WIRELESS COMMUNICATION SYSTEM WACO WM868

WM868-TI4

Revision 2.0

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1 Introduction

This document describes the configuration options of the WM868-TI4 radio module, which is used for measuring temperature in interiors and for 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-TI4 module is designed to measure air temperature in interiors (residential buildings, warehouses, production halls...) with a recommended temperature range of (0 ÷ 70) °C. The module is equipped with an integrated temperature sensor, mounted directly on the printed circuit board.

The module transmits current data on the measured temperature in the form of radio messages, sent automatically at a set time interval. The message with current values of the measured quantity is of the "INFO" type and, in addition to data on the current temperature value, it also contains the module's system time, battery voltage, and processor temperature.

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

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

Message transmission in the 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 through a private or public IP service to the communication gateway, which converts it into the appropriate radio format and sends it to the end device at an appropriate time.

The principle of data transmission from the WM868-TI4 module through a communication gateway is shown in Figure 1.

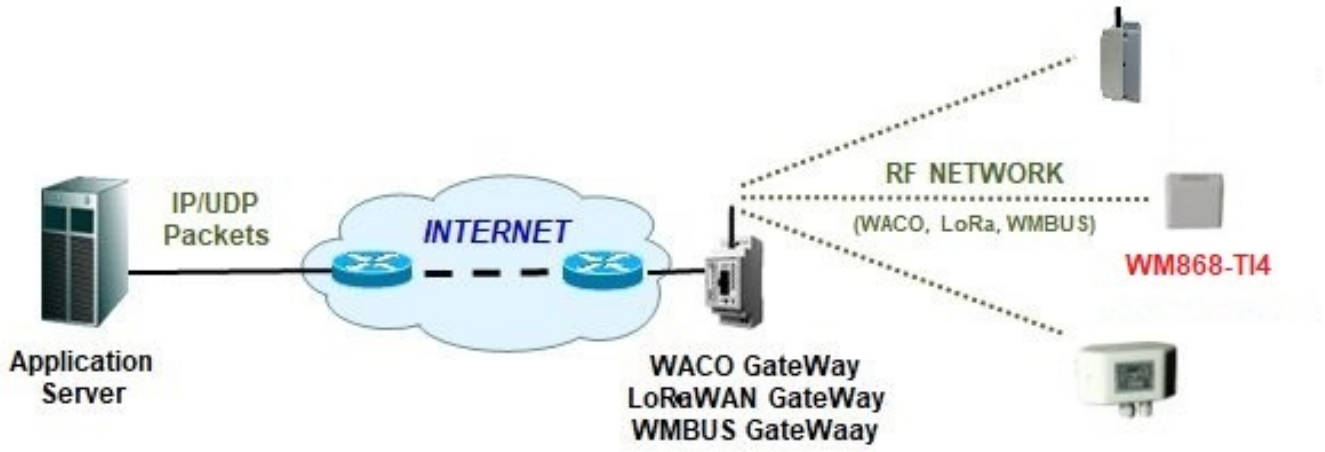

Figure 1: Principle of data transmission from the WM868-TI4 module through a communication gateway

In WACO transmission mode, messages can be transmitted directly to another WACO system module that is constantly receiving. Figure 2 shows the data transmission from the WM868-TI4 module to the so-called **"Collecting Unit"** of the WACO system, which collects data from battery-powered WACO modules, converts the data into standard M-Bus protocol messages and forwards them to the bus control unit (device type "M-Bus Master") in M-Bus format on a physical bus.

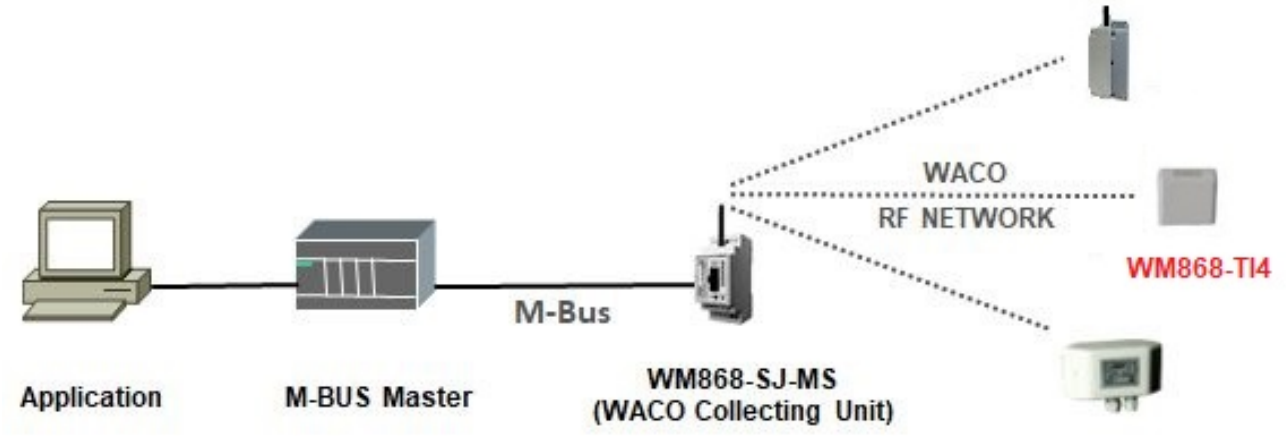

Figure 2: Principle of data transmission from the WM868-TI4 module to another WACO radio module

The WM868-TI4 module is enclosed in a plastic box designed for wall mounting. The device is not suitable for placement in an outdoor environment without additional cover.

