PlexCom RTU 150

User manual

smart
grid
networks

smart grid networks

Content

History

Document revision
r06

Software version
V1.4.2

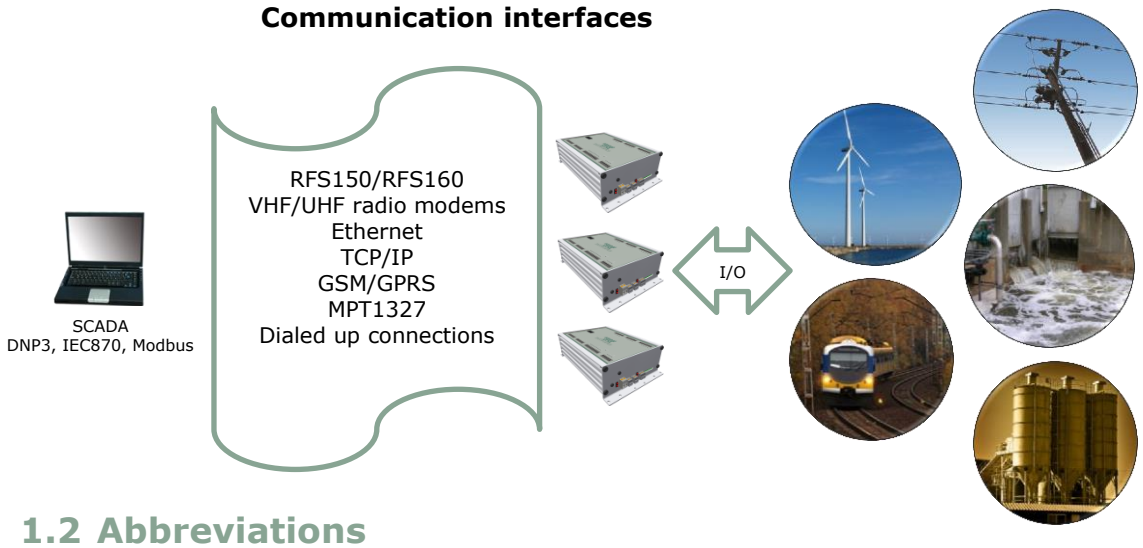
Hardware revision
r02

1. Introduction

RTU 150 is a compact RTU designed for use in electricity transmission and distribution systems. Mainly for use with distribution automation equipment in the secondary electricity networks, it can be used as a data concentrator and or a primary SCADA RTU through IEC60870-5-101, IEC60870-5-104, and DNP3 or Modbus protocols. But there are also other application areas that can be applicable, such as wind/water power and oil/gas installation.
The software contains a menu systems (MMI) used for system configuration, simulation and diagnostics. Configuration parameters are saved in a file, which can be imported/exported via RS232, FTP or SD card.

1.1 Application areas

- Distribution automation for electricity networks
- Rail systems
- Oil and gas installations
- Water and wastewater
- District heating
- Wind Power
- Industrial Processes control
- Remote Traffic Control
- Railroad Communication Systems
- Remote PLC control



1.2 Abbreviations

Following abbreviations are used in this manual:

- **CAN–** Controller Area Network
- **CT –** Current Transformers
- **RTU –** Remote Terminal Unit
- **SGN –** Smart Grid Networks
- **SCADA –** Supervisory Control And Data Acquisition
- **SBE–** Select Before Execute

1.3 Technical specification

GENERAL
Housing Material: Extruded Aluminium
Size: H 216 X W 142 X D 61mm, H 8,50 x W 5,59 x D 2,40 inch
Weight: 1250 g
Mounting: Wall mounting and DIN rail with mounting brackets
Input Voltage Range: 9-30 VDC
Current Consumption: Dependent on Input Voltage. Typical 0.1 to 0.3 A
Power Consumption: Max 6 W. Typical 2 W
Processor Type: ColdFire 32-bit
Real time clock: Real-time Clock – accuracy +/-20ppm
Internal RAM/Flash Memory: 64 kb/512 kb
External RAM/Flash Memory: 8 Mb/4 Mb
SD Card (Optional): All types/sizes supported, except for High Capacity (HC)
Temperature Range (operation): -25°C to +75°C, -13°F to +167°F
Relative Humidity: 0 to 95% Non-Condensing
Capsulation Class: IP52

COMMUNICATION
1 Ethernet
4 RS232
2 RS485
1 CAN
Protocols: IEC60870-5-101, IEC60870-5-104, MODBUS, DNP3
Isolation: RS485 to GND 0.5 kV, Ethernet to GND 1.5 kV

INPUTS & OUTPUTS
8 Analogue Inputs:
Input Range: -10 V to +10 V, 0 to 10 V, -5 to +5 V, 0 to 5V, -20, 0 to 20 mA to 20 mA possible on request
Isolation: 2.5 kV

18 Digital Inputs:
Voltage Input Range: 9 to 70 VDC
Optical Isolation: 4 kV
Input Impedance: 10 kΩ
Functions: Pulse Counting, Time Stamp, On Delay Time/Off Delay Time, Double Indication Filtering

14 Digital Outputs:
Outputs 1 to 10
Max Rated Current: 2 A
Voltage: 125 VAC, 60 VDC
Power Resistive: 62.5 VA, 30 W
Isolation: 1.0 kV
Outputs 11 to 14
Max Rated Current: 3 A
Voltage: 250 VAC, 130 VDC
Power Resistive: 50 VA, 60 W
Power Inductive: 25 VA, 30 W
Isolation: 1.0 kV

Expandable: 1-1000 Digital Inputs
1- 1000 Digital Outputs

LED INDICATORS
4 status, 4 x RS232 Tx/Rx, Ethernet link/activity, Digital Inputs, Digital Outputs

STANDARDS for EMC and LVD directive
EMC emission
RF emission: EN 55022:1998, -A1:2000, -A2:2003 Class B
EMC immunity
Electrostatic Discharge: EN 61000-4-2:1995
Radio-frequency Electro Magnetic Field: EN 61000-4-3:1997
Fast Transients: EN 61000-4-4:1995
Induced Radio-frequency Field: EN 61000-4-6:1996
Power Frequency Magnetic Field: EN 61000-4-8:1994
Safety
Electrical safety: EN60950-1

2. Installation

Follow the installation steps below:

1. Mount the RTU in a dry and ventilated area.
2. Connect protective ground.
3. Connect IO and communication cables.
4. Connect DC power.
5. Configure the RTU according to chapter 4.

RTU 150 has protective earth connection on the power side. This should be connected to protective earth. It is to be noted that this ground connector is internally connected to the negative pole of the power supply connector.

NOTE! Use a power supply with nominal voltage 12VDC or 24VDC.
The power source should have a current limiting function. An external fuse is necessary in battery systems or if the power supply has high current capacity, recommended value of the fuse are 2A to 6A.

3. Indications and connections

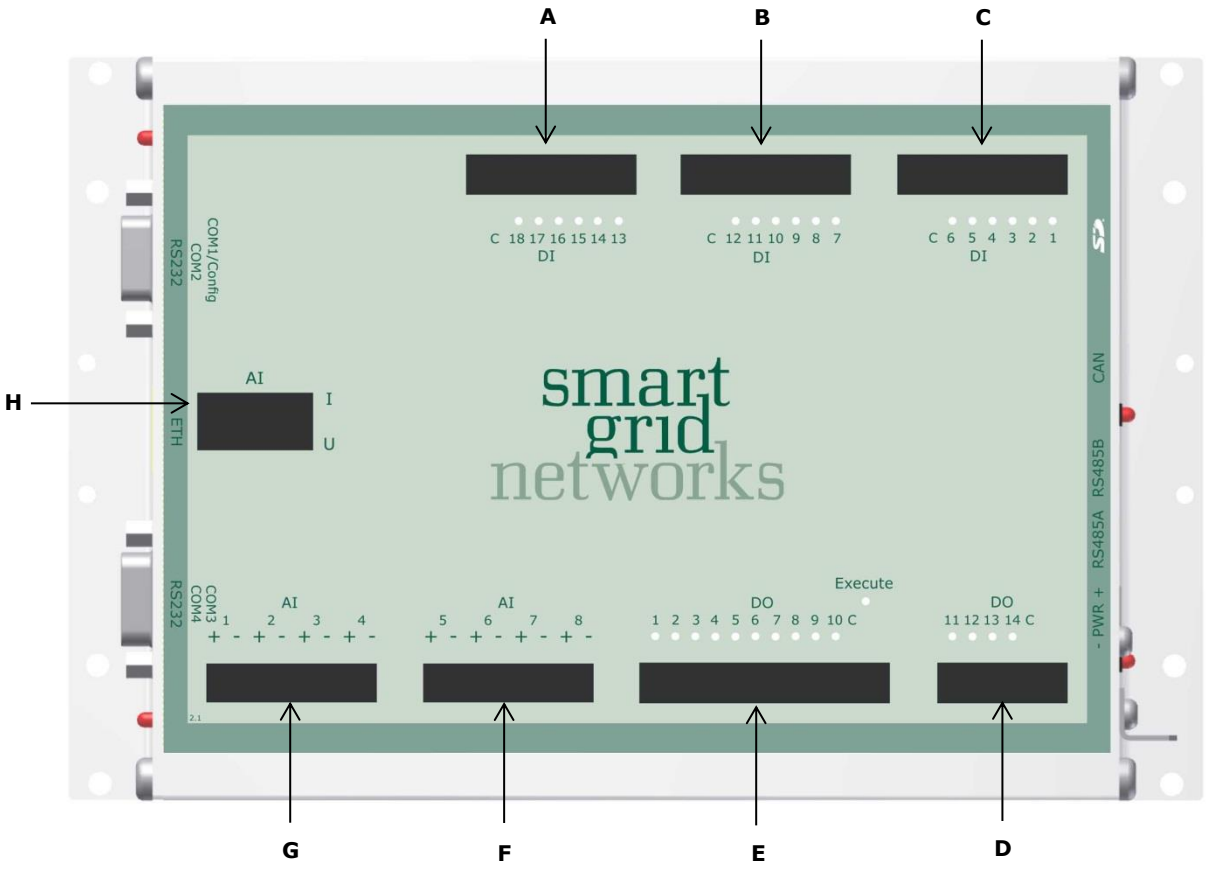


Figure 1. RTU overview

Object	Description
A	Digital Inputs (13-18)
B	Digital Inputs (7-12)
C	Digital Inputs (1-6)
D	Digital Outputs (11-14)
E	Digital Outputs (1-10)
F	Analogue Inputs (5-8)
G	Analogue Inputs (1-4)
H	Select current/voltage on analogue Inputs

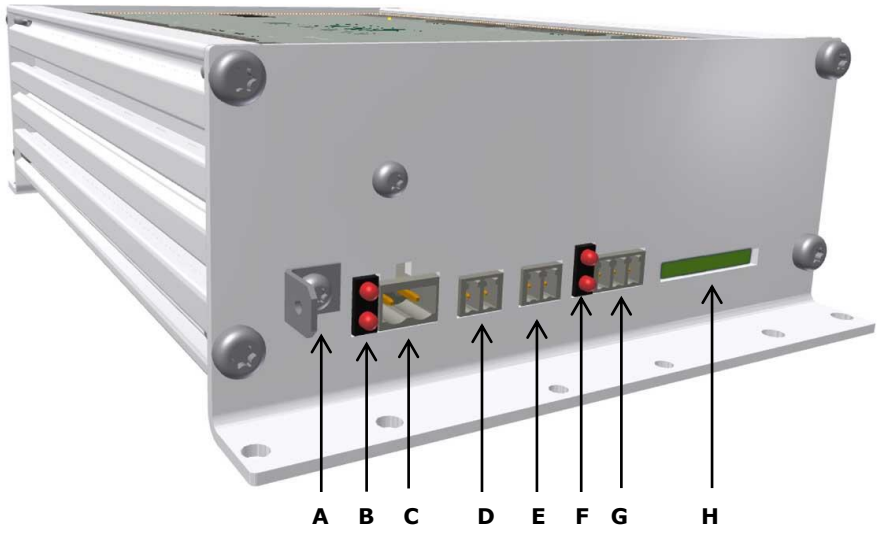


Figure 2. RTU 150 from power side view

Object	Description	Connector
A	Ground	Blade Connector 6.35 mm
B	LED – Blue LED: SCADA connection status. White LED: clock synchronization status. (See chapter 5.1 for more details)	
C	Voltage Connection - For connection of 9-30VDC 2 Pin 5.08 mm	2-way screw terminal
D	RS485A - Serial Communication	2-way screw terminal
E	RS485B - Serial Communication	2-way screw terminal
F	LED - Indicates communication status	
G	CAN - CAN Communication	3-way screw terminal
H	SD card - Option All types/sizes supported, except for High Capacity (HC)	

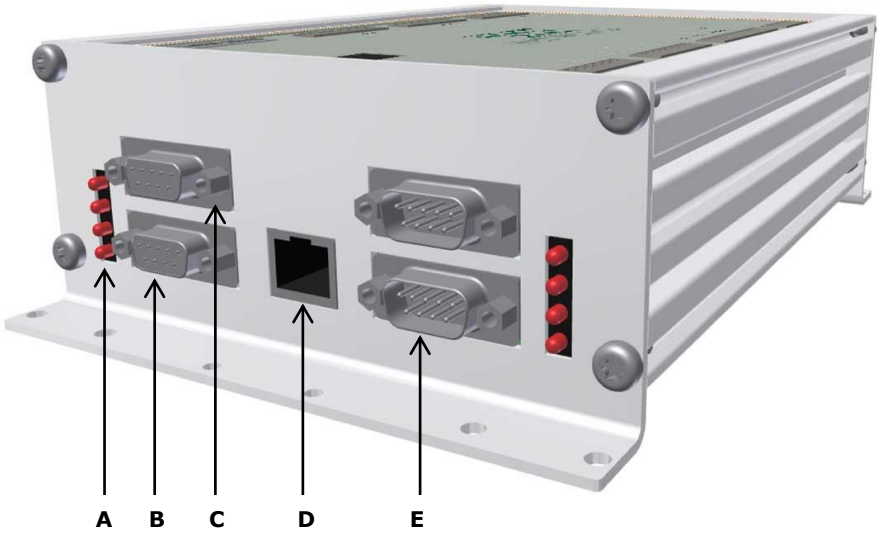


Figure 3. RTU 150 from communication side view

Object	Description	Connector
A	LED - Indicate Tx (red) /Rx (green) RS232	
B	RS232 F Com 2	DB9 F
C	RS232 F Com 1 - For connection of serial cable 9-pole D-sub DCE	DB9 F
D	Ethernet - Ethernet communication (10 and 100 Mbps)	RJ45
E	RS232 M Com 3, 4 - For connection of serial cable 9-pol D-sub DTE	DB9 M

3.1 Serial Interfaces

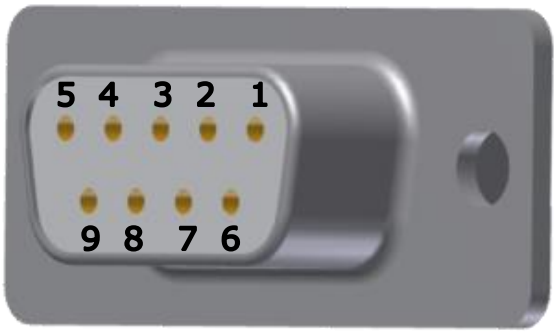


Figure 5. RS232 Female

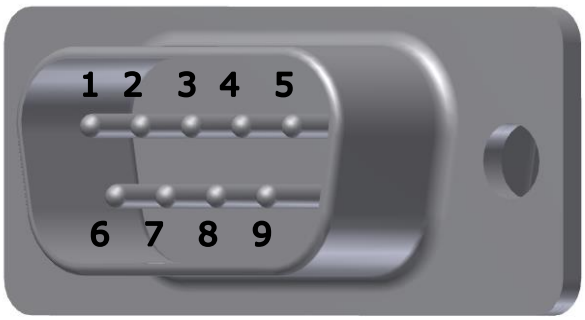


Figure 4. RS232 Male

3.1.1 RS232 Port Com1

The 9-pol female connector for the Com 1 port is a part of the CB20. Mainly used for configuration.

