WIRELESS COMMUNICATION SYSTEM WACO WM868

WM868-TE-B

WM868-TES-B

Revision 1.0

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1 Introduction

This document describes the features, parameters and configuration options of WM868-TE-B and WM868-TES-B radio modules, which are used for temperature measurement and radio transmission of information about the current state of the measured quantity 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-TE-B** module is designed for measuring air temperature in both interior and exterior spaces, especially in non-residential spaces, warehouses, production halls, or (most commonly) for measuring **outdoor temperature**.

The **WM868-TES-B** module is designed for measuring temperature of individual parts of technological units, especially for **temperature measurement in refrigerators and cooling boxes**, or **in heating system pipes**.

Both above-mentioned module types use the same hardware platform and software, differing only in the temperature sensor design. Both module types have the same temperature sensor with recommended measurement range of (-40 ÷ 105) °C with measurement accuracy of ± 0.25 °C.

The modules transmit current temperature readings in the form of radio messages, sent automatically at preset time intervals. The message with current measured values is of "INFO" type and contains, besides current temperature value data, also the module's system time, battery voltage and processor temperature.

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

The principle of data transmission from WM868-TE-B module via communication gateway is shown in figure 1.

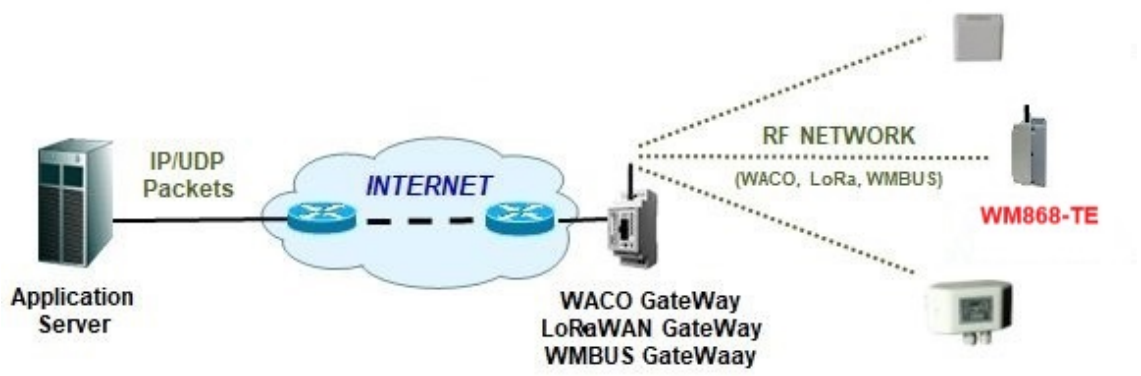

Figure 1: Principle of data transmission from WM868-TE-B module via communication gateway

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

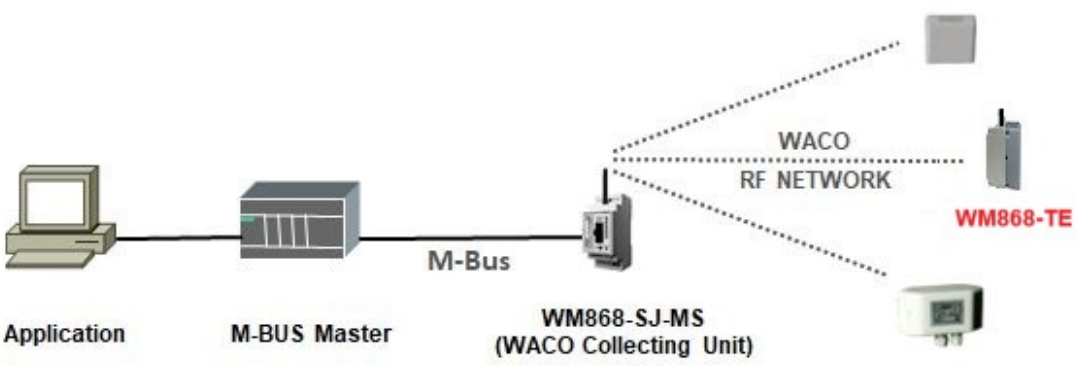

Figure 2: Principle of data transmission from WM868-TE-B module to another WACO radio module

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

Message transmission in opposite 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 via private or public IP service to communication gateway, which converts it to appropriate radio format and sends it to the end device at suitable time.

WM868-TE-B/WM868-TES-B modules are enclosed in moisture-resistant plastic case (IP65 protection) and are suitable for both indoor and outdoor use. The case is adapted for wall mounting or mounting on any structural element (beam, pipe...). The module can be equipped with additional moisture protection (to IP68 degree) by sealing with high-adhesion silicone filling. If this modification is required from manufacturer, it must be ordered with special order code.

The modules are powered by internal 3.6 Ah capacity battery, enabling operation for more than 10 years with 12-hour message transmission period. Battery life can be negatively affected not only by shorter set temperature reading interval, but also by operating device in installation locations with temperature outside recommended operating range, or in networks with high radio traffic or radio interference.

The modules are equipped with external temperature sensor, which in WM868-TE-B module is located under protective plastic cover protruding from module case, while in WM868-TES-B module it is attached at end of 5 m long cable, led out through cable gland from module case.

Appearance of both module types is shown in figure 3.

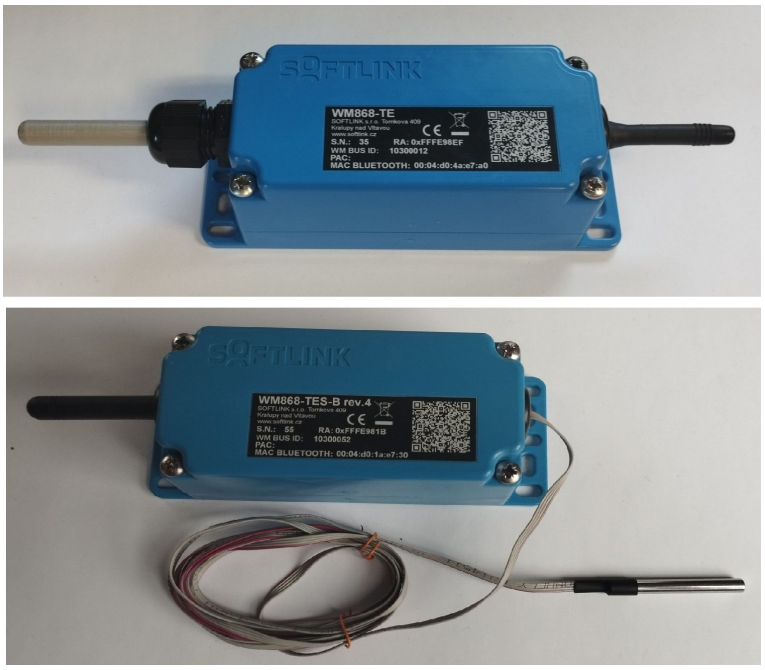

Figure 3: Appearance of WM868-TE-B module (top) and WM868-TES-B module (bottom)

