MITSUBISHI ELECTRIC

ME-RTU

User´s Manual

Remote Terminal Unit

Art. no.: 278247
31.07.2014
Version A

MITSUBISHI ELECTRIC INDUSTRIAL AUTOMATION

Version check

About this Manual

The texts, illustrations, diagrams and examples in this manual are provided for information purposes only. They are intended as aids to help explain the installation, operation, programming.

If you have any questions about the installation and operation of any of the products described in this manual please contact your local sales office or distributor (see back cover). You can find the latest information and answers to frequently asked questions on our website at https://eu3a.mitsubishielectric.com.

User's Manual
Remote Terminal Unit ME-RTU
Art. no.: 278247

Version	Changes / Additions / Corrections
A 07/2014 pdp	First edition

Safety Guidelines

For use by qualified staff only

This manual is only intended for use by properly trained and qualified electrical technicians who are fully acquainted with the relevant automation technology safety standards. All work with the hardware described, including system design, installation, configuration, maintenance, service and testing of the equipment, may only be performed by trained electrical technicians with approved qualifications who are fully acquainted with all the applicable automation technology safety standards and regulations. Any operations or modifications to the hardware and/or software of our products not specifically described in this manual may only be performed by authorised Mitsubishi Electric staff.

Proper use of the products

The RTU module is only intended for the specific applications explicitly described in this manual. All parameters and settings specified in this manual must be observed. The products described have all been designed, manufactured, tested and documented in strict compliance with the relevant safety standards. Unqualified modification of the hardware or software or failure to observe the warnings on the products and in this manual may result in serious personal injury and/or damage to property. Only peripherals and expansion equipment specifically recommended and approved by MITSUBISHI ELECTRIC may be used with the RTU module.

All and any other uses or application of the products shall be deemed to be improper.

Relevant safety regulations

All safety and accident prevention regulations relevant to your specific application must be observed in the system design, installation, setup, maintenance, servicing and testing of these products. The regulations listed below are particularly important in this regard.

This list does not claim to be complete; however, you are responsible for knowing and applying the regulations applicable to you in your location:

- VDE Standards
  - VDE 0100
    Regulations for the erection of power installations with rated voltages below 1000 V
  - VDE 0105
    Operation of power installations
  - VDE 0113
    Electrical installations with electronic equipment
  - VDE 0160
    Electronic equipment for use in power installations
  - VDE 0550/0551
    Regulations for transformers
  - VDE 0700
    Safety of electrical appliances for household use and similar applications
  - VDE 0860
    Safety regulations for mains-powered electronic appliances and their accessories for household use and similar applications.
- Fire safety regulations
- Accident prevention regulation
  - VBG No. 4
    Electrical systems and equipment

Safety warnings in this manual

In this manual special warnings that are important for the proper and safe use of the products are clearly identified as follows:

CAUTION:

Equipment and property damage warnings. Failure to observe the safety warnings identified with this symbol can result in damage to the equipment or other property.

General safety information and precautions

The following safety precautions are intended as a general guideline for using PLC systems together with other equipment. These precautions must always be observed in the design, installation and operation of all control systems.

DANGER:

- ***Observe all safety and accident prevention regulations applicable to your specific application. Always disconnect all power supplies before performing installation and wiring work or opening any of the assemblies, components and devices.***
- ***Assemblies, components and devices must always be installed in a shockproof housing fitted with a proper cover and fuses or circuit breakers.***
- ***Devices with a permanent connection to the mains power supply must be integrated in the building installations with an all-pole disconnection switch and a suitable fuse.***
- ***Check power cables and lines connected to the equipment regularly for breaks and insulation damage. If cable damage is found immediately disconnect the equipment and the cables from the power supply and replace the defective cabling.***
- ***Before using the equipment for the first time check that the power supply rating matches that of the local mains power.***
- ***You are responsible for taking the necessary precautions to ensure that programs interrupted by brownouts and power failures can be restarted properly and safely. In particular, you must ensure that dangerous conditions cannot occur under any circumstances, even for brief periods. EMERGENCY OFF must be switched forcibly, if necessary.***
- ***EMERGENCY OFF facilities conforming to EN 60204/IEC 204 and VDE 0113 must remain fully operative at all times and in all control system operating modes.The EMERGENCY OFF facility reset function must be designed so that it cannot ever cause an uncontrolled or undefined restart.***
- ***You must implement both hardware and software safety precautions to prevent the possibility of undefined control system states caused by signal line cable or core breaks.***

Symbols Used in this Manual

Use of instructions

Instructions concerning important information are marked separately and are displayed as follows:

NOTE | Text of instruction

Example▽ Example text △

Use of handling instructions

Handling instructions are steps that must be carried out in their exact sequence during startup, operation, maintenance and similar operations.

They are numbered consecutively (black numbers in white circles):

① Text.

② Text.

③ Text.

Use of footnotes in tables

Instructions in tables are explained in footnotes underneath the tables (in superscript). There is a footnote character at the appropriate position in the table (in superscript).

If there are several footnotes for one table then these are numbered consecutively underneath the table (black numbers in white circle, in superscript):

① Text
② Text
③ Text

Contents

1 Overview

This User's Manual specifies the functionality and programming of the Remote Terminal Unit module (hereafter known as ME-RTU) for the FX3, L and Q family of programming PLCs.

The ME-RTU is used to connect the FX3, Q and L family of programing PLCs to a DNP3 or IEC 60870-5-101/104 network.

Main hardware features are:

- Micro SD card socket
- SIM card socket
- Ethernet port 10/100
- USB host port
- GSM/GPRS/EDGE Quad-Band 850/900/1800/1900 MHz
- Integration with Mitsubishi Electric FX Bus (bus variant)
- 2 digital inputs, 24 V DC, IEC 61131 Type 3
- 2 digital outputs, 24 V DC, 100 mA

1.1 Outline

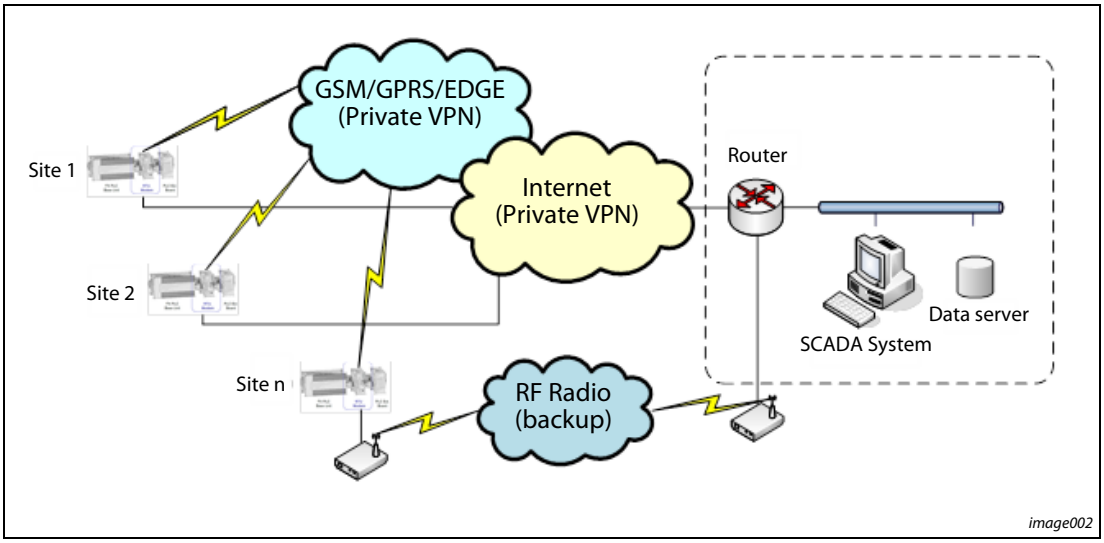


Fig. 1-1: *Basic network configuration*

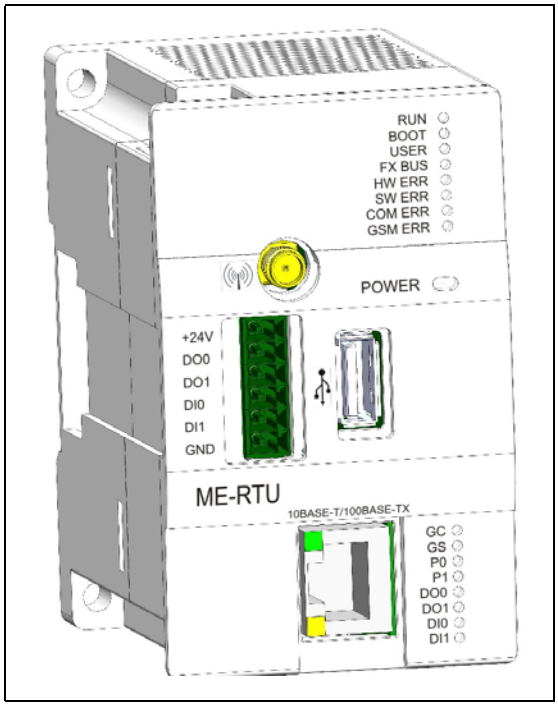


Fig. 1-2:
ME-RTU with top cover attached (symbolic picture)

image006

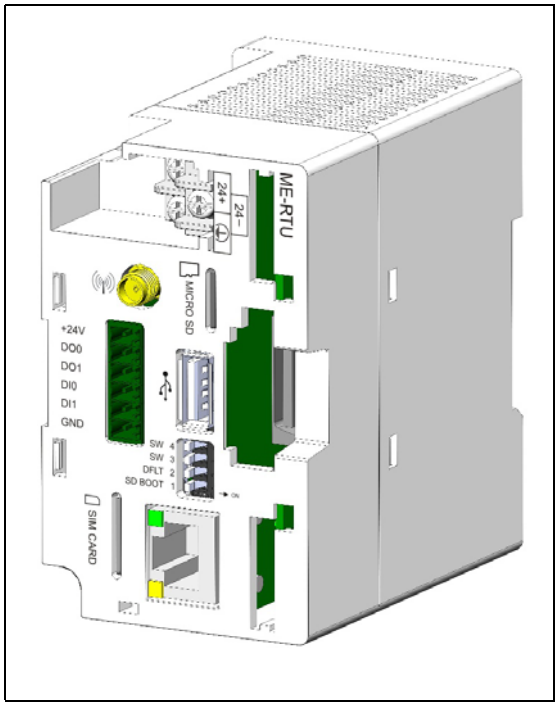


Fig. 1-3:
ME-RTU with top cover removed (symbolic picture)

image007

2 Specifications

Item			Specification	
General specification	Ambient temperature	Operating temperature	0 °C to 55 °C (32 °F to 131 °F)	
		Storage temperature	–40 °C to 85 °C (–40 °F to 185 °F)	
	Dielectric withstand voltage between 24 V power and digital circuit		500 V DC/300 V AC for one minute	
	Insulation resistance between digital circuit and earth terminal		5 MΩ or more by 500 V DC	
	IP protection		IP20	
Power supply specification	Power supply		24 V DC +20 %, –10 %, ripple (p-p) less than 5 %	
	Current consumption at 24 V	typical	200 mA	
		maximum	330 mA	
	USB current limit		200 mA	
Module digital inputs	Nominal voltage		24 V DC	
	Input impedance		2 kΩ	
	Input signal current		12 mA @ 24 V DC	
Digital outputs	Nominal load		100 mA @ 24 V DC	
	Maximum load		250 mA @ 24 V DC	
Wireless communication	GSM/GPRS/EDGE frequency bands		850/900/1800/1900 MHz	
	SIM interface		3V SIM	
Ethernet communication	Baud rate		100 Mbps	10 Mbps
	Communication method		Full duplex	
			Crossover detection	
External dimensions (H x W x D)①			98 x 55 x 87 mm (3.86 x 2.17 x 3.43")	

Tab. 2-1: *General ME-RTU specification*

① with module I/Os terminal block attached

2.1 External dimensions

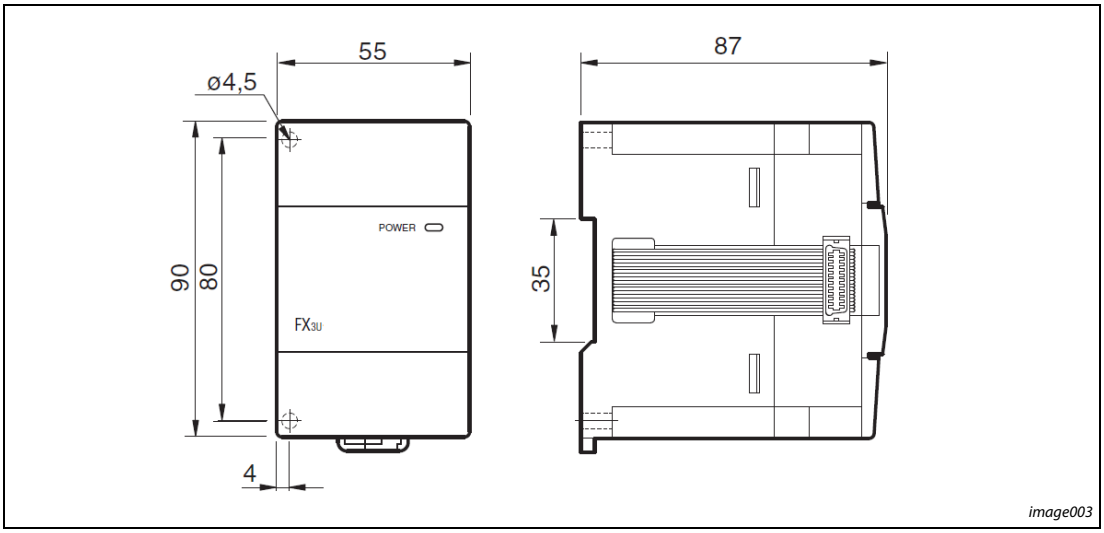


Fig. 2-1: *Housing dimensions*

CAUTION:
Internal fuse protects internal circuit of ME-RTU. Internal fuse cannot break due to user's actions. Melted internal fuse indicates ME-RTU general failure.
If internal fuse should break, user cannot replace the internal fuse by her-/himself, therefore the ME-RTU must be sent to the manufacturer for servicing.

2.2 Variants

The ME-RTU comes in two variants, for different applicable PLC series:

- For FX3 PLCs – a with-cable variant **"bus-ME-RTU"** unit. This has the FX-extension bus ribbon cable factory-attached to the unit.

For Q and L series PLCs – a sans-cable variant **"non-bus ME-RTU"** unit. This has no ribbon cable attached (since the PLC connection is made via Ethernet).

3 Installation

3.1 Mounting

ME-RTU can be mounted directly using screws or on DIN rail (DIN 46227).

3.1.1 Direct mounting

ME-RTU can be mounted with M4 screws by using direct mounting holes. A space of 1 to 2 mm (0.04" to 0.08") between each unit is necessary.

3.1.2 DIN rail mounting

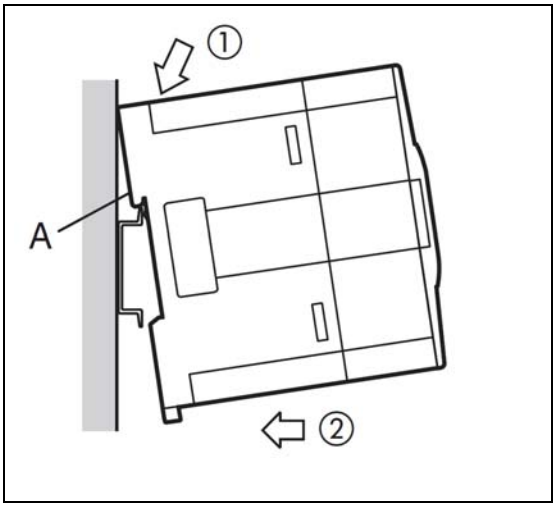


Fig. 3-1:
ME-RTU can be mounted on a DIN rail (DIN 46227, 35 mm width).

image009

① Fit the upper edge of the DIN rail mounting groove (Fig. A) onto the DIN rail.

② Push the unit onto the DIN rail.

3.2 Installation location

Install the ME-RTU in an environment conforming to the generic specifications (chapter 3), installation precautions.

NOTE

Keep a space of 100 mm (3.94") or more between the unit main body and another device or structure. Install the unit as far as possible from the high-voltage devices and power equipment.

To prevent temperature rise, do not install ME-RTU on a floor, a ceiling or a vertical surface. Install it horizontally on a wall as shown in figure 3-2.

When ME-RTU is used as an extension device for FX-series PLC via FX Bus, the ME-RTU may be connected to the right of the PLC or other extension module. Additional extension modules can be connected on the right side of ME-RTU.

In 2 stage configuration with extension cable keep necessary spaces between ME-RTU and other equipment or enclosure walls on all sides of ME-RTU.

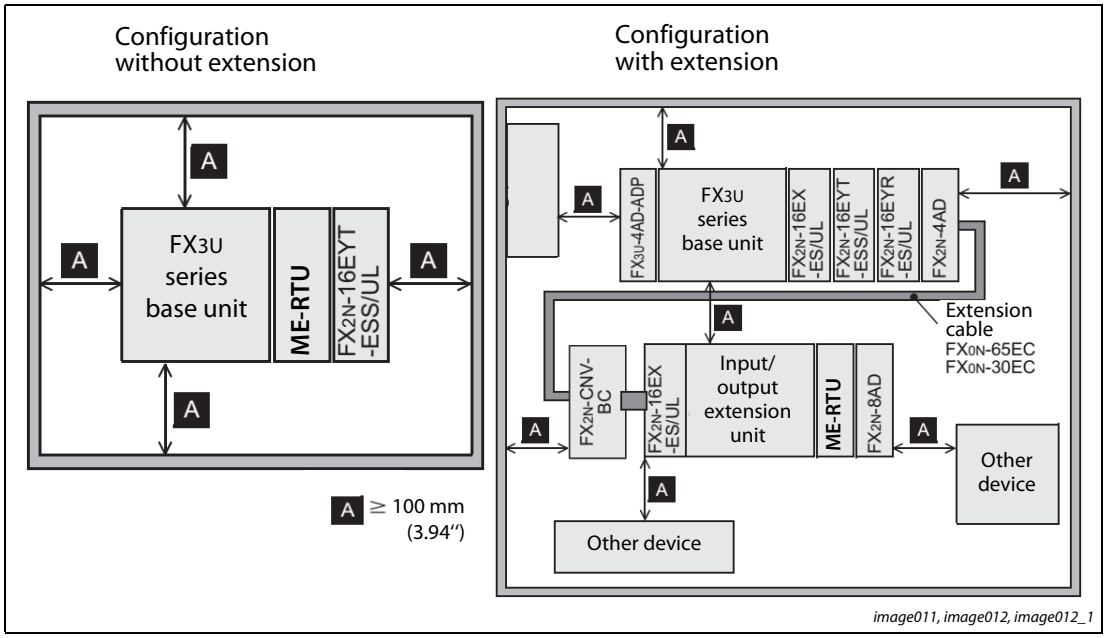


Fig. 3-2: *Installation spacing*

NOTE

When used with Q- or L-series PLC, use cable tie to affix the FX Bus cable firmly to ME-RTU housing, if bus-ME-RTU variant of the unit is used.
However, it is strongly recommended to use a non-bus ME-RTU in conjunction with Q- or L-series PLCs.

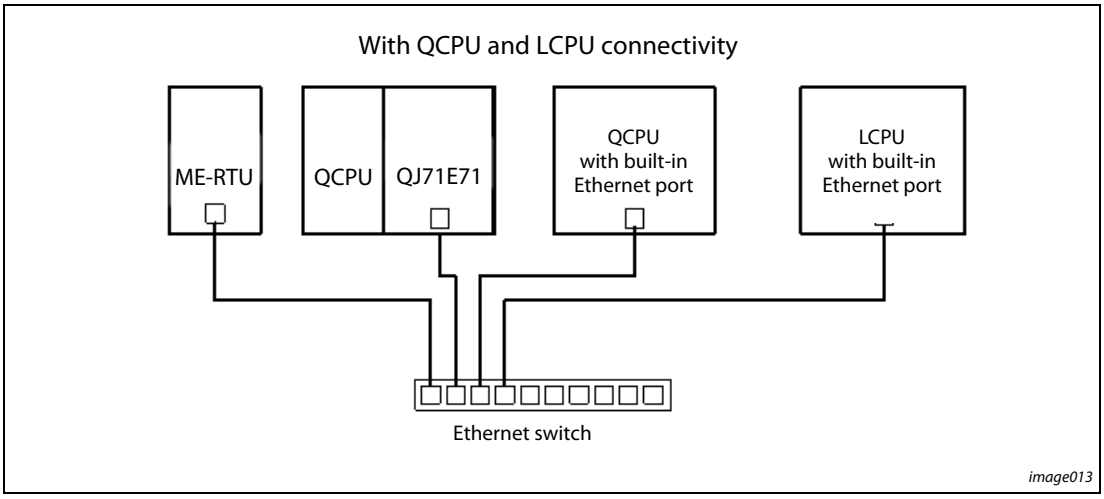


Fig. 3-3: *Q/L PLC Ethernet connectivity example*

NOTE Direct point-to-point connection between ME-RTU and Q/L-series PLC is also possible. Auto-MDI/MDIX is supported.

4 Wiring

This chapter describes the wiring: of power supply and grounding cables, Ethernet, module I/Os, USB and antenna. SIM card and micro-SD card insertion is also described.

4.1 Power supply wiring

CAUTION:
Cut off all phases of the power source externally before starting the installation or wiring work, thus avoiding the potential for electric shock or damages to the product.

Before wiring the unit, confirm that the rated voltage and terminal allocation of the unit are correct.

Example▽ Example of wiring and power supply wiring between FX3U PLC and ME-RTU:

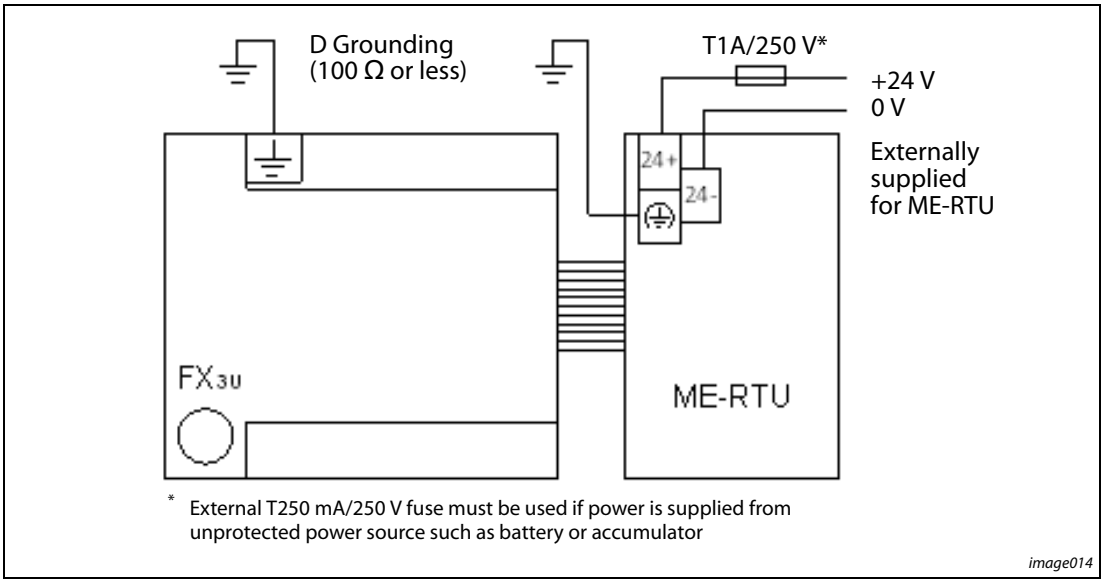


Fig. 4-1: *ME-RTU power supply wiring*

Grounding recommendation

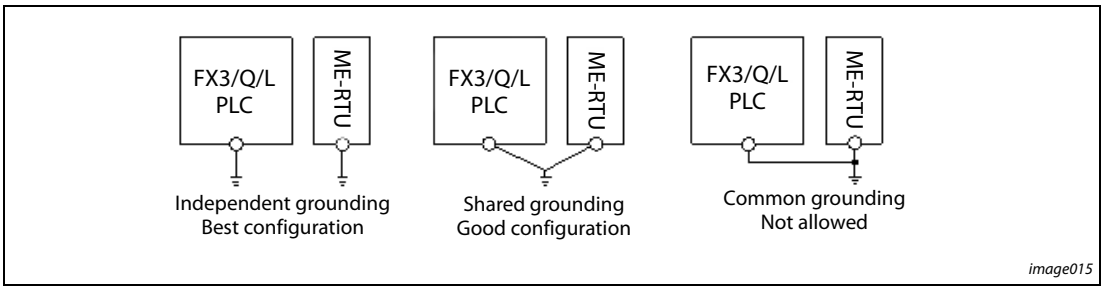


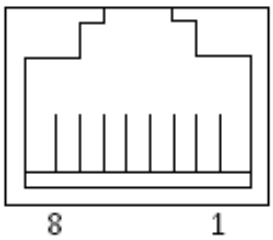
Fig. 4-2: *ME-RTU grounding towards PLC*

CAUTION:

- ***Connecting cables for power supply to ME-RTU must be shorter than 3 metres (9.8').***
- ***Fix the connecting cables for power supply so that the connector is not directly stressed.***
- ***Internal fuse protects internal circuit of RTU-gateway. Internal fuse cannot break due to user's actions. Melted internal fuse indicates ME-RTU general failure.***
- ***If internal fuse should break, user cannot replace the internal fuse by her-/himself, therefore the ME-RTU must be sent to the manufacturer for servicing.***

4.2 Ethernet wiring

For Ethernet connection RJ45 type modular connector is used. The pin configuration of RJ45 connector is shown in the following Table 4-1. The ME-RTU supports crossover detection for point-to-point connection. The ME-RTU uses 10BASE-T and 100BASE-T Ethernet connection. For Ethernet connection category 5 cable (Cat5) must be used. The maximum length of a cable segment is 100 m.



Pin No.	Signal	Direction	Contents
1	TD+	Out	+ side of sending data
2	TD–	Out	– side of sending data
3	RD+	In	+ side of receiving data
4	Not used	—	
5	Not used	—	
6	RD–	In	– side of receiving data
7	Not used	—	
8	Not used	—	

Tab. 4-1: *RJ45 pinout*

CAUTION:

Fix the Ethernet cable so that the connector is not directly stressed.

4.3 Module digital input and output wiring

ME-RTU uses positive logic for digital I/Os (sinking input and sourcing output). The example for module digital I/O wiring is shown on Fig. 4-3. The inputs and outputs are galvanically isolated inside ME-RTU. There is no internal power supply connection for digital I/Os. The power supply must be connected to +24V and GND terminal on I/Os connector.

For module digital input, the positive supply is wired to "DI0" or "DI1" terminal via switch or relay and negative supply terminal is wired to the ground.

For module digital output, the positive supply terminal is wired to "+24V". One load terminal is wired to module digital output terminal and the other is wired to module negative supply terminal.

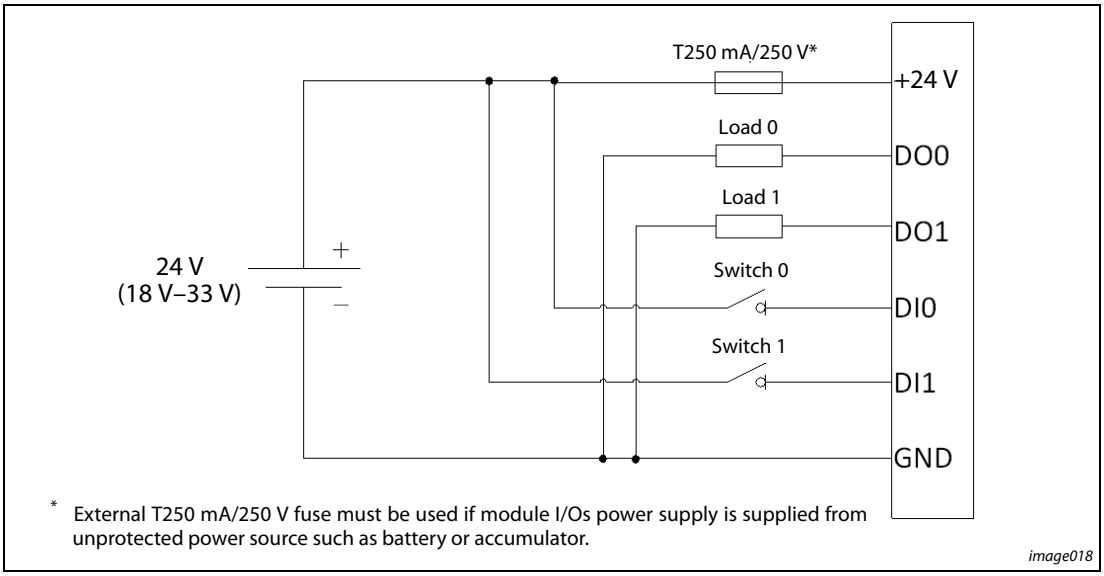


Fig. 4-3: *Input and output wiring example.*

CAUTION:

- ***Connecting cables for module I/Os power supply, module digital inputs and module digital outputs must be shorter than 3 metres (9.8').***
- ***Fix the connecting cables so that the connector is not directly stressed.***

4.4 USB wiring

The serial communication can be used for radio backup connection. For serial communication USB port is used. Thus it is possible to access certain serial interfaces with standard USB converter. The external USB cable maximum length is 3 m (9.8').

CAUTION:

Fix the USB cable so that the connector is not subjected to any mechanical stresses. These could lead to long-term damage and communication failure.

Recommended USB to serial converter: ATEN, USB-to-Serial Converter (Model: UC-232A)

NOTE There is no guarantee that other USB to serial converters will function.

4.5 External memory

ME-RTU uses micro-SD or SDHC card for external memory. The max capacity is 32 GB.

Recommended micro-SD card: Panasonic RP-SMKC04 micro-SD card

4.6 Antenna wiring

The antenna is connected via standard SMA connector. The antenna must meet the requirements specified in the table below.

Characteristic		E-GSM 900	DCS 1800	GSM 850	PCS 1900
TX Frequency		880 to 912 MHz	1710 to 1785 MHz	824 to 849 MHz	1850 to 1910 MHz
RX Frequency		925 to 950 MHz	1805 to 1880 MHz	869 to 894 MHz	1930 to 1990 MHz
Impedance		50 Ω			
VSWR	TX max	1.5:1			
	RX max	1.5:1			
Typical Radiated Gain		0dBi at least in one direction			

Tab. 4-2: *Antenna specifications*

For antenna cable it is recommended to use RG178 coaxial cable with the following characteristic:

- Static curvature radius: 10 mm (0.39'')
- Dynamic curvature radius: 20 mm (0.79'')

If GSM antenna cable is longer than 3 m (9.8') external over voltage protection device must be installed.

Recommended antenna manufacturers and models:

- Delock, GSM/UMTS SMA Antenna (824-960/1710-2170 MHZ)
- SPK Electronics, SPK-GSM External Antenna
- PentaMag, Multiband GSM/3G Antenna SMA

4.7 SIM card and SD card insertion

The SIM card slot accepts ISO/IEC 7810 D-000 format international standard mini-SIM card with external dimensions L x W x H: 25 x 15 x 0.76 mm.

The SIM card is pushed directly into SIM card slot, wherein the cut-off corner of the SIM card is facing upwards-front towards top of the SIM card slot (see Fig. 4-4). For a SIM card to be properly locked inside a SIM card slot, the SIM card needs to be pushed inside about 2 mm from the top case edge. A light "click"-sound indicates that SIM card has properly locked. Retrieve slowly to prevent unexpected kickback if SIM card hasn't locked properly. It is recommended to use flat-edged 0.75 mm (0.03") wide non-conducting (plastic or wooden) tool to ease the insertion of SIM card.

Micro SD card slot accepts micro-SD card with external dimensions L x W x H: 15 x 11 x 1 mm. For the insertion of micro-SD card consider the SIM card insertion directions, wherein the micro-SD card's cut-away edge is facing downwards towards the bottom of the micro-SD card slot (see Fig. 4-4).

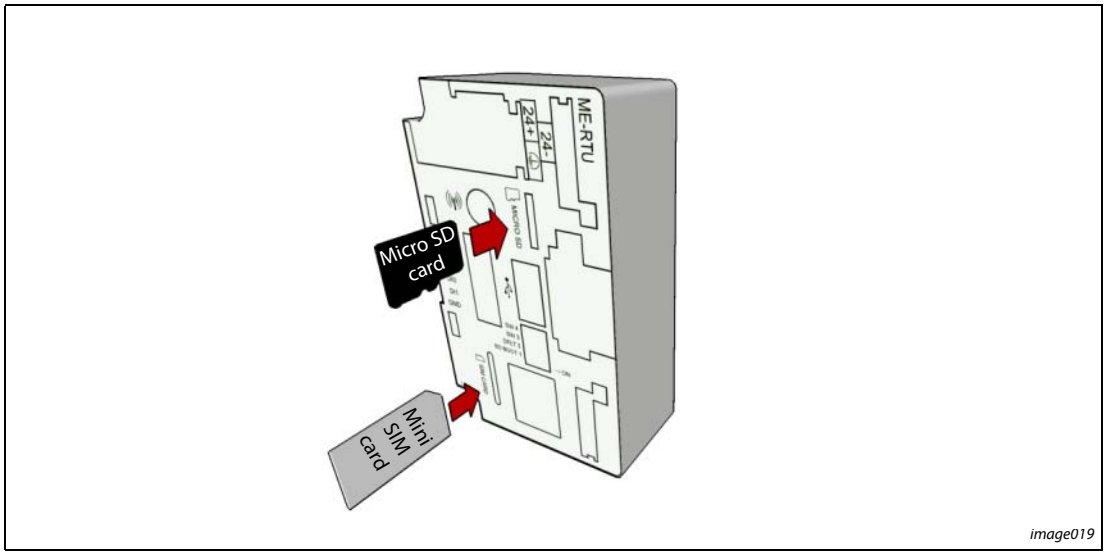


Fig. 4-4: *SIM card and micro-SD card insertion*

5 Features

The following features are supported in the ME-RTU.

Functionality	
DNP3 connectivity	DNP3 slave Level 2
	Ethernet, Serial (via USB to RS232 converter)
IEC 60870-5-101/104 connectivity	IEC 60870-5-101/104 slave support
PLC Q/L series connectivity	L series and Q (after SN11012): Socket communication
	Q (before SN11012): Fixed Buffer communication
Time synchronization	User defines where the time synchronization should be made from. Options are: PLC, SNTP servers, DNP3 or IEC 60870 Master (Controlling) stations.
Integrated I/Os	2 module digital inputs and 2 module digital outputs used as an expansion for the PLC IOs
Online PLC programming and monitoring	Online PLC programming and monitoring via cellular or local network
Communication channels	• Ethernet (10/100) • Cellular network (GPRS/EDGE) • USB Host (type A)
File transfers	FTP, SFTP
PPP	PPP for serial/USB modem connections
IT functionality	DNS, DDNS, SNMP, HTTP
VPN functionality	For secure communications

Tab. 5-1: *ME-RTU features*

5.1 Communication features

The ME-RTU supports three different communication interfaces for connection to SCADA, PLC and programming system:

Interface	To Device/Service	Protocol used
Ethernet interface	SCADA system	DNP3
		IEC 60870-5-104
	PLC	L series
		Q series
	Programing system	Transparent mode (FX3 PLC only)
Cellular interface	SCADA system	DNP3
		IEC 60870-5-104
	Programing system	Transparent mode (FX3 PLC only)
Serial via USB interface	SCADA system	DNP3
		IEC 60870-5-101

Tab. 5-2: *Communication features*

5.2 Functionality overview

The ME-RTU is an extension module for the Mitsubishi Electric PLCs which enables remote monitoring and controlling of processes. It supports the following interfaces:

- GPRS/EDGE is the communication path which enables the remote controlling station to connect to the ME-RTU via the cellular network and using DNP3 or IEC 60870-5-104 protocol.
- Ethernet (10/100) is the communication path to connect the ME-RTU to the Local network or the remote controlling station. On the local network there can also be the Q or L series PLCs.
- USB host (type A) is used as a backup path if the user wants to connect a custom radio modem.
- Irrespective of which of these data paths is in service, the ME-RTU can then communicate to the remote controlling station via the DNP3 or IEC 60870-5-101 protocol.