Pin No	I/O	Description
1. DCD		Not used
2. Rx	O	Receive input data from the connected device.
3. Tx	I	Transmit output data to the connected device.
4. DTR	Strapped to 6	Data Terminal Ready.
5. GND	-	Signal Ground -
6. DSR	Strapped to 4	Data Set Ready.
7. RTS	I	Request To Send. Output.
8. CTS	O	Clear To Send.
9. RI		Not used

3.1.2 RS232 Port Com2

The 9-pol female connector for the Com 2 port is a part of the CB20.

Pin No	I/O	Description
1. DCD	O	Carrier Detect.
2. Rx	O	Receive input data from the connected device.
3. Tx	I	Transmit output data to the connected device.
4. DTR	I	Data Terminal Equipment.
5. GND	-	Signal Ground -
6. DSR	O	Data Set Ready.
7. RTS	I	Request To Send.
8. CTS	O	Clear To Send.
9. RI		Not used

3.1.3 RS232 Port Com3 and Com4

The 9-pol male connector for the Com 3 and Com 4 port is a part of the CB20.

Pin No	I/O	Description
1. DCD	I	Carrier Detect.
2. Rx	I	Receive input data from the connected device.
3. Tx	O	Transmit output data to the connected device.
4. DTR	O	Data Terminal Equipment.
5. GND	-	Signal Ground -
6. DSR	I	Data Set Ready.
7. RTS	O	Request To Send.
8. CTS	I	Clear To Send.
9. RI		Ring Indicator.

3.1.4 RS485A and RS485B

Two isolated RS485 interfaces for differential two-wire multi drop communication. RS485A uses terminal block P702 and RS485B uses terminal block P703. Both ports have a 165 ohm termination resistor. See Figure 2 RS485 A and RS485B.

Terminal block, pin	Function	Direction from CB20
1	RS485 + (A)	I/O
2	RS485 – (B)	I/O

3.1.5 CAN

A CAN differential two-wire interface uses terminal block P800. The port has a 165 ohm termination resistor. See Figure 2 CAN.

Terminal block, Pin	Function	Direction from CB20
1	CAN H	I/O
2	CAN L	I/O
3	GND	-

3.1.6 Ethernet

The Ethernet interface uses a standard wired RJ45 connector and can handle 10 and 100 Mbps communication speed. Green LED indicates status of link and will be lit when link is good. Yellow LED indicates activity and will be lit when activity is present on either transmit or receive. See Figure 3, Ethernet.

4. Configuration

Equipment
RTU 150 can run in two different modes, the regular "Operating mode" and the "Configuration mode". In configuration mode the regular functions, such as SCADA communication and IO scanning, are stopped. For security reasons a timer checks that the unit is not abandoned in configuration state, after a time out the unit will restart.
To configure the RTU 150 a PC with a terminal program (example TeraTerm, HyperTerminal) can be used, but it is also possible to configure RTU 150 via Ethernet (Telnet). The format for serial communication is 57600 bps, 8 bits, 1 stop bit, no parity (57600-N-8-1), standard serial cable is needed.

Procedure
Follow the steps below to enter the configuration menus:

1) Check that the unit is powered. The blue LED will toggle (see chapter 5.1 for more details).
   NOTE! Make sure the polarity is correct. 9-30V DC.
2) Start terminal program on the PC with settings 57600-N-8-1.
3) Connect the serial cable to the PC.
4) Connect the serial cable to the RTU port named *CONFIG* and press space key.
5) Following output shall be visible on the screen (see below). If it is not visible, check that the correct PC COM port is connected and that the correct settings are used.

```
############################################################
                        RTU150S

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Software: RTU150S v1.4.2 Build 23 Apr 2014

Article No    Softw Id    Hardw Id  HardwRev  CRC
1782001-3     0xAA        0x41      0x01      0xFF29

Date          Time        Temperature          Supply Voltage
14-04-24      09:05:32    29.5 C               12.04 V

                 Based on FreeRTOS.org
############################################################
######################### Main menu ########################

1 - Configuration file comment: RTU150S v1.4.2
2 - SCADA menu
3 - Local IO menu
4 - External IO menu
5 - Simulation menu
6 - Port Forwarding menu      : Disabled
7 - Network tools menu

L - List Settings
B - Backup Settings
R - Restore Settings from Backup

D - Restore Settings to Default

E - Exit without saving
S - Save changes and restart system
```

The RTU 150 has now entered the configuration mode.

RTU Configuration
To enter preferred submenus press configuration digit or the letter in front of the submenu.
'*Esc*' return to the previous menu, '*S*' saves configuration and restarts the RTU.
When pressing '*E*', the configuration is <u>not</u> saved and the unit will continue with previous settings.
Note! The configuration will not be saved if voltage is disconnected.

4.1 Configuration File Comment

Name the current configuration with maximum 15 characters. Below is an example:

```
Configuration File Comment: Station ABC
```

4.2 SCADA menu

The SCADA menu shows a summary of selected port and settings. If menu option '3' is pressed a choice of available protocols is shown, i.e. IEC60870-5-101, IEC60870-5-104, DNP3 or Modbus.

```
###################### 2 SCADA menu ######################

1 - Port menu                : COM2, 9600 bps, Even Parity
2 - Protocol                 : IEC60870-5-101
3 - IEC60870-5-101 menu
4 - IEC60870-5-104 menu
5 - DNP3 menu
6 - Modbus menu
7 - Periodic AI Report (min)  : 0
```

4.2.1 Port menu

Port settings for the SCADA communication: COM2, COM3, COM4, RS485-A, RS485-B and Ethernet.
COM-port parity: Odd, Even or None.
SCADA TCP mode, Ethernet TCP port-number and *SCADA IP* are only applicable if the *Ethernet* port is selected. The SCADA client IP needs to be configured. Connections from unknown clients are rejected!
COM-port Bitrate and *COM-port Parity* are only applicable if port *COM2, COM3, COM4* or *RS485 A/B* is selected.

```
######################## 2.1 Port menu ########################

1 - Port                     : COM2
2 - COM-port bitrate         : 9600 bps
3 - COM-port parity          : None
4 - Ethernet TCP port        : 20000
5 - SCADA IP                 : 192.168.1.150
```

4.2.2 Protocol

Protocol selection for the SCADA communication:

```
############ Select Protocol ############

1 -  DNP3
2 -  IEC60870-5-101
3 -  IEC60870-5-104
4 -  MODBUS

Selected Protocol: DNP3
```

4.2.3 IEC60870-5-101 menu

Protocol settings for the IEC60870-5-101 protocol:

```
################# 2.3 IEC60870-5-101 menu #################

1 - Link mode                : Unbalanced
2 - Link address             : 3
3 - Link address size        : 1
4 - ASDU address             : 3
5 - ASDU address size        : 2
6 - Info object address size  : 2
7 - Cause of transmission size: 1
8 - Advanced menu
```

4.2.3.1 Advanced menu

Advanced protocol settings for the IEC60870-5-101 protocol:

```
################## 2.3.8 Advanced menu ##################

1 - Max ASDU size            : 255
2 - Max poll delay           : 20000
3 - Appl. conf timeout       : 30000
4 - Test frame delay         : 0
5 - Offline poll time        : 10000
6 - LinkConf timeout         : 2000
7 - Max link retries         : 3
8 - Rx frame timeout         : 15000
9 - Transmit delay           : 0
```

Description for each parameter is described in table below:

Parameter	Default value	Description
Link mode	Unbalanced	Data link transmission mode. Required for each communications channel. Possible values are balanced (value 0), or unbalanced (value 1).
Link address	3	Link (session) address. Can be any number of 1 to 255.
Link address size	1	Number of bytes in link address field. The link address size can be 1 or 2 bytes, if link mode is set to unbalanced. If balanced mode is selected, link address size may also be set 0 (not used).
ASDU address	3	ASDU address. Possible values are from 0 to 255.
ASDU address size	2	Number of bytes in common address of ASDU (sector address) field. The number of bytes can either be 1 or 2
Info Object Address Size	2	Number of bytes in information object address (point number) field. The number of bytes can be 1, 2 or 3.
Cause of transmission size	1	Number of bytes in Cause Of Transmission (COT) field of ASDU. The number of bytes can either be 1 or 2.
Max ASDU size	255	Maximum ASDU frame size. Can be any number of 1 to 255.
Max poll delay	20000	This parameter specifies how long time to allow between received frames before declaring the session offline. The number is specified in units of ms. Applicable values are 10000 or above.
Application confirm timeout	30000	Incremental application layer timeout. This is the maximum time in milliseconds that this device will wait for some type of response from the remote device if a command is outstanding. Once any response is received on this channel this time is restarted.
Test frame delay (ms)	0	For devices operating in balanced mode this parameter specifies how often to transmit a test frame to verify that the remote device is still online. 0 disables the periodic sending of test frames. This parameter is ignored if link mode is unbalanced.
Offline poll time (ms)	10000	This parameter specifies how often a session that is offline will attempt to re-establish communication. This includes attempting to open/reopen a channel and/or issuing request status messages as appropriate for the current configuration.
Link confirm timeout	2000	Maximum amount of time to wait for a link level confirm if requested.
Max link retries	3	Maximum number of link layer retries if link layer confirm times out.
Rx frame timeout	15000	Maximum amount of time to wait for a complete frame after receiving the frame sync.
Transmit delay	0	Minimum time, in ms, between receiving last byte and transmitting first byte.

4.2.4 IEC60870-5-104 menu

Protocol settings for the IEC60870-5-104 protocol:

```
################## 2.4 IEC60870-5-104 menu ##################

1 - Station address    (ASDU) : 3
2 - T1 ack. period      (sec) : 15
3 - T2 frame period     (sec) : 10
4 - T3 test period      (sec) : 20
5 - W value                   : 8
6 - K value                   : 12
7 - Offline poll period (sec) : 30
8 - Link address              : 1
```

Description for each parameter is described in table below:

Parameter	Default value	Description
Station address	3	ASDU address. Possible values are from 0 to 255.
T1 ack. period	15 sec	Time-out for send or test APDUs.
T2 frame period	10 sec	Time-out for acknowledges in case of no data messages, t2 < t1.
T3 test period	20 sec	Time-out for sending test frames in case of a long idle state. The value zero means no idle monitoring.
W value	8	The receiver acknowledges at the latest after receiving W data messages.
K value	12	The value of K shall indicate the maximum number of sequentially numbered data messages that the DTE may have outstanding (i.e. unacknowledged). Acknowledge messages before k is reached avoid a transmission stop.
Offline poll period	30 sec	This parameter specifies how often a session that is offline will attempt to re-establish communication. This includes attempting to open/reopen a channel and/or issuing request status messages as appropriate for the current configuration.
Link address	1	Link (session) address. Can be any number of 1 to 255.

4.2.5 DNP3 menu

Protocol settings for the DNP3 protocol:

```
###################### 2.5 DNP3 menu ######################

1 - Link address              : 3
2 - Link confirmation Mode    : Never
3 - Advanced menu
4 - DNP3 Class menu
```

4.2.5.1 Advanced menu

Advanced protocol settings for the DNP3 protocol:

```
################## 2.5.3 Advanced menu ##################

1 - Transmission delay    (ms): 0
2 - Rx data timeout       (ms): 1500
3 - Link confirm timeout  (ms): 3000
4 - Max link retries          : 2
5 - Appl. confirm timeout (ms): 5000
6 - Max appl.resp.frag. size  : 2048
7 - Unsolicited messaging     : On
8 - Unsolicited init          : Class none
9 - Unsolicited master address: 1
A - Unsol. retry delay   (sec): 5
B - Unsolicited max retries   : 2
C - Unsol. AIN enabled (event): 0-149
D - Unsol. AIN disabled (poll): -
E - Unsol. BIN enabled (event): 0-449
F - Unsol. BIN disabled (poll): -
```

Description for each parameter is described in table below:

Parameter	Default value	Description
Link address	2	Data link address. Possible values are 0-65535.
Link confirm mode	0	Request the remote device to send a data link layer confirm of the last frame sent. Note that this setting is independent of whether the remote device will require this device to send a data link confirm to frames it receives. Possible values are 0 ('never'), 1 ('sometimes'), or 2 ('always').
Transmission delay	0	Minimum time, in ms, between receiving last byte and transmitting first byte.
Rx data timeout	1500	Maximum time, in ms, between characters. If more than this time elapses between characters, the data link layer state machine is restarted. Set to 0 to disable.
Link confirm timeout	3000	Time, in ms, to wait for master data link layer confirm of the last frame sent, before doing retries (only if frame sent with confirm requested). Measured after last byte of data frame sent.
Max link retries	2	Number of attempts to re-transmit a data link frame that was not confirmed by the master (only if frame sent with confirm requested).
Appl. confirm timeout	5000	Timeout, in ms, waiting for master to confirm previous response, if requested. (If application layer confirms are used with data link confirms, ensure the application layer confirm timeout is set long enough for all data link retries to complete).
Max appl.resp.frag.	2048	Maxim numbers of bytes in a response frame.
Unsolicited Messaging	On	Permit or not-permit unsolicited responses.
Unsolicited Init	Class None	Controls the event classes that are enabled for unsolicited response at start-up.
Unsolicited master address	1	Destination address for unsolicited messages.
Unsolicited retry delay	500	If an unsolicited response is not confirmed within "Appl. Confirm Timeout", this parameter controls how soon another unsolicited response will be sent. If this parameter is zero or less than "Appl. Confirm Timeout", the "retry" unsolicited response will be sent as soon as "Appl. Confirm Timeout" expires (unless a read request was received in the meantime, in which case the read request will be responded first).
Unsolicited max retries	2	Number of attempts to re-transmit an unsolicited response without getting a confirmation from the master. The value of 255 will allow unlimited retries.
Unsolicited enabled/disabled	All enabled	The database objects (AIN, BIN) may individually be configured for unsolicited or not.