2 Technical parameters overview

Overview of technical parameters of WM868-TE-B and WM868-TES-B modules is shown in Table 1.

Table 1: Technical parameters overview of WM868-TE-B and WM868-TES-B modules

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	
Transmission 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
Data rate - WACO	38400 (2400)*	bps
Data rate - wM-Bus	100	kbps
Data rate - LoRa	250 ÷ 11000	bps
Antenna	integrated	
Configuration Interface RS232		
Data rate	9600	Baud
Operation mode	asynchronous	
Transmission parameters	8 data bits, 1 stop bit, no parity	
Signal level	CMOS 3.3	V
Temperature Sensor		
Measurement range	(-40 ÷ 105)	°C
Resolution	0.1	°C
Accuracy for range (-10 ÷ 85)°C	0.2	°C
Accuracy for range (-40 ÷ 105)°C	0.25	°C
Bluetooth Configuration Interface		
Version	BLE 5.2	
Frequency	2.4	GHz
Data 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)
Protection rating	IP65 or IP68	

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

3 Module Configuration

Parameters of the WM868-TE-B and WM868-TES-B modules can be monitored and set from a computer, tablet, or mobile phone in the following ways:

- using the "USB-CMOS" converter and cable through the **configuration connector** equipped on the module
- wirelessly, using an application on a **mobile phone** utilizing Bluetooth communication
- **remotely**, using a bidirectional communication system.

Description of connecting the module to a computer and general rules for module configuration using the **configuration cable** are described in Chapter 2 of the manual **"Configuration of wacoSystem product line devices"**, which is available for download on the manufacturer's website: www.softlink.cz/dokumenty/

Section 3.1 "Setting WM868-TE-B/WM868-TES-B module parameters using configuration cable" provides a description and explanation of parameters that can be set using the cable, as well as how to set them.

Description of connecting the module to a mobile phone via Bluetooth wireless connection and general rules for module configuration using the "Softlink Configurator" mobile application are described in Chapter 3 of the above-mentioned manual "Configuration of wacoSystem product line devices". Section 3.2 "Setting WM868-TE-B/WM868-TES-B module parameters using mobile application" provides a description and explanation of parameters that can be set using the mobile application.

A brief description of the principle of communication with the module via the **reverse channel** is provided in paragraph 3.3 "Setting module parameters from a remote computer using reverse channel".

3.1 Setting of WM868-TE-B/WM868-TES-B module parameters by configuration cable

The following part of the manual describes those module parameters whose current values 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 List of module configuration parameters

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

The following listing will appear in the terminal window:

```
wm868-SI4X>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
TX Power    : 14
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        : T1
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     : -
```

The configuration listing contains sections for individual transmission modes (WACO, LoRa, Wireless M-Bus) and sections for displaying 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 module configuration commands ("HELP")

A 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 listing will appear in the terminal window:

```
wm868-SI4X>?
?            - 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-SI4X>
```

In the upper part of the listing (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 listing (after the space, starting from "rf") are listed the names of individual module subsystems that have their own commands. These commands can be displayed by entering the subsystem name into the command line and pressing "ENTER". Example of displaying commands for the "rf" subsystem:

```
wm868-SI4X>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-SI4X>
```

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

```
wm868-SI4X>rf txp
TX power    : 14 dBm
wm868-SI4X>
```

The meaning of individual commands (including subsystem commands) is described in the next part of this chapter. The meaning and usage of individual commands is 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-SI4X>?
?         - 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-TE-B module").

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

```
wm868-SI4X>info
Device      :  wm868-SI4X
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-SI4X>
```

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-TE-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-SI4X>>write
Writing config ...
wm868-SI4X>
```

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-SI4X>mode wmbus
Mode    :  WMBUS
wm868-SI4X>mode lora
Mode    :  LoRa
wm868-SI4X>mode waco
Mode    :  WACO
wm868-SI4X>mode
Mode    :  WACO
wm868-SI4X>
```

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

```
wm868-SI4X>reset
wm868-SI4X>
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-SI4X>
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-SI4X>sensors
Temp.  int.  :  21.0 C
Temp.  sensor:  -500.0 C
VCC          :  3107 mV
VBat         :  3114 mV
wm868-SI4X>
```

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-TE-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-SI4X>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-SI4X>
```

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-SI4X>rf txp 14
TX power :  14 dBm
wm868-SI4X>
```

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-SI4X>rf rxt 10
RX timeout :  10 (500 ms)
wm868-SI4X>
```

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-TE-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-TE-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-TE-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-TE-B module in WACO transmission mode. These are the following commands:

```
wm868-SI4X>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-SI4X>
```

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-TE-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-SI4X>waco channel
channel :  0
wm868-SI4X>waco channel 2
channel :  2
wm868-SI4X>
```

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-TE-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-SI4X>waco hop
Hop count :  1
wm868-SI4-2>waco hop 3
Hop count :  3
wm868-SI4X>
```

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-SI4X>waco rex 1
Repeater :  1
wm868-SI4X>waco rex 0
Repeater :  0
wm868-SI4X>
```

The WM868-TE-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-SI4X>waco ttout
Test timeout:  20 sec.
wm868-SI4X>waco ttout 5
Test timeout:  5 sec.
wm868-SI4X>
```

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-SI4X>system txtest 1
TX test :  1
wm868-SI4X>system txtest 0
TX test :  0
wm868-SI4X>
```