The module is powered by an internal battery with a capacity of 3.6 Ah, which allows it to operate for more than 10 years with a message transmission period of 12 hours. Battery life can be negatively affected not only by a set shorter interval for sending temperature status, but also by operating the device in installation locations with temperatures outside the recommended operating temperature range, or in networks with low radio signal levels, high radio traffic, or radio interference.

The appearance of the WM868-TI4 module is shown in Figure 3.

Figure 3: Appearance of the WM868-TI4 module

2 Overview of technical parameters

An overview of the technical parameters of the WM868-TI4 module is given in Table 1.

Table 1: Overview of technical parameters of the WM868-TI4 module

Radio interface		
Frequency band	868	MHz
Transmission modes	WACO, wM-Bus, LoRa	
Modulation type - WACO	GFSK	
Modulation type - wM-Bus	FSK	
Modulation type - LoRa	spread spectrum	
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
Transmission speed - WACO	38400 (2400)*	bps
Transmission speed - wM-Bus	100	kbps
Transmission speed - LoRa	250 ÷ 11000	bps
Antenna	integrated	
Configuration interface RS232		
Transmission speed	9600	Baud
Operation type	asynchronous	
Transmission parameters	8 data bits, 1 stop bit, no parity	
Signal level	CMOS 3.3	V
Temperature sensor		
Measured temperature range	(-40 ÷ 80)	°C
Resolution	0.1	°C
Measurement accuracy for range (0 ÷ 65)°C	0.5	°C
Measurement accuracy for range (-40 ÷ 0)°C	1	°C
Bluetooth configuration interface		
Version	BLE 5.2	
Frequency	2.4	GHz
Transmission speed	1	Mbps
Maximum power	8	dBm
Power supply parameters		
Lithium battery voltage	3.6	V
Lithium battery capacity	3.6	Ah
Mechanical parameters		
Length	70	mm
Width	70	mm
Height	27	mm
Weight	220	g
Storage and installation conditions		
Installation environment (according to ČSN 33 2000-3)	normal AA6, AB4, A4	
Operating temperature range	(-10 ÷ 50)	°C
Storage temperature range	(0 ÷ 40)	°C
Relative humidity	95	% (without condensation)
Degree of protection	IP20	

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

3 Module Configuration

Configuration parameters of the WM868-TI4 module can be displayed and changed from the common computer (PC) or smartphone by one of these methods:

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

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

The description and meaning of all configuration parameters that can be checked and changed by cable can be found in the section 3.1 „Setting of WM868-TI4 parameters via configuration cable".

Description of connecting the module to a mobile phone via Bluetooth wireless connection and general rules for configuring the module using the mobile application "Softlink Configurator" are described in Chapter 3 of the above-mentioned manual „Configuration of wacoSystem product family devices". In section 3.2 "Setting the parameters of the WM868-TI4 module using a mobile application", there is a description and explanation of the parameters that can be set using the mobile application.

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

3.1 Setting WM868-TI4 module parameters using a configuration cable

The following part of the manual describes those parameters of the WM868-TI4 module whose current value can be determined by directly connecting the module to a PC using a configuration cable and possibly changing them with configuration commands (configuration "from the command line").

3.1.1 Listing of WM868-TI4 module configuration parameters

To display the configuration parameters, enter the command **"conf"** into the command line and press the "ENTER" key.

The following listing will appear in the terminal window:

```
wm868-TI4>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 includes sections for individual transmission modes (WACO, LoRa, Wireless M-Bus) and a section for 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 WM868-TI4 module configuration commands ("HELP")

To display a summary of configuration commands ("HELP") and their parameters, enter the command **"?"** into the command line and press the "ENTER" key. The following listing will appear in the terminal window:

```
wm868-TI4>?
?            - 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
system       - System commands
wm868-TI4>
```

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"), the names of individual module subsystems that have their own commands are listed. These commands can be displayed by entering the subsystem name into the command line and pressing the "ENTER" key. Example of displaying commands for the "rf" subsystem:

```
wm868-TI4>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-TI4>
```

The listed commands can only be used for the given subsystem, and this is done by first 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 transmission power setting:

```
wm868-TI4>rf txp
TX power    : 14 dBm
wm868-TI4>
```

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-TI4>?
?         - 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-TI4 module").

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