Unsolicited mode may be enabled by SCADA. Another option is to configure the RTU to start using unsolicited mode directly after a power up. This is done by using the parameter "*Unsolicited Init*". Any combination of class 1, 2 and 3 can be configured.
Normally the chosen mode affects all DNP3 objects, but the RTU 150 has the capability of individually enable/disable which objects that shall be sent as unsolicited.

4.2.5.2 DNP3 Class menu

```
################## 2.5.4 DNP3 Class menu ##################

1 - Object group              : Binary Input
2 - Point range               : 0..220
3 - Class                     : 0 (Static)

4 - Assign according to 1..3
5 - Show class for all points
6 - Clear all class 1..3 (event)
7 - Clear all class 0..3 (event and static)
8 - Auto class assignment     : On
9 - Class 0 response          : BI, AI,
A - Gen. status (flag) events : On
```

The RTU automatically populate the DNP3 class assignment by default. Binary inputs are assigned to class 0/1, analogue inputs are assigned to class 0/2 and counters are assigned to class 0/3.

```
If the class assignment shall be configured manually, is option "Auto class assignment" shall be set to
"Off". It is recommended to list the available objects by using menu option "5. Show class for all points"
(see output below) and then disable unwanted objects.
Show Class Assignment

Binary Input    Points 0000..0018 : Assigned Class = 0 1
Binary Input    Points 0019..1023 : Assigned Class = None

Analog Input    Points 0000..0007 : Assigned Class = 0 2
Analog Input    Points 0008..0016 : Assigned Class = None
Analog Input    Points 0017..0021 : Assigned Class = 0 2
Analog Input    Points 0022..0255 : Assigned Class = None

Running Counter Points 0000..0018 : Assigned Class = 0 3
Running Counter Points 0019..0255 : Assigned Class = None

Frozen Counter  Points 0000..0018 : Assigned Class = 0 3
Frozen Counter  Points 0019..0255 : Assigned Class = None

Press any key to continue...
```

4.2.6 Modbus menu

Protocol settings for the Modbus protocol.

```
#################### 2.6 Modbus menu ####################

1 - Address                   : 5
2 - Latch on mode             : Pulse
```

Parameter	Default value	Description
Address	5	RTU Address.
Latch on mode	Pulse	Modbus protocol does only support latch commands, no pulse commands. If this parameter is configured to "pulse", a pulse will be generated on the output even if the Modbus command is "latch". If this parameter is configured to "latch", a latch will respectively be performed.

4.2.7 Periodic AI Report

If protocol DNP3 or IEC60870-5-101/104 is used, the RTU150 may be configured to periodically send all analogs to SCADA, regardless if they have changed or not. The interval is in units of minutes, where 0 means disabled.

4.3 Local IO menu

```
##################### 3 Local IO menu #####################

1 - Analog Inputs menu
2 - Digital Inputs menu
3 - Digital Outputs menu
4 - Chatter Control menu
```

4.3.1 Analog Inputs menu

From this menu the configuration of the analog inputs are made.

```
################## 3.1 Analog Inputs menu ##################

1 - Dead band menu
2 - Measurement range menu
3 - Sampling interval menu
4 - Mean value update time menu
5 - Offset menu
6 - Scale menu
7 - Show values
```

4.3.1.1 Dead Band menu

Dead Band Selection (% of total range) takes place in this menu.

```
########### 3.1.1 Dead band (% of total range) ############

0 - Change all
1 - Input 1                    : 5
2 - Input 2                    : 5
3 - Input 3                    : 5
4 - Input 4                    : 5
5 - Input 5                    : 5
6 - Input 6                    : 5
7 - Input 7                    : 5
8 - Input 8                    : 5
```

4.3.1.2 Measurement Range menu

```
############## 3.1.2 Measurement range menu ###############

0 - Change all
1 - Input 1                    : -10..+10V
2 - Input 2                    :  -5..+5V AC
3 - Input 3                    :   0..+10V
4 - Input 4                    :  -5..+5V
5 - Input 5                    : -10..+10V AC
6 - Input 6                    : -10..+10V
7 - Input 7                    : -10..+10V
8 - Input 8                    : -10..+10V
```

The RTU 150 has following measurement ranges available:

- -5V - +5V
- -10V - +10V
- 0V - +10V
- 0mA - 20mA
- -10VAC - +10VAC
- -5VAC - +5VAC

The RTU is verified against 50/60Hz when using AC measurements. Any higher frequency will result in invalid values.

4.3.1.3 Sampling Interval menu

In this menu sampling interval will be set individually for each input. The minimum sampling interval is 10ms.

```
############ 3.1.3 Sampling interval (0 = off) ############

0 - Change all
1 - Input 1                    : 10 ms
2 - Input 2                    : 10000 ms
3 - Input 3                    : 10 ms
4 - Input 4                    : 10 ms
5 - Input 5                    : 10000 ms
6 - Input 6                    : 10 ms
7 - Input 7                    : 10 ms
8 - Input 8                    : 10 ms
```

Note that 0 = Off, i.e. no sampling at all.

4.3.1.4 Mean Value Update Time menu

It is possible to enable mean value calculation for each of the 8 analogue inputs. If enabled, each sample of the analogue input is stored for mean value calculation. When the configured time has passed, the value is reported to SCADA (if the value has changed since last time).

```
######## 3.1.4 Mean value update time (sec, 0=off) ########

0 - Change all
1 - Input 1                    : 0
2 - Input 2                    : 0
3 - Input 3                    : 0
4 - Input 4                    : 0
5 - Input 5                    : 0
6 - Input 6                    : 0
7 - Input 7                    : 0
8 - Input 8                    : 0
```

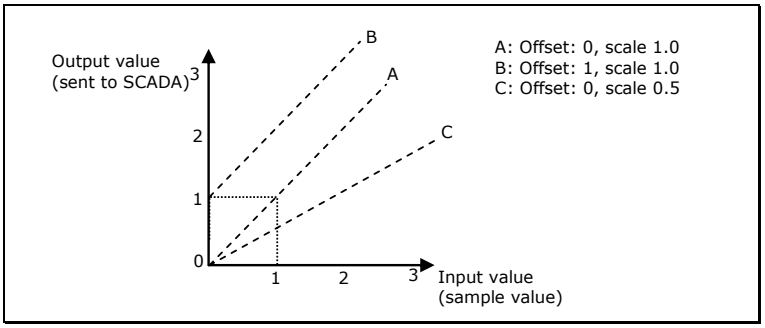
4.3.1.5 Offset menu

```
#################### 3.1.5 Offset menu ####################

0 - Change all
1 - Input 1                    : +0
2 - Input 2                    : +0
3 - Input 3                    : +0
4 - Input 4                    : +0
5 - Input 5                    : +0
6 - Input 6                    : +0
7 - Input 7                    : +0
8 - Input 8                    : +0
```

4.3.1.6 Scale menu

```
#################### 3.1.6 Scale menu ####################

0 - Change all
1 - Input 1                    : 1.00000
2 - Input 2                    : 1.00000
3 - Input 3                    : 1.00000
4 - Input 4                    : 1.00000
5 - Input 5                    : 1.00000
6 - Input 6                    : 1.00000
7 - Input 7                    : 1.00000
8 - Input 8                    : 1.00000
```

By default, the RTU set offset to 0 and scale to 1.0000, i.e. no modification is applied on the analogue input signal (see line A in picture below)



4.3.1.7 Show Values

This menu shows true analogue values on the AI1 to AI8 input ports, based on current settings.

```
Press any key to stop...

     01       02       03       04       05       06       07       08
  ------   ------   ------   ------   ------   ------   ------   ------
 -3100mV  -3934mV   2942mV  -1137mV  -3864mV  -3564mV   5333mV   2251mV
```

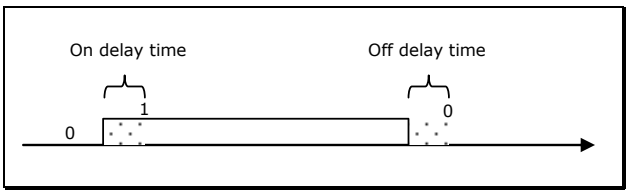
4.3.2 Digital Inputs menu

```
################# 3.2 Digital Inputs menu #################

1 - On delay time menu
2 - Off delay time menu
3 - Double indications menu
4 - Inverted inputs menu
5 - Pulse count mode menu
6 - Show values
```

4.3.2.1 On/Off Delay Time menu

In order to filter out intermittent spikes on the inputs an on/off delay filter time may be applied. This means that the input has to be stable for the specified time, before the value is accepted and sent to SCADA. The delay time may be set to 10-10000 ms, where 200 ms is the default value.

```
################ 3.2.1 On delay time menu #################

0 - Change all
1 - Input 1                    : 200 ms
2 - Input 2                    : 200 ms
3 - Input 3                    : 200 ms
4 - Input 4                    : 200 ms
5 - Input 5                    : 200 ms
6 - Input 6                    : 200 ms
7 - Input 7                    : 200 ms
8 - Input 8                    : 200 ms
9 - Input 9                    : 200 ms
A - Input 10                   : 200 ms
B - Input 11                   : 200 ms
C - Input 12                   : 200 ms
D - Input 13                   : 200 ms
E - Input 14                   : 200 ms
F - Input 15                   : 200 ms
G - Input 16                   : 200 ms
H - Input 17                   : 200 ms
I - Input 18                   : 200 ms
```



4.3.2.2 Double Indications menu

If a status is indicated by two inputs, those inputs shall be enabled as a double input.

```
############### 3.2.3 Double indication menu ################

0 - Change all
1 - Input 1&2                  : OFF
2 - Input 3&4                  : OFF
3 - Input 5&6                  : OFF
4 - Input 7&8                  : OFF
5 - Input 9&10                 : OFF
6 - Input 11&12                : OFF
7 - Input 13&14                : OFF
8 - Input 15&16                : OFF
9 - Input 17&18                : OFF
```

When a double indication is enabled, a function is activated that filters out intermediate position when, for example a switch is moving from open to close.

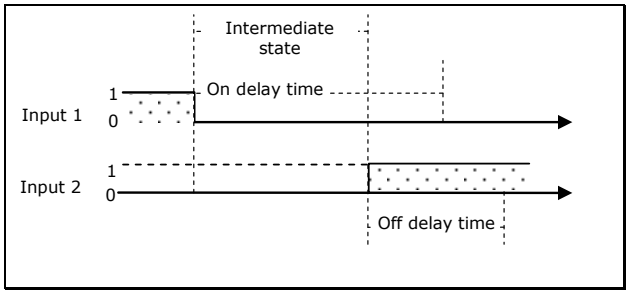


Figure 6. Double Indications

It is recommended to configure the *On/Off Delay time* to a greater value than the switch run time, in order to filter out the '00' positions.

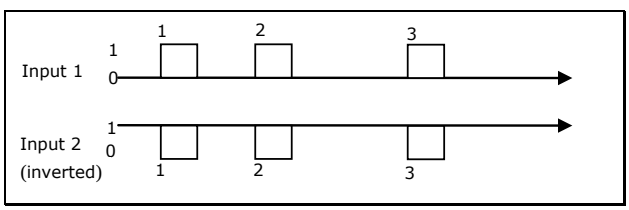
4.3.2.3 Inverted Inputs menu

Inverting an input means that a voltage of 0V is indicated as a logical one '1' and vice versa.

```
################ 3.2.4 Inverted inputs menu #################

0 - Change all
1 - Input 1                    : OFF
2 - Input 2                    : OFF
3 - Input 3                    : OFF
4 - Input 4                    : OFF
5 - Input 5                    : OFF
6 - Input 6                    : OFF
7 - Input 7                    : OFF
8 - Input 8                    : OFF
9 - Input 9                    : OFF
A - Input 10                   : OFF
B - Input 11                   : OFF
C - Input 12                   : OFF
D - Input 13                   : OFF
E - Input 14                   : OFF
F - Input 15                   : OFF
G - Input 16                   : OFF
H - Input 17                   : OFF
I - Input 18                   : OFF
```

4.3.2.4 Pulse Count Mode menu

A digital input may be configured for pulse counting. Each time the input value goes from 0 to 1(non-inverted mode), the counter is incremented.



```
################ 3.2.5 Pulse count mode menu ################

0 - Change all
1 - Input 1                    : OFF
2 - Input 2                    : OFF
3 - Input 3                    : OFF
4 - Input 4                    : OFF
5 - Input 5                    : OFF
6 - Input 6                    : OFF
7 - Input 7                    : OFF
8 - Input 8                    : OFF
9 - Input 9                    : OFF
A - Input 10                   : OFF
B - Input 11                   : OFF
C - Input 12                   : OFF
D - Input 13                   : OFF
E - Input 14                   : OFF
F - Input 15                   : OFF
G - Input 16                   : OFF
H - Input 17                   : OFF
I - Input 18                   : OFF
```

4.3.2.5 Show Values

This menu option shows the true digital values on the DI1-DI18 input ports.

```
 Press any key to stop...

 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18
 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
  0  1  1  0  0  1  0  1  1  0  1  0  0  0  0  0  0  0
```

4.3.3 Digital Outputs menu

```
################# 3.3 Digital outputs menu ##################

1 - Pulse time menu
2 - Select before execute (DOut 1-10): Off
3 - Double commands menu
4 - Activate outputs menu
```

4.3.3.1 Pulse Time menu

If the SCADA protocol message does not include a parameter specifying the pulse time, the RTU will use the configured pulse time.

```
################### 3.3.1 Pulse time menu ###################

0 - Change all
1 - Output 1                   : 1000 ms
2 - Output 2                   : 1000 ms
3 - Output 3                   : 1000 ms
4 - Output 4                   : 1000 ms
5 - Output 5                   : 1000 ms
6 - Output 6                   : 1000 ms
7 - Output 7                   : 1000 ms
8 - Output 8                   : 1000 ms
9 - Output 9                   : 1000 ms
A - Output 10                  : 1000 ms
B - Output 11                  : 1000 ms
C - Output 12                  : 1000 ms
D - Output 13                  : 1000 ms
E - Output 14                  : 1000 ms
```

4.3.3.2 Select before execute

Select before execute is a functionality only applicable when using IEC 60870-5-101/104 protocol. If enabled, SCADA must first send a *select* command, then immediately the *execute* command. Any other combination will not trigger the wanted output. Note that a single execute command will fail.