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-TE-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-SI4X>waco encrypt 37 abcde
Encrypt port:  37
wm868-SI4X>waco encrypt delete 37
Encrypt port:
wm868-SI4X>
```

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-TE-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-TE-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-TE-B module in Wireless M-Bus transmission mode (hereinafter "WMBUS"). These are the following commands:

```
wm868-SI4X>wmbus
mode      - set mode
channel   - set channel
id        - set ID
manuf     - set manufacturer
medium    - set medium
version   - set version
ekey      - set encryption key
wm868-SI4X>
```

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-SI4X>wmbus mode
Mode :  T1
wm868-SI4X>wmbus mode C1
Mode :  C1
wm868-SI4X>
```

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-TE-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-TE-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-TE-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-TE-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-TE-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-SI4X>wmbus medium
Medium :  7
wm868-SI4X>wmbus medium 2
Medium :  2
wm868-SI4X>
```

***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-SI4X>wmbus ekey 1a2b3c4d5e6fa1b2c3d4e5f6778899af
wm868-SI4X>
```

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-SI4X>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-SI4X>wmbus ekey .
wm868-SI4X>
```

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

Warning! *WM868-TE-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-TE-B module in LoRa transmission mode. These are the following commands:

```
wm868-SI4X>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-SI4X>
```

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-TE-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-SI4X>lora chan
Channel :  0
wm868-SI4X>lora chan 1
Channel :  1
wm868-SI4X>
```

The **"lora dr"** command is used to display or set the data rate at which the module transmits data. The WM868-TE-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-TE-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-TE-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-SI4X>lora dr
Data Rate :  0
wm868-SI4X>lora dr 4
Data Rate :  4
wm868-SI4X>
```

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-SI4X>lora rxdly
Recv Delay :  2
wm868-SI4X>lora rxdly 1
Recv Delay :  1
wm868-SI4X>
```

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-TE-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-SI4X>lora netadr
Dev Addr :  0x00000000
wm868-SI4-2>lora netadr 0xffff1234
Dev Addr :  0xffff1234
wm868-SI4X>
```

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-SI4X>lora nwkskey 1a2b3c4d5e6fa1b2c3d4e5f6778899af
NwkSKey :  1a2b3c4d5e6fa1b2c3d4e5f6778899af wm868-SI4X>
```

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-SI4X>lora encrypt
Encrypt :  0
wm868-SI4X>lora encrypt 1
Encrypt :  1
wm868-SI4X>
```

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-SI4X>lora otaa
OTAA : 0
wm868-SI4X>lora otaa 1
OTAA : 1
wm868-SI4X>
```

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-SI4X>app
?         - help
info      - print Rf APP info
sending   - set sending interval in secs.
measure   - set measure interval in secs.
wm868-SI4X>
```

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-SI4X>app sending
Sending :  900 secs.
wm868-SI4X>app sending 1800
Sending :  1800 secs.
wm868-SI4X>
```

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-SI4X>app measure
Measure :  60 secs.
wm868-SI4X>app measure 300
Measure :  300 secs.
wm868-SI4X>
```

3.1.9 Parameters of the "Input" group

The set of commands **set, edge, type, mul, div, on** and **off** are used for setting pulse counters for the WM868-SI4-B module type, with which the WM868-TE-B / WM868-TES-B module has unified firmware. **For modules of type WM868-TE-B and WM868-TES-B , setting parameters of the "Input" group has no meaning.**

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-SI4X>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-SI4X>
```

