WIRELESS COMMUNICATION SYSTEM
Wireless M-BUS

WB169-SI2

Revision 1.0

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1 Introduction

This document describes features, parameters and setting possibilities of the WB169-SI2 module, which is used for reading of either consumption meters with pulse output (water meters, electrometers, gas-meters...), or two-state sensors (e.g. door contacts, flood detectors, fire detectors, electronic seals...etc.) and for radio-broadcasting of the data from connected meters/sensors to the superior remote reading system in form of Wireless M-BUS standard messages. The WB169-SI2 module works either in unidirectional communication mode N1, or in the bidirectional N2 mode. In both modes the module regularly broadcasts information messages of „User Data" type intended for superior „master" device. In bidirectional N2 mode it is possible to use a back channel from master device, that can be used for transfer of „Request" type of messages with remote configuration demands. In „alarm mode" the module sends „Alarm from meter" type of messages based on the sensor status changes. These messages are sent immediately, out of regular broadcasting interval.

1.1 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 back 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.

1.2 Module usage

The WB169-SI2 module can be used either for remote reading of two consumption meters with pulse output, or for transfer of alarm messages from two two-state sensors. It is possible to combine both type of usage.

When using for **remote reading of consumption meters** (water meters, gas-meters, electro-meters...), up to two meters with standard pulse ("SI") output can be connected to the module. The meters can be of different kind, with different quantities and units and with different conversion rates. The module continuously registers incoming pulses (generated by meters) into its internal counters, with using of preconfigured multipliers/divisors converts current status of each counter into the required output units (m3, kWh, MJ...) and broadcasts info-messages with current statuses of all connected meters as Wireless M-BUS „User Data" messages.

When using for **remote monitoring of sensor statuses** (door contacts, flood detectors, fire detectors, electronic seals..), up to two two-state sensors with "off/on" ("0/1") outputs can be connected to the module. The sensors can be of different kind, with different type of output and different logic of signaling. The module continuously monitors status of each sensor and records all its changes. If the counter is switched into alarm mode, the module immediately transmits alarm messages according to preselected rule. The module regularly broadcasts in each info-message the number of „0-to-1" transitions, as well as current sensor status ("0" or "1"). If the counter is switched into the alarm mode, the module sends „Alarm from meter" message immediately at the change of sensor status.

Each regular **information message** contains module identification, values of both counters, actual statuses of all connected sensors in alarm mode and operational entries from embedded sensors (battery voltage, processor temperature). Each **alarm message** contains only module identification and information about the actual status of that port, on which the status was changed. Detailed information about the content and format of information and alarm messages can be found in paragraph 3.3.

Information and alarm messages are transmitted either in open mode (without encryption), or encrypted by AES-128 encryption key. The messages are transmitted on the 169.4 MHz frequency with data rate from 2.4 kbps to 19.2 kbps (according to used frequency channel). Messages can be received either by WB169-RFE communication

gateway (WMBUS Ethernet GateWay produced by SOFTLINK), or any other „Master" device that complies with the Wireless M-BUS EN 13757-3 / EN 13757-4 standard for 169 MHz frequency band. Principle of data transfer from the WB169-SI2 module for both kinds of solutions is depicted in the figure 1.

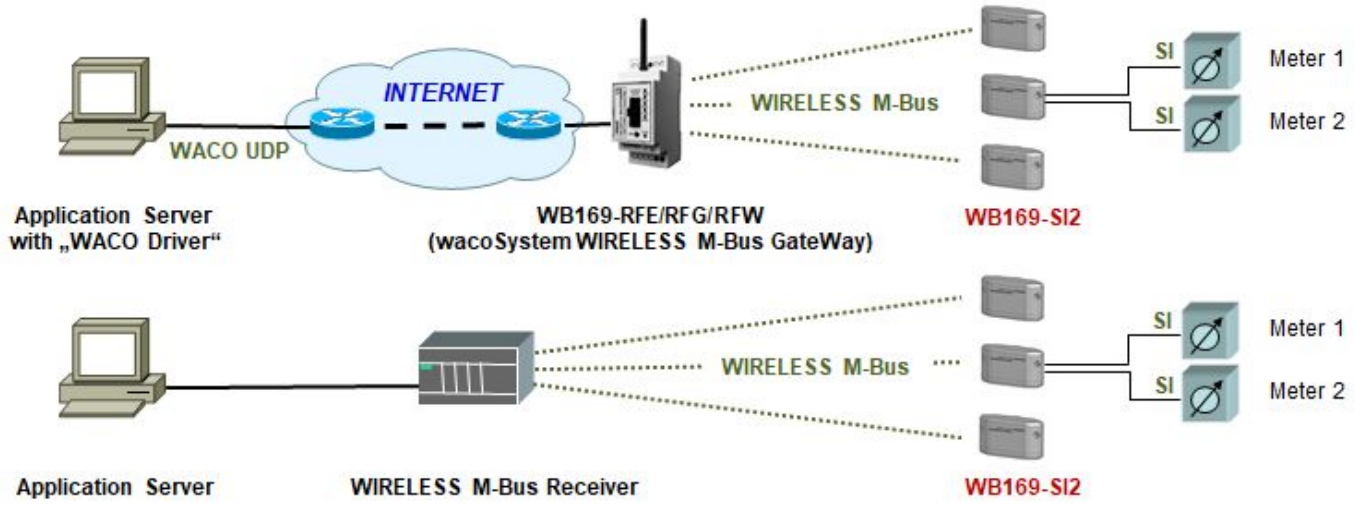


Figure 1: Principle of data transfer from the WB169-SI2 module

1.3 External synchronization, tariff switching and alarm functions

TheWB169-SI2 module can be used in a wide variety of applications within different industries. The **external synchronization** function is intended especially for measurement of electrical energy and gas. When using this function, broadcasting of the module is synchronized from external source of synchronization pulses. It can be used for measuring of energy consumption in standardized 15-minutes intervals synchronized with parallel measurement of superior energy/gas distributor. Detailed description of this function can be found in paragraph 3.1.5 „WMBUS' group commands for setting of messages".

The **tariff switching** function, that is also intended for energy measurement, enables distribution of input pulses between two internal counters („high tariff" and „low tariff") on the base of external control voltage of daily load diagram system (also known as „DSM" - demand side management). Detailed description of this function can be found in paragraph 3.1.10 „Description and setting of „Tariff switching" function".

The WB169-SI2 module enables also monitoring of operational parameters of objects by reading of **sensor statuses**. Typical example of this usage is monitoring of opening/closing of overhead doors of halls, where the module can provide information about current status of each door and measure number of open/close cycles of the doors. Another example is monitoring of current statuses of circuit breakers or closing valves or monitoring of safety-loops („electronic seals"). Detailed description of special settings for sensor monitoring purposes can be found in paragraph 3.1.9 „Setting of sensor inputs".

The special **alarm functions „Leak" and „Burst"** are intended for measuring of water and gas. The „Leak" function serves for detection of permanent minor leaks in water/gas distribution systems. The „Burst" function serves for detection of breakdowns in water/gas distribution systems, when some kind of accident (e.g. broken pipe) causes huge overconsumption. Each of these functions can be configured for any port of the module. Corresponding „Leak" and „Burst" alarm messages are transmitted immediately after detection of the alarm status. Coding of these alarm messages complies with M-Bus standard. Detailed description of alarm messages can be found in paragraph refsection:struktura-zpravy „Structure of module data messages".

Detailed description of „Leak" function can be found in paragraph 3.1.7 „Description and setting of „Leak" alarm function". Detailed description of „Burst" function can be found in paragraph 3.1.8 „Description and setting of „Burst" alarm function".

1.4 Bi-directional communication mode

If the WB169-SI2 module is preset for working in **bi-directional communication mode N2**, it could receive the **„Request" type of messages** according to the Wireless M-BUS standard. These messages can be originated by superior system or by superior „Master" device and can contain commands for remote configuration of following parameters:

- setting of transmitting power;
- setting of info-messages broadcasting period;
- correction of statuses of pulse counters - relatively („add NN") or absolutely („set NN") ,

Receiving of „Request" type message take place always during the 500 ms long time window that starts immediately after transmitting of regular „User Data" info-message. During this interval the WB169-SI2 module opens its receiver so as to be able to receive possible „Request" message. The module confirms receiving of „Request" by sending of „Acknowledgment" type of message.