4.3.3.3 Double Command menu

The parameter for enabling double command is only applicable for IEC 60870-5-101/104. If enabled, the output pair is controlled by a single *Double Command* message from SCADA.

```
################ 3.3.3 Double command menu ################

0 - Change all
1 - Output 1&2                : OFF
2 - Output 3&4                : OFF
3 - Output 5&6                : OFF
4 - Output 7&8                : OFF
5 - Output 9&10               : OFF
6 - Output 11&12              : OFF
7 - Output 13&14              : OFF
```

4.3.4 Activate Output menu

In the MMI it is possible to activate an output for testing purpose.

```
############### 3.3.4 Activate output menu ################

1 - Output 1                  : SBE-mode
2 - Output 2                  : SBE-mode
3 - Output 3                  : SBE-mode
4 - Output 4                  : SBE-mode
5 - Output 5                  : SBE-mode
6 - Output 6                  : SBE-mode
7 - Output 7                  : SBE-mode
8 - Output 8                  : SBE-mode
9 - Output 9                  : SBE-mode
A - Output 10                 : SBE-mode
B - Output 11                 : Off
C - Output 12                 : Off
D - Output 13                 : Off
E - Output 14                 : Off
```

NOTE! If selecting an output to be activated it will have immediate effect. A switch or other equipment could cause damage if it is connected to the digital output!

4.3.5 Chatter control menu

This function is used to control the maximum number of events that may occur within a specified period of time to report to SCADA.

```
################ 3.4 Chatter control menu #################

1 - Enable                    : OFF
2 - Interval (s)              : 3
3 - Threshold                 : 10
```

4.4 External IO menu

The RTU 150 IO may be expanded with IO from external devices. Since Modbus only supports latching control commands, there is an option to convert the latch functionality into a pulse (which is more commonly used). If pulse mode is selected, the RTU 150 will first send latch on, wait 500ms and finally send latch off.

```
################### 4 External IO menu ####################

1 - External Master menu
2 - Modbus latch on mode      : Pulse
```

4.4.1 External Master Menu

The RTU 150 supports up to 5 slaves, which all may have individual settings.

```
################ 4.1 External Master menu #################

1. Slave 1 menu              : RS485-A, Adr 5, Poll Time 500 ms
2. Slave 2 menu              : Disabled
3. Slave 3 menu              : Disabled
4. Slave 4 menu              : Disabled
5. Slave 5 menu              : Disabled
```

4.4.1.1 Slave 1-5 menu

A summary for a configured slave, such as port, protocol and configured objects is shown below. It is disabled if the address is set to 0.

```
#################### 4.1.1 Slave 1 menu ####################

1. Port menu                 : RS485-A, 9600 bps, None Parity
2. Adr                       : 5
3. Poll Time                 : 500 ms
4. Digital In menu           : [0]-[1],[9]-[10],
5. Digital Out menu          : [0]-[1],
6. Analogue In menu          : [0]-[1],
7. Analogue Out menu         : [10]-[11],
8. Counters menu             : [20]-[21],
9. Read Exception Status     : Disabled

A. Analogue In Deadband menu
B. Protocol                  : Modbus
```

4.4.1.2 Port menu

Port settings for the external slave.

```
#################### 4.1.0.1 Port menu ####################

1. Port                      : RS485-A
2. COM-port Bitrate          : 9600 bps
3. COM-port Parity           : None
4. Ethernet TCP port-number  : 502
5. Slave IP address          : 10.0.0.5
```

4.4.1.3 Digital Out menu

The RTU 150 supports 6 kinds of Modbus types:

Description	Modbus Object Type	Function Code
Digital Out	Write Single Coil	0x05
Digital Input	Read Discrete Input	0x02
Analogue Out	Write Single Register	0x06
Analogue Input	Read Input Register	0x04
Counters	Read Holding Registers	0x03
Read the contents of eight exception status outputs in a remote device.	Read Exception Status	0x07

In order to activate a slave object, it must be defined for each type. Below is an example for digital outputs with offset 0-3 that are mapped to external Modbus objects 2200-2203. The RTU 150 will report these objects to SCADA as object numbers 100-103 (if using DNP3 or Modbus) or with numbers 1100-1103 (if using IEC60870-5-101 or IEC60870-5-104).

```
####### 4.1.1.5 Digital Out/Write Single Coil menu ########

Offs Obj  SCADA Obj    Offs Obj  SCADA Obj    Offs Obj  SCADA Obj
=== ===== ===========  === ===== ===========  === ===== ===========
00:  2200 100/1100     34: -----              68: -----
01:  2201 101/1101     35: -----              69: -----
02:  2202 102/1102     36: -----              70: -----
03:  2203 103/1103     37: -----              71: -----
04: -----              38: -----              72: -----
05: -----              39: -----              73: -----
06: -----              40: -----              74: -----
07: -----              41: -----              75: -----
08: -----              42: -----              76: -----
09: -----              43: -----              77: -----
10: -----              44: -----              78: -----
11: -----              45: -----              79: -----
12: -----              46: -----              80: -----
13: -----              47: -----              81: -----
14: -----              48: -----              82: -----
15: -----              49: -----              83: -----
16: -----              50: -----              84: -----
17: -----              51: -----              85: -----
18: -----              52: -----              86: -----
19: -----              53: -----              87: -----
20: -----              54: -----              88: -----
21: -----              55: -----              89: -----
22: -----              56: -----              90: -----
23: -----              57: -----              91: -----
```

```
24: -----               58: -----               92: -----
25: -----               59: -----               93: -----
26: -----               60: -----               94: -----
27: -----               61: -----               95: -----
28: -----               62: -----               96: -----
29: -----               63: -----               97: -----
30: -----               64: -----               98: -----
31: -----               65: -----               99: -----
32: -----               66: -----
33: -----               67: -----

SCADA object indicates object address for DNP3,Modbus / IEC101,IEC104


RTU150S> Offset [0-99]: 00
```

4.4.1.4 Analogue In Deadband menu

In order to prevent that too many events are sent to SCADA, dead band may be applied to the external analog inputs. By default, dead band for the external analogs are disabled (set to 0). Below is an example where the dead band for the first analog input is set to 5% (configuration is done in units of 0.01%, i.e. 500 * 0.01 = 5). Five percent of the full positive range (32767) is 1638 units.

```
############ 4.1.1.B Analogue In Deadband menu ############

Offs Deadband      Offs Deadband      Offs Deadband
=== ============   === ============   === ============
00:  500 (±1638)   34: ----           68: ----
01: ----           35: ----           69: ----
02: ----           36: ----           70: ----
03: ----           37: ----           71: ----
04: ----           38: ----           72: ----
05: ----           39: ----           73: ----
06: ----           40: ----           74: ----
07: ----           41: ----           75: ----
08: ----           42: ----           76: ----
09: ----           43: ----           77: ----
10: ----           44: ----           78: ----
11: ----           45: ----           79: ----
12: ----           46: ----           80: ----
13: ----           47: ----           81: ----
14: ----           48: ----           82: ----
15: ----           49: ----           83: ----
16: ----           50: ----           84: ----
17: ----           51: ----           85: ----
18: ----           52: ----           86: ----
19: ----           53: ----           87: ----
20: ----           54: ----           88: ----
21: ----           55: ----           89: ----
22: ----           56: ----           90: ----
23: ----           57: ----           91: ----
24: ----           58: ----           92: ----
25: ----           59: ----           93: ----
26: ----           60: ----           94: ----
27: ----           61: ----           95: ----
28: ----           62: ----           96: ----
29: ----           63: ----           97: ----
30: ----           64: ----           98: ----
31: ----           65: ----           99: ----
32: ----           66: ----
33: ----           67: ----

In units of 0.01% of total range.
Number in brackets show raw value.


RTU150S> Offset [0-99]: 01
```

4.4.1.5 Protocol

RTU 150 supports Modbus or FRE 150 devices. Selection of connected device is done in menu below:

```
############ Select Protocol ############

1 -  Modbus
2 -  FRE150

Selected Protocol: Modbus
```

If protocol FRE 150 is selected, a new menu option "*Set Default FRE150 IO-Map*" will be visible which allow configuring the RTU with a default IO-Map.

```
################### 4.1.1 Slave 1 menu ####################
```

```
1. Port menu                : RS485-B, 9600 bps, None Parity
2. Adr                      : 1
3. Poll Time                : 500 ms
4. Digital In menu          : [0]-[1],
5. Digital Out menu         : [0],
6. Analogue In menu         : [0]-[30],
7. Analogue Out menu        : -
8. Counters menu            : -
9. Read Exception Status    : Disabled

A. Analogue In Deadband menu
B. Protocol                 : FRE150
C. Set Default FRE150 IO-Map
```

4.5 Simulation menu

In order to verify the SCADA communication, simulation may be enabled in order to generate events without the need of external stimuli to the local inputs.

```
#################### 5 Simulation menu ####################

1 - Binary input (toggle)     : Off
2 - Analog input (+1 inc.)    : Off
3 - Update period (x100ms)    : 1
4 - Binary input points       : 0...0
5 - Analog input points       : 0...0
```

For example, as configured below events from binary inputs 3-6 are generated each 5: Th seconds.

```
1. Binary Input (toggle)     : On
2. Analog Input (+1 inc.)    : Off
3. Update Period (x100ms)    : 50
4. Binary Input Points       : 3...6
5. Analog Input Points       : 0...0
```

NOTE! Simulating an input overrides the true input value. Be sure to disable simulation mode after the test is done.

4.6 Port forwarding menu

RTU 150 allows the unused serial ports to be used for port forwarding.

```
################# 6 Port Forwarding menu ##################

1 - RS485-A port bitrate      : Disabled
2 - RS485-B port bitrate      : Disabled
3 - COM2-port  bitrate        : Disabled
4 - COM3-port  bitrate        : Disabled
5 - COM4-port  bitrate        : Disabled
6 - RS485-A port parity       : None
7 - RS485-B port parity       : None
8 - COM2-port  parity         : None
9 - COM3-port  parity         : None
A - COM4-port  parity         : None
```

4.7 Network Tools menu

It is possible to enable Telnet, FTP and SNMP in the RTU 150. They are disabled at default. Username and password can be changed (for Telnet/FTP).

```
################## 7 Network tools menu ###################

1 - Telnet enabled            : ON
2 - FTP enabled               : OFF
3 - SNMP v1 enabled           : ON
4 - SNMP client IP            : 10.0.0.100
5 - User name                 : sysadm
6 - Password                  : plexus
7 - RTU 150S IP               : 10.0.0.2
8 - RTU 150S netmask          : 255.255.255.0
9 - RTU 150S gateway          : 10.0.0.100
A - SCADA IP                  : 192.168.1.150
B - Ping SCADA IP
```

The parameters IP, netmask and gateway are not stored in the configuration file; they are stored in the boot parameters area (resident in flash).

4.8 List Settings

This menu option may be used to display a summary of the current RTU 150 settings.

```
###################### List Settings ######################

File comments         : RTU150S v1.4.2
Protocol              : IEC60870-5-104
Scada port            : Ethernet, SCADA Client, port 2404
Scada IP address      : 10.0.0.100
Command Output mode   : Normal

Scada TCP port        : 2404
IEC104 link address   : 1
IEC104 asdu address   : 3
IEC104 off poll period: 30
IEC104 t1 ack period  : 15
IEC104 t2 frame period: 10
IEC104 t3 test period : 20
IEC104 w value        : 8
IEC104 k value        : 12
Chatter interval      : 3
Chatter threshold     : 10
Periodic AI report    : 0

Chatter ctrl. enabled : Off
Telnet enabled        : Off
Ftp enabled           : On
SNMP v1 enabled       : Off
Nw username           : sysadm
Nw passwd             : plexus
EXT[0].adr            : 1
EXT[0].protocol       : Modbus
EXT[0].port           : RS485-B, 9600 bps, None Parity
EXT[0].poll           : 500
EXT[0].din            : [0]-[4],
EXT[0].dout           : [0]-[3],
EXT[0].ain            : [0]-[4],
EXT[0].aout           : [0]-[3],
EXT[0].cnt            : [0]-[3],

     ----- Digital In ----  - DOut -  -------------- Analog In --------------
 Ch.   On  Off Dbl Inv Cnt  Time Dbl  Deadb Sampl Range MeanTime Offset Scale

 #01:  20   20  on off off   100  on      1    10     0      600 +00000 1.00000
 #02:  20   20  on off off   100  on      5    10     0      600 +00000 1.00000
 #03:  20   20 off off off   100 off     10    10     0      600 +00000 1.00000
 #04:  20   20 off off off   100 off     20    10     0      600 +00000 1.00000
 #05:  20   20 off off off   100 off      5     1     0      600 +00000 1.00000
 #06:  20   20 off off off   100 off      5    10     0      600 +00000 1.00000
 #07:  20   20 off off off   100 off      5   100     0      600 -01000 1.00000
 #08:  20   20 off off off   100 off      5    10     0      600 +01000 1.00000
 #09:  20   20 off off off   100 off
 #10:  20   20 off off off   100 off
 #11:  20   20 off off off   100 off
 #12:  20   20 off off off   100 off
 #13:  20   20 off off off   100 off
 #14:  20   20 off off off   100 off
 #15:  20   20 off off off
 #16:  20   20 off off off
 #17:  20   20 off off off
 #18:  20   20 off off off
```

4.9 Backup Settings

This menu option may be used to backup current RTU settings into a file and store the file on a PC. The backup format is ASCII and may be saved as a text file (.txt) on the PC.

```
B - Backup Settings
R - Restore Settings from Backup

D - Restore Settings to Default

E - Exit without saving
S - Save changes and restart system

To export settings to file, use the terminal program's 'Capture/Log text file' option.
Press any key when ready...
```

The content of the backup file starts with a summary of the RTU configuration and then plain Intel-hex format for all the parameters. Lines that does not start with colon (ASCII code 58) are treated as comments.