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-SI4X>ble
txp       - TX power in dBm
chmask    - Advertisement channel mask
advtout   - Advertisement timeout/period
conntout  - Connection timeout
pin       - BLE pin
wm868-SI4X>
```

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 mobile application

The module is equipped with a Bluetooth Low Energy wireless subsystem (hereinafter "Bluetooth" or "BLE"), which serves for its remote configuration using an application on a **mobile phone**. The module can be configured 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 wacoSystem product line devices".

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

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

1. Download the "Softlink Configurator" mobile application from "Google Play" (Android) or "App Store" (iOS). Use the keyword "Softlink" for search, the application is presented under the name "BLE Configurator";
2. If you have had the application installed for a while, check if you have the latest version of the application (menu "Check updates") and download the latest set of configuration forms (menu "Update forms"). Internet connection is required for this;
3. Activate Bluetooth on the mobile phone, or allow the application to turn on Bluetooth when starting the application;
4. Make sure the module is turned on and start 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 (Bluetooth MAC is written on the production label of the configured module);
5. Connect to the configured device using the button with the Bluetooth symbol;
6. When connecting to a given device for the first time, the application may request entering an authorization PIN (default "123456"). A normal connection process occurs, 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 reading a QR code. Clicking the "SCAN QR CODE" button turns on the phone's camera, which we use to scan the QR code on the mobile label. If the QR code enters the camera's field of view, the module automatically connects to the application;
8. After connecting the module to the application, click on the "Configuration" option at the bottom of the form (or "scroll" the configuration form by moving your finger to the side). Click the "START (INIT)" button, which loads the initial "Device Details" form with listed basic device parameters;
9. Then we perform parameter configuration using configuration forms. Each form focuses on some area of configuration (for example, the "Network Settings" form is intended for setting network communication). Select the form from the list that opens by clicking the "SELECT FORM" button;
10. In the form, we check and possibly change individual parameters, either by direct field editing or by selection from preset values. After each edit/selection, press "Save" to close the item. After editing all required items in the form, save the entire set of parameters to the module's memory using the "WRITE (SET)" button. A help dialog box appears with the information "Performing SET", which disappears 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, when the form shows those parameter values that the module currently has stored in memory;

The "Softlink Configurator" application currently offers five configuration forms for configuring the WM868-TE-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 capabilities and functions are gradually expanding.

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

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

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

- setting of **sending period** for information messages
- setting of **communication mode**

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

- **Set WACO** option button for switching to WACO transmission mode
- setting of **radio address** for WACO mode
- setting of **group address** (Group Address)
- setting of **frequency channel** (Channel)

- setting of **max. number of hops** (Hop Count)
- setting of **transmission power**
- setting of **receive window length** (RX TimeOut)
- setting of **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** option button for switching to WMBUS transmission mode
- setting of Wireless M-Bus protocol **mode**
- setting of **transmission power**
- setting of **M-Bus address** (M-Bus ID)
- setting of **manufacturer code** (Manufacturer)
- setting of **version/addressing number** (Version)
- setting of **medium code** (Medium)
- setting of **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** option button for switching to LoRa transmission mode
- setting of LoRa protocol **network address**
- setting of **Network Session Key**
- setting of **Application Session Key**
- setting of **Application Session Key**
- setting of **Application Key** (Root Key)
- setting of **Join EUI**
- setting of device class **Do not use!**
- setting of **activation mode** (ABP/OTAA)
- enabling adaptive power function **Do not use!**
- enabling **application data encryption**
- setting of **frequency band**
- setting of **frequency channel**
- setting of **data rate** (Data Rate)
- setting of **Receive Delay**
- setting of **Join Delay**
- setting of Acknowledge Limit **Do not use!**
- setting of Acknowledge Delay **Do not use!**
- setting of Acknowledge Timeout **Do not use!**

