WIRELESS COMMUNICATION SYSTEM WACO WM868

WM868-SI4-B

Revision 2.0

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1 Introduction

This document describes the configuration options of the WM868-SI4-B radio module, which is used for reading the status of consumption meters with pulse output (water meters, electricity meters, gas meters...) and for radio transmission of information about the current status of consumption meters through radio messages in WACO, LoRa, or Wireless M-Bus format.

1.1 WACO communication system

WACO (Wireless Automatic Collector) is radio frequency (RF) communication system intended especially for the remote reading of consumption meters (smart metering area), automatic data collection from sensors (telemetry area), and bi-directional data transfer among control, sensing and actuating elements in automatic control systems (industrial automation area). Installed WACO radio-frequency elements create local radio network covering object of interest (flat, house, building, compound...) or required area (street, city...).

WACO RF network has a **„mesh"** type of topology, where in reach of each radio element there could be placed several other network elements that could operate also as repeaters of received signal. In this kind of network there are typically several possible communication paths between the central point and other single elements of the network. WACO network communication protocol was designed to provide a **maximum data transmission reliability and redundancy** with using of multiple communication paths, but at the same time the network is protected against circularity and multiplication of messages by sophisticated algorithms so that the network keeps also a **high performance** even with high number of radio elements working in one network.

WACO communication protocol was designed in compliance with a telecommunication standard **ISO/OSI model** that ensures a high variability of supported applications. The WACO communication system works **in the 868 MHz band**, in which it uses 7 frequency channels. Three channels with a bandwidth of 100 KHz are intended for high-speed data transfer **in "WACO"** mode (bit rate 38,400 Baud), four channels with a width of 15 KHz are intended for low-speed data transfer **in "WACO NB" mode "** (bit rate 2400 Baud). The WACO high-speed mode is especially suitable for applications of the "virtual bus" type, where high transmission capacity is important, the low-speed WACO NB (NB = Narrow Band) mode is characterized by a significantly (up to 2.5 times) higher range (thanks to a narrow frequency channel) and is suitable especially for collecting data from meters and sensors in larger objects or areas. The older WACO high-speed mode is supported by all wacoSystem WACO radio modules, the later introduced WACO NB low-speed mode is supported by wacoSystem WACO radio modules manufactured from 2022. WACO radio-frequency devices (hereinafter „radio modules") are equipped with **various types of input/output interfaces** that enables integration of various connected device (meters, sensors, actors...) into one network.

WACO communication system includes also special communication devices - **WACO GateWays**, that enable receiving of radio messages from the local WACO RF-network and transfer them to the local or remote computer through the serial line or Internet and (in inverse direction) receiving messages from the serial line/Internet and broadcast them into „its" RF-network.

1.2 LoRaWAN communication system

The LoRaWAN communication network is a radio network enabling the collection of data from a large number of end devices transmitting messages with LoRa type modulation, which enables the transmission of data over a relatively long distance at low transmission power. Networks with such a purpose and possibilities of use are often referred to as the "Internet of Things" ("Internet of Things" - short for "IoT").

LoRaWAN communication network technology is optimized for wireless data collection from battery-powered devices, when the key requirement is to achieve the greatest possible radio range with the lowest possible energy consumption. Communications between end elements and gateways are transmitted over several frequency subchannels using the principle of spread spectrum, with adaptive setting of the transmission rate.

The LoRaWAN network has a "star of stars" topology, where communication gateways collect data from the end devices within their local radio network and transmit it to a central server via a standard IP protocol. Using the LoRaWAN protocol, local networks can be created to cover individual objects or areas, or even global networks that cover large area. The LoRaWAN protocol also supports two-way communication, where the communication gateway transmits data to the end device in the allocated time interval.

1.3 Wireless M-BUS Communication Protocol

Wireless M-BUS is the communications protocol described by international standards EN 13757-4 (physical and link layer) and EN 13757-3 (application layer), which is intended primarily for radio transmission of remote reading values from consumption meters and sensors. Protocol Wireless M-BUS (hereinafter „WMBUS") is based on a standard M-BUS definition (uses the same application layer as M-BUS standard), but is adapted for data transfer via radio signals.

Communications via WMBUS protocol works in Master-Slave mode, where „Master" is a collecting data device, „Slave" is a providing data device. Slave device could be integrated or external radio module transmitting data from the meter/sensor. The communications protocol WMBUS defines several communication modes (simplex or duplex). If working in simplex mode a „Slave" device only transmits messages to „Master" that these messages receives. If working in „bidirectional" mode, it is possible to use a reverse channel from „Master" device to „Slave" device for „Request" type of messages, that can contain e.g. request for the change of slave's configuration.

Wireless M-BUS communications protocol partially supports repeating of the messages. If receiving from some „Slave" device is not possible because of the low level of radio signal, the messages can be re-transmitted (repeated) by appointed element of the radio network (repeater or slave with such functionality). Each repeated message is marked as „repeated message" so as not to be repeated again.

1.4 Module usage

The WM868-SI4-B module is designed for remote reading of consumption meters (water meters, gas meters, electricity meters, calorimeters) equipped with a standard pulse output commonly used in the field of energy and media consumption measurement (output type "SI"). The module has four SI-type inputs to which four consumption meters can be connected, which can be of different types, with different initial states. The module continuously reads pulses generated by consumption meters into internal counters and transmits current data on the status of individual counters in the form of radio messages, automatically transmitted at a set time interval. The message with current meter readings is of the "INFO" type and, in addition to the readings of connected consumption meters, it also contains the module's system time, battery voltage, and processor temperature.

Individual pulse inputs can also be set to the so-called alarm mode, where the module does not count pulses, but **immediately** sends an alarm message with each change of state on the given input (i.e., when transitioning from state "0 - open" to state "1 - closed", or vice versa). This setting is used for transmitting information from **two-state sensors** such as protective contacts, door contacts, flood sensors, etc.

The module transmits and receives messages in the format of the three types of radio networks mentioned above (hereinafter "transmission modes"). In WACO transmission mode, the recipient of the radio message can be another WACO system module or a WACO communication gateway that converts the message to IP/UDP protocol and sends it over the Internet to a computer with a specified IP address. In LoRa and Wireless M-BUS transmission modes, the recipient of the radio message is always the appropriate type of communication gateway.

In WACO and LoRa transmission modes, the message data content is encoded with the proprietary WACO/NEP protocol, while in Wireless M-Bus transmission mode, the message data content is encoded according to the standard M-Bus protocol. The computer processing the messages must be equipped with the appropriate decoder.

Message transmission in the reverse direction (from computer to end device) is supported only in WACO and LoRa transmission modes. The computer creates a message in WACO/NEP format and sends it through a private or public IP service to the communication gateway, which converts it to the appropriate radio format and sends it to the end device at an appropriate time.

The principle of data transfer from the module through a communication gateway is shown in Figure 1.

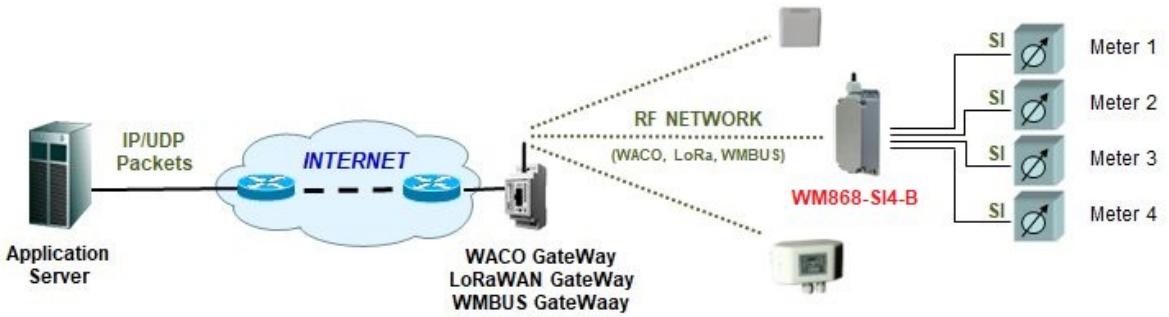

Figure 1: Principle of data transmission from the WM868-SI4-B module through a communication gateway

In WACO transmission mode, messages can be transmitted directly to another WACO system module that is constantly receiving. Figure 2 shows the data transmission from the WM868-SI4-B module to the so-called **"Collecting Unit"** of the WACO system, which collects data from battery-powered WACO modules, converts the data into standard messages of the M-Bus protocol, and further transmits them to the bus control unit (device type "M-Bus Master") in M-Bus format over a physical bus.

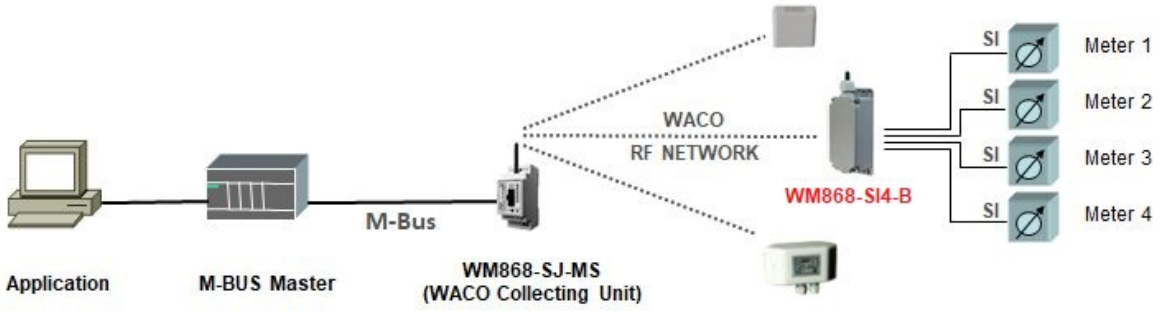

Figure 2: Principle of data transmission from the WM868-SI4-B module to another WACO radio module

The WM868-SI4-B module is enclosed in a moisture-resistant plastic box and is suitable for use in both indoor and outdoor environments. The module is powered by an internal battery with a capacity of 3.6 Ah, which allows it to operate for more than 10 years with a message transmission period of 12 hours. Battery life can be negatively affected not only by a shorter set interval for sending counter status, but also by operating the device in installation locations with temperatures outside the recommended operating temperature range, or in networks with high radio traffic or radio interference.

The appearance of the WM868-SI4-B module is shown in Figure 3.

Figure 3: Appearance of the WM868-SI4-B module

2 Overview of technical parameters

An overview of the technical parameters of the WM868-SI4-B module is given in Table 1.

Table 1: Overview of technical parameters of the WM868-SI4-B module

Radio interface		
Frequency band	868	MHz
Transmission modes	WACO, wM-Bus, LoRa	
Modulation type - WACO	GFSK	
Modulation type - wM-Bus	FSK	
Modulation type - LoRa	spread spectrum	
Transmit power	10 - 25	mW
Channel width - WACO	100 (15)*	kHz
Channel width - wM-Bus	200	kHz
Channel width - LoRa	125	kHz
Receiver sensitivity - WACO	-105 (-118)*	dBm
Receiver sensitivity - wM-Bus	-105	dBm
Receiver sensitivity - LoRa	-148	dBm
Transmission rate - WACO	38400 (2400)*	bps
Transmission rate - wM-Bus	100	kbps
Transmission rate - LoRa	250 ÷ 11000	bps
Antenna	external	SMA female
Output impedance	50	Ω
Configuration interface RS232		
Transmission rate	9600	Baud
Operation type	asynchronous	
Transmission parameters	8 data bits, 1 stop bit, no parity	
Signal level	CMOS 3.3	V
Pulse inputs		
Open switch resistance	greater than 5	MΩ
Closed switch resistance	less than 10	kΩ
Maximum input voltage	0.25	V
Max. frequency of input pulses	300	Hz
Minimum pulse length	1	ms
Bluetooth configuration interface		
Version	BLE 5.2	
Frequency	2.4	GHz
Transmission rate	1	Mbps
Maximum power	8	dBm
Power supply parameters		
Lithium battery voltage	3.6	V
Lithium battery capacity	3.6	Ah
Mechanical parameters		
Length	153	mm
Width	57	mm
Height	51	mm
Weight	220	g
Storage and installation conditions		
Installation environment (according to ČSN 33 2000-3)	normal AA6, AB4, A4	
Operating temperature range	(-10 ÷ 50)	°C
Storage temperature range	(0 ÷ 40)	°C
Relative humidity	95	% (without condensation)
Degree of protection	IP65 or IP68	

* values in parentheses are valid for transmission in the WACO-NB narrow-band channel

3 Module Configuration

Configuration parameters of the WM868-SI4-B module can be displayed and changed from the common computer (PC) or smartphone by one of these methods:

- with using of **„USB-CMOS"** converter and configuration cable connected to the module;
- wirelessly, with using of **smartphone** with Bluetooth communication;
- **remotely**, by using of bi-directional communication system.

Technique of interconnection of the module with configuration computer and general rules of configuration are described in detail in the chapter 2 of **„Configuration of wacoSystem product family devices"**, that can be downloaded from the producer website:

www.wacosystem.com/support/
www.softlink.cz/en/documents/

The description and meaning of all configuration parameters that can be checked and changed by cable can be found in the section 3.1 „Setting of WM868-SI4-B parameters via configuration cable".