Note that RTU 150 has support for a SD card which may be used for exporting the RTU 150 configuration file. The procedures for exporting to SD card are following:

- Make sure the SD card is formatted in FAT16.
- Power off the RTU
- Insert the SD card
- Power on the RTU.
- Use menu option "*Save changes and restart system*". The parameter file is now copied to the SD card.
- Pull out the SD card and the export is finished. The backup file name on the SD card is "RTUCONF.HEX"

4.10 Restore Settings from Backup

This menu option may be used to restore RTU settings from a backup file. If using TeraTerm terminal program, sending a file is done by selecting menu option *File->Send File* or copy all text in the backup file and use *Edit->Paste*.

```
B - Backup Settings
R - Restore Settings from Backup

D - Restore Settings to Default

E - Exit without saving
S - Save changes and restart system

Are you sure to "Restore Settings from Backup" (Y/N) ? : y
Start sending the file now...
```

If the file is sent properly and the file is correct, following may be displayed:

```
File "RTUCONF.HEX" is now updated in RAM (51889 bytes).

Verifying configuration file

Configuration file imported successfully!

Press any key to continue...
```

Note that RTU 150 has support for a SD card which may be used for importing the RTU 150 configuration file. The procedures for importing to SD card are following:

- Make sure the SD card is formatted in FAT16.
- Copy the backup file "RTUCONF.HEX" to the SD card, using a PC.
- Power off the RTU
- Insert the card
- Power on the RTU.
- When the RTU is starting up, it will copy the new parameter file from the SD card and save it into non-volatile memory.
- When the RTU has started, pull out the SD card and the import is finished.

4.11 Restore Settings to Default

This menu option will, after confirmation, set all RTU 150 parameters to default.

```
B - Backup Settings
R - Restore Settings from Backup

D - Restore Settings to Default

E - Exit without saving
S - Save changes and restart system

All user settings will be lost!
Continue ? (Y/N)
```

4.12 Exit without saving

This menu option discards the user settings and restores the configuration that was loaded before the MMI was entered. The RTU will continue without a restart.

```
Are you sure to "Exit without saving"? (Y/N)
```

4.13 Save changes and restart system

This menu option saves the user settings and restarts the RTU. The setting is also saved on the SD card (if present).

```
Are you sure to "Save changes and restart system"? (Y/N)
```

5. Functions

5.1 SCADA LEDs

The blue and the white LED (on the left side on the power connector) are used for indicating useful RTU status.

Immediately when the RTU is powered on, the blue LED will be power on with a steady light, and the RTU software application begins to load. When the RTU software application has read the configuration file and is ready for SCADA connection, the RTU loudspeaker will beep twice and the blue LED alter functionality and now show SCADA connection status, as shown in picture below.

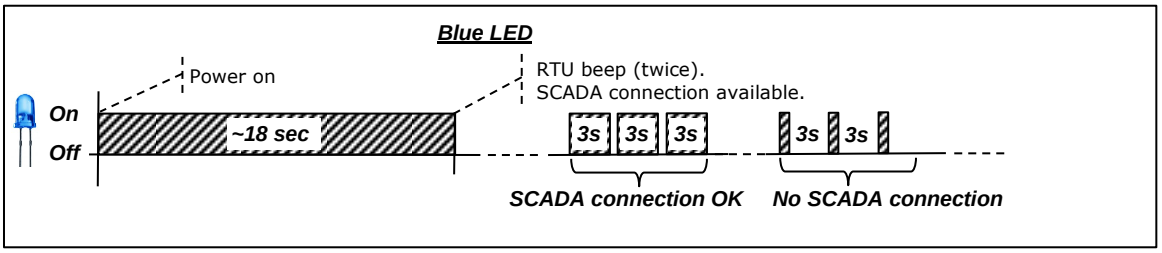


Figure 7. Blue LED indication

The white LED indicates whether the date and time in the RTU is synchronized by SCADA. The date and time shall be updated from SCADA in a regular interval using a clock synchronization message. The RTU clock normally needs to be updated once or twice per day, at least.

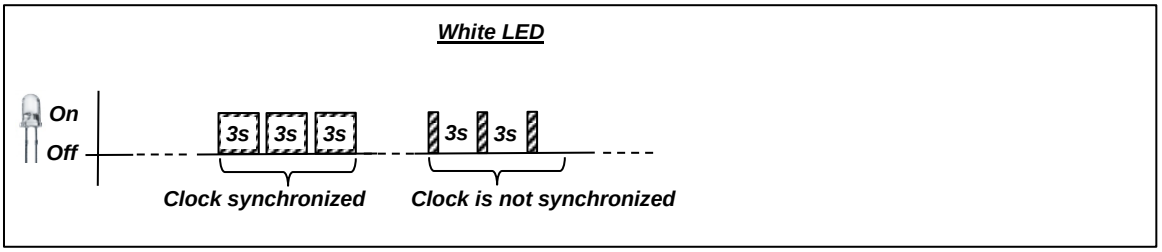


Figure 8. White LED indication

5.2 In- and outputs

5.2.1 Digital Inputs

RTU 150 has 18 digital inputs. All inputs are map able to different DNP3 or IEC870 points. (Allocate for 1000 inputs in further use via distributed IO: s.)

5.2.1.1 Input 1-18

Digital inputs are separated in three groups with 6 inputs and one common in each group. They have an input range from 9-70V DC and an input impedance of 10kohm. The trip level is approximately 7V DC.

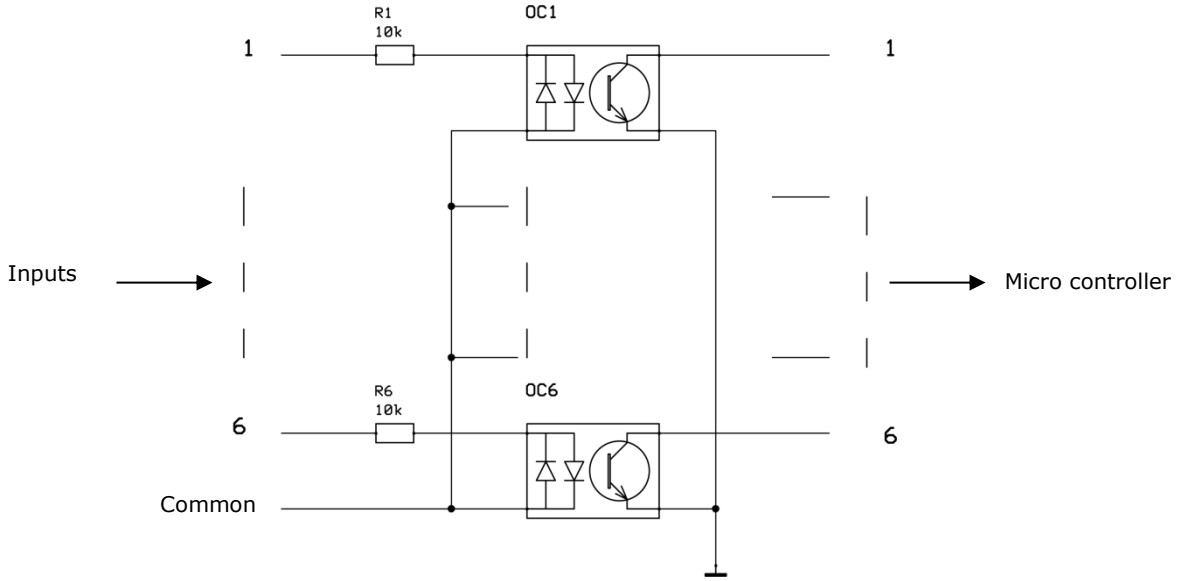


Figure 9. Digital inputs 1-6 x 3

5.2.2 Digital Outputs

The digital output is divided into two groups. Output 1-10 has one common relay to enable the output. In this way "select before execute" functionality can be realized in software. Output 11-14 has one common reference. Summary of relay contact rating:

Relay	Current	Voltage	Power	Isolation
1-10	2A	125VAC, 60VDC	62,5VA, 30W	1,5kV
11-14 and Execute	3A	250VAC, 220VDC	50VA, 60W	1,5kV

5.2.2.1 Output 1-10

The digital outputs 1-10 on RTU 150 are designed as 5 command pairs with the possibility to use SBE-mode (Select Before Execute) but they can also work as 10 separate outputs in normal mode.

In order to activate an output when using the SBE mode, SCADA first needs to send a select message which activates the physical select relay. Immediately after the first message, SCADA needs to send the execute message which activates the second execute relay. These two messages have to be sent within 5 seconds, otherwise the command is rejected.

5.2.2.2 Output 11-14

Output 11-14 operates in normal mode.

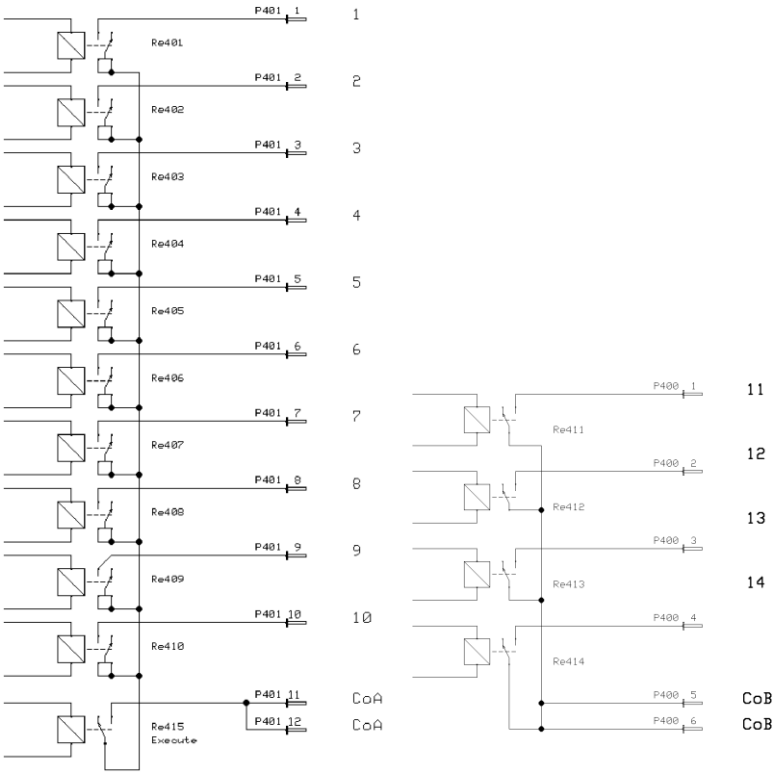


Figure 10. Outputs 1-10 SBE type, Output 11-14 normal type

5.2.2.3 Connection of inductive loads to digital outputs

Outputs can be connected to AC or DC supplies. Due to the wide range of voltages and polarities it is not possible to handle overvoltage protection inside the RTU. Normal types of protection for inductive loads and overvoltage protection has to be connected to the load. Preferably the overvoltage protection should be connected as close as possible to the load that causes the overvoltage. Recommended types are diodes for DC loads and varistors for AC loads.

5.2.3 Analogue Inputs

Following ranges are available for the analogue inputs: ±5V, ±10V, 0-10V, 0-20mA, ±5V AC and ±10V AC. If current measurement is selected (0-20mA), the DIP switch on the RTU front panel has to be set in ON position. Setting the DIP switch in ON position connects a 200 ohm resistor in parallel to the analogue input. The resistor can maximum handle 1W, any higher power will damage the resistor.

The RTU 150 send the analogue values to SCADA as signed 16-bit values where the highest bit (bit 16) indicates the sign. The hexadecimal value 0x7FFF (32767) means the maximum positive value for the selected range, and 0x8000 means the maximum negative value for the selected range. Note that following ranges do not allow negative values; 0-10V, 0-20mA, ±5V AC and ±10V AC (see table below).

	16-bit signed data		
Range	**0xFFFF**	**0x0000**	**0x7FFF**
±5V	-5V	0V	+5V
±10V	-10V	0V	+10V
0-10V	Not applicable	0V	+10V
0-20mA	Not applicable	0mA	20mA
±10V AC	Not applicable	0VAC	10VAC
±5V AC	Not applicable	0VAC	5VAC

5.2.3.1 Dead band

A dead band monitoring function may be enabled in order to reduce the number of analogue events sent to SCADA. When the analogue level is outside the dead band, the new value is sent to SCADA and a new dead band is calculated. The dead band may be configured from 1-50% of the measuring range.

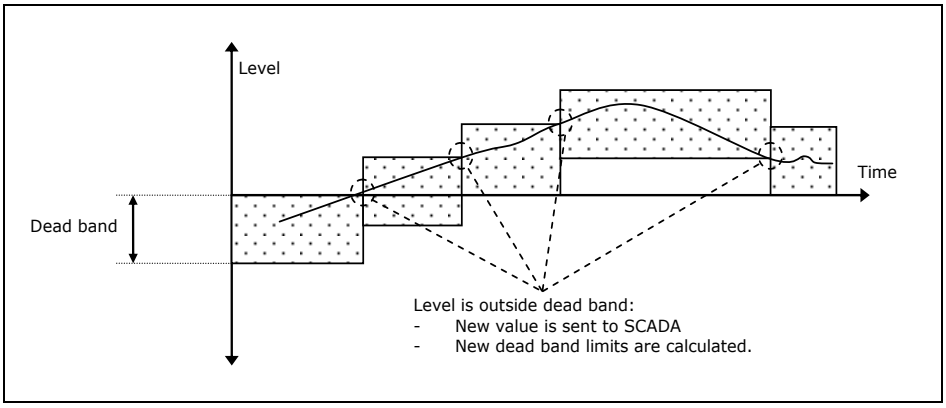


Figure 11. Dead band monitoring

5.2.3.2 AC Measurement

The RTU 150 can measure AC RMS voltage (aimed for a 50/60Hz signal). Available input ranges are –5V to +5V and –10V to +10V, peak to peak. When AC calculation is about to be done, a burst of 30 samples are taken (1 sample/1 ms) and then RMS calculation is performed. The interval when the burst of AC samples are taken is specified by the parameter *sample rate*.