```
wm868-TI4>info
Device      :  wm868-TI4
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-TI4>
```

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-TI4 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-TI4>>write
Writing config ...
wm868-TI4>
```

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-TI4>mode wmbus
Mode    :  WMBUS
wm868-TI4>mode lora
Mode    :  LoRa
wm868-TI4>mode waco
Mode    :  WACO
wm868-TI4>mode
Mode    :  WACO
wm868-TI4>
```

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

```
wm868-TI4>reset
wm868-TI4>
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-TI4>
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-TI4>sensors
Temp.  int.  :  21.0 C
Temp.  sensor:  -500.0 C
VCC          :  3107 mV
VBat         :  3114 mV
wm868-TI4>
```

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-TI4 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-TI4>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-TI4>
```

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-TI4>rf txp 14
TX power :  14 dBm
wm868-TI4>
```

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-TI4>rf rxt 10
RX timeout :  10 (500 ms)
wm868-TI4>
```

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-TI4 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-TI4 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-TI4 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-TI4 module in WACO transmission mode. These are the following commands:

```
wm868-TI4>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-TI4>
```

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-TI4 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-TI4>waco channel
channel :  0
wm868-TI4>waco channel 2
channel :  2
wm868-TI4>
```

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-TI4 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-TI4>waco hop
Hop count :  1
wm868-SI4-2>waco hop 3
Hop count :  3
wm868-TI4>
```

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-TI4>waco rex 1
Repeater :  1
wm868-TI4>waco rex 0
Repeater :  0
wm868-TI4>
```

The WM868-TI4 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-TI4>waco ttout
Test timeout:  20 sec.
wm868-TI4>waco ttout 5
Test timeout:  5 sec.
wm868-TI4>
```

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-TI4>system txtest 1
TX test :  1
wm868-TI4>system txtest 0
TX test :  0
wm868-TI4>
```

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-TI4 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-TI4>waco encrypt 37 abcde
Encrypt port:  37
wm868-TI4>waco encrypt delete 37
Encrypt port:
wm868-TI4>
```

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-TI4 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-TI4 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-TI4 module in Wireless M-Bus transmission mode (hereinafter "WMBUS"). These are the following commands:

```
wm868-TI4>wmbus
mode      - set mode
channel   - set channel
id        - set ID
manuf     - set manufacturer
medium    - set medium
version   - set version
ekey      - set encryption key
wm868-TI4>
```

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-TI4>wmbus mode
Mode :  T1
wm868-TI4>wmbus mode C1
Mode :  C1
wm868-TI4>
```

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-TI4 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-TI4 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-TI4 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-TI4 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-TI4 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-TI4>wmbus medium
Medium :  7
wm868-TI4>wmbus medium 2
Medium :  2
wm868-TI4>
```

***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-TI4>wmbus ekey 1a2b3c4d5e6fa1b2c3d4e5f6778899af
wm868-TI4>
```

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-TI4>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-TI4>wmbus ekey .
wm868-TI4>
```

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

Warning! *WM868-TI4 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-TI4 module in LoRa transmission mode. These are the following commands:

```
wm868-TI4>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-TI4>
```

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-TI4 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-TI4>lora chan
Channel :  0
wm868-TI4>lora chan 1
Channel :  1
wm868-TI4>
```

The **"lora dr"** command is used to display or set the data rate at which the module transmits data. The WM868-TI4 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-TI4 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-TI4 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-TI4>lora dr
Data Rate :  0
wm868-TI4>lora dr 4
Data Rate :  4
wm868-TI4>
```

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-TI4>lora rxdly
Recv Delay :  2
wm868-TI4>lora rxdly 1
Recv Delay :  1
wm868-TI4>
```

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-TI4 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-TI4>lora netadr
Dev Addr :  0x00000000
wm868-SI4-2>lora netadr 0xffff1234
Dev Addr :  0xffff1234
wm868-TI4>
```

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-TI4>lora nwkskey 1a2b3c4d5e6fa1b2c3d4e5f6778899af
NwkSKey :  1a2b3c4d5e6fa1b2c3d4e5f6778899af wm868-TI4>
```

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-TI4>lora encrypt
Encrypt :  0
wm868-TI4>lora encrypt 1
Encrypt :  1
wm868-TI4>
```

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-TI4>lora otaa
OTAA : 0
wm868-TI4>lora otaa 1
OTAA : 1
wm868-TI4>
```

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-TI4>app
?         - help
info      - print Rf APP info
sending   - set sending interval in secs.
measure   - set measure interval in secs.
wm868-TI4>
```

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-TI4>app sending
Sending :  900 secs.
wm868-TI4>app sending 1800
Sending :  1800 secs.
wm868-TI4>
```

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-TI4>app measure
Measure :  60 secs.
wm868-TI4>app measure 300
Measure :  300 secs.
wm868-TI4>
```

3.1.9 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-TI4>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-TI4>
```

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.**

3.1.10 Commands for setting the Bluetooth subsystem

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