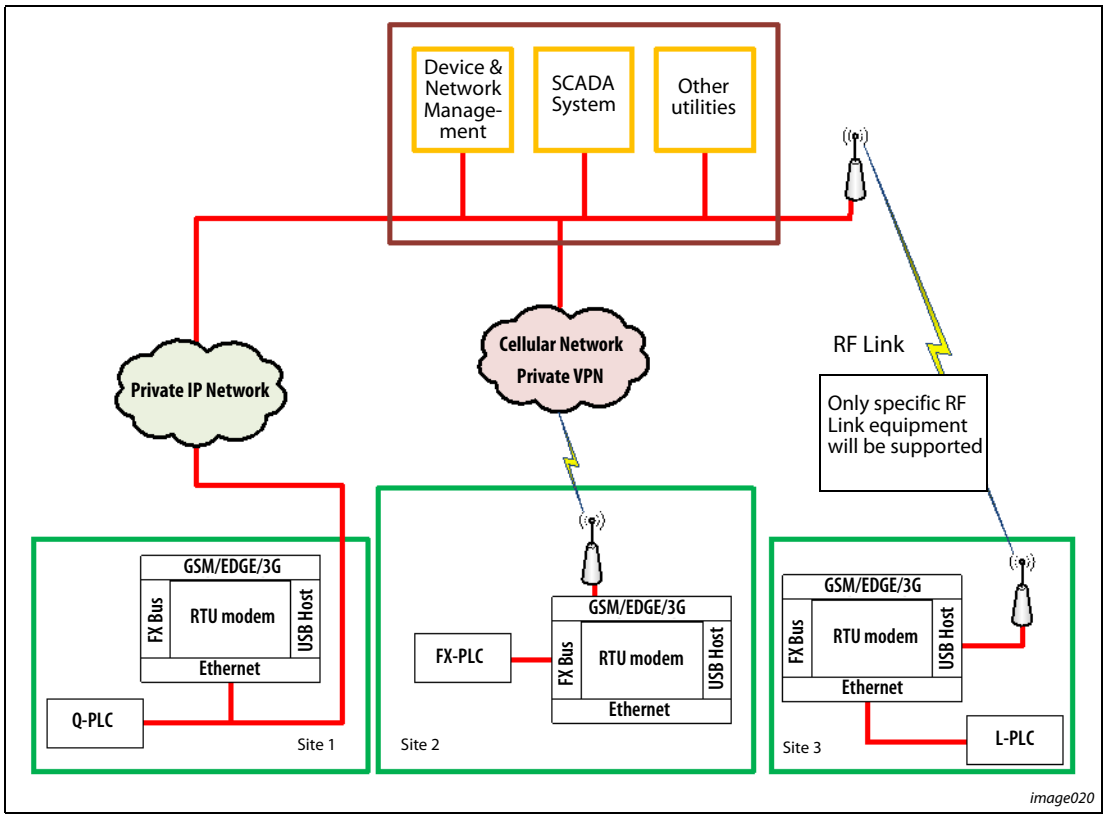


Fig. 5-1: *ME-RTU example system configuration*

5.2.1 PLC communication via FX Bus

The ME-RTU can communicate with the FX family of PLCs over the FX Bus (only bus-ME-RTU). That enables data exchange between the ME-RTU and the FX-PLC. In this configuration the PLC can be accessed from the PC to monitor the data (online monitoring) or transfer a program. This can be done using the cellular or the local network.

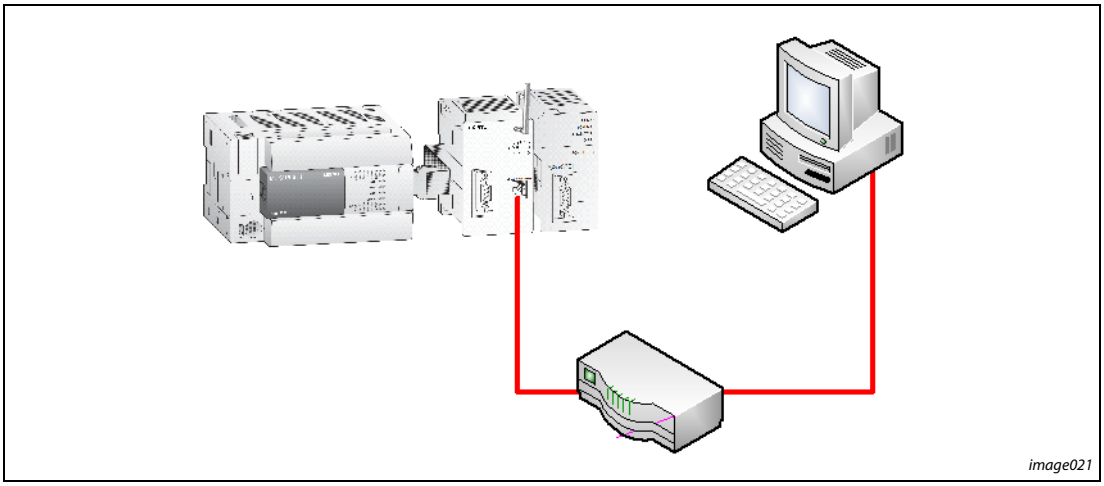


Fig. 5-2: *ME-RTU configuration using the FX-PLC*

5.2.2 Q and L series communication

The ME-RTU can also be used in combination with Q or L series PLC. The communication takes place over two different interfaces:

- Socket communication for L series and Q series (after SN11012)
- Fixed Buffer communication for Q series (before SN11012)

The interface allows the Q/L series PLC to accesses the internal BFM of the ME-RTU.

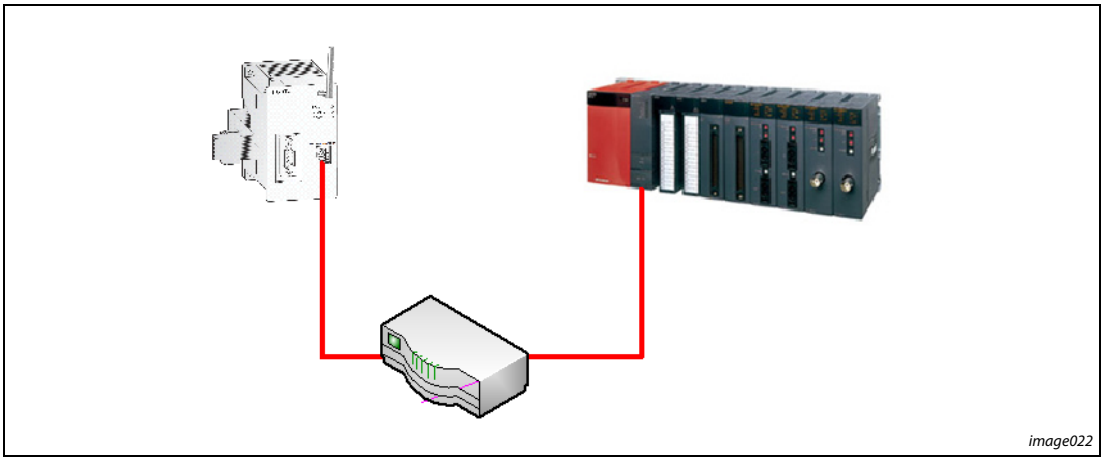


Fig. 5-3: *Q/L series configuration*

CAUTION:

If FX3 series PLC is connected to the ME-RTU via FX Bus and even though Q/L PLC type is selected (refer to Fig. 11-9), the FX3 PLC can still communicate with ME-RTU. This may cause data collision when writing to the same ME-RTU BFM address with FX3 series PLC and Q/L-series PLC.

5.2.3 Communication with remote controlling station via cellular network

The ME-RTU can communicate with the remote controlling station over the cellular network. The ME-RTU can be accessed using the DNP3 or IEC 60870-5-104 communication protocol. If the IP address is dynamically allocated, the ME-RTU IP address can be resolved using DDNS. To secure the data transfer a VPN connection can also be established.

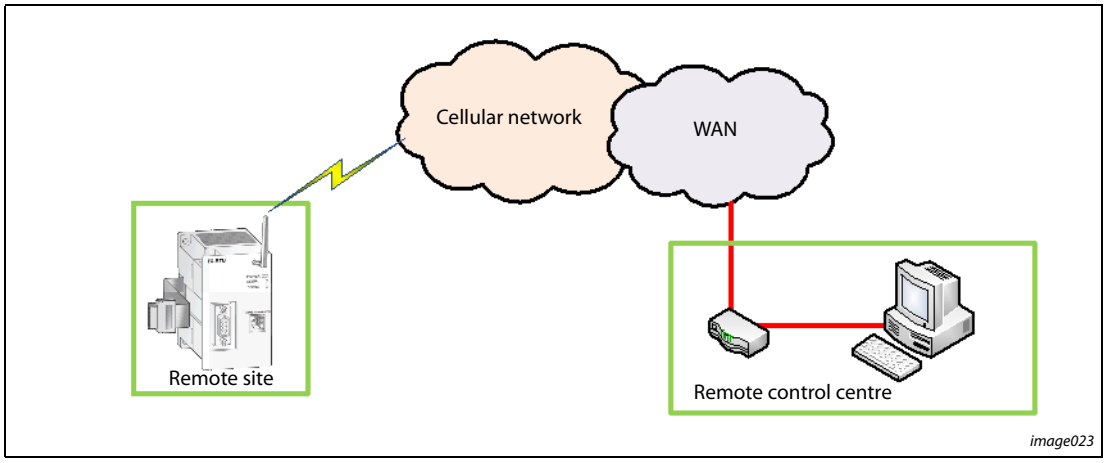


Fig. 5-4: *Communication via cellular network*

5.2.4 Communication with remote controlling station via Ethernet

The ME-RTU can communicate with the remote controlling station via the Ethernet network. The ME-RTU can be accessed using the DNP3 or IEC 60870-5-104 communication protocol. If the IP address is dynamically allocated, the ME-RTU IP address can be resolved using DDNS. To secure the data transfer a VPN connection can also be established.

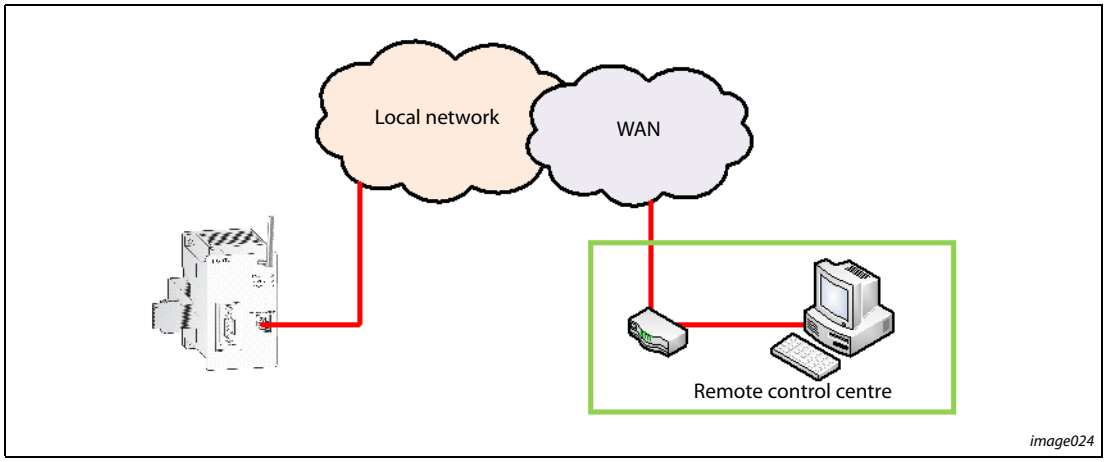


Fig. 5-5: *Communication via Ethernet network*

CAUTION:

If ME-RTU detects inoperability on Ethernet connection, the built-in watchdog timer will reset the ME-RTU.

5.2.5 Communication with remote controlling station via radio modem

The ME-RTU contains an USB port where an appropriate radio modem can be connected. If the modem isn't compatible with USB, an appropriate USB-to-serial converter can be used. In this case the ME-RTU can be accessed via the IEC 60870-5-101 protocol (serial version).

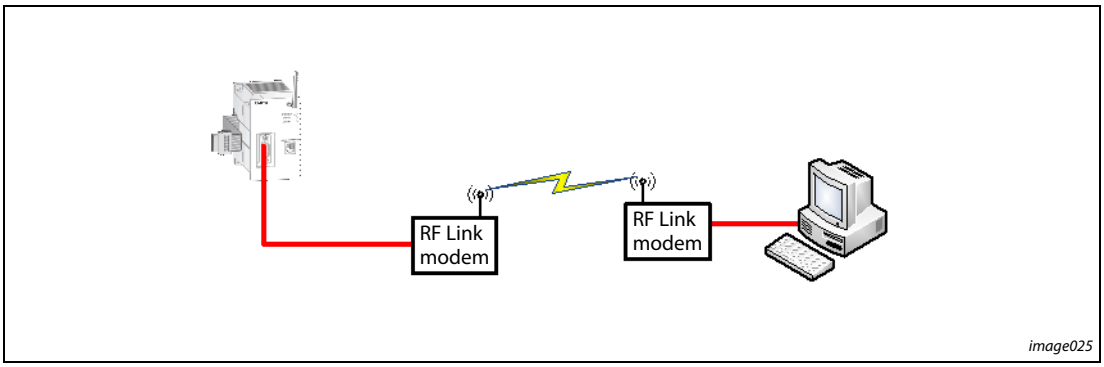


Fig. 5-6: *Communication via a radio modem*

5.2.6 Integrated web server

The ME-RTU has an integrated web server which allows a user-friendly way for configuring and diagnostic of the device. The web server can be accessed via the Ethernet port (refer to chapter 11.3 Configuring ME-RTU via Integrated Web Server, when configuring ME-RTU for the first time) or via the cellular network if VPN is established.

6 System Configuration

The following chapter describes the applicable PLC types and software packages. Minimum user functionality test is described in the last section.

6.1 Applicable systems

In the following chapter the applicable PLC types and software packages are described.

6.1.1 Applicable PLC types

PLC type	Supported interface	ME-RTU variant
FX3G	FROM/TODFROM/DTO	bus
FX3GC	FROM/TODFROM/DTO	bus
FX3U	FROM/TODFROM/DTO	bus
FX3UC ①	FROM/TODFROM/DTO	bus
Q Series	TCP/UDP Fixed Buffer Ethernet Communication	bus/non-bus ②
L Series	TCP/UDP Ethernet Socket Communication	bus/non-bus ②

Tab. 6-1: *Applicable PLC types*

① When connecting to FX3UC main unit, either FX3UC-1-PS-5V or FX2NC-CNV-IF module is required to connect the FX Bus.

② When bus variant is used with Q- or L-series PLC, use cable tie to affix the FX Bus cable firmly to ME-RTU housing, if bus-ME-RTU variant of the unit is used. However, it is strongly recommended to use a non-bus ME-RTU in conjunction with Q- or L-series PLCs.

6.1.2 Applicable software packages

For configuring the ME-RTU, the following software is needed:

- A standard web browser like Internet Explorer, Chrome or Firefox
- GX Works2, GX Developer or GX IEC Developer

CAUTION:

- ***The DWORD (32-bit – DINT, REAL) data type values cannot be modified with GXworks2's Batch monitor, GX Developer's Buffer memory batch or GX IEC Developer's Buffer memory batch monitor in order to assure that all 32 bits are written to BFM in one piece. These programs always use two consecutive TO instructions to write DWORD (32-bit) values.***
- ***To identify the BFM areas to which this rule applies, refer to Table 7-18 and Table 7-19 (DINT and REAL data types).***
- ***This rule does not apply to data flags.***

6.2 User functionality tests

The following tests define the minimal test procedures to define if the module is working normally.

6.2.1 Normal operation at first power on

Step	Operation	Expected results
1	Insert a SIM card	
2	Connect Ethernet cable to the ME-RTU and computer	Ethernet LEDs should turn ON at the Ethernet connector
3	Turn the power on	BOOT LED is blinking until the module initializes (up to 30 seconds) then the BOOT LED turns ON and then then the RUN LED must turn ON
4	Ping the ME-RTU on the default IP address	ME-RTU must reply
5	Enter the ME-RTU default IP address into the web browser.	An web page should be loaded
6	Configure network related settings and connect the GSM antenna	The GSM LED should be ON
7	Write from PLC allowed	Bit b1 in BFM#0 is set (end of boot procedure)

Tab. 6-2: *User testing steps*

7 Functions and Buffer Memory

The following sections describe the data storage and direction of data flow, the supported data types. The assignment of Buffer Memory (hereafter known as BFM) is explained, including the statuses BFM allocation and data allocation. Following, is the description for the time synchronization, power down and data retention, and Windows command line program for configuration transfer.

7.1 Data storage and flow

The ME-RTU stores its data in the internal database. The internal database stores the monitoring and control data, protocol specific data, and time tags etc. This data is exchanged between the PLC and controlling station. The data stored can be a basic data type or a structured data (e.g. double bool). For the user the internal database structure is hidden and direct access is blocked. The user can access the internal database via the buffer memory interface from the PLC or via the protocol data (such as DNP3 data objects).

The data is divided into two groups:

- **Input data** which represents the data from the process to the controlling station. This data is marked as read-only for the controlling station
- **Output data** which represents the data from the controlling station to the process. This data is marked as write-only for the controlling station.

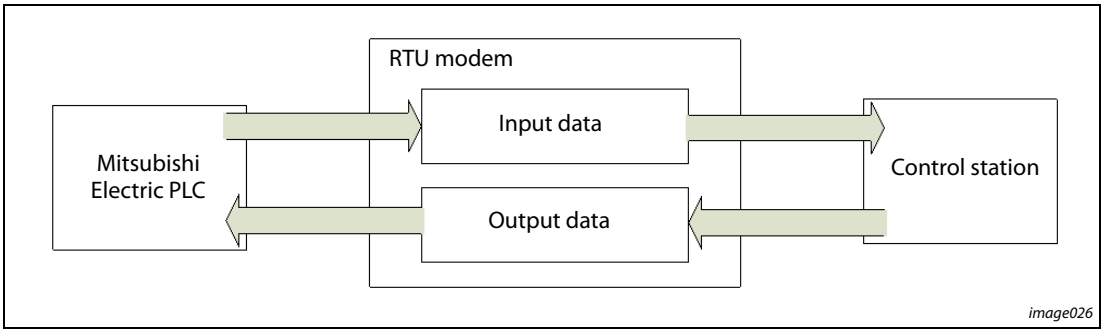


Fig. 7-1: *Data flow*

The input data value is stamped with a time tag in the ME-RTU, when the value is written into the database, if the ME-RTU has valid time and protocol events are enabled for the specific data type. The time-stamped data (events) can only be accessible by the telemetry protocols (DNP3 or IEC 60870-5101/104). The BFM shows only static (current) data.

7.2 Supported basic process data types

The process data types which are supported in the ME-RTU and applicable FX3 PLC access functions are shown in following table:

No.	IEC tag	Description	FX3 PLC access instructions
1	BOOL	Boolean value	TO/FROM, DTO/DFROM
2	WORD	16-bit packed binary	TO/FROM
3	INT	Signed integer	TO/FROM
4	DINT	Signed double integer	DTO/DFROM
5	REAL	Short floating point	DTO/DFROM

Tab. 7-1: *Supported data types*

7.3 Assignment of buffer memory

Data transmission and reception between the PLC and the ME-RTU is performed via the BFM. If the ME-RTU is used in combination with a FX3-series PLC, then the reading/writing of data must be performed by FROM/TO instructions (DFROM/DTO for certain data types – see Table 7-1). Otherwise, if the ME-RTU is used in combination with a Q/L PLC series, then the reading/writing of data is performed via the Ethernet Socket or Fixed Buffer Communication.

7.3.1 BFM user area

The BFM user area contains 31744 words of data which is used to exchange the data from/to the used PLC. In general the BFM user area is divided into two parts:

- ME-RTU configuration and statuses which is used to map statuses and configuration parameters
- Protocol data which is used to map the data to the telemetry communication protocols

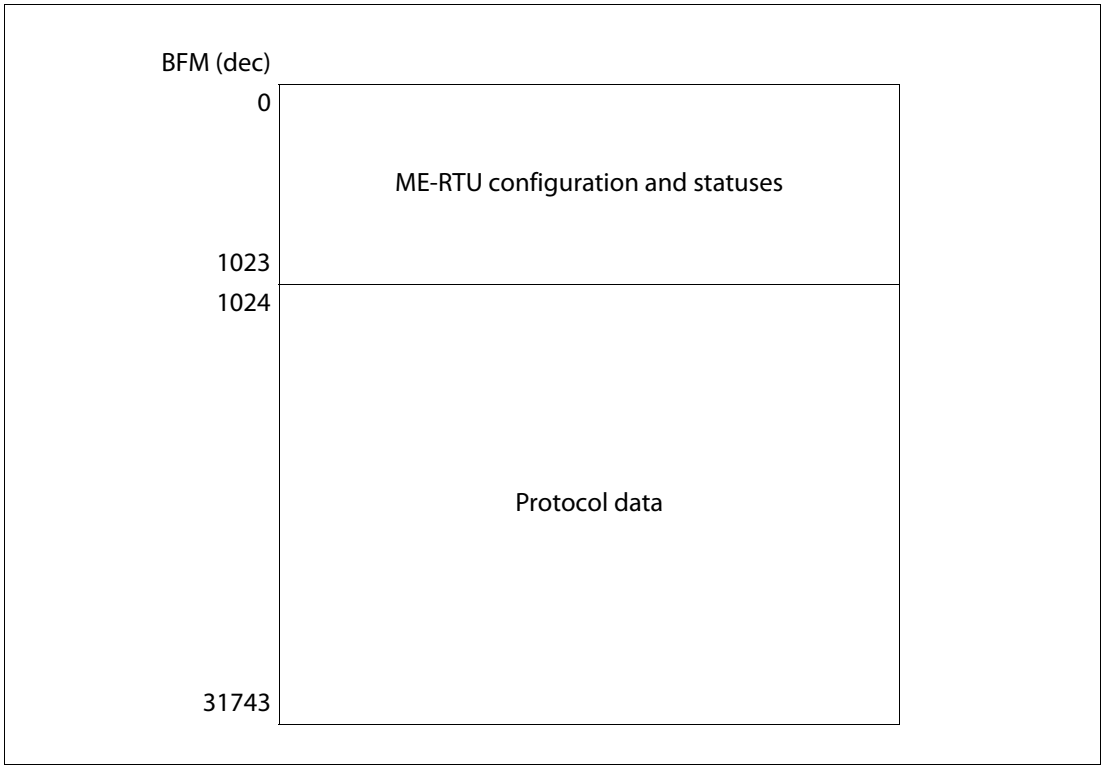


Fig. 7-2: *BFM user area*

7.3.2 ME-RTU configuration and statuses BFM area

The ME-RTU Configuration and statuses area is used to show module depending statuses and controls, settings and some diagnostic information. This area is not intended to provide an interface to change the module settings – for this purpose the Web interface is provided.

BFM address Decimal	Description	Initial value	PLC permission
0	Module Status	2	R
1	Mode Status	0	R
2	LED Status	3	R
3	DIP Switch Statuses	0	R
4	Digital Input values	0	R
5	Digital Output values	0	R
6	Reserved	0	R
7	PLC RTC – Year (0 to 99, lower two digits or 2000 to 2099)	0	R/W
8	PLC RTC – Month (1 to 12)	0	R/W
9	PLC RTC – Day (1 to 31)	0	R/W
10	PLC RTC – Hour (0 to 23)	0	R/W
11	PLC RTC – Minute (0 to 59)	0	R/W
12	PLC RTC – Second (0 to 59)	0	R/W
13	PLC RTC – Day of week (0-Sunday to 6-Saturday)	0	R/W
14	RTU RTC – Year (0 to 99, lower two digits or 2000 to 2099)	1970	R
15	RTU RTC – Month (1 to 12)	1	R
16	RTU RTC – Day (1 to 31)	1	R
17	RTU RTC – Hour (0 to 23)	1	R
18	RTU RTC – Minute (0 to 59)	1	R
19	RTU RTC – Second (0 to 59)	1	R
20	RTU RTC – Day of week (0-Sunday to 6-Saturday)	4	R
21	Reserved	0	R
22	Busy signal	0	R
23	BFM Buffer free space	4000	R
24	Q/L PLC heartbeat	0	R/W
25	Reserved	0	R
26	Reserved	0	R
27	Reserved	0	R
28	Reserved	0	R
29	Error status	0	R
30	Model code	K1060	R
31	Reserved	0	R
32	Communication Status and Control	0	R
33	DNP3 Error Code	0	R
34	IEC 60870-5-101 Error Code	0	R
35	IEC 60870-5-104 Error Code	0	R
36	Reserved	0	R
37	Reserved	0	R

Tab. 7-2: *ME-RTU configuration and statuses mapping (1)*

BFM address Decimal	Description	Initial value	PLC permission
38	Reserved	0	R
39	Module version number	100	R
40	Number of Binary Inputs	32	R
41	Number of Double Binary Inputs	32	R
42	Number of 16–bit Counters	4	R
43	Number of 32–bit Counters	4	R
44	Number of 16–bit Analog Inputs	4	R
45	Number of 32–bit Analog Inputs	4	R
46	Number of Short float Analog Inputs	4	R
47	Number of Binary Output	4	R
48	Number of 16–bit Analog Outputs	4	R
49	Number of 32–bit Analog Outputs	4	R
50	Number of Short float Analog Outputs	4	R
51	Ethernet IPv4 address (1 octet)	192	R
52	Ethernet IPv4 address (2 octet)	168	R
53	Ethernet IPv4 address (3 octet)	0	R
54	Ethernet IPv4 address (4 octet)	10	R
55	Ethernet IPv6 address (Word 1)	0	R
56	Ethernet IPv6 address (Word 2)	0	R
57	Ethernet IPv6 address (Word 3)	0	R
58	Ethernet IPv6 address (Word 4)	0	R
59	Ethernet IPv6 address (Word 5)	0	R
60	Ethernet IPv6 address (Word 6)	0	R
61	Ethernet IPv6 address (Word 7)	0	R
62	Ethernet IPv6 address (Word 8)	0	R

Tab. 7-2: *ME-RTU configuration and statuses mapping (2)*

The value of the words and bits which are not used or are reserved is set to 0.

Module status [BFM address 0]

The Module status is allocated as follows.

Bit No.	Name	Description
b0	Booting	During start-up (boot) time of the ME-RTU the Booting signal is ON. After the ME-RTU has completed the internal start-up procedure and all BFMs are initialized, the flag is set to OFF.
b1	Ready	During start-up (boot) time of the ME-RTU the Ready signal is OFF. After the ME-RTU has completed the internal start-up procedure and all BFMs are initialized, the flag is set to ON. Data exchange with BFM should start after this flag becomes ON.
b2 to b15	Reserved	

Tab. 7-3: *Module status BFM allocation*

Mode status [BFM address 1]

The Mode Status is allocated as follows.

Bit No.	Name	Description
b0	DNP3 Serial	When signal is ON the DNP3 Serial is active
b1	DNP3 Ethernet	When signal is ON the DNP3 Ethernet is active
b2	IEC 60870-5-101	When signal is ON the IEC 60870-101 is active
b3	IEC 60870-5-104	When signal is ON the IEC 60870-104 is active
b4 to b15	Reserved	

Tab. 7-4: *Mode settings BFM allocation*

LED Statuses [BFM address 2]

The LED Status is allocated as follows.

Bit No.	Name	Description
b0	RUN	Value of Led 1
b1	BOOT	Value of Led 2
b2	USER	Value of Led 3
b3	FXBUS	Value of Led 4
b4	HW ERR	Value of Led 5
b5	SW ERR	Value of Led 6
b6	COM ERR	Value of Led 7
b7	GSM ERR	Value of Led 8
b8	GSM CONN	Value of Led 9
b9	GSM STATUS	Value of Led 10
b10	PROT 0	Value of Led 11
b11	PROT 1	Value of Led 12
b12	DO 0	Value of Led 13
b13	DO 1	Value of Led 14
b14	DI 0	Value of Led 15
b15	DI 1	Value of Led 16

Tab. 7-5: *LED Statuses BFM allocation*

DIP Switch Statuses [BFM address 3]

The DIP switch statuses are allocated as follows.

Bit No.	Name	Description
b0	DIP1	Value of DIP switch 1
b1	DIP2	Value of DIP switch 2
b2	DIP3	Value of DIP switch 3
b3	DIP4	Value of DIP switch 4
b4 to b15	Reserved	

Tab. 7-6: *LED Statuses BFM allocation*

Digital inputs values [BFM address 4]

The digital input values are allocated as follows.

Bit No.	Name	Description
b0	DI0	Current value of digital input 0
b1	DI1	Current value of digital input 1
b2 to b15	Reserved	

Tab. 7-7: *Digital inputs BFM allocation*

Digital output values are [BFM address 5]

The digital output values are allocated as follows.

Bit No.	Name	Description
b0	DO0	Current value of digital output 0
b1	DO1	Current value of digital output 1
b2 to b15	Reserved	

Tab. 7-8: *Digital outputs BFM allocation*

PLC RTC [BFM addresses from 7 to 13]

On these BFM locations the current PLC real time clock is allocated. These values are written by the PLC and are used for synchronizing ME-RTU's internal clock on the start-up.

BFM address	Name	Description
7	PLC RTC – Year (0 to 99, lower two digits)	The RTC year value which is in range from 0 to 99 and is located on the lower two digits (lower byte)
8	PLC RTC – Month (1 to 12)	The RTC month value which is in range from 1 to 12
9	PLC RTC – Day (1 to 31)	The RTC day value which is in range from 1 to 31
10	PLC RTC – Hour (0 to 23)	The RTC hour value which is in range from 0 to 23
11	PLC RTC – Minute (0 to 59)	The RTC minute value which is in range from 0 to 59
12	PLC RTC – Second (0 to 59)	The RTC second value which is in range from 0 to 59
13	PLC RTC – Day of week (0-Sunday to 6-Saturday)	The RTC day of weak value which can consist the following values: • 0 – Sunday • 1 – Monday • 2 – Tuesday • 3 – Wednesday • 4 – Thursday • 5 – Friday • 6 – Saturday

Tab. 7-9: *PLC RTC allocation*

RTU RTC [BFM addresses 14 to 20]

On these BFM locations the current ME-RTU real time clock is allocated. These values are written by the ME-RTU.

BFM address	Name	Description
14	RTU RTC – Year (0 to 99, lower two digits)	The RTC year value which is in range from 0 to 99 and is located on the lower two digits (lower byte)
15	RTU RTC – Month (1 to 12)	The RTC month value which is in range from 1 to 12
16	RTU RTC – Day (1 to 31)	The RTC day value which is in range from 1 to 31
17	RTU RTC – Hour (0 to 23)	The RTC hour value which is in range from 0 to 23
18	RTU RTC – Minute (0 to 59)	The RTC minute value which is in range from 0 to 59
19	RTU RTC – Second (0 to 59)	The RTC second value which is in range from 0 to 59
20	RTU RTC – Day of week (0-Sunday to 6-Saturday)	• The RTC day of weak value which can consist the following values: • 0 – Sunday • 1 – Monday • 2 – Tuesday • 3 – Wednesday • 4 – Thursday • 5 – Friday • 6 – Saturday

Tab. 7-10: *ME-RTU RTC allocation*

Busy signal [BFM address 22]

BFM Buffer size may fill up after fast multiple successive requests by the FX3 PLC (TO/DTO) are sent to ME-RTU via FX Bus. The Buffer frees-up, as the requests are being processed. If the size of BFM Buffer drops under 100 WORDs, the status bit is set as follows:

Bit No.	Name	Description
b0	BFM Buffer full status	If this bit is set, then a BFM Buffer has less than 100 WORDs free. Stop sending request until Buffer is freed.
b1 to b15	Reserved	

Tab. 7-11: *BFM Buffer size status*

BFM Buffer free space signal [BFM address 23]

The current free size of BFM Buffer is displayed at this location. The maximum size of BFM Buffer is 4000 Words. This BFM is only accessible by FX3 PLC via FX Bus. The value of this BFM is not available to BFM Debug Web page and Q/L-series PLC.

Q/L PLC heartbeat [BFM address 24]

To this BFM location an incrementing value from 1 to 10000 is written by Q/L PLC periodically with period configured in function block. If the value is not incremented within 60 seconds, the PLC Ethernet communication status bit (b0) in Table 7-14 is cleared.

Error Status [BFM address 29]

The Error statuses are allocated as follows.

Bit No.	Name	Description
b0	General error	If this bit is set, then a serious error is present (one bit is set from b1 to b7)
b1	Ethernet error	If this bit is set, then an Ethernet error is present on the ME-RTU and for more information the ME-RTU should be checked
b2	GSM error	If this bit is set, then a GSM error (e.g. no connection) is present on the ME-RTU and for more information the ME-RTU should be checked
b3	Reserved	
b4	Reserved	
b5	DNP3 error	If this bit is set, an error occurred on the DNP3 communication system. A detailed description can be found in the DNP3 Error Status register.
b6	IEC 60870-5-101 error	If this bit is set, an error occurred on the IEC 60870-5-101 communication system
b7	IEC 60870-5-104 error	If this bit is set, an error occurred on the IEC 60870-5-104 communication system
b8	Reserved	
b9	FX3 PLC STOP	Turns ON if FX3 PLC goes to STOP
b10 to b15	Reserved	

Tab. 7-12: *Error statuses BFM allocation*

Module code [BFM address 30]

Shows the ME-RTU Module Code K1060, which is a unique identifier of the module.

Communication Control Status [BFM address 32]

The Communication Status and Control status are allocated as follows.

Bit No.	Name	Description
b0	PLC Ethernet	When signal is ON the Ethernet with PLC connection is active (communication with Q and L PLCs via Ethernet)
b1	GSM	When signal is ON the GSM connection is active
b2	GPRS-EDGE	If this bit is set, then a GSM error (e. g. no connection) is present on the ME-RTU and for more information the ME-RTU should be checked
b3	Reserved	
b4	Reserved	
b5	Reserved	
b6	Reserved	
b7	PLC FX3	When signal is ON, the FX3 PLC is running. When signal is OFF, the FX3 PLC is in STOP or RESET mode.
b8 to b15	Reserved	

Tab. 7-13: *Communication Control Status BFM allocation*

DNP3 Error Code [BFM address 33]

Shows error code returned by the DNP3 protocol. Error codes are described in Table 7-14. If no error is present value is 0.

IEC 60870-5-101 Error Code [BFM address 34]

Shows error code returned by IEC 60870-5-101 protocol. Error codes are described in Table 7-14. If no error is present value is 0.

IEC 60870-5-104 Error Code [BFM address 35]

Shows error code returned by IEC 60870-5-104 protocol. Error codes are described in Table 7-14. If no error is present value is 0.

Error number	Description
0	No error
1	Intercharacter timeout occurred
2	Remote side of channel closed connection
3	Incoming frame exceeded buffer size
4	Received frame was for an unknown link address
5	Illegal link function code in received frame
6	Invalid checksum or CRC
7	Link has not been reset, frame rejected
8	Received invalid frame count bit
9	Did not receive correct starting sync char
10	Entire frame was not received in specified time
11	Link Confirm was not received in specified time
12	Link status response not received in specified time
13	Response was not from expected session
14	Received unexpected reply, frame rejected
15	Did not receive correct second sync char
16	Did not receive correct ending sync character
17	Variable length bytes in FT1.2 frame did not match
18	Received invalid dir bit in control octet
19	Confirm of 104 U-format APDU not received
20	Acknowledge of 104 I-format APDU not received
21	Unknown confirming sequence number in received APDU
22	Received APDU not in sequence with previous APDU
23	Sequence number error

Tab. 7-14: *Protocols error numbers description*

Module version number [BFM address 39]

Shows the ME-RTU Module Version, which is used to identify the supported functionalities.

Internal database configuration [BFM addresses from 40 to 50]

On these BFM locations the actual ME-RTU internal database configuration is allocated.

BFM address	Name	Description
40	Number of Binary Inputs	The actual number of Binary Inputs
41	Number of Double Binary Inputs	The actual number of Double Binary Inputs
42	Number of 16 – bit Counters	The actual number of 16 – bit Counters
43	Number of 32 – bit Counters	The actual number of 32 – bit Counters
44	Number of 16 – bit Analog Inputs	The actual number of 16 – bit Analog Inputs
45	Number of 32 – bit Analog Inputs	The actual number of 32 – bit Analog Inputs
46	Number of Short float Analog Inputs	The actual number of Short float Analog Inputs
47	Number of Binary Output	The actual number of Binary Output
48	Number of 16 – bit Analog Outputs	The actual number of 16 – bit Analog Outputs
49	Number of 32 – bit Analog Outputs	The actual number of 32 – bit Analog Outputs
50	Number of Short float Analog Outputs	The actual number of Short float Analog Outputs

Tab. 7-15: *ME-RTU RTC allocation*

Ethernet IPv4 address [BFM addresses from 51 to 54]

On these BFM locations the current Ethernet interface IPv4 address is mapped. If DHCP is used and the module hasn't acquired a valid address yet or the address is not valid then this fields have value 0.0.0.0.

BFM address	Name	Description
51	Ethernet IP address (octet 1)	First octet of the actual IP address
52	Ethernet IP address (octet 2)	Second octet of the actual IP address
53	Ethernet IP address (octet 3)	Third octet of the actual IP address
54	Ethernet IP address (octet 4)	Fourth octet of the actual IP address

Tab. 7-16: *Ethernet IPv4 address BFM field*

Ethernet IPv6 address [BFM address from 55 to 62]

On these BFM locations the current Ethernet interface IPv6 address is mapped.

BFM address	Name	Description
55	Ethernet IPv6 address (Word 1)	Word 1 of the 128-bit Ethernet IPv6 address
56	Ethernet IPv6 address (Word 2)	Word 1 of the 128-bit Ethernet IPv6 address
57	Ethernet IPv6 address (Word 3)	Word 1 of the 128-bit Ethernet IPv6 address
58	Ethernet IPv6 address (Word 4)	Word 1 of the 128-bit Ethernet IPv6 address
59	Ethernet IPv6 address (Word 5)	Word 1 of the 128-bit Ethernet IPv6 address
60	Ethernet IPv6 address (Word 6)	Word 1 of the 128-bit Ethernet IPv6 address
61	Ethernet IPv6 address (Word 7)	Word 1 of the 128-bit Ethernet IPv6 address
62	Ethernet IPv6 address (Word 8)	Word 1 of the 128-bit Ethernet IPv6 address

Tab. 7-17: *Ethernet IPv6 address BFM field*

CAUTION:

IPv6 is not yet fully supported and cannot be used as communication interface for applications (Web User Interface, Q/L PLC connectivity, VPN tunnelling, etc.).

7.3.3 Protocol data BFM area

The protocol data BFM area is used to map the data to the network communication protocol. The protocol data is divided into two parts:

- Input data: is data which is transferred from the PLC to the remote master. The following data groups are available in the input protocol data.