Description of connecting the module to a mobile phone via Bluetooth wireless connection and general rules for configuring the module using the mobile application "Softlink Configurator" are described in Chapter 3 of the above-mentioned manual „Configuration of wacoSystem product family devices". In section 3.2 "Setting the parameters of the WM868-SI4-B module using a mobile application", there is a description and explanation of the parameters that can be set using the mobile application.

Principles and short description of communication through the **reverse channel** can be found in paragraph 3.3 „Remote setting of module parameters through the reverse channel".

3.1 Setting WM868-SI4-B module parameters using a configuration cable

The following part of the manual describes those parameters of the WM868-SI4-B module whose current value can be determined by directly connecting the module to a PC using a configuration cable and possibly changed using configuration commands (configuration "from the command line").

3.1.1 Listing of configuration parameters of the WM868-SI4-B module

The configuration parameters can be browsed by entering the command **"conf"** into the command line and pressing the "ENTER" key.

The following output will appear in the terminal window:

```
wm868-SI4-2>conf
Config      : OK
--- WACO protocol ---
channel     : 0
Group       : 0
Hop count   : 3
Repeater    : 0
Test timeout: 20 sec.
Encrypt port:
Repeat count: 1
Master      : 0x010000FE
Repeat tout : 1 (50 ms)
--- RF Driver ---
TX power    : 14 dBm
RX timeout  : 4 (200 ms)
WOR         : 0
CD          : 1
High Gain   : 0
--- Application ---
Sending     : 900 secs.
Measure     : 60 secs.
--- LoRa driver ---
Band        : 0
Channel     : 0
Data Rate   : 0
Recv Delay  : 2
Join Delay  : 2
Ack Limit   : 0
Ack Delay   : 0
Ack Tout    : 0
--- LoRa App ---
Dev Addr    : 0x00000000
NwkSKey     : 00000000000000000000000000000000
AppSKey     : 00000000000000000000000000000000
AppKey      : 00000000000000000000000000000000
JoinEUI     : 0000000000000000
OTAA        : 0
Encrypt     : 0
Adaptive TX : 0
--- WMBUS driver ---
Mode        : C1
Channel     : 0
--- WMBUS  ---
ID          : 10300017
Manuf       : SFT
Version     : 1
Medium      : 7
Encrypt key : 00000000000000000000000000000000
Encrypt type: none
--- BLE configuration ---
TX Power    : -6
Channel mask: 7
Adv timeout : 50
Conn timeout: 400
BLE PIN     : -
```

In the configuration listing, there are sections for individual transmission modes (WACO, LoRa, Wireless M-Bus) and a section for listing Bluetooth communication settings (BLE Configuration). The procedure for setting individual parameters and a more detailed explanation of their meaning can be found below.

3.1.2 Overview of configuration commands of the WM868-SI4-B module (”HELP”)

The summary of configuration commands (”HELP”) and their parameters can be displayed by entering the command **”?”** into the command line and pressing the ”ENTER” key. The following output will appear in the terminal window:

```
wm868-SI4-2>?
?            - help
info         - print system info
conf         - print configuration
write        - write configuration
clear        - clear configuration
mode         - set mode [waco|lora|wmbus]
reset        - RESET chip
sensors      - print sensors info
rf           - rf commands
waco         - WACO commands
lora         - LoRa commands
wmbus        - WMBUS commands
app          - application commands
ble          - BLE configuration
input        - INPUT commands
system       - System commands
wm868-SI4-2>
```

In the upper part of the output (up to the ”sensors” command) are the main commands used to check or set the functionality of the module as a whole. They are always entered directly after the prompt.

In the lower part of the output (after the space, starting from ”rf”) are listed the names of individual subsystems of the module, which have their own commands. We can display these commands by entering the name of the subsystem into the command line and pressing the ”ENTER” key. Example of displaying commands for the ”rf” subsystem:

```
wm868-SI4-2>rf
?            - help
info         - print driver info
clear        - clear statistics
txp          - set TX power
rxt          - RX timeout
active       - RF driver active mode
cd           - set Listen Before Talk
wor          - set WOR
hg           - set high gain
cw           - CW tramission
xtal         - set Rf Xtal frequency
regs         - print registers
pins         - print pins
wm868-SI4-2>
```

The listed commands can only be used for the given subsystem, and this is done by first entering the name of the subsystem after the prompt, and then the command itself after a space. Example of entering the ”txp” command (without a parameter) to check the current transmit power setting:

```
wm868-SI4-2>rf txp
TX power    : 14 dBm
wm868-SI4-2>
```

The meaning and usage of individual commands are explained in the following parts of section 3.1.

3.1.3 Commands for basic module control

This group of commands contains commands for controlling and monitoring the module as a whole. These are the following commands:

```
wm868-SI4-2>?
?         - help
info      - print system info
conf      - print configuration
write     - write configuration
clear     - clear configuration
mode      - set mode [waco|lora|wmbus]
reset     - RESET chip
sensors   - print sensors info
```

Use the command **"?" ("HELP")** to display a list of system configuration commands (see paragraph 3.1.2 "Overview of configuration commands for the WM868-SI4-B module").

Use the command **"info"** command to display a brief list of basic identification information about the module:

```
wm868-SI4-2>info
Device      :  wm868-SI4-2
Device type :  868.120
Hardware    :  0.4
Software    :  1.1
Reset Cause :  4
Uptime      :  67 secs.
jxSystime   :  67 secs.
Mode        :  WACO
DevEUI (HW) :  0080e11500134c31
WACO address:  fffe9e9a
wm868-SI4-2>
```

The first part of the output shows the **device manufacturing designation** (Device name), **hardware version** and **software version**. The next part shows the **"Reset cause"** value (cause of the last reset), **"Uptime"** and **Systime** values in seconds, and the currently set transmission mode (WACO/WMBUS/LoRa). The following lines display the module's identification data.

The value of the **"Systime"** variable shows the setting of the module's real-time clock. The time is maintained in the same format as in computer systems, i.e. in seconds since 1.1.1970 (so-called "UNIX Time" or "epoch"). In the default state (after power-on), the real-time counter has a zero value, which increases by one unit every second. The synchronization of the module with real time can be performed by using of the SET command (using the "Systime (s)" variable identifier), where the current time value must be entered in UNIX-time seconds. However, no module application requires setting the system time.

The value of the **"Uptime"** variable shows the time since the last device reset in seconds. From the value of this variable, we can determine when the last module reset occurred. The variable is "read only".

The value of the **"Reset cause"** variable informs about how the device was last reset. For this type of device, the following reset types are relevant:

- **"0"** is the reset code for "Cold start" (module reset by external "RESET" command)
- **"1"** is the reset code for "Warm start" (reset after specific cases of "suspension")
- **"2"** is the reset code for "Watchdog reset" (reset by the "watchdog" system when "frozen")
- **"3"** is the reset code for "Error reset" (reset due to invalid instruction, inconsistent data...)
- **"4"** is the reset code for "Power reset" (reset due to power supply voltage decrease)

The variable is "read only" and is mainly used for diagnostic purposes.

The **"conf"** command displays a complete configuration output of the module (see paragraph 3.1.1 "Output of configuration parameters of the WM868-SI4-B module").

The current operational configuration can be saved to FLASH memory by using of the **"write"** command. The module contains two configuration sets: operational configuration and stored configuration. When the system starts, the module copies the stored configuration to the operational one, which it then works with. If the user changes configuration parameters, this only happens in the operational configuration. *If the current operational configuration is not saved to FLASH memory, after a reset the module will "return" to the set of configuration*

parameters stored in FLASH. If the parameter should be set only temporarily (for example when turn on a "test"), it is not needed to save the operational configuration to FLASH memory (after finishing diagnostics the "test" will be turned off anyway). However, if it is necessary for the currently changed operating parameters to remain set permanently, it is necessary to enter at the end of the configuration sequence a command to save the current configuration to FLASH..

Example of saving configuration to FLASH memory:

```
wm868-SI4-2>>write
Writing config ...
wm868-SI4-2>
```

Usie the **"clear"** command to **erase the configuration from** Flash memory. It is recommended using this command **only for users with good knowledge of the system, or after consultation with the manufacturer**.

The **"mode"** command sets the module's transmission mode as follows:

- entering the string **"waco"** switches the module to "WACO" mode
- entering the string **"lora"** switches the module to "LoRa" mode
- entering the string **"wmbus"** switches the module to "Wireless M-Bus" mode

Using the command without a parameter displays the current transmission mode setting. Example of setting individual modes and final setting check:

```
wm868-SI4-2>mode wmbus
Mode    :  WMBUS
wm868-SI4-2>mode lora
Mode    :  LoRa
wm868-SI4-2>mode waco
Mode    :  WACO
wm868-SI4-2>mode
Mode    :  WACO
wm868-SI4-2>
```

The **"reset"** command performs a restart of the module's processor. After the restart, the module's startup sequence gradually appears:

```
wm868-SI4-2>reset
wm868-SI4-2>
smons2 I2C error:  1
TMP112 not present !!!
- System moniHDC1080 I2C result:  1
HDC1080 not present !!!
tor, Version 2.0
Copyright (c) 2020, Petr Volny *MSoft*
Compiled at Apr 13 2023, 09:36:44
wm868-SI4-2>
BLE-DTM ver.:  3.2.0
BLE-Stack   :  2.1.c, build:  2353
Advertising...
```

The **"sensors"** command displays the current data from the module's integrated sensors:

```
wm868-SI4-2>sensors
Temp.  int.  :  21.0 C
Temp.  sensor:  -500.0 C
VCC          :  3107 mV
VBat         :  3114 mV
wm868-SI4-2>
```

The first line shows the processor temperature sensor reading (21.0 C). The second line is reserved for the external temperature sensor reading, which this type of module is not equipped with. The next two lines show the supply voltage of the internal source for the processor and the voltage of the power battery.

3.1.4 Commands for configuring the RF subsystem of the module

This group of commands is used to set those parameters of the RF subsystem of the WM868-SI4-B module that are common to all modes. These are the following commands:

```
?           - help
info        - print driver info
clear       - clear statistics
txp         - set TX power
rxt         - RX timeout
active      - RF driver active mode
cd          - set Listen Before Talk
wor         - set WOR
hg          - set high gain
cw          - CW tramission
xtal        - set Rf Xtal frequency
regs        - print registers
pins        - print pins
```

Use the command **"rf ?"** to display the above "HELP" listing for the RF section.

Use the command **"rf info"** to display the status of the radio interface and statistics of transmission and reception of radio packets:

```
wm868-SI4-2>rf info
-- RF stats --
IN pkts     :  0
OUT pkts    :  4
IN Errors   :  0
OUT Errors  :  0
WOR Wakeup  :  0
Interr      :  0
-- RF automaton --
RFA         :  SLEEP
TX queue    :  0
rfDrvTimer  :  0
SetRfFreq   :  911159090
wm868-SI4-2>
```

The data in the listing is used for module diagnostics. You can reset the statistics in the upper part of the listing using the command **"rf clear"**.

You can set the transmitting power of the module using the command **"rf txp"**:

```
wm868-SI4-2>rf txp 14
TX power :  14 dBm
wm868-SI4-2>
```

The maximum settable power value is 14 dBm, which corresponds to the maximum allowed transmitting power in the 868 MHz band (25 mW). Setting a value higher than 14 dBm will not affect the module's power. It is recommended not changing the transmitting power. *(*) In the first production series, this command is intended only for WACO and Wireless M-Bus transmission modes; the command for setting the transmitting power in LoRa mode can be found in the LoRa command group.*

Using the command **"rf rxt"**, you can change the setting of the length of the time interval **"RX TimeOut"**, during which the receiver is active after sending a message. This interval is used in WACO and Wireless M-Bus modes to receive a message from the so-called "reverse channel", which can be used to send an acknowledgment message, configuration change, or other type of information to the module. In LoRa mode, the reverse channel parameters are set by other commands (see LoRa settings in the section "Commands for setting LoRa transmission mode").

The RX TimeOut value is set in system units of 50 ms (20 units = 1 second). The default setting for this parameter is 200 ms. Example of a command to set RX TimeOut to 500 ms (10 units):

```
wm868-SI4-2>rf rxt 10
RX timeout :  10 (500 ms)
wm868-SI4-2>
```

Using the command **"rf active"**, you can switch the RF subsystem to a permanently active mode, where the receiver is constantly receiving, except for moments of transmission. For the battery-powered WM868-SI4-B module, such a setting would lead to rapid battery discharge, so it is **strongly advised against using this command during normal module operation**.

Using the command **"rf cd"**, you can set or turn off the "Listen Before Talk" function, where the module "listens" on the transmission channel before each message transmission in WACO transmission mode and only starts transmitting if the carrier frequency of the given channel is free and if a valid frame transmission is not already in progress. This maximally reduces the probability of signal collision with interfering signals at the given frequency, as well as collisions with transmissions from other modules. This function is by default turned on to the optimal mode "1" and we **strongly advise against changing the setting of this function** without consulting the manufacturer.

The command **"rf wor [0/1]"** is reserved for activating the "Wake On Radio" function in WACO transmission mode. The current version of the WM868-SI4-B module does not support this function, so using this command has no effect.