```
wm868-TI4>ble
txp       - TX power in dBm
chmask    - Advertisement channel mask
advtout   - Advertisement timeout/period
conntout  - Connection timeout
pin       - BLE pin
wm868-TI4>
```

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

3.2 Setting module parameters using a mobile application

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

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

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

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

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

The "Softlink Configurator" application currently offers five configuration forms for configuring the WM868-TI4 module, which allow checking and setting all module parameters that are necessary for its installation and normal operation. However, the application is continuously developing and its possibilities and functions are gradually expanding.

The **"Administration formular"** is used to check the functionality of the module. It contains a listing of the main operating parameters and a button for starting the function. The form contains the following non-editable information:

- **RESET** button for resetting the module
- **Uptime** value since the last reset
- **measured temperature** value
- **battery voltage** value

- current **processor temperature**
- **packet transmission statistics** since reset

The **"General Settings RF"** form is used to set communication parameters. The form contains the following information and tools:

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

The **"WACO RF settings"** form is used to set parameters for communication in WACO transmission mode. The form contains the following information and tools:

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

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

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

The **"LoRa RF settings"** form is used to set parameters for communication in LoRa transmission mode. The form contains the following information and tools:

- **Set LORA** option button for switching to LoRa transmission mode
- setting the **network address** of the LoRa protocol
- setting the **Network Session Key**
- setting the **Application Session Key**
- setting the **Application Session Key**
- setting the **Application Key** (Root Key)
- setting the **Join EUI**
- setting the device class **Do not use!**
- setting the **activation mode** (ABP/OTAA)
- enabling adaptive power function **Do not use!**
- enabling **application data encryption**
- setting the **frequency band**
- setting the **frequency channel**
- setting the **data rate** (Data Rate)
- setting the **Receive Delay**
- setting the **Join Delay**
- setting Acknowledge Limit **Do not use!**
- setting Acknowledge Delay **Do not use!**
- setting Acknowledge Timeout **Do not use!**

The meaning of individual parameters is described in detail in section 3.1 "Setting WM868-TI4 module parameters using a configuration cable".

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

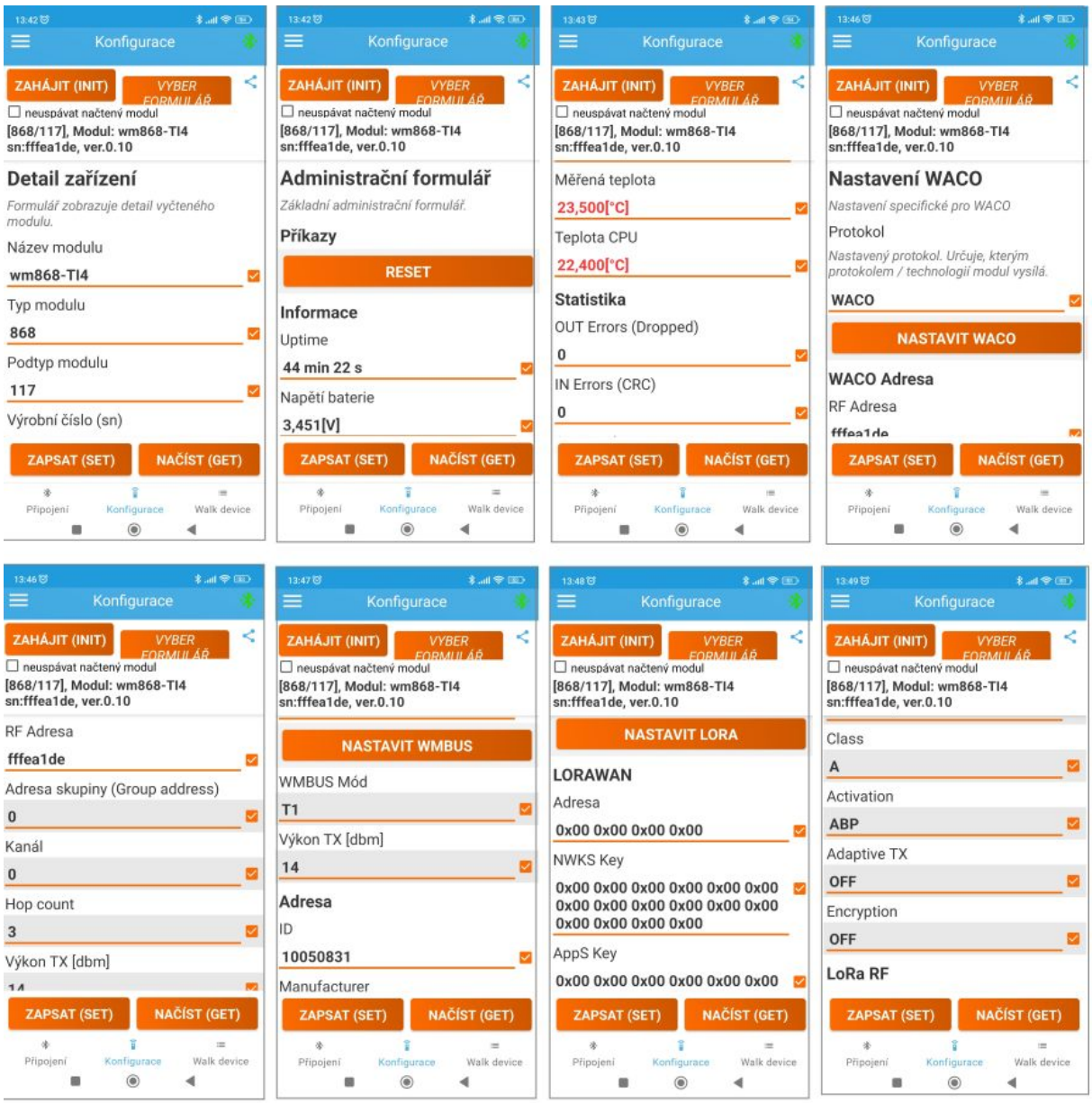

Figure 4: Preview of forms for setting the WM868-TI4 module using a mobile application

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

The WM868-TI4 module supports communication in the so-called **reverse channel** (from the central application to the module) in WACO and LoRa transmission modes. The possibilities of two-way communication via the reverse channel can be used for remote parameter setting from a remote computer. The reverse channel opens only for a short time to save battery, always following data transmission (see receive window setting in WACO and LoRa transmission modes), during this time the module can receive a message from the central application that is prepared for it in the BackEnd or in the communication gateway.

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