Management of „Request" type of messages must be implemented into the central application software or into the superior „Master" device. The messages are coded by M-Bus standard principles with short Wireless M-BUS header with special indication of „Request" type messages (C-byte ="53", CI-byte = "5A"). The message contains one data block (with appropriate DIFE/VIFE code and required value) for each parameter, that should be remotely changed. More detailed description of „Request" type of message can be provided by producer of the module on request.

1.5 Hardware features and power supplying

The module is enclosed in transparent humidity-proof plastic casing and can be used in interiors as well as in exteriors. The casing is designed for mounting on the wall or other construction element (beam, pipe...). Module can be treated with an additional sealing by high-adhesion silicon filling, that can ensure proof against inundation by water (IP68 grade). If this treatment is required from the manufacturer, it must be ordered separately.

The module can be controlled and configured either by configuration cable, or wirelessly - by infra-red remote control with using of optical converter. The module is equipped with the circular crater-shaped pit, that supports magnetic fixing of optical converter with holding on magnet in right position.

The module is power supplied by internal battery with 13 Ah or 5.8 Ah capacity (see ordering options). If using of 13 Ah battery, the module lifetime for 60 minutes broadcasting period is more than 8 years. If using of 5.8 Ah battery, the lifetime is up to 8 years for 120 minutes broadcasting period. Battery lifetime can be negatively influenced by shorter broadcasting period or by storing and operation in sites with the temperatures exceeding the recommended range for module storage and operation. Operation in bi-directional mode (N2) with using of back channel decreases the battery lifetime by 5 %. External appearance of the WB169-SI2 module is shown in the Figure 2.

Figure 2: Appearance of the WB169-SI2 module

1.6 Variants and ordering codes

The WB169-SI2 module is delivered in four variants with different capacity of internal battery and with different degree of protection. There are four ordering codes for delivery of required hardware configuration of the module:

- **WB169-SI2-B13** - ordering code for variant with **13 Ah battery** and **IP65** degree of protection
- **WB169-SI2-B13/IP68** - ordering code for variant with **13 Ah battery** and **IP68** degree of protection
- **WB169-SI2-B5** - ordering code for variant with **5.8 Ah battery** and **IP65** degree of protection;
- **WB169-SI2-B5/IP68** - ordering code for variant with **5.8 Ah battery** and **IP68** degree of protection.

Together with the WB169-SI2 module also some time-tested sensors for industrial use can be ordered directly from module's producer (e.g. magnetic position sensor, security loop, flood detector...). Actual list of offered sensors is available at producer's e-shop: www.softlink.cz/obchod.

2 Technical parameters overview

Overview of WB169-SI2 module technical parameters is shown in the Table1 below.

Table 1: Overview of WB169-SI2 module technical parameters

RF subsystem parameters		
Frequency band *	169.40625 to 169.46875	MHz
Modulation *	2-GFSK, 4-GFSK	
Bandwidth *	12.5 or 50	kHz
Transmitting power	500	mW
Sensitivity of back-channel receiver	-109	dBm
Communication protocol	Wireless M-BUS	
Communication mode (by EN 13757-4)	N1, N2	
Transmission speed *	2400, 4800, or 19200	Baud
Antenna connector	SMA female	
Antenna characteristic impedance	50	Ω
Configuration interface RS232		
Transmission speed	9600	Baud
Operation mode	asynchronous	
Transmission parameters	8 data bits, 1 stop bit, none parity	
Signal level	TTL/CMOS	
Optical configuration interface		
Transmission speed	115 200	Baud
Optical I/F specification	complies with IrPHY 1.4 standard	
Pulse/sensor inputs		
Resistance of released contact	more than 10	MΩ
Resistance of short-circuited contact	less than 1	kΩ
Maximum frequency of input pulses	10	Hz
Minimum pulse length	40	ms
Range of voltage measurement in analog mode	(0 ÷ 3,6)	V
Maximum voltage on the input	3,6	V
Power supplying		
3,6 V lithium battery capacity	5.8 or 13	Ah
Weight and dimensions		
Length	145	mm
Width	45	mm
Height	100	mm
Weight	cca 300	g
Storage and installation conditions		
Installation environment (by ČSN 33 2000-3)	normal AA6, AB4, A4	
Operation temperature range	(-20 ÷ 40)	°C
Storage temperature range	(0 ÷ 40)	°C
Relative humidity **	95	% (w/o condensation)
Degree of protection **	IP65 or IP68	

* in reliance on selected frequency channel - see EN 13757-4, Mode N, Physical link parameters (Table 18).

** modules with additional silicon filling are waterproof with IP68 degree of protection.

3 Configuration of the WB169-SI2 module

Configuration parameters of the WB169-SI2 module can be displayed and changed from the common computer (PC) by one of these methods:

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

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

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

The description and meaning of all configuration parameters that can be checked and changed by cable can be found in the section 3.1 „Setting of WB169-SI2 parameters via configuration cable".

Description of interconnection of the converter with PC („USB-IRDA") or smartphone („BT-IRDA") and general rules of configuration with using of **optical converters** are described in the chapter 3 of above mentioned manual „Configuration of wacoSystem product family devices". The description and meaning of the parameters that can be changed by optical converter can be found in the section 3.2 „Setting of parameters by using of optical converter".

Principles and short description of communication through the **Wireless M-Bus back channel** can be found in paragraph 1.4 „Bi-directional communication mode".

3.1 Setting of WB169-SI2 module parameters by configuration cable

3.1.1 List of module configuration parameters

List of all module configuration parameters can be displayed by entering of **"show"** command and pressing of „ENTER" key. The following list of parameters will display in the terminal window:

```
mon#show
----- Configuration -----
 Timezone : 1
 MBUS ID : 00100017

 MBUS version : 5
 MBUS manufacturer : SFT
 MBUS medium : 7
 MBUS manuf info : SI2N1
  MBUS value[0] DIB : 04, VIB 13, multiplier 1, divider 1, mode falling, quick, alr: none
  Leak detection periode 24 hour(s), zero periode 90 minutes
  Broken pipe min. 50 pulse/10 min. during 30 minutes
  MBUS value[1] DIB : 44, VIB 13, multiplier 1, divider 1, mode falling, quick, alr: none

MBUS power : 3 (20 dbm)
 MBUS mode  : N2
 WMBUS channel : 3 - 169,43125 Mhz
 Send periode : 60 min
 Send mask is 3 : I1, I2

Data will be encrypted by AES
 Next send : 30 min.
  No. sent : 3 msg(s)
  No. recv : 0 msg(s)

Conf. version : 12
 SW version 0.01, date Aug  9 2019
mon#
```

