominal values of 230V and 5A. Since the **I500** also has a fully configurable connection mode the default information is shown as 4u (three phase 4 wire unbalanced) and the default connection diagram also shows this connection. This information is shown on the label as detailed in TABLE 8-16, the different wiring connections are shown in section 16.

| |
|---------------|
| INPUTS |
| Current: |
| Voltage: |
| Frequency: |
| Connection: |

TABLE 8-16: MEASUREMENT INPUTS

8. SETTINGS

8.1 Introduction

Instrument settings can be remotely modified with the QDSP software, when connected to a PC, or with the use of the keyboard on the **i5RD** Remote display if fitted. The settings that can be modified using the i5RD Remote display are indicated by (RD) in the sections below.

8.2 QDSP Software

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

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

8.2.1 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.

8.2.2 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, QDSP can also store the data to settings files and read it back when required.

8.2.3 Real time measurements

All measurements can be displayed in real time in a table. 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.

8.2.4 Data Analysis

Analysis can be performed on the recorded data in the i5MR and i5MQ. 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.

8.2.5 Software upgrading

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

8.3 Setting Procedure

In order to modify the settings with QDSP the current parameters must be loaded first. Instrument settings can be acquired via a communications link or they can be loaded off-line from a file on a local disk. The QDSP 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 QDSP setting window, the left part displays a hierarchical tree structure of settings, the right hand part displays parameter values of the chosen setting group, see Figure 9-1.

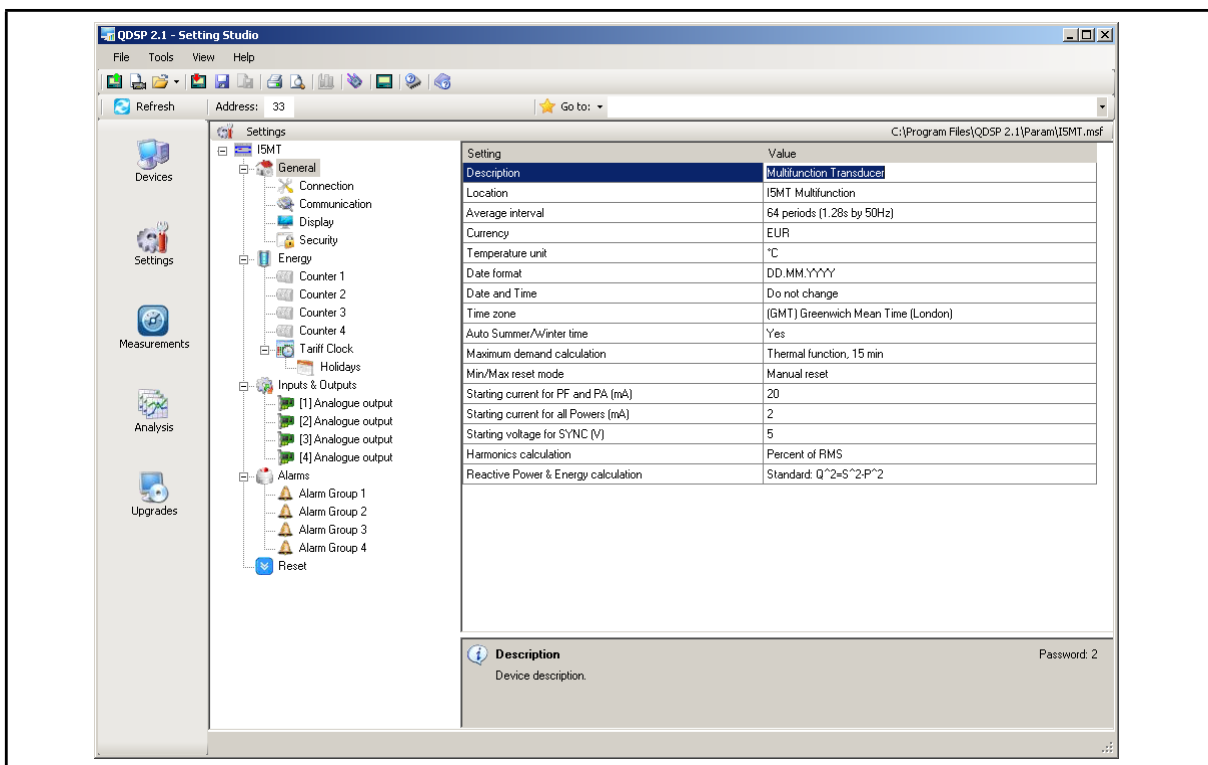


FIGURE 9-1: QDSP INTERFACE

8.4 General Settings

General Settings are essential for the operation of the measuring transducer. They are divided into three additional sublevels (Connection, Communication and Security).

8.4.1 Description and Location

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

8.4.2 Average Interval

The averaging interval defines the refresh rate of measurements for communications and i5RD Remote display.

8.4.3 Currency (RD)

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 |

8.4.4 Temperature unit (RD)

Choose temperature units for display °C or °F.

8.4.5 Date Format (RD)

Set a date format

8.4.6 Date and Time (RD)

Set the date and time of the meter, Setting is important for correct data storage operation, maximum values (MD), etc.

8.4.7 Auto Summer/Winter time (RD)

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

8.4.8 Maximum Demand calculation (MD mode) (RD)

The **I500** provides maximum demand values from a number of different demand values.

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

See section 5 for details.

8.4.9 Resetting Min/Max (RD)

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

The reset can either be Manual 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 (1st January) at 00:00

8.4.10 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.

8.4.11 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.

8.4.12 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.

8.4.13 Reactive power calculation

Two different principles of reactive power and energy calculation are 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).

Delayed current 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).

8.5 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.

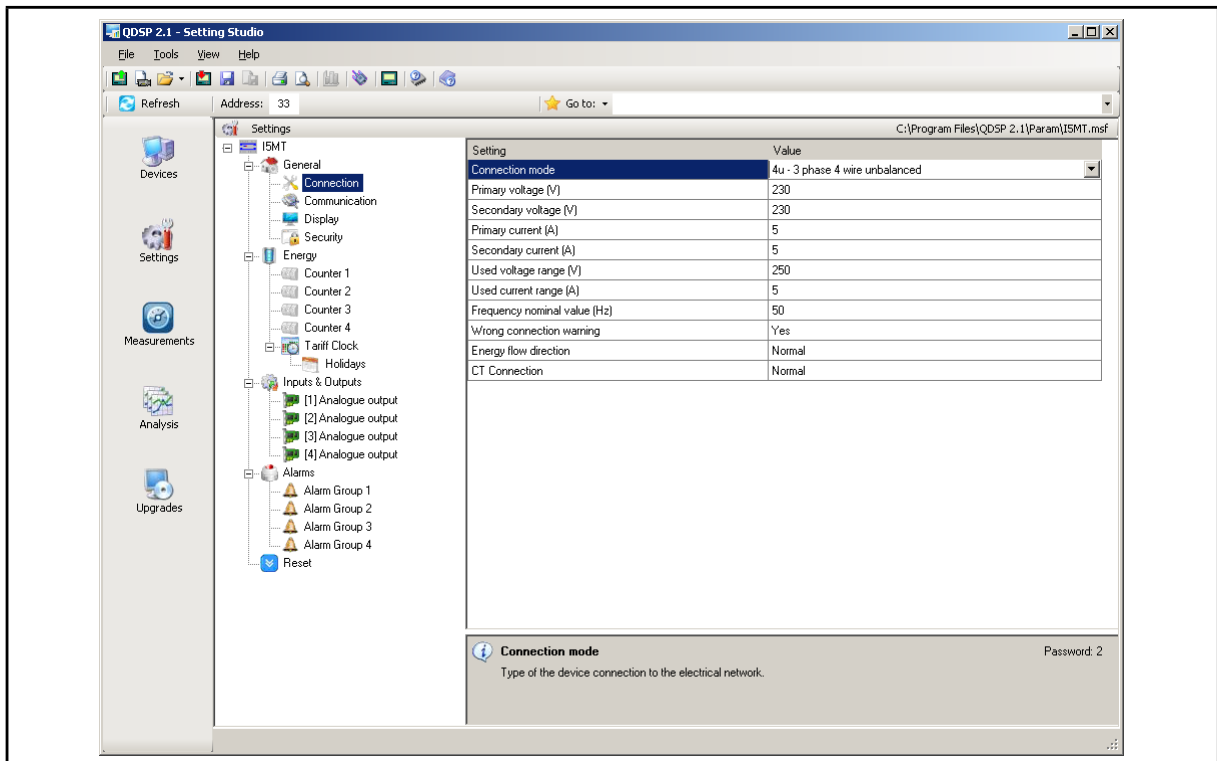


FIGURE 9-2: CONNECTION

8.5.1 Connection (RD)

When the connection is selected, the load connection and the supported measurements are defined (see section 10).

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

8.5.2 Setting of current and voltage ratios (RD)

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.

| Settings range | 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 |

8.5.3 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 QDSP, 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.

8.5.4 Nominal Frequency

A valid frequency measurement is within $\pm 32\text{Hz}$ of the nominal frequency. This setting is only used for alarms and recorders.

8.6 Communication

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

8.6.1 Serial Communication parameters (COM1) (RD)

These parameters are important for the correct operation in RS485 networks or connections with PC via RS232 communications. Factory settings for communication are #33\19200,n,8,2 (previous default #33\115200,n,8,2) (address 1 to 247\data rate 2400 to 115200 b/s, parity, data bits, stop bit). To find the communications parameters of a specific product use the 'Scan the Network' feature on QDSP.

8.6.2 Ethernet Communication

8.6.2.1 Device Address (RD)

The device address should be maintained at the default value of 33.

8.6.2.2 IP address (RD)

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

- **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.

8.6.2.3 Local Port (RD)

Use a non-reserved port number from 1025 to 65535. Do not set the Local Port to any of the reserved port numbers.

If using Redirector software, the port number should be between 14000 and 14009.

| Port numbers | Function |
|------------------------------|-------------------------|
| 1 – 1024, 9999, 30718, 33333 | Reserved numbers |
| 14000 – 14009 | Reserved for Redirector |

Factory settings for Ethernet Communications are:

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

8.6.3 USB

The transducer will be identified as a USB device when connected to a USB port on the PC, refer to the separate QDSP manual for details of the driver installation.

8.7 Security

Parameter settings are divided into 2 groups for regarding security level:

1. If the passwords are set to 'AAAA' (default) there is no restriction to the access of parameter settings.
2. At the first level (PL1), the settings for the real time clock and the reset of the energy registers and MD can be accessed.
3. At the second level (PL2), access is given to all parameter settings.
4. 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 6.2.
5. A Backup password (BP) is used if the passwords at level 1 (PL1) and level2 (PL2) have been forgotten, and it differs for each device depending on the serial number of the instrument. The BP password is available from Technical Support and is entered instead of password PL1 and/or PL2. The serial number is stated on the product label or can be read with QDSP and must be supplied when requesting the BP.
6. Passwords are the same regardless of which communications port (COM1 or COM2) the user is accessing for the settings. But unlocking the access via COM1 doesn't unlock the access via COM2 and vice versa.

8.7.1 Password setting (RD)

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 after which they become active, can be set.

8.7.2 Password modification (RD)

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

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

8.8 Energy

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

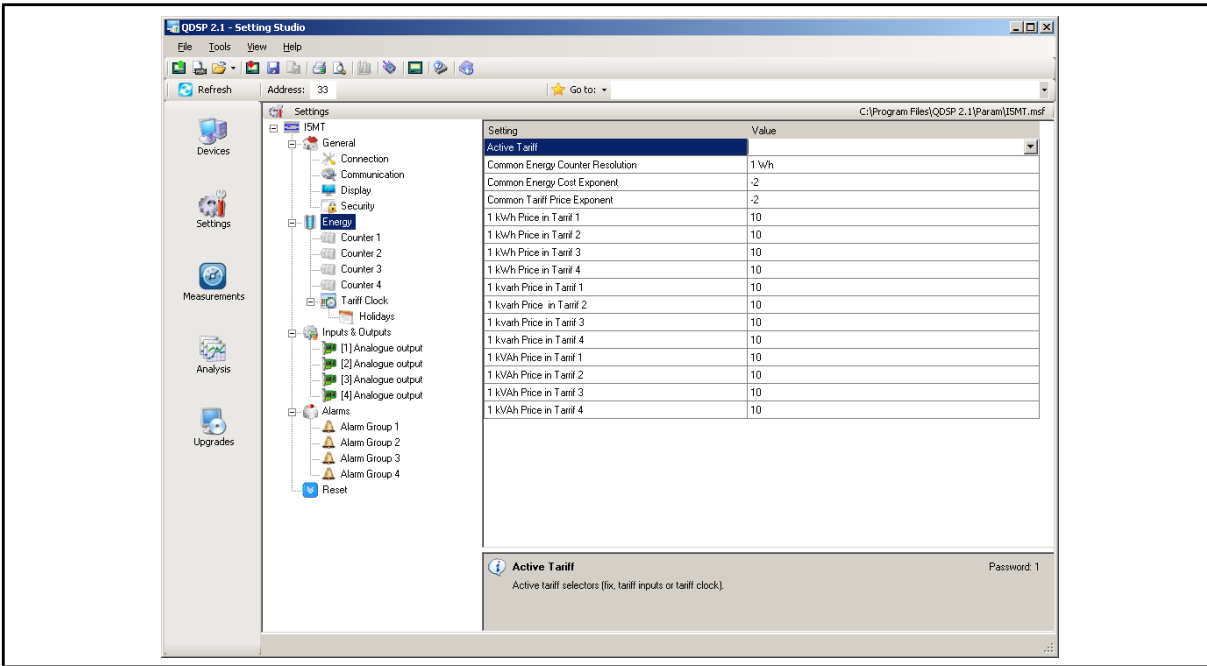


FIGURE 9-3: ENERGY

8.8.1 Active Tariff (RD)

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.

8.8.2 Common Energy Exponent

The Common energy exponent 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 exponent 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 exponent, where the counter divider is at its default value of 10.

| Current Voltage | 1 A | 5 A | 50 A | 100 A | 1000 A |
|--------------------|-----|-----|------|-------|--------|
| 110 V | -1 | 0 | 1 | 1 | 2 |
| 230 V | 0 | 0 | 1 | 2 | 3 |
| 1000 V | 0 | 1 | 2 | 3 | 4 |
| 30 kV | 2 | 2 | 3 | 4 | 4* |

* - Counter divider should be at least 100

8.8.3 Common exponent of energy cost

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.

8.8.4 Common exponent of tariff price 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.

8.8.5 Measured Energy

Each counter is enabled or disabled and can be configured to read any energy value from a drop down selection. The Energy counters can operate in all four quadrants; this is chosen using a graphical interface as shown in Figure 9-4.

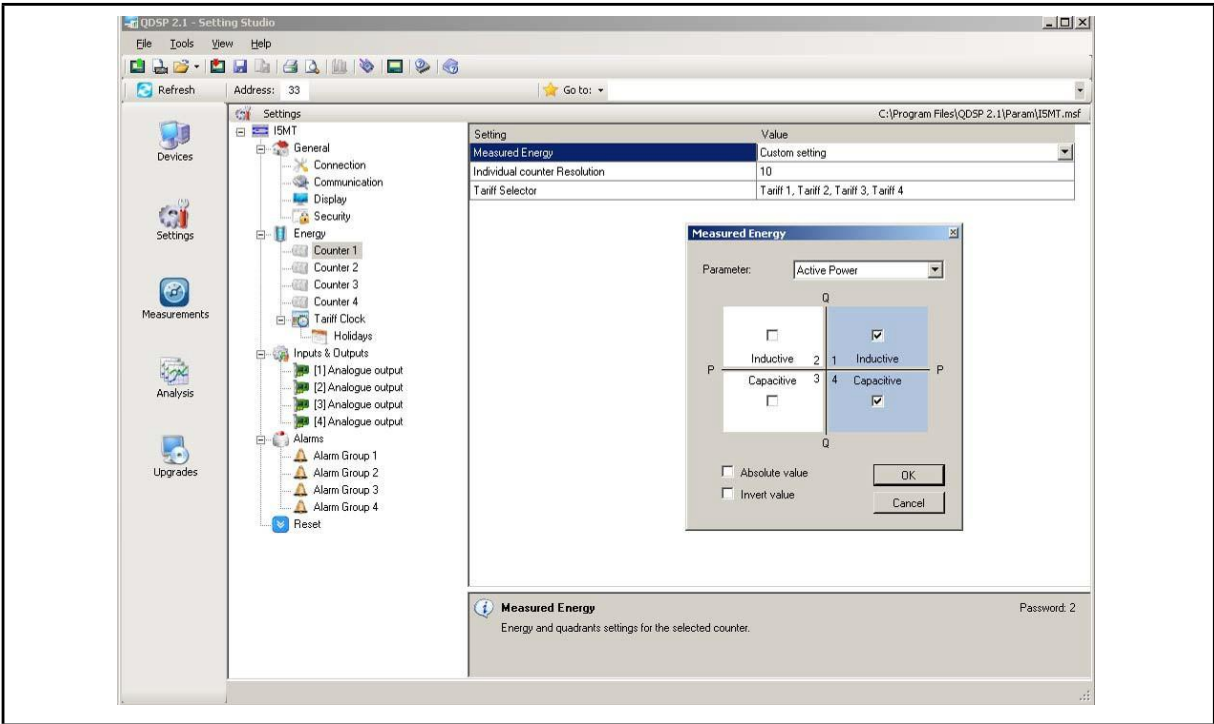


FIGURE 9-4: MEASURED ENERGY

8.8.6 Counter Divider

The counter divider defines the precision of a specific counter, according to settings of the Common energy exponent.

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

| | | | |
|------------------------------|------------------------|-----------------------|-------------------|
| Common energy exponent | 0 | 2 | 2 |
| Counter divider | 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 |

8.8.7 Tariff selector

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

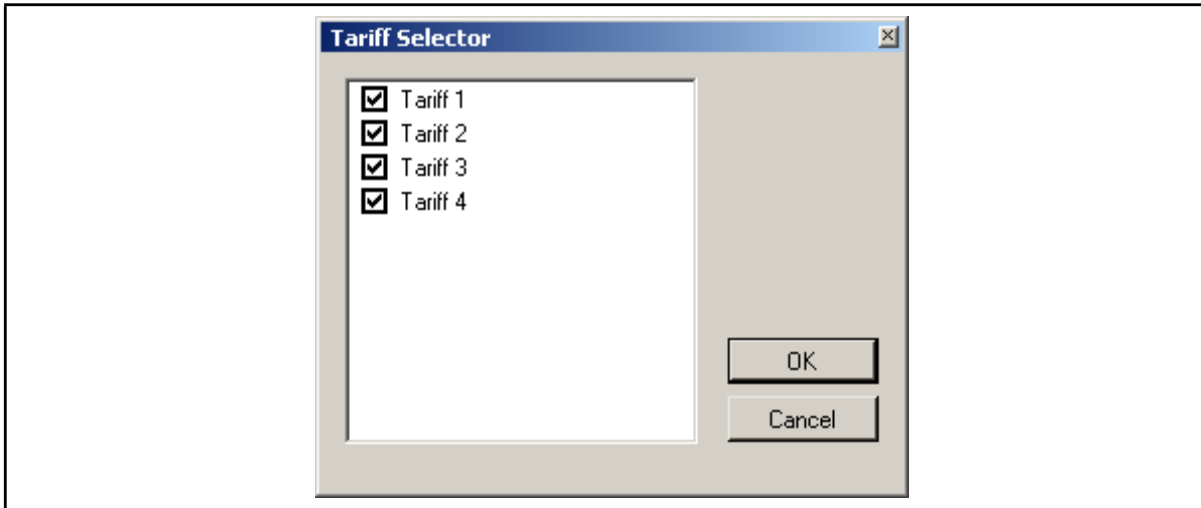


FIGURE 9-5: TARIFF SELECTION

8.8.8 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

Figure 9-6 shows the QDSP 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.