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

4 Structure of the module's data message

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

Table 2: Overview of communication protocols of the WM868-TI4 module

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

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

4.1 WACO

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

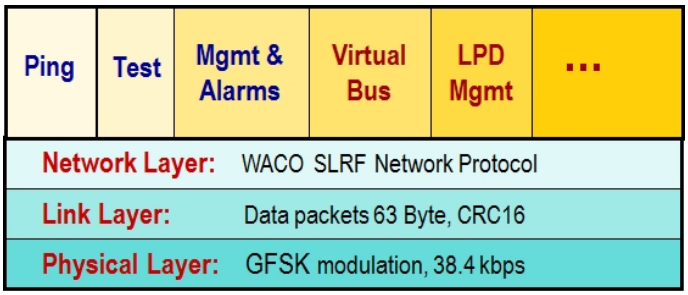

Figure 5: WACO SLRF protocol structure

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

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

The WM868-TI4 module is used for measuring temperature in interiors and sending temperature data to the WACO radio network through "INFO" type messages. The transmission of "INFO" messages takes place in the "SISA_TX" type application (port number 37) of the "LPD Management" group (LPD=Low Power Devices), used for data collection from battery-powered devices. These devices communicate in the so-called "active mode", where the device actively sends data at adjustable intervals and does not wait for confirmation of message receipt. The content of the "INFO" message of the WM868-TI4 module includes these variables:

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

Individual variables are coded into the data content of the message by using of "NEP" proprietary coding system invented by SOFTLINK. In this system each type of variable has its own designation called "OID" (Object ID), which determines meaning, character and data type of the variable. These variables, that could be used multiple times (as multiple inputs, temperatures, voltages...) must be used jointly with order number of the variable called "Index". „NEP coding table" is centrally maintained by SOFTLINK and it is available on the public WEB address NEP Page. Preview of „NEP coding table" for coding of variables in the WACO system is shown in the figure 7.

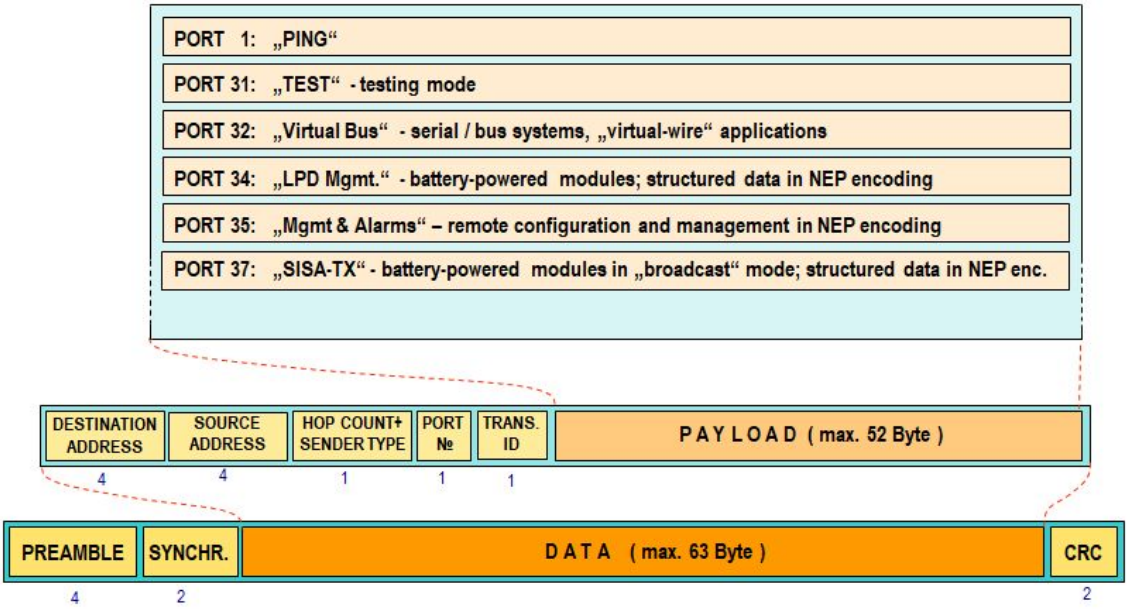

Figure 6: Structure of WACO system data packet

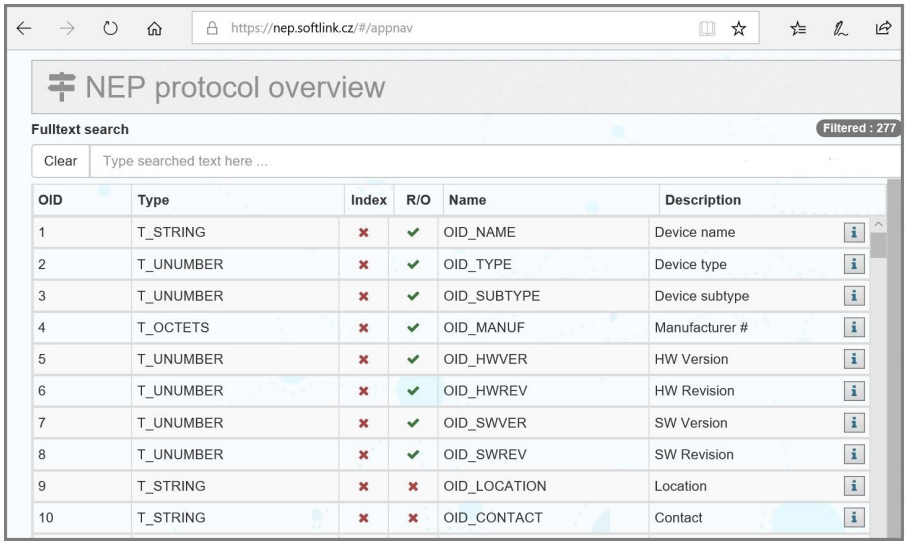

Figure 7: Preview of „NEP coding table” for coding of variables in WACO system

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

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

A preview of ”INFO” type messages of the WM868-TI4 module in the ”Packets” table of the RFAN 3.x analyzer is shown in Figure 8. The current values of variables contained in individual messages are displayed in the ”tooltip” window when the cursor is placed over the ”Data” area of the given message.

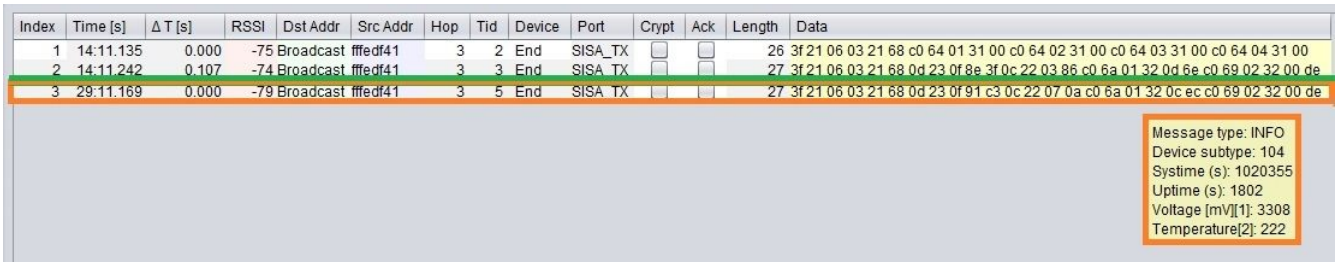

Figure 8: Display of the "INFO" message of the WM868-TI4 module in the RFAN 3.x analyzer

4.2 LoRa

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

4.3 wM-Bus

Messages sent from the WM868-TI4 module fully comply with the EN 13757 standard. The structure of the Wireless M-BUS module message header is shown in Table 3. The Wireless M-BUS header contains complete device

Table 3: Structure of the Wireless M-BUS module WM868-TI4message 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"

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

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

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

5 Operating conditions

This section of the document provides basic recommendations for transportation, storage, installation and operation of WM868-TI4 type radio modules.

5.1 General operational risks

The WM868-TI4 radio modules are electronic devices powered by their own internal battery, which measure ambient air temperature at short intervals and send a radio message with the current temperature reading at set intervals. During operation of the device, the following risks are particularly present:

5.1.1 Risk of mechanical and electrical damage