3.1.2 Displaying the List of configuration commands („HELP")

List of all configuration commands can be displayed by entering of **"?"** command and pressing of „ENTER" key. The following list of commands will display in the terminal window:

```
 Help :
 --- System commands ---
deb              : Show or set debug level
ta               : Show tasks
mb               : Show mail boxes
du addr          : Dump memory
rb addr          : Read byte from addr
rw addr          : Read word from addr
rd addr          : Read dword from addr
sb addr val      : Set byte on addr
sw addr val      : Set word on addr
sd addr val      : Set dword on addr
port             : Show port [a,b,..]
show             : Show info
write            : Write configuration to flash
cread            : Read configuration from flash
clear            : Clear configuration and load defaults
 ---  WMBUS commands --- ---
mid              : Show or set MBUS ID (0 - 99999999)
power            : Show or set MBUS power (1 - 5)
manuf            : Show or set MBUS manufacturer code (AAA)
info             : Show or set MBUS info string (0-30 chars)
vers             : Show or set MBUS version (0 - 255)
medium           : Show or set MBUS medium (0 - 255)
periode          : Change periode of send  0 - disable, >0 periode in minutes, <0 from input
mode             : Set WMBUS mode 1 - N1, 2 - N2
chan             : Set WMBUS channel, type ? for help
ekey             : Set encrypt key, point '.' no encrypt
 --- Inputs ---
val              : Show or set counters values[0-1]
mul              : Set multiplier of value[0-1]
div              : Set divider of value[0-1]
dib              : Set DIF and DIFE for value[0-1]
vib              : Set VIF and VIFE for value[0-1]
det              : Detection 0 - falling, 1 - rising
dmode            : 0 - quick, 1 - slow
amode            : 0 - disable, 1 - enable
alr              : Send alarm : 0 - none, 1 - falling, 2 - rising, 3 - both
leakp            : Leak detection periode in hours - 0 disabled
leakz            : Leak zero periode in minutes (rounded up to ten minutes)
burstp           : Burst min puls in 10 minutes
burstt           : Burst check time in minutes (rounded up to ten minutes)
trf              : Set tarrif 0 - off, 1 - t1 high, 2 - t1 low
 --- Modem commands ---
mr               : Modem receive mode 0 - off, 1 - on
mt test time     : Set test on modem, 1 - TX carrier, 2 - TX sync, time is in second, default 10
ms               : Get modem state
mi               : Get modem info
mfreq            : Set or get radio frequency correction
cfreq            : Set +- frequency correction, 1 = 1Hz
. . .
```

```
. . .
 --- Utils ---
smask            : Send mask bits, 0 - I1, 1 - I2, 2 - temp. 3 - hum. ,default 3 - I1 and I2
tz               : Time offset in hours
time             : Show or set rtc time, set as BCD : 0x102033 is 10:20:33
date             : Show or set rtc date, set as BCD : 0x171231 is 2017-12-31
uptime           : Show uptime
sens             : Show sensors
sendp            : Send nx WMBUS messages
send             : Send WMBUS message
reset            : Reset device
?                : Show this help
```

Overview of configuration parameters with short description of their meaning can be also found in table 2 on the page 23. The meaning and usage of individual commands are described below.

3.1.3 „System commands" group for general diagnostics

Commands „**"deb", "ta", "mb", "du addr", "rw addr", "rb addr", "rd addr", "sw addr", "sb addr", "sd addr"** and **"uptime"** are used for troubleshooting and repair of the device in a factory. **Manufacturer strongly recommends not to use these commands during common operation.**

Other system commands **"show"** (configuration statement) and **„?'** („Help") are described in previous part of section3.1.

By using of **"port"** command an actual setting of module ports can be displayed. This command is intended only for module diagnostics.

3.1.4 Commands for writing of configuration and reset

The module contains two sets of configuration: operating configuration and saved configuration. At the start of the system the module copies saved configuration to operating configuration, with which continues to work. If the user changes configuration parameters, it does so only in operating configuration.

If the current operating configuration was not stored to FLASH memory, the module returns to the saved configuration after reset. If the parameter should be changed only temporarily (for example shorten of the broadcasting period during installation), it is not necessary to save operating configuration in FLASH memory (after the work finishing module can be returned to normal configuration by its reset). If the parameter should be changed permanently, there is necessary to save configuration to FLASH memory.

If operating configuration corresponds to the saved set (ie. there are no differences between commands in FLASH and in the operating set), the module will „report" prompt in the format "mon#". If operating configuration was changed so that it no longer matches to the saved set, the module will report prompt in the format "cfg#".

Every time the current configuration is saved into FLASH memory the value of the „Configuration version" parameter increases by one and the prompt changes to "mon#". The parameter resets to zero by erasing of the FLASH memory.

Current operating configuration can be displayed by using of **"show"** command (see paragraph 3.1.1):

```
cfg#show
```

Current operating configuration can be rewrite the to FLASH memory by using of **"write"** command:

```
cfg#write
Writing config ... OK, version 3
```

Reading of the configuration from FLASH memory can be done by by using of **"cread"** command (for older some modifications the command is **"read"**):

```
cfg#cread
Reading config ... OK, version 3
```

The configuration can be erased in Flash memory by using of **"clear"** command:

```
cfg#clear
Clearing configuration ... OK, version
```

This command deletes all configuration parameters from the FLASH memory, so it is necessary to set them again. If after erasing all parameters in FLASH memory the module goes to reset, default set of parameters (configured in the program of the device) is duplicated to FLASH memory. There is only one exception - frequency constant keeps the actual value also after cleaning of FLASH memory by "clean" command.

This command is recommended to use only by users with good knowledge of the system or after consultaion with the manufacturer.

The module reset can be performed by using of **"reset"** command.

3.1.5 „WMBUS" group commands for setting of messages

This group of commands serves for setting of Wireless M-BUS addressing of the WB169-SI2 module and for setting of broadcasting parameters. There are following command:

mid	*setting of device fabrication number („M-BUS ID" – range 0 to 99999999)*
manuf	*setting of manufacturer code („Manufacturer" - supplement of M-BUS address)*
vers	*setting of „addressing version" („Version" - supplement of M-BUS address)*
medium	*setting of media code („Medium" - supplement of M-BUS address)*
info	*setting device name*
periode	*setting of regular messages broadcasting period*
power	*setting of transmitting power (mW)*
mode	*setting of communication mode (1 - N1 mode, 2 - N2 mode)*
chan	*setting of frequency channel (choice from 7 options)*
ekey	*setting of encryption key (".." - encryption disabled)*

Variable **„M-BUS ID"** is a serial number of the device in M-Bus standard identification system. The address is „read only" type for the WB169-SI2 module and cannot be changed. Assigned serial number of the module can be displayed by**„mid"** command (without parameter):

```
cfg#mid
MBUS ID : 00112233
cfg#
```

Variable **„Manufacturer"** is an international code of device producer according to the M-Bus standard. The code is „read only" type for the WB169-SI2 module, its value is „SFT" (Softlink) and it cannot be changed. Assigned manufacturer code can be displayed by**„manuf"** command (without parameter):

```
cfg#manuf
MBUS manufacturer : SFT
cfg#
```

Variable **„Version"** is number of addressing version according to the M-Bus standard (each type and modification of the device could have its own line of serial numbers). The code is „read only" type for the WB169-SI2 module and cannot be changed. Assigned version number can be displayed by **„vers"** command (without parameter):

```
cfg#vers
MBUS version : 101
cfg#
```

Variable **„Medium"** is an international code of measured medium (water, energy, physical quantity..) according to the M-Bus standard. The variable is editable and it is factory preset to 07 („Water"). Current setting of the medium value can be displayed by **„medium"** command (without parameter). Medium parameter can be changed by entering of required code of medium according to M-Bus standard (range: 0 to 255).

Example of medium code setting to "02" value (electricity):

```
cfg#medium
MBUS medium : 7
cfg#medium2
MBUS medium changed from 7 to 2
cfg#
```

***Note**: The full identification of the device in M-Bus standard systems is done by combination of four ID components: „M-BUS ID", „Manufacturer", „Version" and „Medium". This combination must be unambiguous that means there cannot exist two M-Bus devices worldwide, that have the same combination of all these parameters. If fixed configuration of the address components used, producer of the device is responsible for unique setting of „read only" address components for each device. If M-Bus address components are configurable, operator of the M-Bus system can use serial number of connected meter in combining with its type, subtype and manufacturer. Using of „independent" addressing line is possible only in that case, if the operator of the system owns its M-Bus manufacturer code and can assure that the identification of all operated devices under his code will be unique*

„Info" command can be used for setting of device name that is a part of each broadcasted message (see paragraph 3.3). The parameter is preset from the factory to „SI2" value. By using of **„info"** command (without parameter) an actual value of the name can be displayed. The device name can be set by entering of any string of characters after „info" command.

Example of displaying, setting and follow-up checking of the device name:

```
cfg#info
MBUS manuf info  : 'ABC'
cfg#info XYZ
Change MBUS manuf info from : 'ABC' to : 'XYZ'
cfg#info
MBUS manuf info  : 'XYZ'
cfg#
```

Maximum length of the string is 29 characters. The only basic set of characters can be used (without diacritics). It is not recommended to change this parameter.

„Periode" command serves for setting of broadcasting period of regular info messages. The value of the parameter is factory preset to 60 minutes. Current value can be checked by **„periode"** command (without parameter). Broadcasting period can be changed by entering of required number of minutes after „periode" command.