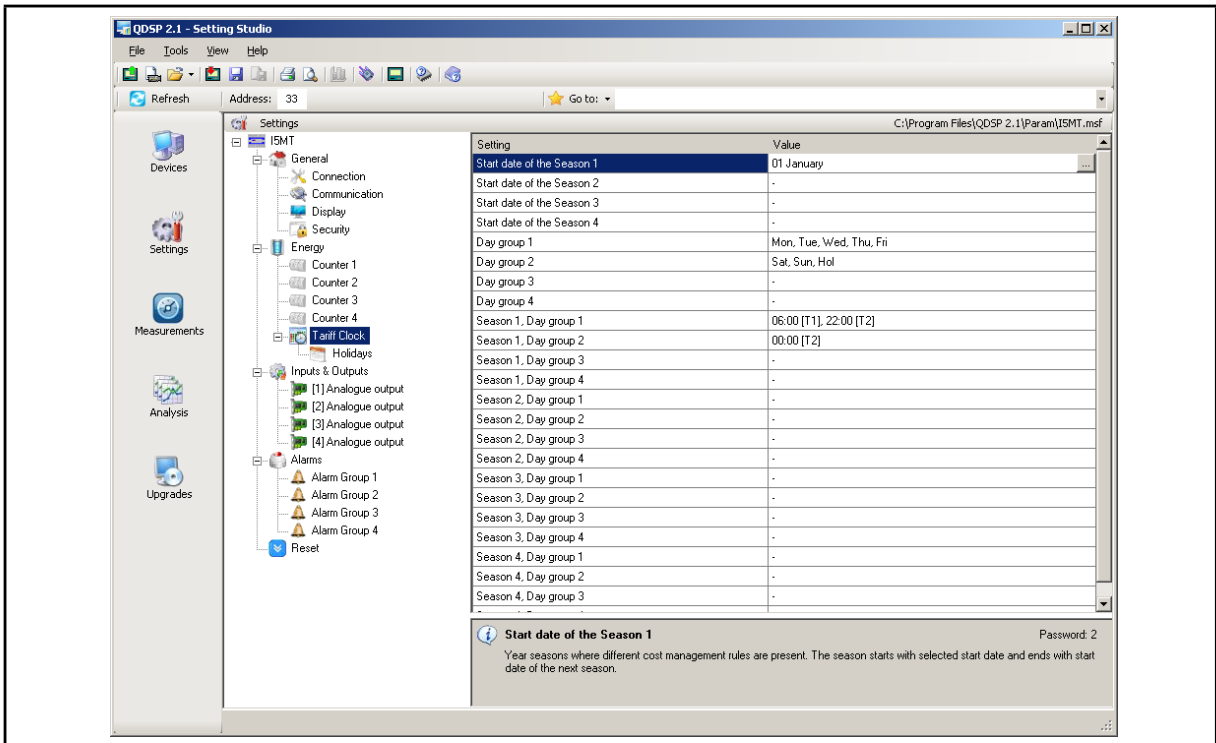


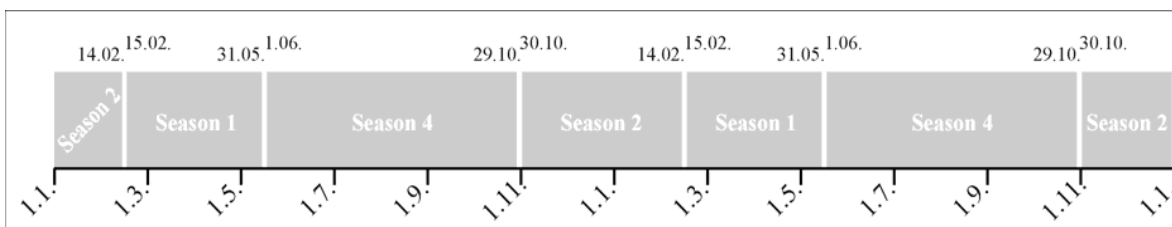
FIGURE 9-6: TARIFF STRUCTURE

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)

8.9 Inputs and Outputs

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.

8.9.1 Analogue output module

Each of the analogue outputs is fully programmable.

8.9.1.1 Output parameter

Define the Measured or calculated parameter that is to be output on the specific analogue output. This can include the value from an analogue input channel.

8.9.1.2 Output range

The analogue output can be configured to one of six hardware output ranges within which the analogue output will operate. To ensure the highest accuracy for the output, the range selected should be the lowest that covers the required analogue output range.

| DC current output | DC voltage output |
|-------------------|-------------------|
| -1...0...1 mA | -1...0...1 V |
| -5...0...5 mA | |
| -10...0...10 mA | -10...0...10 V |
| -20...0...20 mA | |

8.9.1.3 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.

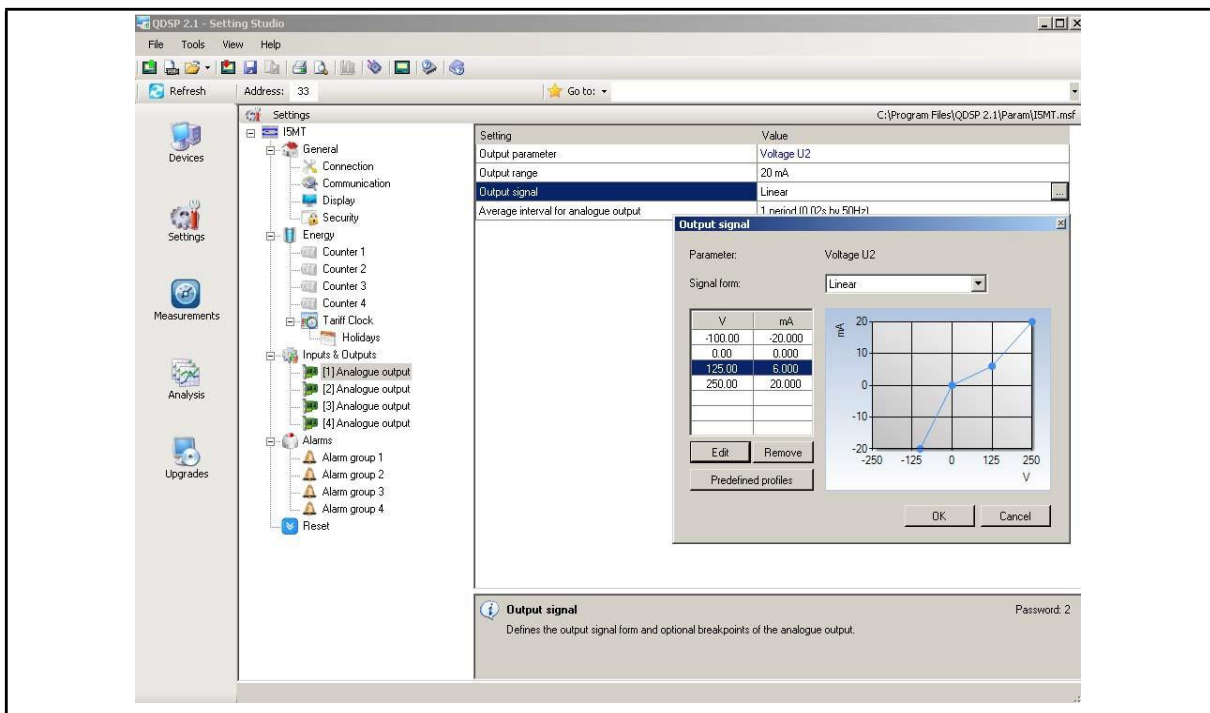


FIGURE 9-7: ANALOGUE OUTPUT SETTINGS

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' ranges are changed after the analogue settings have been defined, then the analogue settings will be modified automatically, see section 9.5.3. It may be necessary to subsequently modify the settings for the analogue outputs.

8.9.1.4 Average interval for analogue output

Defines the time interval over which the measurement used for an analogue output will be averaged.

8.9.2 Alarm/Digital Output Module (RD)

Alarm groups that are connected with an alarm module and a signal shape are 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 μ s ($R \cdot C \geq 250 \mu$ s) should be fitted when connected to a sensitive pulse counter, to attenuate the relay transient signals.

8.9.2.1 Output signal

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

- Normal – The relay is closed until the alarm condition is fulfilled.
- Normal Inverse – The relay is open until the alarm condition is fulfilled.
- Holds – The relay is closed when the alarm condition is fulfilled, and remains closed until it is reset via communication.
- Pulse – an impulse of the defined length is sent when the alarm condition is fulfilled.
- Always switched ON / OFF – The relay is switched ON or OFF irrespective of the alarm condition. This enables remote control via communication to be implemented.

8.9.3 Pulse Output Module (RD)

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.

$$1,5 \dots 15 \text{ eW} \rightarrow 100 \text{ p} \blacksquare 1 \text{ eWh}$$

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 |

8.9.4 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.

8.9.5 Digital Input module

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.

8.9.6 Watchdog Output module

The purpose is to detect potential malfunction of the transducer or auxiliary power supply failure. This module can be set for normal operation (relay in close position) or for test purposes to open position (manual activation). After test the module should be set back to normal operation.

8.9.7 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.

QDSP 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 or ± 2 mA maximum input value

DC voltage range:

Range setting allows bipolar ± 10 V or ± 1 V maximum input value

Resistance / temperature range:

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

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

8.9.8 Pulse Input module

There are no settings for the Pulse Input module. It acts as a general purpose pulse counter from external meters (water, gas, heat ...). Its value can be assigned to any of the four energy counters.

8.9.9 2nd Communications module (COM2) (RD)

The module is pre-set as RS485 communications and is fitted as I/O 4.

The module settings define parameters that are important for the operation in a RS485 network. Factory settings for the communication parameters are #33\19200,n,8,2 (previous default #33\115200,n,8,2) (address 1 to 247\rate 2400 to 115200, parity, data bits, stop bit). To find the communications parameters of a specific product use the 'Scan the Network' feature on QDSP.

The COM2 communications port has a device address that is set independently of that used by COM1. This allows two independent communications networks to be connected to the same transducer.

8.10 Alarms

There are 32 alarms available split into 4 alarm groups. On the **i5MR** and **i5MQ** the alarm status can be stored in a recorder.

8.10.1 Alarm setting

For each of the 4 alarm groups a time constant of maximum values in thermal mode, a delay on time and alarm deactivation hysteresis can be defined.

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, if the **i5RD** Remote Display is fitted, 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 9.5.3. It may be necessary to subsequently modify the settings for the alarm outputs.

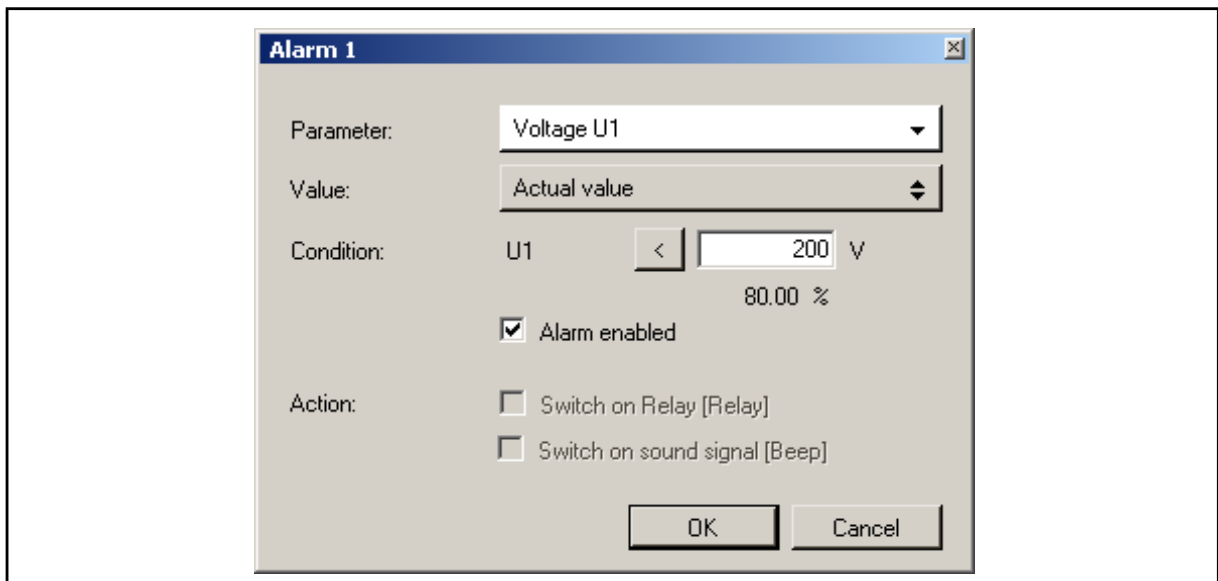


FIGURE 9-8: ALARM SETTINGS

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

8.10.2 Types of Alarm

8.10.2.1 Visual Alarm

Available when the **i5RD** Remote display is connected. When an alarm is switched on, a red LED on the front of the remote display will blink.

8.10.2.2 Audible alarm

Available when the **i5RD** Remote display is connected. When an alarm is switched on, an audible alarm is given by the remote display (a beep). It can be switched off by pressing any key on the front plate.

8.10.2.3 Alarm Output (pulse)

According to the alarm signal shape the output relay will behave as shown below.

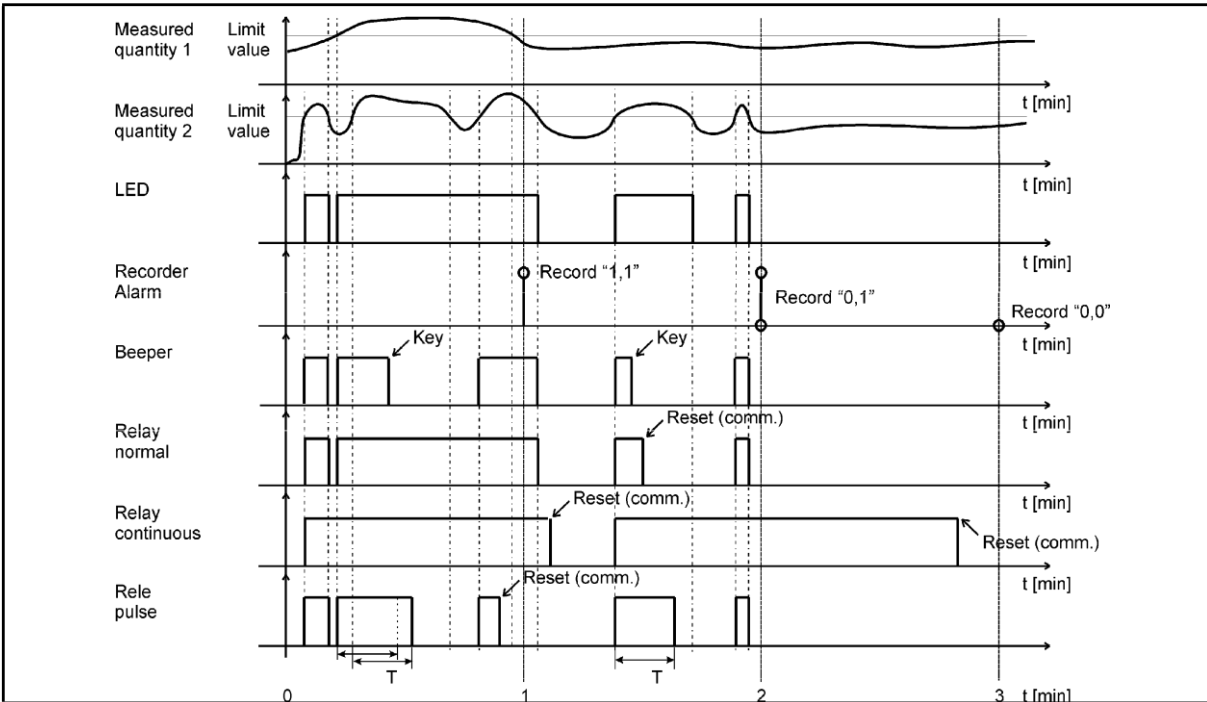


FIGURE 9-9: ALARM OUTPUTS

8.11 Memory

Measurements, alarms, reports and details of supply voltage quality can be stored in the 8MB of internal memory on the **i5MR** and **i5MQ**. All records stored in the memory are accessible using QDSP.

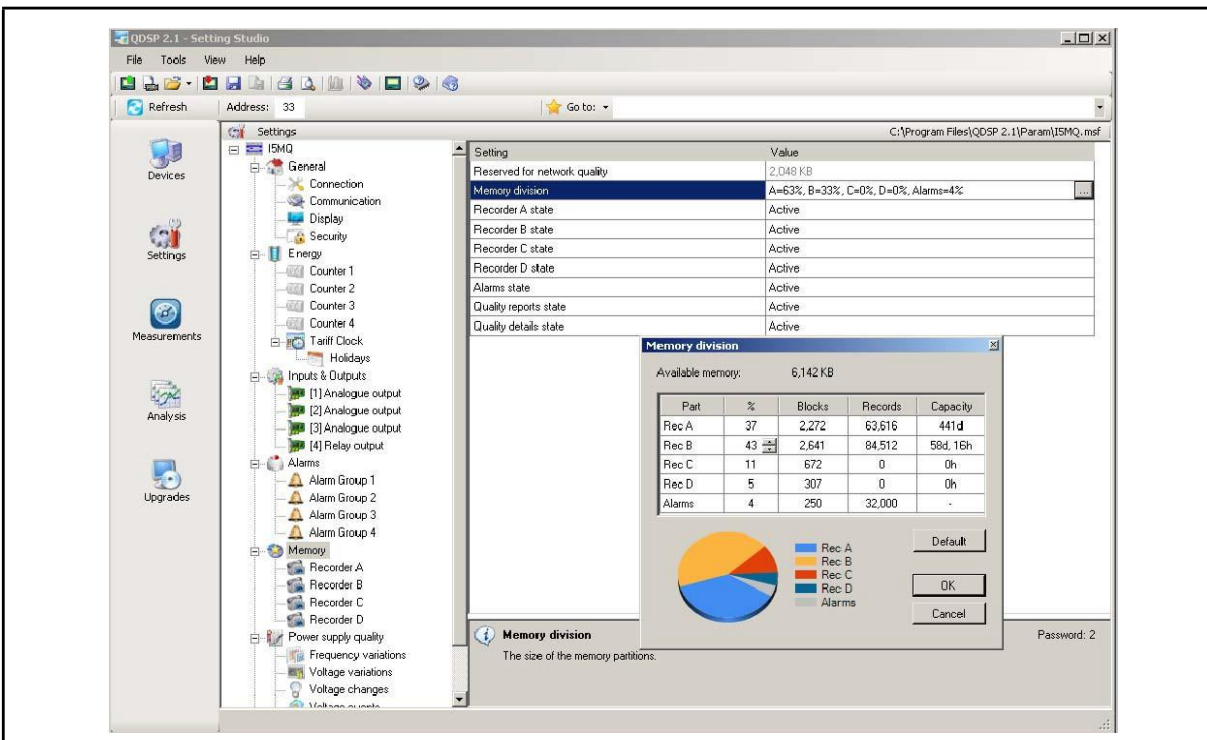


FIGURE 9-10: MEMORY SETTINGS

8.11.1 Memory division

The internal memory is divided into up to 5 partitions, whose size can be defined by the customer, see Figure 9-10. The recorders are intended for recording measurements, while alarms are recorded in a separate partition. The **i5MQ** has 2 additional partitions for recording reports and details on the quality of supply voltage.

8.11.2 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 you need to clear memory then follow these steps:

- Read the instrument readings with QDSP and set “Recorder state” in Memory to ‘stopped’.
- Download the changes to the device and open Memory info form and then click on Clear memory button.
- Select memory partitions to be cleared on Memory form and click OK.
- Set “Recorder state” setting back to ‘Active’.

8.12 Data Recorders

The **i5MR** and **i5MQ** have up to 4 data recorders, which can only be configured using the QDSP software. The recorders are independent from each other and each can be configured to record up to 16 different values. The Maximum Demand integration time can be set between 1 and 255 minutes and the recorder sample time can be set between 1 and 255 minutes.

Figure 9-11 shows the QDSP Data Recorder menu. This shows the 16 different record values for each of the recorders, each of which is configurable to any measurement or analogue /digital input to the **M2x3**.