The meaning of individual parameters is described in detail in section 3.1 "Setting WM868-TE-B module parameters by configuration cable". A preview of individual configuration form screens is shown in Figure 4.

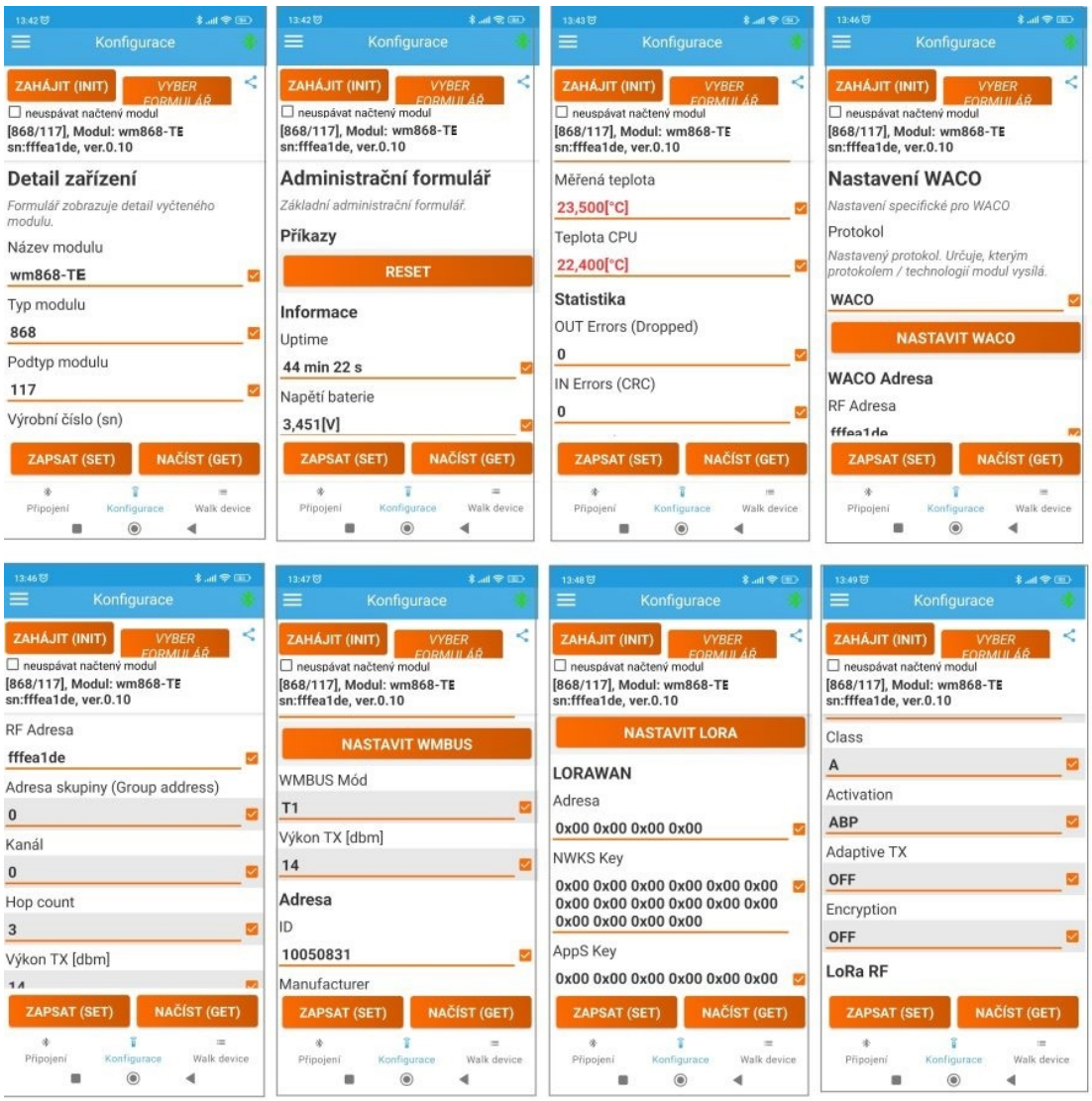

Figure 4: Preview of forms for setting the module using mobile application

3.3 Setting module parameters from a remote computer using reverse channel

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

Messages in the reverse direction used for setting module parameters (so-called "setting messages") are encoded using 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 **message type**. Setting messages are always of type **"SET"** (OiD 63 = **"1"**). This variable is followed by one or more variables for which change is requested.

The WM868-TE-B module performs the setting of requested parameters (update of specified variables) and sends back a message of type **"RESPONSE"** (OiD 63 = **"4"**), which contains the values of changed variables after the change is made.

Using setting messages via 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 communication possibilities via reverse channel can be obtained by inquiring with the module manufacturer.

4 Module Data Message Structure

Struktura datové zprávy se liší dle nastavené komunikační technologie viz tabulka 4.

Table 2: Přehled komunikačních protokolů modulu WM868-TE-B

rádiová technologie	komunikační protokol
WACO	NEP
LoRa	NEP
wM-BUS	M-BUS

Nastavení volby rádiové technologie se věnuje kapitola 3.1.3

4.1 WACO

Modul komunikuje s ostatními prvky radiové sítě WACO prostřednictvím datových zpráv komunikačního protokolu WACO SLRF, který respektuje standardní komunikační ISO/OSI model, vyznačuje se vysokou efektivností a spolehlivostí a umožňuje vysokou variabilitu komunikace a její otevřenost pro realizaci různorodých aplikací. Struktura jednotlivých komunikačních vrstev protokolu WACO SLRF je znázorněna na obrázku 5.

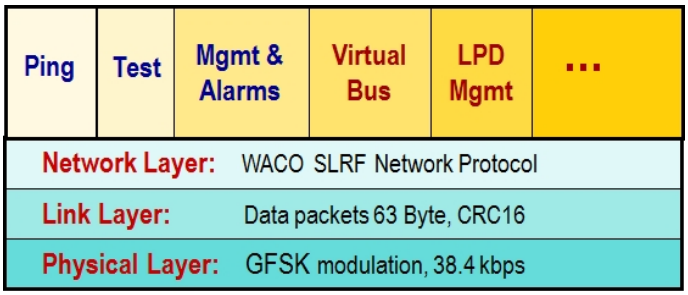

Figure 5: Struktura komunikačních vrstev protokolu WACO SLRF

Datové zprávy („pakety") protokolu WACO SLRF mají maximální délku 63 Byte a jsou na začátku ohraničeny preambulí a synchronizačními bity (celkem 6 Byte), na konci jsou chráněny 16-bitovým kontrolním kódem (CRC).

Každá datová zpráva obsahuje pevnou hlavičku o délce 11 Byte a samotný datový obsah („Payload") o velikosti maximálně 52 Byte. Hlavička zprávy je velmi jednoduchá a obsahuje pouze informace důležité pro směrování paketu (zdrojová a cílová adresa, počet povolených retranslací, číslo transakce) a informaci o typu aplikace, pro kterou je daný paket určen („číslo portu"). Typem aplikace je určen i způsob kódování datového obsahu. Struktura datové zprávy protokolu WACO SLRF je znázorněna na obrázku 6.

The WM868-TE-B/WM868-TES-B module is used for temperature measurement and sending temperature data to WACO radio network through "INFO" type messages. "INFO" message transmission takes place in "SISA_TX" type application (port number 37) of "LPD Management" group (LPD=Low Power Devices), used for data collection from battery-powered devices. These devices communicate in "active mode", where device actively sends data at adjustable intervals and doesn't wait for message reception confirmation. The "INFO" message content of WM868-TE-B module includes these variables:

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

Jednotlivé proměnné jsou do datového obsahu zprávy kódovány pomocí proprietárního systému kódování "NEP" firmy SOFTLINK, kdy každý typ proměnné má své označení "OID" (Object ID), určující význam, charakter a datový typ dané proměnné. U proměnných, které se mohou používat vícenásobně (několik vstupů, teplot, napětí...) je povinným údajem i pořadové číslo proměnné ("Index"). Tabulka kódování "NEP" je udržována centrálně firmou SOFTLINK a je dostupná na veřejné WEBové adrese NEP Page. Náhled tabulky "NEP" pro kódování proměnných v systému WACO je uveden na obrázku 7.

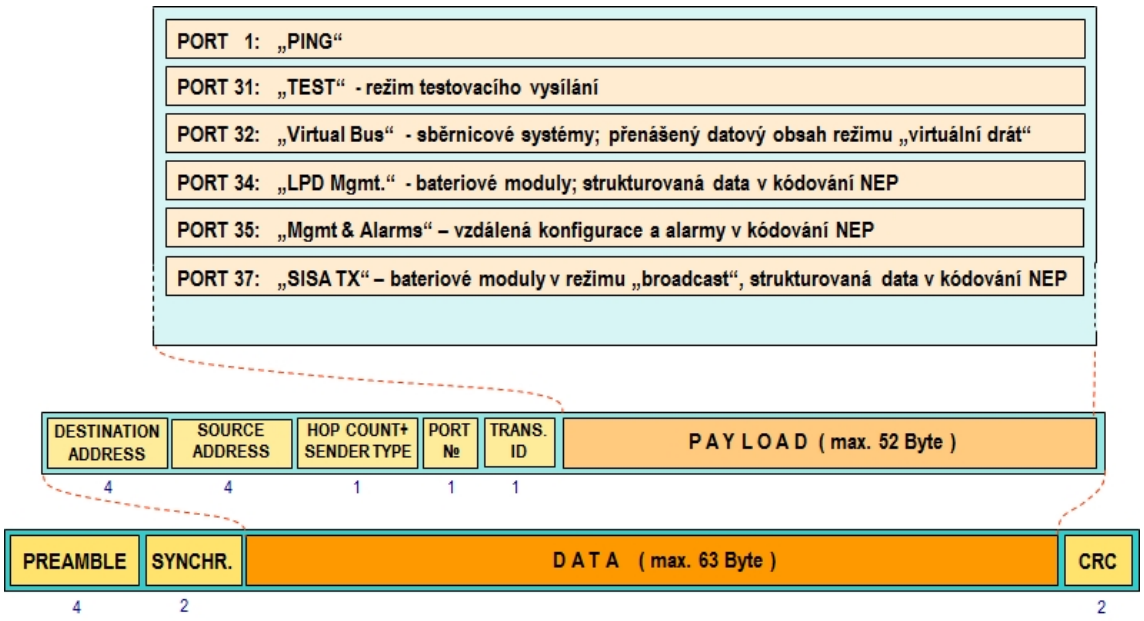

Figure 6: Struktura datové zprávy systému WACO

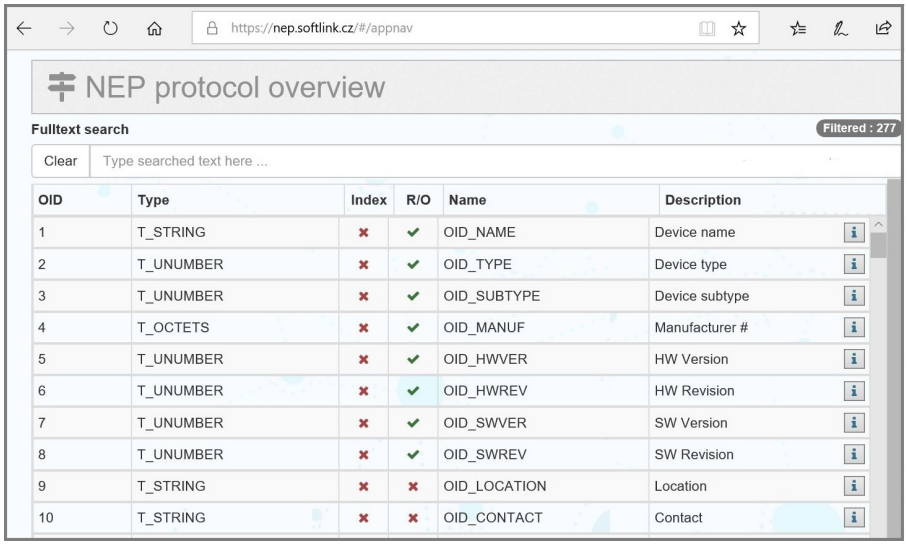

Figure 7: Náhled tabulky "NEP" pro kódování proměnných v systému WACO

Je-li příjemcem zpráv "INFO" z modulu „sběrná jednotka" systému WACO (viz odstavec 1.4 „Použití modulu"), dekódování zpráv a jejich transformaci do kódování systému M-Bus provede sběrná jednotka.

Je-li příjemcem zpráv "INFO" od modulu jiná aplikace, musí být vybavena dekódovacím programem pro práci s protokolem radiové sítě WACO (tzv. „WACO Driver"), jehož součástí je i NEP-dekodér. Systém kódování "NEP" má obecně platná pravidla, takže je zajištěno dekódování hodnot všech proměnných i v tom případě, pokud dekódovací systém na přijímací straně „nezná" některý typ přijaté proměnné. V tomto případě dekodér vyhodnotí OID, index a hodnotu proměnné, pouze k ní nedokáže přiřadit její název a význam. Analyzátor radiového provozu systému WACO RFAN 3.x má implementovanou tabulku proměnných v konfiguračním souboru "oids.xml". Pokud je tato tabulka zastaralá a modul posílá zprávy obsahující „neznámé" proměnné, v tabulce proměnných se objeví řádky s neúplným popisem. V tomto případě doporučujeme nahradit konfigurační soubor analyzátoru "oids.xml" jeho nejnovější verzí, která je k dispozici u dodavatele analyzátoru.

Preview of "INFO" type message display from WM868-TE-B module in "Packets" table of RFAN 3.x analyzer is shown in figure 8. Current values of variables contained in individual messages are displayed in "tooltip" window when cursor is placed over "Data" area of given message.