Example of displaying, setting and follow-up checking of broadcasting period:

```
cfg#periode
Periode is 60 min.
cfg#periode 30
Periode changed from 60 to 30 min.
cfg#periode
Periode is 30 min.
cfg#
```

The module enables also **an external synchronization of its broadcasting** from external source of synchronization pulses. For this purpose any of module ports can be assigned as „synchronizing" by using of **„Periode -X"** command, where "X" is number of assigned port.

Example of setting of port No. 2 to „synchronization" mode:

```
cfg#periode -2
Periode changed from 60 min. to I2
mon#
```

If using of this setting, the process of transmitting of info message launch after each falling edge of the synchronization pulse is received on the synchronizing port. There is a protective interval of 1 minute implemented in the system, so the broadcasting period could be at least 1 minute. Requirements for the synchronization pulses are the same, as for metering pulses.

This feature is important in that case, if the measurement and broadcasting of measured values should be synchronized with some other process. Typical example is measurement of electrical energy in 15-minutes intervals, that must be

synchronized with measuring intervals of superior part of the electrical grid. In this case it is necessary to bring 15-minutes synchro-signal (e.g. from electrometer with such kind of output) to the synchronizing port.

***WARNING:** If there are synchronization pulses with inverse logic connected, it could cause a slight decreasing of battery lifetime (up to 5 %). „Inverse logic" means that the input is permanently short-circuited and only during short time pulses it is released.*

Regular broadcasting can be **disabled** by entering of "periode" command with "0" parameter. Example:

```
cfg#periode 0
Periode changed from 60 min. to disabled
mon#
```

Group of **„power"** (transmitting power), **„chan"** (frequency channel), **„mode"** (communication mode) and **„ekey"** (encryption key) commands is intended for setting of module **RF-subsystem parameters**.

The command **„Power"** is used for adjusting of the module broadcasting power. Factory setting is 100 mW (average power). Actual value of the power can be displayed by using of the **"power"** command without parameter. Transmitting power can be set-up by entering of the number of power level. There are five levels available:

- value "1" for transmitting power 14 dBm (25 mW)
- value "2" for transmitting power 17 dBm (50 mW)
- value "3" for transmitting power 20 dBm (100 mW)
- value "4" for transmitting power 24 dBm (250 mW)
- value "5" for transmitting power 27 dBm (500 mW)

An example of checking, setting and re-checking of transmitting power:

```
cfg#power
MBUS power : 3 (20 dBm)
cfg#power 5
MBUS power changed from 3 to 5 (27 dbm)
cfg#power
MBUS power : 5 (27 dBm)
cfg#
```

The command **„Communication mode"** is used for selecting of the module's communication mode. Factory setting is N1 (unidirectional), or N2 (bidirectional), actual setting can be checked by using of **„mode"** command without parameter. Change of mode can be done by entering of desired option as a parameter of the command. Communication modes are defined by the Wireless M-BUS standard, accurate choice of relevant communication modes of the module is stated in the line "mode" of "Help" summary (see the paragraph 3.1).

An example of checking, setting and re-checking of communication mode:

```
cfg#mode
Mode N1
cfg#mode 2
CC1120 state 0x0f, marcstate 65, fifo tx 0, rx 0
Mode changed from 1 to 2
cfg#mode
Mode N2
cfg#
```

The command **„Frequency channel"** is used for selecting of the module's radio frequency channel. Frequency channels for the particular frequency bands are defined by the Wireless M-BUS standard. Actual setting can be checked by using of **„chan"** command without parameter. Change of channel can be done by entering of desired option as a parameter of the command. Accurate choice of relevant broacasting communication modes of the module is stated in a line "mode" in "Help" summary (see the paragraph 3.1.2).

An example of checking, setting, saving and re-checking of frequency channel:

```
cfg#chan
Help :
  1 - chan 1a (169.40625 Mhz), 4.8 kbps
  2 - chan 1b (169.41875 Mhz), 4.8 kbps
* 3 - chan 2a (169.43125 Mhz), 2.4 kbps
  4 - chan 2b (169.44375 Mhz), 2.4 kbps
  5 - chan 3a (169.45625 Mhz), 4.8 kbps
  6 - chan 3b (169.46875 Mhz), 4.8 kbps
  7 - chan 3g (169.43750 Mhz), 19.2 kbps
cfg#chan 1
Channel changed from 3 to 1 : chan 1a (169.40625 Mhz), 4.8 kbps
CC1120 state 0x0f, marcstate 65, fifo tx 0, rx 0
cfg#chan
Help :
* 1 - chan 1a (169.40625 Mhz), 4.8 kbps
  2 - chan 1b (169.41875 Mhz), 4.8 kbps
  3 - chan 2a (169.43125 Mhz), 2.4 kbps
...
```

The command **„Encryption key"** is used for setting of the encryption key for an encryption of transmitted messages by using of AES-128 key. The encryption key of 16 bytes length is entered by using of **„ekey"** command, followed by the string of 16 bytes that can be entered in a decimal or hexadecimal format (see examples).

An example of insertion of the encryption key in hexadecimal format:

```
cfg#ekey 0x1a 0x2b 0x3c 0x4d 0x5e 0x6f 0xa1 0xb2 0xc3 0xd4 0xe5 0xf6 0x77 0x88 0x99 0xaf
Setting encyption key : 1a 2b 3c 4d 5e 6f a1 b2 c3 d4 e5 f6 77 88 99 af
cfg#
```

An example of insertion of the encryption key in decimal format:

```
cfg#ekey42 53 159 188 255 138 241 202 136 21 98 147 235 15 145 136
Setting encyption key : 2a 35 9f bc ff 8a f1 ca 88 15 62 93 eb 0f 91 88
cfg#
```

If the encryption key is set to the module's configuration, an information ***„Data will be encrypted by AES"*** displays in the list of configuration parameters (see chapter 3.1.1)

Encryption can be switched off by setting of "." (dot) parameter after the „ekey" command:

```
cfg#ekey.
Encyption disabling
cfg#
```

In this case an information ***„Data will be unencrypted"*** appears in the list of configuration parameters.

3.1.6 „Inputs" group parameters

This group of parameters and commands enables setting of internal pulse registers (counters) and setting of output values of the module.

The WB169-SI2 module is equipped with two inputs (port 1 and 2), that are connected to the corresponding pulse counters (index 0 and 1). Each counter increases its value up one unit each time it receives pulse from a consumption meter connected to its port. Below listed commands are used for settings of the initial counter values and constants (multipliers, divisors) that can be used for adjusting of the output statuses to required values, and also for setting of auxiliary „DIF" and „VIF" M-Bus codes that enable correct decoding of measured values (especially correct decoding of measuring units).

Each input can be switched to so called **„alarm mode"**, in which after each change of input value the counter only changes its status (goes from "0" to "1" or vice versa) and the module transmits the message immediately with the change of status. Thus the module can read and transfer status information from **binary sensors** (e.g.

door contacts, flood detectors..). Detailed description of setting of inputs in alarm mode can be found in the paragraph 3.1.9 „Settings of sensor inputs".

Setting of pulse inputs can be performed with using of following commands:

val[index]	*initial counter value setting*
mul[index]	*setting of multiplier (output value = status * multiplier)*
div[index]	*setting of divisor (output value = status / divisor)*
dib[index]	*setting of DIF value (= coding method information)*
vib[index]	*setting of VIF value (= measuring unit information)*
det[index]	*setting of trigger edge (0 - falling edge, 1 - rising edge)*
dmode[index]	*setting of pulse input mode (0 - quick pulses, 1 - slow pulses)*
amode[index]	*switching of analog mode (for WB169-SI2 not used)*
alr[index]	*setting of alarm mode (sensor input setting)*
alcok[index]	*specification of alarm mode for "OK" status (sensor input setting)*
alcerr[index]	*specification of alarm mode for "Error" status (sensor input setting)*
leakp[index]	*period of leak detection setting (see „leak" function)*
leakz[index]	*zero interval of leak detection setting (see „leak" function)*
burstp[index]	*burst alarm limit setting (see „burst" function)*
burstt[index]	*burst measuring interval setting (see „burst" function)*
trf[index]	*setting of second port to tariff switching mode (see „tariff" function)*

By using of **"val[index]"** command an initial (or actual) value of the counter can be set. After the value is setup, it increases from this value with each new-coming pulse. Actual counter value can be displayed by using of „val[index]" command (without parameter). Counter status can be set to required value by using of „val[index]" command followed by required whole number (integer).