Data group	Data type	PLC permission	Remote master permission	Description
Binary Input	WORD (16 in single WORD)	R/W	R	Data representing physical digital inputs or program flags
Double Binary Input	WORD (grouped as 2 BOOLs – 8 in single WORD)	R/W	R	Data representing physical digital inputs used by the same device representing 4 states (ON, OFF and two intermediate states)
16 – bit Counters	INT	R/W	R	Data representing 16-bit counters
32 – bit Counters	DINT	R/W	R	Data representing 32-bit counters
16 – bit Analog Inputs	INT	R/W	R	Data representing 16-bit physical analog inputs or internal values
32 – bit Analog Inputs	DINT	R/W	R	Data representing 32-bit physical analog inputs or internal values
Short float Analog Inputs	REAL	R/W	R	Data representing short float physical analog inputs or internal values

Tab. 7-18: *Input data*

- Output data: is data which is transferred to the PLC from the remote master. The following data groups are available in the output protocol data.

Data group	Data type	PLC permission	Remote master permission	Description
Binary Output	WORD	R	R/W	Data representing physical digital outputs or program flags
16 – bit Analog Outputs	INT	R	R/W	Data representing 16-bit physical analog outputs or internal values
32 – bit Analog Outputs	DINT	R	R/W	Data representing 32-bit physical analog outputs or internal values
Short float Analog Outputs	REAL	R	R/W	Data representing short float physical analog outputs or internal values

Tab. 7-19: *Output data*

7.3.4 Mapping of the protocol data into the BFM

The protocol data is mapped into sections. Each data group is mapped into its own section. Also each data group has a section reserved for signal flags, whose structure is depended on the used protocol.

Input protocol data starts at address 1024 in the BFM. Each section with data is 512 words long. The size of data flags is adjusted to number of maximum data point of each type. If the PLC is in STOP state then an appropriate flags are set which indicates that the signals are offline.

BFM address (dec)		PLC perm.
1024	Binary Input	RO ①
1025		R/W
1535		
1536	Binary Inputs Flags	RO ①
1544		R/W ②
5631		
5632	Double Binary Input	R/W
6143		
6144	Binary Double Inputs Flags	R/W ②
8191		
8192	16-bit Counters	R/W ③
8703		
8704	16-bit Counter Flags	R/W ②
8959		
8960	32-bit Counters	R/W ④
9471		

BFM address (dec)		PLC perm.
9472	32-bit Counter Flags	R/W ②
9599		
9600	16-bit Analog Inputs	R/W ③
10111		
10112	16-bit Analog Inputs Flags	R/W ③
10367		
10368	32-bit Analog Inputs	R/W ④
10879		
10880	32-bit Analog Inputs Flags	R/W ②
11007		
11008	Short Float Analog Inputs	R/W ④
11519		
11520	Short Float Analog Inputs Flags	R/W ②
11647		

Tab. 7-20: *Mapping of Input protocol data into the BFM*

① First WORD is only accessible by module digital inputs. The PLC cannot write to this BFM area. PLC cannot set flags for first 16 points. The ONLINE/VALID flags is set automatically.

② The first bit b0 is not settable by PLC. This bit is modified automatically when data value is written, PLC goes to STOP or communication with PLC is lost.

③ Write access only by TO instruction

④ Write access only by DTO instruction

Output protocol data starts on address 16384 in the BFM. Each data section is 512 words long. The size of flags is adjusted to number of maximum data. If the PLC is in STOP state then the PLC flags are ignored and appropriate flags are set which indicates that the signals are offline.

BFM address (dec)		PLC perm.
16384 16895	Binary Output	RO
16896	Binary Output Flags	RO
16904 20991		R/W
20992 21503	16-bit Analog Outputs	RO
21504 21759	16-bit Analog Outputs Flags	R/W
21760 22271	16-bit Analog Outputs Actual Values	R/W ①
22272 22783	32-bit Analog Outputs	RO
22784 22911	32-bit Analog Outputs Flags	R/W
22912 23423	32-bit Analog Outputs Actual Values	R/W ②
23424 23935	Short Float Analog Outputs	RO
23936 24063	Short Float Analog Outputs Flags	R/W
24064 24576	Short Float Analog Outputs Actual Values	R/W ②

Tab. 7-21: *Mapping of Output protocol data into the BFM*

① Write access only by TO instruction

② Write access only by DTO instruction

7.3.5 Default and maximum data configuration of BFM

At the first start-up, all groups have a default configuration of the available points inside a data group. The default configuration and maximum number of elements available is shown in following table. The amount of data types are quite small because the larger amount of data increase the PLC cycle time. Setting number of elements of multiple data types to maximum will result in increase of traffic and slow down the ME-RTU. If those default values are too small for user application, then the number of every data type could be increased in the configuration settings.

	Default number of elements (dec)	Resulting BFM Address (dec)	Maximum number of elements (dec)
Number of Binary Inputs	32	1024–1025	8192
Number of Double Binary Inputs	32	5632–5635	4096
Number of Binary Counters (16-bit)	4	8192–8195	512
Number of Binary Counters (32-bit)	4	8960–8967	256
Number of Analog Input (16-bit)	4	9600–9603	512
Number of Analog Input (32-bit)	4	10368–10374	256
Number of Analog Input (float)	4	11008–11014	256
Number of Binary Outputs	4	16384–16894	8192
Number of Analog Output (16-bit)	4	20992–20996	512
Number of Analog Output (32-bit)	4	22272–22280	256
Number of Analog Output (float)	4	23424–23432	256

Tab. 7-22: *Default and maximum data configuration*

7.3.6 Data groups

Binary inputs

Binary inputs are signals which are represented in the application as physical digital inputs or software flags. The user has to write an actual value of the digital input into an appropriate BFM location (bits are grouped into words).

The mapping of the digital input values in the BFM area starts at the address 1024. The data points are mapped into 16-bit packed BOOLs. Binary inputs located on BFM address 1024 are reserved for binary inputs located on ME-RTU and their value should not be set by the PLC (can only be read using FROM (16-bit) or DFROM (32-bit) instruction). The values of BI0 and BI1 are set by module digital inputs. Binary inputs at BFM address 1025 or higher may be controlled by PLC using TO/FROM (16-bit) or DTO/DFROM (32-bit) instructions.

After the data values, the flags of the data points are mapped to address 1536. User writes the flags of the data points into the appropriate flag bit for a specific data point. The structure of the flags is protocol dependent:

- For DNP3 flags mapping refer to section 9.4.1 Binary Inputs, Table 9-5
- For IEC 60870-5 flags mapping refer to section 10.4.1 Binary inputs, Table 10-3

BFM address (dec)																	PLC perm.	Data type
1024	BI15	BI14	BI13	BI12	BI11	BI10	BI9	BI8	BI7	BI6	BI5	BI4	BI3	BI2	BI1	BI0	RO	WORD
1025	BI31	BI30	BI29	BI28	BI27	BI26	BI25	BI24	BI23	BI22	BI21	BI20	BI19	BI18	BI17	BI16	R/W	WORD
….	…																R/W	WORD
1535	BI 8191	BI 8190	BI 8189	BI 8188	BI 8187	BI 8186	BI 8185	BI 8184	BI 8183	BI 8182	BI 8181	BI 8180	BI 8179	BI 8178	BI 8177	BI 8176	R/W	WORD

Tab. 7-23: *Binary Inputs BFM mapping*

CAUTION:

Binary Inputs on BFM address 1024 are used by the system and should not be used on the PLC side. The BI0 and BI1 are the locations to which module digital Inputs DI0 and DI1 values are mapped. Also take this into consideration when defining number of Binary Inputs in database.

Double binary inputs

Double binary inputs are signals which are represented in the application as physical digital inputs or software flags which have four logical states (ON, OFF, Intermediate and Invalid). The user has to write an actual value of the double binary input into an appropriate BFM location (bits are grouped into words).

The mapping of the double binary input values in the BFM area starts on the address 5632. The 8 data points are mapped into a word and grouped into 2 bits for each data and may be controlled by PLC using TO/FROM (16-bit) or DTO/DFROM (32-bit) instructions.

After the data values, the flags of the data points are mapped in the BFM area which starts at address 6144. User writes the flags of the data points into the appropriate flags bit for a specific data point. The structure of the flags is protocol dependent:

- For DNP3 flags mapping refer to section 9.4.2 Double Binary inputs, Table 9-6
- For IEC 60870-5 flags mapping refer to section 10.4.2 Double Binary inputs, Table 10-6

BFM address (dec)									PLC perm.	Data type
5632	DBI7	DBI6	DBI5	DBI4	DBI3	DBI2	DBI1	DBI0	RO	WORD
5633	DBI15	DBI14	DBI13	DBI12	DBI11	DBI10	DBI9	DBI8	R/W	WORD
….	…								R/W	WORD
6143	DBI4095	DBI4094	DBI4093	DBI4092	DBI4091	DBI4090	DBI4089	DBI4088	R/W	WORD

Tab. 7-24: *Double Binary Input BFM mapping*

Binary outputs

Binary outputs are signals which are represented in the application as physical digital outputs or software flags. The user has to read the actual value of a binary output in the BFM and map it into the appropriate physical output or marker of the PLC.

The mapping in the BFM area starts at the address 16384. The data is mapped into a 16-bit packed binary. From this area the user reads the value of the requested digital output by PLC using FROM (16-bit) or DFROM (32-bit) instructions. Binary outputs BO0 and BO1 at BFM address 16384 are mapped to ME-RTU module digital outputs DO0 and DO1.

After the data values, the flags of the signals are mapped in the BFM area which starts at address 16896. User writes the flags of the signal into the appropriate flags bit for specific signal. Structure of the flags is protocol dependent:

- For DNP3 flags mapping refer to section 9.4.5 Binary Outputs, Table 9-15
- Not supported in IEC 60870-5

BFM address (dec)																	PLC perm.	Data type
16384	BO15	BO14	BO13	BO12	BO11	BO10	BO9	BO8	BO7	BO6	BO5	BO4	BO3	BO2	BO1	BO0	RO	WORD
16385	BO31	BO30	BO29	BO28	BO27	BO26	BO25	BO24	BO23	BO22	BO21	BO20	BO19	BO18	BO17	BO16	RO	WORD
….	…																RO	WORD
16895	BO 8191	BO 8190	BO 8189	BO 8188	BO 8187	BO 8186	BO 8185	BO 8184	BO 8183	BO 8182	BO 8181	BO 8180	BO 8179	BO 8178	BO 8177	BO 8176	RO	WORD

Tab. 7-25: *Binary Output BFM mapping*

Binary counters

Binary counters are values used for counting events in the application. The user has to write the actual value of a counter into an appropriate BFM location. The mapping of the binary counter values in the BFM area starts at the address 8192. There are two types of counters:

- 16-bit counters – located in one BFM location (one word) and starts at the address 8192. May be controlled by PLC using TO/FROM (16-bit) instructions.
- 32-bit counters – located in two BFM locations (two words) and starts at the address 8960. May be controlled by PLC using DTO/DFROM (32-bit) instructions.

After the data values, the flags are mapped in the BFM area which starts at address 8704 for 16-bit counters and 9472 for 32-bit counters. User writes the flags of the signal into the appropriate flags bits for specific signal. Structure of the flags is protocol dependent:

- For DNP3 flags mapping refer to section 9.4.3 Counters, Table 9-8 for 16-bit and Table 9-9 for 32-bit counters
- For IEC 60870-5 flags mapping refer to section 10.4.3 32-bit Counters, Table 10-8 for 32-bit counters. 16-bit counters are not supported.

BFM address (dec)		PLC perm.	Data type
8192	BC0 16-bit	R/W	INT
8193	BC1 16-bit	R/W	INT
8194	BC2 16-bit	R/W	INT
…	…	R/W	INT
8703	BC511 16-bit	R/W	INT

Tab. 7-26: *16-bit Binary Counters BFM mapping*

BFM address (dec)		PLC perm.	Data type
8960	DBC0 32-bit	R/W	DINT
8962	DBC1 32-bit	R/W	DINT
…	…	R/W	DINT
9470 9471	DBI255 32-bit	R/W	DINT

Tab. 7-27: *32-bit Binary Counters BFM mapping*

Analog inputs

Analog inputs are values which represent an analog input in the application or a calculation value inside PLC registers. The user has to write the actual values into the appropriate BFM locations.

The mapping in the BFM area starts at the address 9600. At first all the data values are mapped. There are three types of analog inputs:

- 16-bit analog inputs – located in one BFM location (1 word) and starts at the address 9600. May be controlled by PLC using TO/FROM (16-bit) instructions.
- 32-bit analog inputs – located in two BFM locations (2 word) and starts at the address 10368. May be controlled by PLC using DTO/DFROM (32-bit) instructions.
- Float analog inputs – located in two BFM locations (2 word) and starts at the address 11008. May be controlled by PLC using DTO/DFROM (32-bit) instructions.

After the data values, the flags are mapped in the BFM area which starts at address 10112 for 16-bit Analog Inputs, 10880 for 32-bit Analog Inputs and 11520 for Float Analog Inputs. User writes the flags of the signal into the appropriate flags bits for specific signal. Structure of the flags is protocol dependent:

- For DNP3 flags mapping refer to section 9.4.4 Analog inputs, Table 9-11 for 16-bit, Table 9-12 for 32-bit and Table 9-13 for Short Floating Point Analog Inputs
- For IEC 60870-5 flags mapping refer to section 10.4.4 Analog Inputs, Table 10-10 for 16-bit and Table 10-11 for Short Floating Point Analog Inputs. 32-bit Analog Inputs are mapped as 32-Bit string, refer to section 10.4.4 Analog Inputs, Table 10-12.

BFM address (dec)		PLC perm.	Data type
9600	AI0 16-bit	R/W	INT
9601	AI1 16-bit	R/W	INT
9602	AI2 16-bit	R/W	INT
	…	R/W	INT
10111	AI511 16-bit	R/W	INT

Tab. 7-28: *16-bit Analog Inputs BFM mapping*

BFM address (dec)		PLC perm.	Data type
10368	DAI0 32-bit	R/W	DINT
10370	DAI1 32-bit	R/W	DINT
	…	R/W	DINT
10878 10879	DAI255 32-bit	R/W	DINT

Tab. 7-29: *32-bit Analog Inputs BFM mapping*

BFM address (dec)		PLC perm.	Data type
11008	RAI0 float	R/W	REAL
11010	RAI1 float	R/W	REAL
	…	R/W	REAL
11518 11519	RAI255 float	R/W	REAL

Tab. 7-30: *Short Floating Point Analog Inputs BFM mapping*

Analog Outputs

Analog Outputs are values which represent an analog output in the application or a value of a software registers (like set points). The user has to read the values from the BFM and write them into the appropriate physical analog outputs or PLC registers.

The mapping in the BFM area starts at the address 20992. At first all the data is mapped. There are three types of analog inputs:

- 16-bit analog outputs – located in one BFM location (one word) and starts at the address 20992. May be read by PLC using FROM (16-bit) instruction.
- 32-bit analog outputs – located in two BFM locations (two words) and starts at the address 22272. May be read by PLC using DFROM (32-bit) instruction.
- Float analog outputs – located in two BFM locations (one word) and starts at the address 23424. May be read by PLC using DFROM (32-bit) instruction.

After the data values, the flags of the signals are mapped. The user writes the flags of the signal into the appropriate BFM flags bits for the specific signal. Structure of the flags is protocol dependent:

- For DNP3 flags mapping refer to section 9.4.6 Analog outputs, Table 9-17 for 16-bit, Table 9-19 for 32-bit and Table 9-21 Short Floating Point Analog Outputs
- Not supported in IEC 60870-5

After the flags, the actual values of signals are mapped. The user writes the actual values of the signals into appropriate BFM locations. Analog outputs actual values are protocol dependant:

- For DNP3 mapping refer to section 9.4.6 Analog outputs, Table 9-17 for 16-bit, Table 9-19 for 32-bit and Table 9-21 for Short Floating Point Analog Outputs Actual Values.
- Not supported in IEC 608760-5

BFM address (dec)		PLC perm.	Data type
20992	AO0 16-bit	RO	INT
20993	AO1 16-bit	RO	INT
20994	AO2 16-bit	RO	INT
	…	RO	INT
21503	AO511 16-bit	RO	INT

Tab. 7-31: *16-bit Analog Outputs BFM mapping*

BFM address (dec)		PLC perm.	Data type
22272	DAO0 32-bit	RO	DINT
22274	DAO1 32-bit	RO	DINT
…	…	RO	DINT
22782 22783	DAO255 32-bit	RO	DINT

Tab. 7-32: *32-bit Analog Outputs BFM mapping*

BFM address (dec)		PLC perm.	Data type
23424	RAO0 float	RO	REAL
23426	RAO1 float	RO	REAL
…	…	RO	REAL
23934 23935	RAO255 float	RO	REAL

Tab. 7-33: *Short Floating Point Analog Outputs BFM mapping*

7.4 Time synchronization

The ME-RTU has to be time-synchronized every time when it turns on and during the operation. ME-RTU can perform synchronization with any of the following sources:

- PLC
- SNTP server
- Control station

The ME-RTU Clock time directly affects the following functionalities:

- Telemetry protocol event data
- VPN connectivity

Telemetry protocols need valid clock in order to generate event. Clock is considered valid, when clock and date are equal or above 1th January 2013, 0:00:00. The VPN connectivity needs valid clock in order to establish VPN connection.

If SNTP server is selected as time synchronization source, user must provide access to SNTP server by setting the correct configuration of SNTP server address (refer to Time synchronization), gateway and DNS priority (refer to General communication settings) to enable ME-RTU to gain access to SNTP server.

CAUTION:

- ***The initial time synchronization with SNTP server is essential to establish VPN connection.***
- ***Time synchronization affects sending of DNP3 and IEC 60870-5 events. The events are not registered until RTU RTC is valid. Date is considered to be valid, when date is equal or above 1.1.2013, 0:00:00.***
- ***Time synchronization with Control station using DNP3 or IEC 60870-5 protocol is dependent on protocol settings on Control station. If DNP3 or IEC 60870-5 protocol on Control station is configured to use UTC (Coordinated Universal Time) with time synchronization, the day-light saving time is not taken into account, when setting time on ME-RTU.***

7.4.1 ME-RTU time synchronization

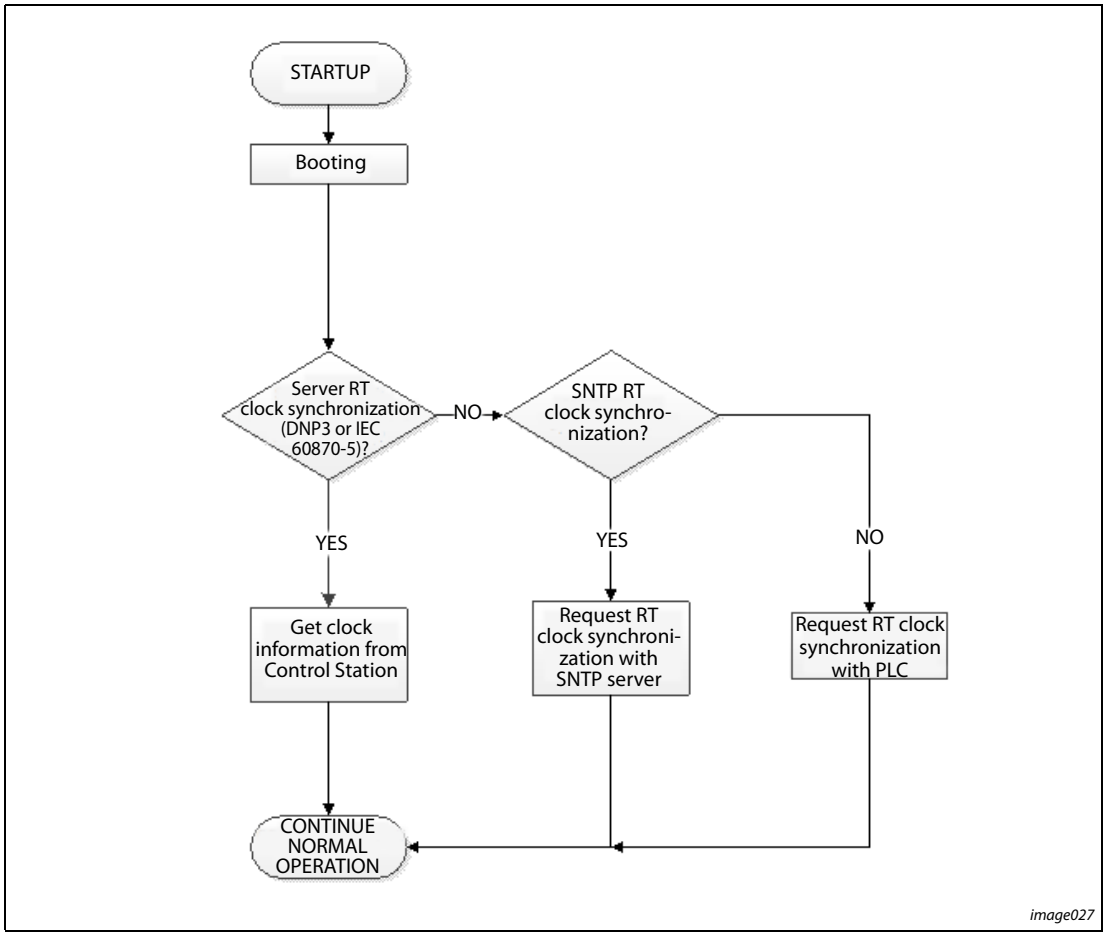


Fig. 7-3: *Time synchronization at start-up*

7.4.2 Writing time directly to ME-RTU BFM with PLC

Time synchronization with PLC is performed by having PLC write it's time to BFM addresses ranging from 7 to 13 by using TO instruction. Value at BFM address 13 should be written as last. The ME-RTU synchronization task then modifies the value at the BFM address 13 by adding value 1000 to current value as a notification that time has been taken and ME-RTU is synchronized with PLC. PLC may use FROM instruction to read modified value at the BFM address 13 as a confirmation.

7.5 Power down and data retention

In the event of power failure, the ME-RTU can restore the outputs data commands and inputs events data as they were before the power failure. The power down and data retention will:

- Save telemetry output data commands (DNP3, IEC 60870-5) received from SCADA before the event of power failure. The power down failure is detected when +24 V power supply drops below 19.6 V.
- Periodically save telemetry events data that have not yet been sent to SCADA. The time interval is defined in Web user interface (refet to Data Retention Settings). The events are considered as sent, when the SCADA replies to the sent event with the reception confirmation (telemetry protocol dependent).

Additionally to power down phase, the commands received from SCADA are also saved:

- Periodically every 5 minutes, in order to keep the internal FLASH in ready condition,
- At the time of ME-RTU configuration changing (at the application restart).

Stored information	Storage location	Storage trigger
Output data commands	Internal FLASH	Power-down and periodically every 5 minutes
Input Events data	SD card	Periodically (user defined)

Tab. 7-34: *Data retention*

The last commands received from SCADA will be restored after the ME-RTU recovers (just before boot process finished) – output data commands will be written to the respective outputs BFM area.

CAUTION:

- ***Before using the commands, PLC should always check the ME-RTU status bits (BFM#0 bit b1 must be set to ON). This only applies to the FX Bus connected FX3-series PLC$_{[FJ1]}$.***
- ***During the ME-RTU start-up, the output data BFMs contain invalid values.***
- ***When communicating with Q/L-series PLC, the communication is not possible before ME-RTU stop booting.***

The events stored on the SD card are written to events buffer after the RTU has synchronized clock. The events are sent to SCADA, when the connection with SCADA is established. The events will keep the original timestamp (appended at the time of event being generated).

CAUTION:

- ***The events will not be written to the event buffer if:***
  1. ***ME-RTU clock has not been synchronized,***
  2. ***The timestamp of event is in the future according to ME-RTU clock.***
- ***It may occur that some events are sent to SCADA, even if they were already confirmed by the SCADA. The timestamps of such events will match the timestamp of events already received by the SCADA.***
- ***Data write since the last periodical to the power fail is not guaranteed, therefore it is recommended to use the UPS power supply with the ME-RTU. The UPS guaranteed power supply time to the ME-RTU must be longer than the user-defined input events data retention write interval (see Figure 11-13).***

Limitations on saving events: The amount of events that can be saved is limited to maximum of 10 days and by the capacity of the SD card.

NOTES

Only use "fresh" – unused SD card. The SD card memory is limited to the number of erase and write cycles. With increased erase and write cycles, the probability of data corruption increases.

In order to ensure the proper functioning of the events data retention, the micro-SD card must be formatted using ME-RTU user interface (refer to Data Retention Settings).

CAUTION:

- ***Do NOT remove or insert SD card when ME-RTU is powered ON.***
- ***Always power OFF ME-RTU before inserting or removing SD card for data retention.***

Required hardware:

- Industrial micro-SD card with build-in wear-levelling algorithm and high-speed operation. The minimum memory capacity of micro-SC card should be at least 4 GB.
- ME-RTU with hardware v1.23 or higher.

Recommended micro-SD card: Panasonic RP-SMKC04 micro-SD card

7.6 Windows command line configuration upload/download

For SCADA applications running in Windows environment, a command line program RTUSCP.exe is available for uploading and downloading .xml configuration file from/to ME-RTU.

To upload configuration file from SCADA to ME-RTU, use the following command syntax:

```
rtuscp -pw <password> <path_to_settings_file> rtuadmin@<ME-RTU_IPaddress>
```

with the following parameters:

- <password> – password for command line access. The default value is "rtuadmin". To change the password, use the Web user interface.
- <path_to_settings_file> – the valid .xml file containing ME-RTU configuration.
- <ME-RTU_IPaddress> – ME-RTU IP address.

Example ▽ The following command will upload settings.xml file, containing ME-RTU configuration, to the ME-RTU with IP address 192.168.0.10 and command line access password "rtuadmin":

```
rtuscp -pw rtuadmin settings.xml rtuadmin@192.168.0.10
```

△

To download configuration file from ME-RTU to SCADA (PC), use the following command syntax:

```
rtuscp -pw <password> rtuadmin@<ME-RTU_IPaddress> <target>
```

with the following parameters:

- <password> – password for command line access. The default value is "rtuadmin". To change the password, use the Web user interface.
- <ME-RTU_IPaddress> – ME-RTU IP address.
- <target> – path to the location on SCADA, to which the "settings.xml" will be downloaded.

Example ▽ The following command will download settings.xml file to the path "C:/User/Documents" from ME-RTU with IP address 192.168.0.10 and password “rtuadmin”:

```
rtuscp -pw rtuadmin rtuadmin@192.168.0.10 C:/User/Documents
```

△

CAUTION:

Do NOT upload modified xml file to the ME-RTU – only use .xml files downloaded from ME-RTU. There is a risk of corruption and improper configuration, if .xml file is modified.

8 PLC Data Exchange

The following sections describe how FX3 and Q/L-series PLCs can exchange data with ME-RTU.

8.1 FX3 PLC data exchange

The FX3 PLC is communicating with the ME-RTU via the FX Bus (be sure to use the bus-ME-RTU variant). For transferring 16-bit data the FROM/TO instructions are used. For 32-bit data DFROM/DTO instructions are used.

8.1.1 Raw programing examples

Following are the examples for FX3U PLC data exchange.

Mapping of binary outputs

Binary outputs are commands from the remote controlling station, defining in which state the device should be. In the program, the user must read the value which is in the ME-RTU BFM and map it to the actual physical output. The binary outputs are located at address 16384 in the ME-RTU BFM.

In the user program the following two steps should be made:

① Using a FROM instruction, read the content of the BFM. The input parameters to the FROM instruction are:

- n1: The ME-RTU is at address 4
- n2: The BFM address in the ME-RTU where the digital outputs are mapped
- n3: Number of words to be read
- d: Destination where the data should be stored in this case this is a register D0

② Mapping of the actual value into the physical output. We assume that we are using the first binary output.

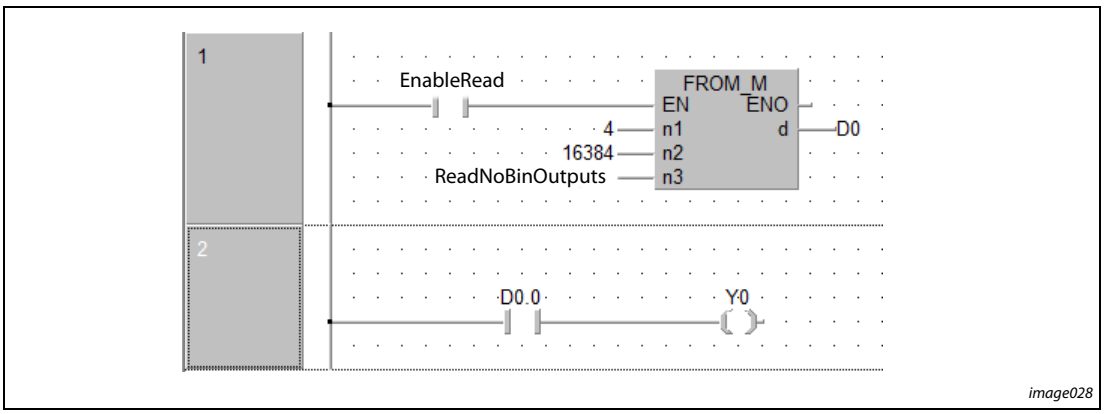


Fig. 8-1: *Reading digital outputs using FROM instruction*

Mapping of binary inputs

Binary inputs represent the actual state of digital signals in the PLC. They are transferred from the PLC into the remote controlling station by writing the value into the ME-RTU BFM. The binary inputs are located in the BFM at address 1024.

In the user program the following two steps should be made:

① Map or copy the data into some working registers which are sent to the ME-RTU

② Write the data into the ME-RTU using a TO instruction. The input parameters to the TO instruction are:

- n1: The ME-RTU is at address 4
- n2: The BFM address in the ME-RTU where the binary inputs are mapped
- n3: Number of words to be written
- s: Source from where the data should be written. In this case this is a register D0

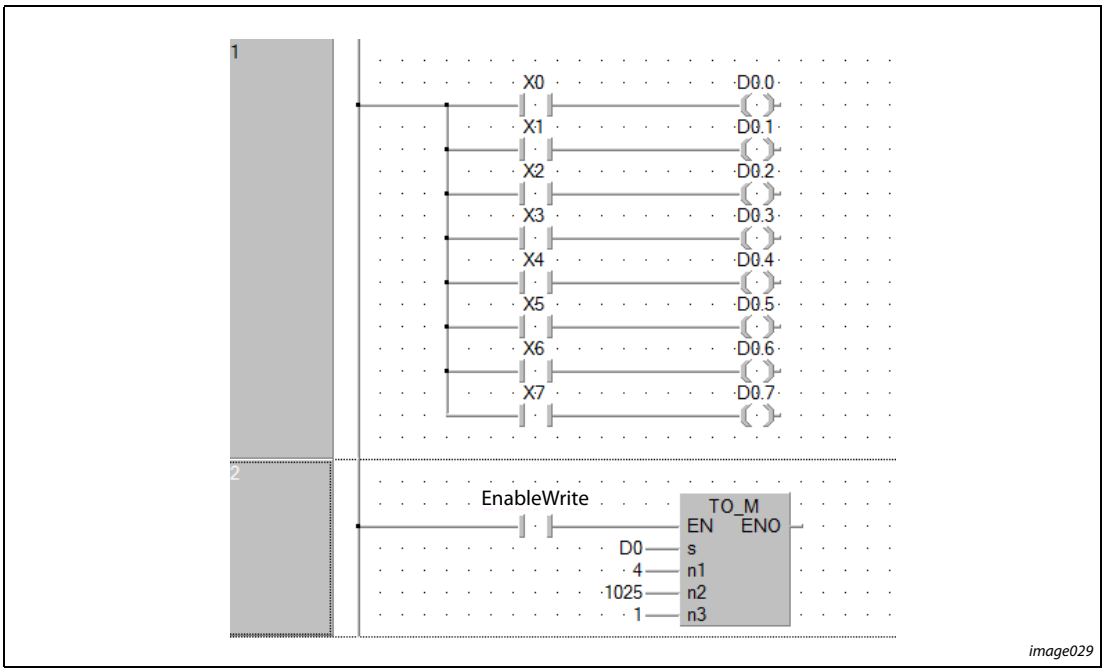


Fig. 8-2: *Mapping of digital inputs using a TO instruction*

8.2 L/QnUDE series PLC data exchange

L series of PLC uses the simple socket interface via Ethernet to exchange data with the ME-RTU. The size of data is limited to 1 kB. The programing interface is provided through function blocks which manage connection with ME-RTU and send/receive data. The access to data in BFM is limited to single data type or flags per operation. E.g. if user wants to set BIs with flags, only the number of BIs set in database settings could be written (see Figure 11-20). Depending on direction and data type, four operations are distinguished:

- Send 16-bit (WORD) data
- Request 16-bit (WORD) data
- Send 32-bit (DWORD) data
- Request 32-bit (DWORD) data

IP/TCP or IP/UDP protocol may be used for communication.

8.2.1 UDP communication

For UDP, all operations are joined into a single function block. The operation type is selected by function block inputs.

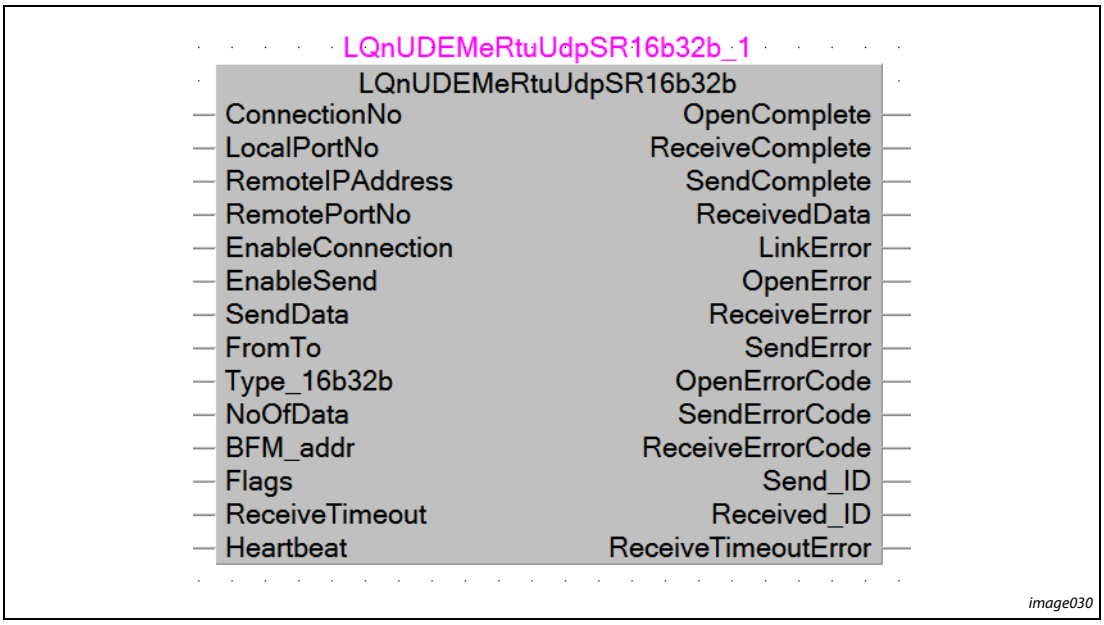


Fig. 8-3: *Function block for L/QnUDE PLC Socket UDP communication*

The following tables describe inputs and outputs of function block.

Input variables:

Signal	Type	Description
ConnectionNo	WORD [Signed]	Specify the Socket communication number to be used (from 1 to 16)
LocalPortNo	WORD [Signed]	Local port number (from 1 to 4999 or 5010 to 65534)
RemoteIPAddress	DWORD [Unsigned]/ Bit String [32-bit]	ME-RTU IP address
RemotePortNo	Word [Signed]	ME-RTU port number (refer to General ME-RTU settings)
EnableConnection	BIT	Signal whether to open or close the Socket communication connection
EnableSend	BIT	Start the data send operation on the rising edge of this signal
SendData	WORD [Unsigned]/ Bit String [16-bit]	Specify the head address of the memory area storing the send data
FromTo	BIT	Select operation type: **FALSE** – Request data **TRUE** – Send data
Type_16b32b	BIT	Data type: **FALSE** – 16-bit data (NoOfData unit is WORD), **TRUE** – 32-bit data (NoOfData unit is DWORD)
NoOfData	WORD [Signed]	Number of WORDs to send (max value: 512 for 16-bit data or 256 for 32-bit data)
BFM_addr	WORD [Unsigned]	ME-RTU Buffered Memory head address
Flags	WORD [Signed]	Set data flags (16#abcd): • If 16#ab = 16#00 – don't set flags • If 16#ab = 16#01 – set flags • 16#cd – flags values (Input data values only)
ReceiveTimeout	TIME	ME-RTU response timeout timer
Heartbeat	TIME	Heartbeat send period (max. 60 seconds)

Tab. 8-1: *L/QnUDE PLC Socket UDP communication function block inputs*

Output variables:

Signal	Type	Description
OpenComplete	BIT	Signals the Socket communication connection open status
ReceiveComplete	BIT	Signals when a receive operation is completed successfully
SendComplete	BIT	Signals when a send operation is completed successfully
ReceivedData	WORD [Unsigned]/ Bit String [16-bit]	Specify the head address of the memory area storing the received data
LinkError	BIT	Signals the cable disconnection between the built-in Ethernet port of the QnUDE-series or L-series PLC system and the Ethernet hub
OpenError	BIT	Signals if a connection open error has occurred
ReceiveError	BIT	Signals if a receive error has occurred
SendError	BIT	Signals if a send error has occurred
OpenErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stored the error code in case of a connection open error
SendErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stores the error code if a transmission error has occurred
ReceiveErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stores the error code if a receive error has occurred
Received_ID	WORD [Signed]	Received data ID. Must equal Send_ID
Send_ID	WORD [Signed]	ID of request. Increments with every sent request for data
ReceiveTimeoutError	BIT	Signals if ReceiveTimeout expired before receiving data. This can be interpreted as: lag in network, slow response from ME-RTU, or loss of communication link.