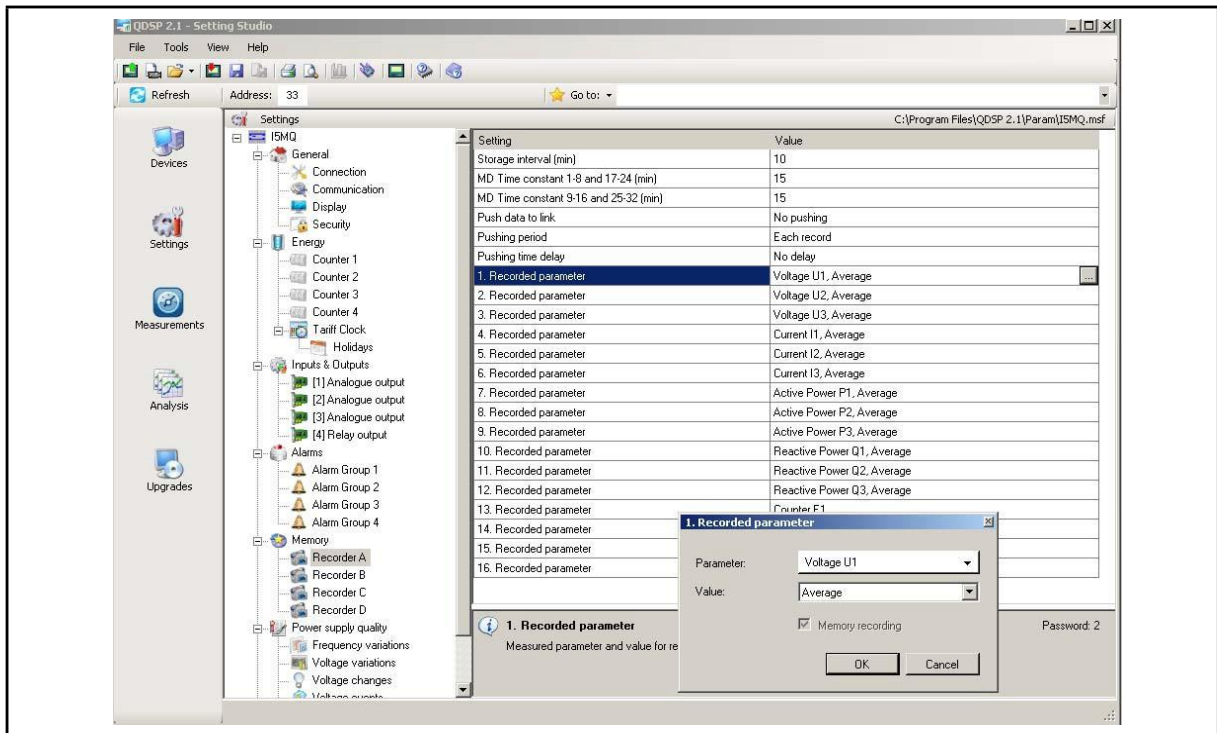


FIGURE 9-11: DATA RECORDER

8.12.1 Storage interval

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

8.12.2 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 and 9-16.

8.12.3 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.
- **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). (recommended for Pst and Plt measurements)
- **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.

8.13 Power Quality Recorder Report

The **i5MQ** has a power quality measurement function that monitors compliance to the European standard EN50160. The power quality features can be set on the **i5MQ** and this then determines what data is communicated.

The EN 50160 standard deals with voltage characteristics of electricity supplied by public distribution systems. This specifies the limits or values within which a customer can expect voltage characteristics to lie. Within this definition the **i5MQ** Network Analyser supervises the compliance of distribution systems with the EN 50160 standard.

Based on the requirements stated in the standard, default parameters are set in the meter according to which supervision of all required parameters is done. Parameters can also be changed in detailed setting of individual characteristics.

The **i5MQ** has 2MB of non-volatile memory reserved for storing power quality data with a capacity for storing 170,000 variations from standard.

The EN50160 standard monitors the following electrical characteristics:

- Frequency and voltage variations
- Voltage unbalances, interruptions and dips
- Long and Transient (fast) interruptions
- Flicker, short and long term
- Individual Harmonics and %THD

All the Power Quality settings, extraction and tabulation of findings are done using the QDSP software.

The following definitions are used in Power Quality applications:

Un = nominal supply voltage for the electrical system

Uc = agreed supply voltage for the electrical system, this may be the same as Un.

8.13.1 Power Supply Quality

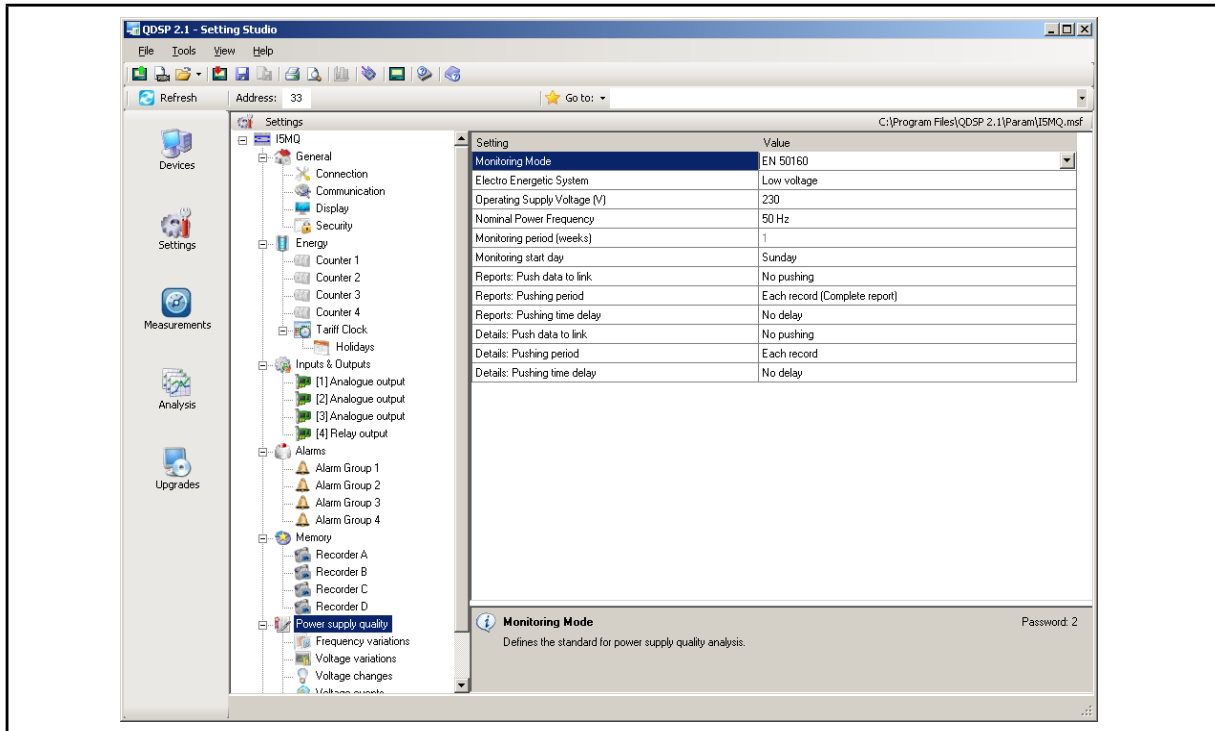


FIGURE 9-12: POWER SUPPLY QUALITY

Basic parameters are defined that influence other settings

8.13.1.1 Monitoring mode

This defines that the instrument performs measurements for network compliance with the standard.

8.13.1.2 Electric energetic system

Public distribution system and if necessary all default settings are selected.

8.13.1.3 Nominal supply voltage

A value that is usually equal to nominal network voltage is entered.

8.13.1.4 Nominal power frequency

Nominal frequency of supply voltage is selected.

8.13.1.5 Monitoring period

For a report of electric voltage quality a monitoring period is defined. A number of monitored weeks are entered.

8.13.1.6 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.

8.13.1.7 Voltage Hysteresis

Hysteresis for voltage dips, interruptions and over voltages is set in percentage from nominal voltage.

8.13.2 Frequency Variations

All frequency measurements are performed in 10-second averaging intervals. There are two variation classes and for each a variation is defined as a percentage of nominal and also the percentage of measurements which have to be within the variation limits (required quality).

8.13.3 Voltage Variations

All Voltage measurements are performed in 10-second averaging intervals. There are two variation classes and for each a variation is defined as a percentage of nominal and also the percentage of measurements which have to be within the variation limits (required quality).

8.13.4 Dips and Interruptions

Limits for voltage dips and interruptions are defined as a percentage of the nominal voltage. A threshold between short-term and long-term interruptions is defined in seconds. And also the allowable number of dips and interruptions are defined by other parameters.

8.13.5 Rapid Voltage Changes

The limits and the number of allowable changes are defined.

8.13.6 Temporary overvoltages, flickers.

There are two types of flicker: short-term flicker intensity (P_{st}) and long-term flicker intensity (P_{lt}) for each a monitoring period, performance limit and required signal quality are defined.

8.13.7 Harmonics and THD

The permitted limits for the first 25 harmonic components and the THD are defined with the required quality in the monitoring period.

8.13.8 Resetting quality parameter reports

Some quality parameter reports are made on a weekly basis and other on yearly basis. The parameter reports are reset at the end of each observed period. Weekly based reports will be reset every week. Even if the instruments' location or mode of operation is altered, the weekly report will reset at the end of the week. But yearly reports will not be reset until the end of the year. Therefore when required the yearly reports must be reset manually.

In order to reset reports choose setting <Power supply quality>< Monitoring mode> and change the value to "No monitoring". Download settings to instrument. Then choose the same setting and change the value back to "EN50160". Again download the settings to the instrument. Then all yearly reports (anomaly counters) will have been reset.

8.14 Reset Operations

8.14.1 Reset Min/Max values (RD)

All Min/Max values are reset.

8.14.2 Set energy counters (RD)

All or individual energy counters are reset.

8.14.3 Reset Energy counter costs (RD)

All or individual energy costs are reset.

8.14.4 Reset maximal MD values (RD)

8.14.4.1 Thermal mode

Current and stored MD's are reset.

8.14.4.2 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.

8.14.5 Reset the last MD period (RD)

8.14.5.1 Thermal mode

Current MD value is reset.

8.14.5.2 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.

8.14.6 MD synchronization (RD)

8.14.6.1 Thermal mode

In this mode, synchronization does not have any influence.

8.14.6.2 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:

| | | | |
|----------------------------|--------|--------|-------|
| 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 |

8.14.7 Reset alarm output (RD)

All alarm outputs are reset.

9. SYSTEM MODES

9.1 Connection mode

The connection mode of the **I500** is configurable. The following options are available:

- 1b - single phase connection,
- 3b - three-phase, three-wire connection with balanced load,
- 4b - three-phase, four-wire connection with balanced load,
- 3u - three-phase, three-wire connection with unbalanced load
- 4u - three-phase, four-wire connection with unbalanced load.

9.1.1 Valid measurements

The following tables list the valid measurements for each connection type.

Key: ● – measured, ○ – calculated, × – not supported

| | TABLE 10-1: BASIC MEASUREMENTS | Parameter | Unit | Connection | | | | |
|----------------------------|--------------------------------|-----------|------|------------|----|----|----|----|
| | | | | 1b | 3b | 3u | 4b | 4u |
| Phase | Voltage U_1 | U1 | V | ● | × | × | ● | ● |
| | Voltage U_2 | U2 | V | × | × | × | ○ | ● |
| | Voltage U_3 | U3 | V | × | × | × | ○ | ● |
| | Average voltage U^{\sim} | $U_{\#}$ | V | × | × | × | ○ | ● |
| | Current I_1 | I1 | A | ● | ● | ● | ● | ● |
| | Current I_2 | I2 | A | × | ○ | ● | ○ | ● |
| | Current I_3 | I3 | A | × | ○ | ● | ○ | ● |
| | Current I_n | In | A | × | ○ | ○ | ○ | ● |
| | Total current I_t | I | A | ● | ○ | ○ | ○ | ● |
| | Average current I_a | Iavg | A | × | ○ | ○ | ○ | ● |
| | Active power P_1 | P1 | W | ● | × | × | ● | ● |
| | Active power P_2 | P2 | W | × | × | × | ○ | ● |
| | Active power P_3 | P3 | W | × | × | × | ○ | ● |
| | Total active power P_t | P | W | ● | ● | ● | ○ | ● |
| | Reactive power Q_1 | Q1 | var | ● | × | × | ● | ● |
| | Reactive power Q_2 | Q2 | var | × | × | × | ○ | ● |
| | Reactive power Q_3 | Q3 | var | × | × | × | ○ | ● |
| Total reactive power Q_t | Q | var | ● | ● | ● | ○ | ● | |

| | TABLE 10-2: BASIC MEASUREMENTS | Parameter | Unit | Connection Type | | | | |
|--|--|------------------------|-------------------|-----------------|----|----|----|----|
| | | | | 1b | 3b | 3u | 4b | 4u |
| Phase | Apparent power S_1 | S1 | VA | ● | × | × | ● | ● |
| | Apparent power S_2 | S2 | VA | × | × | × | ○ | ● |
| | Apparent power S_3 | S3 | VA | × | × | × | ○ | ● |
| | Total apparent power S_t | S | VA | ● | ● | ● | ○ | ● |
| | Power factor PF_1 | PF1/ePF1 | | ● | × | × | ● | ● |
| | Power factor PF_2 | PF2/ePF2 | | × | × | × | ○ | ● |
| | Power factor PF_3 | PF3/ePF3 | | × | × | × | ○ | ● |
| | Total power factor PF^{\sim} | PF/ePF | | ● | ● | ● | ○ | ● |
| | Power angle φ_1 | φ_1 | ° | ● | × | × | ● | ● |
| | Power angle φ_2 | φ_2 | ° | × | × | × | ○ | ● |
| | Power angle φ_3 | φ_3 | ° | × | × | × | ○ | ● |
| | Total power angle φ^{\sim} | φ | ° | ● | ● | ● | ○ | ● |
| | THD of phase voltage U_{f1} | U1% | %THD | ● | × | × | ● | ● |
| | THD of phase voltage U_{f2} | U2% | %THD | × | × | × | ○ | ● |
| | THD of phase voltage U_{f3} | U3% | %THD | × | × | × | ○ | ● |
| | THD of phase current I_1 | I1% | %THD | ● | ● | ● | ● | ● |
| THD of phase current I_2 | I2% | %THD | × | ○ | ● | ○ | ● | |
| THD of phase current I_3 | I3% | %THD | × | ○ | ● | ○ | ● | |
| Phase-to-phase | Phase-to-phase voltage U_{12} | U12 | V | × | ● | ● | ○ | ● |
| | Phase-to-phase voltage U_{23} | U23 | V | × | ● | ● | ○ | ● |
| | Phase-to-phase voltage U_{31} | U31 | V | × | ● | ● | ○ | ● |
| | Average phase-to-phase voltage (U_{ff}) | U_{Δ} | V | × | ● | ● | ○ | ● |
| | Phase-to-phase angle φ_{12} | φ_{12} | ° | × | × | × | ○ | ● |
| | Phase-to-phase angle φ_{23} | φ_{23} | ° | × | × | × | ○ | ● |
| | Phase-to-phase angle φ_{31} | φ_{31} | ° | × | × | × | ○ | ● |
| | Voltage unbalance U_u | U_u | % | × | ● | ● | × | ● |
| | THD of phase-to-phase voltage $THD_{U_{12}}$ | U12% | %THD | × | ● | ● | ○ | ● |
| | THD of phase-to-phase voltage $THD_{U_{23}}$ | U23% | %THD | × | ● | ● | ○ | ● |
| THD of phase-to-phase voltage $THD_{U_{31}}$ | U31% | %THD | × | ● | ● | ○ | ● | |
| Energy | Counters 1-4 | E1, E2, E3, E4 | Wh Vah varh | ● | ● | ● | ● | ● |
| | Active tariff | Atar | | ● | ● | ● | ● | ● |
| | Cost by meters | E1\$, E2\$, E3\$, E4\$ | XXXX | ● | ● | ● | ● | ● |
| | Total cost | E\$ | XXXX | ● | ● | ● | ● | ● |

| | TABLE 10-2: BASIC MEASUREMENTS | Parameter | Unit | Connection Type | | | | |
|----------------|--------------------------------|----------------|------|-----------------|----|----|----|----|
| | | | | 1b | 3b | 3u | 4b | 4u |
| Max. values MD | MD current I_1 | I_1 | A | ● | ● | ● | ● | ● |
| | MD current I_2 | I_2 | A | x | ○ | ● | ○ | ● |
| | MD current I_3 | I_3 | A | x | ○ | ● | ○ | ● |
| | MD active power P (positive) | P+ | W | ● | ● | ● | ● | ● |
| | MD active power P (negative) | P- | W | ● | ● | ● | ● | ● |
| | MD reactive power Q-L | Q_{L} | var | ● | ● | ● | ● | ● |
| | MD reactive power Q-C | Q_{C} | var | ● | ● | ● | ● | ● |
| | MD apparent power S | S | VA | ● | ● | ● | ● | ● |

| | TABLE 10-3: MIN/MAX MEASUREMENTS | Connection Type | | | | |
|--|----------------------------------|-----------------|----|----|----|----|
| | | 1b | 3b | 3u | 4b | 4u |
| Instantaneous / Maximum / Minimum values | Voltage U_1 | ● | x | x | ● | ● |
| | Voltage U_2 | x | x | x | ○ | ● |
| | Voltage U_3 | x | x | x | ○ | ● |
| | Phase-to-phase voltage U_{12} | x | ● | ● | ○ | ● |
| | Phase-to-phase voltage U_{23} | x | ● | ● | ○ | ● |
| | Phase-to-phase voltage U_{31} | x | ● | ● | ○ | ● |
| | Phase current I_1 | ● | ● | ● | ● | ● |
| | Phase current I_2 | x | ○ | ● | ○ | ● |
| | Phase current I_3 | x | ○ | ● | ○ | ● |
| | Active power P_1 | ● | x | x | ● | ● |
| | Active power P_2 | x | x | x | ○ | ● |
| | Active power P_3 | x | x | x | ○ | ● |
| | Common active power P | x | ● | ● | ○ | ● |
| | Apparent power S_1 | ● | x | x | ● | ● |
| | Apparent power S_2 | x | x | x | ○ | ● |
| | Apparent power S_3 | x | x | x | ○ | ● |
| | Common apparent power S | x | ● | ● | ○ | ● |
| | Frequency f | ● | ● | ● | ● | ● |
| Internal temperature | ● | ● | ● | ● | ● | |

Key ● – measured, ○ – calculated, x – not supported

| TABLE 10-4: HARMONIC MEASUREMENTS | | Connection type | | | | |
|-----------------------------------|---------------------------------|-----------------|----|----|----|----|
| | | 1b | 3b | 3u | 4b | 4u |
| Harmonics up to 63rd | Phase voltage U_1 | ● | × | × | ● | ● |
| | Phase voltage U_2 | × | × | × | ○ | ● |
| | Phase voltage U_3 | × | × | × | ○ | ● |
| | Phase-to-phase voltage U_{12} | × | ● | ● | ○ | ● |
| | Phase-to-phase voltage U_{23} | × | ● | ● | ○ | ● |
| | Phase-to-phase voltage U_{31} | × | ● | ● | ○ | ● |
| | Phase current I_1 | ● | ● | ● | ● | ● |
| | Phase current I_2 | × | ○ | ● | ○ | ● |
| | Phase current I_3 | × | ○ | ● | ○ | ● |

Key: ● – measured, ○ – calculated, × – not supported

| TABLE 10-5: GRAPHICAL DISPLAY | | Connection type | | | | |
|-------------------------------|---------------------------------|-----------------|----|----|----|----|
| | | 1b | 3b | 3u | 4b | 4u |
| Time / FFT | Phase voltage U_1 | ● | × | × | ● | ● |
| | Phase voltage U_2 | × | × | × | ○ | ● |
| | Phase voltage U_3 | × | × | × | ○ | ● |
| | Phase-to-phase voltage U_{12} | × | ● | ● | ○ | ● |
| | Phase-to-phase voltage U_{23} | × | ● | ● | ○ | ● |
| | Phase-to-phase voltage U_{31} | × | ● | ● | ○ | ● |
| | Phase current I_1 | ● | ● | ● | ● | ● |
| | Phase current I_2 | × | ○ | ● | ○ | ● |
| | Phase current I_3 | × | ○ | ● | ○ | ● |

Key: ● – measured, ○ – calculated, × – not supported

| TABLE 10-6: POWER QUALITY | | Connection Type | | | | |
|---------------------------|----------------------------|-----------------|----|----|----|----|
| | | 1b | 3b | 3u | 4b | 4u |
| Quality parameters | Frequency variations 1 / 2 | ● | ● | ● | ● | ● |
| | Voltage variations 1 / 2 | ● | ● | ● | ● | ● |
| | Voltage unbalances | ● | ● | ● | ● | ● |
| | Voltage dips | ● | ● | ● | ○ | ● |
| | Voltage interruptions | ● | ● | ● | ○ | ● |
| | Long interruptions | × | ● | ● | ○ | ● |
| | Transients | × | ● | ● | ○ | ● |
| | Flickers Pst / Plt | ● | ● | ● | ● | ● |
| | Temporary overvoltages | ● | ● | ● | ● | ● |
| | THD's | × | ○ | ● | ○ | ● |
| | Harmonics | × | ○ | ● | ○ | ● |

Key: ● – measured, ○ – calculated, × – not supported

NOTE: For 3b and 3u connection mode, only phase-to-phase voltages are measured. Because of that, factor $\sqrt{3}$ is applied to calculation of quality considering nominal phase voltage.
For 4u connection mode measurements support is same as for 1b.