Using the command **"rf hg"**, you can turn on a specific function of the RF subsystem, which is supported only by some versions of the used RF chips. The "High Gain" parameter is optimally set at the factory for the WM868-SI4-B module, and it is **strongly advised against using this command during normal module operation**.

The command **"rf cw"** is used to turn on the carrier frequency transmission for the purpose of tuning the RF subsystem during the manufacturing process. It is **strongly advised against using this command during normal module operation**.

The command **"rf xtal"** is used for tuning the crystal of the RF subsystem during the manufacturing process. It is **strongly advised against using this command during normal module operation**. The commands **"rf regs"** and **"rf pins"** are used to display the status of system registers during the manufacturing process or during module diagnostics in the manufacturer's laboratory. It is **strongly advised against using this command during normal module operation**.

3.1.5 Commands for configuring WACO transmission mode

This group of commands is used to set the parameters of the WM868-SI4-B module in WACO transmission mode. These are the following commands:

```
wm868-SI4-2>waco ?
?       - help
channel - set channel
group   - set group
hop     - set hop count
rex     - set range extender
ttout   - set test timeout
encrypt - set/delete encryption, (encrypt delete 20, encrypt 20 key)
repeat  - set repeat count
tout    - set repeat timeout
master  - set WACO master address (e.g.  0xff8fa123)
wm868-SI4-2>
```

The command **"waco ?"** displays the above "HELP" listing for the WACO section. The command **"waco channel"** displays or changes the frequency channel of the RF subsystem in WACO mode. In WACO mode, 7 frequency channels are available:

- channel "0": 868.05000 to 868.15000 MHz, (width 100 kHz)
- channel "1": 868.25000 to 868.35000 MHz, (width 100 kHz)
- channel "3": 868.35505 to 868.36995 MHz, (width 15 kHz)
- channel "4": 868.38005 to 868.39495 MHz, (width 15 kHz)
- channel "5": 868.40505 to 868.41995 MHz, (width 15 kHz)
- channel "6": 868.43005 to 868.44495 MHz, (width 15 kHz)
- channel "2": 868.45000 to 868.55000 MHz, (width 100 kHz)

Channels labeled "0", "1" and "2" have a width of 100 kHz and are used for data transmission at a speed of 38.4

kb/s with a theoretical receiver sensitivity of about 104 dBm, which allows communication in built-up objects in the order of tens of meters. Channels labeled "3", "4", "5" and "6" have a width of 15 kHz and are used for data transmission at a speed of 2.4 kb/s with a theoretical receiver sensitivity of about 120 dBm. In this case, the radio range of the module is about 2.5 times longer.

Note: *When designing a radio network and making changes to the network, it is necessary to take into account that older generation WACO modules only have the wider channels "0", "1" and "2" implemented. If such modules are in the same radio network as the WM868-SI4-B module, the narrowband channels 3 to 6 cannot be used. When designing radio network parameters, it is always necessary to consider the requirements for transmission speed and required radio range, which are mutually contradictory.*

Example of checking the current state and then setting frequency channel "2":

```
wm868-SI4-2>waco channel
channel :  0
wm868-SI4-2>waco channel 2
channel :  2
wm868-SI4-2>
```

After setting the frequency channel, it is always necessary to **save the settings and reset the module**. The module will switch to the newly set channel only after a reset.

The command **"waco group"** is used to set the group address of the module in WACO transmission mode (variable **"SLRF Group Address"**. In the WACO system, an almost unlimited number (65536) of groups ("virtual buses") can be created using group addresses. When addressing messages, in addition to the specific radio address of the module, group addressing can also be used, where the message is always delivered to all modules in the given group (i.e. all modules that have the given group address). For standard functionality of the WM868-SI4-B module, setting the group address is not important, because this type of module uses the general "broadcast" address for sending INFO type messages. However, some applications may use group addressing.

Setting the **group address of the module** ("SLRF Group Address") is done with the command **"waco group [number]"**, where the number 0 to 65535 is the group address of the module.

The variable **"SLRF Hop Count"** indicates the maximum number of retransmissions (repetitions) of a radio message sent by the given module. If the parameter is set to "3", for example, the sent message is automatically deleted after three transmissions, thus preventing its cyclic circulation in the radio network. It is recommended setting the parameter to n or n+1, where "n" is the lowest number of retransmissions that is absolutely necessary for the message to reach the recipient. Too low a "SLRF Hop Count" parameter causes the message to be automatically deleted before it reaches the recipient and thus does not reach its destination. Too high a parameter value causes unnecessary load on the radio network by pointless repetition of messages and their duplication.

The "SLRF Hop Count" variable is set using the command **"waco hop [number]"**, where the number 0 to 15 means the maximum number of retransmissions of messages sent by the given module. Example of checking the current setting of the "hop count" parameter and then commanding to set the maximum number of hops to "3":

```
wm868-SI4-2>waco hop
Hop count :  1
wm868-SI4-2>waco hop 3
Hop count :  3
wm868-SI4-2>
```

The command **"waco rex 0/1"** is used to switch the module to message repeater mode. When this mode is turned on, the module forwards (repeats) all received messages except those that have already exhausted the maximum number of repetitions. Example of turning on and off the repeater function:

```
wm868-SI4-2>waco rex 1
Repeater :  1
wm868-SI4-2>waco rex 0
Repeater :  0
wm868-SI4-2>
```

The WM868-SI4-B module is in a "hibernated" state for the vast majority of its operating time. It switches to active reception and transmission state only for the absolutely necessary time when it is necessary to send a message. The possibility of repeating foreign messages is thus practically unrealizable, so for this type of module, the repeater mode is turned off by default and we recommend not changing this setting.

The command **"waco ttout [number]"** is used to set the **period of sending a test message**. Test transmission

can be used when verifying radio connection possibilities at the installation site. After turning on this mode, the module sends a test message at regular intervals, which can be received in the vicinity of the module by a radio traffic analyzer and thus verify the possibility of radio connection. The transmission period is set in seconds. Example of a command to check the current status and make a change to set the test message transmission period to 5 seconds:

```
wm868-SI4-2>waco ttout
Test timeout:  20 sec.
wm868-SI4-2>waco ttout 5
Test timeout:  5 sec.
wm868-SI4-2>
```

We turn the test transmission on and off using the command **"system txtest 0/1"** which is listed in the "system" group commands. Example of a command to turn test transmission on and off:

```
wm868-SI4-2>system txtest 1
TX test :  1
wm868-SI4-2>system txtest 0
TX test :  0
wm868-SI4-2>
```

After turning on the test transmission, the module sends "empty" messages of type "TEST" (port "31") at set intervals until the command to turn off the test transmission is given, or until the module is restarted. **The manufacturer recommends using the test transmission mode only in justified cases and for the shortest possible time so as not to unnecessarily drain the battery**.

The command **"waco encrypt [port] [key]"** is used to set the **encryption key** for encrypting the content of the sent message. Different encryption keys can be set for different ports (applications). Set the encryption key by writing the WACO protocol port number and any string of up to 16 characters after the "waco encrypt" command. Based on this string, the module generates a cipher according to the proprietary Softlink algorithm. Spontaneously sent INFO messages of the WM868-SI4-B module have port number "37". The same string can be used to generate a key for decrypting messages on the receiving side (in the central data collection application) using the same algorithm. Cancel the encryption setting for a given port with the command "waco encrypt delete [port]". Example of setting and deleting the key for INFO messages (port 37):

```
wm868-SI4-2>waco encrypt 37 abcde
Encrypt port:  37
wm868-SI4-2>waco encrypt delete 37
Encrypt port:
wm868-SI4-2>
```

Warning! *The encryption setting always needs to be addressed in the project, in coordination with the module manufacturer.*

The commands **app repeat** and **app tout** are intended to set the number and period of repetition of unconfirmed messages in WACO transmission mode. Some applications require confirmation of messages by their recipients, and if the sending module does not receive confirmation ("acknowledgement") from the recipient, it repeats the message once or several times after a set time interval. The WM868-SI4-B module does not use any application with message confirmation, so the manufacturer recommends **leaving the parameter values in the default setting**.

The command **app master** is intended to set the address of the virtual bus master in WACO transmission mode. Since the WM868-SI4-B module does not use the "virtual bus" application, this setting has no practical significance and the manufacturer recommends **leaving the parameter value in the default setting**.

3.1.6 Commands for configuring Wireless M-Bus transmission mode

This group of commands is used to set the parameters of the WM868-SI4-B module in Wireless M-Bus transmission mode (hereinafter "WMBUS"). These are the following commands:

```
wm868-SI4-2>wmbus
mode      - set mode
channel   - set channel
id        - set ID
manuf     - set manufacturer
medium    - set medium
version   - set version
ekey      - set encryption key
wm868-SI4-2>
```

The command **"wmbus ?"** displays the above "HELP" listing for the WMBUS section.

The command **"wmbus mode"** sets the communication mode according to the Wireless M-Bus standard. The module supports communication modes "T1" and "C1", with T1 mode set by default. Change the communication mode by entering the desired option as a parameter after the "wmbus mode" command. Example of checking the current setting and making a change to the communication mode:

```
wm868-SI4-2>wmbus mode
Mode :  T1
wm868-SI4-2>wmbus mode C1
Mode :  C1
wm868-SI4-2>
```

The command **"wmbus channel [number]"** is used to set the frequency channel of the RF part of the module. The transmission channels for individual frequency bands are defined by the Wireless M-BUS standard. For the WM868-SI4-B module operating in the 868 MHz frequency band, only one frequency channel is available (option "0") with a center frequency of 868.950 MHz and a bandwidth of 200 kHz. Using the "wmbus channel" command has no significance for this type of module.

The command **"wmbus id"** is used to set the device identification number in the identification system according to the M-Bus standard. The identification number of the WM868-SI4-B module is set at the factory to be unique for the manufacturer code "SFT" and is listed on the module's production label ("WM BUS ID"). Unless there is a serious reason, the module manufacturer does not recommend changing the identification number setting.

The command **"wmbus manufacturer"** is used to set the international manufacturer code in the identification system according to the M-Bus standard. The code value for the WM868-SI4-B module is set at the factory to "SFT" (unique code of the manufacturer SOFTLINK) and unless there is a serious reason, the module manufacturer does not recommend changing the manufacturer code setting.

The command **"wmbus version"** is used to set the generation or version number of the module in the identification system according to the M-Bus standard. The value for the WM868-SI4-B module is set at the factory and unless there is a serious reason, the module manufacturer does not recommend changing this setting.

The command **"wmbus medium"** is used to set the international code of the measured medium (energy, water, physical quantity...) in the identification system according to the M-Bus standard. The parameter value for the WM868-SI4-B module is set at the factory to "7" (Water). If the module measures a medium other than water, change the setting by entering the desired medium code according to the M-BUS standard (allowed range: 0 to 255) after the "wmbus medium" command. Example of checking the current setting and changing the medium code to value "2" (electricity):

```
wm868-SI4-2>wmbus medium
Medium :  7
wm868-SI4-2>wmbus medium 2
Medium :  2
wm868-SI4-2>
```

***Note**: For the M-Bus identification system, it generally applies that the combination of all four components of the M-Bus address (i.e. "M-BUS ID", "Manufacturer", "Version" and "Medium") must be unique, so there must not be two devices with the same combination of these four parameters. For devices with a fixed configuration of these parameters, the uniqueness of identification is ensured by the device manufacturer. For devices with configurable identification parameters, depending on the specific identification rules used, the serial number of the connected meter can be used (in combination with its type, model and manufacturer), or the serial number of the radio module (in combination with its type and manufacturer). The use of an "independent" number series is only possible if the system operator has its own manufacturer code and is able to ensure that in combination with this code, the identification of each device will be unique.*

The command **"wmbus ekey"** is used to set the encryption key for message encryption using the **AES-128** algorithm. Enter the 16-byte encryption key using the "wmbus ekey" command followed by a string of 16 bytes, which we enter in hexadecimal form as 32 consecutive characters (characters "0" to "f", without spaces and without prefixed "0x"). Example of entering the encryption key 1A 2B 3C 4D 5E 6F A1 B2 C3 D4 E5 F6 77 88 99 AF:

```
wm868-SI4-2>wmbus ekey 1a2b3c4d5e6fa1b2c3d4e5f6778899af
wm868-SI4-2>
```

The current value of the encryption key displays in the module configuration listing, where the key value is displayed at the end of the "WMBUS" section:

```
wm868-SI4-2>conf
Config      :  Not Written
--- WACO protocol ---
channel     :  0
Group       :  0
...
--- WMBUS ---
ID          : 10300017
Manuf       :  SFT
Version     :  1
Medium      :  7
Encrypt key :  1a2b3c4d5e6fa1b2c3d4e5f6778899af
Encrypt type:  AES2
...
```

The encryption can by turned off by entering the parameter "." (period) after the **"wmbus ekey"** command:

```
wm868-SI4-2>wmbus ekey .
wm868-SI4-2>
```

In the WMBUS configuration listing, the encryption type line will show "Encrypt type: none".