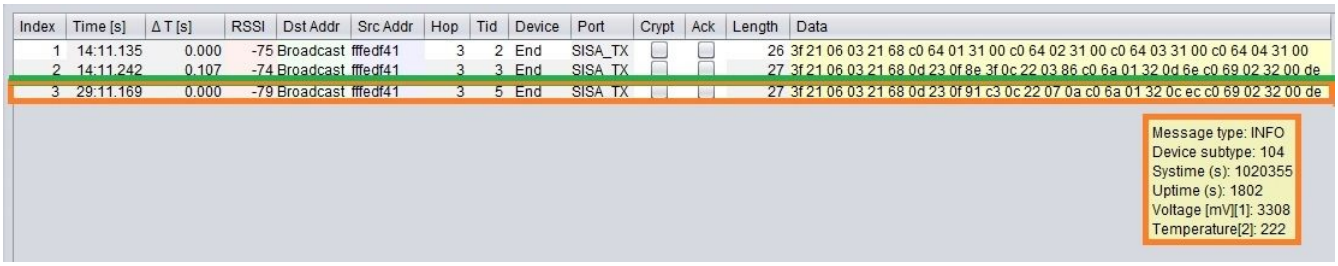

Figure 8: Display of "INFO" message from WM868-TE-B module in RFAN 3.x analyzer

4.2 LoRa

Data message sent via LoRa WAN radio technology is encoded using NEP protocol see chapter 4.1.

4.3 wM-Bus

Messages sent from WM868-TE-B module fully comply with 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 device iden-

Table 3: Structure of the Wireless M-BUS module WM868-TE-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"

tification 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 document provides basic recommendations for transport, storage, installation and operation of WM868-TE-B/WM868-TES-B radio modules.

5.1 General Operating Risks

WM868-TE-B/WM868-TES-B radio modules are electronic devices powered by internal battery that measure ambient air temperature at short intervals and transmit radio message with current temperature reading at set intervals. During device operation, following risks exist in particular:

5.1.1 Risk of mechanical and/or electric damage

The devices are enclosed in plastic boxes, so that the electrical components are protected from the direct damage by human touch, tools, or static electricity. In normal operation no special precautions are needed, besides avoiding of the mechanical damage from strong pressure or shocks.

Special attention is required for cables that connect the radio modules with the meters, sensors, or external antennas. In operation it is necessary to ensure that the cables are not stressed by mechanical tension or bending. In case of damage of any cable isolation it is recommended to replace the cable immediately. If the module is equipped with a remote antenna on a coaxial cable, much attention should be paid for the antenna and the antenna cable as well. The minimum bending radius of the antenna cable with 6 mm diameter is 4 cm, for the antenna cable with the 2,5 mm diameter the bending radius is 2 cm. Violation of these bending parameters can lead to breach of homogeneity of the coaxial cable that can cause reducing of radio range of the device. Further it is necessary to ensure that the connected antenna cable will not stress the antenna connector of the device by tension or twist. Excessive loads can damage or destroy antenna connectors.

Installation of the module can be performed only by a person with necessary qualification in electrical engineering and at the same time trained for this device installation. It is recommended to lead antenna and signal cables as far from 230/50 Hz power cables as possible.

5.1.2 Risk of premature battery discharge

The devices are equipped with the long duration batteries. Battery life can be influenced by these factors:

- storage and operation temperature – in high temperatures the spontaneous discharging current increases, in low temperature the battery capacity reduces;
- frequency of radio-transmitting.

Modules are delivered with preset period of regular transmitting of info-messages as stated in the configuration table in section of this document and the battery life cycle is quoted for this period. If the transmitting period is significantly reduced, battery life will be proportionally shortened.

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

WM868-TE-B/WM868-TES-B radio modules are enclosed in IP65 rated plastic cases, prepared for mounting on wall, pipe or other structural element. Battery switch, configuration connector, antenna connector and connector for external temperature probe (sensor) cable are located on printed circuit board, so access to them is only possible after opening case.

Figure 10 shows WM868-TES-B module with cover removed.

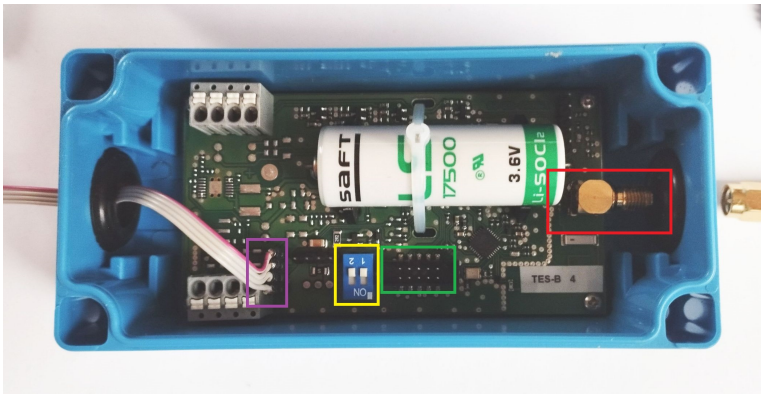

Figure 9: Detailed view of WM868-TES-B module

Important parts are color-marked on PCB in image: configuration connector (green), battery switch (yellow), external temperature probe cable connector (purple) and antenna connector (red).

Figure 10 shows WM868-TES-B module disassembled into individual components. WM868-TES-B module has

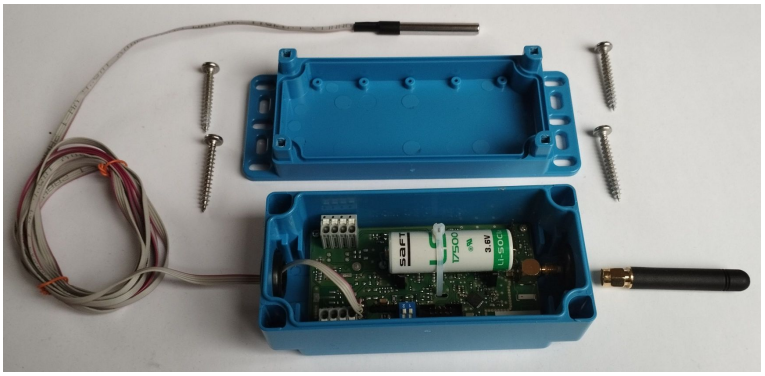

Figure 10: WM868-TES-B module assembly with rod antenna

external temperature probe connected at end of approx. 2 m long cable, which can be flat version (suitable for measuring in freezers) or standard round cross-section version which is more mechanically durable (suitable for measuring heating water temperature for example). Cable type needs to be specified in order. Probe is enclosed in metal housing which ensures quick reaction time to temperature changes.

WM868-TE-B module has external temperature probe inserted directly into cable gland and connected to connector by short cable. Temperature probe is thus practically integrated into module case.

The case consists of two parts:

- module base, to which the printed circuit board is attached with bushings for antenna and input signal cables;
- case lid, covering the printed circuit board, with moldings for mounting the module to a surface.

Module installation is performed as follows:

- choose a suitable location for module placement. For WM868-TE-B module choose the location considering measurement purpose (installation location is also measurement location), for WM868-TES-B module must be within reach of temperature probe cable length;