9.2 Power mode

The power mode is used for the signing of power measurements. The user cannot set the **I500** power mode. It is defined as follows:

- When displaying active power on the **i5RD** Remote display, a positive sign indicates export power (a consumer) whilst a negative sign indicates import power (a generator).
- When displaying reactive power on the **i5RD** Remote display, a coil symbol indicates an inductive load (a consumer) whilst a capacitor symbol indicates a capacitive load (a generator).

9.3 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.

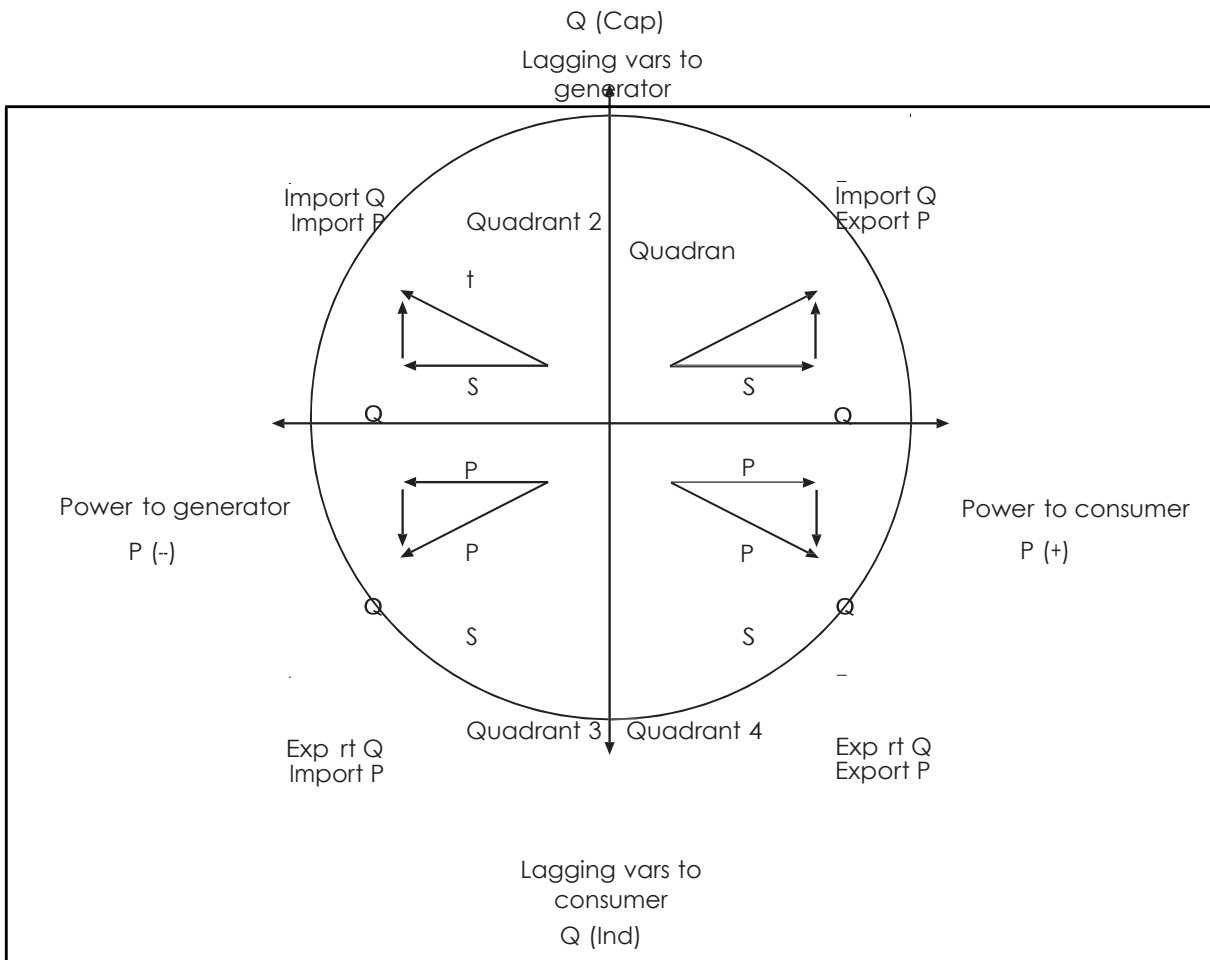


FIGURE 10-1: POWER FLOW

10. INSTRUMENTATION

10.1 Measurements

With the increase in harmonics present in today's power systems, due to the increased use of electronic loads such as computers, variable frequency drives, etc. it is important, when accurate monitoring of electrical parameters is required, to use a measuring technique that allows for their presence. Conventional measurement methods, that use a mean sensing technique, respond to the mean or average of the input waveform. This is only accurate when the input waveform approaches a pure sinusoid.

The **I500** uses a true RMS (root-mean-square) measurement technique that provides accurate measurement with harmonics present up to the 63rd harmonic. The **I500** reads 128 samples per cycle and the true RMS measurement is obtained using these sampled values. A graphical display of Individual harmonics is available using the QDSP Software program.

The **i5RD** remote display can display the measured values in a number of pre-set display views or the user can customise the display. An example is shown in figure 11.1 below.

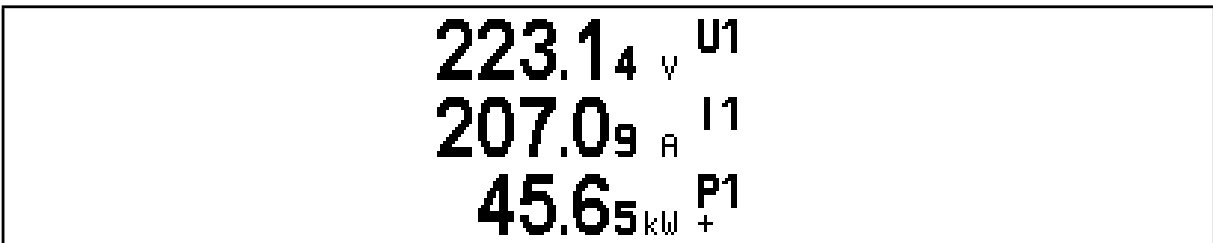


FIGURE 11-1: i5RD DISPLAY SHOWING VOLTAGE, CURRENT AND POWER IN PHASE 1

10.2 Glossary

The following terms and symbols are used:

| TABLE 10-1: SYMBOLS | |
|---------------------|--|
| M _v | Sample factor |
| M _P | Averaging interval |
| U _f | Phase voltage (U ₁ , U ₂ or U ₃) |
| U _{ff} | Phase-to-phase voltage (U ₁₂ , U ₂₃ or U ₃₁) |
| N | Total number of samples in a period |
| n | Sample number (0 ≤ n ≤ N) |
| x, y | Phase number (1, 2 or 3) |
| i _n | Current sample n |
| u _{fn} | Phase voltage sample n |
| u _{ffn} | Phase-to-phase voltage sample n |
| φ _f | Power angle between current and phase voltage f (φ ₁ , φ ₂ or φ ₃) |
| U _u | Voltage unbalance |
| U _c | Agreed supply voltage |

| TABLE 10-2: GLOSSARY | |
|-----------------------------|--|
| Term | Explanation |
| RMS | Root Mean Square value |
| Flash | Type of a memory module that keeps its content in case of power supply failure |
| Ethernet | IEEE 802.3 data layer protocol |
| MODBUS / DNP3 | Industrial protocols for data transmission |
| QDSP | Software for iSTAT family |
| AC | Alternating current |
| PA | Power angle (angle between current and voltage) |
| PF | Power factor |
| THD | Total harmonic distortion |
| MD (maximum demand) | Measurement of average values in time interval |
| Harmonic voltage – harmonic | Sine voltage with frequency equal to integer multiple of basic frequency |
| Hand-over place | Connection spot of consumer installation in public network |
| Flicker | Voltage fluctuation causes changes of luminous intensity of lamps, which causes the so-called flicker affect |
| RTC | Real Time Clock |
| Sample factor (Mv) | Defines a number of periods for measuring calculation on the basis of measured frequency |
| Averaging interval (Mp) | Defines frequency of refreshing displayed measurements on the basis of a Sample factor |

10.3 Supported Measurements

The measurements that the I500 family supports will depend on the model selected and whether the measurements are available over the communications or on the **i5RD** Remote display. The following tables show which measurements are available on each **I500** model.

| TABLE 10-3: BASIC MEASUREMENTS | | i5MT | i5MR | i5MQ |
|---------------------------------------|--|-------------|-------------|-------------|
| Phase | Voltage U_1, U_2, U_3 in U^\sim | ● | ● | ● |
| | Current I_1, I_2, I_3, I_n, I_t in I_{avg} | ● | ● | ● |
| | Active power $P_1, P_2, P_3,$ and P_t | ● | ● | ● |
| | Reactive power $Q_1, Q_2, Q_3,$ and Q_t | ● | ● | ● |
| | Apparent power $S_1, S_2, S_3,$ and S_t | ● | ● | ● |
| | Power factor PF_1, PF_2, PF_3 and PF^\sim | ● | ● | ● |
| | Power angle $\varphi_1, \varphi_2, \varphi_3$ and φ^\sim | ● | ● | ● |
| | THD of phase voltage U_{f1}, U_{f2} and U_{f3} | ● | ● | ● |
| Phase-to-phase | THD of power angle I_1, I_2 and I_3 | ● | ● | ● |
| | Phase-to-phase voltage U_{12}, U_{23}, U_{31} | ● | ● | ● |
| | Average phase-to-phase voltage U_{ff} | ● | ● | ● |
| | Phase-to-phase angle $\varphi_{12}, \varphi_{23}, \varphi_{31}$ | ● | ● | ● |
| | Voltage unbalance U_u | ● | ● | ● |
| Energy | THD of phase-to-phase voltage | ● | ● | ● |
| | Counter 1 | ● | ● | ● |
| | Counter 2 | ● | ● | ● |
| | Counter 3 | ● | ● | ● |
| | Counter 4 | ● | ● | ● |
| | Total | ● | ● | ● |
| | Active tariff | ● | ● | ● |
| | Cost by counters | ● | ● | ● |
| Total cost | ● | ● | ● | |

● – supported × – not supported

| | TABLE 10-4: OTHER MEASUREMENTS | i5MT | i5MR | i5MQ |
|------------------------|--|---|---|---------------------|
| Maximal values MD | Phase current I ₁ | ● | ● | ● |
| | Phase current I ₂ | ● | ● | ● |
| | Phase current I ₃ | ● | ● | ● |
| | Active power P (Positive) | ● | ● | ● |
| | Active power P (Negative) | ● | ● | ● |
| | Reactive power Q – L | ● | ● | ● |
| | Reactive power Q – C | ● | ● | ● |
| | Apparent power S | ● | ● | ● |
| Min./max. measurements | Voltage U ₁ | ● | ● | ● |
| | Voltage U ₂ | ● | ● | ● |
| | Voltage U ₃ | ● | ● | ● |
| | Phase-to-phase voltage U ₁₂ | ● | ● | ● |
| | Phase-to-phase voltage U ₂₃ | ● | ● | ● |
| | Phase-to-phase voltage U ₃₁ | ● | ● | ● |
| | Phase current I ₁ | ● | ● | ● |
| | Phase current I ₂ | ● | ● | ● |
| | Phase current I ₃ | ● | ● | ● |
| | Active power P ₁ | ● | ● | ● |
| | Active power P ₂ | ● | ● | ● |
| | Active power P ₃ | ● | ● | ● |
| | Total active power P | ● | ● | ● |
| | Apparent power S ₁ | ● | ● | ● |
| | Apparent power S ₂ | ● | ● | ● |
| | Apparent power S ₃ | ● | ● | ● |
| | Total apparent power S | ● | ● | ● |
| | Frequency f | ● | ● | ● |
| Internal temperature | ● | ● | ● | |
| Other functions | Frequency | ● | ● | ● |
| | Internal temperature | ● | ● | ● |
| | RTC date | ● | ● | ● |
| | RTC time | ● | ● | ● |
| | Time graphs (I ₁ , I ₂ , I ₃ , U ₁ , U ₂ , U ₃ , U ₁₂ , U ₂₃ and U ₃₁) | ● | ● | ● |
| | FFT graphs (I ₁ , I ₂ , I ₃ , U ₁ , U ₂ , U ₃ , U ₁₂ , U ₂₃ and U ₃₁) | ● | ● | ● |
| | Phase voltage harmonics | to 31 st or 63 rd | to 31 st or 63 rd | to 63 rd |
| | Phase-to-phase voltage harmonics | to 31 st or 63 rd | to 31 st or 63 rd | to 63 rd |
| | Current harmonics | to 31 st or 63 rd | to 31 st or 63 rd | to 63 rd |
| | Analysis in compliance with EN 50160 | × | × | ● |

- – supported
- × – not supported

10.3.1 Voltage

All versions of the **I500** except for the 3-phase 3-wire versions, measure the true RMS value of the phase voltages (U_1, U_2, U_3) connected to the unit. The three line voltages (U_{12}, U_{23}, U_{31}), average phase voltage (U_f) and average line voltage (U_Δ) are calculated from these measured parameters. For 3-phase 3-wire balanced systems, the **I500** creates a virtual neutral internally.

The 3-phase 3-wire versions of the **I500** measure the true RMS value of the phase to phase voltage.

| | |
|---|--|
| $U_f = \sqrt{\frac{\sum_{n=1}^N u_n^2}{N}}$ | $U_{xy} = \sqrt{\frac{\sum_{n=1}^N (u_{xn} - u_{yn})^2}{N}}$ |
| <p>V rms Phase calculation</p> <p>N = 128 samples in one period (up to 65Hz) N = 128 samples in M periods (above 65Hz), eg at 400Hz, n=7</p> | <p>V rms Phase to Phase calculation</p> <p>N = samples in one period Ux,Uy = phase voltages Uf</p> |

The available phase, line and average voltages (instantaneous, minimum and maximum values), can be viewed via the remote communications link or on the **i5RD** remote display.

The voltage unbalance is measured as:

| |
|--|
| $U_u = \sqrt{\frac{1 - \sqrt{3 - 6\beta}}{1 + \sqrt{3 - 6\beta}}} \cdot 100\%$ $\beta = \frac{U_{12fund}^4 + U_{23fund}^4 + U_{31fund}^4}{(U_{12fund}^4 + U_{23fund}^4 + U_{31fund}^4)^2}$ |
| <p>Voltage unbalance</p> <p>Ufund = first harmonic of the phase to phase voltage</p> |

10.3.2 Current

The **I500** measures the true RMS value of the phase currents (I_a, I_b, I_c) connected to the unit. The neutral current (I_n), the average of all phase currents and the sum of all phase currents (I_t) are calculated from the three phase currents.

The available phase currents, average current and neutral current (instantaneous, minimum and maximum values) can be viewed via the remote communications link or on the **i5RD** remote display whilst the sum of all phase currents is only available via the remote communications link.

| | |
|---|--|
| $I_{RMS} = \sqrt{\frac{\sum_{n=1}^N i_n^2}{N}}$ | $I_n = \sqrt{\frac{\sum_{n=1}^N (i_{1n} + i_{2n} + i_{3n})^2}{N}}$ |
| <p>I rms calculation N = 128 samples in one period (up to 65Hz) N = 128 samples in M periods (above 65Hz), eg at 400Hz, n=7</p> | <p>RMS Neutral calculation i-n samples in phase current 1,2 or 3 N = 128 samples in a period (up to 65Hz)</p> |

10.3.3 Angles between Phases

Angles between phases indicate the angles between the vectors of phase voltages. A positive mark indicates correct phase sequence, while a negative mark indicates an opposite phase sequence of the measured system.

The Phase Angles can be viewed via the remote communications link or on the **i5RD** remote display.

10.3.4 Frequency

The system frequency is calculated from the time period of the measured voltage and can be viewed from both the remote communications link and the **i5RD** remote display (Also the frequency with instantaneous 10 second average).

10.3.5 Harmonics

The percentage total harmonic distortion (%THD) value is the ratio of the sum of the powers of the harmonic frequencies above the fundamental frequency to the power of the fundamental frequency. This sum of the powers is a geometric total, formed by taking the square root of the sum of the squares of the amplitude of each of the harmonics.

The **1500** provides %THD values for each phase current, each phase voltage, and for the line voltages (instantaneous, minimum and maximum values).

| | |
|---|-----------------------------------|
| $I_f \text{THD}(\%) = \frac{\sqrt{\sum_{n=2}^{63} I_n^2}}{I_1} \cdot 100$ | |
| <p>Current THD calculation I1 = value of first harmonic N = number of harmonic</p> | <p>i5RD remote display</p> |

| | |
|---|-----------------------------------|
| $U_f \text{THD}(\%) = \frac{\sqrt{\sum_{n=2}^{63} U_n^2}}{U_1} \cdot 100$ | |
| <p>Phase Voltage THD calculation U1 = value of first harmonic N = number of harmonic</p> | <p>i5RD remote display</p> |

| | |
|--|-----------------------------------|
| $U_{ff} \text{THD}(\%) = \frac{\sqrt{\sum_{n=2}^{63} U_n^2}}{U_1} \cdot 100$ | |
| <p>Line to Line Voltage THD calculation U1 = value of first harmonic N = number of harmonic</p> | <p>i5RD remote display</p> |

The **i5MT** and **i5MR** calculate the harmonics up to the 31st or 63rd, and makes them available on the communications. They can be displayed graphically on the **i5RD** Remote display.

The **i5MQ** calculates the harmonics up to the 63rd, and makes them available on the communications. They can be displayed graphically on the **i5RD** Remote display.

10.4 Power, power factor and energy

10.4.1 Power

The **I500** provides accurate measurement of active (P_a , P_b , P_c , P_t), reactive (Q_a , Q_b , Q_c , Q_t) and apparent power (S_a , S_b , S_c , S_t). For a four-wire system the powers are calculated both for each phase separately and as a total. For a three-wire system only total power values are measured.

- Total active power (P_t).

$$P_f = \frac{1}{N} \cdot \sum_{n=1}^N (u_f N_n \times i_f N_n)$$

Active Power

N = number of periods

n = number of samples 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

- Total reactive power (Q_t).
 - Reactive Power by Phases (Standard)

$$Q_f = \text{Sign}Q_f(\phi) \times \sqrt{S_f^2 - P_f^2}$$

Reactive Power

S_f = apparent power by phase

P_r = active power by phase

- Reactive Power by Phases (Delayed current method)

$$Q_f = \frac{1}{N} \cdot \sum_{n=1}^N (u_{f n} \times i_{f[n+N/4]})$$

Reactive Power

N – a number of samples in a period

n – sample number ($0 \leq n \leq N$)

f – phase designation

$$Q_t = Q_1 + Q_2 + Q_3$$

Total Reactive Power

Q_f = reactive power by phase

- Total apparent power (S_t).

$$S_f = U_f \times I_f$$

Apparent Power
 U_f = phase voltage
 I_f = phase current

$$S_t = S_1 + S_2 + S_3$$

Total Apparent Power
 S_f = apparent power by phase

- Power direction.