Warning! *WM868-SI4-B modules are supplied from the factory with data encryption turned off. Setting encryption in Wireless M-Bus transmission mode always needs to be addressed in the project, in coordination with the module manufacturer.*

3.1.7 Commands for configuring LoRa transmission mode

This group of commands is used to set the parameters of the WM868-SI4-B module in LoRa transmission mode. These are the following commands:

```
wm868-SI4-2>lora
info      - print LoRa driver info
regs      - print LoRa driver registers
band      - set band
channel   - set channel
dr        - set data rate
rxdly     - set receive delay
jadly     - set join accept delay
acklimit  - set ACK limit
ackdelay  - set ACK delay
acktimeout - set ACK timeout
netadr    - set LoRa network address
nwkskey   - Network SKey
appskey   - Application SKey
appkey    - Root Key
joineui   - JoinEUI
encrypt   - Enable Application encryption
otaa      - Join to LoRaWAN
wm868-SI4-2>
```

The commands **"lora info"** and **"lora regs"** are used to display the settings of the LoRa subsystem. These commands are only used for module diagnostics in the manufacturer's laboratory.

The **"lora band"** command can be used to set the regional frequency plan according to the LoRa specification. For the Czech Republic region in the 868 MHz band, the frequency plan EU863-870 (abbreviated as "EU868") is reserved, which corresponds to option "0". The current version of the WM868-SI4-B module only supports the EU868 frequency plan, which is set at the factory. The manufacturer does not recommend changing this parameter.

The **"lora channel"** command is used to set the RF subsystem frequency channel for operation in ABP mode in LoRa transmission mode. For the EU868 frequency plan, 3 default frequency channels with a width of 125 kHz are defined:

- channel "0": center frequency 868.10 MHz,
- channel "1": center frequency 868.30 MHz,
- channel "2": center frequency 868.50 MHz.

***In ABP mode (Activation by Personalization)**, the module transmits only on the set transmission channel, which is always one of the default LoRa system channels in the given country.*

***In OTAA mode (Over The Air Activation)**, the module sends a "Join-Request" message on the set channel in the initialization phase to join the network. After the request is accepted ("Join Accept" message), the module may be assigned additional transmission channels from the network, of which there are a total of 8 available in the EU868 frequency plan. In OTAA mode, the module transmits randomly (cycles) on all available channels (default and additionally assigned).*

Example of checking the current status and then setting frequency channel "1":

```
wm868-SI4-2>lora chan
Channel :  0
wm868-SI4-2>lora chan 1
Channel :  1
wm868-SI4-2>
```

The **"lora dr"** command is used to display or set the data rate at which the module transmits data. The WM868-SI4-B module supports these Data Rate (DR) values:

- channel "DR0" - 250 bit/s
- channel "DR2" - 440 bit/s
- channel "DR2" - 980 bit/s
- channel "DR3" - 1,760 bit/s
- channel "DR4" - 3,125 bit/s
- channel "DR5" - 5,470 bit/s
- channel "DR6" - 11,000 bit/s
- channel "DR7" - 50,000 bit/s

The WM868-SI4-B module always transmits messages with the set Data Rate value. The "Adaptive Data Rate" function is not supported in the current version of the WM868-SI4-B module. In OTAA mode, a Data Rate value for communication in the second receive window (RX2) may come from the network. The module respects this setting and presets the DR value received from the network for reception in the second window.

Example of checking the current Data Rate setting and then setting it to "DR4":

```
wm868-SI4-2>lora dr
Data Rate :  0
wm868-SI4-2>lora dr 4
Data Rate :  4
wm868-SI4-2>
```

Battery-powered LoRa devices open two transmission windows after sending each message: RX1 and RX2. The **"lora rxdly"** command (Receive Delay) is used to set the delay of the first receive window (i.e., the time interval between the end of the transmission window and the start of the first receive window) in seconds. The recommended initial setting for this parameter for the EU868 frequency plan is 1 second, which is also the value to which the "lora rxdly" parameter is set at the factory. Example of checking the current "lora rxdly" setting and changing it to "1" (1 second):

```
wm868-SI4-2>lora rxdly
Recv Delay :  2
wm868-SI4-2>lora rxdly 1
Recv Delay :  1
wm868-SI4-2>
```

In ABP mode (Activation by Personalization), the first receive window always opens with the set "lora rxdly" delay. This value is also stored in the network's BackEnd, so the network always sends reverse channel messages in this window.

In OTAA mode (Over The Air Activation), a different time interval for the RX1 window delay is used for the initial phase of the device activation process, which is set using the **"lora jadly"** command (Join Accept Delay). This parameter is set to 5 seconds and the manufacturer strongly recommends not changing its value. In the "Join Accept" confirmation packet, the network sends the module an assigned Receive Delay value, which the module saves instead of the originally set "lora rxdly" value.

For both modes, the **second receive window RX2** is always opened 1 second after the first transmission window opens.

The receive windows are opened for the time necessary to detect a possible message in the reverse channel. If the module receives a message in the receive window, the receive window closes only after the message is delivered.

The commands **"lora acklimit", "lora ackdelay"** and **"lora acktimeout"** are reserved for setting functions that are not supported in the current version of the module. Using these commands has no significance for the current version of the WM868-SI4-B module.

The **"lora netadr"** command is used to set the module's **network address** for ABP mode to match the address set for the given module in the network BackEnd. In OTAA mode, the module receives the network address during the initialization process in the confirmation packet. The network address is 4 bytes and is entered in hexadecimal format (prefixed with "0x"). Example of checking the current network address setting and then setting the address to "FF FF 12 34":

```
wm868-SI4-2>lora netadr
Dev Addr :  0x00000000
wm868-SI4-2>lora netadr 0xffff1234
Dev Addr :  0xffff1234
wm868-SI4-2>
```

This address is valid locally in the given network. For global addressing, a unique identification code "Dev EUI" is used, which is directly stored in the RF chip (similar to the MAC address in Ethernet). The "Dev EUI" value is shown on the module's production label and is displayed in the module configuration listing in the first line of the "LoRa App" section:

```
--- LoRa App ---
Dev Addr :  0xffff1234
```

The commands **"lora nwkskey"** and **"lora appskey"** are used to set the "Network Session Key" and "Application Session Key" for generating the cipher that will encrypt the data contents of messages in LoRa transmission mode. The "Network Session Key" is used to encrypt service messages (these messages always have port number "0"), the "Application Session Key" is used to encrypt application messages.

Both keys are created (along with the network address) when the module is introduced to the BackEnd. In ABP mode, all three pieces of information must be "rewritten" from the BackEnd database to the module parameters. In OTAA mode, the module creates these keys itself based on the "JoinNonce" information it receives from the network during the initialization process.

Both keys are 16 bytes long and are entered in hexadecimal format as 32 consecutive characters (characters "0" to "f", without spaces and without prefixed "0x"). Example of setting the "lora nwkskey" key to "1A 2B 3C 4D 5E 6F A1 B2 C3 D4 E5 F6 77 88 99 AF":

```
wm868-SI4-2>lora nwkskey 1a2b3c4d5e6fa1b2c3d4e5f6778899af
NwkSKey :  1a2b3c4d5e6fa1b2c3d4e5f6778899af wm868-SI4-2>
```

The current value of the encryption key appears in the module configuration listing, where the key value is displayed in the "LoRa App" section:

```
--- LoRa App ---
Dev Addr :  0x00000000
NwkSKey :  1a2b3c4d5e6fa1b2c3d4e5f6778899af
AppSKey :  00000000000000000000000000000000
```

Similarly, the key for encrypting application data is entered using the "lora appskey" command.

Warning! *For modules with OTAA activation mode, these two keys are not entered, the module creates them during the initialization process based on information from the network. However, for this mode, it is necessary to set the "lora appkey" and "joineui" keys, which serve (together with the "Dev EUI" identifier) as identification and personalization elements when the module logs into the network.*

The commands **"lora appkey"** and **"lora joineui"** are used to display the "Root Key" and "Join EUI" keys with which the module reports during the initialization process in OTAA mode. The module creates these keys itself during the manufacturing process. These keys must be pre-set in the network BackEnd database so that the network can identify and activate the given module. These keys are not needed for operation in ABP mode. The "lora appkey" and "lora joineui" keys can also be entered manually using the mentioned commands in a similar way as the "Network Session Key" and "Application Session Key" keys, with the only difference being that the "Join EUI" key is only 8 bytes long (16 hexadecimal characters).

The **"lora encrypt [0/1]"** command can be used to turn application data encryption on or off. Example:

```
wm868-SI4-2>lora encrypt
Encrypt :  0
wm868-SI4-2>lora encrypt 1
Encrypt :  1
wm868-SI4-2>
```

For application data encryption to function, it is necessary to enter the "Application Session Key" or "Root Key" encryption keys as described above. Service messages on port "0" are always encrypted.

The **"lora otaa [0/1]"** command is used to switch between ABP (Activation by Personalization) and OTAA (Over The Air Activation) activation modes. OTAA mode is turned on by setting the parameter to "1". Turning off OTAA mode (value "0") turns on ABP mode. Example of checking the current setting and then turning on OTAA mode:

```
wm868-SI4-2>lora otaa
OTAA : 0
wm868-SI4-2>lora otaa 1
OTAA : 1
wm868-SI4-2>
```

The difference between the module activation modes is as follows:

In **ABP mode**, the manufacturer provides the network operator with 3 pieces of information with the device delivery:

- unique device identification code "Dev EUI",
- login key "Root Key"
- login key "Join EUI"

The network operator enters this information into the BackEnd database and based on this, the BackEnd generates these 3 pieces of information that need to be set in the module configuration:

- network address "NetAddr"
- encryption key "Network Session Key"
- encryption key "Application Session Key"

The disadvantage of ABP mode is the need to set parameters in the module configuration before putting it into operation.

In **OTAA mode**, the manufacturer provides the network operator with the same 3 pieces of information with the device delivery:

- unique device identification code "Dev EUI",
- login key "Root Key"
- login key "Join EUI"

The network operator enters this information into the BackEnd database. In this case, however, nothing needs to

be entered into the module configuration. When the module first logs into the network, it receives back from the network the network address "NetAddr" and the "JoinNonce" information, which it uses to create the "Network Session Key" and "Application Session Key" keys. The network BackEnd simultaneously generates both of these keys using the same algorithm. In OTAA mode, it is thus possible to deploy modules directly from production, without the need for any settings.

3.1.8 Commands of the "Application" group for setting the data sending application

This group of commands is used to set the parameters of the message sending application. The commands are common for all modes. These are the following commands:

```
wm868-SI4-2>app
?         - help
info      - print Rf APP info
sending   - set sending interval in secs.
measure   - set measure interval in secs.
wm868-SI4-2>
```

Use the command **"app ?"** to display the above "HELP" listing for the "Application" section.

Use the command **"app info"** to display the status of selected internal registers of the radio subsystem. This command is only used for module diagnostics in the manufacturer's workshop.

The command **"app sending [number]"** is used to set the repetition period for sending information messages. The transmission repetition period is set in seconds, so if the module should send messages every hour, set the parameter value to "3600". Example of checking the current setting and then changing the repetition period from 900 to 1800 seconds (30 minutes):

```
wm868-SI4-2>app sending
Sending :  900 secs.
wm868-SI4-2>app sending 1800
Sending :  1800 secs.
wm868-SI4-2>
```

After this setting, the module will transmit an information message every 30 minutes.

The command **"app measure [number]"** is used to set the period for measuring analog values (temperature, voltage...) in seconds. This period should always be significantly shorter than the message sending period. The measured value is updated after each measurement, and the current value at the time of sending the message is sent in the "INFO" message. Example of a command to set the analog value measurement period to 5 minutes:

```
wm868-SI4-2>app measure
Measure :  60 secs.
wm868-SI4-2>app measure 300
Measure :  300 secs.
wm868-SI4-2>
```

3.1.9 Commands for setting internal counters

The WM868-SI4-B module is equipped with four pulse counters (index 0 to 3), allowing connection of up to four consumption meters with pulse output. Each counter is individually configurable, so the connected meters can be of different types (with different pulse frequencies, initial states, multipliers, dividers...).

Each input can also be set to "alarm mode", where the module immediately sends an alarm message when the input value changes (i.e., when transitioning from state "0" to state "1", or vice versa). The module can thus transmit information from **two-state sensors** such as protective contacts, door contacts, flood sensors, etc.

We configure the counters using the following commands from the "input" group:

/input [index] set [value]	*setting the initial value of the counter (which is added to)*
/input [index] edge [0/1]	*setting the trigger edge of the counter*
/input [index] type [0/1/2]	*setting the counter operation mode: 0-fast pulses, 1-edges, 2-slow pulses*
/input [index] mul [value]	*setting the multiplier*
/input [index] div [value]	*setting the divider*
/input [index] on [value]	*setting the alarm code for transition to state "1"*
/input [index] off [value]	*setting the alarm code for transition to state "0"*
/input	*listing the settings of individual inputs*

We can display the list of the above commands using the "input ?" command:

```
wm868-SI4-2>input ?
set     - set value
mult    - set multiplier
div     - set divider
edge    - set edge
type    - set type 0-interrupt driven, 1-alarm input, 2-slow input
on      - set alarm code for ON
off     - set alarm code for OFF
wm868-SI4-2>
```

Using the command **"input [index] set [value]"**, we set the initial state of individual counters by entering a positive integer to which the pulse counter of the given input should be set.

The command **"input [index] edge [0/1]"** is used to specify the "edge detection" mode. Depending on the parameter setting, the counter value increases from the falling or rising edge of the measuring pulse.