Tab. 8-2: *L/QnUDE PLC Socket UDP communication function block outputs*

8.2.2 TCP communication

For TCP, all operations are joined in single function block.

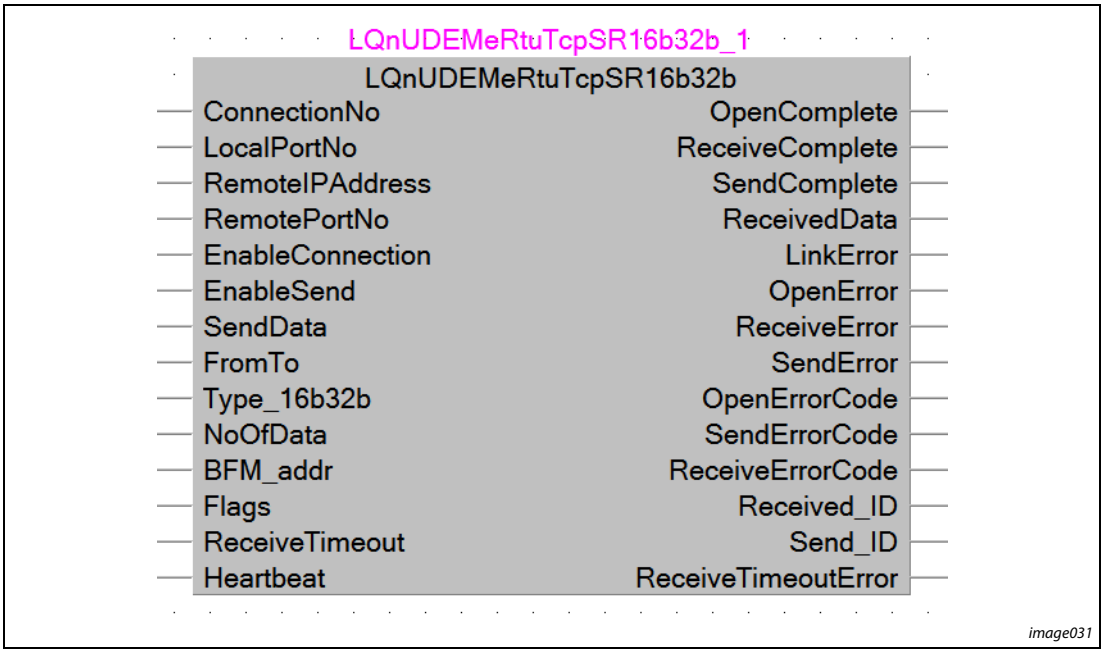


Fig. 8-4: *Function block for L/QnUDE PLC Socket TCP communication*

Input variables:

Signal	Type	Description
ConnectionNo	WORD [Signed]	Specify the Socket communication connection number to be used (from 1 to 16)
LocalPortNo	WORD [Signed]	Local port number (from 1 to 4999 or 5010 to 65534)
RemoteIPAddress	DWORD [Unsigned]/ Bit String [32-bit]	ME-RTU IP address
RemotePortNo	WORD [Signed]	ME-RTU port number (refer to General ME-RTU settings)
EnableConnection	BIT	Signal whether to open or close the Socket communication connection
EnableSend	BIT	Start the data send/receive operation on the rising edge of this signal
SendData	WORD [Unsigned]/ Bit String [16-bit]	Specify the Head address of the memory area storing the send data
FromTo	BIT	**OFF (FALSE)**: TO/send data **ON (TRUE)**: FROM/receive data operation
Type_16b32b	BIT	Data type: **OFF (FALSE)**: 16-bit data (NoOfData unit is WORD) **ON (TRUE)**: 32-bit data (NoOfData unit is DWORD)
NoOfData	WORD [Signed]	Number of: • WORDs sent/requested if Type_16b32b = **FALSE** (max value: 512); • DWORDs sent/requested if Type_16b32b = **TRUE** (max value: 256)
BFM_addr	WORD [Signed]	ME-RTU Buffered Memory head address
Flags	WORD [Signed]	Set data flags (16#abcd): • If 16#ab = 16#00 – don't set flags • If 16#ab = 16#01 – set flags • 16#cd – flags values (Input data values only)
ReceiveTimeout	TIME	ME-RTU response timeout timer
Heartbeat	TIME	Heartbeat send period (max. 60 seconds)

Tab. 8-3: *L/QnUDE PLC Socket TCP communication function block inputs*

Output variables:

Signal	Type	Description
OpenComplete	BIT	Signals the Socket communication connection open status
ReceiveComplete	BIT	Signals when a receive operation is completed successfully
SendComplete	BIT	Signals when a send operation is completed successfully
ReceivedData	WORD [Unsigned]/ Bit String [16-bit]	Head address of the received data storage area
LinkError	BIT	Signals the cable disconnection between the built-in Ethernet port of the QnUDE-series or L-series PLC system and the Ethernet hub
OpenError	BIT	Signals if a connection open error has occurred
ReceiveError	BIT	Signals if a receive error has occurred
SendError	BIT	Signals if a send error has occurred
OpenErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stored the error code in case of a connection open error
OpenErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stored the error code in case of a send error
ReceiveErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stored the error code in case of a receive error
Receive_ID	WORD [Signed]	Received data ID, equals sent request's Send_ID. May be received with delay if ReceiveTimeout is set to low
Send_ID	WORD [Signed]	ID of request, get incremented with every sent request for data
ReceiveTimeoutError	BIT	Signals if ReceiveTimeout expired before receiving response (one scan long). This can be interpreted as: lag in network, slow response from ME-RTU, or loss of communication link.

Tab. 8-4: *L/QnUDE PLC Socket TCP communication function block outputs*

8.3 Q series (before SN11012) PLC data exchange

The Q series PLCs before SN11012 use fixed buffer communication interface to exchange data with the ME-RTU. The Q series PLCs after SN11012 can use the same interface to exchange data with the ME-RTU as the L series (socket communication).

If a Q series PLC before SN11012 is used, then the Q system must have an Ethernet communication module QJ71E71.

For the Fixed buffer communication interface, modified function blocks for IP/TCP and IP/UDP communication from the original Mitsubishi Electric library are used. Function blocks perform four different operations:

- Send 16-bit (WORD) data
- Request (request) 16-bit (WORD) data
- Send 32-bit (DWORD) data
- Request (request) 32-bit (DWORD) data

Next to original IP/TCP and IP/UDP communication function block inputs and outputs, modified function blocks have additional input and outputs used for communication with ME-RTU. Up to 1 kB (512 WORDs for 16-bit data or 256 Double WORDs for 32-bit data) of data can be transferred in either direction. The access to data in BFM is limited to single data type or flags per operation. E.g. if user wants to set BIs with flags, only the number on BIs set in database settings could be written (see Figure 11-20). For more information on Ethernet communication module QJ71E71 see document Art. no. 130029.

8.3.1 UDP communication

All send and receive operations described above are supported in single function block. The Ethernet communication module must be configured. In GX works2 this is done by selecting Project in the Project Navigation pane. Expand Parameter section, then, expand Network Parameter subsection and double-click on the "Ethernet/CC IE/MELSECNET" option. Select "Open Settings". For the chosen Connection number in the configuration table, select UDP protocol. Under "**Fixed Buffer Communication Procedure**" select "**No Procedure**". Under "**Pairing Open**" select "**Enable**". Under "Existence Conformation" select "No Confirm". Fill in the last three columns as shown in Table 8-5.

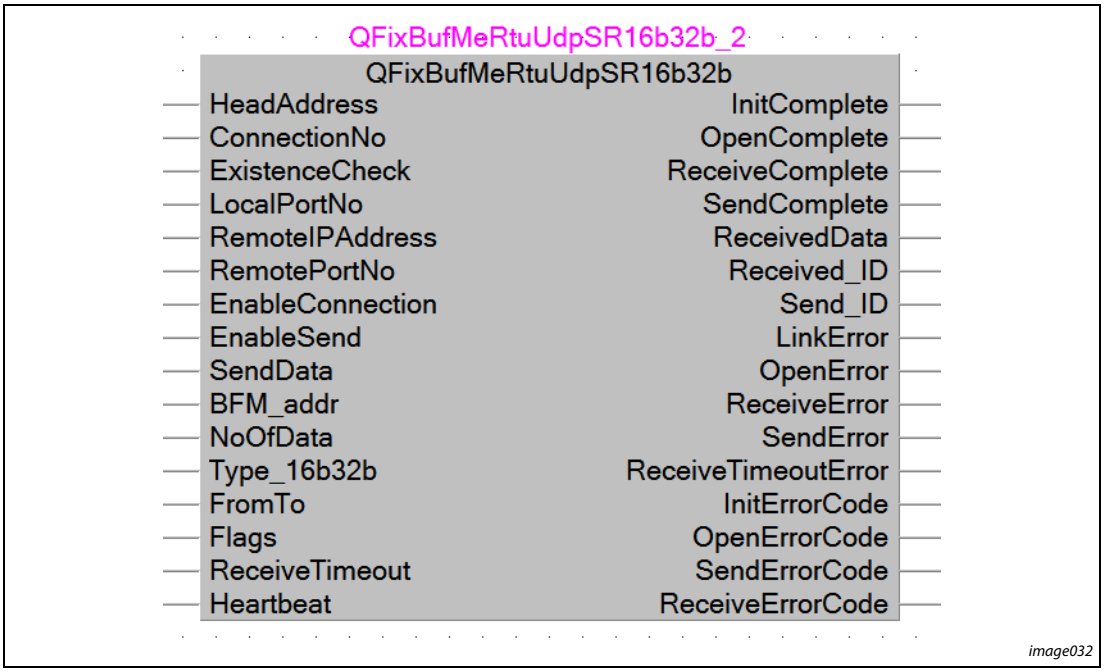


Fig. 8-5: *Function block for Q PLC (before SN11012) Fixed Buffer UDP communication*

The following tables describe inputs and outputs of function block

Input variables:

Signal	Type	Description
Head Address	WORD [Unsigned]/ Bit String [16-bit]	QJ71E71 Ethernet interface module head address
ConnectionNo	WORD [Signed]	Connection number which must be unique
ExistenceCheck	BIT	Usage of destination existence check
LocalPortNo	WORD [Signed]	Local port number (from 1025 to 5548 or 5552 to 65534)
RemoteIPAddress	DWORD [Unsigned]/ Bit String [32-bit]	ME-RTU IP address
RemotePortNo	Word [Signed]	ME-RTU port number (refer to General ME-RTU settings)
EnableConnection	BIT	Open the Ethernet communication connection
EnableSend	BIT	Start the send/request data operation
SendData	WORD [Unsigned]/ Bit String [16-bit]	Head address of the send data storage area
BFM_addr	WORD [Signed]	ME-RTU Buffered Memory head address
NoOfData	WORD [Signed]	Number of WORDs to send (max value: 512 for 16-bit or 256 for 32-bit data)
Type_16b32b	BIT	Data type: **FALSE** – 16-bit data (NoOfData unit is WORD), **TRUE** – 32-bit data (NoOfData unit is DWORD)
Type_16b32b	BIT	Select operation type: **FALSE** – Request data **TRUE** – Send data
Flags	WORD [Signed]	Set data flags (16#abcd): • If 16#ab = 16#00 – don't set flags • If 16#ab = 16#01 – set flags • 16#cd – flags values (Input data values only)
ReceiveTimeout	TIME	ME-RTU response time out timer
Heartbeat	TIME	Heartbeat send period (max. 60 seconds)

Tab. 8-5: *Q PLC (before SN11012) Fixed Buffer UDP communication function block inputs*

Output variables:

Signal	Type	Description
InitComplete	BIT	Signals the initialization procedure completion
OpenComplete	BIT	Signals the connection open status
ReceiveComplete	BIT	Signals when a receive operation is completed
SendComplete	BIT	Signals when a send operation is completed
ReceivedData	WORD [Unsigned/ Bit String [16-bit]	Head address of the received data storage area
Received_ID	WORD [Signed]	Received data ID. Must equal Send_ID
Send_ID	WORD [Signed]	ID of request. Increments with every sent request for data
LinkError	BIT	Signals the cable disconnection between the Ethernet module and the Ethernet hub
OpenError	BIT	Signals if a connection open error has occurred
ReceiveError	BIT	Signals if a receive error has occurred
SendError	BIT	Signals if a send error has occurred
ReceiveTimeoutError	BIT	Signals if Receive Timeout expired before receiving data. This can be interpreted as: lag in network, slow response from ME-RTU, or loss of communication link.
InitErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stored the error code in case of a module initialization error
OpenErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stored the error code in case of a connection open error
SendErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stored the error code in case of a send error
ReceiveErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stores the error code in case of a receive error

Tab. 8-6: *Q PLC (before SN11012) Fixed Buffer UDP communication function block outputs*

8.3.2 TCP communication

For TCP, all operations are joined in single function block.

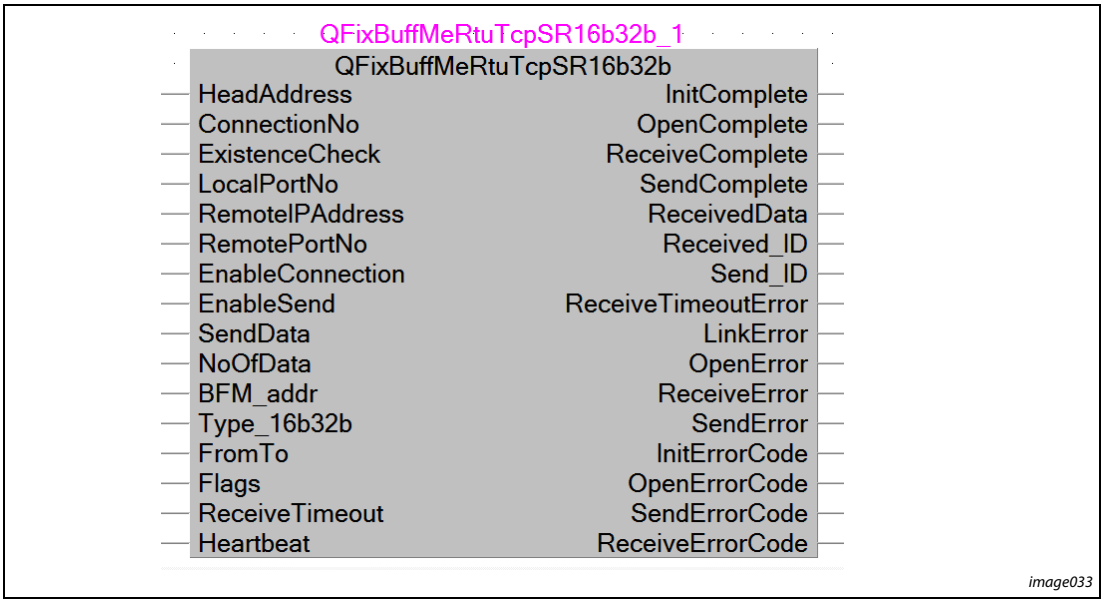


Fig. 8-6: *Function block for Q PLC (before SN11012) Fixed Buffer TCP communication*

Inputs and outputs are described in the following tables

Input variables:

Signal	Type	Description
Head Address	WORD [Unsigned]/ Bit String [16-bit]	QJ71E71 Ethernet interface module head address
ConnectionNo	WORD [Signed]	Connection number (from 1 to 15)
ExistenceCheck	BIT	Usage of destination existence check
LocalPortNo	WORD [Signed]	Local port number (from 1025 to 5548 or 5552 to 65534)
RemoteIPAddress	DWORD [Unsigned]/ Bit String [32-bit]	ME-RTU IP address
RemotePortNo	Word [Signed]	ME-RTU port number (refer to General ME-RTU settings)
EnableConnection	BIT	Open the Ethernet communication connection
EnableSend	BIT	Start the send/request data operation
SendData	WORD [Unsigned]/ Bit String [16-bit]	Specify the Head address of the memory area storing the send data
NoOfData	WORD [Signed]	Number of: • WORDs sent/requested if Type_16b32b = **FALSE** (max value: 512); • DWORDs sent/requested if Type_16b32b = **TRUE** (max value: 256)
BFM_addr	WORD [Signed]	ME-RTU Buffered Memory head address
Type_16b32b	BIT	Data type: **FALSE** – 16-bit data (NoOfData unit is WORD), **TRUE** – 32-bit data (NoOfData unit is DWORD)
FromTo	BIT	Select operation type: **FALSE** – Request data **TRUE** – Send data
Flags	WORD [Signed]	Set data flags (16#abcd): • If 16#ab = 16#00 – don't set flags • If 16#ab = 16#01 – set flags • 16#cd – flags values (Input data values only)
ReceiveTimeout	TIME	ME-RTU response timeout timer
Heartbeat	TIME	Heartbeat send period (max. 60 seconds)

Tab. 8-7: *Q PLC (before SN11012) Fixed Buffer TCP communication function block inputs*

Output variables:

Signal	Type	Description
InitComplete	BIT	Signals the initialization procedure completion.
OpenComplete	BIT	Signals the Socket communication connection open status
ReceiveComplete	BIT	Signals when a receive operation is completed successfully
SendComplete	BIT	Signals when a send operation is completed successfully
ReceivedData	WORD [Unsigned]/ Bit String [16-bit]	Head address of the received data storage area
Receive_ID	WORD [Signed]	Received data ID, equals sent request's Send_ID. May be received with delay if ReceiveTimeout is set to low
Send_ID	WORD [Signed]	ID of request, get incremented with every sent request for data
ReceiveTimeoutError	BIT	Signals if ReceiveTimeout expired before receiving response (one scan long). This can be interpreted as: lag in network, slow response from ME-RTU, or loss of communication link.
LinkError	BIT	Signals the cable disconnection between the Ethernet module and the Ethernet hub
OpenError	BIT	Signals if a connection open error has occurred
ReceiveError	BIT	Signals if a receive error has occurred
SendError	BIT	Signals if a send error has occurred
OpenErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stores the error code in case of a connection open error
SendErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stores the error code in case of a send error
ReceiveErrorCode	WORD [Unsigned]/ Bit String [16-bit]	Stores the error code in case of a receive error

Tab. 8-8: *Q PLC (before SN11012) Fixed Buffer TCP communication function block outputs*

8.4 Q/L PLC Data exchange programming examples and rules

In the following chapters, the interaction between ME-RTU and Q/L PLC is described.

8.4.1 Heartbeat

The heartbeat is used to inform the ME-RTU, that TCP/IP or UDP/IP connection between ME-RTU and Q/L PLC is active. The Q/L PLC writes heartbeat values into BFM#24 (refer to Q/L PLC heartbeat [BFM address 24]). The Q/L PLC is considered connected and active (b0 in BFM#32 is set – refer to Communication Control Status [BFM address 32], if heartbeat value changes within 60 seconds.

The Q series (before SN11012) and L/QnUDE PLC function blocks for TCP and UDP already implement heartbeat sending, with send the period defined by function block input (heartbeat is not sent if value is set to 0). The heartbeat send is first triggered when the OpenComplete signal rising front is detected. The SendComplete signal is not set, when the heartbeat is sent. Sending heartbeat has higher priority than sending and requesting data, which will be blocked while sending heartbeat.

8.4.2 Setting flags

The Function Block's Flags input may be used to set Flags for multiple data points, simultaneously with data values. This option can only be used for input data, when writing to input data value BFM area. The exception is the address BFM#1024; if user wishes to write to this address, the Flags (and data values) for this or any following BFM will not be set.

Flags can also be set by writing directly to telemetry protocols' Flags BFM area. Exception is the BFM area ranging from BFM#1536 to BFM#1543. In cases where DNP3 protocol is used and user wants to set the Flags for output data, the Flags can only be set by writing directly to output data flags BFM area. Exception is the BFM ranging from BFM#16896 to BFM#16903, where PLC is blocked from writing the flags.

8.4.3 Exchanging data with ME-RTU

When requesting data from ME-RTU (FROM or DFROM operation), the ME-RTU may need some time to respond. Maximum time to wait for response is defined by ReceiveResponse function block input. The request, sent from PLC is numbered by sequence number Send_ID (function block output). The response from ME-RTU is considered valid, when Received_ID matches Send_ID. If ReceiveResponse timer expires before valid response is received, the ReceiveTimeoutError bit is set for one PLC program cycle.

Only one request at the time can be processed. This means, that after sending one request, the function block is blocked from sending second request until the response to first request has been received (signalled by ReceiveComplete bit and Receive_ID matching Send_ID) or ReceiveResponse timer expired (signalled by ReceiveTimeoutError bit).

9 DNP3 Functionality

DNP3 (Distributed Network Protocol) is a standards based communications protocol initially designed for the electric utility industry. Due to its robustness, flexibility, and interoperability, it is now also being used in water, waste water, traffic management, oil and gas, industrial, and other applications. It is an open protocol that was developed to establish interoperability between RTUs, IEDs (Intelligent Electronic Devices) and master stations. DNP3 has been adopted by the Substation Committee of the IEEE Power Society (1379–2000) as a recommended practice for RTU-IED communication.

9.1 DNP3 features

ME-RTU DNP3 implementation features:

- Conforms to DNP3 Level 2 Subset Definitions requirements.
- Supports any physical communication network including RS232 (with USB-to-RS232 converter) and TCP/IP.
- Supports binary (input and output), analog (input and output), counter (running and frozen) and internal indications.
- Supports Unsolicited Responses and/or polled Report-By-Exception (RBE) for change event objects.
- Supports function codes for confirm, read, write, direct operate, freeze, freeze and clear, cold/warm restart, assign class and enable/disable unsolicited response.
- Supports qualifier codes for start-stop range (0 x 00,0 x 01), all points (0 x 06), limited quantity (0 x 07,0 x 08), indexed (0 x 17,0 x 28), and free format (0 x 1B).
- Large response messages can consist of multiple data link frames and multiple application layer fragments.

9.2 DNP3 configuration settings

Parameter Name	Description
Port number	TCP port number when communication via TCP/IP
Link layer address	Device link layer address
Enable Unsolicited Messages	Enable unsolicited messages to master station
Unsolicited confirm timeout	Unsolicited messages response timeout from master station
Source address	ME-RTU address
Destination address	Control station address
Delete oldest event	If events buffer is full, replace oldest event with newly generated event

Tab. 9-1: *DNP3 settings*

9.3 DNP3 supported data types

The ME-RTU DNP3 protocol implementation supports the following data types:

- Digital inputs and outputs
- Double digital inputs
- 16 and 32-bit counters
- 16-bit, 32-bit and short floating point analog inputs and outputs

All communications between the DNP master and the PLC takes place through these data types. ME-RTU implementation of DNP3 also supports generating events and sending events (unsolicited massages). The events are generated for every input data type on value change or flag status change. If control station is not connected or unsolicited messages (sending of events) is blocked, the events are stored is events buffer. The size of the buffer is configurable via Web User Interface (refer to Data Events settings).

If the connection to the PLC is lost (FX3 PLC goes to STOP or no heartbeat is received Q/L PLC), then all input data ONLINE flags are set to OFFLINE. The ONLINE flag is automatically set for each data point, when PLC writes its value to ME-RTU. All other flags must be set manually by the PLC.

9.4 DNP3 BFM mapping

In the following Table the supported DNP3 group objects, in which the protocol data is mapped from the BFM, are shown.

	Basic data type	Default Static DNP3		BFM address	
		Object group	Variation	Start	End
Input data	Binary Input	1	2	1024	1535
	Double Binary Input	3	2	5632	6143
	16–bit Counters	20	2	8192	8703
	32–bit Counters	20	1	8960	9471
	16–bit Analog Inputs	30	2	9600	10111
	32–bit Analog Inputs	30	1	10368	11519
	Short float Analog Inputs	30	5	11008	10879
Output data	Binary Output	10	2	16384	16895
	16–bit Analog Outputs	40	2	20992	21503
	32–bit Analog Outputs	40	1	22272	22783
	Short float Analog Outputs	40	3	23424	23935 [FJ2]

Tab. 9-2: *DNP3 supported objects*

As defined by the DNP3 protocol, every data objects group's address start with 0. The address of each following element is incremented by 1.

Special care must be taken for Analog Inputs, Counters and Analog Outputs DNP3 addresses, where the addresses for 16-bit AI, 16-bit Counters and 16-bit AO start at 0, the address of 32-bit AI, 32-bit Counters and 32-bit AO continue their address numbering from the end address of 16-bit AIs and 16-bit AOs. The Short Floating Point (SFP) AI and SFP AO continue their address numbering from the end of 32-bit AIs and 32-bit AOs.

9.4.1 Binary inputs

Binary inputs are mapped into following variation of Object group 1:

- Variation 1 (Binary Input single bit): in this variation the value of the digital inputs are mapped which is located in the binary input BFM section:
- Variation 2 (Binary Input with flags) in this variation the value of the digital input is mapped which is located in the binary input BFM section and the flags which is located in the Digital Inputs flags BFM section.

CAUTION:

- ***If FX3 series PLC is selected as the only PLC (see Figure 11-9) then the following operation applies:***
  - ***If FX3 PLC is in reset or stop mode, all flags are automatically set to OFFLINE.***
  - ***After the FX3 PLC goes to RUN mode and value is written to data point, the ONLINE flag is set for this data point.***
- ***If Q/L series PLC is selected as the PLC type (see Figure 11-9), then the following operation applies:***
  - ***When Heartbeat timer runs out, all flags are automatically set to OFFLINE.***
  - ***After connection is established and value is written to data point, the ONLINE flag is set for this data point.***

The flags of Binary Inputs are 1 byte long. In the following Table the supported flags are shown.

Flag	Short form	Value	Description
ONLINE	ONL	1 = online	If the point is OFFLINE, the returned state of this point may not be correct. The ONLINE binary input point has been read successfully.
		0 = offline	
RESTART	RES	1 = restart	The field device that originated the data object has been restarted. This device may be the device reporting this data object.
		0 = normal	
COMM LOST	CER	1 = lost	The device reporting this data object has lost communication with the originator of the data object.
		0 = normal	
REMOTE FORCED	REM	1 = remote	The state of the binary object has been forced to its current state at the originating device.
		0 = normal	
LOCAL FORCED	LOC	1 = local	The state of the binary object has been forced to its current state at the device reporting.
		0 = normal	
CHATTER	CHA	1 = chatter	This data object binary input point has been filtered in order to remove unneeded transitions in the state of the input.
		0 = normal	

Tab. 9-3: *DNP3 Binary input supported flags*

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
BFM address (dec)	—	—	CHA	LOC	REM	CER	RES	ONL	—	—	CHA	LOC	REM	CER	RES	ONL		
1536	BI1 flags								BI0 flags								RO	WORD
1537	BI3 flags								BI2 flags								RO	WORD
…	…								…								…	…
1543	BI15 flags								BI14 flags								RO	WORD
1544	BI17 flags								BI16 flags								R/W	WORD
1545	BI19 flags								BI18 fags								R/W	WORD
…	…								…								…	…
5631	BI8191 flags								BI8190 flags								R/W	WORD

Tab. 9-4: *DNP3 Binary Inputs BFM flags signals structure*

NOTES

All empty grayed flags **"–"** should always be set to 0 by PLC program.

The ONLINE flags ***ONL*** should be set to 1 by PLC program. The ONL flag is set automatically to value 1, when data values are written. Value is automatically set to 0, when FX3-series PLC goes to STOP, or heartbeat is lost when communicating with Q/L-series PLC.

Because 16 BIs are group in WORD of 16-bits, the ONLINE flags are set for all those 16 BIs, which are mapped to the same WORD.

9.4.2 Double binary inputs

Double Binary inputs are mapped into following variations of Object group 3:

- Variation 1 (Double Binary Input single bit): in this variation the value of the double digital input is mapped which is located in the double binary input BFM section
- Variation 2 (Binary Input with flags) in this variation the value of the double binary input is mapped which is located in the double binary input BFM section and the flags which is located in the Double Binary Inputs flags BFM section.

The flags of Double Binary Inputs are 1 byte long. In Table 9-5 the supported flags are shown.

Flag	Short form	Value	Description
ONLINE	ONL	1 = online	If the point is OFFLINE, the returned state of this point may not be correct. The ONLINE binary input point has been read successfully.
		0 = offline	
RESTART	RES	1 = restart	The field device that originated the data object has been restarted. This device may be the device reporting this data object.
		0 = normal	
COMM LOST	CER	1 = lost	The device reporting this data object has lost communication with the originator of the data object.
		0 = normal	
REMOTE FORCED	REM	1 = remote	The state of the binary object has been forced to its current state at the originating device.
		0 = normal	
LOCAL FORCED	LOC	1 = local	The state of the binary object has been forced to its current state at the device reporting.
		0 = normal	
CHATTER	CHA	1 = chatter	This data object the binary input point has been filtered in order to remove unneeded transitions in the state of the input.
		0 = normal	

Tab. 9-5: *DNP3 Double Binary input supported flags*

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
BFM address (dec)	—	—	CHA	LOC	REM	CER	RES	ONL	—	—	CHA	LOC	REM	CER	RES	ONL		
6144	DBI1 flag								DBI0 flag								R/W	WORD
6145	DBI3 flag								DBI2 flag								R/W	WORD
6146	DBI5 flag								DBI4 flag								R/W	WORD
…	…								…								…	…
8191	DBI4095 flag								DBI4094 flag								R/W	WORD

Tab. 9-6: *DNP3 Double Binary Inputs BFM flags signals structure*

NOTES

All empty grayed flags **"–"** should always be set to 0 by PLC program.

The ONLINE flags ***ONL*** should be set to 1 by PLC program. The ONL flag is set automatically to value 1, when data values is written. Value is automatically set to 0, when FX3-series PLC goes to STOP, or heartbeat is lost when communicating with Q/L-series PLC.

Because 8 DBIs are group in WORD of 16-bits, the ONLINE flags are set for all those 8 DBIs, which are mapped to the same WORD.

9.4.3 Counters

Counters are mapped into following variations of Object group 20:

- Variation 5 (32-bit counter): in this variation the values of the 32-bit counters are mapped which are located in the 32-bit Counters BFM section
- Variation 6 (16-bit counter): in this variation the values of the 16-bit counters are mapped which are located in the 16-bit Counters BFM section.

Flag	Short form	Value	Description
ONLINE	ONL	1 = online	If the point is OFFLINE, the returned state of this point may not be correct. The ONLINE binary input point has been read successfully
		0 = offline	
RESTART	RES	1 = restart	The field device that originated the data object has been restarted. This device may be the device reporting this data object.
		0 = normal	
COMM LOST	CER	1 = lost	The device reporting this data object has lost communication with the originator of the data object
		0 = normal	
REMOTE FORCED	REM	1 = remote	The state of the binary object has been forced to its current state at the originating device.
		0 = normal	
LOCAL FORCED	LOC	1 = local	The state of the binary object has been forced to its current state at the device reporting.
		0 = normal	
COUNTER ROLLOVER	CRO	1 = rollover	The accumulated value has exceeded its maximum and rolled over to zero. The counter value should be set to 0 upon rollover, and counting is resumed as normal. The Rollover bit should be cleared when the counter value and roll-over state have been reported. NOTE: This maximum value is not necessarily equal to (2^32-1) for 32 bit counters or (2^16-1) for 16 bit counters. It can be different for each counter instance. Technical Bulletin TB-2002-001 Counter Objects recommends "slave devices do not set the Rollover flag and that host (master) devices ignore the Rollover flag".
		0 = normal	
DISCONTINUITY	DIS	1 = discontinuous	Value cannot be compared against a prior value to obtain the correct count difference.
		0 = normal	

Tab. 9-7: *DNP3 Counter supported flags*

BFM address (dec)	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
	—	DIS	CRO	LOC	REM	CER	RES	ONL	—	DIS	CRO	LOC	REM	CER	RES	ONL		
8704	BC1 flag								BC0 flag								R/W	WORD
8705	BC3 flag								BC2 flag								R/W	WORD
8706	BC5 flag								BC4 flag								R/W	WORD
…	…								…								…	…
8959	BC511 flag								BC510 flag								R/W	WORD

Tab. 9-8: *DNP3 16-bit Counter flags*

BFM address (dec)	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
	—	DIS	CRO	LOC	REM	CER	RES	ONL	—	DIS	CRO	LOC	REM	CER	RES	ONL		
9472	DBC1 flag								DBC0 flag								R/W	WORD
9473	DBC3 flag								DBC2 flag								R/W	WORD
9474	DBC5 flag								DBC4 flag								R/W	WORD
…	…								…								…	…
9599	DBC255 flag								DBC254 flag								R/W	WORD

Tab. 9-9: *DNP3 32-bit Counter flags*

NOTES

All empty grayed flags **"–"** should always be set to 0 by PLC program.

The ONLINE flags ***ONL*** should be set to 1 by PLC program. The ONL flag is set automatically to value 1, when data values is written. Value is automatically set to 0, when FX3-series PLC goes to STOP, or heartbeat is lost when communicating with Q/L-series PLC.

9.4.4 Analog inputs

Analog inputs are mapped into following variations of Object group 30:

- Variation 1 (32-bit analog input with flag): in this variation the values of the 32-bit analog inputs are mapped which are located in the 32-bit analog inputs BFM section and the appropriate flag bits which are located in the 32-bit analog input flag BFM section.
- Variation 2 (16-bit analog input with flag): in this variation the values of the 16-bit analog inputs are mapped which are located in the 16-bit analog inputs BFM section and the appropriate flag bits which are located in the 16-bit analog input flag BFM section.
- Variation 3 (32-bit analog input): in this variation the values of the 32-bit analog inputs are mapped which are located in the 32-bit analog inputs BFM section.
- Variation 4 (16-bit analog input): in this variation the values of the 16-bit analog inputs are mapped which are located in the 16-bit analog inputs BFM section.
- Variation 5 (short float analog input): in this variation the values of the short floating analog inputs are mapped which are located in the short floating analog inputs BFM section and the appropriate flag bits which are located in the short floating analog input flag BFM section.

Flag	Short form	Value	Description
ONLINE	ONL	1 = online	If the point is OFFLINE, the returned state of this point may not be correct. The ONLINE binary input point has been read successfully.
		0 = offline	
RESTART	RES	1 = restart	The field device that originated the data object has been restarted. This device may be the device reporting this data object.
		0 = normal	
COMM LOST	CER	1 = lost	The device reporting this data object has lost communication with the originator of the data object.
		0 = normal	
REMOTE FORCED	REM	1 = remote	The state of the binary object has been forced to its current state at the originating device.
		0 = normal	
LOCAL FORCED	LOC	1 = local	The state of the binary object has been forced to its current state at the device reporting.
		0 = normal	
OVER RANGE	OVR	1 = rollover	The digitized signal or calculation is greater than the type specified.
		0 = normal	
REFERENCE CHECK	REC	1 = reference ch.	The reference signal used to digitize the signal is not stable, and the resulting digitized value may not be correct.
		0 = normal	

Tab. 9-10: *DNP3 Analog input flags*

BFM address (dec)	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
	—	REC	OVR	LOC	REM	CER	RES	ONL	—	REC	OVR	LOC	REM	CER	RES	ONL		
10112	AI1 flag								AI0 flag								R/W	WORD
10113	AI3 flag								AI2 flag								R/W	WORD
10114	AI5 flag								AI4 flag								R/W	WORD
…	…								…								…	…
10367	AI511 flag								AI510 flag								R/W	WORD

Tab. 9-11: *DNP3 16-bit Analog Inputs flags BFM mapping*

BFM address (dec)	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
	—	REC	OVR	LOC	REM	CER	RES	ONL	—	REC	OVR	LOC	REM	CER	RES	ONL		
10880	DAI1 flag								DAI0 flag								R/W	WORD
10881	DAI3 flag								DAI2 flag								R/W	WORD
10882	DAI5 flag								DAI4 flag								R/W	WORD
…	…								…								…	…
11007	DAI255 flag								DAI254 flag								R/W	WORD

Tab. 9-12: *DNP3 32-bit Analog Inputs flags BFM mapping*

BFM address (dec)	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
	—	REC	OVR	LOC	REM	CER	RES	ONL	—	REC	OVR	LOC	REM	CER	RES	ONL		
11520	RAI1 flag								RAI0 flag								R/W	WORD
11521	RAI3 flag								RAI2 flag								R/W	WORD
11522	RAI5 flag								RAI4 flag								R/W	WORD
…	…								…								…	WORD
11647	RAI255 flag								RAI254 flag								R/W	WORD

Tab. 9-13: *DNP3 Short Floating Point Analog Inputs flags BFM mapping*

NOTES

All empty grayed flags **"–"** should always be set to 0 by PLC program.

The ONLINE flags ***ONL*** should be set to 1 by PLC program. The ONL flag is set automatically to value 1, when data values is written. Value is automatically set to 0, when FX3-series PLC goes to STOP, or heartbeat is lost when communicating with Q/L-series PLC.

9.4.5 Binary outputs

Binary outputs are mapped into following variations of Object group 10:

- Variation 1 (Binary output packed binary): in this variation the value of the digital output is mapped to the binary output BFM section
- Variation 2 (Binary Output with flag) in this variation the current value of the digital output is mapped which is located in the binary output flag BFM section.

Flag	Short form	Value	Description
ONLINE	ONL	1 = online	If the point is OFFLINE, the returned state of this point may not be correct. The ONLINE binary output point has been set successfully.
		0 = offline	
RESTART	RES	1 = restart	The field device that originated the data object has been restarted. This device may be the device reporting this data object.
		0 = normal	
COMM LOST	CER	1 = lost	The device reporting this data object has lost communication with the originator of the data object.
		0 = normal	
REMOTE FORCED	REM	1 = remote	The state of the binary object has been forced to its current state at the originating device.
		0 = normal	
LOCAL FORCED	LOC	1 = local	The state of the binary object has been forced to its current state at the device reporting.
		0 = normal	

Tab. 9-14: *DNP3 Binary Output flags*

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
BFM address (dec)	—	—	—	LOC	REM	CER	RES	ONL	—	—	—	LOC	REM	CER	RES	ONL		
16896	BO1 flags								BO0 flags								RO	WORD
…	…								…								RO	WORD
16903	BO15 flags								BO14 flags								RO	WORD
16904	BO17 flags								BO16 flags								R/W	WORD
16905	BO19 flags								BO18 flags								R/W	WORD
…	…								…								R/W	WORD
20991	BO8191 flag								BO8190 flag								R/W	WORD

Tab. 9-15: *DNP3 Binary outputs flags BFM mapping*

NOTES

All empty grayed flags **"–"** should always be set to 0 by PLC program.