- attach module to a suitable fixed object (wall, structural element...) using screws or cable tie. Use moldings on sides of case lid for mounting;
- for WM868-TES-B module, position and secure temperature probe at desired measurement location and secure cable between probe and module case to minimize probability of cable damage;
- unscrew four screws on top of case to release module cover and slide base out of lid;
- connect rod or whip antenna, or antenna cable from remote external antenna to antenna connector. Route antenna or cable through cable gland directly opposite antenna connector;
- secure cable against pulling using mounting mechanism;
- switch both micro-switches ("jumpers") located on PCB next to configuration connector to "ON" position to connect module power;
- perform basic module diagnostics and configuration (parameter settings) using cable or mobile phone according to procedure described in section 3 "Module Parameter Configuration". If module was preconfigured during installation preparation phase, at minimum check correctness of transmitted temperature measurement value using mobile application;
- insert module base into lid and secure with screws;
- if installation procedure or customer internal rules require module sealing (as protection against tampering), seal module in specified way (for example by sealing joint between case parts with adhesive seal).

After installation, fill out installation protocol and verify module functionality and correctness of measured temperature output value again, preferably using "end-to-end" method, i.e. checking temperature data display and module operational parameters directly in remote reading system.

5.7 Module replacement

When replacing module due to module failure or battery depletion, proceed as follows:

- if module was sealed, check seal condition before disassembly. Handle broken seals according to internal rules for given customer/project;
- unscrew screws on top of case to release module cover and remove module base from lid;
- switch both micro-switches (”jumpers”) located on PCB next to configuration connector to ”Off” position to turn off module;
- disconnect temperature probe cable and remove temperature probe;
- loosen mounting screws holding case lid to wall or other surface and remove lid (*);
- reassemble original module by screwing lid to base (*). Clearly mark module as ”defective”, fill out appropriate form (installation sheet) or other required documentation for module replacement;
- install new module in place of original one and proceed according to procedure in section 5.6. Pay particular attention to correctly setting configuration parameters;
- record serial number and seal number of new module and measured temperature value if applicable;
- if possible, immediately ensure new serial number is entered into collection system database

Case lid does not carry any functional parts, type label with module serial number is on module base. When using mechanically identical product for replacement, it is acceptable to only replace module base and keep original lid that is already mounted. However, always check condition of rubber seal in lid mating surface groove and replace lid if there is any doubt about seal condition.

5.8 Module disassembly

For disassembly, open module, turn off battery, disconnect antenna cable if applicable and remove case lid from wall, ceiling or other surface. Reassemble module (put lid on case). After disassembly, properly mark module as disassembled and fill out appropriate documentation required by internal regulations for this case. If possible, immediately ensure module deactivation in collection system.

5.9 Module functionality check

After putting WM868-TE-B/WM868-TES-B module into operation (or after each repair and module replacement) we recommend checking its basic functions:

- check setting of basic module parameters, especially message sending system parameters (transmission mode, encryption, transmission period, frequency channel, transmission power);
- check correctness of temperature measurement using ”sensors” command;
- check RF subsystem functionality using RFAN 3.x analyzer. For this module must be switched to WACO transmission mode and receive messages from module with analyzer in ”Packets” or ”Radar” mode (according to procedure described in analyzer documentation), preferably using test transmission function;
- perform comprehensive module functionality check, including correctness of module introduction into data collection system, by checking correctness and currency of obtained data directly in data collection system.

5.10 Operating WM868-TE-B/WM868-TES-B module

Remote temperature reading using WM868-TE-B/WM868-TES-B modules in **automatic reading system** works completely automatically. Greatest risks here are associated with facility user activities, especially risk of mechanical module damage during handling objects at installation location, risk of relocating radio module to different location, or risk of signal shielding by metal object. Typical consequence of damage is complete loss of connection with module. Module relocation may manifest as change in received signal level from module, resulting in reduced reliability of consumption meter reading or interruption of connection with module.