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).

All the available power parameters can be viewed using either the I500 remote display or via the remote communications link.

$$\text{Sign}Q_f(\varphi)$$

$$\varphi \in [0^\circ - 180^\circ] \Rightarrow \text{Sign}Q_f(\varphi) = +1$$

$$\varphi \in [180^\circ - 360^\circ] \Rightarrow \text{Sign}Q_f(\varphi) = -1$$

Reactive Power direction
 Q_f - reactive power (by phases)
 φ - power angle

$$\varphi_s = \arctan 2(P_t, Q_t)$$

$$\varphi_s = [-180^\circ, 179,99^\circ]$$

Total Power angle

10.4.2 Power factor

The power factor is calculated as a quotient of active and apparent power for each phase separately ($\cos\phi_1$, $\cos\phi_2$, $\cos\phi_3$) and as a total ($\cos\phi_t$). A positive sign and a coil symbol denotes an inductive load (a consumer) whilst a negative sign and a capacitor symbol defines a capacitive load (a generator).

$$\text{PF} = \frac{P}{S}$$

Power Factor

All available power factor parameters can be read via the remote communications link or from the **i5RD** remote display.

10.4.3 Energy

Four counters are available so that energy in each of the four quadrants can be measured. The configuration of the four counters can be adapted to the customer's needs via the front menu or via the remote communications link.

All four energy measurements may be viewed using the remote communications link or the **i5RD** remote display.

Energy Tariff Price:

The tariff calculation used in the Cost Management function is derived as follows:

$$\text{Price in tariff} = \text{Price} \cdot 10^{\text{Tariff price exponent}}$$

Energy Tariff Price

10.4.4 Real time clock (energy clock)

The **i5MT**, **i5MR** and **i5MQ** are provided with a built-in real time clock. It is intended for registration of time of the occurrence of Maximum demands, and for synchronisation of the time interval. The clock is also used by the Cost Management feature when allocating different cost or tariff structures throughout the day and for periodic (seasonal) times throughout the year.

10.4.5 Maximum demands (MDs)

The **I500** stores the maximum demand value since last reset and its corresponding time stamp. The unit also displays the present or 'dynamic' maximum demand.

10.4.6 Average demands

10.4.6.1 Fixed window

The fixed interval method calculates an average demand value over a fixed time period. The period can be set over the range 1 to 255 minutes. This is available in the **i5MT**, **i5MR** and **i5MQ** as a selectable function.

»TIME IN A PERIOD« will actively show the remaining time until the end of the period, until a 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.

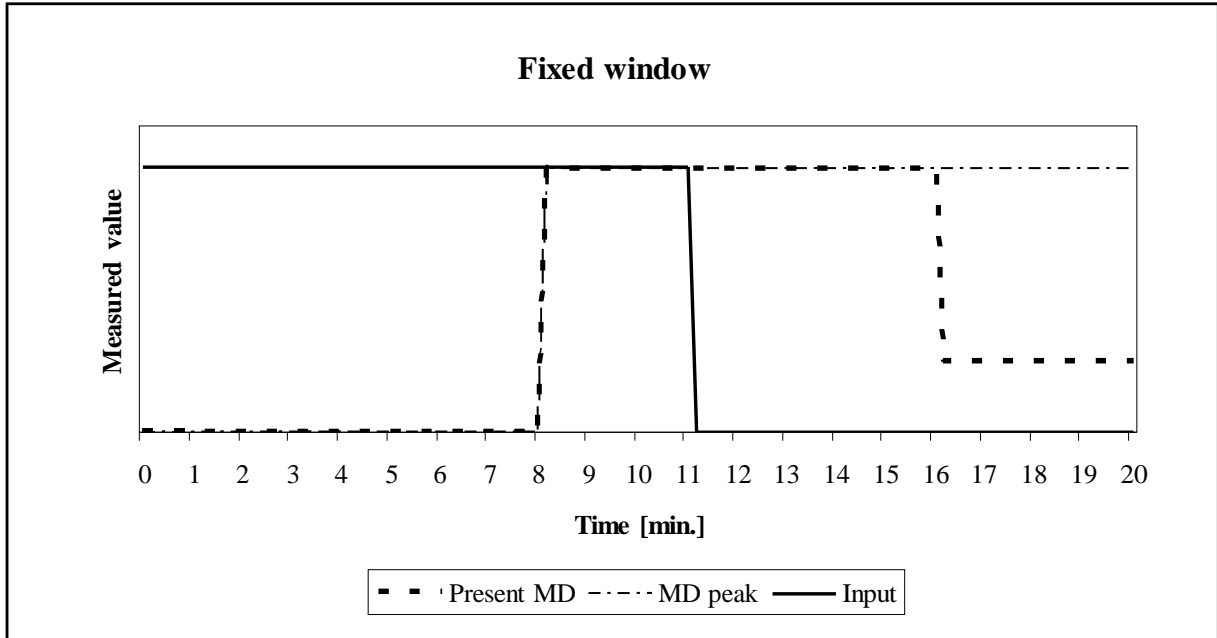
A new period also starts after a longer interruption of power supply (more than 1 s). If time constant is set to one of the values of 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 or 60 minutes, »TIME IN A PERIOD« is set to such value that one of the following intervals will be terminated at a full hour. In other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

Example:

Mode: Fixed window

Time constant: 8 min.

Current MD and maximal MD: Reset at 0 min.



10.4.6.2 Sliding window

The sliding window technique allows the user to divide the time period into a number of sub-periods. The average demand value over the demand period is displayed, however, after the initial demand period has elapsed, the demand value will be updated by the addition of a further sub-period, thus creating a 'sliding window' measurement.

For example if the total period is 30 minutes (consisting of 5 sub-periods of 6 minutes duration), after the first 5 sub-periods have elapsed a new window will be added and the oldest window will be deleted, thus creating a sliding window.

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

The number of sub-periods may be set between 2 to 15, with each period set between 1 to 255 minutes.

This is available in the **i5MT**, **i5MR** and **i5MQ** as a selectable function.

Example:

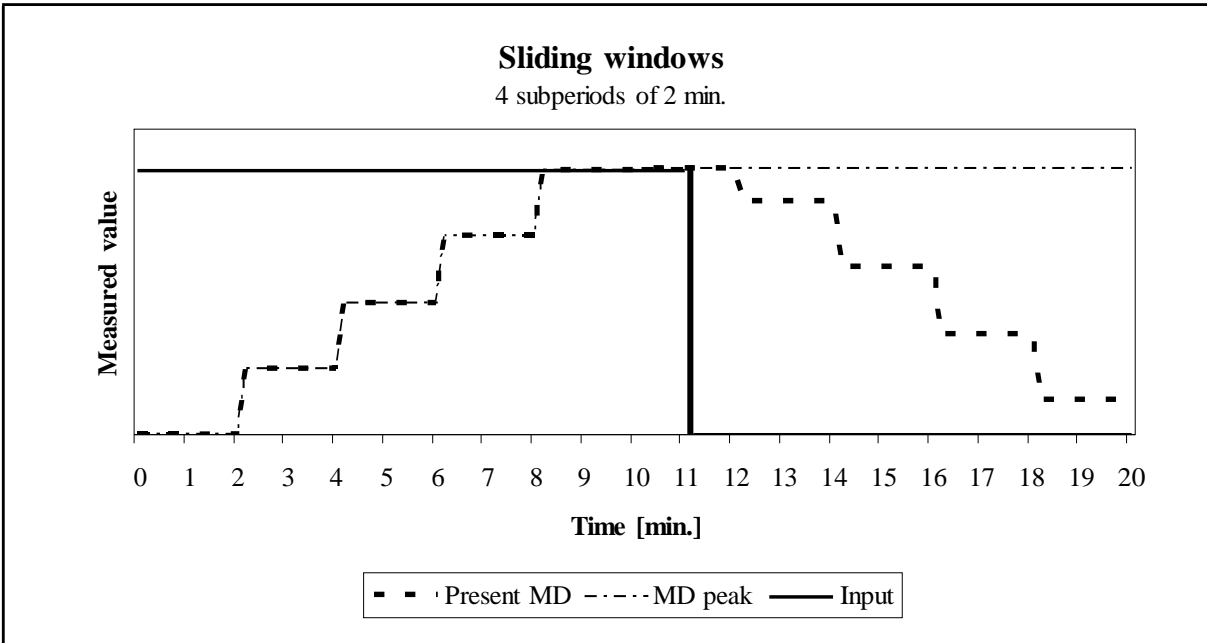
Mode: Sliding windows

Time constant: 2 min.

No. of sub-periods: 4

Current 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 current MD and a maximal MD are reset at 0 min. "TIME IN A PERIOD" is data for a sub-period so that the values for a current MD and a maximal MD are regenerated 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.



10.4.6.3 Thermal Demand

The thermal demand option will provide an exponential thermal characteristic, based on the bimetal element principal. Maximum demand and the time of its occurrence are stored in the unit.

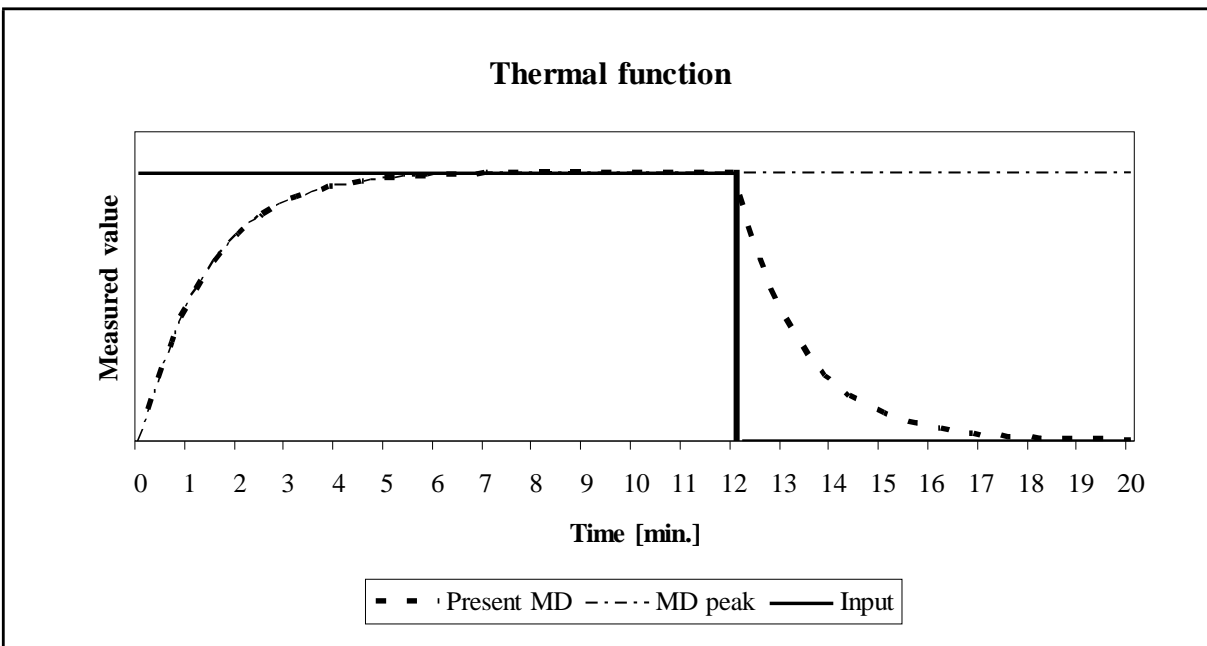
Maximal values and time of their occurrence are stored in **I500**. A time constant (t. c.) can be set from 1 to 255 minutes and is 6-time thermal time constant (t.c. = 6 * thermal time constant).

Example:

Mode: Thermal function

Time constant: 8 min.

Current MD and maximal MD: Reset at 0 min.



10.4.6.4 Resetting Min/Max values

The Min/Max demand values can be reset using either manual or automatic modes. The automatic mode can reset the period each day at midnight (time 00:00), weekly (Monday at 00:00), monthly (first day at 00:00) or yearly (first day of the year at 00:00)

10.5 Power Quality

10.5.1 Frequency and Voltage variations

All frequency and voltage variations are averaged over a 10 second interval. The measured value is defined as a % from the nominal value and the number of variations over time is also defined by the user.

10.5.2 Voltage Interruptions and dips

All interruptions and dips are defined as a % change from the nominal voltage; the difference is that an interruption is classified as falling to 1% of nominal whilst a dip is generally about 90% of nominal. The time that the variation occurs is also classified over time, generally between ½ cycle to 1 minute.

10.5.3 Fast Voltage changes

A limit is defined as the number of variations within a pre-set time period; each variation is measured as a % change from the nominal slope over time (%Un/t).

10.5.4 Flicker – short term

Short term flicker intensity is measured over a 10 minute period and is calculated as:

$$P_{50S} = (P_{30} + P_{50} + P_{80})^{1/3}$$

$$P_{10S} = (P_6 + P_8 + P_{10} + P_{13} + P_{17})^{1/5}$$

$$P_{3S} = (P_{2,2} + P_3 + P_4)^{1/3}$$

$$P_{1S} = (P_{1,7} + P_1 + P_{1,5})^{1/3}$$

$$P_{st} = \sqrt[3]{0,0314P_{0,1} + 00525P_{1S} + 0,0657P_{3S} + 0,28P_{10S} + 0,08P_{50S}}$$

Flicker – short term intensity

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)

10.5.5 Flicker – long term

$$P_{lt} = \sqrt[3]{\sum_{i=1}^{12} \frac{P_{sti}^3}{12}}$$

Flicker – long term intensity

Calculated from twelve successive values of short-term flicker intensity in a two-hour period

11. COMMUNICATIONS

11.1 Communications ports

The **i5MT/MR/MQ** are fitted with a primary communications (COM1) port and an optional secondary port (COM2).

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

COM2 can be RS485

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

The communication parameters of the **i500** can be obtained by using the 'Scan the network' feature in the QDSP setting software.

11.2 QDSP Setting and Monitoring Software

See the separate QDSP Manual for details of how to Install and use the QDSP Software.

11.3 MODBUS

For details, see the separate M2x3 & I500 Communications Manual.

11.4 DNP3

The implementation of DNP3 in the **i5MT/MR/MQ** is basic and some DNP3 Masters may have difficulty interfacing to the **i5MT/MR/MQ**.

For details, see the separate M2x3 & I500 Communications Manual.

12. BATTERY REPLACEMENT

The **i500** contains a lithium battery. It is used to preserve data (date and time) in the device memory when the power supply is off. Life time of battery is approximately 6 years (typical) but high temperatures and humidity can shorten the battery's life.

The Battery has no effect on any functionality of the device, except date and time.

It is recommended that the instrument is sent back in the factory for battery replacement. It is possible that the replacement can be made by a qualified person, but in this case GE Grid Solutions does not take responsibility for any injuries, malfunction of the instrument or mechanical damage.

Instructions for replacement

1. Disconnect the instrument from measuring grid and power supply (Caution! - Read the safety section!) and take it off the mounting rail..
2. With flat screwdriver remove the cover [3] from instrument [1] (see picture 13.1)
3. Remove PCB assembly [2] from case [1] (Read section on 'HANDLING OF ELECTRONIC EQUIPMENT')
4. Remove the battery from its holder on the PCB, and replace it with the same model (Varta, type 6032 CR2032 SLF)
5. To put the instrument together follow steps 2 to 3 in reverse order
6. Set device date and time.

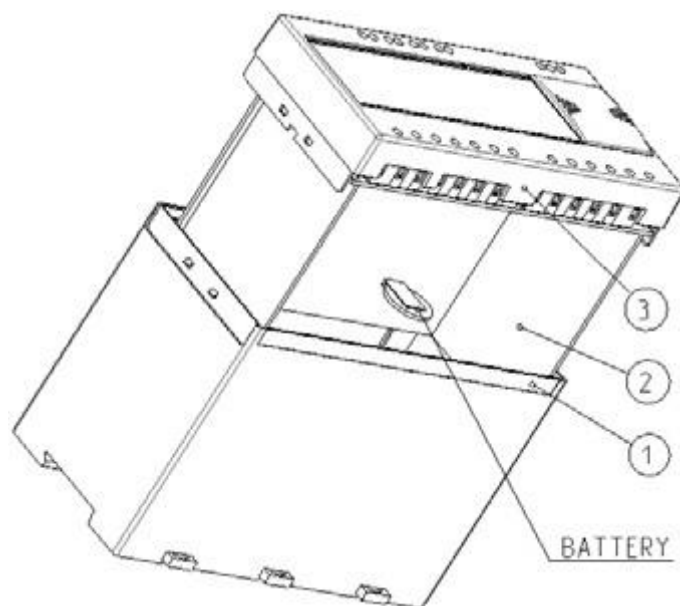


FIGURE 13-1: BATTERY REPLACEMENT

13. REMOTE DISPLAY FEATURES

13.1 Hardware

The settings, measurements and functions of the **I5MT/MR/MQ** can be accessed using an **i5RD Remote display** mounted on the front panel. The **i5RD** is available in 2 enclosures, a 96mm DIN style and a 4 inch round ANSI style, the features of both versions are the same.



FIGURE 14-1: REMOTE DISPLAY

Communications with the Remote Display can be implemented using the RS485 on either COM1 or COM2 of the **I500** allowing the Remote Display to be connected to a maximum of 31 Transducers.

In addition a dedicated Remote Display port option can be selected which allows the connection of a single Transducer to a Remote Display using a dedicated RS485 port via a RJ11 connector. The **I500** cannot support both COM2 and the Remote display port being fitted on the same transducer.

The **i5RD** can be supplied with a DB9 connector or terminals for the RS485 connection. The DB9 is suggested when the **i500** is fitted with a Remote Display port as a DB9 to RJ11 cable is supplied with the **i5RD** with DB9 fitted. The terminal connection version of **i5RD** is suggested for all other connection schemes.

| COMMUNICATION | | COMMUNICATION | |
|---------------|---|---------------|----|
| DB9 - FEMALE | | TERMINAL | |
| RS485 | | RS485 | |
| B | A | A | B |
| 7 | 8 | 23 | 24 |

TABLE 14-2: RS485 CONNECTIONS

13.2 Programming i500

The **i5RD** Remote display start-up begins after electrical connection to the RS485 network with one or more **I500** measuring transducers. Using the five Navigation keys and the LCD display, measurements can be viewed and remote configuration can be performed without a PC connected, see Figure 14-1.

By choosing different **i5RD** target communication addresses it is possible to view measurements and change settings on up to 31 off **I500** measuring transducers.

The **I500** has a number of features which can assist the setting up, but these are only accessible when the **i5RD** Remote display is connected.

The Setup Wizard takes the user through the basic settings required to commission the **I500**. The benefit of the wizard is that it leads the commissioning engineer through all the basic settings required to install the **I500** ensuring that the **I500** is correctly setup.

The **I500** 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 **i5RD** Remote display. This is useful when direction is important, such as in energy applications, to ensure that the values calculated are correct.

The **I500** provides over 140 different measurements that the operator can scroll through and read on the **i5RD** Remote 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 give the operator time to interpret the information on the display.

13.3 Remote display settings

Settings of the remote display are divided into 3 sublevels: General settings, Communication and Display.

13.3.1 General settings

13.3.1.1 Language

Set language on the remote display. When language is changed from or to Russian, characters of the password are changed too. 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 |
| Russian | А | Б | В | Г | Д | Е | Ж | З | И | Й | К | Л | М | Н |

| | | | | | | | | | | | | |
|---------|---|---|---|---|---|---|---|---|---|---|---|---|
| English | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| Russian | О | П | Р | С | Т | У | Ф | Х | Ц | Ч | Ш | Щ |

Main menu ⇒ Settings ⇒ General ⇒ Language

NOTE: If a wrong language is set, a menu of languages can be displayed by simultaneous pressing up and down keys.

13.3.1.2 Communication

Communication parameters are important for the operation in RS485 network.

Main menu ⇒ Settings ⇒ Communication ⇒

Device address

The address of remote display must be different of the measuring transducer address. We recommended number 247 for remote display address.