The ONLINE flag ***ONL*** should always be set to 1 by PLC program.

The ONLINE (ONL) flags should be set to value 1 by PLC program. The ONL flag is set automatically to value 1, when data value is written by Master station for the first time.

9.4.6 Analog outputs

Current values of Analog outputs are mapped into following variations of Object group 40:

- Variation 1 (32-bit analog output flag): in this variation the current values of the 32-bit analog inputs are mapped which are located in the 32-bit analog outputs flags BFM section.
- Variation 2 (16-bit analog output flag): in this variation the current values of the 16-bit analog inputs are mapped which are located in the 16-bit analog outputs flags BFM section.
- Variation 3 (short float analog output flag): in this variation the current values of the short float analog outputs are mapped which are located in the short float analog outputs flags BFM section.

Analog outputs are mapped into following variations of Object group 41:

- Variation 1 (32-bit analog output block): in this variation the values of this variation are mapped to the 32-bit analog outputs BFM section.
- Variation 2 (16-bit analog output block): in this variation the values of this variation are mapped to the 16-bit analog outputs BFM section.
- Variation 3 (short float analog output block): in this variation the values of this variation are mapped to the short float analog outputs BFM section.

Flag	Short form	Value	Description
ONLINE	ONL	1 = online 0 = offline	If the point is OFFLINE, the returned state of this point may not be correct. The ONLINE binary output point has been set successfully.
RESTART	RES	1 = restart 0 = normal	The field device that originated the data object has been restarted. This device may be the device reporting this data object.
COMM LOST	CER	1 = lost 0 = normal	The device reporting this data object has lost communication with the originator of the data object.
REMOTE FORCED	REM	1 = remote 0 = normal	The state of the binary object has been forced to its current state at the originating device.
LOCAL FORCED	LOC	1 = local 0 = normal	The state of the binary object has been forced to its current state at the device reporting.
OVER RANGE	OVR	1 = over 0 = normal	The digitized signal or calculation is greater than the type specified.
REFERENCE CHECK	REC	1 = reference ch. 0 = normal	The reference signal used to digitize the signal is not stable, and the resulting digitized value may not be correct.

Tab. 9-16: *DNP3 Analog outputs supported flags*

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
BFM address (dec)	—	REC	OVR	LOC	REM	CER	RES	ONL	—	REC	OVR	LOC	REM	CER	RES	ONL		
21504	AO1 flag								AO0 flag								R/W	WORD
21504	AO3 flag								AO2 flag								R/W	WORD
…	…								…								R/W	WORD
21759	AO511 flag								AO510 flag								R/W	WORD

Tab. 9-17: *DNP3 16-bit Analog Outputs flags BFM mapping*

BFM address (dec)		PLC perm.	Data type
21760	AO0 16-bit Actual Values	R/W	INT
21761	AO1 16-bit Actual Values	R/W	INT
21762	AO2 16-bit Actual Values	R/W	INT
…	…	R/W	INT
22271	AO511 16-bit Actual Values	R/W	INT

Tab. 9-18: *DNP3 16-bit Analog Outputs Actual Values BFM mapping*

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0		
BFM address (dec)	—	REC	OVR	LOC	REM	CER	RES	ONL	—	REC	OVR	LOC	REM	CER	RES	ONL	PLC perm.	Data type
22784	DAO1 flag								DAO0 flag								R/W	WORD
22785	DAO3 flag								DAO2 flag								R/W	WORD
…	…								…								R/W	WORD
22911	DAO255 flag								DAO254 flag								R/W	WORD

Tab. 9-19: *DNP3 32-bit Analog Outputs flags BFM mapping*

BFM address (dec)		PLC perm.	Data type
22912	DAO0 32-bit Actual Values	R/W	DINT
22914	DAO1 32-bit Actual Values	R/W	DINT
…	…	R/W	DINT
23422 23423	DAO255 32-bit Actual Values	R/W	DINT

Tab. 9-20: *DNP3 32-bit Analog Outputs Actual Values BFM mapping*

BFM address (dec)	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
23936	—	REC	OVR	LOC	REM	CER	RES	ONL	—	REC	OVR	LOC	REM	CER	RES	ONL	R/W	WORD
23937	RAO1 flag								RAO0 flag								R/W	WORD
…	RAO3 flag								RAO2 flag								R/W	WORD
24063	…								…								R/W	WORD
	RAO255 flag								RAO254 flag									

Tab. 9-21: *DNP3 Short Floating Point Analog Outputs flags BFM mapping*

BFM address (dec)		PLC perm.	Data type
24064	RAO0 float Actual Values	R/W	REAL
24066	RAO1 float Actual Values	R/W	REAL
…	…	R/W	REAL
24574 24575	RAO255 float Actual Values	R/W	REAL

Tab. 9-22: *DNP3 Short Floating Point Analog Outputs Actual Values BFM mapping*

NOTES

All empty grayed flags **"–"** should always be set to 0 by PLC program.

The ONLINE flag ***ONL*** should always be set to 1 by PLC program.

The ONLINE (ONL) flags should be set to value 1 by PLC program. The ONL flag is set automatically to value 1, when data value is written by Master station for the first time.

9.5 Device profile

The ME-RTU contains a device profile which lists the supported functionalities. In Appendix A the device profile for the ME-RTU is provided.

10 IEC 60870-5-101/104 Functionality

IEC 60870-5 is a general protocol definition developed by the International Electrotechnical Commission (IEC) Technical Committee 57. It is an outline for the structure of a protocol and can only be implemented with a companion standard (profile) to specify options such as one of five link layer formats.

ME-RTU IEC 60870-5-101/104 implementation features:

- Supports unbalanced link layer configuration using one address fields
- Clock synchronization commands
- Supports any applicable physical communication including RS232 (with USB-to-RS232 converter) and TCP/IP
- Can be used in event-driven or non-event driven environments
- Provides support for statistics of communication protocol errors such as bad CRC, invalid synchronization byte, and incorrect frame sequence number to help identify faulty communication lines.

10.1 IEC 60870-5-101/104 configuration settings

Parameter Name	Description
ASDU Address	Device link layer address
Delete oldest event	If events buffer is full, replace oldest event with newly generated event

Tab. 10-1: *IEC 60870-5 configuration settings*

10.1.1 IEC 60870-5-101 channel and session configuration

When configuring IEC 60870-5-101 master, consider the following settings:

Channel configuration:

– Link mode: UNBALANCED

– Link address size: 1

Session configuration

– ASDU address size: 2

– Cause of transmission (COT) size: 1

– Information object address (IOA) size: 3

– Link address: 3

10.2 IEC 60870-5-101/104 supported data types

The ME-RTU IEC60870-5-101/104 protocol implementation supports the following data types:

- Digital inputs (M_SP_NA_1) and outputs (C_SC_NA_1)
- Double digital inputs (M_DP_NA_1)
- 32-bit counters (M_IT_NA_1)
- 16-bit and short floating point analog inputs (M_ME_NB_1 and M_ME_NC_1) and outputs (C_SE_NB_1 and C_SC_NC_1)
- Bitstring of 32-bit inputs (M_BO_NA_1) and outputs (C_BO_NA_1)

All communications between the IEC 60870-5 control station and the PLC takes place through these data types. ME-RTU implementation of IEC 60870-5-101/104 also supports generating events and sending events (unsolicited massages). The events are generated for every input data type on value change or flag status change. If control station is not connected or unsolicited messages (sending of events) is blocked, the events are stored is events buffer. The size of the buffer is configurable via Web User Interface (refer to Data Events settings).

If the connection to the PLC is lost (FX3 PLC goes to STOP or no heartbeat is received Q/L PLC), then all input data VALID flags are set to INVALID. The VALID flag is automatically set for each data point, when PLC writes its value to ME-RTU. All other flags must be set manually by the PLC.

10.3 IEC 60870-5-101/104 information objects addresses and BFM mapping

The data which is in the BFM is mapped to the Information Objects Address space.

	Basic data type	IEC 60870-5 type	BFM address		Start Information object Address	Description
			Start	End		
Input data	Binary Input	M_SP_NA_1	1024	1535	10000	Single-point information
	Double Binary Input	M_DP_NA_1	5632	6143	20000	Double-point information
	32–bit Counters	M_IT_NA_1	8960	9471	30000	Integrated totals
	16–bit Analog Inputs	M_ME_NB_1	9600	10111	40000	Measured value, scaled value
	32–bit Analog Inputs	M_BO_NA_1	10368	10879	90000	Bitstring of 32 bit
	Short float Analog Inputs	M_ME_NC_1	11008	11519	50000	Measured value, short floating point
Output data	Binary Output	C_SC_NA_1	16384	16895	60000	Set point command, scaled value
	16–bit Analog Outputs	C_SE_NB_1	20992	21503	70000	Set point command, scaled value
	32–bit Analog Outputs	C_BO_NA_1	22272	22783	100000	Command bitstring of 32 bit
	Short float Analog Outputs	C_SE_NC_1	23424	23935	80000	Set point command, short floating point number

Tab. 10-2: *IEC 60870-5-101/104 Information objects Address and BFM mapping*

10.4 IEC 60870-5-101/104 flags BFM mapping

The following chapters describe mapping of IEC 60870-5-101/104 flags (referred to as Quality Descriptors in IEC 60870-5-101 standard) to the BFM.

CAUTION:

- ***If FX3 series PLC is selected as the only PLC (see figure 11-9), then the following operation applies:***
  - ***If FX3 PLC is in reset or stop mode, the INVALID Quality Descriptors are set for all data points.***
  - ***After the FX3 PLC goes to RUN mode and value is written to data point, the INVALID Quality Descriptor must be written by the PLC for this data point.***
- ***If Q/L series PLC is selected as the PLC type (see figure 11-9), then the following operation applies:***
  - ***When Heartbeat timer runs out, the INVALID flags are set.***
  - ***After connection is established and value is written to data point, the INVALID status must be written by the PLC for this data point.***

10.4.1 Binary inputs

Binary inputs are mapped as monitored single point information. The Quality Descriptors are mapped to the Binary Inputs flags BFM section.

Status	Short form	Value	Description
BLOCKED	BL	1 = blocked	This means that the value of the point is as it was prior to being blocked. Blocking prevents updating of the value of the point.
		0 = normal	
SUBSTITUDED	SB	1 = substituted	This is where a value has been substituted or forced by manual entry or otherwise. It means that the value is not derived from the normal measurement.
		0 = normal	
NOT TOPICAL	NT	1 = not topical	This means that the value was not updated successfully at last time it was due to be updated.
		0 = normal	
INVALID	IV	1 = invalid	This indicates that the value cannot be used because it may be incorrect due to a fault or other abnormal condition.
		0 = valid	

Tab. 10-3: *IEC 60870-5 Single point information supported Quality Descriptors*

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
BFM address (dec)	IV	NT	SB	BL	—	—	—	—	IV	NT	SB	BL	—	—	—	—		
1536	BI1 flags								BI0 flags								RO	WORD
1537	BI3 flags								BI2 flags								RO	WORD
…	…								…								…	…
1543	BI15 flags								BI14 flags								RO	WORD
1544	BI17 flags								BI16 flags								R/W	WORD
1545	BI19 flags								BI18 fags								R/W	WORD
…	…								…								…	…
5631	BI8191 flags								BI8190 flags								R/W	WORD

Tab. 10-4: *IEC 60870-5 Single point information Quality Descriptor BFM mapping*

NOTES

All empty grayed flags ***"–"*** should always be set to 0 by PLC program.

The INVALID flags ***"IV"*** should be set to 0 by PLC program. The IV flag is set automatically to value 0, when data values is written. Value is automatically set to 1, when FX3-series PLC goes to STOP, or heartbeat is lost when communicating with Q/L-series PLC.

Because 16 BIs are group in WORD of 16-bits, the INVALID flags are reset for all those 16 BIs, which are mapped to the same WORD, when PLC first writes value to this WORD.

10.4.2 Double binary inputs

Double Binary inputs are mapped as monitored double point information. The Quality Descriptors are mapped to the Double Binary Inputs flags BFM section.

Status	Short form	Value	Description
BLOCKED	BL	1 = blocked	This means that the value of the point is as it was prior to being blocked. Blocking prevents updating of the value of the point.
		0 = normal	
SUBSTITUDED	SB	1 = substituted	This is where a value has been substituted or forced by manual entry or otherwise. It means that the value is not derived from the normal measurement.
		0 = normal	
NOT TOPICAL	NT	1 = not topical	This means that the value was not updated successfully at last time it was due to be updated.
		0 = normal	
INVALID	IV	1 = invalid	This indicates that the value cannot be used because it may be incorrect due to a fault or other abnormal condition.
		0 = valid	

Tab. 10-5: *IEC 60870-5 Double point information supported Quality Descriptors*

BFM address (dec)	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
6144	**IV**	**NT**	**SB**	**BL**	—	—	—	—	**IV**	**NT**	**SB**	**BL**	—	—	—	—	R/W	WORD
	DBI1 flags								DBI0 flags									
6145	DBI3 flags								DBI2 flags								R/W	WORD
6146	DBI5 flags								DBI4 flags								R/W	WORD
…	…								…								R/W	WORD
8191	DBI4095 flags								DBI4094 flags								R/W	WORD

Tab. 10-6: *IEC 60870-5 Double point information Quality Descriptors BFM mapping*

NOTES

All empty grayed flags ***"–"*** should always be set to 0 by PLC program.

The INVALID flags ***"IV"*** should be set to 0 by PLC program. The IV flag is set automatically to value 0, when data values is written. Value is automatically set to 1, when FX3-series PLC goes to STOP, or heartbeat is lost when communicating with Q/L-series PLC.

Because 8 DBIs are group in WORD of 16-bits, the INVALID flags are reset for all those 8 DBIs, which are mapped to the same WORD, when PLC first writes value to this WORD.

10.4.3 32-bit counters

Counters are mapped as integrated totals. The Quality Descriptors are mapped to the 32-bit counters flags BFM section.

Status	Short form	Value	Description
SEQUENCE NUMBER	SQ	from 0 to 31	This number is incremented with each counter read operation.
CARRY	CY	1 = carry	Counter overflow occurs when value increments from $+2^{32}$-1 to 0 or from -2^{32} to 0.
		0 = normal	
COUNTER ADJUSTED	CA	1 = adjusted	This means that the counter value has been adjusted since the last reading.
		0 = normal	
INVALID	IV	1 = invalid	This indicates that the value cannot be used because it may be incorrect due to a fault or other abnormal condition.
		0 = valid	

Tab. 10-7: *IEC 60870-8 Integrated totals supported Quality Descriptors*

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
BFM address (dec)	IV	CA	CY	SQ					IV	CA	CY	SQ						
9472	DBC1 flags								DBC0 flags								R/W	WORD
9473	DBC3 flags								DBC2 flags								R/W	WORD
9474	DBC5 flags								DBC4 flags								R/W	WORD
…	…								…								R/W	WORD
9599	DBC255 flags								DBC254 flags								R/W	WORD

Tab. 10-8: *IEC 60870-5 Integrated totals Quality Descriptors BFM mapping*

NOTES

All empty grayed flags ***"–"*** should always be set to 0 by PLC program.

The INVALID flags ***"IV"*** should be set to 0 by PLC program. The IV flag is set automatically to value 0, when data values is written. Value is automatically set to 1, when FX3-series PLC goes to STOP, or heartbeat is lost when communicating with Q/L-series PLC.

10.4.4 Analog inputs

The Quality Descriptors are mapped to the Analog Inputs flags BFM section.

Status	Short form	Value	Description
OVERFLOW	OV	1 = overflow	The value of the information object is beyond a predefined range of value.
		0 = normal	
BLOCKED	BL	1 = blocked	This means that the value of the point is as it was prior to being blocked. Blocking prevents updating of the value of the point .
		0 = normal	
SUBSTITUDED	SB	1 = substituted	This is where a value has been substituted or forced by manual entry or otherwise. It means that the value is not derived from the normal measurement.
		0 = normal	
NOT TOPICAL	NT	1 = not topical	This means that the value was not updated successfully at last time it was due to be updated.
		0 = normal	
INVALID	IV	1 = invalid	This indicates that the value cannot be used because it may be incorrect due to a fault or other abnormal condition.
		0 = valid	

Tab. 10-9: *IEC 60870-5 Analog inputs supported Quality Descriptors*

16-bit Analog Inputs are mapped as scaled measured value. The Quality Descriptors are mapped to the 16-bit Analog Inputs flags BFM section.

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
BFM address (dec)	IV	NT	SB	BL	—	—	—	OV	IV	NT	SB	BL	—	—	—	OV		
10112	AI1 flags								AI0 flags								R/W	WORD
10112	AI3 flags								AI2 flags								R/W	WORD
10114	AI5 flags								AI4 flags								R/W	WORD
…	…								…								R/W	WORD
10367	AI511 flags								AI510 flags								R/W	WORD

Tab. 10-10: *IEC 60870-5 Scaled measured values Quality Descriptors BFM mapping*

Short floating analog inputs are mapped as scaled measured value. The Quality Descriptors are mapped to the short floating analog inputs flags BFM section.

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
BFM address (dec)	IV	NT	SB	BL	—	—	—	OV	IV	NT	SB	BL	—	—	—	OV		
11520	RAI1 flags								RAI0 flags								R/W	WORD
11521	RAI3 flags								RAI2 flags								R/W	WORD
11522	RAI5 flags								RAI4 flags								R/W	WORD
…	…								…								R/W	WORD
11647	RAI255 flags								RAI254 flags								R/W	WORD

Tab. 10-11: *IEC 60870-5 Short Floating Point measured values Quality Descriptors BFM mapping*

32-bit Analog Inputs are mapped as bitstring of 32-bit. The Quality Descriptors are mapped from the short floating point analog inputs flags BFM section.

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	PLC perm.	Data type
BFM address (dec)	IV	NT	SB	BL	—	—	—	OV	IV	NT	SB	BL	—	—	—	OV		
10880	DAI1 flags								DAI0 flags								R/W	WORD
10881	DAI3 flags								DAI2 flags								R/W	WORD
10882	DAI5 flags								DAI4 flags								R/W	WORD
…	…								…								R/W	WORD
11007	DAI255 flags								DAI254 flags								R/W	WORD

Tab. 10-12: *IEC 60870-5 Bitstring of 32 bit Quality Descriptors BFM mapping*

NOTES

All empty grayed flags ***"–"*** should always be set to 0 by PLC program.

The INVALID flags ***"IV"*** should be set to 0 by PLC program. The IV flag is set automatically to value 0, when data values is written. Value is automatically set to 1, when FX3-series PLC goes to STOP, or heartbeat is lost when communicating with Q/L-series PLC.

10.4.5 Binary outputs

Binary outputs are mapped as single command. The value is mapped to the binary output BFM section from where the PLC can read the value and set the physical output.

10.4.6 Analog outputs

16-bit Analog Outputs are mapped as set point command scaled value. The value is mapped to the 16-bit Analog Outputs BFM section from where the PLC can read the value and set the physical output.

32-bit Analog Outputs are mapped as 32-Bitstring. The value is mapped to the 32-bit Analog Outputs BFM section from where the PLC can read the value and set the physical output.

Short Floating Analog Outputs are mapped as set point command short floating point value. The value is mapped to the Short Floating Point Analog Outputs BFM section from where the PLC can read the value and set the physical output.

10.5 Device profile

The device profile for the IEC 60870-5-101/104 is found in the Appendix B.

11 Settings and Diagnostics

11.1 Settings overview

The settings of the ME-RTU are divided into more main groups:

- Operating mode
- General settings
- Network settings
- Cellular settings
- Database settings
- DNP3 settings
- IEC 60870-5-101/104 settings
- PLC communication settings

Each main group has also different sub sections of settings.

11.2 Parameter setting and setting procedure

The ME-RTU has an integrated basic webserver which provides a web user interface for configuration of the module and diagnostic of the functionality.

The web user interface made up of the following sections:

- Header where a logo is located and the name of the device
- A navigation menu to address different sections
- Current page where the desired information is listed
- Footer with Copyright information

The web user interface has the following sections:

- **Main page**: provides basic information about the ME-RTU and provides an overview of the functionality
- **Local network**: enables the user to configure the network settings of the device like DHCP, IP address, DNS, DDNS, SNMP, VPN
- **Cellular network**: configuration settings for the SIM card such as PIN code and some other mobile operator depending settings e.g. APN, data connection type (GPRS, EDGE)
- **Diagnostic**: diagnostic information for the ME-RTU such as uptime, interface flags, error and statistical information about the quantity of data being sent via protocol stacks and cellular network
- **Database**: Settings for configuring the database elements
- **Protocol settings**: Settings for configuring the communication protocols to the control center. This page also has an option for diagnostic if a remote connection to the master station is established.
- **PLC communication settings:** setting for configuring the PLC interface

To dynamically refresh the data on the diagnostic web pages the AJAX technology is being used. This enables the status of the module to be automatically refreshed in a specific time period or on an event.

11.3 Configuring ME-RTU via integrated web server

When accessing web server for the first time, ME-RTU must be connected locally to computer and appropriate network configuration must be carried out in order to establish LAN network connection.

11.3.1 Computer network adapter configuration for direct access

In order to directly access web user interface, computer's network adapter must be properly configured. Static IP and subnet mask must be set. IP address is set to 192.168.0.11 (default ME-RTU IP address is 192.168.0.10) and subnet mask must be set to 255.255.255.0.

Computer's network adapter configuration

Network configuration can be accessed via "Control panel". In control panel "Network and Sharing Center" is selected.

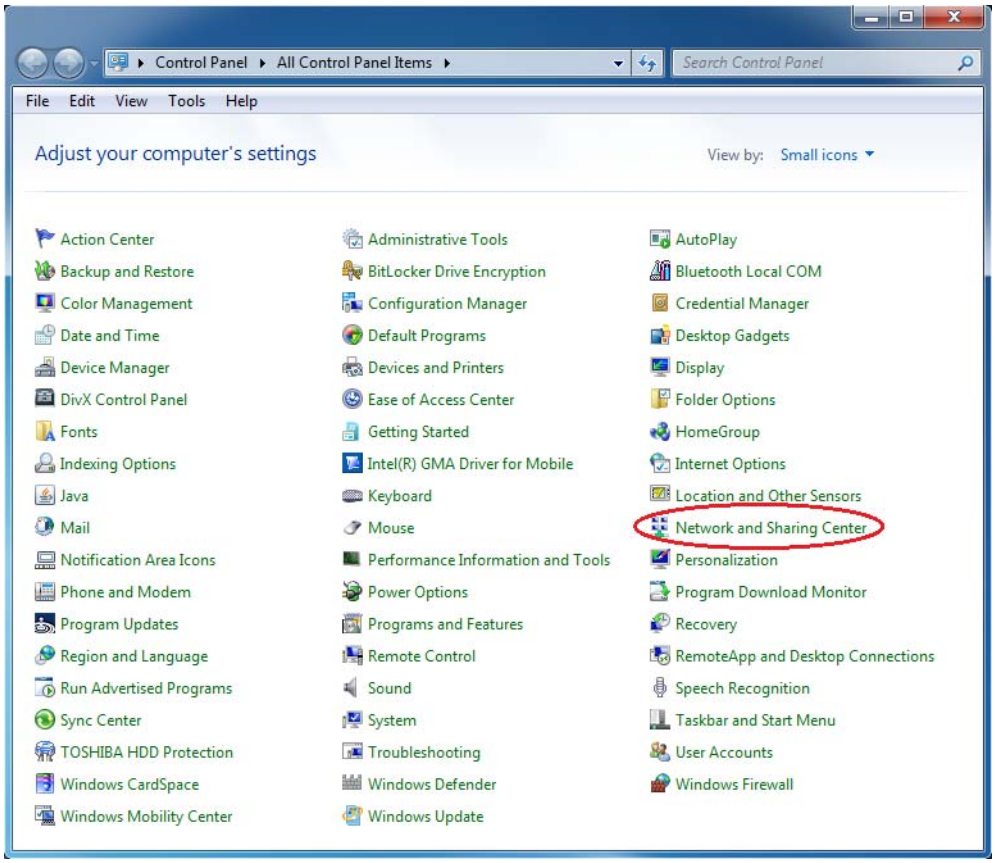


Fig. 11-1: *Control panel*

In opening window "Change adapter settings" is selected.

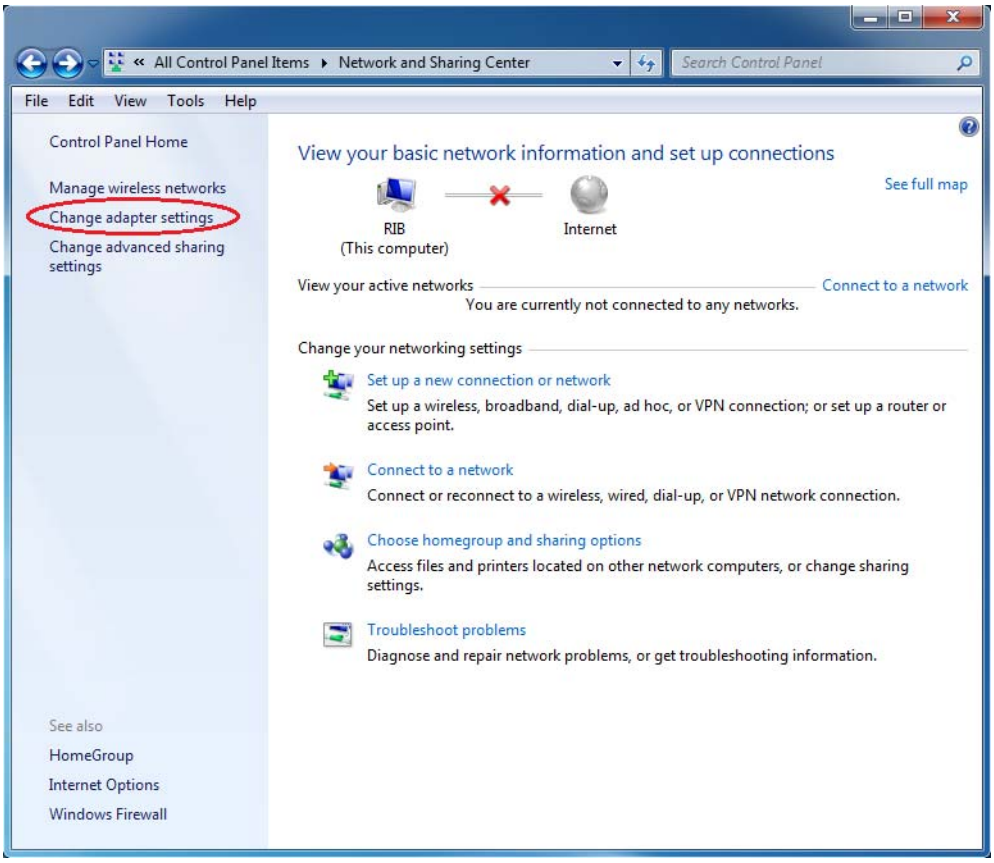


image035

Fig. 11-2: *Network and Sharing Center*

"Local Area Connection" is selected.

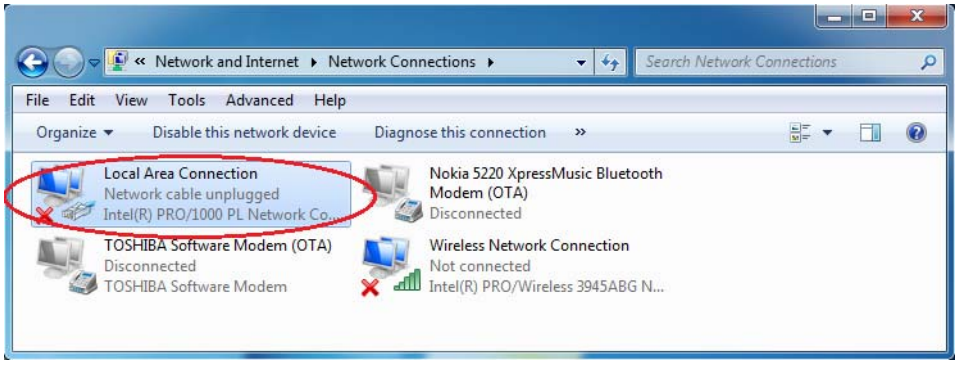


image036

Fig. 11-3: *Network Connections*

IP address and subnet mask window is opened by selecting IPv4 and clicking "Properties".

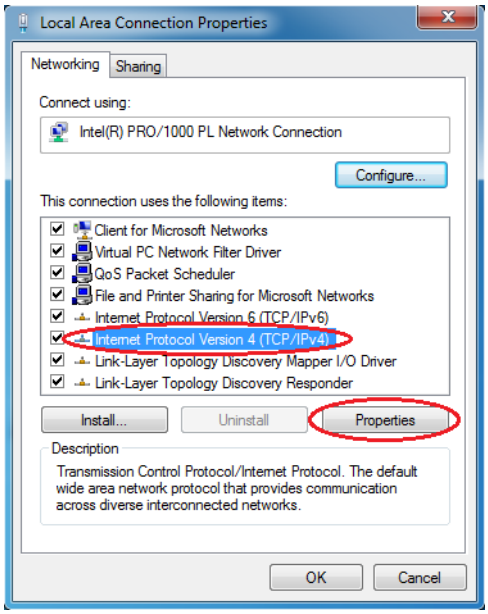


image037

Fig. 11-4: *Local Area Connection Properties*

In a window that opens, IP address 192.168.0.11 is inserted in "IP address" field and subnet mask 255.255.255.0 is inserted in "Subnet mask" field.

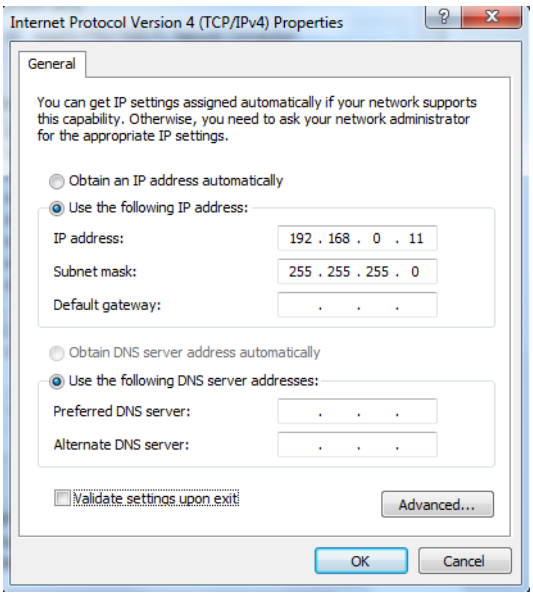


image038

Fig. 11-5: *IP address and subnet mask configuration*

11.3.2 Accessing web user interface

To access web user interface, computer and ME-RTU have to be on the same subnet. Connecting to ME-RTU is performed by entering the default IP address 192.168.0.10 in internet browser. After that, ME-RTU login window appears. The default username **rtuadmin** and default password rtuadmin must be entered.

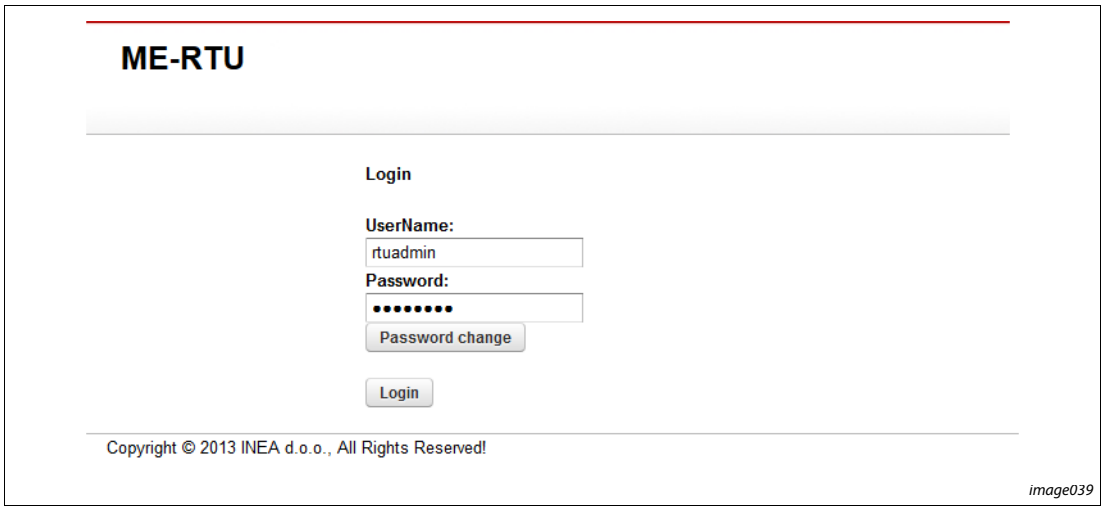


Fig. 11-6: *Web User Interface login window*

To change password, first insert the username and password into login form (figure 11-6), then press "Password change". In the password change form (figure 11-7), the username is already inserted and cannot be changed. Enter the new password twice and press "Change password". To abort changing password, select one of the tags in the menu tab (figure 11-8).

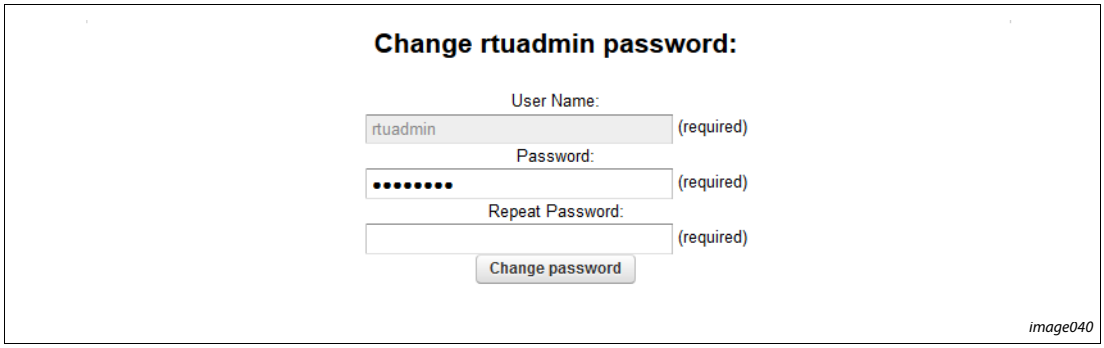


Fig. 11-7: *Web User Interface change password*

Web User Interface menu consists of following tags:

- General
- Network
- Database
- DNP3
- IEC 60870-5
- BFM Debug
- Mobile
- VPN
- Logout

Fig. 11-8: *Web User Interface menu*

11.3.3 General tab

General tab contains basic ME-RTU operational settings.

Operating mode

The operating mode, which affects the telemetry protocols (DNP3 and IEC 60870-5). One operating modes are available:

- Slave Only

In **Slave Only** mode, the available protocols are:

- DNP3 via Ethernet (slave)
- DNP3 via Serial (slave)
- IEC 60870-5-101 (slave)
- IEC 60870-5-104 (slave)

General ME-RTU settings

Here, user selects the PLC type which communicates with ME-RTU. Supported options are FX series, which communicates via FX cable and Q/L series, which communicate via Ethernet. If Q/L series is selected as connected PLC, an IP Protocol and Port number become configurable. If PLC type is changed, ME-RTU must be restarted by powering OFF and back ON after 5 seconds.

SCADA side protocol (DNP3 or IEC 60870-5) is set, including the protocol communication path (Ethernet or Serial). For Ethernet protocol communication path, the Ethernet port interface or mobile (GPRS) interface can be used, depending on network configuration. If Serial protocol communication path is selected, communication takes place via USB host port.

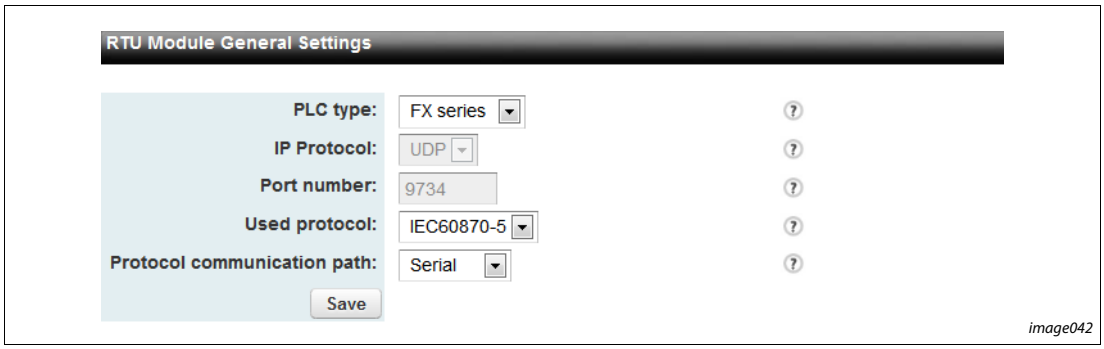


Fig. 11-9: *Web User Interface general settings*

CAUTION:

If FX3 series PLC is connected to the ME-RTU via FX Bus and even though Q/L PLC type is selected, the FX3 PLC can still communicate with ME-RTU. This may cause data collision when writing to the same ME-RTU BFM address.

Serial Connection Settings

Here, serial connection is configured. Serial connection settings become active; if Protocol communication path is set to "Serial" (see figure 11-9). For the serial connection Baudrate, Number of data bits, Number of stop bits, Parity and Flow control can be configured.