Using the command **"input [index] type [0/1/2]"** set the counter's operation mode. Enter number "0" for the standard "fast" mode without a filter, number "2" enter for the "slow" mode with a smoothing filter. Value "1" is intended for the "edge detection" mode in alarm mode, where the counter state only changes from "0" to "1" and vice versa depending on the input signal values. In alarm mode, the module only registers and sends changes in the input state.

The commands **"input [index] mul [value]"** and **"input [index] div [value]"** are used to set multiplication and division constants for any mathematical adjustment of the number of counted pulses to the required output units.

The commands **"input [index] on [value]"** and **"input [index] off [value]"** are used to set the code of the sent event in alarm mode. Using the "on" command, we set the event code that is generated and sent when the input transitions from state "0" to state "1". Using the "off" command, we set the event code for the transition from state "1" to state "0".

We can introduce here a pair of general codes "5" (alarm state) and "4" (normal state), or specific pairs "9" - "8" (open - closed), "6" - "7" (connected - disconnected), or "13" - "14" (flooded - not flooded). The current list of alarm codes is published at the WEB address NEP Page.

The settings of the module's pulse counters can be checked by using the **"input"** command. For each input, the following data are listed in the output: value - edge - type - multiplier - divider - alarm ON - alarm OFF

Example of a sequence of commands for setting the counter of the first and second port (index "0" and "1") with subsequent checking of the settings:

```
wm868-SI4-2>input 0 set 127
wm868-SI4-2>input 0 set 127
wm868-SI4-2>input 0 edge 1
wm868-SI4-2>input 0 type 0
wm868-SI4-2>input 0 mul 5
wm868-SI4-2>input 0 div 10
wm868-SI4-2>input 1 type 1
wm868-SI4-2>input 1 on 5
wm868-SI4-2>input 1 off 4
wm868-SI4-2>input
Idx.  VALUE Edge Type Multiplier Divider AlarmON AlarmOFF
-------------------------------------------------------------------
I1:     127   1    0    5       10     8     9
I2:     0     0    1    1       1      5     4
I3:     0     0    0    1       1      8     9
I4:     0     0    0    1       1      8     9
wm868-SI4-2>
```

From the output, it is clear that the first port is set to fast pulses, the counter value increases from the rising edge, the initial counter state is set to 127, and in the message, the counter values will be multiplied by a coefficient of 0.5 (*5 /10). The second port is in alarm mode, when transitioning to state "1", an event of type "5" (alarm state) is generated, when transitioning to "0", an event of type "4" (normal state) is generated.

3.1.10 Commands of the "System" group for module initialization and diagnostics

This group of commands is used for initial checking and setting of module parameters during its production and initialization, and for its diagnostics in the manufacturer's laboratory. The commands are common for all transmission modes, but some of them are only relevant for setting the "WACO" mode. These are the following commands:

```
wm868-SI4-2>system
?       - help
info    - print system info
rfa     - set RF address
txtest  - run TX test
debug   - set debug level
dump    - [address] dump memory
modify  - [address] modify memory
task    - print tasks
mbox    - print mailboxes
port    - print port A,B,C,H
mco     - set MCO output, 0-disable,1-enable
adc     - print ADC info
i2c     - I2C driver commands
ble     - ble commands
wm868-SI4-2>
```

The command **"system ?"** displays the above "HELP" listing for the "System" section.

The command **"system rfa"** displays the radio address of the module for the WACO transmission mode. The command is also used for the initial input of the radio address, which can only be entered once and cannot be overwritten.

The command **"system txtest [0/1]"** turns on or off the test transmission in WACO transmission mode. The use of the command is described in more detail in paragraph 3.1.5 "Commands for configuring the WACO transmission mode".

Other commands are used exclusively for setting basic parameters of the module during its initialization, or for its diagnostics in the manufacturer's workshop. **The manufacturer strongly recommends against using them during normal operation of the module.**

3.1.11 Commands for setting the Bluetooth subsystem

This group of commands can be displayed by entering the command "ble":

```
wm868-SI4-2>ble
txp       - TX power in dBm
chmask    - Advertisement channel mask
advtout   - Advertisement timeout/period
conntout  - Connection timeout
pin       - BLE pin
wm868-SI4-2>
```

The commands are used exclusively for setting basic parameters of the module during its initialization, or for its diagnostics in the manufacturer's workshop. **The manufacturer strongly recommends against using them during normal operation of the module.** The exception is the "pin" command, which can be used to enter the PIN value for authorizing the connection of an external device (mobile phone) to the module via Bluetooth. Even this step should be consulted with the manufacturer.

3.2 Setting module parameters using a mobile application

The module is equipped with a Bluetooth Low Energy wireless subsystem (hereinafter "Bluetooth" or "BLE"), which is used for its remote configuration using an application on a **mobile phone**. The module can be configured in this way at a distance of up to several meters using only a "smartphone" category mobile phone with the installed "Softlink Configurator" application, which is available for mobile phones with Android or iOS operating systems.

The description of connecting the module to a mobile phone via Bluetooth wireless connection and general rules for configuring the module using the "Softlink Configurator" mobile application are described in Chapter 3 of the manual "Configuration of devices in the wacoSystem product line".

A great advantage of setting up the module using a mobile application is communication through the closed plastic cover of the module, without the need to open it, or setting up a module placed in a more difficult to access location (for example, on the ceiling of a room).

Configuring the module from a mobile application via the Bluetooth wireless interface has several general steps:

1. Download the "Softlink Configurator" mobile application from the "Google Play" (Android) or "App Store" (iOS) store. Use the keyword "Softlink" to search, the application is presented under the name "BLE Configurator";
2. If you have had the application installed for a long time, check if you have the latest version of the application (menu "Check for updates") and download the latest set of configuration forms (menu "Update forms"). To do this, you need to activate an Internet connection;
3. Activate the Bluetooth system on your mobile phone, or allow the application to turn on Bluetooth when starting the application;
4. Make sure the module is turned on and launch the application. A list of devices with Bluetooth transmitter turned on will appear on the screen. Find the configured device in the list according to the MAC address (the Bluetooth MAC is written on the production label of the configured module);
5. Connect to the configured device with the Bluetooth symbol button;
6. When connecting to a given device for the first time, the application may require entering an authorization PIN (default "123456"). A normal connection process will take place, the same as with other Bluetooth devices. The process ends with the message "Connected to device";
7. The entire connection process can be simplified by scanning a QR code. By clicking on the "SCAN QR CODE" button, the phone's camera turns on and the QR code on the mobile label can be scanned. If the QR code enters the camera's field of view, the module will automatically connect to the application;
8. After connecting the module to the application, click on the "Configuration" option at the bottom of the form (or "swipe" the configuration form by moving your finger to the side). Click on the "START (INIT)" button, which loads the initial "Device Details" form with the basic device parameters listed;
9. We then configure the parameters using configuration forms. Each form focuses on some area of configuration (for example, the "Network Settings" form is intended for setting communication with the network). Select the form from the list that opens by clicking on the "SELECT FORM" button;

10. In the form, check and possibly change individual parameters, either by direct editing of the field or by selecting from preset values. After each edit/selection press "Save", which closes the item. After editing all desired items in the form save the entire set of parameters to the module's memory using the "WRITE (SET)" button. A help dialog box will pop up with the information "Performing SET", which will disappear after the operation is completed;
11. The success of the operation can be verified by downloading the configuration parameters directly from the module using the "READ (GET)" button, which will display in the form the parameter values that the module currently has stored in memory;

The "Softlink Configurator" application currently offers five configuration forms for configuring the WM868-SI4-B module, which allow checking and setting all module parameters that are needed for its installation and normal operation. However, the application is continuously developing and its possibilities and functions are gradually expanding.

The **"Administrative form"** is used to check the functionality of the module. It contains a listing of the main operational parameters and a button for launching a function. The form contains these non-editable information:

- **RESET** button for resetting the module
- **Uptime** value since the last reset
- **battery voltage** value
- current **processor temperature**
- **packet transfer statistics** since reset

The **"Basic Settings"** form is used to set communication parameters and pulse input parameters. The form contains these information and tools:

- setting the **sending period** of information messages
- setting the **communication mode**
- setting **parameters of individual inputs** (state, type, level)

The **"WACO Settings"** form is used to set parameters for communication in WACO transmission mode. The form contains these information and tools:

- **Set WACO** choice button for switching to WACO transmission mode
- setting the **radio address** for WACO mode
- setting the **group address** (Group Address)
- setting the **frequency channel** (Channel)
- setting the **max. number of hops** (Hop Count)
- setting the **transmit power**
- setting the **receive window length** (RX TimeOut)
- setting the **carrier detection function** (Carrier Detect)

The **"WMBUS Settings"** form is used to set parameters for communication in Wireless M-Bus transmission mode. The form contains these information and tools:

- **Set WMBUS** choice button for switching to WMBUS transmission mode
- setting the **mode** of the Wireless M-Bus protocol
- setting the **transmit power**
- setting the **M-Bus address** (M-Bus ID)
- setting the **manufacturer code** (Manufacturer)
- setting the **version/addressing number** (Version)
- setting the **medium code** (Medium)
- setting the **encryption key** for WMBUS transmission mode

The **"LoRa Settings"** form is used to set parameters for communication in LoRa transmission mode. The form contains these information and tools:

- **Set LORA** choice button for switching to LoRa transmission mode
- setting the **network address** of the LoRa protocol
- setting the **Network Session Key**
- setting the **Application Session Key**
- setting the **Application Key** (Root Key)
- setting the **Join EUI**
- setting the device class **Do not use!**
- setting the **activation mode** (ABP/OTAA)
- allowing adaptive power function **Do not use!**
- allowing **application data encryption**

- setting the **frequency band**
- setting the **frequency channel**
- setting the **data rate** (Data Rate)
- setting the **Receive Delay**
- setting the **Join Delay**
- setting Acknowledge Limit **Do not use!**
- setting Acknowledge Delay **Do not use!**
- setting Acknowledge Timeout **Do not use!**

The meaning of individual parameters is described in detail in section 3.1 "Setting WM868-SI4-B module parameters using a configuration cable".

A preview of the screens of individual configuration forms is shown in Figure 4.

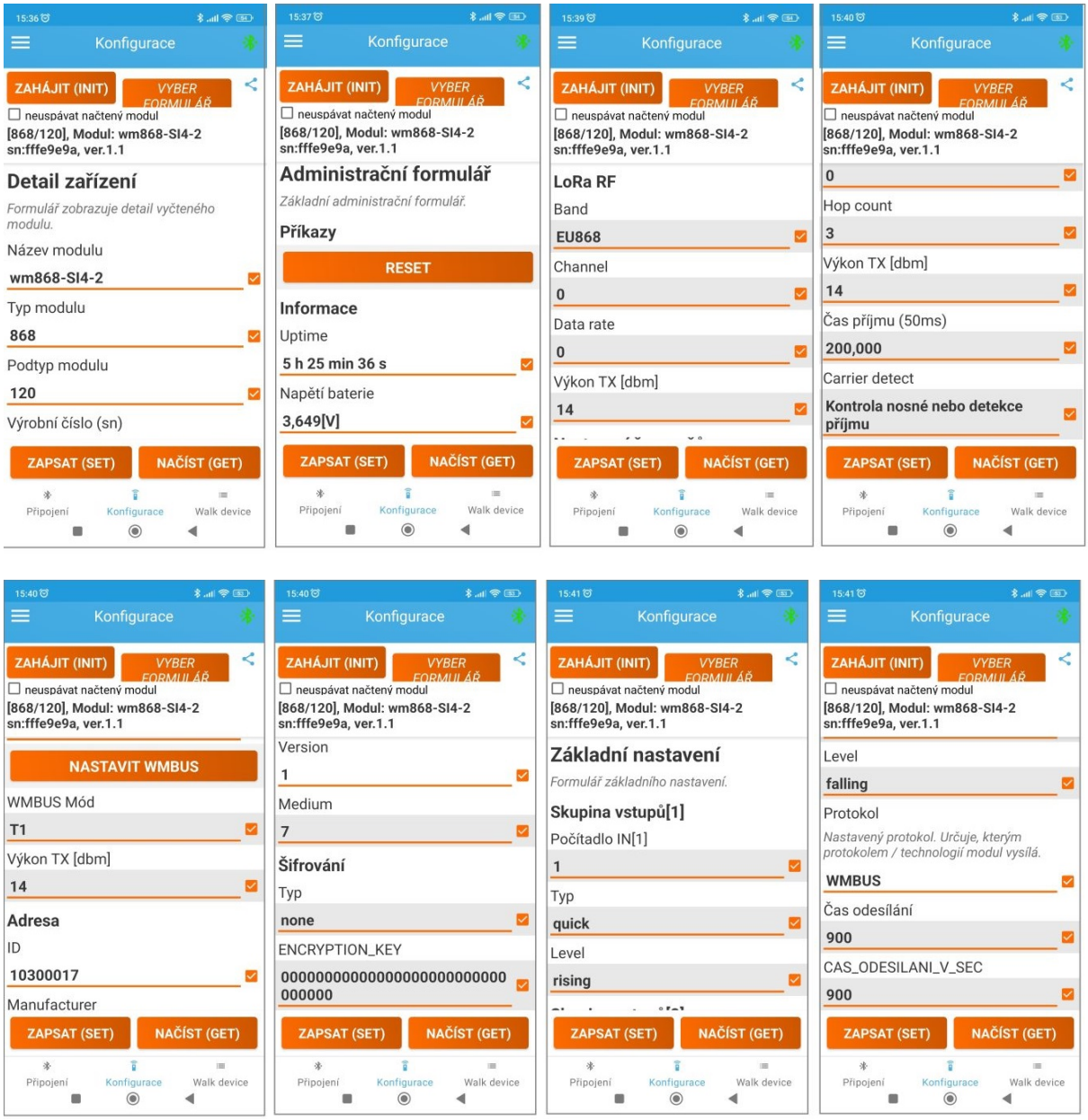

Figure 4: Preview of forms for setting the WM868-SI4-B module using a mobile application

3.3 Setting module parameters from a remote computer using a reverse channel

The WM868-SI4-B module supports communication in the so-called **reverse channel** (from the central application to the module) in WACO and LoRa transmission modes. The possibilities of two-way communication via the reverse channel can be used for remote parameter setting from a remote computer. The reverse channel opens for a short time only to save battery, following data transmission (see setting the receive window in WACO and LoRa

transmission mode), during this time the module can receive a message from the central application that is prepared for it in the BackEnd or in the communication gateway.