The devices are enclosed in plastic boxes with small ventilation slots allowing air flow around the measuring sensor. The slots, measuring 35 mm x 2 mm, prevent direct damage to electronic components by touch and static electricity, but do not prevent mechanical and electrical damage mediated by a thin tool. Another possible risk of module damage is the possibility of water damage. The module is intended for use in a dry indoor environment with the expected method of installation on the ceiling or wall. Under normal use, no special precautions are necessary, except for preventing mechanical damage from strong pressure and shocks and preventing water from entering the module.

5.1.2 Risk of premature internal battery discharge

The devices are equipped with a long-life internal battery. The following factors have a significant impact on battery life:

- storage and operating temperature – at high temperatures, the battery's self-discharge current increases; at low temperatures, the battery capacity decreases. Optimal storage and operating temperatures are in the range of $(0 \div 30)$°C;
- frequency of transmitter and receiver activation.

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

5.2 The condition of modules on delivery

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

5.3 Modules storage

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

5.4 Safety precautions

Warning! Mechanical and electrical installation of the WM868-TI4 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-TI4 radio modules are enclosed in plastic enclosures with IP20 protection rating. The enclosure consists of two parts:

- module enclosure with printed circuit board. There are ventilation slots on two sides of the enclosure;
- enclosure lid with moldings indicating the location for drilling holes for screws used to mount the module.

A view of both parts of the WM868-TI4 module is shown in Figure 9.

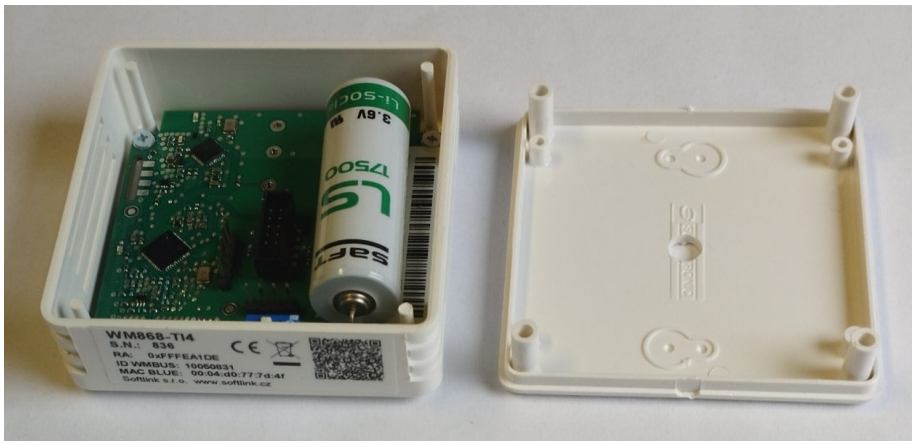

Figure 9: WM868-TI4 module assembly

In Figure 10, the position of the battery switch (jumper) is marked in yellow on the printed circuit board, and the configuration connector is marked in green.

Figure 10: Detailed view of the WM868-TI4 module

Install the module as follows:

- remove the enclosure lid from the WM868-TI4 module enclosure by pulling with your fingers or using a suitable tool (such as a thin screwdriver);

- attach the enclosure lid to the wall or ceiling of the room using one or two screws (*). The locations for drilling screw holes are marked by moldings on the inside of the enclosure lid. First drill holes for screws in the enclosure lid, then use these to mark locations on the wall for drilling holes for wall plugs. Use common screws of appropriate dimensions (according to the properties and material of the surface, for example 2.5 x 30 mm, or a 6 mm diameter hammer-in wall plug). Firmly screw the enclosure lid to the wall or ceiling;
- switch the battery switch to the "ON" position to connect power to the module;
- perform basic module diagnostics and, if the module was not configured in the preparatory installation phase, configure it using a cable (or radio) according to the procedure described in section 3 "Module Configuration".
- place the module enclosure on the attached lid. When mounting on a wall, rotate the enclosure so that the vents are on the top and bottom of the enclosure. When mounting on a ceiling, you can place the enclosure in any direction;
- if the installation procedure or customer's internal rules require sealing the module (as protection against tampering), seal the module by covering the joint between the two parts of the enclosure with an adhesive seal.

(*) Due to its minimal weight, the module can also be attached using a single screw (preferably in the center of the enclosure), or using a suitable mounting adhesive. For short-term installation, the module can also be attached using double-sided adhesive tape.