The Device name is name of device for asynchronous serial communication (USB Host type A). The default value is "/dev/ttyUSB10".

Initial Modem String is used to initiate Modems connected to USB Host and act as a carrying medium.

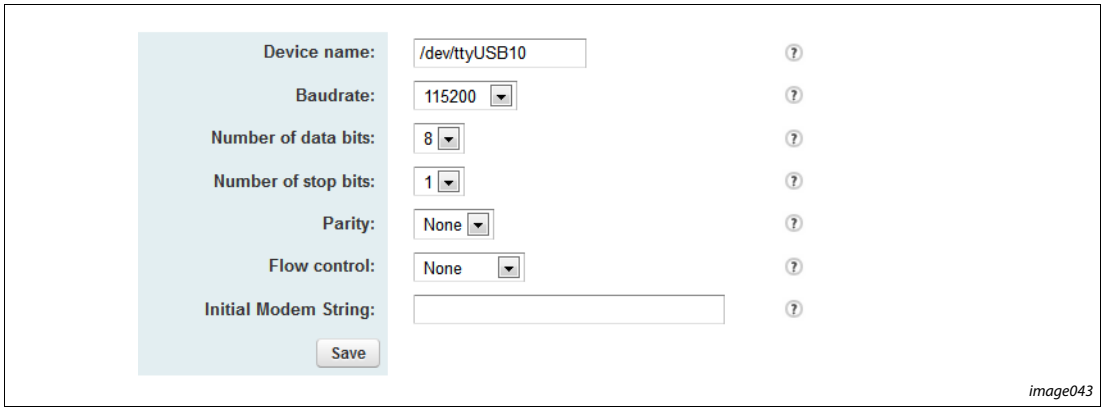


Fig. 11-10: *Web User Interface Serial Connection Settings*

Time synchronization

Time synchronization can be performed using PLC, SNTP server or Control Station. If SNTP server is used, a SNTP address (IP or hostname) must be provided. Time zone is used to set local time and is only used for synchronization with SNTP server.

Time synchronization with PLC is defined by PLC program, which writes time to ME-RTU BFM. Time synchronization with Control station is performed by the DNP3 or IEC 60870-5 protocol.

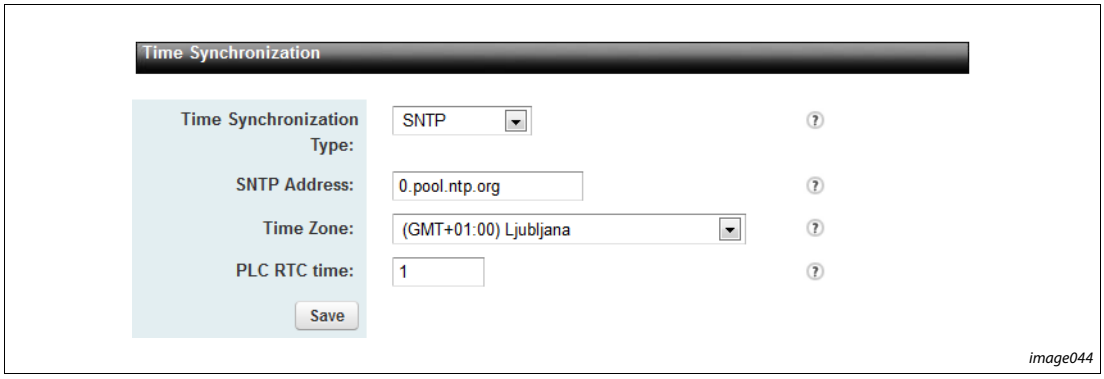


Fig. 11-11: *Web User Interface Time synchronization*

ME-RTU Configuration

ME-RTU configuration can be performed using XML configuration file. To upload XML configuration file to ME-RTU, click "Browse" button and select configuration file from computer. Then click "Upload configuration" to start the configuration process. The ME-RTU XML configuration file can be downloaded with "Backup configuration" button.

ME-RTU configuration can be set to default (as configured when first powered up) by clicking "Restore to defaults" button.

Fig. 11-12: *Web User Interface ME-RTU configuration*

Data Retention Settings

Here, the data retention functionality, described in section 7.5 Power down and data retention, can be enabled. A "Data retention write interval" (in minutes) defines the period at which the retained data is written to the SD card.

"Prepare SD card" formats the SD card and sets-up the required SD card memory partitions. After pressing the button wait up to 15 seconds for the process to complete – message-box pops-up.

NOTE

Only use "fresh" – unused SD card. The SD card memory is limited to the number of erase and write cycles. With increased erase and write cycles, the probability of data corruption increases. It is highly recommended to use industrial SD card with built-in wear-levelling algorithm and high-speed operation.

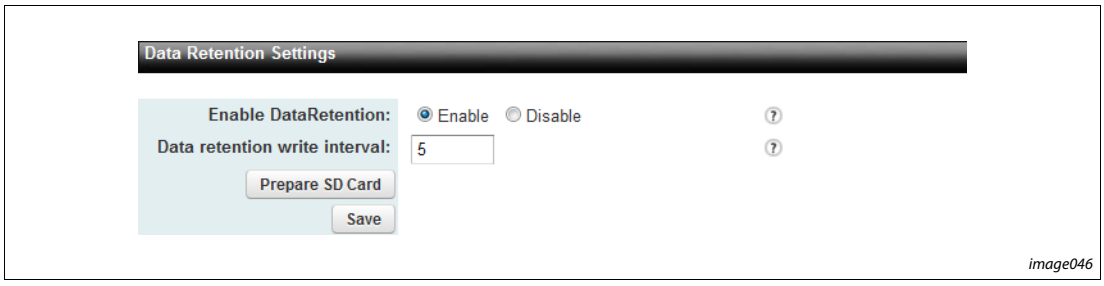


Fig. 11-13: *Web User Interface Data retention*

11.3.4 Network tab

Network tab holds network communication settings such as: DNS server settings, Gateway settings, Dynamic DNS (DDNS), SNMP settings.

General communication settings

In this section it is possible to select the DNS priority which is either Ethernet or Mobile. If former is selected, the DNS servers entered in Local Area Network settings have the priority when resolving host name. The Mobile connection interface obtains DNS servers IPs when GPRs connection is established.

The Gateway priority sets the priority communication route, which is either via Ethernet or via cellular network (Mobile).

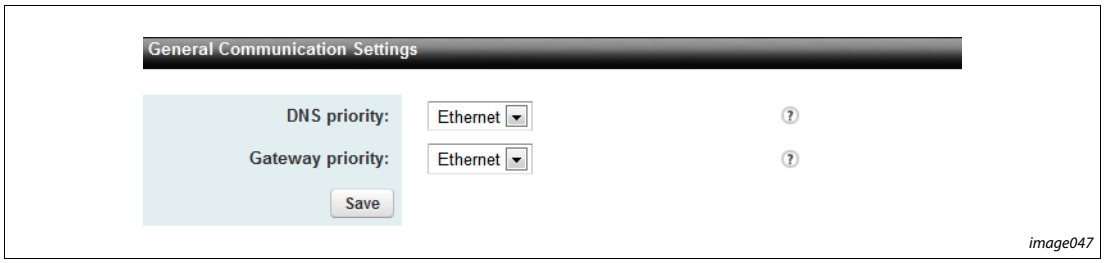


Fig. 11-14: *Web User Interface General communication settings*

Local Network settings

Here, Ethernet communication is configured. If DHCP is enabled and supported by your network, then IP address is obtained automatically. Otherwise, IP address, Network mask Gateway address and DNS servers must be inserted manually.

Tip: If DHCP is going to be enabled, before doing so, change the name of device in SNMP Settings to unique name (refer to SNMP settings). The SNMP client's (not supplied) SNMP Agent discovery functionality (usually available in SNMP clients) may be used to discover each ME-RTU. After network settings change ME-RTU should be restarted by power OFF/ON.

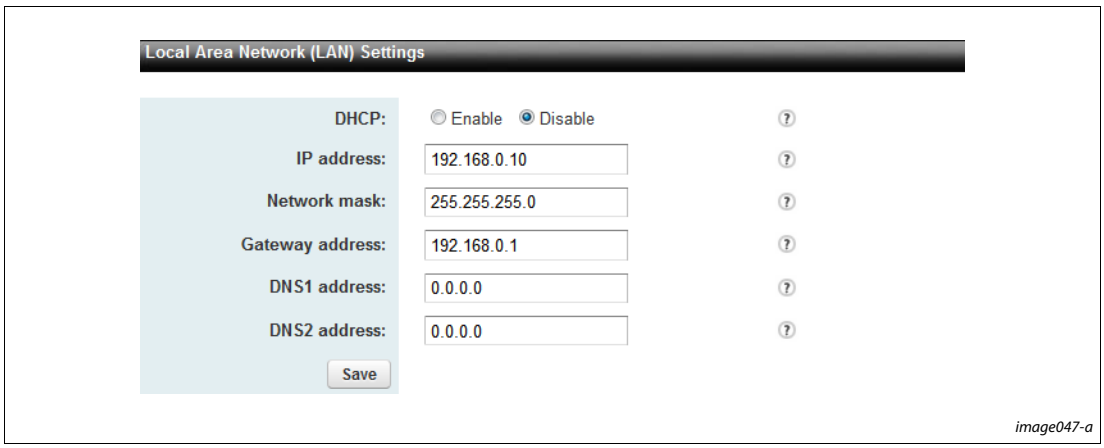


Fig. 11-15: *Web User Interface Local Network settings*

NAT Settings

NAT (Network Address Translation) is a network protocol that allows multiple devices to connect to a public network using the same address. NAT translates traffic from one IP and port number to another. To access NAT settings click "Edit NAT settings" (figure 11-16) in Network tab.

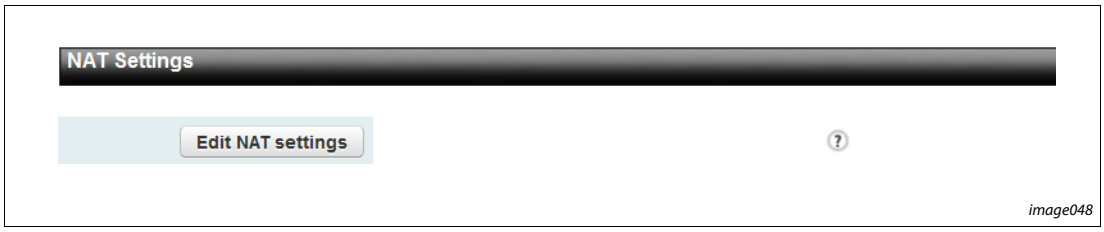


Fig. 11-16: *Web User Interface open NAT Settings*

A new page is loaded (figure 11-17). Here transmission protocol **Type** is selected (TCP or UDP), a connection **Inbound port** number which is then translated to **Destination IP** address and **Destination port** number. The **Enable** tick allows the translation to be active or disabled (without losing previous parameters).

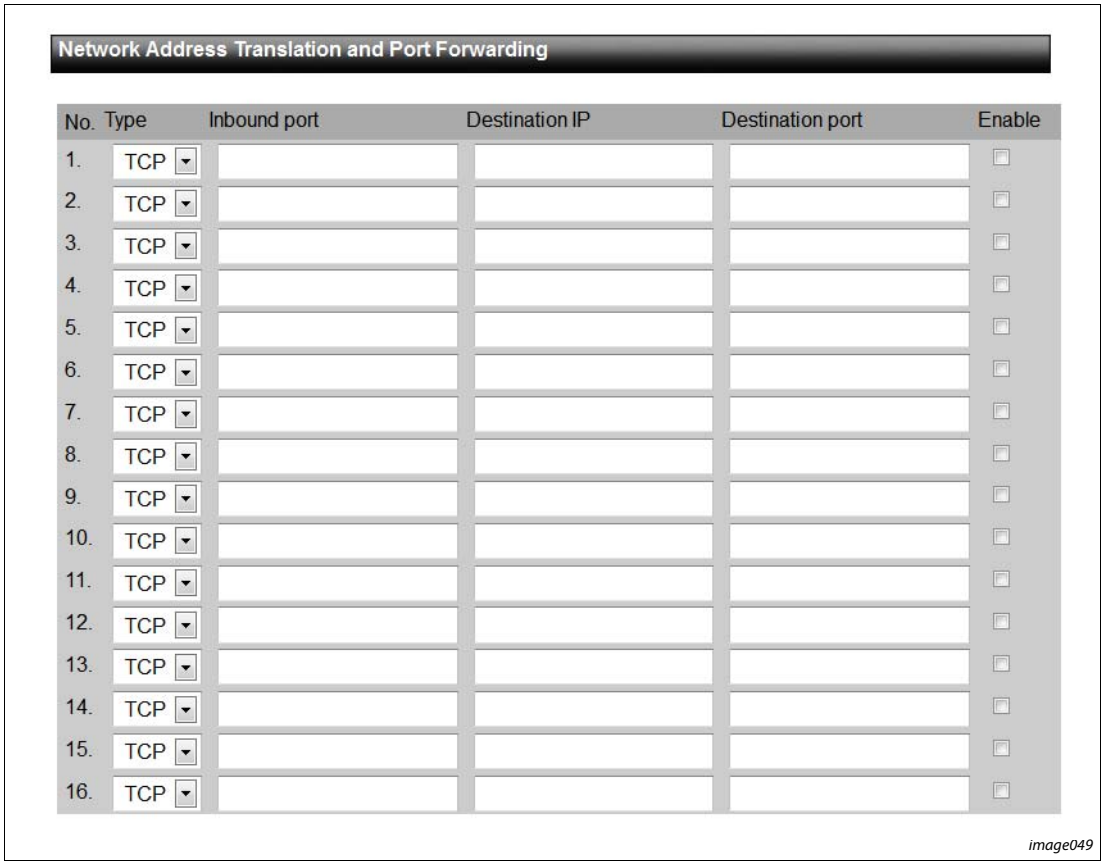


Fig. 11-17: *Web User Interface NAT settings configuration*

DDNS settings

A Dynamic DNS server may be set up for the ME-RTU. Here, DDNS server login information is inserted. For more information about DDNS functionality, refer to section 12.3 DDNS.

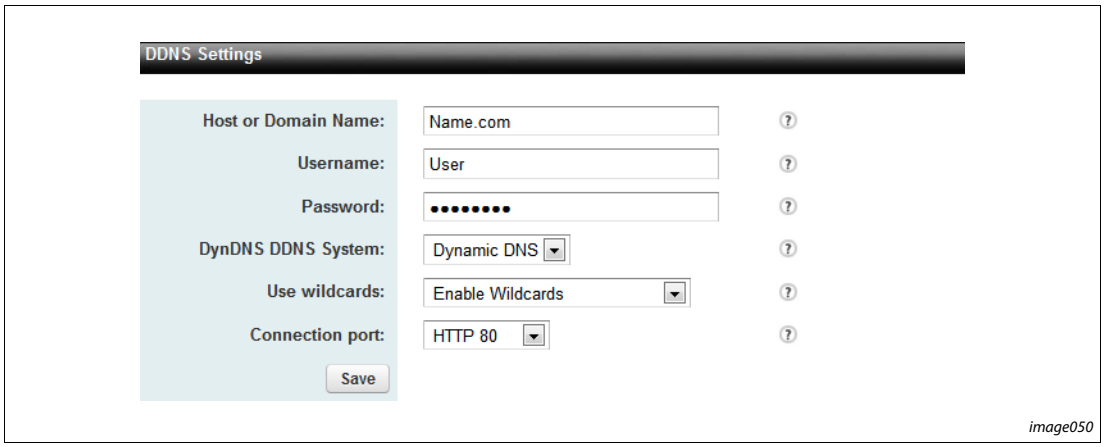


Fig. 11-18: *Web User Interface DDNS settings*

SNMP settings

Here, Simple Network Management Protocol can be configured.

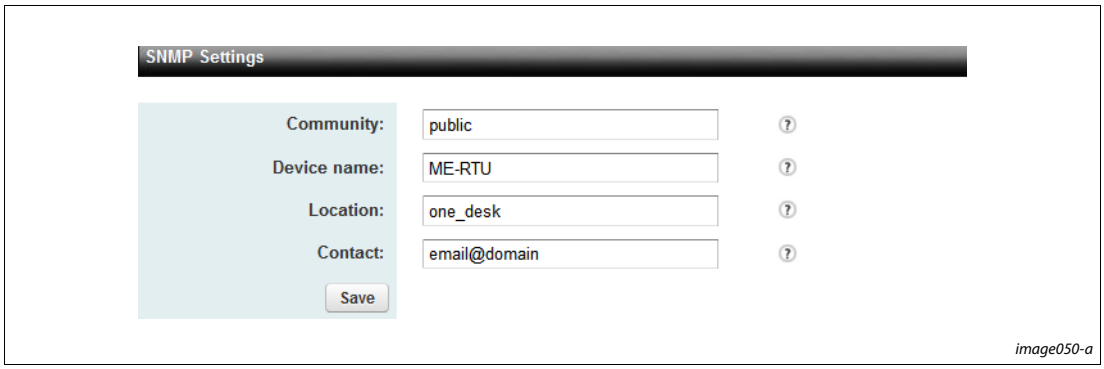


Fig. 11-19: *Web User Interface SNMP settings*

11.3.5 Database tab

In this tab, a number of each data type in database is configured; also data events can be enabled or disabled.

Database elements

In this section number of each data type is set.

CAUTION:

- ***Take caution at setting number of binary inputs!***
  The first 16 binary inputs are reserved for ME-RTU digital inputs (DI0 and DI1), which are mapped to first two binary inputs (BI0 and BI1). Set number of binary inputs at least, 32 or higher to possess PLC controlled binary inputs.
- ***Take caution at setting number of binary outputs!***
  He first two binary outputs at BFM address 16384 (BO0 and BO1) are reserved for RTU digital outputs (DO0 and DO1), to which they are mapped.

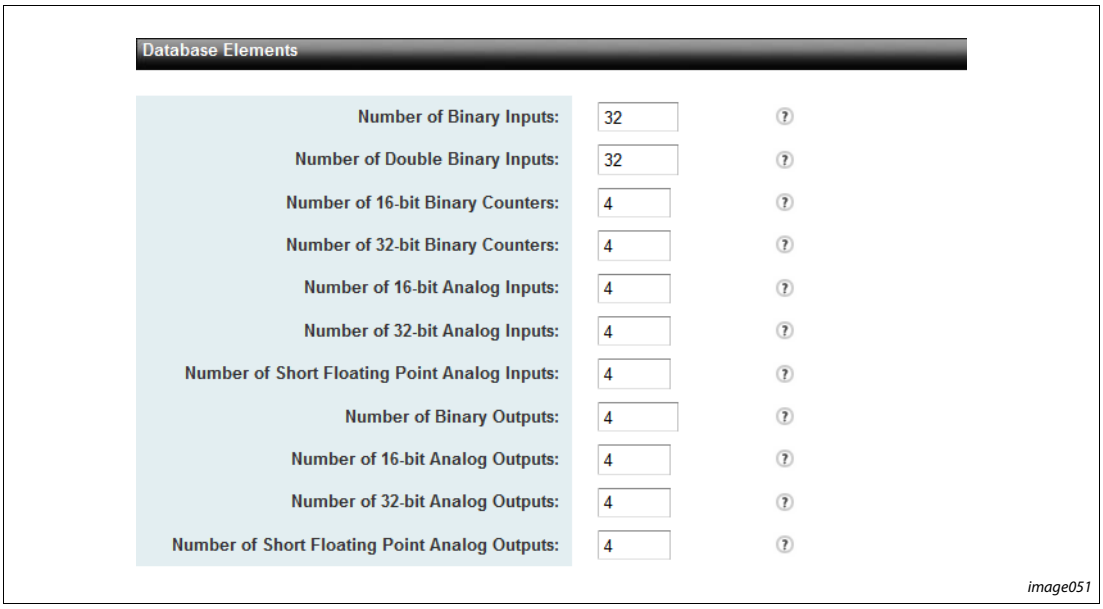


Fig. 11-20: *Web User Interface Database elements*

Data Events settings

Data's events can be enabled on disabled in this section. If events are enabled, size of events buffer must be defined. The user should enter maximum value of 65000. If this number is exceeded, the number is lowered to maximum value. The size of events buffer is protocol dependant (refer to Table 11-1).

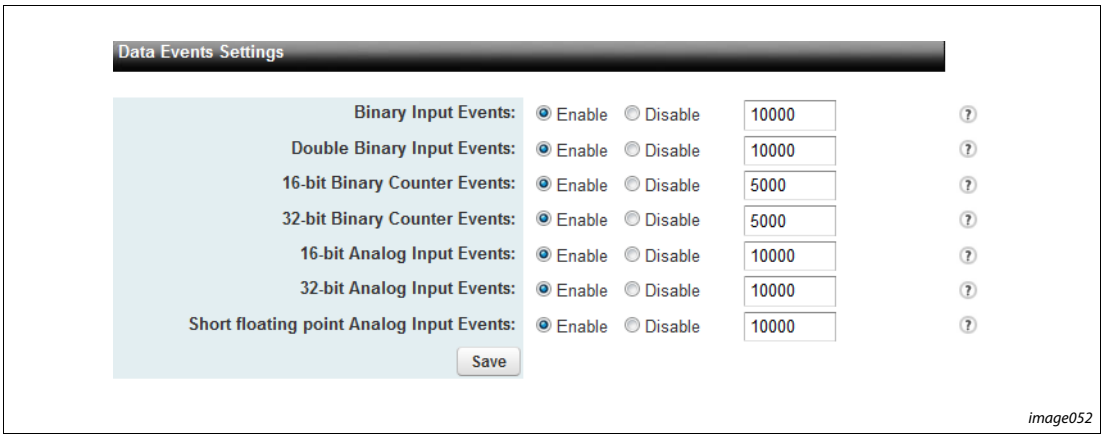


Fig. 11-21: *Web User Interface Data Events settings*

Data type	Telemetry protocol events buffer maximum value	
	DNP3	IEC 60870-5-101/104
BI	65000	65000
DBI	65000	65000
16-bit Counter	Sum of 16-bit Counters and 32-bit Counters ≤ 65000	Not supported
32-bit Counter		65000
16-bit AI	Sum of 16-bit AI, 32-bit AI and Short Floating Point AI ≤ 65000	65000
32-bit AI		65000
SFP AI		65000

Tab. 11-1: *Data Events buffer maximum values*

11.3.6 DNP3 settings

In this section DNP3 protocol is configured.

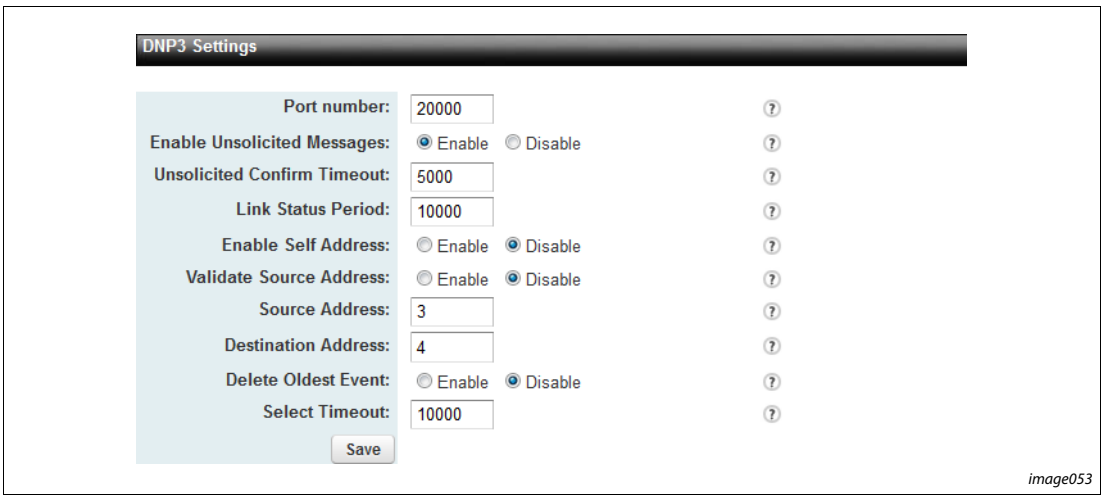


Fig. 11-22: *Web User Interface DNP3 settings*

11.3.7 IEC 60870-5 settings

In this section IEC 60870-5 protocol is configured.

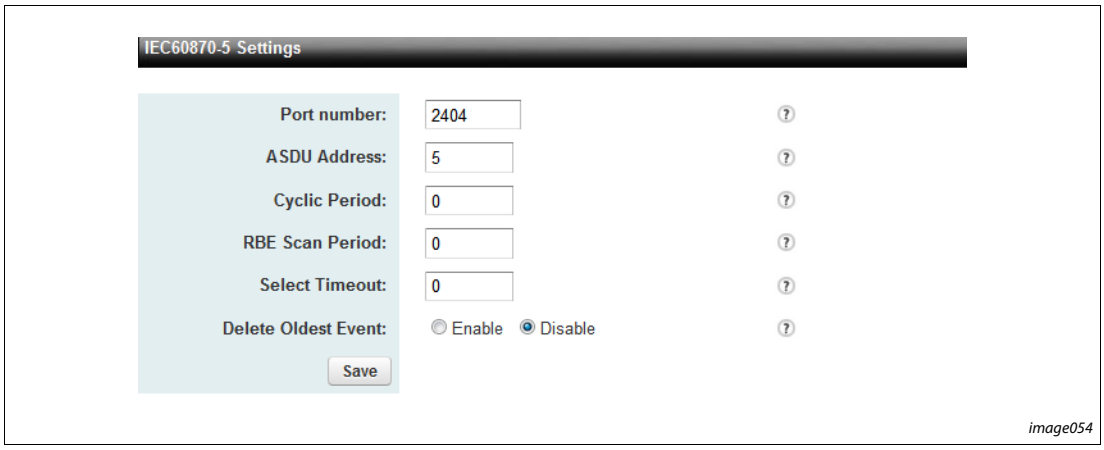
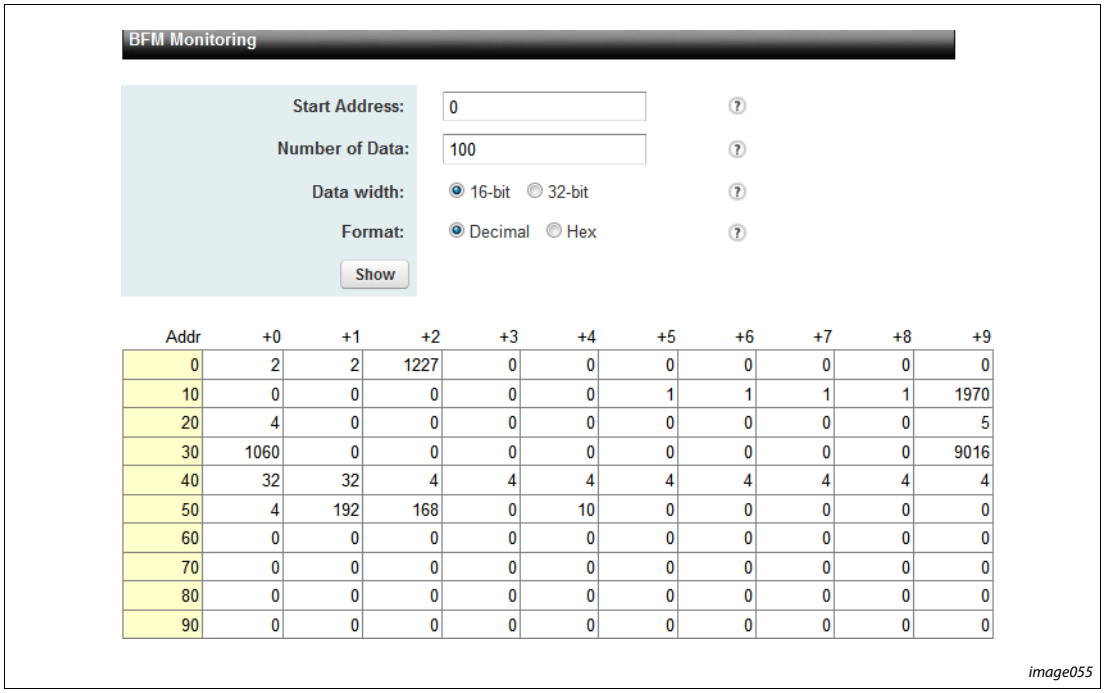


Fig. 11-23: *Web User Interface IEC 60870-5 settings*

11.3.8 BFM debug

In this section Buffered Memory can be monitored. Start address and number of data are given in decimal format.



Addr	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
0	2	2	1227	0	0	0	0	0	0	0
10	0	0	0	0	0	1	1	1	1	1970
20	4	0	0	0	0	0	0	0	0	5
30	1060	0	0	0	0	0	0	0	0	9016
40	32	32	4	4	4	4	4	4	4	4
50	4	192	168	0	10	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0

Fig. 11-24: *Web User Interface BFM debug*

11.3.9 Mobile

In this section GSM parameters needed to establish internet connection via cellular network are inserted. Also mobile connection status is available.

Mobile Network Provider Connection Settings

The mobile connection may be active or disabled. If SIM card has enabled PIN code, then the PIN code is entered and the PIN Check button must be pressed to verify the PIN code. Wait few seconds (up to 10 seconds) for response text before performing any other action, or the response text may get deleted. The returned text consists of up to three parts:

- PIN is required or not
- Entered PIN is correct, already set or incorrect
- Number of attempts left

If inserted PIN is correct, the "PIN Save" button must be pressed, to save PIN number to FLASH. The "PIN check" enters the PIN directly to SIM card and tries to unlock it. If the PIN is correct, the SIM card will be unlocked and fully functional. If ME-RTU is powered down and up (or restarted any other way), the PIN code stored in FLASH will be used to unlock the SIM card.

CAUTION:

- ***The "PIN Check" does not save PIN code to ME-RTU memory.***
- ***Always check PIN before saving the configuration.***
- ***After the PIN code has been checked and confirmed, press the PIN Save button to keep the PIN code stored in configuration.***
- ***Do NOT change the PIN code and press "PIN Save" again.***
- ***Normally user has three attempts to insert the correct PIN. Every "PIN check" usage also uses one attempt, if incorrect PIN is inserted.***
- ***If "PIN check" returns "Inserted Pin is incorrect" it is still possible to press "PIN Save" and therefore saving wrong PIN to FLASH.***
- ***Consequently, SIM card will get locked immediately.***

CAUTION:

- ***Do NOT change PIN code after it has already been confirmed by the "PIN Check" function, as there is no safety algorithm to prevent user from inserting incorrect PIN code after the correct PIN code has already been confirmed.***
- ***If incorrect PIN code is by any means stored to FLASH, the GSM module will lock the SIM card immediately!***
- ***If PIN code is changed or the SIM card with different PIN code is going to be used, first delete the PIN code in Web Interface PIN code entry window and press Save. After this, insert the SIM card and repeat the upper procedure. If this procedure is avoided, there is a risk of SIM card becoming locked.***
- ***If SIM card is locked, the PUK code can NOT be inserted by ME-RTU. Remove the SIM card and use other means to unlock the SIM card (such as standard mobile phone).***

Access Point Name (APN), Username and Password are supplied by GSM provider. Some GSM providers do not have Username and/or Password defined, in this case Enable PAP must be disabled.

Parameters, other than PIN, are stored to FLASH when Save button is pressed.

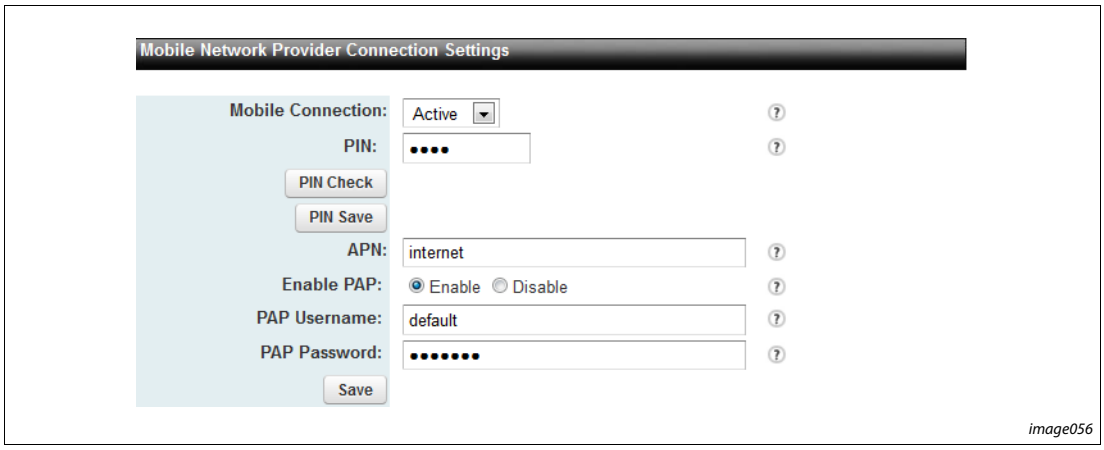


Fig. 11-25: *Web User Interface Mobile parameters settings*

Mobile Connection Test

Under the Mobile Connection Test tag, mobile signal strength is displays as a bar. It is also possible to check connectivity by using ping test. It is possible to IP address or hostname. If hostname is used for testing, make sure that "Mobile" is set as DNS priority (refer to General communication settings).

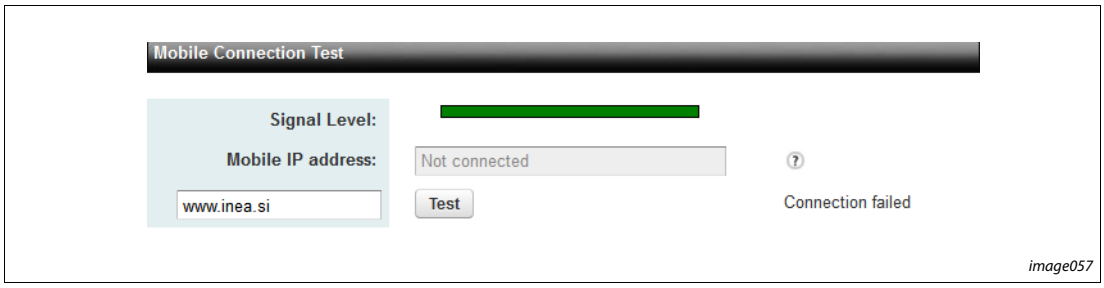


Fig. 11-26: *Web User Interface Mobile connection test*

11.3.10 VPN

In this tab Virtual Private Network (VPN) parameters are inserted and Certificate is uploaded to ME-RTU.

Open VPN settings

In this section OpenVPN server address, port number, username and password are inserted. Once VPN tunnel has been established, the VPN tunnel IP address is displayed in openVPN IP address window.

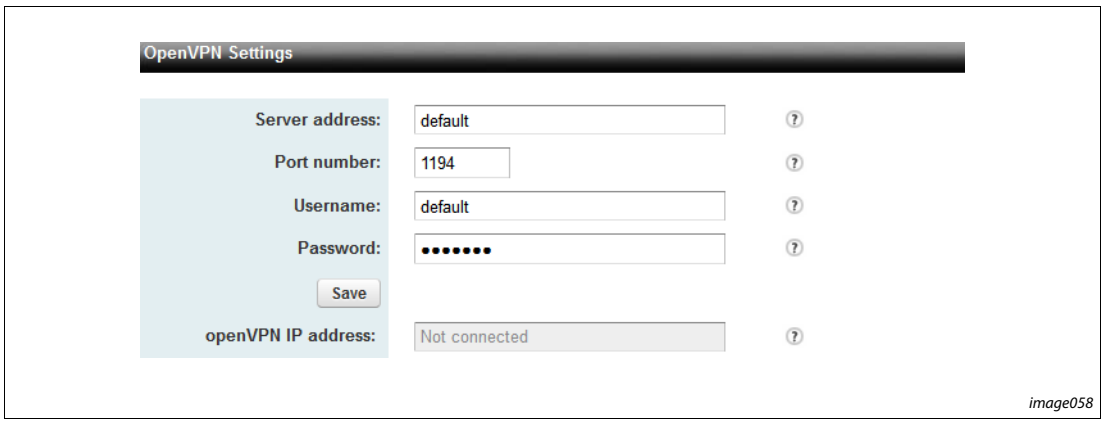


Fig. 11-27: *Web User Interface Open VPN settings*

CAUTION:

In cases when openVPN service is used via GPRS interface and GPRS link is broken, the openVPN tunnel may be reported active for undefined time. Once the openVPN service detects the loss of connection to openVPN server, the closed VPN tunnel will be reported.

OpenVPN server certificate

OpenVPN server certificate must be uploaded to ME-RTU (client), which is done in this section. Once certificate is uploaded, the basic certificate info is displayed in Loaded Certificate Info text-box.

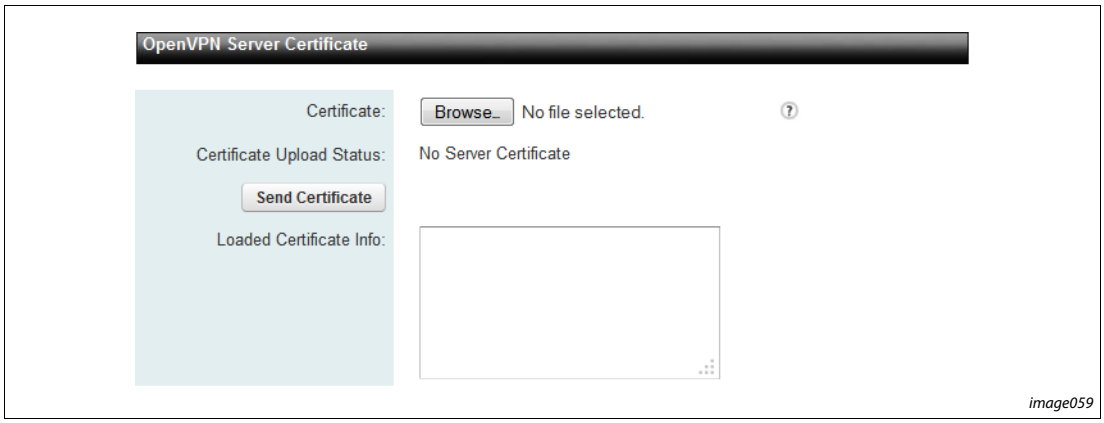


Fig. 11-28: *Web User Interface OpenVPN server certificate*

11.4 Settings parameters

The following chapters describe ME-RTU settings, their input values and default values.