Messages in the reverse direction used for setting module parameters (so-called "setting messages") are encoded by the NEP protocol, so they have essentially the same structure as messages sent by the module in WACO and LoRa transmission mode. The first variable in each setting message is always the **message type**. Setting messages are always of type **"SET"** (OiD 63 = **"1"**). This variable is followed by one or more variables for which a change is requested.

The WM868-SI4-B module sets the required parameters (updates the specified variables) and sends back a message of type **"RESPONSE"** (OiD 63 = **"4"**), which contains the values of the changed variables after the change is made.

Using setting messages of the reverse channel, the same parameters can be set as when setting the module using radio or mobile application, because both methods work on the same principle. More detailed information about the possibilities of communication via the reverse channel can be obtained by contacting the module manufacturer.

4 Structure of the module's data message

The data message structure differs according to the set communication technology, see table 4.

Table 2: Overview of communication protocols of the WM868-SI4-B module

radio technology	communication protocol
WACO	NEP
LoRa	NEP
wM-BUS	M-BUS

The setting of the radio technology choice is covered in chapter 3.1.3

4.1 WACO

The module communicates with other elements of the WACO RF network by data messages of the WACO SLRF communication protocol, which observes ISO/OSI communication model, its typical features are high effectivity and reliability, and enables huge variability of supported applications. A structure of individual layers of the WACO SLRF protocol is shown in the figure 5.

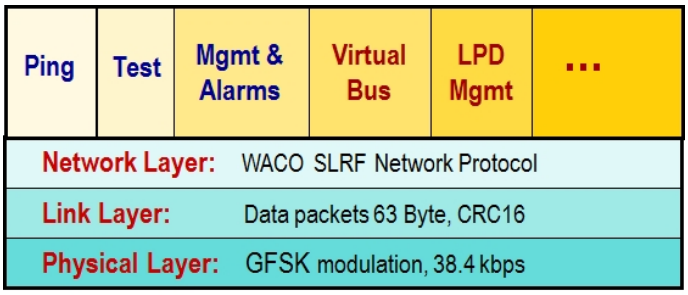

Figure 5: WACO SLRF protocol structure

Maximum total length of WACO SLRF data packet („packet") is 63 Byte. The packets are bordered by preamble code and synchro-bits (6 Byte in total) at the beginning and by 16-bit checksum code (CRC) at the end.

Each data message contains 11 Byte long fixed header and data content („Payload") with maximum length of 52 Byte. Packet header is very simple and contains only information that are necessary for routing of the packet (source and destination address, hop count, transaction ID) and a type of respective application („port number"). Payload data coding method is determined by application type. WACO SLRF data packet structure is shown in the figure 6.

The WM868-SI4-B module is used for reading the status of consumption meters with pulse output and sending current data on the status (reading) of meters to the WACO radio network through "INFO" type messages. The transmission of "INFO" messages takes place in the "SISA_TX" type application (port number 37) of the "LPD Management" group (LPD = Low Power Devices), used for data collection from battery-powered devices. These devices communicate in the so-called "active mode", where the device actively sends data at adjustable intervals and does not wait for confirmation of message receipt.

The WM868-SI4-B module sends current data on the status of counters of connected meters and accompanying operational data in **two** consecutive "INFO" type messages. The content of the **first message** "INFO" includes these variables:

- designation of the device **"subtype"** (modification) (OID=3)
- current **counter status** (OID=100/1, 100/2, 100/3, 100/4)

The content of the **second message** "INFO" includes these variables:

- designation of the device **"subtype"** (modification) (OID=3)
- current value of the module's **system time** in seconds (OID=13)
- **system runtime** (Uptime) in seconds (OID=12)
- current value of the **power supply battery voltage** in millivolts (OID=106/1)
- current value of the module's **processor temperature** in tenths of Celsius (OID=105/2)

Individual variables are coded into the data content of the message by using of "NEP" proprietary coding system invented by SOFTLINK. In this system each type of variable has its own designation called "OID" (Object ID), which determines meaning, character and data type of the variable. These variables, that could be used multiple

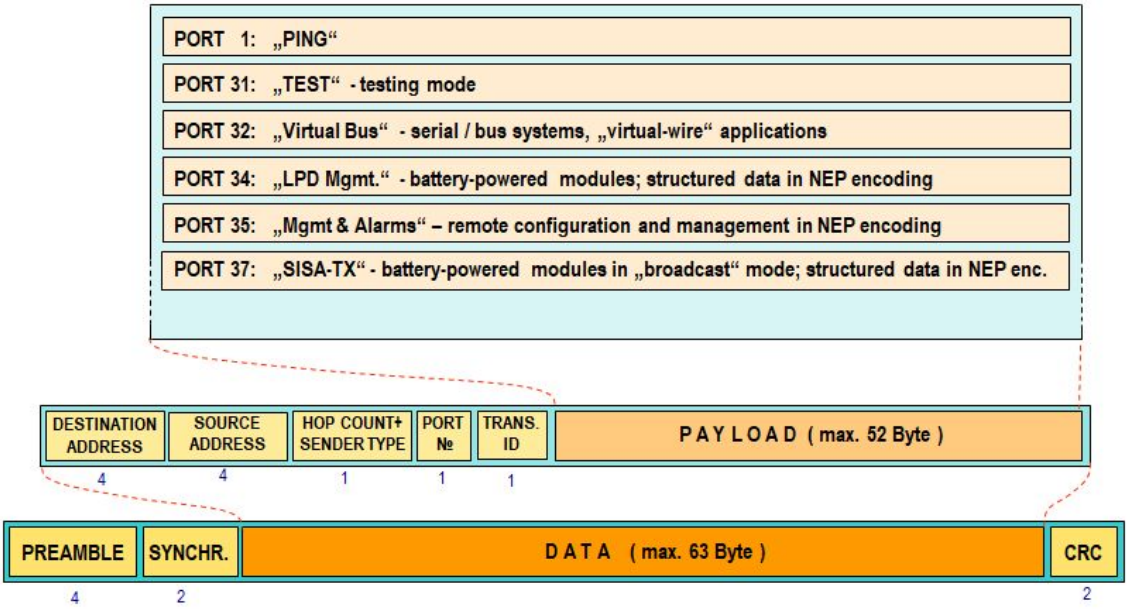

Figure 6: Structure of WACO system data packet

times (as multiple inputs, temperatures, voltages...) must be used jointly with order number of the variable called "Index". „NEP coding table" is centrally maintained by SOFTLINK and it is available on the public WEB address NEP Page. Preview of „NEP coding table" for coding of variables in the WACO system is shown in the figure 7.

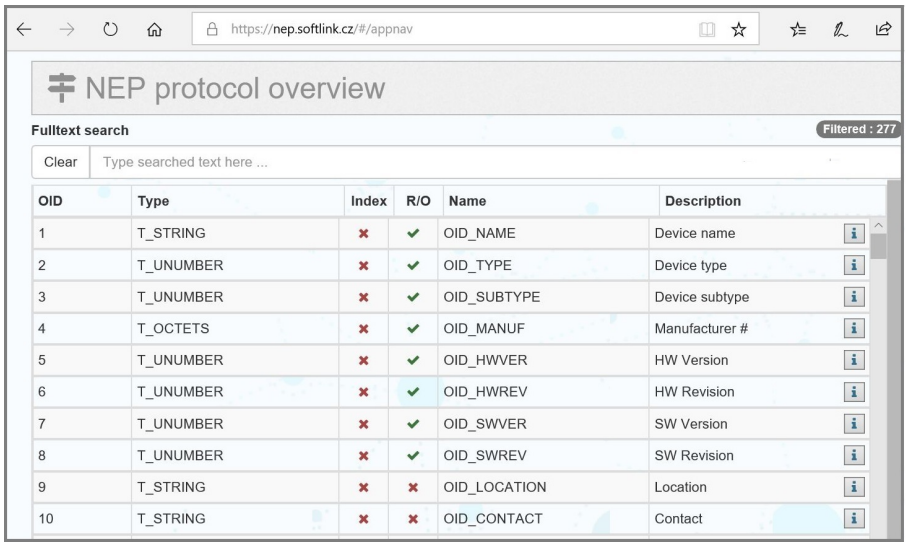

Figure 7: Preview of „NEP coding table" for coding of variables in WACO system

If a receiver of "INFO" messages from the module is „WACO collection unit" (see paragraph 1.4 „Module usage"), decoding of variables and their conversion into M-Bus system coding is performed by the collection unit.

If a receiver of "INFO" messages from the module is any other application, it must be equipped with a decoding program for working with WACO communication protocol („WACO Driver") that includes also NEP-decoder. Fixed general rules of NEP coding system enable decoding of any variable even if decoding system on the receiving side does not have all of them implemented. In this case the decoder extracts OID, index and value of the variable, but is not able to specify its meaning and measuring unit. WACO RFAN 3.x radio network analyzer has implemented a table of variables in the "oids.xml" file. If the table is not up to date, it could receive messages with „unknown" variables that appear in the table of variables as records with incomplete description. In this case it is recommended to replace "oids.xml" file by newest version that is available at producer of the analyzer.

A preview of the display of both "INFO" type messages of the WM868-SI4-B module in the "Packets" table of the RFAN 3.x analyzer is shown in Figure 8. The current values of variables contained in individual messages are displayed in the "tooltip" window when placing the cursor over the "Data" area of the given message.

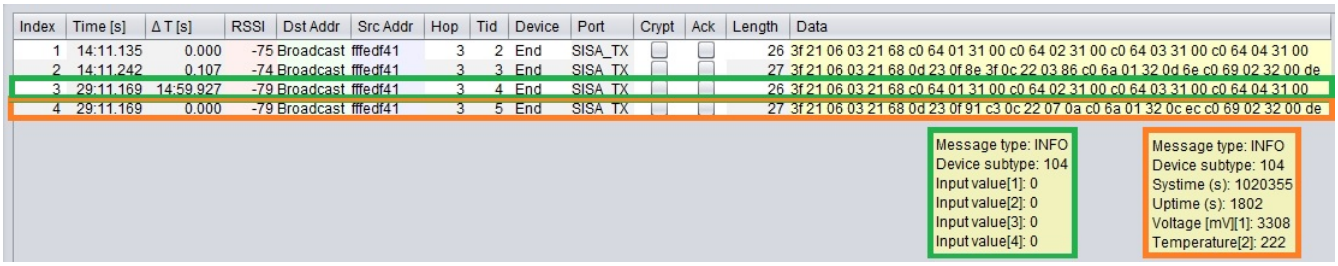

Figure 8: Display of the "INFO" message of the WM868-SI4-B module in the RFAN 3.x analyzer

4.2 LoRa

The data message sent via LoRa WAN radio technology is encoded using the NEP protocol, see chapter 4.1.

4.3 wM-Bus

Messages sent from the WM868-SI4-B module fully comply with the EN 13757 standard. The structure of the Wireless M-BUS module message header is shown in Table 3. The Wireless M-BUS header contains complete

Table 3: Structure of the Wireless M-BUS module WM868-SI4-Bmessage header

Name	Length (Byte)	Description/meaning
Message length (L)	1	Message length in Bytes
Packet type (C)	1	"Spontaneous User Data"
Manufacturer ID (M)	2	"SFT" (Softlink manufacturer code)
Serial number (A)	4	Module identification according to M-BUS standard (configurable)
Version (V)	1	Module generation/version according to M-BUS standard (configurable)
Medium (T)	1	Type of measured medium according to M-BUS standard (configurable)
Application type (Cl)	1	"Slave to Master, 4-Byte header, variable data format"

device identification according to the M-BUS standard (manufacturer/medium/version/serial number) and information about the message type and its content format. The header length is 10 Bytes (or 11 Bytes including the "Length" field). The shortened 4-Byte header of the M-Bus application layer message contains the following data:

- The "Sequence number" (Access No) item will increase with each sent message;
- The "Status" item is zero in normal state, value "04" ("Low Power") indicates low battery voltage;
- The "Signature" item contains the encryption type and parameter (if without encryption, then "00 00").