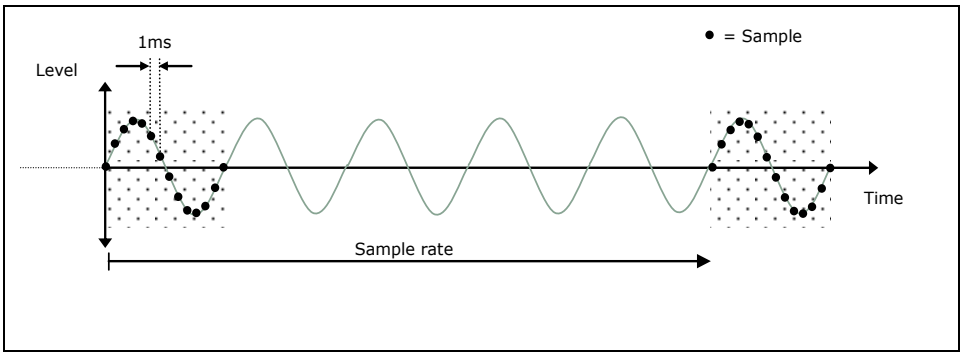


Figure 12. AC Measurement

Formula for calculating RMS value:

RMS= $\sqrt{\frac{S_1^2+S_2^2+S_3^2+\cdots+S_{30}^2}{30}}$ where S_n is the samples

5.2.3.3 Mean Value Calculation

The RTU 150 provides a feature to calculate a mean value for each analogue input channel. Mean value calculation provide a more accurate presentation of the true input value, since the ordinary analogue value may be limited by the dead band (see picture below). The mean value update time can be configured from 1-65535 seconds. If, for instance the time is configured to 600 seconds, it means that each 10 minute a mean value is reported to SCADA (if the new value is different than previous reported value).

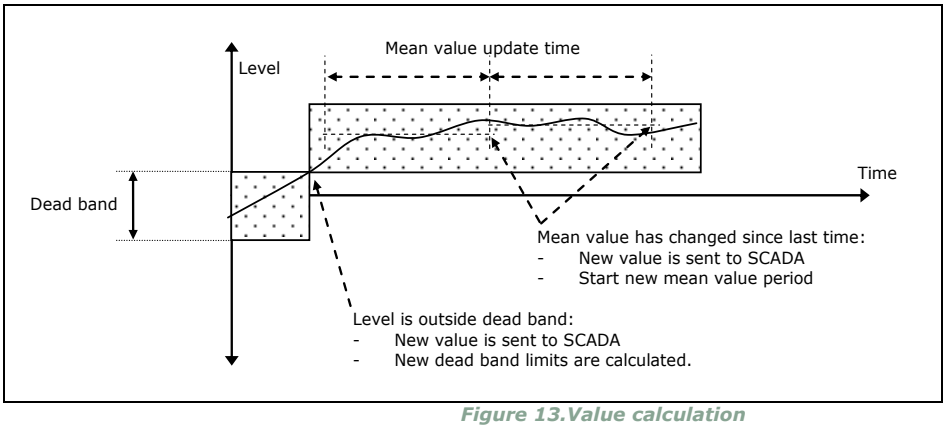


Figure 13.Value calculation

5.3 Port Forwarding

The RTU 150 has 3 RS232 ports (COM2, COM3 and COM4) and 2 RS485 ports available for data traffic. One of them is aimed for the SCADA traffic, but the other ones can be used for port forwarding. With help of this feature one channel to SCADA can be used for more than one RTU.
Everything that is received on the SCADA port is copied to the port forwarding ports. Regardless of what data that is received on the SCADA port there is no decoding of the messages, it is copied to the port forwarding ports (even if the message was aimed for master RTU or not), see figure below.

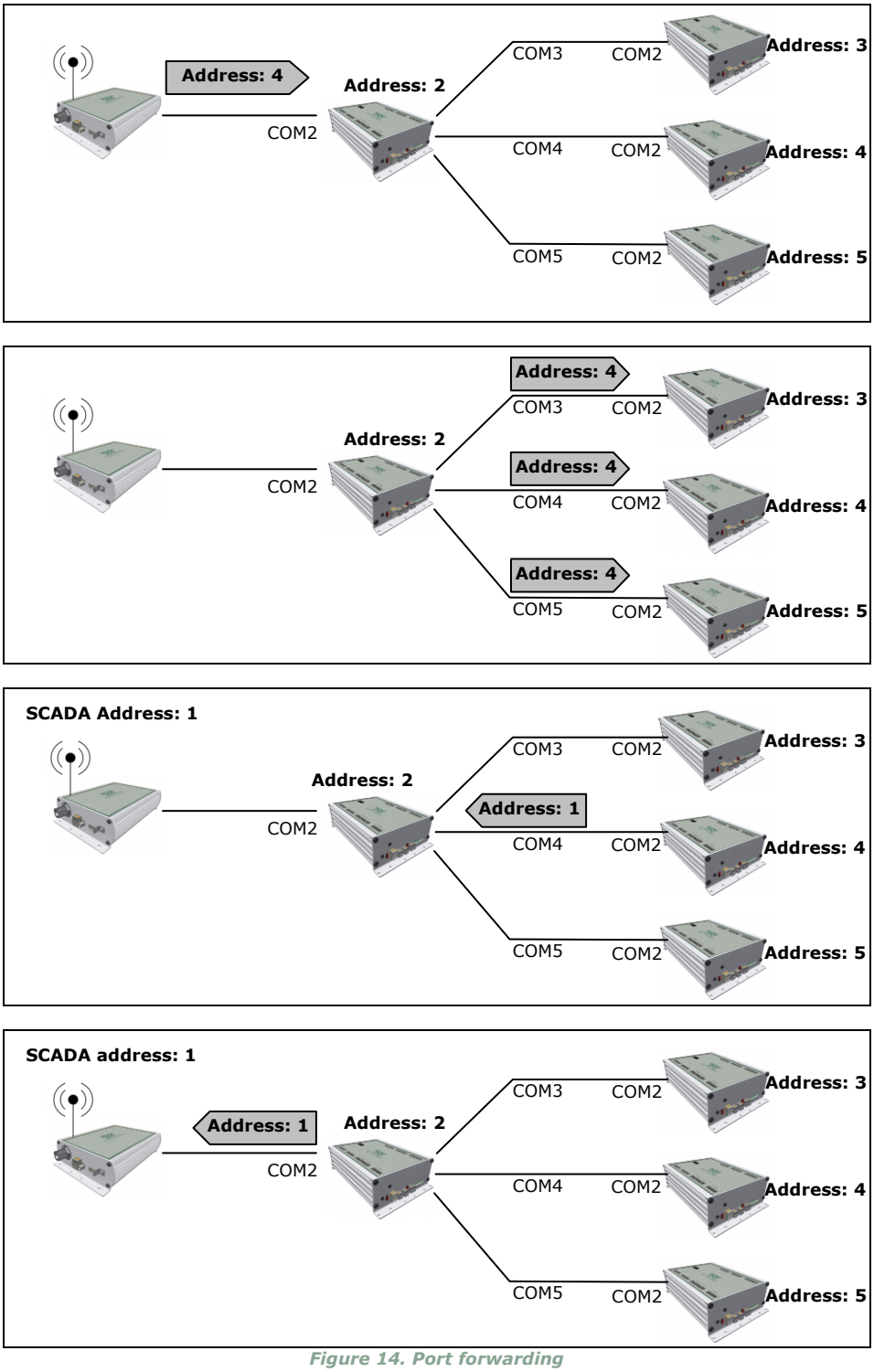


Figure 14. Port forwarding

5.4 External I/O

The RTU 150 supports external I/O cards using the Modbus RTU protocol or the FRE 150 device. The RTU 150 is able of polling up to 5 slaves using any of the available ports (RS485-A/B, COM2-4). Below is a summary of available objects per external device.

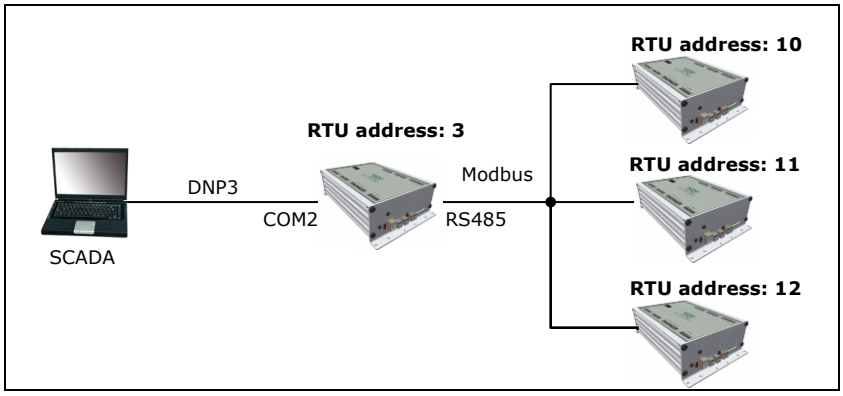
Modbus

Type	Maximum number of objects	Function Code
Read Discrete Inputs (Digital Inputs) Read Exception Status	100	0x02 0x07
Read Input Registers (Analogue Inputs)	100	0x04
Read Holding Registers (Counters)	100	0x03
Write Single Coil (Binary Outputs)	100	0x05
Write Single register (Analogue Outputs)	100	0x06

FRE150

Type	Maximum number of objects	Comment
Digital Inputs	2	Earth fault indication Over current indication
Analogue Inputs	31	L1-L3 measurements
Binary Outputs	1	Reset earth fault or over current alarm

Below is an example, of polling 3 devices.



5.5 Network Tools

5.5.1 Telnet

The RTU is normally configured using a serial cable (RS232) connected to COM1 port. The RTU then provides a menu system for changing the RTU parameters. The same functionality is provided by the telnet protocol (TCP port 23), which allow the RTU to be configured remotely. In order to prevent unauthorized connections, a username and password must be entered (which are configurable).

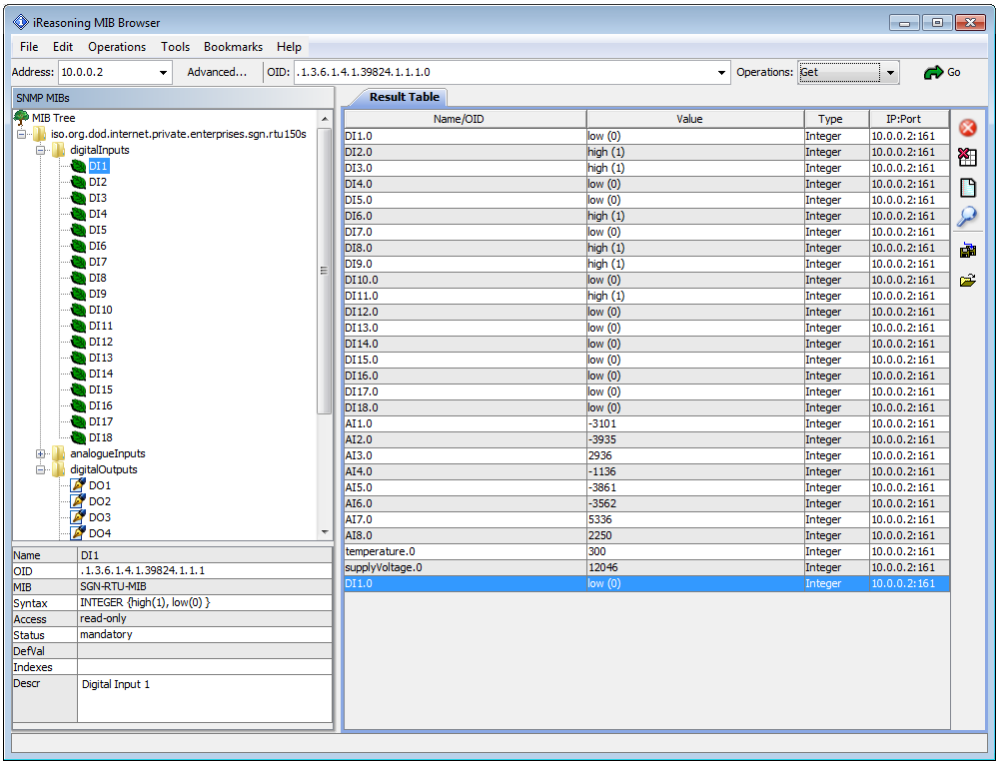
5.5.2 FTP

FTP is a file transfer service which use TCP ports 21 (commands) and 20 (data). Apart from the mandatory FTP commands, the RTU has 3 custom commands which are described in table below:

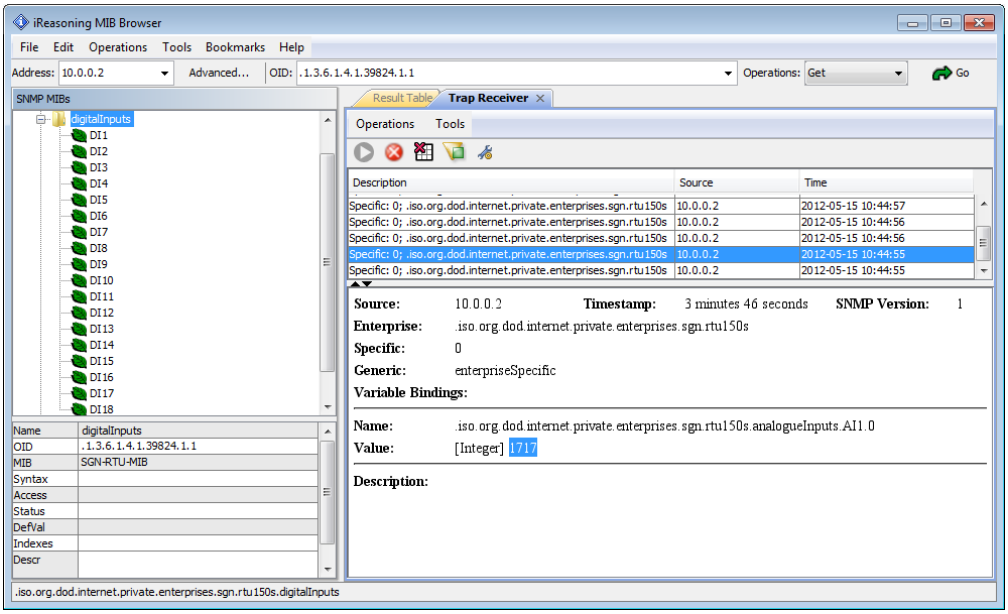
Command	Description	Example
quote SYNC	The file system is resident in the volatile RAM memory area. If a modification is done to the file system and it shall be permanent it has to be saved into the non-volatile flash memory.	ftp> **quote SYNC** 200 Command okay ftp>
quote RST	Reset the RTU 150	ftp> **quote RST** 200 Command okay Connection closed by remote host. ftp>
quote UPGR	The RTU 150 software may be upgraded by using FTP.	ftp> **open 10.0.0.2** Connected to 10.0.0.2. 220 RTU 150S v1.0.0 RC1 Service Ready User (10.0.0.2:(none)): 331 User name okay, need password. 230 User logged in, proceed. ftp> **put appl.bin** 200 Command okay 150 File status okay, about to open data connection. 226 Closing data connection. Requested file action successful. ftp: 297903 bytes sent in 1,43Seconds 209,05Kbytes/sec. ftp> **quote UPGR** 200 Command okay ftp> **quote RST** 200 Command okay Connection closed by remote host. ftp>

5.5.3 SNMP

Simple Network Management Protocol (SNMP) is an "Internet-standard protocol for managing devices on IP networks. SNMP is mostly used in network management systems to monitor network-attached devices for conditions that warrant administrative attention.
RTU 150 supports following SNMP v1 messages: GET, GET-NEXT, SET and Trap messages (Asynchronous notifications from agent to manager using UDP port 162).
The configuration of the SNMP objects for the RTU 150 is based on a MIB file (Management information base). The unique MIB file for RTU 150 can be achieved upon request to Smart Grid Networks. Below is an example of a SNMP MIB browser which gives access to all RTU 150 objects (digital inputs/outputs and analogue inputs) using UDP port 161:



All I/O events that happen in the RTU are sent as trap message, see example below.