11.4.1 General settings

Settings Subsection	Setting name	Description	Details	Default value
Operating Mode	ME-RTU Operating Mode	Slave only operating mode (DNP3 and IEC 60870-5 slave protocols), or IEC 60870-4-104 master and slave protocol	0 – Slave Only, 1 – Master and Slave	0 – Slave Only
	1st Sector Reserved for PLC (Master and Slave operating mode only)	Reserve first sector for PLC write access to Input Data BFM area	0 – User for IED, 1 – Reserved	0 – User for IED
RTU Module General Settings	PLC type	Communication with FX series PLC via FX Bus, or Q/L series PLC via Ethernet IP (TCP or UDP)	0 – FX series, 1 – Q/L series	0 – FX series
	IP Protocol	PLC communication transport layer protocol (if Q/L series PLC is selected)	0 – UDP, 1 – TCP	0 – UDP
	Port number	Port on ME-RTU for PLC communication (if Q/L series PLC is selected)	Integer from 1 to 65535	9734
	Used protocol	Communication port to SCADA system	0 – DNP3, 1 – IEC 60870-5	0 – DNP3
	Protocol communication path	Connection path to SCADA system	0 – Ethernet, 1 – Serial	0 – Ethernet
Serial Connection Settings (if Serial protocol communication path is selected)	Device name	Device name used for asynchronous serial communication (USB host)	String – device name	/dev/ttyUSB10
	Baudrate	Baud rate on serial communication	Selectable from 300 to 1152000	115200
	Number of data bits	Number of data bits	7 or 8	8
	Number of stop bits	Number of stop bits	1 or 2	1
	Parity	Parity	0 – None, 1 – Even, 2 – Odd	0 – None
	Flow control	Type of flow control used with the connected device	0 – None, 1 – Hardware	0 – none
	Initial Modem String	Initial string sent to connected device at start-up. Typically string of AT commands.	String (No blanks allowed!)	

Tab. 11-2: *Parameters for General setting (1)*

Settings Subsection	Setting name	Description	Details	Default value
Time synchronization	Time Synchronization Type	Determines the source from where the time is synchronized (Control station, PLC or SNTP)	0 – Local PLC, 1 – SNTP, 2 – Control station	0 – PLC
	SNTP Server Address	IP address or domain name of the SNTP Server	String or IP address	0.pool.ntp.org
	Time Zone	Time zone used to set local time for SNTP synchronization	Selectable	(GMT+1) Ljubljana
	PLC RTC period	Period of PLC RTC synchronization in minutes. If set to 0 then it is disabled.	0 min – 65536 min	0
RTU configuration	Upload configuration	Upload XML configuration file and read RTU configuration from it	XML File	
	Back-up configuration	Backup configuration to XML file and store it to local hard drive	XML File	
	Restore to defaults	All ME-RTU setting will be set to default values		
Data Retention Settings	Enable Data Retention	Enable or disable data retention functionality	Enable/Disable	Enable
	Data Retention write interval	Time interval (in minutes) between data retention writes to the SD card	Integer from 0 to 99999	5

Tab. 11-2: *Parameters for General setting (2)*

CAUTION:

ME-RTU XML configuration is designed to store and copy configuration to other ME-RTUs. Do not change the content of XML file manually. Only use XML file generated directly by ME-RTU. No safety mechanism is provided to ensure the validity of the configuration written in the file.

11.4.2 Network settings

Settings Subsection	Setting name	Description	Details	Default value
General Communication Settings	DNS priority	Select communication source for DNS resolving	0 – Ethernet, 1 – Mobile	0 – Ethernet
	Gateway priority	Choose gateway path	0 – Ethernet, 1 – Mobile	0 – Ethernet
IPv4 Settings	Use DHCP	Obtain IP settings from DHCP	Enable/Disable	Disable
	IP address	Static IP address	0.0.0.0 – 255.255.255.255	192.168.0.10
	Network mask	Subnet mask	0.0.0.0 – 255.255.255.255	255.255.255.0
	Gateway address	Default gateway IP address	0.0.0.0 – 255.255.255.255	192.168.0.1
	DNS1 address	First DNS server address	0.0.0.0 – 255.255.255.255	0.0.0.0
	DNS2 address	Second DNS server address	0.0.0.0 – 255.255.255.255	0.0.0.0
NAT Settings (16 configurable translations)	Type	Transport layer port type	0 – TCP, 1 – UDP	0 – TCP
	Inbound port	Inbound port number	1 – 65535	/
	Destination IP	IP address of the device providing the service application	0.0.0.0 – 255.255.255.255	/
	Destination port	Outbound port number	1 – 65535	/
	Enable	Enable or disable the defined translation	0 – Disabled, 1 – Enabled	0 – Disabled
DDNS Settings	Host and domain name	Dynamic DNS domain name	String	Name.com
	Username	Username registered with dynamic name provider	String	User
	Password	Password registered with dynamic name provider	String	password
	DynDNS DDNS System	Dynamic, Static or custom DNS system	0 – Dynamic, 1 – Static, 2 – Custom	0 – Dynamic DNS
	Use wildcards	Enable or disable wildcards	0 – Enable, 1 – Disable, 2 – Default	0 – Enable
	Connection method	Standard HTTP 80 port or alternate 8245 port or HTTPS port 443	0 – HTTP 80, 1 – HTTP 8245, 2 – HTTPS 443	0 – HTTP 80
SNMP	Community	SNMP community name	String	public
	Device name	SNMP unit name	String	ME-RTU
	Location	Location identification	String	one_desk
	Contact	SNMP contact name	String	email@domain

Tab. 11-3: *Parameters for Network settings*

11.4.3 Database settings

Settings Subsection	Setting name	Description	Details	Default value
Binary input signals quantity	Binary inputs quantity	Number of binary inputs	Integer from 0 to 8192	32
	Double binary inputs quantity	Number of double binary inputs	Integer from 0 to 4096	32
Counters quantity	16-bit counters quantity	Number of 16-bit counters	Integer from 0 to 512	4
	32-bit counters quantity	Number of 32-bit counters	Integer from 0 to 256	4
Analog inputs quantity	16-bit AI quantity	Number of 16-bit AI	Integer from 0 to 512	4
	32-bit AI quantity	Number of 32-bit AI	Integer from 0 to 256	4
	Short floating point AI quantity	Number of short floating point AI	Integer from 0 to 256	4
Binary output signals quantity	Binary outputs quantity	Number of digital outputs	Integer from 0 to 8192	4
Analog outputs quantity	16-bit AO quantity	Number of 16-bit AO	Integer from 0 to 512	4
	32-bit AO quantity	Number of 32-bit AO	Integer from 0 to 256	4
	Short floating point AO quantity	Number of short floating point AO	Integer from 0 to 256	4

Tab. 11-4: *Parameters for Database elements settings*

Settings Subsection	Setting name	Description	Details	Default value
Digital signals events	Binary inputs events	Enable or disable events	Enable/Disable	Disable
	Binary Inputs events buffer size	Size of buffer to store BI events	Integer from 1 to 65000	10000
	Double binary inputs events	Enable or disable events	Enable/Disable	Disable
	Double Binary Inputs events buffer size	Size of buffer to store DBI events	Integer from 1 to 65000	10000
Counters events	16-bit counters events	Enable or disable events	Enable/Disable	Disable
	16-bit Counters events buffer size	Size of buffer to store 16-bit Counter events	Integer from 1 to 65000	5000
	32-bit counters events	Enable or disable events	Enable/Disable	Disable
	32-bit Counters events buffer size	Size of buffer to store 32-bit Counter events	Integer from 1 to 65000	5000
Analog inputs events	16-bit AI events	Enable or disable events	Enable/Disable	Disable
	16-bit AI events buffer size	Size of buffer to store 16-bit AI events	Integer from 1 to 65000	10000
	32-bit AI events	Enable or disable events	Enable/Disable	Disable
	32-bit AI events buffer size	Size of buffer to store 32-bit AI events	Integer from 1 to 65000	10000
	Short floating point AI events	Enable or disable events	Enable/Disable	Disable
	Short Floating Point AI events buffer size	Size of buffer to store Short Floating Point AI events	Integer from 1 to 65000	10000

Tab. 11-5: *Parameters for Database events settings*

11.4.4 DNP3 settings

Settings Subsection	Setting name	Description	Details	Default value
Common	Port number	TCP port number for protocol communication	Integer from 1 to 65535	20000
	Enable Unsolicited Messages	Enable unsolicited messages to master station	Enable/Disable	Enable
	Unsolicited Confirm Timeout	Time (in milliseconds) to wait for confirmation response from control station for the unsolicited response	Integer from 1 to 65535	5000
	Link Status Period	Link status check interval [milliseconds]	Integer from 1 to 65535	10000
	Enable Self Address	Enable or disable self-address	Enable/Disable	Disable
	Validate Source Address	Enable or disable validation of source address	Enable/Disable	Enable
	Source Address	ME-RTU DNP3 address	Integer from 0 to 65519	3
	Destination Address	DNP3 Master (SCADA) address	Integer from 0 to 65519	4
	Delete Oldest Event	Enable or disable deleting of oldest event	Enable/Disable	Enable
	Select timeout	Select command timeout [milliseconds]		10000

Tab. 11-6: *Parameters for DNP3 settings*

11.4.5 IEC 60870-5-101/104 settings

Settings Subsection	Setting name	Description	Details	Default value
Common	Port number	TCP port number for protocol communication	Integer from 1 to 65535	2404
	ASDU Address	Common address of the ASDU	Integer from 1 to 65534	5
	Cyclic period	Cyclic data generation period [milliseconds]		0
	RBE Scan Period	Events scan period [milliseconds]		0
	Select timeout	Select command timeout [milliseconds]		0
	Delete Oldest Event	Enable or disable deleting of oldest event	Enable/Disable	Enable
	T0	Timeout of connection establishment		
	T1	Time to wait for ACK to a transmitted APDU		
	T2	Time to wait before sending Supervisory APDU ACK		
	T3	Idle time before sending TEST APDU		

Tab. 11-7: *Parameters for IEC 60870-5-101/104 settings*

11.4.6 Mobile settings

Settings Subsection	Setting name	Description	Details	Default value
Mobile Network Provider Connection Settings	Mobile Connection	Enable or disable GPRS connection	Active/Disable	Active
	PIN	SIM card PIN number (if enabled)	0 – 99999999	
	APN	APN identifier (check with mobile operator)	String	internet
	Enable PAP	Enable PAP authentication for GPRS	Enable/Disable	Enable
	PAP Username	PAP username	String	default
	PAP Password	PAP password	String	default
Mobile Connection Test	Signal Level	Mobile connection signal level	Bar	
	Mobile IP address	Assigned mobile IP address	0.0.0.0 – 255.255.255.255	
	Test	Perform PING test to IP address or domain name on GPRS interface	String	www.inea.si

Tab. 11-8: *Parameters for Cellular settings*

CAUTION:

Ping test on domain name depends on DNS priority and/or DNS server IP address.

11.4.7 VPN settings

Settings Subsection	Setting name	Description	Details	Default value
OpenVPN Settings	Server address	OpenVPN Server IP or domain name	0.0.0.0 – 255.255.255.255 or String	default
	Port number	OpenVPN port number	Integer from 1 to 65535	1194
	Username	Connection username	String	default
	Password	Connection password	String	default
	openVPN IP address	Assigned tunnel IP address	0.0.0.0 – 255.255.255.255	
OpenVPN Server Certificates	Certificate	Upload openVPN server certificate	File (*.crt)	
	Certificate Upload Status	Certificate upload status information	String	No Server Certificate
	Loaded Certificate Info	Display of Loaded certificate Version, Serial Number, Validity time range, Subject information	String	

Tab. 11-9: *Parameters for VPN settings*

CAUTION:

In cases when openVPN service is used via GPRS interface and GPRS link is broken, the openVPN tunnel may be reported active for undefined time. Once the openVPN service detects the loss of connection to openVPN server, the closed VPN tunnel will be reported.

11.5 Basic operation and indication

The basic status of the ME-RTU is visible on the front LEDs. There are 17 LEDs located at the front of the ME-RTU expansion module, divided into two groups. The Power LED indicates if the module is connected to the power supply. This will be hardware controlled.

The first group of LEDs indicates the status of the ME-RTU:

No.	LED name	LED color	LED off	LED flashing	LED on
1.	RUN	Green	Module operations are not running	/	Module operations are running
2.	BOOT	Green	Module is off	Booting is in progress	Boot is done
3.	USER	Green	User defined	User defined	User defined
4.	FXBUS	Green	Q/L-series is selected as connected PLC type	/	FX3-series is selected as connected PLC type
5.	HW ERR	Red	Hardware of module is OK	/	Internal error on hardware
6.	SW ERR	Red	No Error	/	Internal error on software
7.	COM ERR	Red	No Error	/	An error occurred on communication
8.	GSM ERR	Red	No Error	/	An error occurred on GSM communication

Tab. 11-10: *Flags of the ME-RTU*

The second group of LEDs indicates the status of the connections:

No.	LED name	LED color	LED OFF	LED flashing	LED ON
9.	GSM CONN	Green	Not connected to GSM network	Connecting to GSM network	Connected to GSM network
10.	GPRS STATUS	Green	Not connected to GPRS network	Connecting to GPRS network	Connected to GPRS network
11.	PROT 0	Green	DNP3 is not active	/	DNP3 is active
12.	PROT 1	Green	IEC 60870-5-101/ 104 is not active	/	IEC 60870-5-101/ 104 is active
13.	OUT 0	Green	Digital output 0 is OFF	/	Digital output 0 is ON
14.	OUT 1	Green	Digital output 1 is OFF	/	Digital output 1 is ON
15.	IN 0	Green	Digital input 0 is OFF	/	Digital input 0 is ON
16.	IN 1	Green	Digital input 1 is OFF	/	Digital input 1 is ON

Tab. 11-11: *Flags of ME-RTU connections*

11.6 DIP switch settings

On the ME-RTU there are 4 DIP switches which are used for different cases.

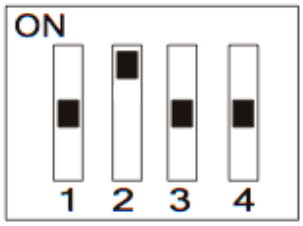


image060

Fig. 11-29: *DIP switches*

DIP switch number	DIP switch name	Position	Description
1.	SD BOOT 1	OFF	Boot from internal eMMC
		ON	Boot from SD card
2.	DFLT 2	OFF	—
		ON	Restore on factory default settings
3.	SW 3	OFF	—
		ON	—
4.	SW 4	OFF	—
		ON	Restore on factory default setup (from SD card)

Tab. 11-12: *DIP switch position*

11.6.1 Updating firmware from SD card

When updating firmware from SD card, the eMMC is erased; partitions are creates and formatted; U-boot is installed; the following are copied: kernel image, root file system, kernel modules…All parameters are restored to factory default settings.

To update ME-RTU firmware, follow these steps:

① Power OFF the ME-RTU

② Insert SD card which holds the Firmware image

③ Switch DIP switches **SD BOOT 1** and **SW 4** to **ON**

④ Power ON the ME-RTU

⑤ Updating procedure (do nothing):

- After start-up, BOOT LED (LED no. 2) stops blinking and stays ON
- RUN, BOOT, FX BUS and P0 LEDs (LEDs no. 1, 2, 4 and 11) turn ON
- After few seconds USER LED (LED no. 3) starts blinking
- LEDs: SW ERR, COM ERR, GSM ERR and GC (LEDs no. 6, 7, 8 and 9) provide information about updating firmware phases as presented in Table 11-13 (some steps may be undetectable due to their fast execution)
- After firmware update finished successfully, USER LED (LED no. 3) turns OFF. FX BUS, HW ERR, SW ERR, COM ERR, GSM ERR and GC LEDs (LEDs no. 4, 5, 6, 7, 8 and 9) start blinking.

⑥ Power OFF the ME-RTU

⑦ Switch DIP switches **SD BOOT 1** and **SW 4** to **OFF**

⑧ Remove the SD card

⑨ Power ON the ME-RTU

Updating procedure may take up to 10 minutes to complete.

If there were errors during restoring of factory default setup, the FX BUS LED (LED no. 4) is flashing and the SW ERR, COM ERR, GSM ERR and GC LEDs (LEDs no. 6, 7, 8 and 9) signalize error type (see Table 11-13).

Phase no.	SW ERR (LED no. 6)	COM ERR (LED no. 7)	GSM ERR (LED no. 8)	GC (LED no. 9)	Description
1	OFF	ON	ON	OFF	Installing U-Boot
2	OFF	ON	ON	ON	Mounting eMMC partition 1
3	ON	OFF	OFF	OFF	Copying kernel image
4	ON	OFF	OFF	ON	Unmounting eMMC partition 1
5	ON	OFF	ON	OFF	Mounting eMMC partition 2
6	ON	OFF	ON	ON	Copying Root File System.
7	ON	ON	OFF	ON	Updating /etc/fstab
8	ON	ON	ON	OFF	Updating /etc/rc.local
9	ON	ON	ON	ON	Updating /etc/network/ interfaces
10	BLINK	OFF	OFF	OFF	Copying settings.xml

Tab. 11-13: *Updating firmware from SD card LED phases*

11.6.2 Restore factory default settings

To restore **FACTORY DEFAULT SETTINGS ONLY** (only settings file is restored) from SD card, DIP switches **SD BOOT 1** and **DFLT 2** must be switched on (SD card must also be inserted).

To restore on factory default settings, the DIP switch DFLT 2 must be switched ON and OFF twice in 5 second intervals. If restore to factory default settings procedure is initiated, then USER LED (third LED) start to blink. Once writing factory default settings is completed, LEDs HW ERR and SW ERR (LEDs 5 and 6) start to blink and ME-RTU enters re-boot phase. Once ME-RTU is re-booted the restore to factory default settings is completed.

CAUTION:

If ME-RTU is connected to FX-series PLC via FX Bus, it is recommended to perform the power down/up of the PLC.

12 IT Functionality

The ME-RTU supports many basic and advanced IT services.

12.1 VPN services

For VPN services the last stable version (2.2.2) of OpenVPN is used (http://openvpn.net/). The OpenVPN features:

- tunnel any IP sub network or virtual Ethernet adapter over a single UDP or TCP port,
- configure a scalable, load-balanced VPN server farm using one or more machines which can handle thousands of dynamic connections from incoming VPN clients,
- use all of the encryption, authentication, and certification features of the OpenSSL library to protect your private network traffic as it transits the internet,
- use any cipher, key size, or HMAC digest (for datagram integrity checking) supported by the OpenSSL library,
- choose between static-key based conventional encryption or certificate-based public key encryption,
- use static, pre-shared keys or TLS-based dynamic key exchange,
- use real-time adaptive link compression and traffic-shaping to manage link bandwidth utilization,
- tunnel networks whose public endpoints are dynamic such as DHCP or dial-in clients,
- tunnel networks through connection-oriented stateful firewalls without having to use explicit firewall rules,
- tunnel networks over NAT, create secure Ethernet bridges using virtual tap devices

12.1.1 Installing OpenVPN server on Windows host

① Download and install OpenVPN for Windows from: http://openvpn.net/index.php/open-source/downloads.html.

② During installation, when asked, select all components, including OpenSSL tools and OpenVPN RSA Certificate Management Script (for managing RSA keys), as seen on Figure 12-1.

③ During installation, when asked, allow the installation of TAP network adapter (this is part of OpenVPN), as seen on Figure 12-2.

12.1.2 Configuring OpenVPN server on Windows

CAUTION:

Computer acting as a server must have internet access and static public IP address or Domain Name (if IP address is dynamic), to be accessible over long term.
If computer acting as a server is behind router, port forwarding must be set on the router for selected port (the default port in this example is 1194 – see the server configuration file on page 12-6). Consult your router's documentation for details on this.

Preparation steps:

① Navigate to "C:\Program Files \OpenVPN\easy-rsa" folder, if installation path was not changed.

- Press "Windows Key + R"
- Type **"cmd.exe"** and press Enter.
- Navigate to the correct folder by typing the following command into cmd:

```
cd "\Program Files\OpenVPN\easy-rsa"
```

② Initialize the OpenVPN configuration by typing the following command into cmd:

```
init-config
```

③ Open the **"vars.bat"** in text editor.

④ Edit the following lines in **"vars.bat"**, replacing "US", "CA", etc. with your company's information (place dot (.) if not used instead of blank):

```
set KEY_COUNTRY=US
set KEY_PROVINCE=CA
set KEY_CITY=SanFrancisco
set KEY_ORG=OpenVPN
set KEY_EMAIL=mail@host.domain
```

⑤ Save the file and exit text editor.

⑥ Run the following commands in cmd:

- type the following command and press enter:

```
vars
```

- type the following command and press enter:

```
clean-all
```

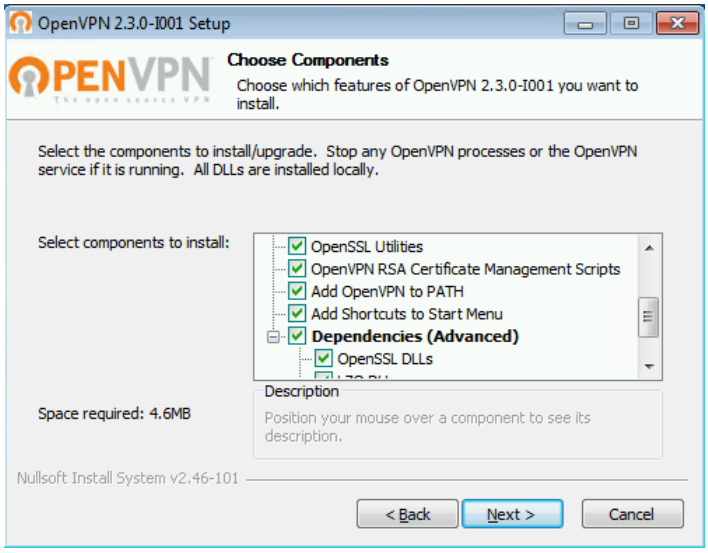


image061

Fig. 12-1: *OpenVPN setup – components selection*

Fig. 12-2: *OpenVPN setup – TAP network adapter setup*

Building Certificates and Keys:

① The certificate authority (CA) certificate and key:

– Type and run the following command in cmd:

```
build-ca
```

– When prompted enter your country, etc. These will have default values, which appear in brackets. For your "Common Name", a good choice is to pick a name to identify your company's Certificate Authority. For example, "OpenVPN-CA":

```
Country Name (2 letter code) [US]:
State or Province Name (full name) [CA]:
Locality Name (eg, city) [SanFrancisco]:
Organization Name (eg, company) [OpenVPN]:
Organizational Unit Name (eg, section) [ ]:
Common Name (eg, your name or your server's hostname)
[ ]: OpenVPN-CA
Email Address [mail@host.domain]:
```

CAUTION:

The default validity of certificate is 10 years. After certificate validity expires, upper procedure must repeat.
In order to create certificate with longer validity, open "build-ca" with text editor and increase the number of days, after the "-days" tag.

② The server certificate and key:

– Type the following command into cmd:

```
build-key-server server
```

– When prompted enter the Common Name as "server".

– When prompted to sign the certificate, enter "y".

– When prompted to commit, enter "y".

③ Generate Diffie-Hellman parameters (This is necessary to set up the encryption) by typing the following command into cmd:

```
build-dh
```

Configuration files:

① Find the sample configuration files by clicking "Windows start menu -> All Programs -> OpenVPN -> OpenVPN Sample Configuration Files"

Server configuration file:

① Open server.ovpn file

② Find the following lines:

```
ca ca.crt
cert server.crt
key server.key
```

and

```
dh dh1024.pem
```

③ Edit them as follows (do not omit double backslashes):

```
ca "C:\\Program Files\\OpenVPN\\config\\ca.crt"
cert "C:\\Program Files\\OpenVPN\\config\\server.crt"
key "C:\\Program Files\\OpenVPN\\config\\server.key"
```

and

```
dh "C:\\Program Files\\OpenVPN\\config\\dh1024.pem"
```

④ Save the file as "C:\Program Files\OpenVPN\easy-rsa\server.ovpn"

⑤ OpenVPN client will authenticate using username and password, therefore user has to supply script that will check if username exists and password is correct. LDPA authentication can also be used.

– The script for authentication has to be placed in "C:\Program Files\OpenVPN\config" folder. In following configuration the script is called "CheckUserCredentialsviaFile.exe". The script should accept file location/name as parameter. The script must then open the file and read the username in first line and password from the second line. These should then be compared to username(s) and password(s) allowed to connect. If they credentials pass, the script should return 0, otherwise 1 is returned.

⑥ Sample server configuration file:

```
########################
# start of config file #
########################
port 1194
proto udp
dev tun
ca "C:\\Program Files\\OpenVPN\\config\\ca.crt"
cert "C:\\Program Files\\OpenVPN\\config\\server.crt"
key "C:\\Program Files\\OpenVPN\\config\\server.key"
dh "C:\\Program Files\\OpenVPN\\config\\dh1024.pem"
server 10.8.0.0 255.255.255.0
ifconfig-pool-persist ipp.txt
comp-lzo
persist-key
persist-tun
status openvpn-status.log
verb 9
auth-nocache
client-cert-not-required
script-security 3
username-as-common-name
auth-user-pass-verify "CheckUserCredentialsviaFile.exe" via-file
reneg-sec 0
######################
# end of config file #
######################
```

Client configuration file is already included in ME-RTU. Configuration is preformed via Web user interface (refer to Open VPN settings).

Copying the Server and Client files to their appropriate directories:

① Copy these files from "C:\Program Files\OpenVPN\easy-rsa\" to "C:\Program Files\OpenVPN\config\" on the server:

```
ca.crt
dh1024.pem
server.crt
server.key
server.ovpn
```

② Upload the following certificate to ME-RTU using Web user interface (refer to OpenVPN server certificate):

```
ca.crt
```

Starting OpenVPN:

① On server, run OpenVPN from:

```
Start Menu -> All Programs -> OpenVPN -> OpenVPN GUI
```

② Double click the icon which shows up in the system tray to initiate the connection. The resulting dialog should close upon a successful start.

Running OpenVPN as a service on Windows host

① Running OpenVPN as a service will allow to OpenVPN to run from non-administrative account

② OpenVPN can be started automatically on system start-up.

③ Run the Windows Service administrative tool:

- Press "Windows Key + R"
- Type the following command into cmd:

```
services.msc
```

④ Find the OpenVPN service, and set its Start-up Type to "automatic."

⑤ Optionally, start the service now.

12.1.3 Including multiple machines on the client side when using routed VPN (dev tun)

Tutorial on the OpenVPN side describes how to accomplish this:
http://openvpn.net/index.php/open-source/documentation/howto.html#scope

Example▽ Connect to PC from OpenVPN server via ME-RTU:

In this example we try to connect to a device (PC in our example) from OpenVPN server. PC is on the same local network as ME-RTU.

System configuration:

- VPN subnet: 172.32.0.0/24
- ME-RTU subnet: 192.168.112.0/20
- ME-RTU IP address: 192.168.112.68
- PC (local to ME-RTU) IP address: 192.168.112.139

ME-RTU connects to OpenVPN server with username "test3".

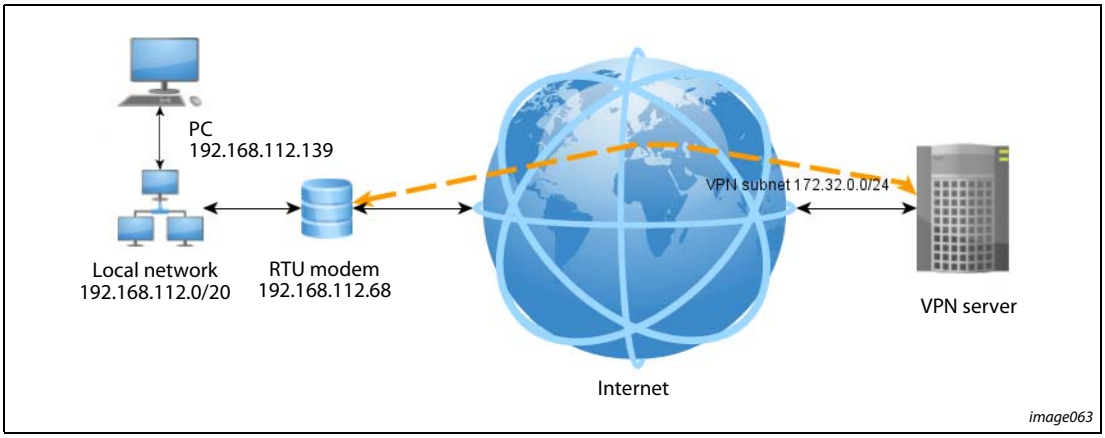


Fig. 12-3: *System configuration example*

△

Procedure on server:

① Open server.ovpn with text editor, located in "C:\Program Files\OpenVPN\config" and add the following lines (refer to Figure 12-3 for the meaning of IP addresses):

```
client-config-dir ccd
route 192.168.112.0 255.255.240.0
client-to-client
push "route 192.168.112.0 255.255.240.0"
```

② Create folder named "ccd" in "C:\Program Files\OpenVPN\config" and create file named "test3" (no extension type)

– Open "test3" file with text editor and add the following line:

```
iroute 192.168.112.0 255.255.240.0
```

③ Press "Windows Key + R" and type cmd.exe. Enter the following command in cmd:

```
route add 192.168.112.0 mask 255.255.240.0 172.32.0.2
```

Procedure on Device (PC):

① Add the ME-RTU's IP address to Device as gateway address.

– On the PC – press "Windows Key + R" and a type "cmd.exe". Enter the following command:

```
route add 172.32.0.0 mask 255.255.255.0 192.168.112.68
```

Testing connection from the VPN server side:

① On VPN server open the "cmd" by pressing "Windows Key + R" and typing "cmd.exe"

② Test connection by pinging the remote (Local to ME-RTU) PC by typing the following command into cmd:

```
ping 192.168.112.139
```

12.2 SNMP

SNMP statuses

- ME-RTU statuses:
  - Communication statistics
  - Online time
  - Data volumes
  - Firmware version
- PLC statuses:
  - PLC status (Stop, Running, Error)
  - Memory utilization
  - IO & other module statuses

12.2.1 SNMP client

With SNMP client information can be retrieved from ME-RTU. One possible SNMP client program is NET-SNMP, available for download at http://www.net-snmp.org/ or http://sourceforge.net/projects/net-snmp/files/net-snmp%20binaries/. Important notice: Windows binaries from second link have been built with OpenSSL version 0.9.8r. Installing Net-SNMP on a system with where OpenSSL 1.0 has been installed will fail.

Usage:

With Net-SNMP it is possible to read BFM values from ME-RTU. To do this, press "Windows Key + R" and enter cmd.exe. In this example ME-RTU IP address is 192.168.112.68.

① Set the desired BFM address (in this example the desired BFM address is 2), by typing the following command in cmd:

```
snmpset -v2c -c private 192.168.112.68
1.3.6.1.4.1.1138.1.1.1.0 i 2
```

② Request the value by entering the following command into cmd:

- ME-RTU returns the value at this BFM address.

```
snmpget -v2c -c public 192.168.112.68
1.3.6.1.4.1.1138.1.1.2.0
```

12.3 DDNS

ME-RTU supports dynamic DNS entries update for Counterpoints on Dynamic DNS Network Services' free DNS service. The user has some pre-defined DDNS free services where he can create a Counterpoint and then he has to provide his Counterpoint details into the ME-RTU settings. The dnsdynamic.org (http://dyn.com/) DDNS provider is included.

The following settings are required in the WEB user interface:

- Host or Domain name (configured by user on http://dyn.com DNS server)
- Username
- Password
- DDNS system
- Use of Wildcards
- Connection port

12.4 Network Address Translation (NAT)

NAT (Network Address Translation) is a network protocol that allows multiple devices to connect to a public network using the same address. NAT translates traffic from one IP and port number to another.

12.4.1 Remote access to Q PLC

This example presents the usage of NAT feature for accessing remote site Q-series PLC with fixed buffer Ethernet module, with GX Works2 via GPRS network and established VPN connection.

First the ME-RTU must be properly configured. For configuring VPN connection see section 12.1 VPN services. In NAT settings (refer to NAT Settings) set the Q-series PLC MELSOFT connection TCP port number (for Q-series PLC the TCP connection port number is fixed on 5002) as inbound and outbound port numbers. The destination IP is the IP of the Q-series PLC's Ethernet module.

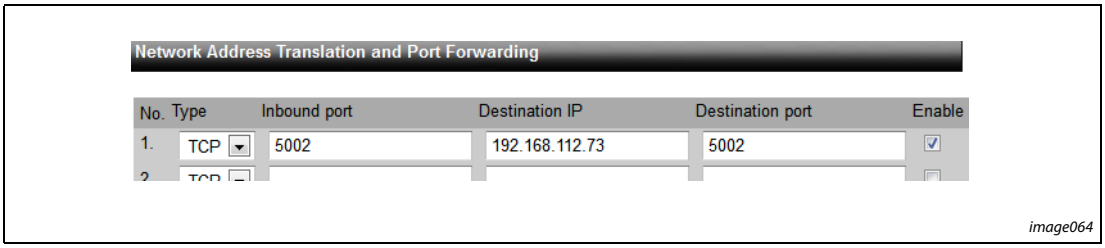


Fig. 12-4: *NAT setting for Q PLC MELFSOFT TCP connection*

In GX Works2 configure the transfer setup. Set the ME-RTU VPN tunnel's IP address as destination IP address.

NOTE

Consult your system administrator to provide you mechanism to gain access to VPN tunnel IP address or access ME-RTU as described in section 12.1.3 Including multiple machines on the client side when using routed VPN (dev tun).

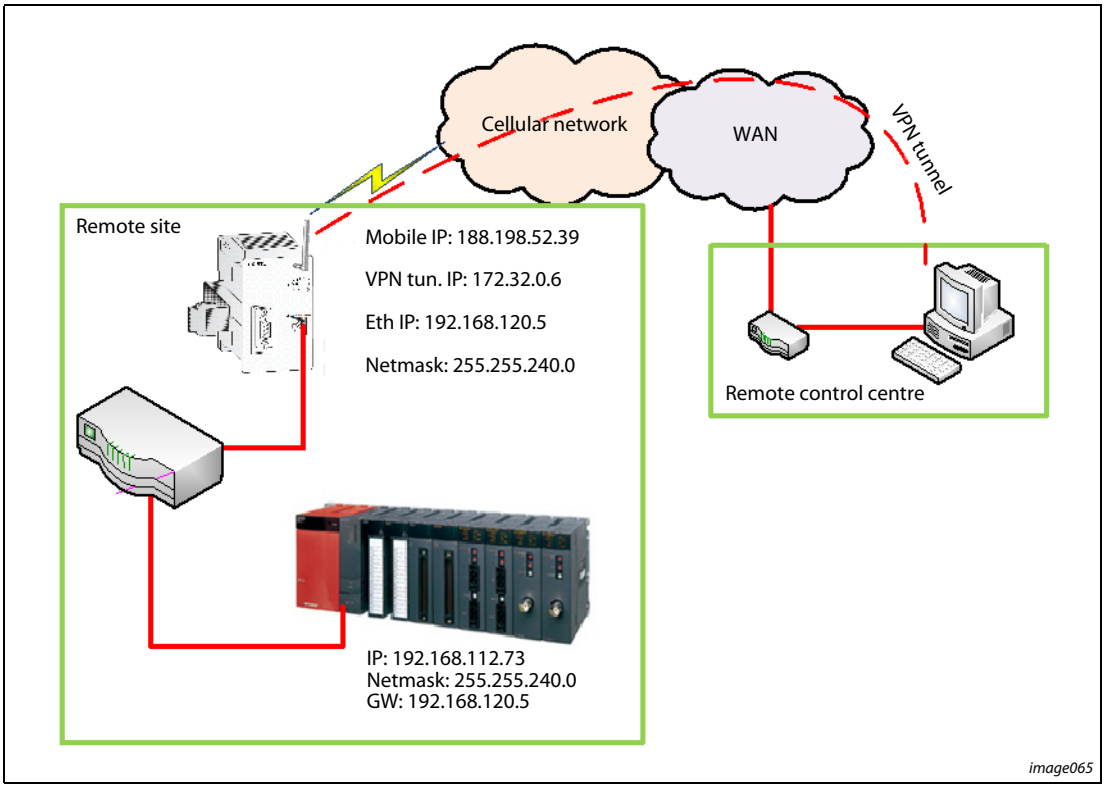


Fig. 12-5: *Connectivity via NAT and VPN to Q PLC*

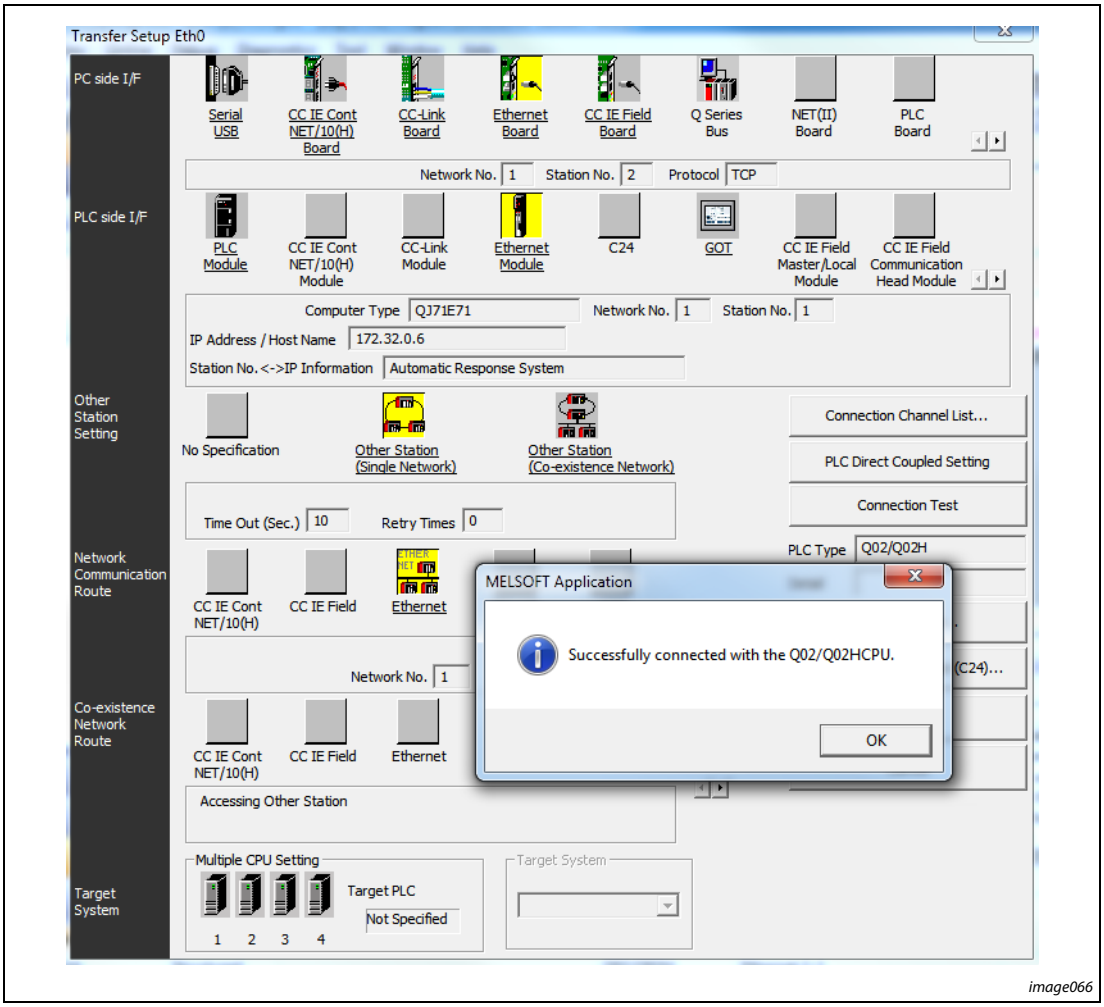


Fig. 12-6: *Q PLC MELFSOFT transfer setup via VPN and NAT*

12.4.2 Access to multiple ME-RTUs via one GPRS connection

With NAT it is possible to access other ME-RTUs' web interface or SCADA can connect to them with DNP3 (Ethernet) or IEC 60870-5-104 protocol.