Example of setting port No 1 (index=0) counter to "1892" value and follow-up checking of correctness of the configuration:

```
cfg#val0 1892
 Value[0] changed from 1565252980 to 1892
cfg#val0
 Value[0] : 1892 * 1 / 1 -> 1892
cfg#
```

It is evident from the example, that when checking of current status by „val[index]" command, the system displays not only current status value, but also current settings of multiplier and divisor and output value after multiplying/dividing.

By using of **"mul[index]"** and **"div[index]"** commands a value of multiplier and divisor can be set to the counter. Default setting of both values is "1". If it is necessary to adjust the counter value by some coefficient, enter convenient combination of multiplier and divisor as shown in example below.

Actual value of multiplier and divisor can be displayed by using of "val[index]", "mul[index]" or "div[index]" commands (without parameter) as shown in the example:

```
cfg#mul0
Multiplier[0] = 1
cfg#div0
Divider[0] = 1
cfg#
```

Multiplier and divisor setting example:

Watermeter generates measuring pulses after each 50 litres of consumed water. To indicate water consumption in m^3, it is necessary to adjust the original counter value by using of multiplier and divisor as shown in the example:

50 litres = 0.05 m^3, so to convert the value to m^3, it must be multiplied by 5/100.

It could be done by setting of multiplier to "5" and divisor to "100" - see example:

```
cfg#mul0 5
Multiplier[0] = 5
cfg#div0 100
Divider[0] = 100
cfg#val0
 Value[0] : 2000 * 5 / 100 -> 100
cfg#
```

*From the display of summary shown in the last sequence of commands it is evident that current status value (2000) will be interpreted as output value 100 (m^3). As one unit of the counter represents 50 litres, output value of the counter is: 2000*50 = 100 000 litres = 100 m^3.*

By using of **"dib[index]"** command a value of DIF code could be set. The DIF code describes character of the variable, number of „storage" and format of data field according to the M-Bus standard. Default setting of DIF parameters of the module counters is as follows:

counter:"0" DIF = 04 00 (instant value, 32-bit integer, storage No "0")
counter:"1" DIF = 44 00 (instant value, 32-bit integer, storage No "1")

Warning: It is not recommended to make changes of DIF parameter.

By using of **"vib[index]"** command a value of VIF code could be set. The VIF code describes the kind of measured quantity (e.g. volume, temperature, voltage...) and the measuring unit (including multiplier) in which the value is presented (e.g. m^3, °C, mV, kWh...) according to the M-Bus standard. Default setting of VIF parameter of all counters is:

VIF = "13" (quantity: „Volume", measuring unit: 10^-3 * m^3)

It means that with using of default setting the information message contains value of measured volume in thousandth of m^3, i.e. **in litres.** If a watermeter is connected to the module with default setting of VIF code, it is necessary to check out how many litres represent one measuring pulse and setup multiplier and divisor values so as to get output value in litres. If, as an example, the watermeter generates measuring pulse after each 10 litres of volume, it is necessary to set multiplier to value "10".

If it is needed to get volume in other units than litres (e.g. in m^3), or other quantity than volume is measured (e.g. electrical work in kWh), it is necessary to adjust values of multiplier and divisor to get result in required units as well as setup correct VIF value to ensure correct presentation of the unit in auxiliary information.

Examples of settings of VIF code

Example of VIF setting in case the water consumption is presented in m^3:

Setup values of multiplier and divisor in order to convert output value into "m^3" units (see example of multiplier/divisor setting above). Calculate value of VIF code for "m^3" units as follows:

„Codes for Value Information Field (VIF)" table of M-Bus standard designates for „Volume" quantity "0001 0nnn" code, where the result is in $10^(nnn - 6)$ m^3 units. It means that the last three bits of code determine value of unit multiplier. To get result in litres it is necessary to use multiplier $10^(-3)$ (because 1 liter = 0.001 m^3), so that the value of last three bits must be '3" (nnn=3). In this case the multiplier is $10^(3 - 6)$, that is $10^(-3) = 0.001$). It means that the correct VIF code for volume in litres is "0001 0**011**", because decadic value nnn=3 converted into binary code means "011" value. Conversion of binary "00010011" value into decadic transcription gives number "13", what is default setting of VIF parameter.

To present the measured volume in m^3, it is necessary to put multiplier "1" before „m^3" value. For this case the value of "nnn' must be "6" (so that the multiplier value is $10^(6 - 6)$, that is $10^(0) = 1$). The correct value of VIF code for volume in m^3 is "0001 0**110**" (because decadic value nnn=6 converted into binary code means "110" value). Conversion of binary "00010110" value into decadic transcription gives number "16", what is required setting of VIF parameter.

Parameter VIF can be setup to "16" value as follows:

```
cfg#vib0
VIB[0] : 13
cfg#vib0 0x16
Set VIB[0] : 16
VIB[0] : 16
cfg#
```

The same input of VIF parameter could be entered also in decadic form as follows:

```
cfg#vib0 22
Set VIB[0] : 16
```

Example of VIF code setting in case the variable is electric work in kWh:

„Codes for Value Information Field (VIF)" table of M-Bus standard designates for "Energy" quantity "0000 0nnn" code, where the result is in $10^{(nnn-3)}$ Wh units. The last three bits of code determine unit multiplier. To get result in kWh it is necessary to use multiplier $10^{(3)}$ (because 1 kWh = 1000 Wh), so that the value of nnn=6 (in this case the value of multiplier is $10^{(6-3)}$, that is $10^{(3)} = 1000$). It means that the correct VIF code for electric work in kWh is "0000 0**110**", because decadic value nnn=6 converted into binary code means "110" value. Conversion of binary "00000110" value into decadic transcription gives number "06", what is required setting of VIF parameter.

Parameter VIF can be setup to "06" value as follows:

```
cfg#vib1 0x06
Set VIB[1] : 06
```

Above described setting of VIF parameter reflects in decoded message as seen in the figure 3.

```
cfg#dib
DIB[0] : 04
DIB[1] : 44
cfg#vib
VIB[0] : 16
VIB[1] : 06
cfg#val
 Value[0] : 1000 * 1 / 1 -> 1000
 Value[1] : 1000 * 1 / 1 -> 1000
```

Index	Value	Dim	Tarif	Storage	Unit	DIF	VIF	Data
1	- filler -		0	0	0	2f		
2	- filler -		0	0	0	2f		
3	1000.0	m3	0	0	0	04	16	e8 03 00 00
4	1000000.0	Wh	0	1	0	44	06	e8 03 00 00
5	3.617	V	0	0	0	02	fd 46	21 0e
6	0.1	W	0	0	0	02	28	64 00
7	20.0	°C	0	0	0	02	5e	c8 00
8	170.0	sec	0	0	0	04	20	aa 00 00 00

Figure 3: Setting of VIF and its effect on decoding of message

In the figure 3 can be seen a decoded message of the WB169-SI2 module, where there is the same "1000" multiplier value and the same "1" divisor value set up on both counters.

It is clear from the picture that:

- counter value "0" with preset "1 x m^3" unit is presented as "1000 m^3"
- counter value "1" with preset "1000 x Wh" unit is presented as "1000 000 Wh"

By using of **"det[index]"** command a trigger edge of the counter could be chosen. If it is preset to "0" option (default setting) the value of counter will increase with falling edge of incoming pulse (i.e. when the mechanical contact is short-circuited, or when an electronic pulse generator goes from "1" to "0"). If it is preset to "1" option, the value of counter will increase with rising edge of incoming pulse (i.e. when the mechanical contact is released, or when an electronic pulse generator goes from "0" to "1"). Actual value of trigger edge setting can be displayed by using of "det[index]" command (without parameter).