The "Signature" message item is modified to "01 XX" when the message is repeated by a repeater (the lower bit of the first Byte is changed from "0" to "1").

5 Operating Conditions

This section of the document provides basic recommendations for transport, storage, installation, and operation of WM868-SI4-B type radio modules.

5.1 General Operational Risks

Radio modules are electronic devices powered by their own internal battery, which register the status of counters or registers of connected consumption meters or sensors. During operation of the device, the following risks are particularly present:

5.1.1 Riziko mechanického a elektrického poškození

Zařízení jsou uzavřena v plastových krabičkách, takže elektronické součástky nejsou přístupné pro přímé poškození dotekem, nástrojem, nebo statickou elektřinou. Při běžném způsobu provozu nejsou nutná žádná zvláštní opatření, kromě zamezení mechanického poškození silným tlakem nebo otřesy.

Zvláštní pozornost vyžadují kabely, kterými jsou radiové moduly propojeny s měřiči spotřeby, čidly, nebo s externími anténami. Při provozu zařízení je potřebné dbát na to, aby tyto kabely nebyly mechanicky namáhány tahem, ani ohybem. V případě poškození izolace propojovacího kabelu doporučujeme kabel okamžitě vyměnit. Je-li modul vybaven externí anténou, stejnou pozornost je potřebné věnovat i anténě a anténnímu kabelu. Minimální poloměr ohybu anténního kabelu o průměru 6 mm jsou 4 cm, pro anténní kabel s průměrem 2,5 mm je minimální poloměr ohybu 2 cm. Nedodržení těchto parametrů ohybu může vést k porušení homogenity koaxiálního kabelu a tím ke snížení rádiového dosahu zařízení. Dále je potřebné dbát na to, aby připojený anténní kabel nadměrně nenamáhal na tah nebo zkrut anténní konektor zařízení. Při nadměrném zatížení může dojít k poškození nebo zničení anténních konektorů

Elektrickou montáž může provádět jen osoba s potřebnou kvalifikací v elektrotechnice a zároveň proškolená pro instalaci tohoto zařízení. Anténní koaxiální kabel i signální kabely je vhodné vést odděleně a co nejdále od silových vedení 230V/50Hz.

5.1.2 Riziko předčasného vybití vnitřní baterie

Zařízení jsou vybavena vnitřní baterií s dlouhou životností. Na životnost baterie mají zásadní vliv tyto faktory:

- skladovací a provozní teplota – při vysokých teplotách se zvyšuje samovybíjecí proud, při nízkých teplotách se snižuje kapacita baterie;
- četnost vysílání informačních zpráv.

Moduly jsou dodávány s nastavenou četností pravidelného vysílání dat podle běžných požadavků a zkušeností s využíváním dané technologie („best practice"), nebo dle konkrétní smluvní/projektové dokumentace a pro tuto četnost vysílání je udávána i životnost baterie. Při vyšší četnosti vysílání informační zprávy se životnost baterie úměrně zkracuje.

Battery life is also shortened if the radio network is congested with dense radio traffic, which can occur especially when installing several hundred radio modules on the same frequency channel, with a high number of installed repeaters, or when the frequency channel is interfered with by a "foreign" device. These influences can be eliminated by proper design of the topology and parameters of the radio network and appropriate setting of the message transmission period.

5.1.3 Risk of damage by excessive humidity

Radio modules could be (as any other electronic devices) damaged by water, that could cause a short-circuit among some electronic elements or corrosion of the elements. Modules are enclosed in plastic boxes that are proof against squirted water and are suitable for indoor as well as outdoor installations. Correctly assembled plastic box protects the device against direct penetration of water, but it not protects properly against gradual penetration of humid air which can cause corrosion or damage by condensed water inside the box. Risks of damage of the device caused by penetration of excessive humidity can be eliminated by these precautions:

- install only modules that are correctly assembled, with undamaged box and undamaged rubber seal;
- in case of any doubt perform additional sealing of connection of both parts of the box and both cable bushings by silicon sealant;

- if higher grade of protection against humidity required (IP68), perform additional sealing of the module by high-adhesion silicon filling according to producer instruction (*). This treatment can be also ordered at manufacturer;
- install modules only to the sites where relative humidity exceed value of 95% only occasionally;
- install modules only to the sites where they can be squirted or sprayed by water only occasionally and only for a short time;
- in any case do not install modules to the sites where they can be dipped into the water.

(*) Do not open the module with additional sealing by silicon filling without serious reason. Switch the module on and perform its setting before this treatment. If there are necessary any changes in configuration, perform this changes via radio (if possible).

5.2 The condition of modules on delivery

Modules are delivered in standard cardboard boxes. The modules are commonly delivered with battery switched off. There is an exception in case the modules are delivered with additional sealing by silicon filling - in this case the modules are switched on.

5.3 Modules storage

It is strongly recommended to store the modules in dry rooms or halls, in the temperature interval $(0 \div 30)$ °C. To prevent the unwanted discharging of internal battery it is recommended storing the modules with batteries disconnected and activate the battery during mounting (with exception of modules with additional sealing by silicon filling - see paragraph 5.2).

5.4 Safety precautions

Warning! Mechanical and electrical installation of the WM868-SI4-B module can be provided only by a person with necessary qualification in electrical engineering.

5.5 Environmental protection and recycling

The equipment contains non-rechargeable lithium battery. It is necessary to remove battery before module disposal and dispose battery separately in compliance with the dangerous waste disposal rules. Damaged, destroyed or discarded devices cannot be disposed as household waste. Equipment must be disposed of in the waste collection yards, which dispose electronic waste. Information about the nearest collection yard can be provided by the relevant local (municipal) authority.

5.6 Installation of Modules

WM868-SI4-B radio modules are enclosed in plastic cases with IP20 protection, prepared for wall or pipe mounting. The battery switch, configuration connector, antenna connector, and terminal block for connecting cables from pulse sensors are located on the printed circuit board, so access to them is only possible after opening the case.

Figure 10 shows the WM868-SI4-B module with the cover removed.

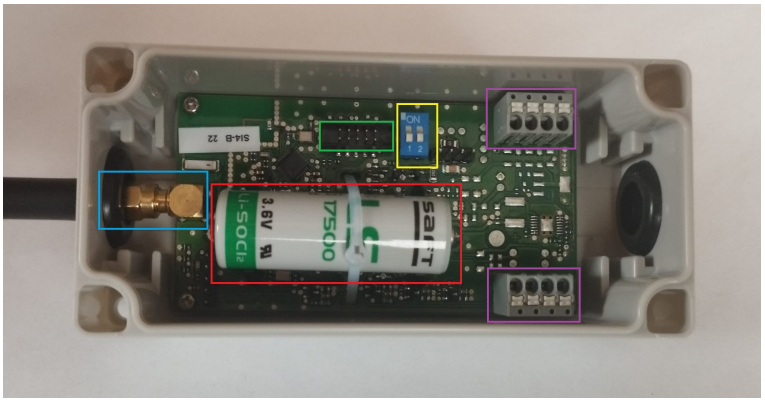

Figure 9: Detailed view of the WM868-SI4-B module

In the figure, important parts on the printed circuit board are color-coded: configuration connector (green), battery switch (yellow), terminal block for connecting input signal cables (purple), and antenna connector (blue).

Figure 10 shows the WM868-SI4-B module disassembled into individual components.

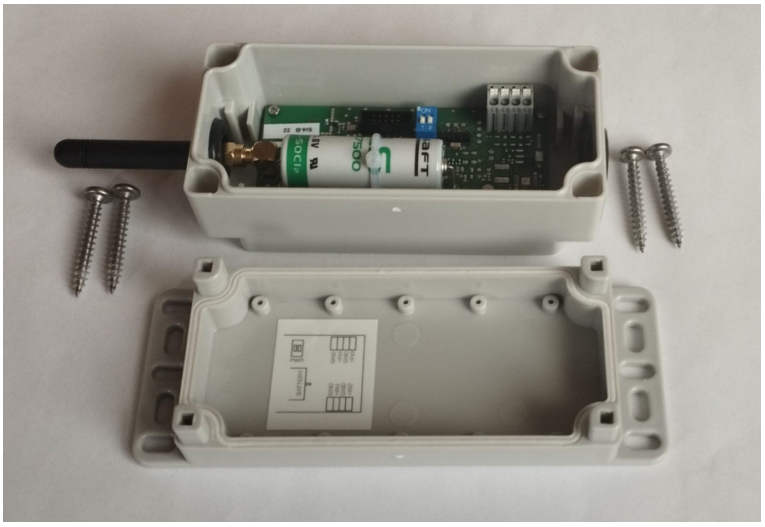

Figure 10: Assembly of the WM868-SI4-B module with a stick antenna

Figure 11 shows the schematic for connecting cables from pulse sensors to the module's terminal block. The schematic is displayed on a label on the inner side of the module cover.

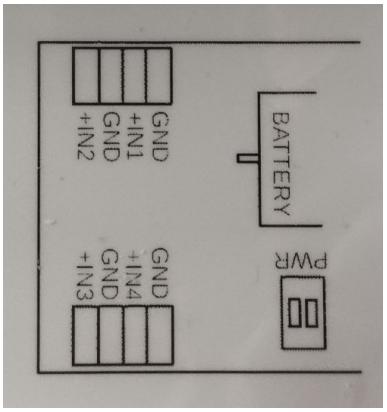

Figure 11: Connection diagram of the WM868-SI4-B module terminals

The case consists of two parts:

- module base, to which the printed circuit board is attached with bushings for the antenna and input signal cables;

- case lid, covering the printed circuit board, with moldings for mounting the module to a substrate.

We install the module following this procedure:

- attach the module to a suitable fixed object (wall, structural element...) using screws or a cable tie. The moldings on the sides of the case lid are used for mounting;
- unscrew the four screws on the top of the case to release the module cover and slide the base out of the lid;
- thread the cable with outputs from consumption meters or sensors through the cable gland and connect individual wires to the module's input terminals. The layout, labeling, and polarity of individual terminals are glued to the inside of the case lid. Make sure that the meters are connected to the module according to the project documentation, or record which meters we connected to the module;
- connect the rod or whip antenna, or antenna cable from a remote external antenna to the antenna connector. Thread the antenna or cable through the cable gland, which is exactly opposite the antenna connector;
- secure the cable against pulling out using the fastening mechanism;
- by switching both micro-switches ("jumpers") located on the printed circuit board next to the configuration connector to the "ON" position, we connect power to the module;
- perform basic diagnostics of the module and possibly its configuration (parameter setting) using the cable according to the procedure described in section 3 "Configuration of module parameters". If the module was pre-configured in the preparatory phase of installation, set at least the pulse inputs so that the module sends messages with the correct reading value;
- insert the module base into the lid and fasten with screws;
- if the installation procedure or the customer's internal rules require sealing of the module (as protection against tampering), seal the module in the specified manner (for example, by pasting over the joint between the two parts of the case with an adhesive seal).

After installation, record the status of the connected consumption meters in the installation protocol and possibly verify once again the functionality of the module and the correctness of the module's output values (whether they correspond to the data on the consumption meter counters), preferably using the "end-to-end" method, i.e., checking the display of consumption data and module operating parameters directly in the remote reading system.

When determining the length of cables between consumption meters and radio modules, follow the recommendations of consumption meter manufacturers.

When selecting the installation location of the module, the type and location of the antenna, and the length of the antenna cable, it is necessary to take into account both the protection of the module from possible mechanical damage (installation outside operationally exposed areas) and especially the conditions for radio signal propagation at the installation site. These conditions can either be determined (estimated) empirically, based on previous experience, or by measuring signal strength using a control transmitter/receiver.

5.7 Replacing modules and replacing meters

When replacing a module due to a fault in the module, or due to battery depletion, proceed as follows:

- if the module was sealed, before dismantling the module, check whether the seal is intact. Deal with seal breakage according to internal rules applicable to the given customer/project;
- unscrew the screws on the top of the case to release the module cover and remove the module base from the lid;
- turn off the module by switching both micro-switches ("jumpers") located on the printed circuit board next to the configuration connector to the "Off" position;
- disconnect the cables from the consumption meters from the input terminals;
- loosen the mounting screws that hold the case lid to the wall or other substrate and remove the lid (*);
- reassemble the original module by screwing the lid to the base (*). Visibly mark the module as "faulty", possibly fill out the appropriate form (installation sheet) or other prescribed documentation for module replacement;
- mount a new module in place of the original module and proceed further according to the procedure described in section 5.6. Especially make sure to correctly connect the input cables (to the same inputs as on the original module) and set the correct configuration parameters, especially the transmission period and configuration parameters of input/output values;
- write down the serial number and seal number of the new module and possibly also the status of mechanical counters of connected meters;

- if possible, immediately ensure the introduction of the new serial number into the collection system database

The case lid does not carry any functional part, the type label with the module's serial number is on the module base. If we use a mechanically identical product for replacement, it is permissible to only replace the module base and keep the original lid, which is already attached. However, it is always necessary to check the condition of the rubber seal in the groove of the lid's seating surface and in case of doubt about the condition of the seal, also replace the case lid.