5.6 Event/Trace logging

Trace and event information is visible to the user without interference to the normal RTU 150 operation. Available options may be displayed by pressing key '*' when connected to the CONFIG port (57600-8-N-1). Depending on the selected SCADA protocol, different options may be shown. Below is an example of available options:

```
############################################################
                      RTU 150S

Copyright Smart Grid Networks

Software: RTU 150S v1.0.0 RC1 Build May 10 2012

Article No   Softw Id   Hardw Id  HardwRev  CRC
1782001-3    0xAA       0x41      0x01      0x2394

Date         Time       Temperature         Supply Voltage
12-05-15     10:55:27   30.0 C              12.04 V

                Based on FreeRTOS.org
############################################################

################### Diagnostic Options ####################


S -  Show historical events
D -  Delete historical events

I -  Enable/disable digital input trace
O -  Enable/disable digital output trace
A -  Enable/disable analogue input trace
L -  Enable/disable local i/o debug trace
M -  Enable/disable modbus master debug trace

1 -  Enable/disable IEC870 link trace
2 -  Enable/disable IEC870 queue trace
3 -  Enable/disable IEC870 frame trace
4 -  Enable/disable IEC870 error trace
```

5.7 SCADA Object Mapping

Below is a summary of all SCADA objects for the supported protocols.

5.7.1 Digital Inputs / Read Discrete Inputs / Single Points

Object	DNP3 / Modbus	IEC60870-5-101/104
Local DI1-DI18	1-18	1-18
External slave 1 DI0-DI99	100-199	100-199
External slave 2 DI0-DI99	200-299	200-299
External slave 3 DI0-DI99	300-399	300-399
External slave 4 DI0-DI99	400-499	400-499
External slave 5 DI0-DI99	500-599	500-599

5.7.2 Digital Outputs / Write Single Coils / Single Commands

Object	DNP3 / Modbus	IEC60870-5-101/104
Local DO1-DO14	0-13	1000-1013
External slave 1 DO0-DO99	100-199	1100-1199
External slave 2 DO0-DO99	200-299	1200-1299
External slave 3 DO0-DO99	300-399	1300-1399
External slave 4 DO0-DO99	400-499	1400-1499
External slave 5 DO0-DO99	500-599	1500-1599

5.7.3 Analogue Inputs / Read Input Registers / Measured Values

Object	DNP3 / Modbus	IEC60870-5-101/104
Local AI1-AI8	0-7	2000-2007
Local AI1-AI8 mean value	8-15	2008-2015
Hardware number	17	2017
Software number	18	2018
Software version/revision	19	2019
Temperature (in tenth of degrees Celsius)	20	2020
Power supply voltage (mV)	21	2021
External slave 1 AI0-AI99	100-199	2100-2199
External slave 2 AI0-AI99	200-299	2200-2299
External slave 3 AI0-AI99	300-399	2300-2399
External slave 4 AI0-AI99	400-499	2400-2499
External slave 5 AI0-AI99	500-599	2500-2599

5.7.4 Analogue Outputs / Force Single Register / Set Point Commands

Object	DNP3 / Modbus	IEC60870-5-101/104
External slave 1 AO0-AO99	100-199	3100-3199
External slave 2 AO0-AO99	200-299	3200-3299
External slave 3 AO0-AO99	300-399	3300-3399
External slave 4 AO0-AO99	400-499	3400-3499
External slave 5 AO0-AO99	500-599	3500-3599

5.7.5 Counters / Read Holding Registers / Integrated Totals

Object	DNP3 / Modbus	IEC60870-5-101/104
Local DI1-DI18	1-18	4000-4018
External slave 1 CNT0-CNT99	100-199	4100-4199
External slave 2 CNT0-CNT99	200-299	4200-4299
External slave 3 CNT0-CNT99	300-399	4300-4399
External slave 4 CNT0-CNT99	400-499	4400-4499
External slave 5 CNT0-CNT99	500-599	4500-4599

5.7.6 Double Indications

Object	DNP3 / Modbus	IEC60870-5-101/104
Local DI1/DI2	-	5000
Local DI3/DI4	-	5001
Local DI5/DI6	-	5002
Local DI7/DI8	-	5003
Local DI9/DI10	-	5004
Local DI11/DI12	-	5005
Local DI13/DI14	-	5006
Local DI15/DI16	-	5007
Local DI17/DI18	-	5008

5.7.7 Double Commands

Object	DNP3 / Modbus	IEC60870-5-101/104
Local DO1/DO2	-	6000
Local DO3/DO4	-	6001
Local DO5/DO6	-	6002
Local DO7/DO8	-	6003
Local DO9/DO10	-	6004
Local DO11/DO12	-	6005
Local DO13/DO14	-	6006

6. SCADA Protocol Interoperability

6.1 DNP 3.0 Device Profile

<table>
<tr><td colspan="2">DNP 3.0 DEVICE PROFILE</td></tr>
<tr><td colspan="2">Vendor Name: Smart Grid Networks</td></tr>
<tr><td colspan="2">Device Name: RTU 150</td></tr>
<tr><td>Highest DNP Level Supported:

For Requests: Level 3
For Responses: Level 3</td><td>Device Function:

☐ Master
☒ Slave</td></tr>
<tr><td colspan="2">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):
For static (non-change-event) object requests, request qualifier codes 00 and 01 (start-stop), 07 and 08 (limited quantity), and 17 and 28 (index) are supported in addition to request qualifier code 06 (no range – or all points).
Static object requests received with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Static object requests received with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event object requests, qualifiers 17 or 28 are always responded.
16-bit and 32-bit Analog Change Events with Time may be requested.
The read function code for Object 50 (Time and Date), variation 1, is supported.</td></tr>
<tr><td>Maximum Data Link Frame Size (octets):
Transmitted: 292
Received 292</td><td>Maximum Application Fragment Size (octets):
Transmitted: 2048
Received: 2048</td></tr>
<tr><td>Maximum Data Link Re-tries:
☐ None
☐ Fixed at _____
☒ Configurable from 0 to 32767, LinkMaxRetries</td><td>Maximum Application Layer Re-tries:
☒ None
☐ Configurable</td></tr>
<tr><td colspan="2">Requires Data Link Layer Confirmation:
☐ Never
☐ Always
☐ Sometimes
☒ Configurable as: Never, Only for multi-frame messages (Sometimes), or Always.</td></tr>
<tr><td colspan="2">Requires Application Layer Confirmation:
☐ Never
☐ Always
☒ When reporting Event Data
☒ When sending multi-fragment responses
☐ Sometimes
☐ Configurable</td></tr>
</table>

DNP 3.0 DEVICE PROFILE

Timeouts while waiting for:

Data Link Confirm:	☐ None ☐ Fixed at ____ ☐ Variable ☒ Configurable
Transmission Delay:	☐ None ☒ Fixed at 0 ☐ Variable ☐ Configurable
Inter-character Timeout:	☐ None ☒ Fixed at 1500 ☐ Variable ☐ Configurable
Need Time Delay:	☐ None ☒ Fixed at 0.5h ☐ Variable ☐ Configurable
Select/OperateArmTimeout:	☐ None ☒ Fixed at 5000 ☐ Variable ☐ Configurable
Unsolicited response notification delay:	☐ None ☒ Fixed at 0 ☐ Variable ☐ Configurable
Unsolicited response retry delay:	☐ None ☒ Fixed at 0 ☐ Variable ☐ Configurable

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
Paired Trip	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Paired Close	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable

Reports Binary Input Change Events when no specific variation requested:
- ☐ Never
- ☒ Only time-tagged
- ☐ Only non-time-tagged
- ☐ Configurable

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 (attach explanation)

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.

Default Counter Object/Variation:
- ☐ No Counters Reported
- ☐ Configurable (attach explanation)
- ☒ Default Object: 20
  Default Variation: 6
- ☒ 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

6.2 IEC60870-5-101

6.2.1 Network Configuration

(network-specific parameter)
[x] Point-to-point
[x] Multiple point-to point
[x] Multipoint-party line
[x] Multipoint-star

6.2.2 Physical Layer

(network-specific parameter)
Transmission speed (control direction)

Unbalance interchange Circuit V.24 / V.28 Standard	Unbalanced interchange Circuit V.24 / V.28 Recommended if>1200 bit/s	Balanced interchange Circuit X.24 / X.27
[ ] 100 bit/s	[x] 4800 bit/s	[ ] 100 bit/s [x] 4800 bit/s
[ ] 200 bit/s	[x] 9600 bit/s	[ ] 200 bit/s [x] 9600 bit/s
[x] 300 bit/s	[x] 19200 bit/s	[x] 300 bit/s [x] 192000 bit/s
[x] 600 bit/s	[x] 38400 bit/s	[x] 600 bit/s [x] 38400 bit/s
[x] 1200 bit/s	[x] 57600 bit/s	[x] 1200 bit/s [x] 57600 bit/s
[x] 2400 bit/s	[x] 115200 bit/s	[x] 2400 bit/s [x] 115200 bit/s

Transmission speed (monitor direction)

Unbalance interchange Circuit V.24 / V.28 Standard	Unbalanced interchange Circuit V.24 / V.28 Recommended if>1200 bit/s	Balanced interchange Circuit X.24 / X.27
[ ] 100 bit/s	[x] 4800 bit/s	[ ] 100 bit/s [x] 4800 bit/s
[ ] 200 bit/s	[x] 9600 bit/s	[ ] 200 bit/s [x] 9600 bit/s
[x] 300 bit/s	[x] 19200 bit/s	[x] 300 bit/s [x] 192000 bit/s
[x] 600 bit/s	[x] 38400 bit/s	[x] 600 bit/s [x] 38400 bit/s
[x] 1200 bit/s	[x] 57600 bit/s	[x] 1200 bit/s [x] 57600 bit/s
[x] 2400 bit/s [x]	115200 bit/s	[x] 2400 bit/s [x] 115200 bit/s

6.2.3 Link Layer

(network-specific parameter)
Frame format FT1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure
[x] Balanced transmission
[x] Unbalanced transmission

Frame length
255 Maximum length L (number of octets)

Address field of the link
[ ] Not present (balanced transmission only)
[x] One octet
[x] Two octets
[ ] Structured
[x] Unstructured

6.2.4 Application Layer

Transmission mode of application data
Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC/870-5-4, is used exclusively in this companion standard.

Common address of ASDU
[x] One octet
[x] Two octets
Information object address
[x] 1 octet
[x] 2 octets
[x] 3 octets
[ ] Structured
[x] Unstructured

Cause of transmission
[x] One octet
[x] Two octets (with originator address)

Selection of standard ASDUs
Process information in monitor direction

[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

[ ]	<5> := Step position information	M_ST_NA_1
[ ]	<6> := Step position information with time tag	M_ST_TA_1
[ ]	<7> := Bit string of 32 bit	M_BO_NA_1
[ ]	<8> := Bit string of 32 bit with time tag	M_BO_TA_1
[ ]	<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
[ ]	<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_IN_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 info of protection equip. with time tag	M_EP_TC_1
[ ]	<20> := Packed single-point information with status change detection	M_PS_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
[ ]	<33> := Bit string 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
[ ]	<36> := Measured value, short floating value with time tag CP56Time2a	M_ME_TF_1
[ ]	<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 prot. Equipment w. time tag CP56Time2a	M_EP_TE_1
[ ]	<40> := Event output circuit info of prot. Equip w. time tag CP56Time2a	M_EP_TF_1

Process information in control direction (station-specific parameter)

[x]	<45> := Single command	C_SC_NA_1
[x]	<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
[ ]	<50> := Set point command, short floating point value	C_SE_NC_1
[ ]	<51> := Bit string of 32 bit	C_BO_NA_1

System information in monitor direction (station-specific parameter)

[x]	<70> := End of initialisation	M_EI_NA_1

System information in control direction (station-specific parameter)

[x]	<100> := Interrogation command	C_IC_NA_1
[x]	<101> := Counter interrogation command	C_CI_NA_1
[x]	<102> := Read command (as slave only)	C_RD_NA_1
[x]	<103> := Clock synchronization command	C_CS_NA_1
[x]	<104> := Test command (as slave only)	C_TS_NB_1
[x]	<105> := Reset process command	C_RP_NC_1
[ ]	<106> := Delay acquisition command	C_CD_NA_1

Parameter in control direction (station-specific parameter)

[ ]	<110> := Parameter of measured value, normalized value	P_ME_NA_1
[ ]	<111> := Parameter of measured value, scaled value	P_ME_NB_1
[ ]	<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)

[ ]	<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	F_DR_TA_1

6.2.5 Basic Application Function

Station initialisation (station-specific parameter)
[x] Remote initialisation
General interrogation (system- or station-specific parameter)
[x] Global
[x] Group 1 [ ] Group 7 [ ] Group 13

[x] Group 2 [ ] Group 8 [ ] Group 14
[ ] Group 3 [ ] Group 9 [ ] Group 15
[x] Group 4 [ ] Group 10 [ ] Group 16
[ ] Group 5 [ ] Group 11
[ ] Group 6 [ ] Group 12

Clock synchronization (station-specific parameter)
[x] Clock synchronization
[ ] Day of week used
[ ] RES1, GEN (time tag substituted/ not substituted) used
[ ] SU-bit (summer time) used

Reset Process
The unit will perform a software restart upon reception of a successful "Reset Process" command.