Example of setting of trigger edge for port No 1 (index=0) to "1" option (rising edge) and follow-up checking of trigger edge setting of all ports:

```
mon#det0 1
Det[0] = 1 - rising
cfg#det
Det[0] = 1 - rising
Det[1] = 0 - falling
Det[2] = 0 - falling
Det[3] = 0 - falling
cfg#
```

By using of **"dmode[index]"** command a smoothening (equalizing) filter of pulse input could be involved or disconnected. If it is preset to "0" option (default setting) the equalizing filter is switched off and the input is preset for detecting of high frequency (quick) pulses. If it is preset to "1" option, the equalizing filter that can suppress disturbing pulses on the input is switched on. This setting could be used if there are some parasitic pulses on the pulse input (e.g. if the input wire is too long), but using of this filter is restricted only for **sensor input**, or for detecting of **slow pulses** with maximum frequency of 2 Hz (minimum length of pulse is 250 ms).

Example of setting of port No 1 (index=0) mode to "1" option with involved equalizing filter (slow pulses):

```
cfg#dmode1 1
Mode[1] = 1 - slow
cfg#
```

Detailed description of „Leak" alarm function can be found in the paragraph 3.1.7 below. Detailed description of „Burst" alarm function can be found in the paragraph 3.1.8 below. Detailed description of sensor input settings can be found in the paragraph 3.1.9 „Setting of sensor inputs" below. Detailed description of „tariff switching" function can be found in the paragraph 3.1.10 below.

3.1.7 Description and setting of „Leak" alarm function

„Leak" function is used for detection of such situations in the consumption of gas, water or other liquids, when there are permanent low-quantity losses caused by minor leaks in the distribution system. In view of the fact that remote reading systems don't record consumption continuously but in some steps (usually given by full turn of its measuring disk), it could take quite long time until the trouble is discovered.

„Leak" function is based on the common pattern that during the normal long-term (e.g. day, week) operation there are usually some regular time intervals, when the consumption is in its „idle" status, because the gas/liquid is not consumed from natural reasons (e.g. during the night, or out of working hours). In these idle time intervals the consumption should be zero volume. If there are any leaks, time intervals with zero consumption practically either do not occur, or there are only short intervals caused by discontinuity of measuring system (e.g. if one metering pulse represents 100 litres, minor leak could become evident even after several hours, when such quantity will leak).
.

„Leak" function principle is shown in the figure 4. When setting of „Leak" alarm function the length of detection period must be entered by setting of **„Leak Detection Period"** parameter. After expiration of this period the system evaluates whether during this period at least one time occurred the situation, when the consumption was in zero level during preset time interval (entered by **„Zero Period"** parameter). If there is no leakage, it is highly probable that zero consumption period occur at least once during the period and system evaluates the period as „no alarm" status (see upper part of the figure 4). But if there is no one interval with zero consumption registered during whole detection period, module transmits to superior system „Leak" alarm message (see lower part of the figure 4).

„Leak" function can be activated for chosen port by using of **"leakp[index]"** command that defines the length of detection period (**„Leak detection period"** parameter) in hours. By using of **"leakz[index]"** command setup concurrently for the same port the length of zero consumption interval (**„Zero period" parameter)** in minutes. If one of these parameters is set to "0" for some port, „Leak" function is deactivated for that port.

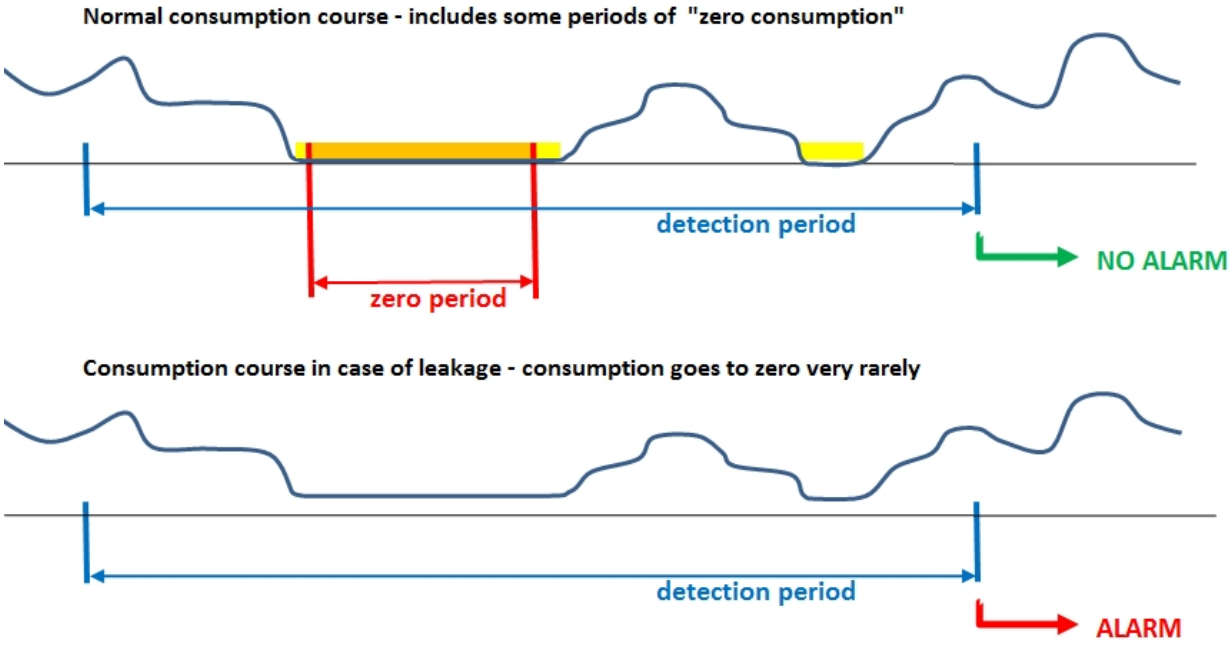


Figure 4: „Leak" alarm function principle

Example of setting **„Leak detection period”** parameter for port No 1 (index ”0”) to 24 hours value:

```
cfg#leakp 0 24
 Value[0] changed from 0 to 24
cfg#
```

Detection period can be set in range of 1 - 1090 hours, typical setting is 24 hours (daily operational cycle), or 168 hours (weekly operational cycle). Detection period starts running from module restart, or from the moment when the parameter is changed. Alarm message is sent at the end of detection period.

Example of setting **„Zero period”** parameter for port No 1 (index ”0”) to 60 minutes value:

```
cfg#leakz 0 90
 Value[0] changed from 0 to 90
cfg#
```

Zero consumption period can be set in range of 1 - 1090 minutes with precision of ten minutes (rounded to tens of minutes, e.g. 10, 20, 30...). If the command is entered with any other value (e.g. 36 minutes) the system will store rounded value anyway (in this case 40 minutes). General principle is that setting of zero period parameter to longer values means that the detection is more sensitive (it is capable to detect smaller leaks), but it is also less reliable with higher probability to produce false alarm due to real consumption caused by random changes of operating cycle (e.g. if somebody was held up at work few hours longer).

Setting of „Leak” alarm function parameters appears in the List of configuration parameters („show” command), in the section of the particular port:

```
 MBUS value[0] DIB : 04 00, VIB : 13 00 ,multiplier 1, divider 1
   Leak detection period 24 hour(s), zero period 90 minutes
```

Structure of alarm message of „Leak” type is described in the paragraph 3.3.2 „Alarm message”.

3.1.8 Description and setting of „Burst” alarm function

„Burst” function is used for detection of such situations in the consumption of gas, water or other liquids, when the burst consumption caused by broken pipe (or similar fatal failure of distribution system) occurs. If the consumption of liquid/gas is abnormally huge for some period of time, the module transmits to the superior system alarm message of ”7” type („Burst”).

„Burst” function principle is shown in the figure 5. „Burst” alarm function is set-up by entering of the **burst consumption limit** (”burstp[index]” command), that means the limit over which the consumption is considered as abnormal, and entering of **„Burst Check Time” period** (”burstt[index]” command) that means the minimum time period during which the consumption must be permanently over limit to detect the „Burst” alarm.