When replacing a meter connected to the module, where the reason for replacement is a meter failure, expired verification period, or other reason on the meter side, proceed as follows:

- if the module was sealed, before dismantling the module, check whether the adhesive seal is intact. Deal with seal breakage according to internal rules applicable to the given customer/project;
- unscrew the screws on the top of the case to release the module cover and slide the base out of the lid. Disconnect the cable from the replaced consumption meter from the input terminals, replace the consumption meter and connect the cable from the new meter to the input terminals;
- set the configuration parameters of input/output values for the input where the meter was replaced (*) according to the procedure described in section 3 "Configuration of module parameters". Check whether the read values sent by the module in radio messages correspond to the counter data of all connected consumption meters, preferably by checking the display of consumption data and module operating parameters directly in the remote reading system;
- fill out the prescribed documentation for meter replacement (installation sheet), especially carefully record the status of the mechanical counter of the new meter;
- cover and seal the module according to the procedure described in section 5.6, or wait for the first reading to be performed.

(*) ATTENTION! *The new consumption meter may have different output settings than the original meter, even if it is a meter of the same type from the same manufacturer. Output value settings may also differ between different modifications of the same meter type.*

5.8 Dismantling the module

When dismantling, open the module, turn off the battery, disconnect the cables and remove the case lid from the wall, ceiling, or other substrate. Reassemble the module by putting the lid back on the case. After dismantling, mark properly the module as dismantled and fill out the appropriate documentation prescribed for this case by internal regulations. If possible, ensure deactivation of the module in the collection system immediately.

5.9 Module Functionality Check

After putting the module into operation (or after each repair and module replacement), we recommend checking its basic functions:

- check the setting of basic module parameters, especially the message sending system parameters (transmission mode, encryption, transmission period, frequency channel, transmission power);
- check the setting of pulse inputs using the "input" group command;
- check the functionality of the RF subsystem using the RFAN 3.x analyzer. For this, it is necessary to switch the module to WACO transmission mode and receive messages from the module with the analyzer in "Packets" or "Radar" mode (according to the procedure described in the analyzer documentation), preferably using the test transmission function;
- perform a comprehensive check of the module's functionality, including the correctness of the module's introduction into the data collection system, by checking the correctness and timeliness of the obtained data directly in the data collection system.

5.10 Operation of the WM868-SI4-B Module

Remote reading of meters and sensors using WM868-SI4-B modules in an **automatic reading system** works completely automatically. The greatest risks here are associated with the activities of the facility user, especially the risk of mechanical damage to modules when handling objects at the installation site, the risk of relocating the radio module to another location, or the risk of signal shading by a metal object. A typical consequence of damage is a complete loss of connection with the module. Relocating the module may manifest as a change in the level of

the received signal from the module, which may reduce the reliability of reading the status of consumption meters or interrupt the connection with the module.

To eliminate these risks, pay attention to the selection of the installation location of the module and its antenna, not only from the perspective of radio signal quality but also from the perspective of the possibility of mechanical damage to the module during normal operation of the facility. It is recommended to perform the installation itself carefully, using high-quality cables and installation materials.

Unexpected interruption of connection with the module can be prevented by continuous monitoring of the regularity and correctness of the read data (including accompanying data on processor temperature and battery voltage) and in case of detecting outages or non-standard values, contacting the facility user or performing a physical check at the installation site.

The risk of **premature battery depletion** can be easily eliminated by following the recommendations given in section 5.1.2.

6 Troubleshooting

6.1 Possible causes of system failures

During operation of the WM868-SI4-B device, failures, malfunctions, or other operational problems may occur, which can be divided into the following categories according to their cause:

6.1.1 Power supplying failures

The module is supplied by electrical power from the long-life internal battery. Approximate battery life is specified in paragraph 1.4 „Modul usage". Battery life can be negatively influenced by circumstances that are described in detail in paragraph 5.1.2 „Risk of premature battery discharge".

Low battery power becomes evident as irregular drop-outs of signal reception from the module, finally the radio connection with the module completely fails.

Battery is soldered into the printed circuit board of the module and the module has to be disassembled for its replacement. Battery replacement can be performed only by qualified and experienced person. Soldering of battery by unskilled person can cause irretrievable damage of the module. There are only top-quality batteries used in the wacoSystem modules, that have been carefully selected and properly tested. In case of battery replacement by user the new battery parameters should meet same technical requirements (type, capacity, voltage, current load, auto-discharging current...) as the original battery. It is strongly recommended to use for replacement same type of battery as used in production.

6.1.2 System failures

As „system failure" are considered mainly failures of module's processor, memory, internal supplying or any other failures that cause a complete breakdown of the device. If module's battery has correct voltage with no signs of discharging and the device still does not communicate through its configuration port and does not respond to any commands and this status will not change even after module's restart (by switching off and switching on its battery), the system failure probably occur. Perform the replacement of the module according to the instructions in paragraph 5.7 and check functionality of the new module. If the new device works properly, label the original module as „defective" and fill in the appropriate documentation prescribed by internal rules for this case.

6.1.3 Failures of communication with meters

Failures of pulse signal transfer from the consumption meters to the correspond module inputs typically appear as „zero consumption" of the meter even though the consumption of the meter is evident, or generally, meter status from remote reading is different than meter status shown in meter's mechanical counter. In this case try to proceed with troubleshooting of the connection with meters in following steps:

1. Visually check the meter and connecting cable between meter and radio-module, especially whether the meter's pulse generator is correctly mounted on the meter (if it is removable) and whether the meter or cable are not damaged;
2. in case of any doubt check the functionality of cable connection by ohm-meter. If there is a problem with reliability of the connection, or the cable is evidently damaged, replace the cable immediately;
3. check whether the cable is correctly associated with the module input (correct port number, correctness of polarity - if required by meter producer);
4. Visually check if there are not placed any objects or devices radiating a magnetic field (for example a device for water treatment with magnet, electrical installation...) around the consumption meter. The pulse generators of some types of the consumption meters are very sensitive to the magnetic field presence. If such devise is detected, it must be removed or there must be taken necessary measures to eliminate the magnetic field influence on the pulse generator of the consumption meter. To find more about the influence of the magnetic field on a particular consumption meter, you must follow its manufacturer instructions;
5. if there is some possibility of measuring metering pulses, make sure that the meter generates the pulses properly and that these pulses lead up entirely to the radio module input;
6. correctness of generating and transfer of metering pulses can be alternatively checked by short-circuiting of the cable on the meter side. If after each short-circuit the status value of the module's counter goes up, the module and cable are probably correct, and the trouble is probable caused by meter or by its pulse generator;
7. if the module doesn't read the data even the metering pulses are provably brought to the correct radio module input, check the pulse counter parameter settings (counter mode, trigger edge) according to the paragraph 3.1.9

„Internal Counter Setting Commands". In case the setting is correct, the problem is the most probably in the malfunction of the radio module. Replace the module following the instructions in the paragraph 5.7.

If the module register „false" pulses (consumption registered by remote reading is significantly higher than consumption registered by mechanical counter) and setting of the counter to „slow" mode has not solved the problem, the failure could be caused either by too long or poor-quality cable or strong local disturbance (or combining of these two circumstances). In this case replace the cable for high-quality shielded one or make changes in the installation to shorten the cable.

In case of unstable data transfer from connected sensors the signs of failure are very similar to the troubles with pulse meters - the wrong indication of measured data from sensors. Troubleshooting of this failure is similar with troubleshooting of pulse meters:

1. visually check the sensor and connecting cable between sensor and radio-module for any damage;
2. check whether the cable is correctly associated with the module input (correct port number, correctness of polarity - if required by sensor producer);
3. visually check if there are not placed any objects or devices around the sensor that can influence its functioning;
4. check correctness of the sensor input by short-circuiting of the cable on the sensor side. If after each short-circuit the value of the module's counter changes, the module and cable are probably correct, and the trouble is with high probability caused by sensor;
5. if the module doesn't register the changes of sensor status even though the changes are provably brought to the correct radio module input, check the counter parameter settings (counter mode, trigger edge) according to the paragraph 3.1.9 „Internal Counter Setting Commands". In case the setting is correct, the problem is the most probably in the malfunction of the radio module. Replace the module following the instructions in the paragraph 5.7.

6.1.4 Transmitter and receiver failures

If the module is powered by correct voltage, the module communicates through the configuration port, responds to the configuration commands but the radio-messages from the module are still not received steadily, the possible reason of the trouble can be a failure of transmitting or receiving of radio signal. The typical indication of transmitting or receiving failures is state of „partial" functionality, that have following external signs:

- the module transfers data only from certain elements of the radio-network, data from other elements are not transferred;
- certain elements of the network do not receive data from the module;
- data from certain elements of the network are incorrect or incomplete;
- there are numerous breakdowns in the data communication (sometimes the data pass through the module, sometimes not).

All above described troubles could have on common ground, which is unreliability of radio-communication caused by one of these reasons:

- incorrect setting of transmitter parameters, mainly frequency channel, maximum number of re-translations, or transmitting power;
- permanent or occasional blocking of radio signal caused by construction works or any construction changes within the premises, or by operation around the installation site (moving of machines, cars, etc.);
- permanent, periodical or occasional interference (jamming) of radio signal from external source (another radio system in the same frequency band, or industrial disturbance).
- low level of transmitting signal caused by wrong setting or failure of transmitter;
- low level of receiving signal caused by wrong setting or failure of receiver;
- low level of transmitting and receiving signal caused by damage of antenna or antenna cable (if external antenna used).

If above described indications of unreliable radio-communication become evident, proceed with troubleshooting of the malfunctioning in following steps:

- visually check surrounding of the installation site to find out if there are any changes that can influence radio signal (e.g. new objects, things, machines...). If there are such negative circumstances, solve the trouble by reorganization of the object or by redesign of radio network;
- visually check an external antenna and antenna cable (if used), possibly replace these elements for the spare ones with proven functionality;

- check correctness of module settings, especially setting of radio parameters as described in paragraph 3.1.4 and perform the check of module overall functionality as described in paragraph 5.9;
- if there are breakdowns in communication with some specific element of the network, check functionality of that element according to the respective documentation;
- replace the module according to the paragraph 5.7 and perform the setting and check of overall functionality off the new module after that;
- if the module is not properly working even after its replacement for proven device and equipment, the trouble can be caused by local interference (jamming) from external source. Another possible reason could be an unsuitable setting of some configuration parameter that has not been discovered. In this case ask for your supplier, producer, or other experienced person for some form of assistance.

Appropriate level of transmitting power can be checked by comparing of its signal strength with the reference signal from another module (modules) under comparable circumstances, for example with using of signal analyzer or testing receiver placed to the suitable spot. If the signal strength is similar to the signal of reference transmitter, then the module's transmitting power is adequate, and the reason of troubles could be in insufficient signal strength on the receiving side. Attenuation of the signal can be caused by making of some change in module installation site (e.g. turning of antenna or placing of some object nearby, installation of iron bars, rack or shelfs...) or similar changes in the installation site of receiver (GateWay). This kind of troubles can be solved by redesign of the radio network in order to secure sufficient signal reception (that means changing of antenna for better type, moving of antenna or whole device etc.).

6.2 Procedure for determining the cause of failure

When determining the probable cause of a failure, proceed as follows:

1. The module communicates normally, data can be read, but the values of some consumption meters are clearly incorrect. In this case, it is recommended checking the functionality of individual module subsystems in this order:
   - check the correctness of the given input settings in the reading system, especially the correctness of the identification settings of the given meter and its correct assignment to the appropriate module port, as well as the correctness of the initial counter value settings;
   - check the functionality of correct pulse signal reading to the module input according to section 6.1.3 "Communication failures with consumption meters",

2. Data comes from the module irregularly, there are periodic outages in receiving data from the module. In this case, it is recommended checking the functionality of individual module subsystems in this order:
   - check the functionality of data transmission and reception according to section 6.1.4 "Transmitter and receiver failures",
   - check the battery functionality according to section 6.1.1 "Power supply failures".
   - check the functionality of the device receiving data from the WM868-SI4-B module according to the documentation for that device.

3. No data is coming from the module. In this case, it is recommended checking the functionality of individual module subsystems in this order:
   - check the correctness of the given module address settings in the collection system,
   - check the power supply functionality according to section 6.1.1 "Power supply failures",
   - check the system functionality according to section 6.1.2 "System failures",
   - check the functionality of data transmission and reception according to section 6.1.4 "Transmitter and receiver failures".

WARNING: The WM868-SI4-B module is a reliable device of relatively simple and durable construction, so there is a high probability that any failure is caused by external installation circumstances, especially mechanical damage, moisture ingress, internal battery discharge or damage to inputs by induced voltage in the cable. With each module replacement due to failure, it is recommended verifying whether the cause of the failure was one of these circumstances and possibly taking measures to eliminate it.

7 Additional information

This manual is focused on description, parameters and configuration options of radio modules WM868-SI4-B of the WACO RF system, operating in the 868 MHz band, that are a part of the Softlink's **wacoSystem** product family. More information about all WM868 (WACO), WB169 (Wireless M-BUS), WS868 (Sigfox), or NB (NB-IoT) series of the modules can be found on the manufacturer website:

www.wacosystem.com
www.softlink.cz

If interested in any additional information related to application of radio modules of WM868, WB169, WS868 or NB series or other manufacturer's equipment for telemetry and remote reading of consumption meters, feel free to contact the manufacturer:

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