To enable access to second ME-RTU, configure NAT as follows (No. 1 in Figure 12-7):

- Inbound port is the any free TCP port. In this example the port number is 8080
- Destination IP is the static Ethernet IP address of the second ME-RTU. In this example the IP address is 192.168.120.6
- Destination port is a default HTTP destination port. For ME-RTU this is always 80.

In standard web browser type the VPN IP address of the first ME-RTU followed by colon and the port number as web address, e.g.:

```
172.32.0.6: 8080
```

Similar principle may be used by SCADA to connect to DNP3 (Ethernet) or IEC 60870-5-104. The following example shows the NAT configuration for DNP3 (No. 2 in Figure 12-7).

NOTE

Additional connections will create bigger traffic overhead. This and the bigger traffic itself may congest the communication channel.

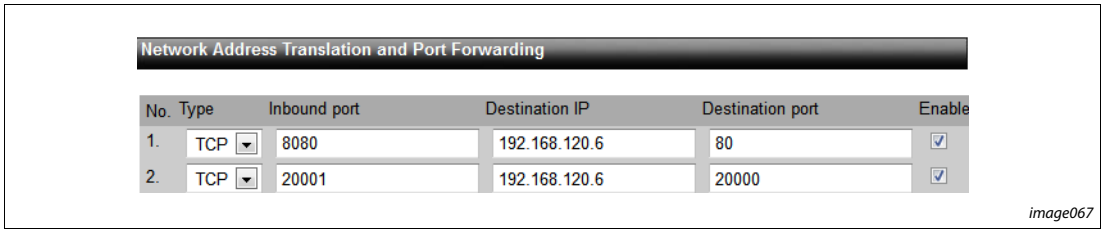


Fig. 12-7: *NAT settings for under-lying ME-RTU access*

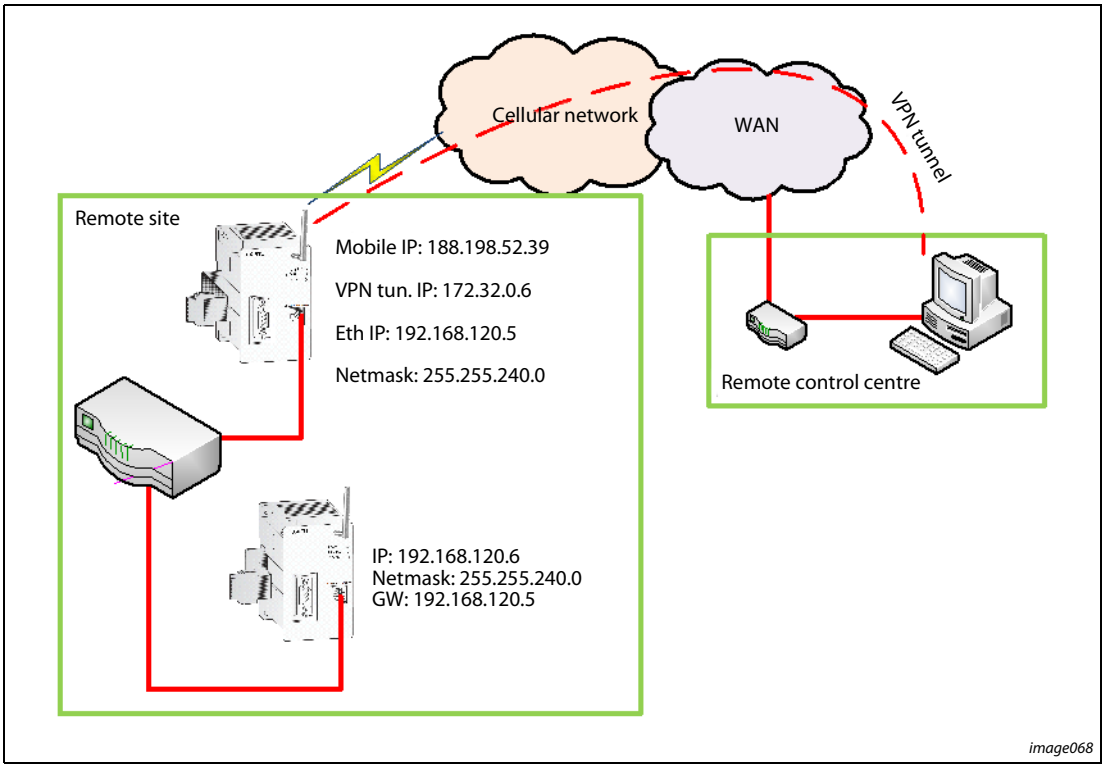


Fig. 12-8: *Connectivity via NAT and VPN to under-laying ME-RTU*

13 Online Programming Access

The ME-RTU enables the GX IEC Developer (hereafter known as GID) or GX Works 2 to be remotely connected to the FX3 PLC via network. The ME-RTU sends the received data on the port 5551 to the PLC and waits for the response and sends the response back (transparent mode).

A DNP V3.0 Device Profile

The following table provides a "Device Profile Document" in the standard format defined in the DNP 3.0 Subset Definitions Document. While it is referred to in the DNP 3.0 Subset Definitions as a "Document," it is in fact a table, and only a component of a total interoperability guide. The table, in combination with the Implementation Table provided and the Point List Tables provided in, should provide a complete configuration/interoperability guide for communicating with a device.

DNP V3.0

DEVICE PROFILE DOCUMENT

(Also see the DNP 3.0 Implementation Table in section A.1, beginning on page 13-4)

Vendor Name: **INEA d.o.o.**

Device Name: **ME-RTU**

Highest DNP Level Supported:	Device Function:
For Requests: **Level 2**	☐ Master
For Responses: **Level 2**	☒ **Slave**

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

For static (non-change-event) object requests, request qualifier codes 07 and 08 (limited quantity), and 17 and 28 (index) are supported. Static object requests sent with qualifiers 07, or 08, will be responded with qualifiers 00 or 01.

16-bit, 32-bit and Floating Point Analog Change Events with Time may be requested. Analog Input Deadbands, Object 34, variations 1 through 3, are supported. Floating Point Analog Output Status and Output Block Objects 40 and 41 are supported.

Maximum Data Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted: **292**	Transmitted: **Configurable up to 2048**
Received **292**	Received **2048**

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
☐ None	☒ **None**
☒ **Fixed**	☐ Configurable
☐ Configurable from 0 to 65535	

Requires Data Link Layer Confirmation:

☒ **Never**
☐ Always
☐ Sometimes
☐ Configurable as: Never, Only for multi-frame messages, or Always

Requires Application Layer Confirmation:

☐ Never
☐ Always
☐ When reporting Event Data (Slave devices only)
☐ When sending multi-fragment responses (Slave devices only)
☐ Sometimes
☒ **Configurable as: "Only when reporting event data", or "When reporting event data or multi-fragment messages."**

DNP V3.0

DEVICE PROFILE DOCUMENT

(Also see the DNP 3.0 Implementation Table in section A.1, beginning on page 13-4)

Timeouts while waiting for:

Data Link Confirm:	☐ None	☒ **Fixed at 2 s**	☐ Variable	☐ Configurable
Complete Appl. Fragment:	☒ **None**	☐ Fixed at ____	☐ Variable	☐ Configurable
Application Confirm:	☐ None	☒ **Fixed at 10 s**	☐ Variable	☐ **Configurable**
Complete Appl. Response:	☒ **None**	☐ Fixed at____	☐ Variable	☐ Configurable

Others: Transmission Delay, 0 s

Select/Operate Arm Timeout, configurable

Need Time Interval, 30 min

Unsolicited Notification Delay, 5 s (all classes)

Unsolicited Response Retry Delay, 5 s

Unsolicited Offline Interval, 30 s

Binary Change Event Scan Period, Always

Double Bit Change Event Scan Period, Always

Analog Change Event Scan Period, Always

Counter Change Event Scan Period, Always

Frozen Counter Change Event Scan Period, Always

Sends/Executes Control Operations:

WRITE Binary Outputs:	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE:	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
DIRECT OPERATE:	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
DIRECT OPERATE - NO ACK:	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
Count > 1	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Pulse Off	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
Latch Off	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
Queue	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable

Attach explanation if "Sometimes" or "Configurable" was checked for any operation.

Reports Binary Input Change Events when no specific variation requested: ☐ Never ☒ **Only time-tagged** ☐ Only non-time-tagged ☐ Configurable to send one or the other	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐ Never ☒ **Binary Input Change With Time** ☐ Binary Input Change With Relative Time ☐ Configurable
Sends Unsolicited Responses: ☐ Never ☒ **Configurable** ☐ Only certain objects ☐ Sometimes (attach explanation) ☒ **ENABLE/DISABLE UNSOLICITED** **Function codes supported**	Sends Static Data in Unsolicited Responses: ☒ **Never** ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.

DNP V3.0

DEVICE PROFILE DOCUMENT

(Also see the DNP 3.0 Implementation Table in section A.1, beginning on page 13-4)

Default Counter Object/Variation: ☐ No Counters Reported ☐ Configurable ☐ Default Object Default Variation: ☒ **Point-by-point list attached**	Counters Roll Over at: ☐ No Counters Reported ☐ Configurable (attach explanation) ☒ **16 Bits** ☒ **32 Bits** ☐ Other Value: ___ ☐ Point-by-point list attached
Sends Multi-Fragment Responses: ☒ **Yes** ☐ No ☐ Configurable	

A.1 DNP V3.0 implementation table

The following table identifies which object variations, function codes, and qualifiers the ME-RTU supports in both request messages and in response messages. For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28 . For change-event objects, qualifiers 17 or 28 are always responded.

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
1	0	Binary Input – Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
1	1 (default)	Binary Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
1	2	Binary Input with Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
2	0	Binary Input Change – Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
2	1	Binary Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	2 (default)	Binary Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	3	Binary Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
3	0	Double Bit Input - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
3	1 (default)	Double Bit Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
3	2	Double Bit Input with Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
4	0	Double Bit Input Change – Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
4	1	Double Bit Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
4	2 (default)	Double Bit Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
4	3	Double Bit Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
10	0	Binary Output – Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
10	1	Binary Output	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
			1 (read)	00, 01 (start-stop)		
10	2 (default)	Binary Output Status	1(read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
12	0	Control Relay Output Block	22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
12	1	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 28 (index)	129 (response)	echo of request

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
12	2	Pattern Control Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	7 (limited quantity)	129 (response)	echo of request
12	3	Pattern Mask	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	00, 01 (start-stop)	129 (response)	echo of request
20	0 (default)	Binary Counter – Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
			7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty)		
20	1	32-Bit Binary Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
20	2	16-Bit Binary Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
20	5	32-Bit Binary Counter without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
20	6	16-Bit Binary Counter without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
22	0 (default)	Counter Change Event – Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
22	1	32-Bit Counter Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	2	16-Bit Counter Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	5	32-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	6	16-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	0	Counter Change Event – Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
30	0 (default)	Analog Input – Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
30	3	32-Bit Analog Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
30	2	16-Bit Analog Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
30	3	32-Bit Analog Input without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
30	4	16-Bit Analog Input without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
30	5	short floating point	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
32	0 (default)	Analog Change Event – Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
32	1	32-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	2	16-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	3	32-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	4	16-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	5	short floating point Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	7	short floating point Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
34	0	Analog Input Deadband (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
34	1	16 bit Analog Input Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
34	2 (default)	32 bit Analog Input Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
34	3	Short Floating Point Analog Input Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
40	0	Analog Output Status	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
40	1	32-Bit Analog Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
40	2 (default)	16-Bit Analog Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
40	3	Short floating point Analog Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
41	0	Analog Output Block	22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
41	1	32-Bit Analog Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 28 (index) 27 (index)	129(response)	echo of request
41	2	16-Bit Analog Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 28 (index) 27 (index)	129(response)	echo of request
41	3	Short floating point Analog Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 27, 28 (index)	129 (response)	echo of request
50	0	Time and Date				
50	1 (default)	Time and Date	1 (read)	07, (limited qty = 1)	129 (response)	07 (limited qty = 1)
			2 (write)	07 (limited qty = 1)		
50	3	Time and Date Last Recorded Time	2 (write)	07 (limited qty)		
51	1	Time and Date CTO			129 (response) 130 (unsol. resp)	07 (limited qty) (qty = 1)
51	2	Unsynchronized Time and Date CTO			129 (response) 130 (unsol. resp)	07 (limited qty) (qty = 1)
52	1	Time Delay Coarse			129 (response)	07 (limited qty) (qty = 1)
52	2	Time Delay Fine			129 (response)	07 (limited qty) (qty = 1)
60	0	60Not Defined				
60	1	Class 0 Data	1 (read)	06 (no range, or all)		

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
60	2	Class 1 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
60	3	Class 2 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
60	4	Class 3 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
80	1	Internal Indications	1 (read)		129 (response)	00, 01 (start-stop)
			2 (write)	00 (start-stop) index = 4 or 7		
87	0	Data Set – Present Value	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
			2 (write)	5b (free-format)		
No Object (function code only)			13 (cold restart)			
No Object (function code only)			14 (warm restart)			
No Object (function code only)			23 (delay meas.)			
No Object (function code only)			24 (record current time)			

A.2 A.1 DNP V3.0 point list

The point list depends on the user implementation. In example is used a sample point list for binary inputs.

Binary Input Points Static (Steady-State) Object Number: **1** Change Event Object Number: **2** Static Variation reported when variation 0 requested: **1 (Binary Input 2 without status)** Change Event Variation reported when variation 0 requested: **3 (Binary Input Change with Relative Time)**		
Point Index	**Name/Description**	**Default Change Event Assigned Class (1, 2, 3 or none)**
0-XX	(determined by implementation)	1

B IEC 60870-5-101/104 Device Profile

Interoperability

This companion standard presents sets of parameters and alternatives from which subsets must be selected to implement particular telecontrol systems. Certain parameter values, such as the choice of "structured" or "unstructured" fields of the information object address of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers, it is necessary that all partners agree on the selected parameters.

The interoperability list is defined as in IEC 60870-5-101 and extended with parameters used in this standard. The text descriptions of parameters which are not applicable to this companion standard are strike-through (corresponding check box is marked black).

NOTE Direct point-to-point connection between ME-RTU and Q/L-series PLC is also possible. Auto-MDI/MDIX is supported.

The selected parameters should be marked in the white boxes as follows:

☐	Function or ASDU is not used
☒	Function or ASDU is used as standardized (default)
☒ R	Function or ASDU is used in reverse mode
☒ B	Function or ASDU is used in standard and reverse mode
■	Not permitted in this companion standard

The possible selection (blank, X, R, or B) is specified for each specific clause or parameter.

A black check box indicates that the option cannot be selected in this companion standard.

B.1 System or device

System-specific parameter, indicate the station's function by marking one of the following with ***X***.

☐ System definition

☐ Controlling station definition (Master)

☒ Controlled station definition (Slave)

B.2 Network configuration

Network-specific parameter, all configurations that are used are to be marked ***X.*** If the text is strike-through then this option is not available.

■ Point-to-point

■ Multipoint

■ Multiple point-to-point

■ Multipoint-star

B.3 Physical layer

Network-specific parameter, all interfaces and data rates that are used are to be marked ***X.***

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard		Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s		Balanced interchange Circuit X.24/X.27	
■	100 bit/s	■	2 400 bit/s	■	2 400 bit/s	■	56 000 bit/s
■	200 bit/s	■	4 800 bit/s	■	4 800 bit/s	■	64 000 bit/s
■	300 bit/s	■	9 600 bit/s	■	9 600 bit/s		
■	600 bit/s			■	19 200 bit/s		
■	1 200 bit/s			■	38 400 bit/s		

Transmission speed (monitor direction)

Unbalanced interchange Circuit V.24/V.28 Standard		Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s		Balanced interchange Circuit X.24/X.27	
■	100 bit/s	■	2 400 bit/s	■	2 400 bit/s	■	56 000 bit/s
■	200 bit/s	■	4 800 bit/s	■	4 800 bit/s	■	64 000 bit/s
■	300 bit/s	■	9 600 bit/s	■	9 600 bit/s		
■	600 bit/s			■	19 200 bit/s		
■	1 200 bit/s			■	38 400 bit/s		

B.4 Link layer

Network-specific parameter, all options that are used are to be marked ***X***. Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the Type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure

- ■ Balanced transmission
- ■ Unbalanced transmission

Address field of the link

- ■ not present (balanced transmission only)
- ■ One octet
- ■ Two octets

Frame length

Maximum length L (number of octets)

- ■ Structured
- ■ Unstructured

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

■ The standard assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission
9, 11, 13, 21	<1>

NOTE In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available.

B.5 Application layer

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked ***X***)

■	One octet	[X]	Two octet

Information object address

(system-specific parameter, all configurations that are used are to be marked ***X***)

■	One octet	[X]	Structured
■	Two octets	[X]	Unstructured
[X]	Three octets		

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked ***X***)

■	One octet	[X]	Two octets (with originator address) Originator address is set to zero if not used

Length of APDU

(system-specific parameter, specify the maximum length of the APDU per system)

The maximum length of APDU for both directions is 253. It is a fixed system parameter.

■ Maximum length of APDU per system in control direction

■ Maximum length of APDU per system in monitor direction

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each Type ID ***X*** if it is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

[X]	<1> := Single-point information	M_SP_NA_1
■	<2> := Single-point information with time tag	M_SP_TA_1
[X]	<3> := Double-point information	M_DP_NA_1
■	<4> := Double-point information with time tag	M_DP_TA_1
[X]	<5> := Step position information	M_ST_NA_1
■	<6> := Step position information with time tag	M_ST_TA_1

X	<7> :=	Bitstring of 32 bit	M_BO_NA_1
■	<8> :=	Bitstring of 32 bit with time tag	M_BO_TA_1
X	<9> :=	Measured value, normalized value	M_ME_NA_1
■	<10>:=	Measured value, normalized value with time tag	M_ME_TA_1
X	<11>:=	Measured value, scaled value	M_ME_NB_1
■	<12>:=	Measured value, scaled value with time tag	M_ME_TB_1
X	<13>:=	Measured value, short floating point value	M_ME_NC_1
■	<14>:=	Measured value, short floating point value with time tag	M_ME_TC_1
X	<15>:=	Integrated totals	M_IT_NA_1
■	<16>:=	Integrated totals with time tag	M_IT_TA_1
■	<17>:=	Event of protection equipment with time tag	M_EP_TA_1
■	<18>:=	Packed start events of protection equipment with time tag	M_EP_TB_1
■	<19>:=	Packed output circuit information of protection equipment with time tag	M_EP_TC_1
□	<20>:=	Packed single-point information with status change detection	M_SP_NA_1
□	<21>:=	Measured value, normalized value without quality descriptor	M_ME_ND_1
X	<30>:=	Single-point information with time tag CP56Time2a	M_SP_TB_1
X	<31>:=	Double-point information with time tag CP56Time2a	M_DP_TB_1
□	<32>:=	Step position information with time tag CP56Time2a	M_ST_TB_1
X	<33>:=	Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
□	<34>:=	Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
X	<35>:=	Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
X	<36>:=	Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
X	<37>:=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
□	<38>:=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
□	<39>:=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
□	<40>:=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

In this companion standard only the use of the set <30> – <40> for ASDUs with time tag is permitted.

Process information in control direction

(station-specific parameter, mark each Type ID ***X*** if it is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

X	<45>:= Single command	C_SC_NA_1
	<46>:= Double command	C_DC_NA_1
	<47>:= Regulating step command	C_RC_NA_1
	<48>:= Set point command, normalized value	C_SE_NA_1
X	<49>:= Set point command, scaled value	C_SE_NB_1
X	<50>:= Set point command, scaled value	C_SE_NB_1
X	<51>:= Bitstring of 32 bit	C_BO_NA_1
	<58>:= Single command with time tag CP56Time 2a	C_SC_TA_1
	<59>:= Double command with time tag CP56Time 2a	C_DC_TA_1
	<60>:= Regulating step command with time tag CP56Time 2a	C_RC_TA_1
	<61>:= Set point command, normalized value with time tag CP56Time 2a	C_SE_TA_1
	<62>:= Set point command, scaled value with time tag CP56Time 2a	C_SE_TB_1
	<63>:= Set point command, short floating point value with time tag CP56Time 2a	C_SE_TC_1
	<64>:= Bitstring of 32 bit with time tag CP56Time 2a	C_BO_TA_1

Either the ASDUs of the set <45> – <51> or of the set <58> – <64> are used.

System information in monitor direction

(station-specific parameter, mark with an ***X*** if it is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions).

X	<70>:= End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each Type ID ***X*** if it is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

X	<100>:= Interrogation command	C_IC_NA_1
X	<101>:= Counter interrogation command	C_CI_NA_1
X	<102>:= Read command	C_RD_NA_1
X	<103>:= Clock synchronization command (option see 7.6)	C_CS_NA_1
■	<104>:= Test command	C_TS_NA_1
	<105>:= Reset process command	C_RP_NA_1
■	<106>:= Delay acquisition command	C_CD_NA_1
	<107>:= Test command with time tag CP56time2a	C_TS_TA_1

Parameter in control direction

(station-specific parameter, mark each Type ID ***X*** if it is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

	<110>:= Parameter of measured value, normalized value	P_ME_NA_1
X	<111>:= Parameter of measured value, scaled value	P_ME_NB_1
X	<112>:= Parameter of measured value, short floating point value	P_ME_NC_1
	<113>:= Parameter activation	P_AC_NA_1

File Transfer

(station-specific parameter, mark each Type ID ***X*** if it is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

☐	<120>:= File ready	F_FR_NA_1
☐	<121>:= Section ready	F_SR_NA_1
☐	<122>:= Call directory, select file, call file, call section	F_SC_NA_1
☐	<123>:= Last section, last segment	F_LS_NA_1
☐	<124>:= Ack file, ack section	F_AF_NA_1
☐	<125>:= Segment	F_SG_NA_1
☐	<126>:= Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1
☐	<127>:= Query Log - Request archive file	F_SC_NB_1

Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Black boxes are not permitted in this companion standard

Blank: functions or ASDU not used.

Mark Type Identification/Cause of transmission combinations:

X if only used in the standard direction

R if only used in the reverse direction

B if used in both directions

Type identification		Cause of transmission																	
		periodic, cyclic	background scan	spontaneous	initialized	request or requested	activation	activation confirmation	deactivation	deactivation confirmation	activation termination	return info caused by a remote cmd	return info caused by a local cmd	file transfer	interrogated by group <number>	request by group <n> counter request	unknown type identification	unknown cause of transmission	unknown common address of ASDU	unknown information object address
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1		X	X		X						X	X		X					
<2>	M_SP_TA_1		X	■		■						■	■							
<3>	M_DP_NA_1		X	X		X						X	X		X					
<4>	M_DP_TA_1			■		■						■	■							
<5>	M_ST_NA_1																			
<6>	M_ST_TA_1			■		■						■	■							
<7>	M_BO_NA_1		X	X		X									X					
<8>	M_BO_TA_1			■		■														
<9>	M_ME_NA_1																			
<10>	M_ME_TA_1			■		■														
<11>	M_ME_NB_1	X	X	X		X									X					
<12>	M_ME_TB_1			■		■														
<13>	M_ME_NC_1	X	X	X		X									X					
<14>	M_ME_TC_1			■		■														
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1			■												■				
<17>	M_EP_TA_1			■																
<18>	M_EP_TB_1			■																
<19>	M_EP_TC_1			■																
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X		X						X	X							

Type identification		Cause of transmission																		
		periodic, cyclic	background scan	spontaneous	initialized	request or requested	activation	activation confirmation	deactivation	deactivation confirmation	activation termination	return info caused by a remote cmd	return info caused by a local cmd	file transfer	interrogated by group <number>	request by group <n> counter request	unknown type identification	unknown cause of transmission	unknown common address of ASDU	unknown information object address
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<31>	M_DP_TB_1			X		X						X	X							
<32>	M_ST_TB_1																			
<33>	M_BO_TB_1			X		X														
<34>	M_ME_TD_1																			
<35>	M_ME_TE_1			X		X														
<36>	M_ME_TF_1			X		X														
<37>	M_IT_TB_1			X												X				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						X	X	X	X	X						X	X	X	X
<46>	C_DC_NA_1																			
<47>	C_RC_NA_1																			
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1						X	X	X	X	X						X	X	X	X
<50>	C_SE_NC_1						X	X	X	X	X						X	X	X	X
<51>	C_BO_NA_1						X	X			X						X	X	X	X
<58>	C_SC_TA_1																			
<59>	C_DC_TA_1																			
<60>	C_RC_TA_1																			
<61>	C_SE_TA_1																			
<62>	C_SE_TB_1																			
<63>	C_SE_TC_1																			
<64>	C_BO_TA_1																			
<70>	M_EI_NA_1*				X															
<100>	C_IC_NA_1						X	X	X	X	X						X	X	X	X
<101>	C_CI_NA_1						X	X			X						X	X	X	X
<102>	C_RD_NA_1					X											X	X	X	X
<103>	C_CS_NA_1			X			X	X									X	X	X	X
<104>	C_TS_NA_1																			
<105>	C_RP_NA_1																			
<106>	C_CD_NA_1																			
<107>	C_TS_TA_1																			
<110>	P_ME_NA_1																			

*** Blank or X only**

Type identification		Cause of transmission																	
		periodic, cyclic	background scan	spontaneous	initialized	request or requested	activation	activation confirmation	deactivation	deactivation confirmation	activation termination	return info caused by a remote cmd	return info caused by a local cmd	file transfer	interrogated by group <number>	request by group <n> counter request	unknown type identification	unknown cause of transmission	unknown common address of ASDU	unknown information object address
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<111>	P_ME_NB_1						X	X							X		X	X	X	X
<112>	P_ME_NC_1						X	X							X		X	X	X	X
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1*																			
<127>	F_SC_NB_1*																			
* Blank or X only																				

B.6 Basic application functions

Station initialization

(station-specific parameter, mark ***X*** if function is used)

☐ Remote initialization

Cyclic data transmission

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

☐ Cyclic data transmission

Read procedure

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

☒ Read procedure

Spontaneous transmission

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter, mark each information type ***X*** where both, a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1

☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1

☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1

☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project)

☐ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1

☐ Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1

☐ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

Station interrogation

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

X	global				
	group 1		group 7		group 13
	group 2		group 8		group 14
	group 3		group 9		group 15
	group 4		group 10		group 16
	group 5		group 11	Information Object Addresses assigned to each group must be shown in a separate table	

Clock synchronization

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

X	Clock
	Day of week used
	RES1, GEN (time tag substituted/not substituted) used
	SU-bit (summertime) used

Optional, see 7.6

Command transmission

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

X	Direct command transmission
X	Direct set point command transmission
	Select and execute command
	Select and execute set point command
	C_SE ACTTERM used

X	No additional definition
	Short pulse duration (duration determined by a system parameter in the outstation)
	Long pulse duration (duration determined by a system parameter in the outstation)
X	Persistent output

☐ Supervision of maximum delay in command direction of commands and set point commands

☐ Maximum allowable delay of commands and set point commands

Transmission of integrated totals

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

☐ Mode A: Local freeze with spontaneous transmission

☐ Mode B: Local freeze with counter interrogation

☐ Mode C: Freeze and transmit by counter-interrogation commands

☐ Mode D: Freeze by counter-interrogation command, frozen values reported spontaneously

☒ Counter read

☐ Counter freeze without reset

☐ Counter freeze with reset

☒ Counter reset

☒ General request counter

☐ Request counter group 1

☐ Request counter group 2

☐ Request counter group 3

☐ Request counter group 4

Parameter loading

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

☒ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured values

☐ High limit for transmission of measured values

Parameter activation

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

☐ Test

File transfer

(station-specific parameter, mark ***X*** if function is used)

File transfer in monitor direction

☐ Transparent file

☐ Transmission of disturbance data of protection equipment

☐ Transmission of sequences of events

☐ Transmission of sequences of recorded analog values

File transfer in control direction

☐ Transparent file

Background scan

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

☐ Background

Acquisition of transmission delay

(station-specific parameter, mark ***X*** if function is only used in the standard direction, ***R*** if only used in the reverse direction, and ***B*** if used in both directions)

■ Acquisition of transmission delay

Definition of time outs

Parameter	Default value	Remarks	Selected value
t_0	30 s	Time-out of connection establishment	30 s
t_1	15 s	Time-out of send or test APDUs	15 s
t_2	10 s	Time-out for acknowledges in case of no data messages $t_2 < t_1$	10 s
t_3	20 s	Time-out for sending test frames in case of a long idle state	20 s

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

Maximum number of outstanding I format APDUs k and latest acknowledge APDUs (w)

Parameter	Default value	Remarks	Selected value
k	12 APDUs	Maximum difference receive sequence number to send state variable	12 APDUs
w	8 APDUs	Latest acknowledge after receiving w I-format APDUs	8 APDUs

Maximum range of values k: 1 to 32767 (2^{15}-1) APDUs, accuracy 1 APDU

Maximum range of values w: 1 to 32767 APDUs, accuracy 1 APDU (Recommendation: w should not exceed two-thirds of k).

Port number

Parameter	Value	Remarks
Port number	2404	Configurable

Redundant connections

Configurable	Number N of redundancy group connections used

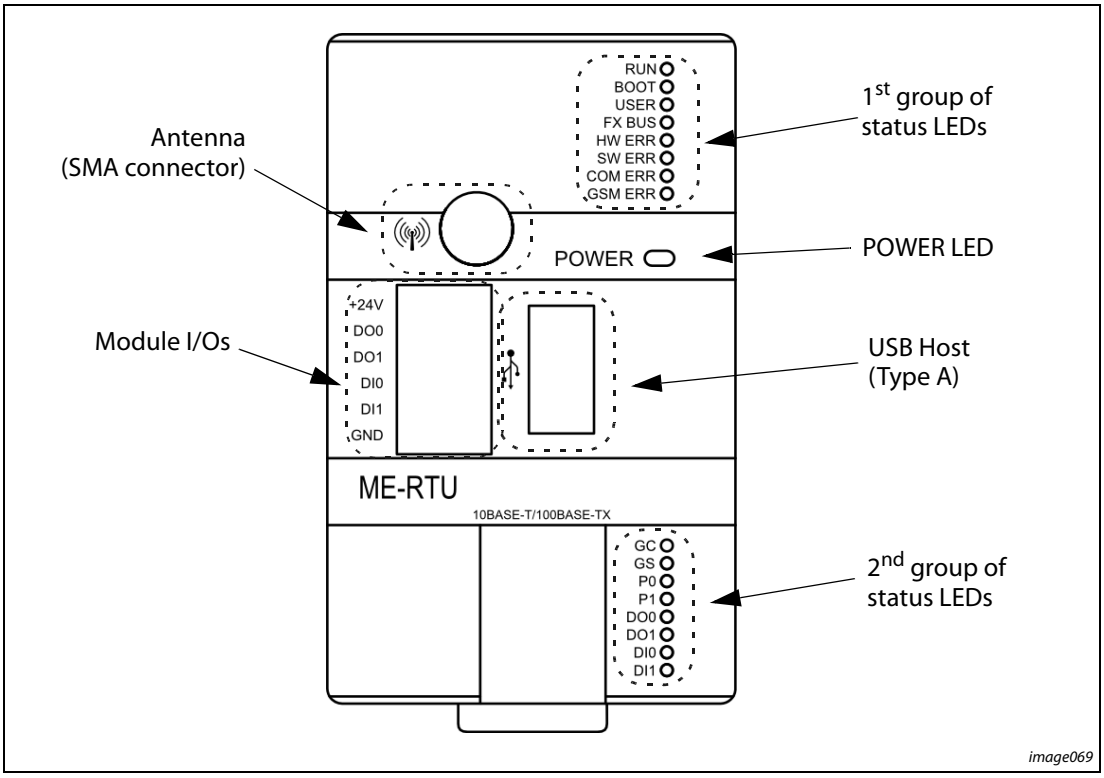
RFC 2200 suite

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

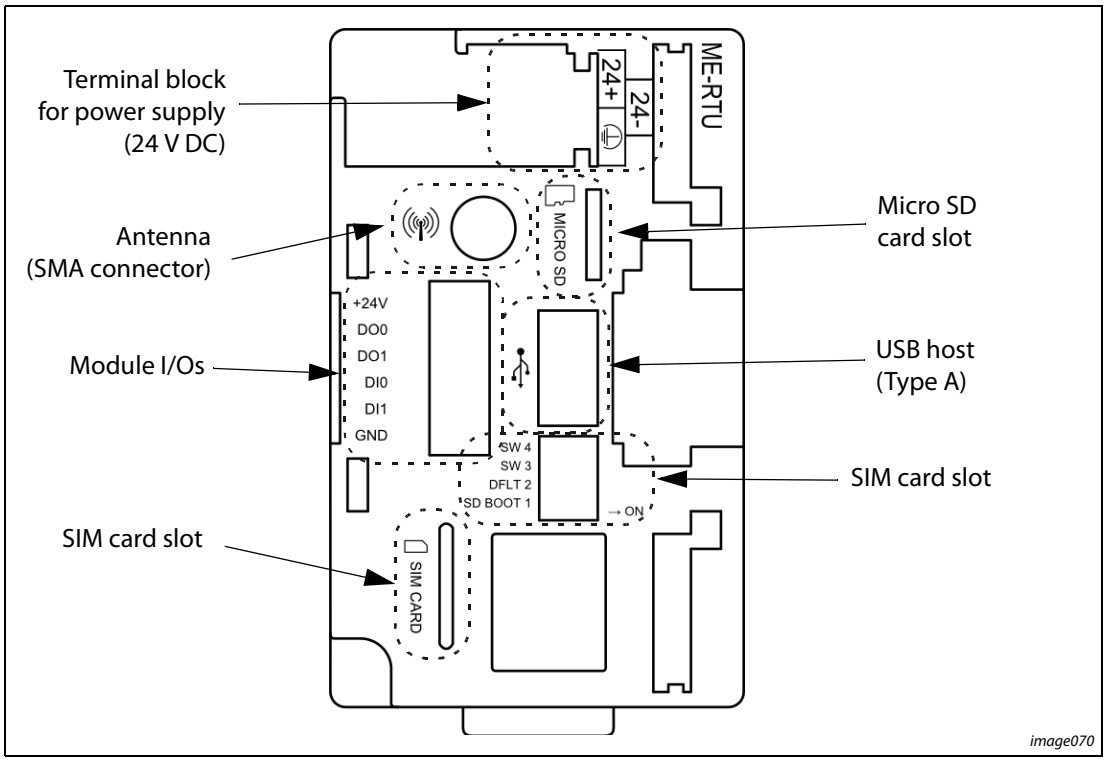
X	Ethernet 802.3
X	Serial X.21 interface
	Other selection from RFC 2200:

C Housing Printings

C.1 Top cover print



C.2 Top case print (top cover removed)



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