In view of the fact that different meters connected to the module could have different conversion rate of volume per measuring pulse, consumption limit is delimited universally as **number of registered pulses per 10 minutes time period**. Conversion table between „pulses per 10 minutes” and „consumption per minute” for frequently used conversion rates of watermeters is available in the figure 6.

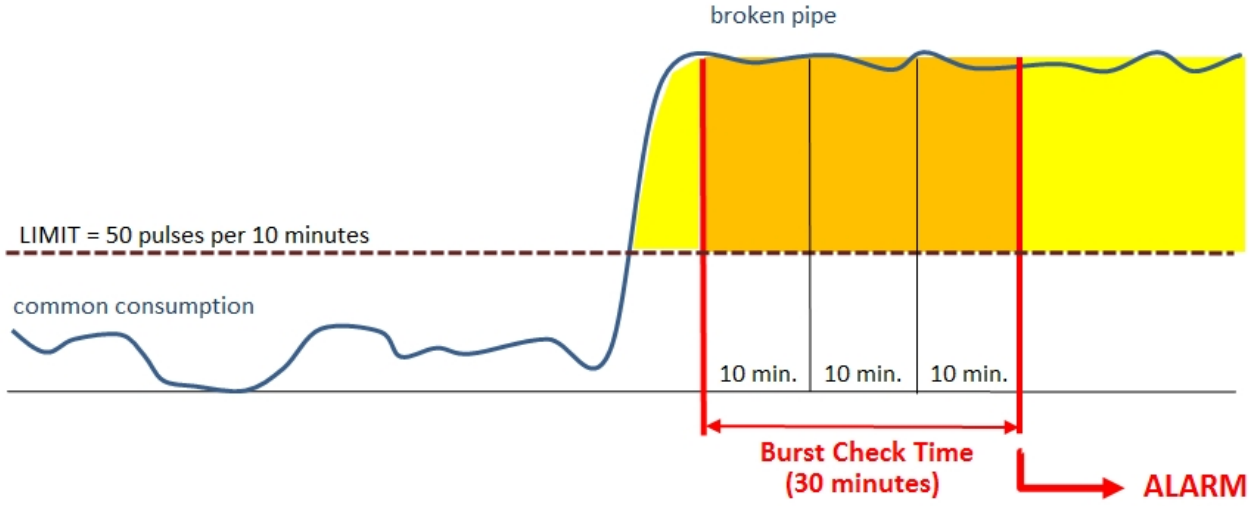
„Burst” function can be activated for chosen port by using of **”burstp[index”]** command that defines required consumption limit in number of pulses per 10 minutes period. By using of **”burstt[index]”** command setup concurrently for the same port minimum duration of abnormal consumption („Burst Check Time”) in minutes. If one of these parameters is set to ”0” for some port, „Burst” function is deactivated for that port.

Example of setting **„LIMIT”** parameter for port No 1 (index ”0”) to 15 pulses per 10 minutes:

```
cfg#burstp 0 15
 Value[0] changed from 0 to 15
cfg#
```

Consumption limit alarm value can be set in practically unlimited range (1 to 65535 pulses per 10 minutes).

Example of setting **„Burst Check Time”** parameter for port No 1 (index ”0”) to 40 minutes value:



If the meter generates more than 50 pulses per 10 minutes (i.e. 5 pulses per minute) during three 10-minutes intervals (30 minutes in total) reading module generates Burst Alarm ("Broken Pipe") that is transmitted immediately.

Figure 5: „Burst" alarm function principle

	"LIMIT" value [pulses per 10 minutes]											
	2	4	6	8	10	15	20	30	40	60	80	100
Conversion rate	Limit flow [m^3 per minute]											
0,001 m^3 / pulse	0,0002	0,0004	0,0006	0,0008	0,001	0,0015	0,002	0,003	0,004	0,006	0,008	0,01
0,01 m^3 / pulse	0,002	0,004	0,006	0,008	0,01	0,015	0,02	0,03	0,04	0,06	0,08	0,1
0,1 m^3 / pulse	0,02	0,04	0,06	0,08	0,1	0,15	0,2	0,3	0,4	0,6	0,8	1
1 m^3 / pulse	0,2	0,4	0,6	0,8	1	1,5	2	3	4	6	8	10
10 m^3 / pulse	2	4	6	8	10	15	20	30	40	60	80	100
100 m^3 / pulse	20	40	60	80	100	150	200	300	400	600	800	1000
1000 m^3 / pulse	200	400	600	800	1000	1500	2000	3000	4000	6000	8000	10000

Figure 6: Conversion table between „LIMIT" value and corresponding minute flow

```
cfg#burstt 0 40
 Value[0] changed from 0 to 40
cfg#
```

Minimum duration of abnormal consumption („Burst Check Time") can be set up in range 1 - 1090 minutes with precision of ten minutes (rounded to tens of minutes, e.g. 10, 20, 30...). If the command is entered with any other value (e.g. 36 minutes) the system will store rounded value anyway (in this case 40 minutes). General principle is that setting of Burst Check Time parameter to longer values means that the detection is more reliable, with lower probability to produce false alarm due to random changes in normal operation (e.g. during filling a tank with water), but in the same time it will prolong the response time between the breakdown and sending of alarm.

Setting of „Burst" alarm function parameters appears in the List of configuration parameters - in the section of the particular port:

```
 MBUS value[0] DIB : 04 00, VIB : 13 00 ,multiplier 1, divider 1
  Broken pipe min. 15 pulse/10 min. during 40 minutes
```

Structure of „Burst" alarm message is described in the paragraph 3.3.2 „Alarm message".

3.1.9 Setting of sensor inputs

Any two-state sensors of „on/off" (0/1) type with contact, relay, or electronic binary output (e.g. door contacts, flood detectors, fire detectors, electronic seals...etc.) can be connected to any WB169-SI2 module port. If the port is not preset to „alarm mode", the module only stores number of 0/1 transitions of the sensor into the counter and

transmits the number in periodical info-messages. If, as an example, the door contact is connected to the port, the module registers each open/close cycle and regularly broadcasts number of cycles from last reset of the counter. If it is required to send a message immediately after each opening/closing of the door, it is necessary to preset the port (counter) into the **alarm mode**. For increasing of detection reliability it is necessary to involve **equalizing filter** for each sensor input as described above (see description of "dmode" command). By involving the filter, the detection will be more resistant to false alarms caused by any signal disturbances on the input wire.

„Alarm mode" can be activated for chosen port by using of **"alr[index]"** command, followed by parameter with 0, 1, 2 or 3 value. If **"0"** value is preset, alarm mode is switched off. If **"1"** value is entered, the input is switched to alarm mode and generates alarm in 1-to-0 transition (e.g. when the smoke sensor contact is switched on). If **"2"** value is entered, the input is switched to alarm mode and generates alarm in 0-to-1 transition (e.g. when the door are opened and the door contact is switched off). If **"3"** value is entered, the input is switched to alarm mode and generates alarm in both transitions (e.g. when the door is opened as well as when it is closed) .

Example of setting port No 2 (index "1") to "2" value, where the module transmits alarm when the sensor goes to "1" status (released contact), and follow-up checking of settings of all ports:

```
cfg#alr1 2
Alr[1] = 2 - rising
cfg#alr
Alr[0] = 3 - both
Alr[1] = 2 - rising
cfg#
```

As shown in the example, second port was switched to alarm mode with sending an alarm only in 0-to-1 transition (released contact). From the follow-up checking of all ports status (by using of "alr" command without index) it is clear, that there is the alarm mode with both announced transitions on the first port and that the alarm mode is switched off on the third and fourth port.

Alarm message always contains **actual status** after transition (value is "0" or "1") and a relevant **port identification**, coded into DIF-code as follows:

- status of "0" input - DIF=31
- status of "1" input - DIF=71

VIF code is alway set to "FD 3A" value, that in M-Bus coding system means dimensionless value („dimensionless - no ViF" option).

If some of the inputs is preset to alarm mode, actual status of the connected sensor is regularly broadcasted in each info-message and the format of the information is the same, as used in alarm message. Data segments with status of „alarm" ports are attached to the very end of the message (i.e. after „Uptime" segment - see section 3.3 „Structure of module data messages"). If the alarm message is lost during broadcasting, the information about actual status of the sensor will be synchronized with reality after next info-message is received.