After installation, complete the prescribed documentation (installation protocol), or ensure that you have installed the correct module according to the installation label or project documentation. If necessary, verify the module's functionality once more using an analyzer or comprehensive "end-to-end" check by displaying temperature data in the remote data collection system.

When selecting the module installation location, consider the purpose of measurement (temperature stratification in the room, air flow...), protection of the module from possible mechanical damage (installation away from operationally exposed areas, out of reach of children, etc.), as well as conditions for radio signal propagation between the module installation site and the communication gateway, repeater, or suitable Walk-By system reading position. These conditions can either be estimated based on previous experience or by measuring signal strength using a WACO RFAN 3.x analyzer. The minimum received signal level (RSSI) value for WACO WM868 series modules in WACO transmission mode is -105 dBm, but at this level there is no reserve for temporary signal "fades" and it is almost certain that radio communication with the module will occasionally fail. The optimal received signal level (RSSI) is in the range of -(80 ÷ 85) dBm.

5.7 Replacing the WM868-TI4 module

When replacing the WM868-TI4 module due to a module malfunction or depleted battery capacity, proceed as follows:

- if the module was sealed, check if the adhesive seal is intact before disassembly. Handle broken seals according to the internal rules applicable to the customer/project;
- remove the enclosure lid from the WM868-TI4 module enclosure by pulling with your fingers or using a suitable tool (such as a thin screwdriver);
- turn off the module by switching off the battery switch on the printed circuit board and visibly mark it as "faulty". If necessary, complete the appropriate form (installation sheet) or other prescribed documentation for module replacement;
- open the new module and (unless there is a reason to replace the original lid as well) place the enclosure with the new module on the original lid in place of the original module;
- connect power to the module by switching on the battery switch and perform basic diagnostics and module setup according to the procedure described in section 5.9 "Checking module functionality". Check and set especially the frequency channel, number of hops (for WACO transmission mode) and time constants of the transmitter and receiver.
- record the identification data of the new module and, if possible, immediately correct the module identification in the reading system database;
- reassemble the original faulty module by attaching the remaining lid.

5.8 Module disassembly

To disassemble, open the module and remove the enclosure lid from the wall, ceiling, or other surface. Turn off the battery and reassemble the module (place the lid on the enclosure). After disassembly, properly mark the module

as disassembled and complete the appropriate documentation prescribed for this case by internal regulations. If possible, ensure deactivation of the module in the remote reading system.

5.9 Checking module functionality

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

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

5.10 Operation of the WM868-TI4 module

Remote temperature reading using WM868-TI4 modules in an automatic reading system operates completely automatically. The greatest risks here are associated with the activities of the facility user, especially the risk of mechanical damage to modules when handling objects at the installation site, the risk of relocating the radio module to another location, or the risk of signal shading by a metal object. A typical consequence of damage is a complete loss of connection with the module. Relocating the module may manifest as a change in the received signal level from the module, which may result in reduced reliability of temperature readings or loss of connection with the module. To eliminate these risks, it is recommended regularly monitoring the functionality of temperature readings and, in case of detected outages or non-standard values, contacting the facility user or performing a physical check at the installation site. The risk of premature battery discharge can be easily eliminated by following the recommendations given in section 5.1.2.