Bits per second, Parity, Stop bits

Those settings of the remote display must match the settings of the measuring transducer. Default settings are: Bits per second = 19200 (or 115200), Parity = None, Stop bits = 2

13.3.1.3 Display

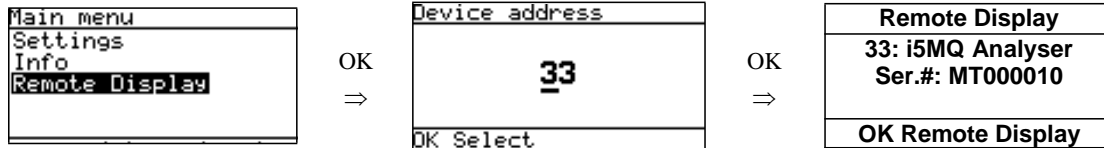
The combination of setting of the contrast and back light defines visibility and legibility of the display. Display settings should be adjusted to match the conditions in which it will be monitored. Economizing mode switches off the back light according to the set time of inactivity.

Main menu ⇒ Settings ⇒ LCD ⇒ Contrast / Back light / Back light time off

13.4 Remote mode

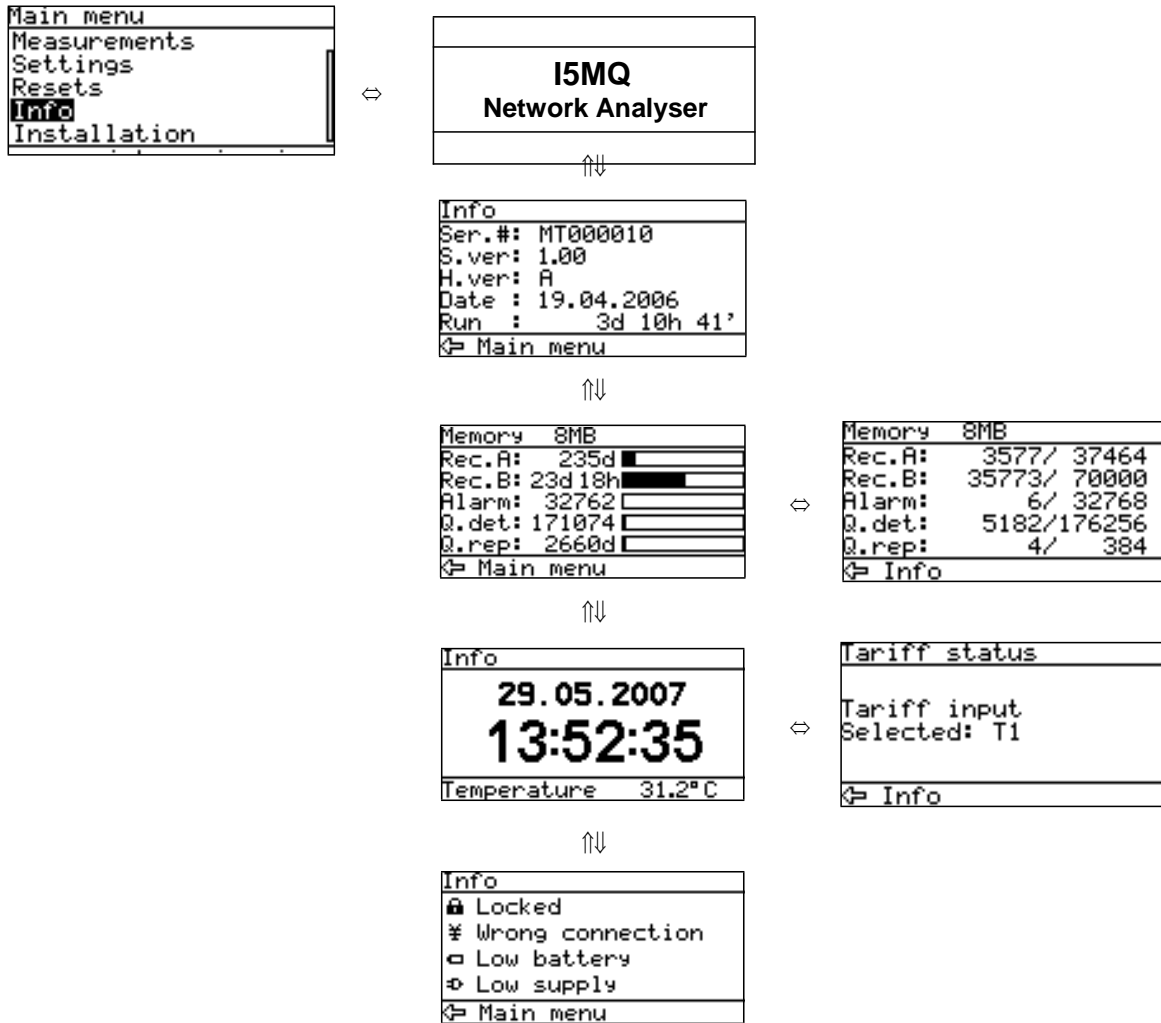
13.4.1 Entering to remote mode

Select Remote Display from Main menu and enter the measuring transducer address, if the Remote Display port (RJ11) on the transducer is being used for connection the Device address must be set to 33. If the Remote Display is connected to COM2 the COM2 device address must be entered and not that for COM1. Device type and serial number should appear on the next screen. Press OK button to enter in to the remote mode.



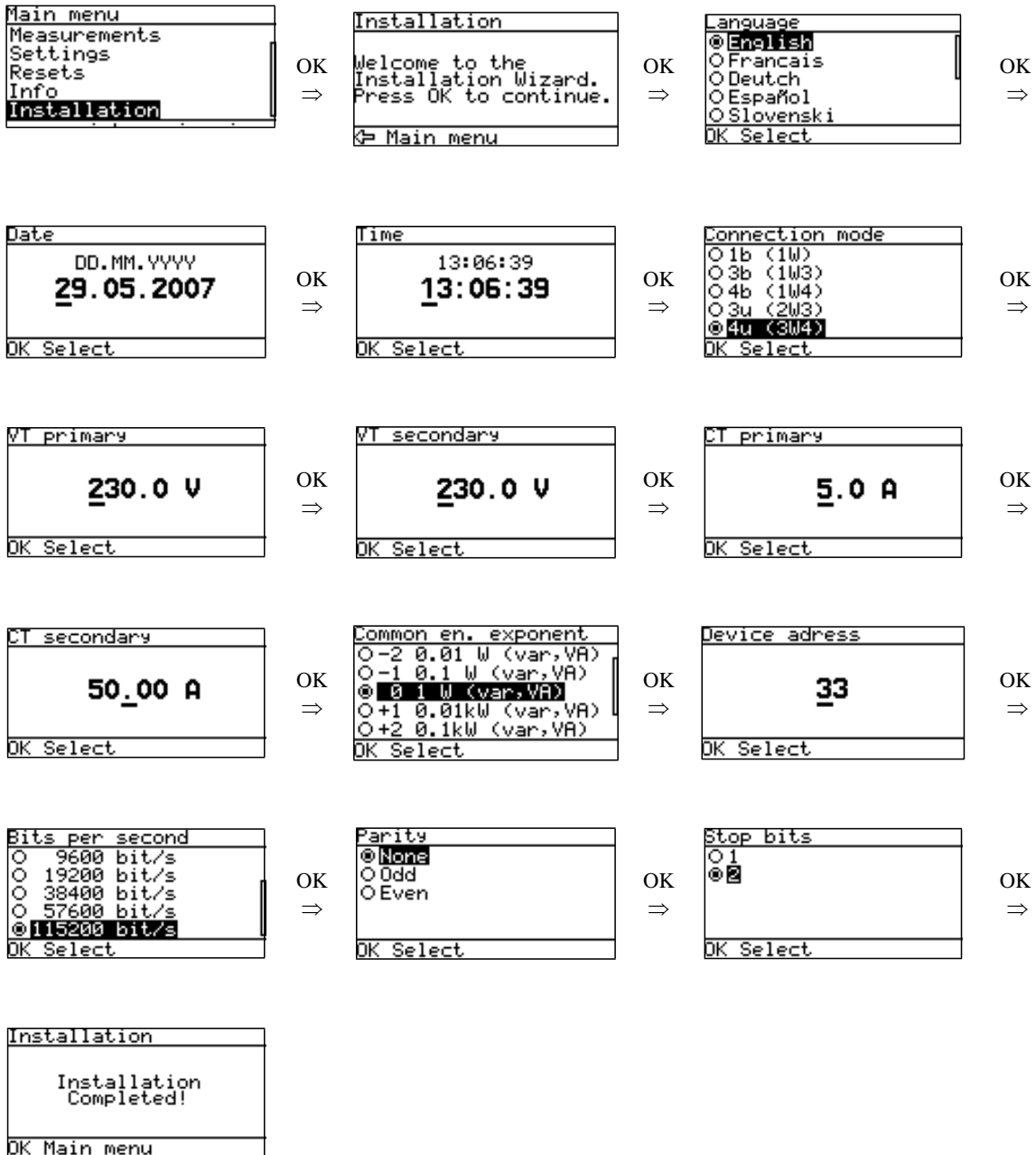
13.4.2 Displaying device information

To display information from a remote device (measuring transducer), select Info from Main menu.



13.4.3 Installation wizard

After installation and electrical connection of the measuring transducer, basic parameters have to be set in order to assure correct operation. The easiest way to achieve that is use the Installation wizard with Remote display. When entering the Installation menu, settings follow one another when the previous one is confirmed. All required parameters should be entered and confirmed. Exit from the menu is possible when all required settings are confirmed or with interruption (key \leftarrow several times) without the changes being stored.



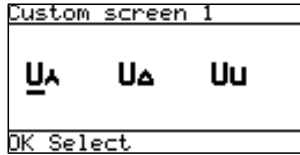
13.4.4 Device settings

All settings of the measuring transducer can be set via communication and QDSP software. Some settings can be also set via the **i5RD** Remote display keyboard. A device setting done via the **i5RD** Remote display keyboard becomes valid after confirmation (OK).

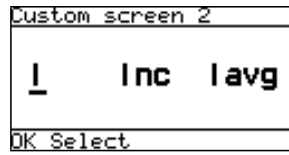
13.4.4.1 Example of setting custom screens:

Main menu ⇒ Settings ⇒ LCD ⇒ Custom screen 1 / 2 / 3

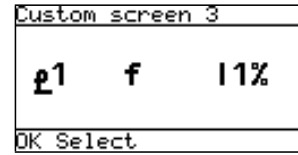
Custom screen 1



Custom screen 2



Custom screen 3

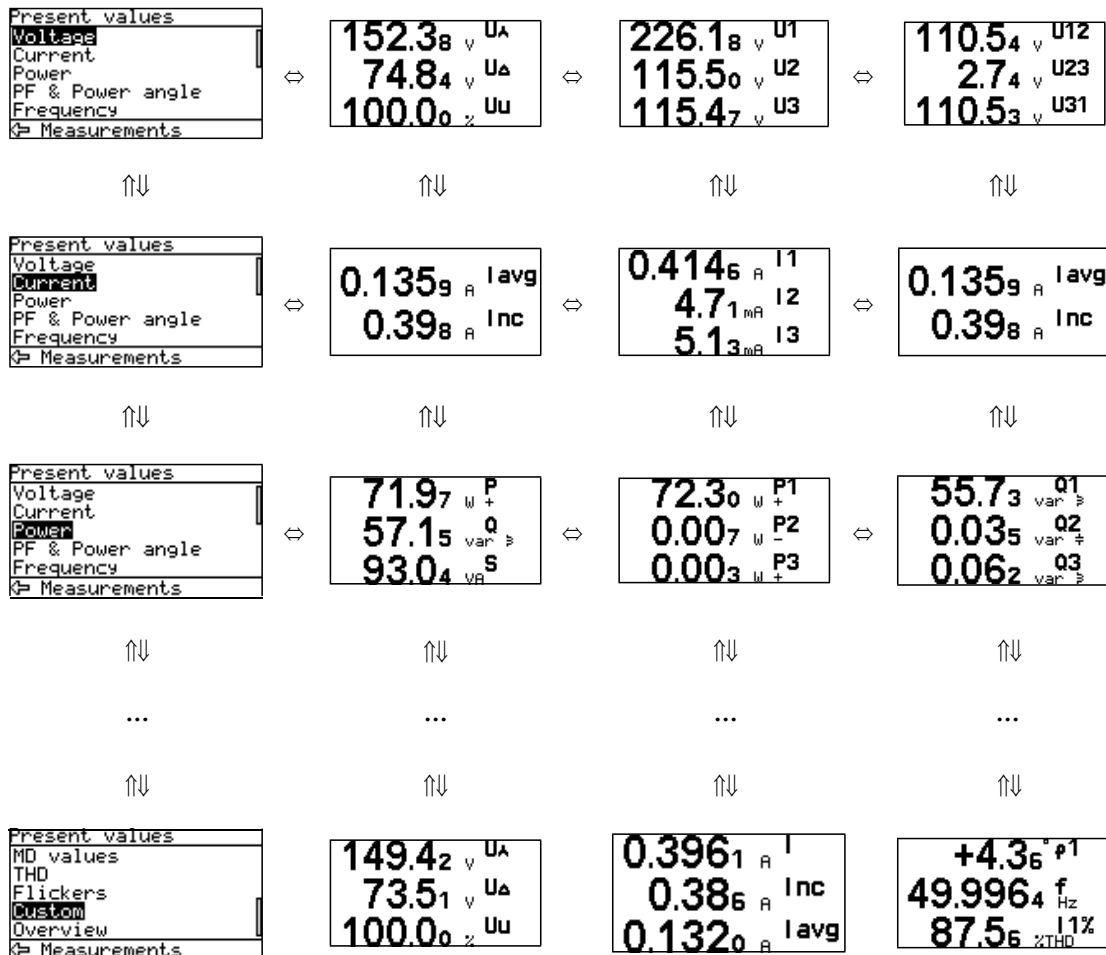


13.4.4.2 Device measurements

For entry and quitting of the measurement display menu, the OK key is used. Direction keys (left / right / up / down) are used for passing between displays as show in example below.

Example for **i5MQ** at 4u connection mode:

Main menu ⇒ Measurements ⇒ Present values ⇒ Voltage OK



13.4.5 Exiting from remote mode

To exit from the remote mode simultaneously press up and down keys. Return to Remote display Main menu by pressing left key twice.

14. TECHNICAL DATA

| INPUTS AND SUPPLY | | | |
|-------------------|-----------------------------|---|--------------|
| Voltage Input | Nominal voltage (U_n) | 230 V_{LN} , 415 V_{LL} | |
| | Rating | 45V/230 V_{LN} 78V/415 V_{LL} | |
| | Max. allowed value | 277 V_{LN} , 480 V_{LL} permanently 2 x U_n for 10 seconds | |
| | Minimum range | 2 V sinusoidal | |
| | Burden | <0.1 VA per phase | |
| Current Input | Rated Current | 0.31 5A | |
| | Rating | 1A/5A | |
| | Overload | 15A continuously 20 x I_n (5 x 1s) | |
| | Minimal range | Set Starting current for power | |
| | Maximum range | 12.5A sinusoidal | |
| | Burden | <0.3 VA per phase | |
| Frequency | Nominal Frequency (F_n) | 50/ 60Hz | |
| | Measuring range | 16 to 400Hz | |
| | Maximum range | 10 to 1000 Hz | |
| Power Supply | Universal High | AC voltage range | 80 to 276Vac |
| | | Frequency range | 40 to 70Hz |
| | | DC voltage range | 70 to 300Vdc |
| | | Burden | <8VA |
| | | Power on transient current | < 20A 1ms |
| | Universal Low | AC voltage range | 45 to 77Vac |
| | | Frequency range | 40 to 70Hz |
| | | DC voltage range | 19 to 70Vdc |
| | | Burden | <8VA |
| | | Power on transient current | < 20A 1ms |
| Battery | Type | CR2032 Li battery | |
| | Nominal voltage | 3V | |
| | Life | Approx 6 years @ 23C | |

| CONNECTIONS | |
|---|---|
| Permitted conductor cross sections | Conductor cross section |
| Voltage terminals | 0.325 ... 2.5 mm ² (22 – 14 AWG) one conductor |
| Current terminals | 0.325 ... 2.5 mm ² (22 – 14 AWG) one conductor |
| Supply | 0.325 ... 2.5 mm ² (22 – 14 AWG) one conductor |
| I/O Modules and Communications | 0.325 ... 2.5 mm ² (22 – 14 AWG) one conductor |
| Volts, currents and supply: Ring terminal version | M4 connection tag |

| ACCURACY | | |
|--|-------------------------|---------------------------|
| RMS Current | 1A | Class 0.2 (0.05**) |
| I1, I2, I3, Iavg, IN | 5A | Class 0.2 (0.05**) |
| RMS Line Voltage U1, U2, U3, Uavg | 75V L-N | Class 0.2 (0.05**) |
| | 250V L-N | Class 0.2 (0.05**) |
| | 500V L-N | Class 0.2 (0.05**) |
| RMS Phase-Phase Voltage U12, U23, U31, Uavg | 120V L-L | Class 0.2 (0.05**) |
| | 400V L-L | Class 0.2 (0.05**) |
| | 800V L-L | Class 0.2 (0.05**) |
| Frequency | | |
| F (instantaneous) | 50Hz/60Hz | Class 0.02 |
| F (10 second average) | 50Hz/60Hz | Class 0.02 |
| Nominal frequency range | 16...400 Hz | Class 0.02 |
| Power Angle | Calculated from U and I | Class 0.5 |
| Power Factor | Calculated from U and I | Class 0.5 |
| Maximum Demand | Calculated from U and I | Class 1 |
| THD | 5 to 500V | Class 0.5 |
| | 0 to 400% | Class 0.5 |
| Power | | |
| Active power (W) ;P | Calculated from U and I | Class 0.2 (0.1**) |
| Reactive power (var): Q, Apparent power (VA): S | Calculated from U and I | Class 0.5 (0.2**) |
| Energy | | |
| Active W | Calculated from U and I | Class 0.5S to EN 62053-22 |
| Reactive VA | Calculated from U and I | Class 2 to EN 62053-23 |
| Real Time clock | | 1minute per month (30ppm) |
| Analogue output (internal supply) | 0...20mA | ± 20 µA |

Total accuracy (measurements and analogue output) according to IEC/EN 60688. Accuracy is defined as percentage of reading of the measurement except when it is stated as an absolute value.