To eliminate these risks we recommend paying attention to selection of module and antenna installation location not only from radio signal quality perspective but also from perspective of possible mechanical module damage during normal facility operation. We recommend performing installation carefully, using quality cables and installation materials.

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

Risk of **premature battery depletion** can be easily eliminated by following recommendations given in paragraph 5.1.2.

6 Troubleshooting

6.1 Possible System Failure Causes

During operation of WM868-TE-B/WM868-TES-B devices, failures, malfunctions, or other operational problems may occur, which can be categorized by their cause into the following categories:

6.1.1 Poruchy napájení

Modul je napájen z vnitřní baterie s dlouhou dobou životností. Přibližná doba životnosti baterie je blíže specifikována v odstavci 1.4 „Použití modulu". Na dobu životnosti baterie mají vliv okolnosti, podrobně popsané v odstavci 5.1.2 „Riziko předčasného vybití vnitřní baterie".

Nízké napětí napájecí baterie se zpočátku projeví nepravidelnými výpadky v příjmu dat od daného modulu, později se radiové spojení s modulem přeruší úplně.

Baterie je zapájena na desce plošného spoje a pro její výmenu je nutná demontáž modulu. Výměnu baterie může provádět pouze osoba s odpovídající kvalifikací a zkušenostmi, při pájení baterie nekvalifikovanou osobou hrozí riziko poškození desky plošného spoje modulu. V modulech řady WACOSystem jsou používány pouze nejkvalitnější baterie, které byly pro daný účel pečlivě vybrány a otestovány. V případě výměny baterie uživatelem zařízení musí nová baterie svými parametry (typ, kapacita, napětí, proudové zatížení, samovybíjecí proud...) co nejvíce odpovídat originální baterii, výrobce modulu důrazně doporučuje použít pro výměnu stejný typ baterie, jaký byl v modulu použitý při jeho výrobě.

6.1.2 Poruchy systému

Za poruchu systému se považují zejména poruchy procesoru, paměti, vnitřního napájení, či jiné fatální poruchy, které způsobí úplnou nefunkčnst zařízení. Je-li zařízení ve stavu, kdy baterie má správné napětí a nevykazuje žádné známky vybití a zařízení přesto nekomunikuje přes konfigurační port, nereaguje na žádné konfigurační příkazy a tento stav se nezmění ani po provedení restartu modulu odpojením a opětovným připojením baterie, jedná se pravděpodobně o poruchu systému. Provedeme výměnu zařízení dle odstavce 5.7 a následně provedeme nastavení a kontrolu funkčnosti nového (vyměněného) zařízení. Pokud nové zařízení normálně funguje, označíme původní modul jako vadný a zaznamenáme údaje o výměně do provozní dokumentace podle interních pravidel.

6.1.3 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.).

6.1.4 Sensor failures

A typical sign of temperature sensor failure is reading incorrect temperature values, meaning that data arrives regularly from the module but the values differ from reality or are obviously nonsensical. In this case, first visually check if there have been any changes in installation circumstances (module relocation, installation/removal of heat sources near the module...). If there is no natural explanation for the indicated temperature change, verify the module identification in the reading system (to check for device mix-up). If the module is set correctly in the reading system database, it is most likely a temperature sensor failure. In this case, replace the module according to section 5.7.

6.2 Failure Cause Determination Procedure

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

1. Module communicates normally, data can be read online or via Walk-By, but the thermometer shows clearly incorrect or suspicious temperature, either under certain circumstances or continuously. In this case, check the temperature sensor functionality according to section 6.1.4 "Sensor failures".
2. Data arrives from the module irregularly, with periodic dropouts in reception. In this case, we recommend checking the functionality of individual module subsystems in this order:
   - check transmission and data reception functionality according to section 6.1.3 "Transmitter and receiver failures",
   - check battery functionality according to section 6.1.1 "Power supply failures".
   - check functionality of the device receiving data from the module according to that device's documentation.
3. No data arrives from the module. In this case, we recommend checking the functionality of individual module subsystems in this order:
   - verify correct address setting of the given module in the collection system,
   - check power supply functionality according to section 6.1.1 "Power supply failures",
   - check system functionality according to section 6.1.2 "System failures",
   - check transmission and data reception functionality according to section 6.1.3 "Transmitter and receiver failures".

WARNING: The WM868-TE-B/WM868-TES-B module is a reliable device with 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 depletion, or input damage from induced voltage in the cable. With each module replacement due to failure, we recommend verifying if possible whether the failure was caused by one of these circumstances and taking measures to eliminate it if necessary.

7 Additional information

This manual is focused on description, parameters and configuration options of radio modules WM868-TE-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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