6 Troubleshooting

6.1 Possible causes of system failures

During the operation of the WM868-TI4 device, failures, functional outages, or other operational problems may occur, which can be divided into the following categories according to their cause:

6.1.1 Power supplying failures

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

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

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

6.1.2 System failures

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

6.1.3 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 a temperature sensor failure is the reading of incorrect temperature values, that is, a condition where data comes regularly from the module, but the values differ from reality or are obviously nonsensical. In this case, first visually check whether there have been any changes in the installation circumstances (relocation of the module, installation/uninstallation of a heat source near the module...). If there is no natural explanation for the change in indicated temperature, check the identification of the module in the reading system (whether there has been a 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 Procedure for determining the cause of failure

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

1. The module communicates normally, data can be read by the system online or by Walk-By, but the thermometer gives obviously incorrect or suspicious temperature, either under some circumstances or constantly. In this case, check the functionality of the temperature sensor according to section 6.1.4 "Sensor failures".
2. Data comes from the module irregularly, there are periodic outages in receiving data from the module. In this case, it is recommended checking the functionality of individual subsystems of the module in this order:
   - check the functionality of data transmission and reception according to section 6.1.3 "Transmitter and receiver failures",
   - check the functionality of the battery according to section 6.1.1 "Power supply failures".
   - check the functionality of the device that receives data from the WM868-TI4 module according to the documentation for that device.
3. No data comes from the module. In this case, it is recommended checking the functionality of individual subsystems of the module in this order:
   - check the correctness of the address setting of the given module in the collection system,
   - check the functionality of the power supply according to section 6.1.1 "Power supply failures",
   - check the functionality of the system according to section 6.1.2 "System failures",

- check the functionality of data transmission and reception according to section 6.1.3 "Transmitter and receiver failures".

WARNING: The WM868-TI4 module is a reliable device of relatively simple and durable construction, so there is a high probability that any failure is caused by external circumstances of installation, especially mechanical damage, moisture ingress, internal battery depletion or damage to inputs by induced voltage in the cable. With each replacement of the module due to failure, it is recommended verifying whether the cause of the failure was not one of these circumstances and, if necessary, take measures to eliminate it.

7 Additional information

This manual is focused on description, parameters and configuration options of radio modules WM868-TI4 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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