(** - accuracy on communication)

| I/O MODULES | | |
|---|---------------------------|--|
| Watchdog & Alarm output | Contact rating | 48 Vac/dc (+40% max) |
| | Maximum switching current | 1000 mA |
| | Pulse | Max 4000 per/hour, Minimum width 100ms |
| High Voltage Watchdog & High Voltage Alarm output | Contact rating | 150 Vdc Max 110 Vac (+30% max) |
| | Maximum switching current | 1000 mA |
| | Pulse | Max 4000 per/hour, Minimum width 100ms |
| Pulse output (solid state) | Maximum switching | 40 Vac/dc, 30mA |
| | Pulse length | Programmable 1 to 999 ms |
| Tariff input | Voltage | 230 / 110Vac \pm 20% |
| | Current | < 0.6 mA |
| | Frequency Range | 45 to 65 Hz |
| | SET voltage | 40120% of rated voltage |
| | RESET voltage | 010% of rated voltage |
| Digital input | Voltage | 48 Vac/dc (+40% max) |
| | Current | < 0.6 mA |
| | Minimum signal width | 20ms |
| | Minimum pause width | 40ms |
| | SET voltage | 40120% of rated voltage |
| | RESET voltage | 010% of rated voltage |

| I/O MODULES | | |
|----------------|---|---|
| Analogue Input | Nominal input range 1 Nominal input range 2 input resistance accuracy temperature drift conversion resolution Analogue input mode | -20...0...20 mA ($\pm 20\%$) -2...0...2 mA ($\pm 20\%$) 20 Ω 0.5 % of range 0.1% / $^{\circ}\text{C}$ (for range 2 only) 16 bit (sigma-delta) internally referenced Single-ended |
| | Nominal input range1 Nominal input range 2 input resistance accuracy temperature drift conversion resolution Analogue input mode | -10...0...10 V ($\pm 20\%$) -1...0...1 V ($\pm 20\%$) 100 k Ω 0.5 % of range 0.1% / $^{\circ}\text{C}$ (for range 2 only) 16 bit (sigma-delta) internally referenced Single-ended |
| | Nominal input range (low)* Nominal input range (high)* connection accuracy conversion resolution Analogue input mode | 0 - 200 Ω (max. 400 Ω) PT100 (-200 $^{\circ}\text{C}$ -850 $^{\circ}\text{C}$) 0 - 2 k Ω (max. 4 k Ω) PT1000 (-200 $^{\circ}\text{C}$ -850 $^{\circ}\text{C}$) 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 QDSP setting software | |
| Pulse Input | Rated voltage | 5 - 48 V DC ($\pm 20\%$) |
| | Max. current | 8 mA (at 48 VDC + 20%) |
| | Min. pulse width | 0.5 ms |
| | Min. pulse periode | 2 ms |
| | SET voltage | 40...120 % of rated voltage |
| | RESET voltage | 0...10 % of rated voltage |

| ANALOGUE Output | | |
|-------------------|---------------------|--------------------------------------|
| General | Linearization | Linear, Quadratic |
| | No. of break points | 5 |
| | Output value limits | $\pm 120\%$ of nominal output |
| | Response time | Input \rightarrow output < 100 ms |
| | Residual ripple | < 0.5 % p.p. |
| DC Current output | Output range values | -100...0...100% |
| | -1...0...1 mA | Range 1 |
| | -5...0...5 mA | Range 2 |
| | -10...0...10 mA | Range 3 |
| | -20...0...20 mA | Range 4 |
| | Other ranges | Programmable using QDSP |
| | Burden voltage | 10 V |
| | External resistance | $RB_{max} = 10 \text{ V} / I_{outN}$ |
| DC Voltage output | Output range values | -100...0...100% |
| | -1...0...1 V | Range 5 |
| | -10...0...10 V | Range 6 |
| | Other ranges | Programmable using QDSP |
| | Burden current | 5 mA |
| | External resistance | $RB_{min} = U_{outN} / 5 \text{ mA}$ |

| COMMUNICATION | | | | |
|-----------------------|---|--------------------------------|-------------------|--------------------------|
| | Ethernet | USB | RS232 | RS485 |
| Connection | Network | Direct | Direct | Network |
| Max connection length | - | - | 3M | 1000M |
| Terminals | RJ45 | USB-B | DB9 female | DB9 female and terminals |
| Transmission mode | Asynchronous | | | |
| Protocol | MODBUS TCP / DNP3 (autodetect) | MODBUS RTU / DNP3 (autodetect) | | |
| Insulation | 2.2KV, 1minute between terminals and all other circuits | | | |
| Transfer rate | 10/100Mb/s (autodetect) | USB 2.0 | 1200 to 115200b/s | |

| ELECTRONIC FEATURES | | |
|---------------------|--|--|
| Response time | Input to communications | Calculated during averaging interval setting (8 to 256 periods), resetting (64 periods) typically 1.28 seconds at 50Hz |
| Memory | i5MR or i5MQ value and alarm recorders | 8MB or 6MB respectively |
| | i5MQ power quality reports | 2MB |
| Status LED's | Green | Communications in progress |
| | Red | Instrument power ON |

| SAFETY FEATURES | | |
|-----------------------|---|--|
| General | Protective earth terminal due to touchable metal parts (USB-B, RJ-45, DB9), current limiting fuse 0,5A on aux. Supply (L terminal) Voltage inputs via high impedance Double insulation on I/O ports and COM1-2 ports | |
| Protection Class | 1 | |
| Installation category | CAT III: 600Vrms, Measurement Inputs CAT III: 300Vrms, Auxiliary Supply In compliance with EN61010-1:2004 | |
| Pollution degree | 2 | |
| Test voltage | $U_{AUX \leftrightarrow I/O, COM1,2}$: 2210 VAC _{rms} $U_{AUX \leftrightarrow U, I}$ inputs: 3320 VAC _{rms} U, I inputs \leftrightarrow I/O, COM1,2: 3320 VAC _{rms} HV Tariff input \leftrightarrow I/O, COM1,2: 2210 VAC _{rms} U inputs \leftrightarrow I inputs: 3320 VAC _{rms} | |
| EMC | Directive on electromagnetic compatibility 2004/108/EC In compliance with EN 61000-6-2:2005 and EN 61000-6-4:2002 | |
| Protection | In compliance with EN60529:1997 IP40 (IP20 for terminals) | |
| Ambient conditions | Climatic | class 3, in compliance with EN62052-11:2004 and EN62052-21:2005 |
| | Ambient Temp | -10...0...45...55°C Acc. To IEC/EN 60688 |
| | Temperature | Operation -30 to +70C Storage -40 to +70C |
| | Humidity | ≤ 93%RH non condensing |
| Enclosure | Material | PC/ABS incombustibility – self extinguishing in compliance with UL94VO |
| | Protection | In compliance with EN60529:1997 IP40 (IP20 for terminals) |
| | Mounting | Rail mounting 35 × 7.5 mm acc. to DIN EN 50 022 |
| | Dimensions | 160 × 123 × 75 mm |
| | Weight | 500g |

| REMOTE DISPLAY i5RD | |
|-------------------------------------|--|
| LCD Type | Graphic LCD |
| LCD Size | 128 x 64 dots |
| LCD refreshing | Every 200 ms |
| Response time Input → display | All calculations are averaged over an interval of between 8 to 256 periods. Pre-set interval is 64 periods, which is 1.28 second at 50 Hz. |
| LED's | Green Communication with i5RD in progress |
| | Red Fulfilled condition for alarm |
| Communication | Type RS485 |
| | Connection DB9 connector or Terminals |
| Power supply | AC voltage range 48...276 V |
| | AC frequency range 45...65 Hz |
| | DC voltage range 20...300V |
| | Burden < 5 VA |
| Safety features | |
| Safety | In compliance with EN 61010-1: 2002 Class 2 300 V rms, installation category III Pollution degree 2 |
| EMC | Directive on electromagnetic compatibility 2004/108/ES In compliance with EN 61000-6-2:2005 and EN 61000-6-4:2002 |
| Protection | In compliance with EN 60529: 1997 Front side: IP52 Rear side: IP20 (With protective cover fitted) |
| Ambient conditions | |
| Climatic class | 3 In compliance with EN 62052-11: 2004 In compliance with EN 62052-21: 2005 |
| Temperature range of operation | -5 to +55°C |
| Storage temperature range | -25 to +70°C |
| Max. storage and transport humidity | ≤ 90% RH |
| Enclosure | ABS & Polycarbonate Blend – self-extinguishing in compliance with UL 94 V0 |
| Weight | 450g |

15. WIRING DIAGRAMS

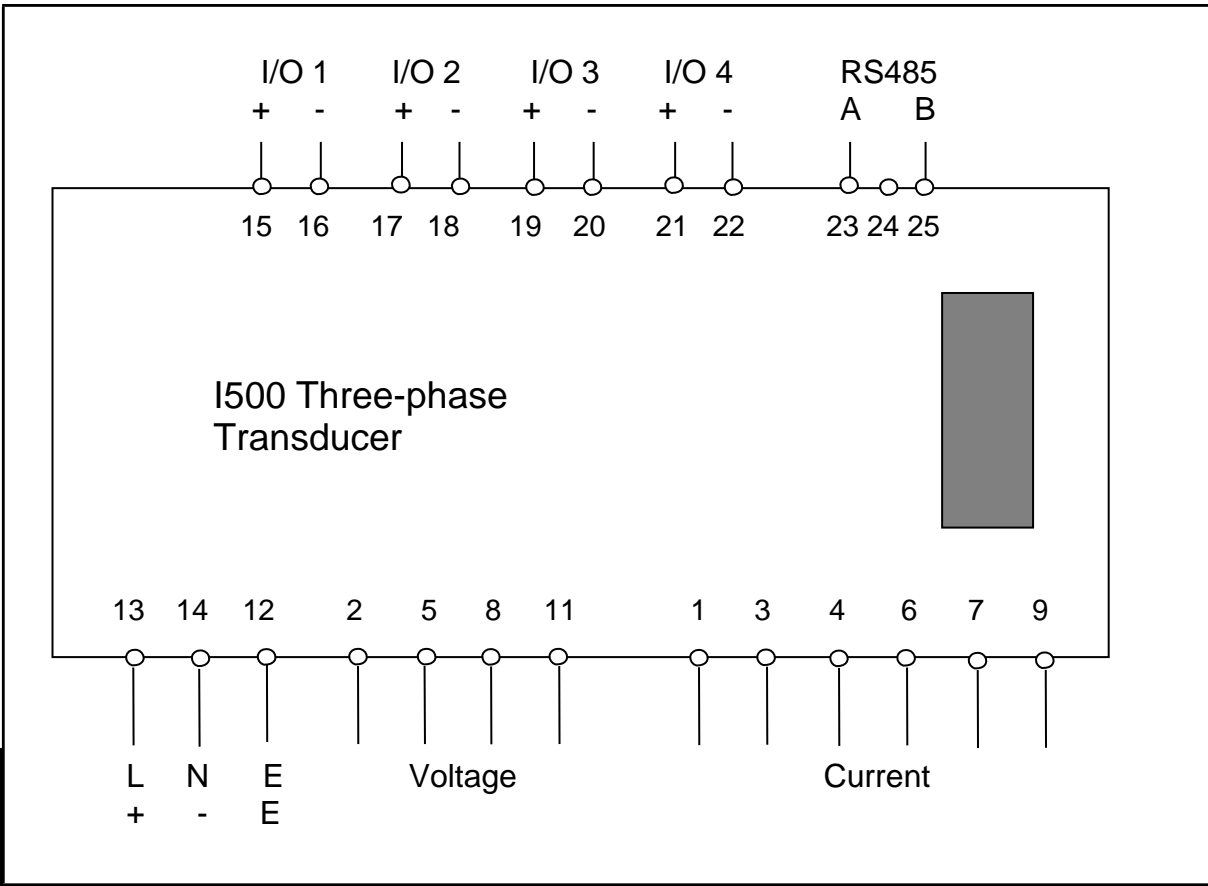


FIGURE 16-1: CONNECTION DIAGRAM

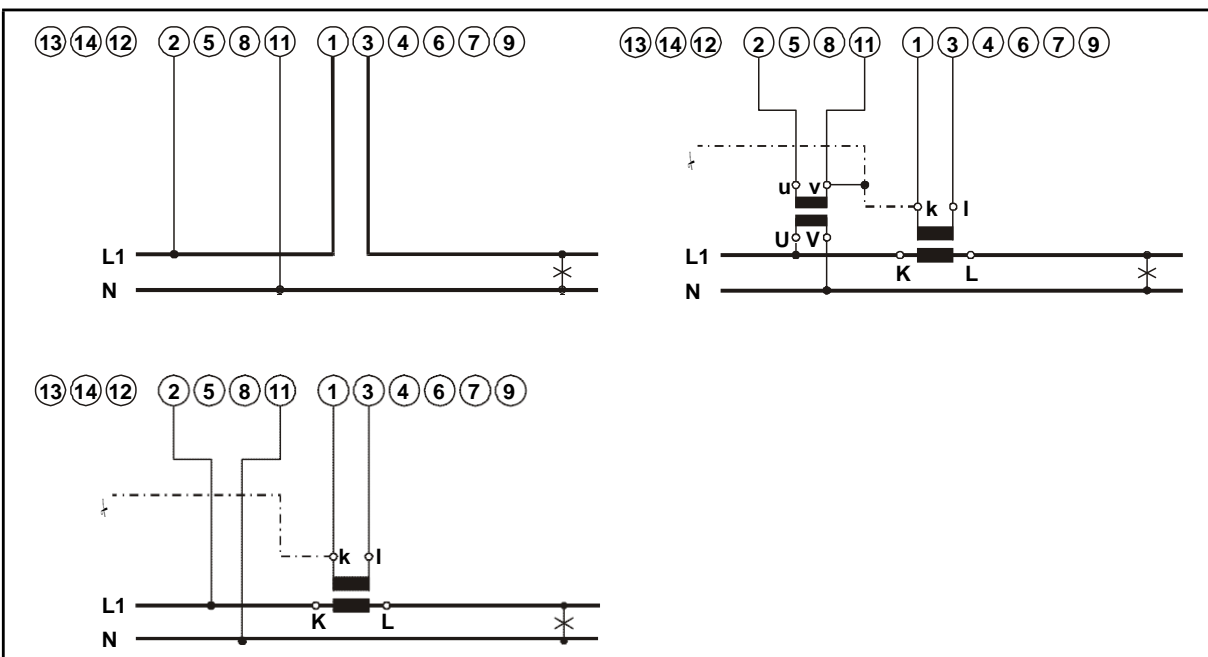


FIGURE 16-2: EXTERNAL WIRING DIAGRAM: SINGLE PHASE (1B)

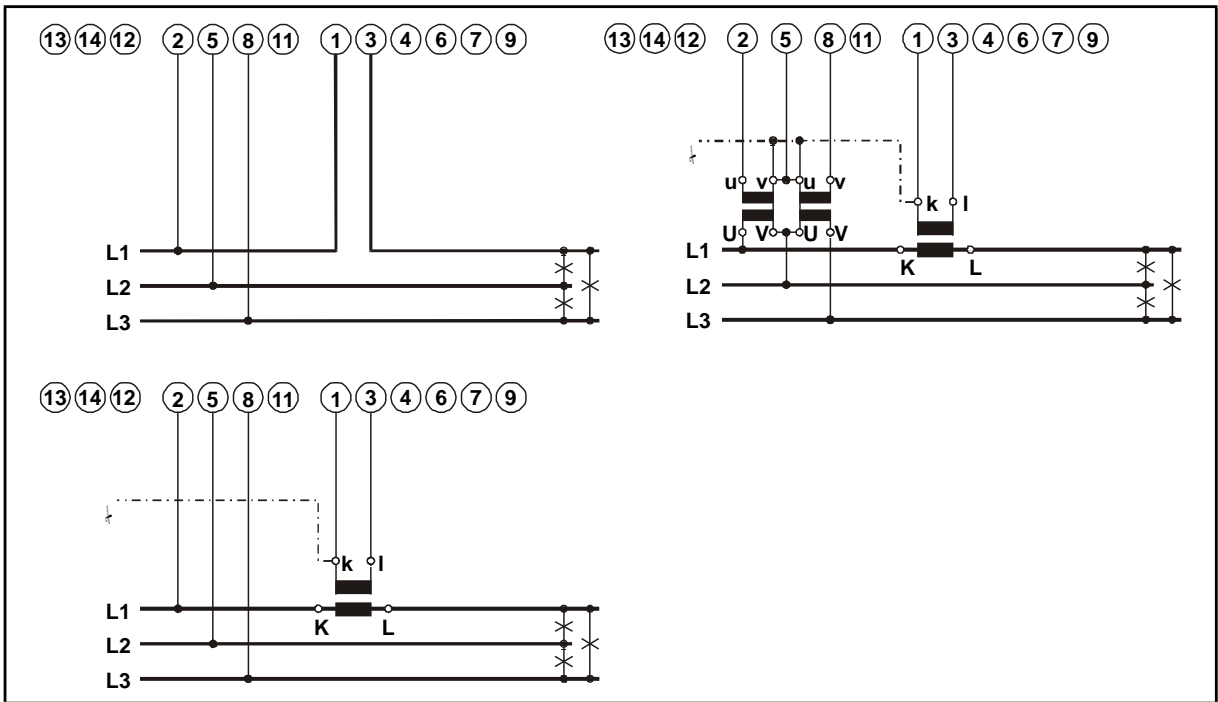


FIGURE 16-3: EXTERNAL WIRING DIAGRAM: 3-PHASE, 3-WIRE BALANCED LOAD (3B)

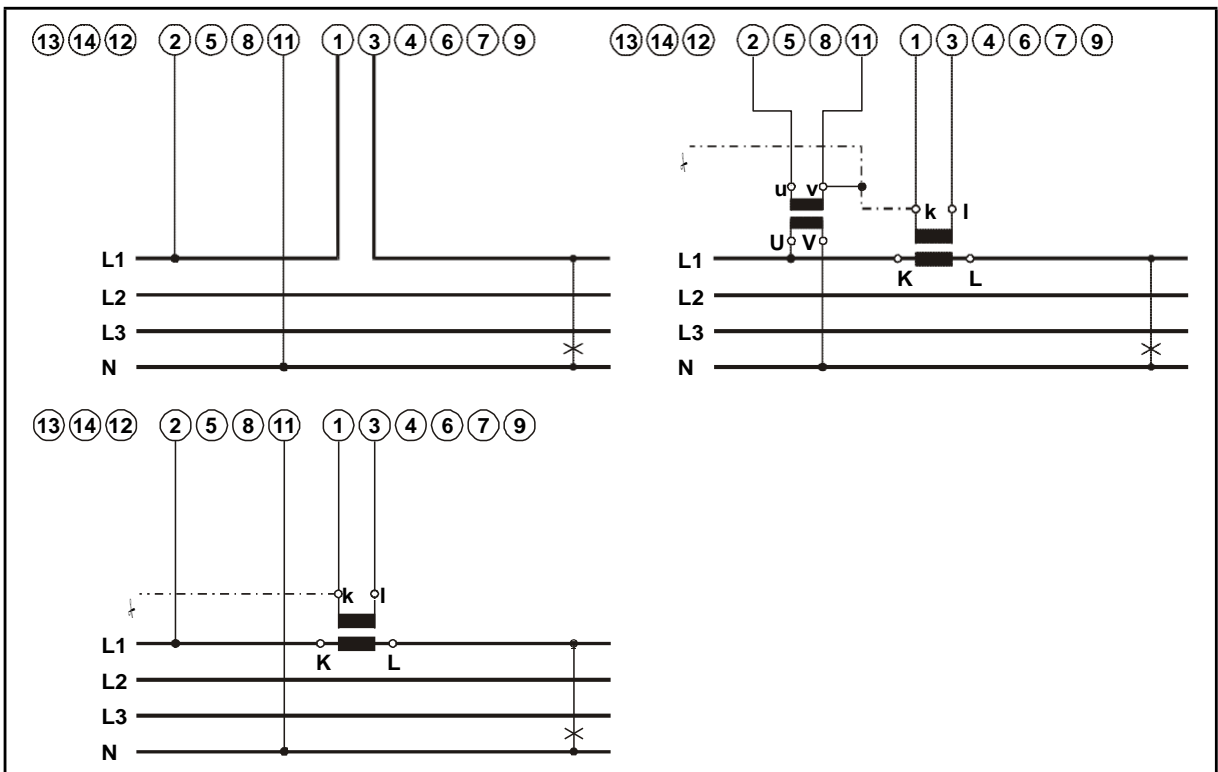


FIGURE 16-4: EXTERNAL WIRING DIAGRAM: 3-PHASE, 4-WIRE BALANCED LOAD (4B)