Command transmission (object-specific parameter)
[x] Direct command transmission
[x] Direct set point command transmission
[x] Select and execute command
[x] Select and execute set point command
[ ] C_SE ACTTERM used
[x] No additional definition
[x] Short pulse duration (duration determined by a system parameter in the outstation)
[x] Long pulse duration (duration determined by a system parameter in the outstation)
[x] Persistent output

Transmission of integrated totals (station- or object-specific parameter)
[x] Counter request
[x] Counter freeze without reset
[ ] Counter freeze with reset
[ ] Counter reset
[x] General request counter
[x] Request counter group 1
[ ] Request counter group 2
[ ] Request counter group 3
[ ] Request counter group 4

Parameter loading (object-specific parameter)
[ ] Threshold value
[ ] Smoothing factor
[ ] Low limit for transmission of measured value
[ ] High-limit for transmission of measured value

Parameter activation (object-specific parameter)
[ ] Act/deact of persistent cyclic or periodic transmission of the addressed object
File transfer (station-specific parameter)
[ ] File transfer in monitor direction
[ ] File transfer in control direction

6.3 IEC 870-5-104

6.3.1 System or Device

[x] System Definition
[ ] Controlling station Definition
[ ] Controlled station Definition

6.3.2 PHYSICAL LAYER

This section is not applicable to 870-5-104.

6.3.3 LINK LAYER

This section is not applicable to 870-5-104.

6.3.4 APPLICATION LAYER

Transmission mode of application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC/870-5-4, is used exclusively in this companion standard.

Common address of ASDU (system-specific parameter)

[ ] One octet [x] Two octets

Information object address (system-specific parameter)

[ ] 1 octet [x] Structured
[ ] 2 octets [x] Unstructured
[x] 3 octets

Cause of transmission (system-specific parameter)

[ ] One octet [x] Two octets (with originator address)

Selection of standard ASDUs

Process information in monitor direction (station-specific parameter)

[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
[ ]	<5> := Step position information		M_ST_NA_1
[ ]	<6> := Step position information with time tag		M_ST_TA_1
[ ]	<7> := Bitstring of 32 bit		M_BO_NA_1
[ ]	<8> := Bitstring of 32 bit with time tag		M_BO_TA_1
[ ]	<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
[ ]	<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_IN_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 info of protection equip. with time tag		M_EP_TC_1
[ ]	<20> := Packed single-point information with status change detection	M_PS_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
[ ]	<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
[ ]	<36> := Measured value, short floating value with time tag CP56Time2a		M_ME_TF_1

[ ]	<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 with time tag CP56Time2a	M_EP_TF_1

Process information in control direction **(station-specific parameter)**

[ ]	<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
[ ]	<50> := Set point command, short floating point value	C_SE_NC_1
[ ]	<51> := Bitstring of 32 bit	C_BO_NA_1
[x]	<58> := Single command with time tag CP56Time2a	C_SC_TA_1
[x]	<59> := Double command with time tag CP56Time2a	C_DC_TA_1
[ ]	<60> := Regulating step command with time tag CP56Time2a	C_RC_TA_1
[ ]	<61> := Set point command, normalized value with time tag CP56Time2a	C_SE_TA_1
[ ]	<62> := Set point command, scaled value with time tag CP56Time2a	C_SE_TB_1
[ ]	<63> := Set point command, short floating point value with time tag CP56Time2a	C_SE_TC_1
[ ]	<64> := Bitstring of 32 bit with time tag CP56Time2a	C_BO_TA_1

System information in monitor direction (station-specific parameter)

[x]	<70> := End of initialization	M_EI_NA_1

System information in control direction (station-specific parameter)

[x]	<100> := Interrogation command	C_IC_NA_1
[x]	<101> := Counter interrogation command	C_CI_NA_1
[x]	<102> := Read command (as slave only)	C_RD_NA_1
[x]	<103> := Clock synchronization command	C_CS_NA_1
[x]	<104> := Test command (as slave only)	C_TS_NB_1
[x]	<105> := Reset process command	C_RP_NC_1
[ ]	<106> := Delay acquisition command	C_CD_NA_1

Parameter in control direction (station-specific parameter)

[ ]	<110> := Parameter of measured value, normalized value	P_ME_NA_1
[ ]	<111> := Parameter of measured value, scaled value	P_ME_NB_1
[ ]	<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)

[ ]	<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	F_DR_TA_1

6.3.5 BASIC APPLICATION FUNCTIONS

Station initialization (station-specific parameter)
[X] Remote initialization
Cyclic data transmission
[x] Cyclic data transmission
Read procedure
[X] Read procedure
Spontaneous transmission
[x] Spontaneous transmission
Double transmission of information objects with cause of transmission spontaneous
[x] Single point information M_SP_NA_1 and M_SP_TB_1
[x] Double point information M_DP_NA_1 and M_DP_TB_1
[ ] Step position information M_ST_NA_1 and M_ST_TB_1
[ ] Bitstring of 32 bit M_BO_NA_1 and M_BO_TB_1
[ ] Measured value, normalized value M_ME_TA_1 and M_ME_TD_1
[x] Measured value, scaled value M_ME_TB_1 and M_ME_TE_1

[ ] Measured value, short floating point value M_ME_TC_1 and M_ME_TF_1

General interrogation (system- or station-specific parameter)
[x] Global
[x] Group 1 [ ] Group 7 [ ] Group 13
[x] Group 2 [ ] Group 8 [ ] Group 14
[ ] Group 3 [ ] Group 9 [ ] Group 15
[x] Group 4 [ ] Group 10 [ ] Group 16
[ ] Group 5 [ ] Group 11
[ ] Group 6 [ ] Group 12

Clock synchronization (station-specific parameter)
[x] Clock synchronization
[ ] Day of week used
[ ] RES1, GEN (time tag substituted/ not substituted) used
[ ] SU-bit (summer time) used

Command transmission (object-specific parameter)
[x] Direct command transmission
[x] Direct set point command transmission
[x] Select and execute command
[ ] Select and execute set point command
[ ] C_SE ACTTERM used
[x] No additional definition
[x] Short pulse duration (duration determined by a system parameter in the outstation)
[x] Long pulse duration (duration determined by a system parameter in the outstation)
[x] Persistent output
[x] Supervision of maximum delay in command direction of commands and set point commands
Maximum allowable delay of commands and set point commands: 5 seconds.

Transmission of integrated totals (station- or object-specific parameter)
[ ] 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
[x] Counter read
[ ] Counter freeze without reset
[ ] Counter freeze with reset
[x] Counter reset
[x] General request counter
[ ] Request counter group 1
[ ] Request counter group 2
[ ] Request counter group 3
[ ] Request counter group 4

Parameter loading (object-specific parameter)
[ ] Threshold value
[ ] Smoothing factor
[ ] Low limit for transmission of measured value
[ ] High-limit for transmission of measured value

Parameter activation (object-specific parameter)
[ ] Act/deact of persistent cyclic or periodic transmission of the addressed object
Test procedure
[x] Test procudure
File transfer (station-specific parameter)
[ ] File transfer in monitor direction
[ ] File transfer in control direction

Background scan
[x] Background scan
Acquisition of transmission delay
[x] Acquisition of transmission delay

7. Software Upgrade

The RTU 150 has two kinds of software; the boot software and the application software. The boot program runs after power on and initializes the unit and then starts up the application. Both the boot program and the application program can be upgraded. See instructions below:

7.1 Boot software

Follow the instructions below to upgrade the boot program.

7.1.1 Upgrade using RS232

1) Establish the serial connection to the RTU as described in chapter 4.
2) Power off RTU 150 RTU.
3) Power up RTU 150 RTU.
4) When the Boot Program starts. Press <spacebar> within 3 seconds to stop the boot sequence and to get the command prompt 'CB20>'.
5) Enter following command "pboot serial 400000", where the number 400000 is the true file size of the application file size.
6) Once the command is entered, start sending the application file. This is done by selecting menu option "Send File" in terminal program. **NOTE!** Transfer shall be in binary mode (not text/ascii). **NOTE!** The RTU 150 will restart once the download is finished and successful.

Below is an example of the procedure:

```
##################################################
                    CB20BOOTS

Copyright Smart Grid Networks

Software: CB20BOOTS v1.0 RC11 10 Apr 2012

Article No    Softw Id    Hardw Id    HardwRev    CRC
1781001-5     0xAC        0x41        0x01        0x46A1

##################################################
AD Mux = AD
IB10 card found! Rev: 7
No SD card found
CAN-bus initialised. Adr=1, Testadr=1

Hit space to enter boot mode...
[ ================== ]

Enter 'help' for help.

CB20> pboot serial 297903
Start sending the binary file now...
Checksum 0x2394 OK.
Erasing sector 0
Erasing sector 1
Erasing sector 2

CB20>
```

7.1.2 Upgrade using SD card

1) Establish the serial connection to the RTU as described in chapter 4.
2) Power off RTU 150 RTU and insert the SD card which contains the file "*boot.bin*".
3) Power up RTU 150 RTU.
4) When the Boot Program starts. Press <spacebar> within 3 seconds to stop the boot sequence and to get the command prompt `'CB20>'`.
5) Enter following command `"pboot sd`. **NOTE!** The RTU 150 will restart once the download is finished and successful.

Below is an example of the procedure:

```
#####################################################
                    CB20BOOTS

Copyright Smart Grid Networks

Software: CB20BOOTS v1.0 RC11 10 Apr 2012

Article No    Softw Id    Hardw Id    HardwRev    CRC
1781001-5     0xAC        0x41        0x01        0x46A1

#####################################################
AD Mux = AD
IB10 card found! Rev: 7
SD card found. Write protection OFF
Capacity = 1015808000 Bytes (1984000 blocks * 512 bytes)
CAN-bus initialised. Adr=1, Testadr=1

Hit space to enter boot mode...
[ ================== ]

Enter 'help' for help.

CB20> pboot sd
Checksum 0x2394 OK.
Erasing sector 0
Erasing sector 1
Erasing sector 2

CB20>
```

7.2 Application software

Follow these instructions step by step to upgrade the application software.

7.2.1 Upgrade using RS232

1) Establish the serial connection to the RTU as described in chapter 4.
2) Power off RTU 150 RTU.
3) Power up RTU 150 RTU.
4) When the Boot Program starts. Press <spacebar> within 3 seconds to stop the boot sequence and to get the command prompt `'CB20>'`.
5) Enter following command `"papp serial 400000"`, where the number 400000 is the true file size of the application file size.
6) Once the command is entered, start sending the application file. This is done by selecting menu option "Send File" in terminal program. **NOTE!** The transfer shall be in binary mode (not text/ascii).

Below is an example of the procedure:

```
##################################################
                   CB20BOOTS

Copyright Smart Grid Networks

Software: CB20BOOTS v1.0 RC11 10 Apr 2012

Article No    Softw Id    Hardw Id    HardwRev    CRC
1781001-5     0xAC        0x41        0x01        0x46A1

##################################################
AD Mux = AD
IB10 card found! Rev: 7
No SD card found
CAN-bus initialised. Adr=1, Testadr=1

Hit space to enter boot mode...
[ ================== ]

Enter 'help' for help.

CB20> papp serial 297903
Start sending the binary file now...
Checksum 0x2394 OK.
Erasing sector 0
Erasing sector 1
Erasing sector 2
Erasing sector 3
Erasing sector 4
Erasing sector 5
Erasing sector 6
Erasing sector 7
Erasing sector 8
Erasing sector 9
Erasing sector 10
Erasing sector 11

CB20>
```

7.2.2 Upgrade using SD card

1) Establish the serial connection to the RTU as described in chapter 4.
2) Power off RTU 150 RTU and insert the SD card which contains the file "*appl.bin*".
3) Power up RTU 150 RTU.
4) When the Boot Program starts. Press <spacebar> within 3 seconds to stop the boot sequence and to get the command prompt '`CB20>`'.
5) Enter following command "*papp sd*".

Below is an example of the procedure:

```
##################################################
                   CB20BOOTS

Copyright Smart Grid Networks

Software: CB20BOOTS v1.0 RC11 10 Apr 2012

Article No   Softw Id   Hardw Id   HardwRev   CRC
1781001-5    0xAC       0x41       0x01       0x46A1

##################################################
AD Mux = AD
IB10 card found! Rev: 7
SD card found. Write protection OFF
Capacity = 1015808000 Bytes (1984000 blocks * 512 bytes)
CAN-bus initialised. Adr=1, Testadr=1

Hit space to enter boot mode...
[ ================== ]

Enter 'help' for help.

CB20> papp sd
Checksum 0x2394 OK.
Erasing sector 0
Erasing sector 1
Erasing sector 2
Erasing sector 3
Erasing sector 4
Erasing sector 5
Erasing sector 6
Erasing sector 7
Erasing sector 8
Erasing sector 9
Erasing sector 10
Erasing sector 11

CB20>
```

7.2.3 Upgrade using FTP

Perform instructions as described in chapter 5.5.2.

8. Fault finding

- Make sure that the unit has power. The blue LED will be lit after a few seconds when the power is OK.
- Make sure earth connections are correctly connected to protective earth.
- Make sure the cable and connectors are correctly mounted.
- Make sure there is no short-circuit.
- Make sure that the units are correctly programmed according to chapter 4.

8.1 Exchange internal fuse

NOTE! Follow these instructions when exchanging the F900 fuse on the CB20 card.

Make sure the circuit board and the surface around is ESD protected.
Lift up the old fuse using a pincers or other suitable tool. Place the new fuse in position and be careful not to damage anything on the board. The fuse is a little fuse NANO 0452 002 2A slow blow with Smart Grid Networks article number: 1430060-7.

NOTE! If the fuse is blown, the RTU 150 might have been subjected to over voltage and the RTU 150 units over voltage protection may have been damaged.

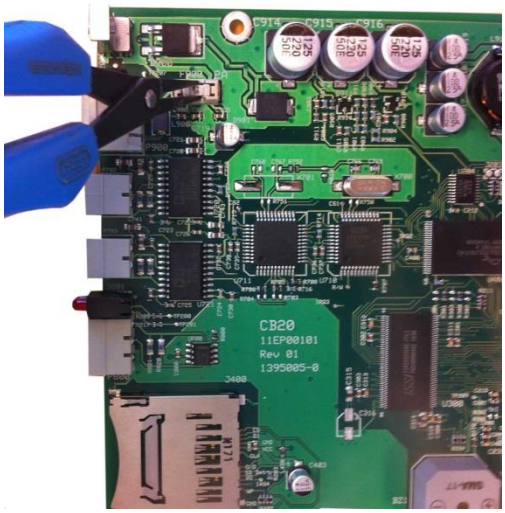


Figure 15. Fuse exchange

8.2 Support

For fault tracing and support contact Smart Grid Networks. Write down the serial number and the RTU´s behavior for fast response.

9. Contact information

Operator: +46 455 600 100
www.smartgridnetworks.net