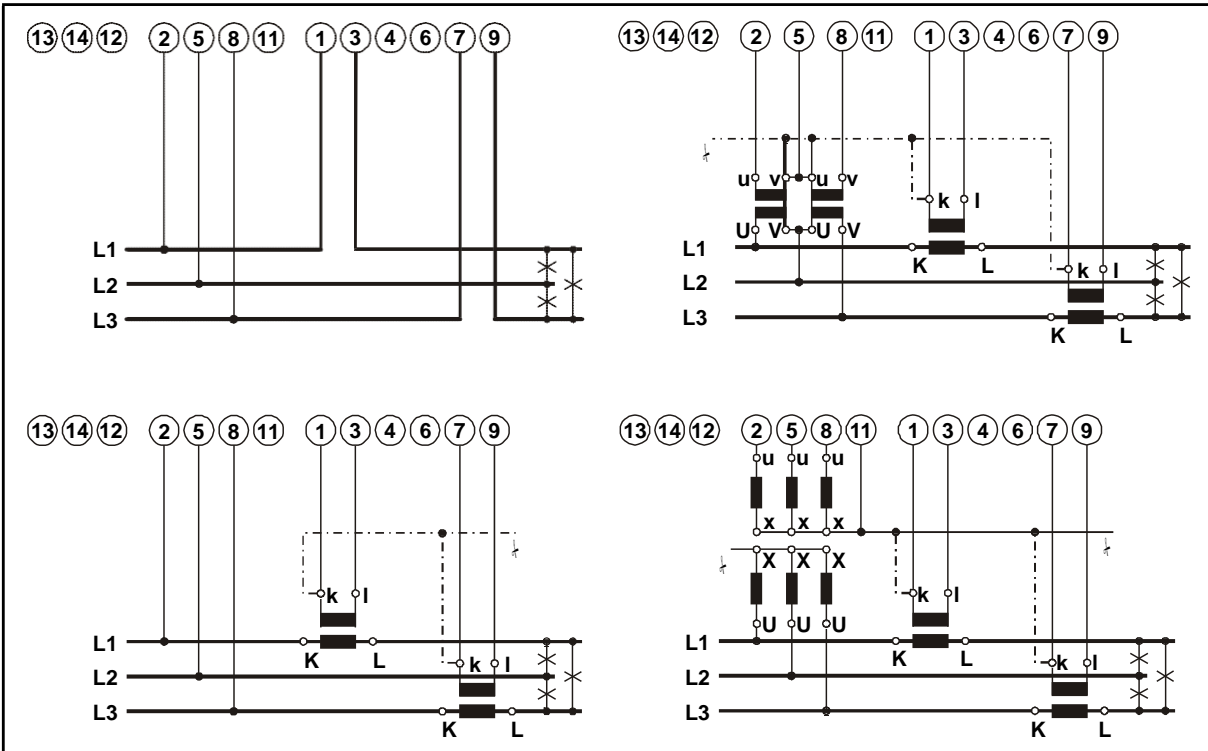


FIGURE 16-5: EXTERNAL WIRING DIAGRAM: 3-PHASE, 3-WIRE UNBALANCED LOAD (3U)

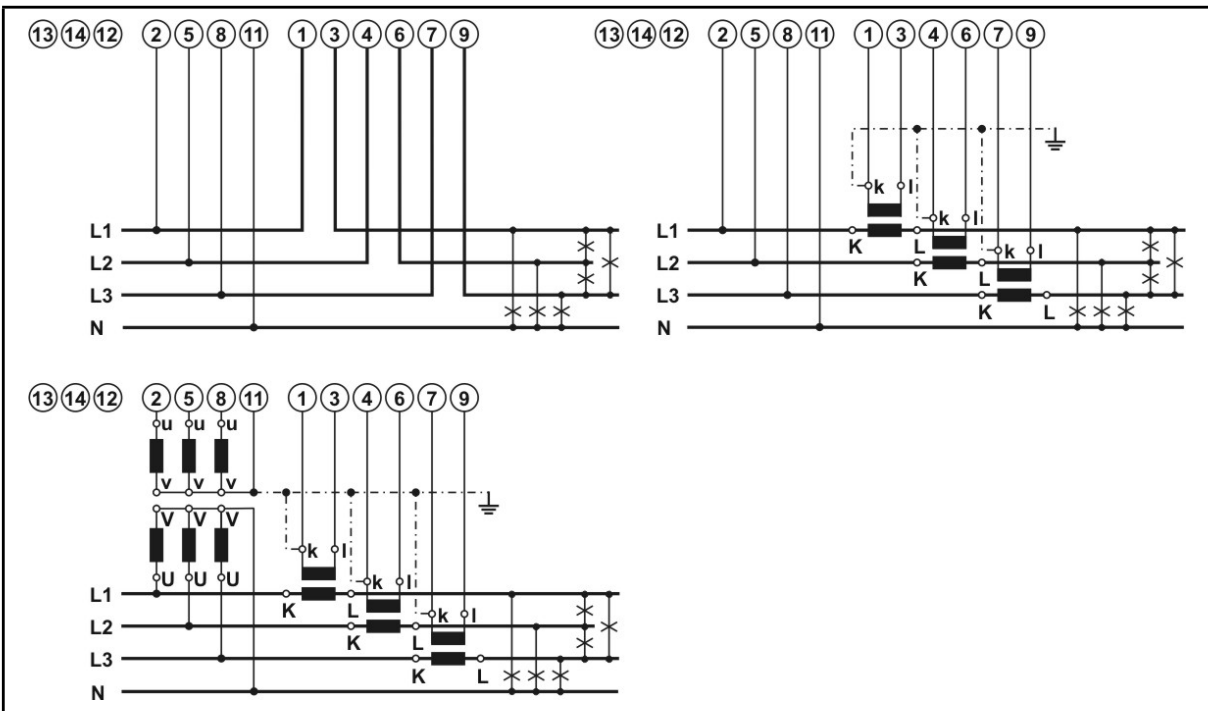


FIGURE 16-6: EXTERNAL WIRING DIAGRAM: 3-PHASE, 4-WIRE UNBALANCED LOAD (4U)

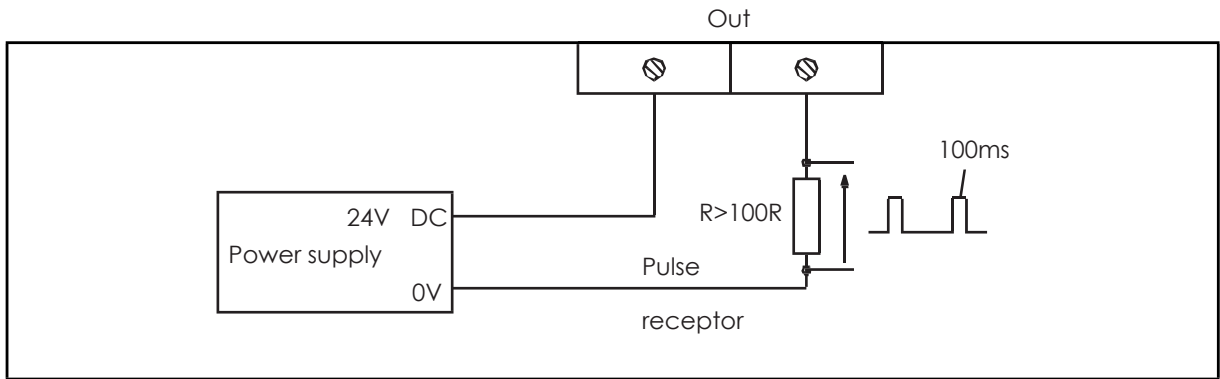


FIGURE 16-7: TYPICAL CONNECTIONS FOR PULSE OUTPUT

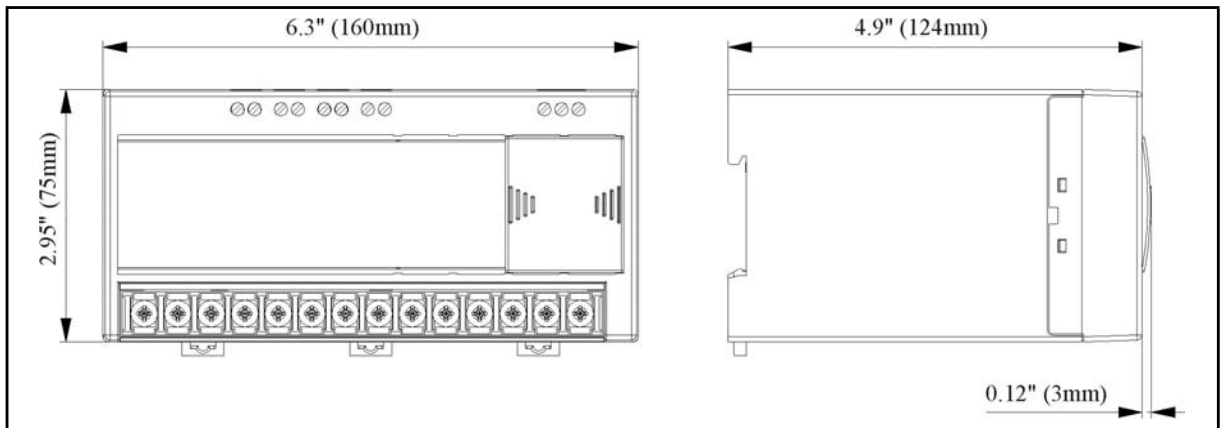


FIGURE 16-8: ENCLOSURE DIMENSIONS

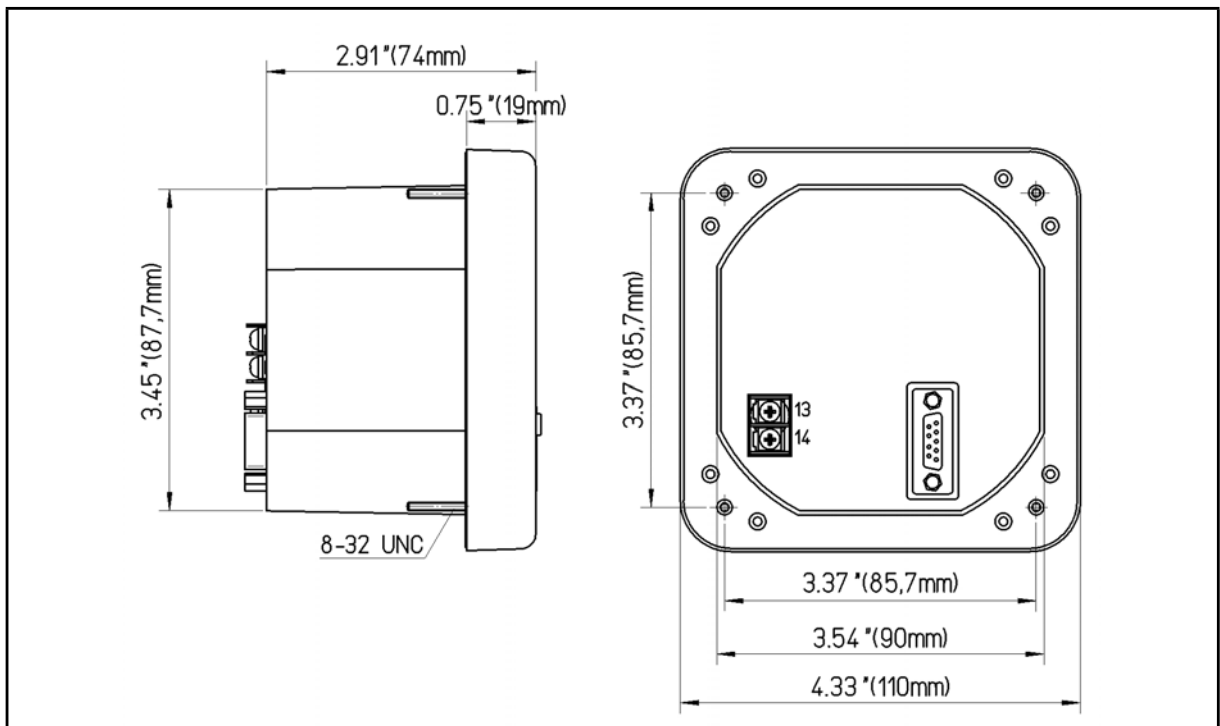


FIGURE 16-9: REMOTE DISPLAY (4" ROUND)

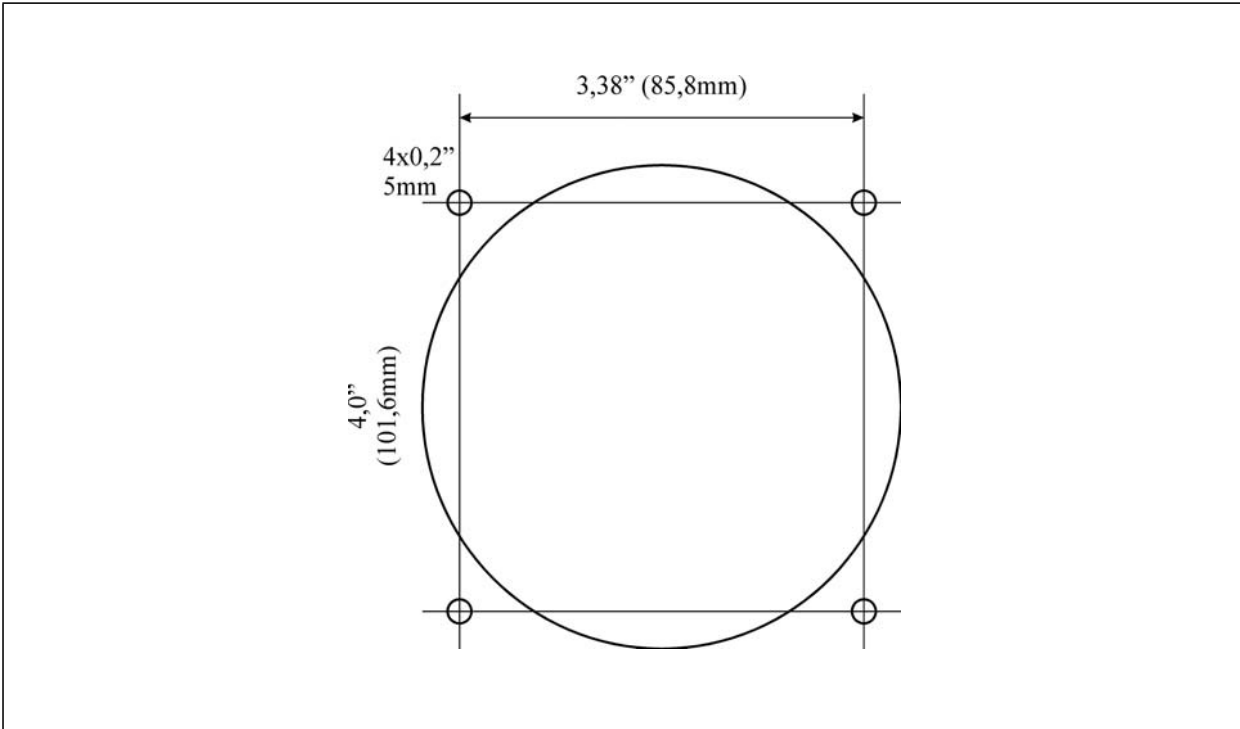


FIGURE 16-10: REMOTE DISPLAY CUTOUT (4" ROUND)

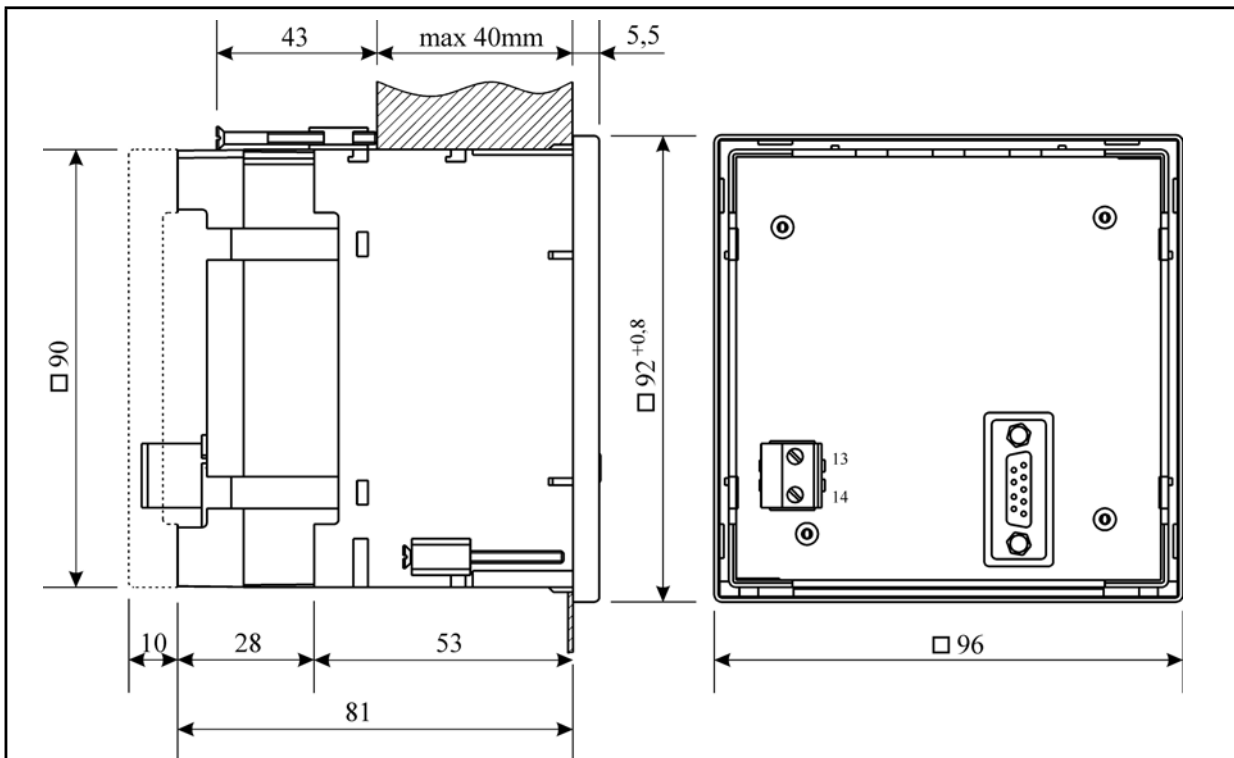


FIGURE 16-11: REMOTE DISPLAY (96MM)

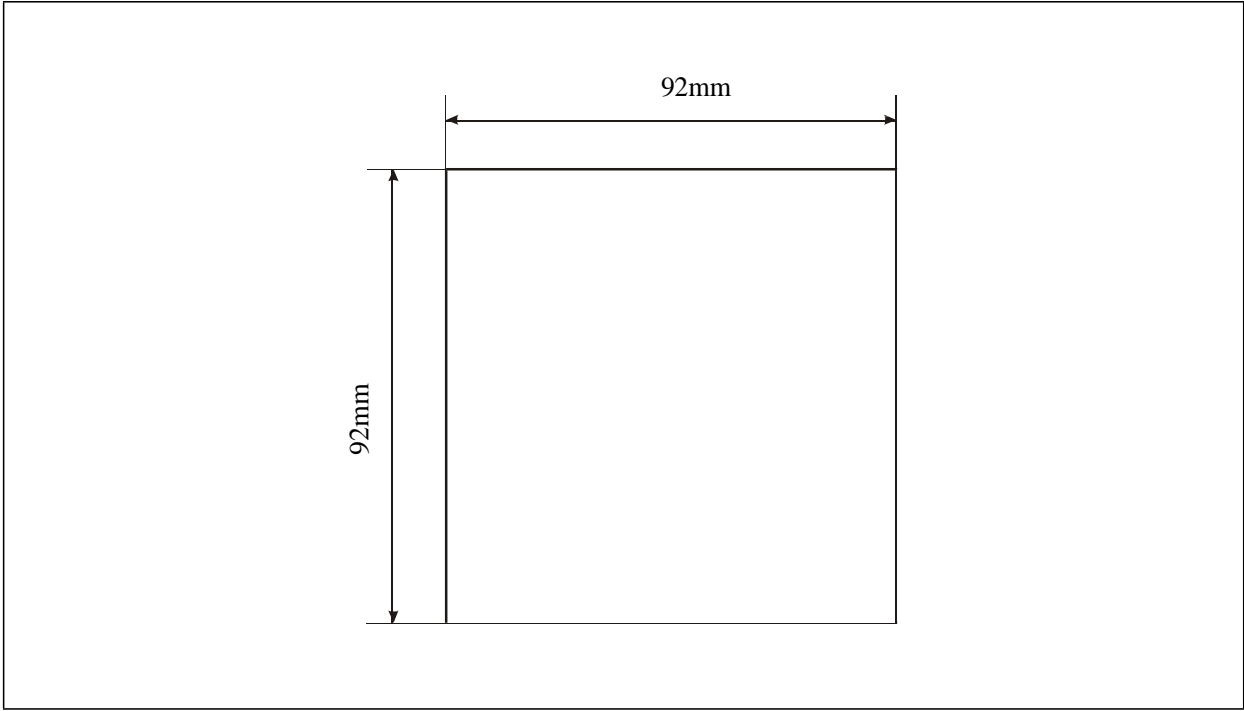


FIGURE 16-12: REMOTE DISPLAY CUTOUT (96MM)

16. RELATED DOCUMENTS

| Ref | Document |
|------------|-------------------------------------|
| 1 | I500 Single Phase Transducer Manual |
| 2 | I500 and M2x3 Communications Manual |
| 3 | QDSP Technical Manual |



Imagination at work

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I500/EN/M/F