From the WB169-SI2 module point of view the "normal status" means "1" value on the input and "error status" means "0" value on the input. On basic (factory) setting the alarm messages are universally interpreted as „alarm status" (OID 60 value "5") and „normal status" (OID 60 value "4"), when **transition to alarm status** means change of input value from **"1"** (open contact) to **"0"** (closed contact). Even the module definition of normal and error status is fixed, by using of "alcerr[index]" and "alcok[index]" commands there is possible to preset outgoing alarm messages such way, that their meaning will be inverse (transition to module's "error" will be declared as "OK" and vice versa). Selection of suitable couple of alarm messages enables also more accurate description of the event.

Different (even inverse) meaning of **"1" to "0" transition** (closing of contact) can be preset by using of **„alcerr[index]"** command.

Different meaning of **"0" to "1" transition** (opening of contact) can be preset by using of **„alcok[index]"** command.

Change of meaning can be done by choosing of convenient couple of alarm codes (e.g. "Open" - "Close") and setting of these codes to both status transitions in accordance with real values on the module input. Actual list of alarm codes is available at the NEP Page website.

Current setting of alarm message interpretation codes can be found with using of the commands without parameter:

```
mon#alcok
AlarmOK[0] = 4
AlarmOK[1] = 4
cfg#alcerr
AlarmErr[0] = 5
AlarmErr[1] = 5
cfg#
```

Example of setting ”9” and ”8” alarm codes (door open / door close) for the first input:

```
mon#alcok0 9
AlarmOK[0] = 9
cfg#alcerr0 8
AlamErr[0] = 8
cfg#
```

After the previous change setting of alarm interpretation is as follows:

```
cfg#alcok
AlarmOK[0] = 9
AlarmOK[1] = 4
cfg#alcerr
AlarmErr[0] = 8
AlarmErr[1] = 5
cfg#
```

This setting will be displayed in the row of relevant input of the List of configuration parameters as follows:

```
Input[0],multiplier 1,divider 1,mode falling, quick, alr: rising, alarm code OK 9, Error 8
```

It is evident from the setting, that transition to ”Error” status (1 - 0) on the ”0” input will be interpreted in alarm message by ”9” code (OID60, value 9 - see paragraph 3.3.2 „Description of TRAP type message”) and the meaning of this code is ”Closed”. Transition to ”OK” status (0 - 1) will be interpreted by ”8” code, that means ”Open”.

3.1.10 Description and setting of „Tariff switching” function

When the „Tariff switching” function activated, all input pulses are carried only to the first input. **The second physical input** is connected to the tariff switching control voltage (see figure 7). Input pulses from the first port are alternatively switched to both counters in accordance with the tariff switching control voltage status, what means that during high tariff (t1) the pulses are directed to the first counter and during low tariff (t2) they are directed to the second counter.

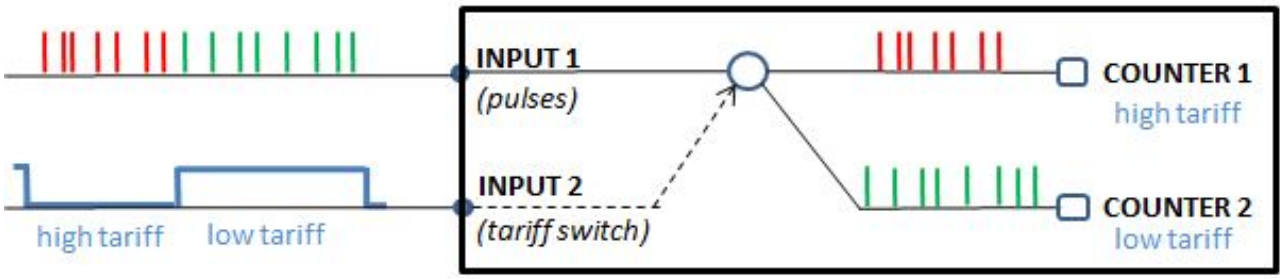


Figure 7: „Tariff switching” function principle

The function can be switched on by **”trf[index]”** command followed by parameter with 0, 1 or 2 value. Default setting with **”0”** value of the parameter means that the tariff switching function is disabled. By setting of **”1”** value the pulses are directed to the first counter (”t1”) when the tariff switching control voltage on the second port is in ”1” status („high”, released contact). By setting of **”2”** value the pulses are directed to the ”t1” counter during ”0” („low”, closed contact) status of control voltage (see figure). As only the second port of the WB169-SI2 module can be used for tariff switching, the ”trf” command should be always entered with index ”1”.

Example of setting port No 2 (index "1") to "1" value, when the module registers pulses to the first counter (t1) during "high" status of the tariff switching control voltage on the second port:

```
cfg#trf1 1
Change Tarrif[1] = t1 high
cfg#
```

Example of setting port No 2 (index "1") to "2" value, when the module registers pulses to the first counter (t1) during "low" status of the tariff switching control voltage on the second port:

```
cfg#trf1 2
Change Tarrif[1] = t1 low
cfg#
```

3.1.11 „Modem commands" group for RF-subsystem diagnostics

This group of commands comprises commands for setting of radio-frequency sub-system of the module. These commands are used primarily for the initial setting of the module in factory. There are following commands:

mr	*receiving mode switch-on (diagnostics)*
mt test	*testing broadcasting switch-on (set-up and diagnostics)*
ms	*internal status of RF-modem (diagnostics)*
mi	*dump of modem internal registers (diagnostics)*
mfreq	*frequency constant setting (frequency setting)*
cfreq	*frequency constant correction (frequency tunnig)*

These commands are intended only for module diagnostics and initial adjustment of the nominal frequency during the manufacturing process and outgoing inspection in factory.

Manufacturer strongly recommends not to use these commands during common operation. Using of these commands can cause inoperability of the device.

3.1.12 Commands of „Utils" group for setting of module common functions

This group of commands is intended for control and setting of other common functions of the module. There are following commands:

smask	*setting of content (selection of transferred information)*
tz	*setting of time zone (UTC + n)*
time	*real time (RTC) displaying/setting (hh:mm:ss)*
date	*real time (RTC) displaying/setting (RR.MM.DD)*
uptime	*show system uptime from last reset*
sens	*show current values of internal sensors (temperature, voltage..)*
send	*immediate sending of radio message*
send	*immediate sending of series of radio messages*
reset	*command for module reset*
?	*show list of configuration commands („Help")*

The **"smask"** command can be used for setting of information message content in order to transfer only useful information. Message structure is described in "mask" table (see figure 8), where there are different masks in different rows (one mask in one row) and all transferred information of one particular mask are marked by "1" in corresponding column. Binary symbols 0/1 from each four columns (Humidity, Temperature, Pulse input 1 and Pulse input 2) put together four-bit binary number. Decimal form of this number can be used as "smask" command parameter.

Required „mask" of message content can be entered by entering of mask decimal number (= number in "Mask" column) after "smask" command. Example:

```
cfg#smask 3
Send mask changed to 3 : I1, I2
cfg#
```

Mask	Humidity	Temperature	Pulse input 1	Pulse input 2
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
7	0	1	1	1
15	1	1	1	1

Figure 8: Table for selection of info-message content („mask")

As it is clear from the example, in the messages with mask number "3" there will be transferred only values of both counters (without temperature and humidity information). By using of **"tz"** command the current **Time Zone** can be preset. The module supports **only one** time zone, that is set in number of hours from UTC.

Example of setting of "UTC+1" Time Zone (Central-European Time):

```
cfg#tz 1
Tz change from 0 to 1
cfg#
```

Current setting of Time Zone displays in the configuration summary as follows:

```
Timezone : 1
```

Current setting of RTC can be displayed by entering of **"time"** or **"date"** command (without parameter). Example:

```
cfg#time
RTC time : 15:30:17 2019-01-30
 systime 1548858617 : 2019-01-30, 15:30:17+01
cfg#
```

RTC value can be entered by using of **time** and **date** commands as follows:

```
cfg#time 0x182555
RTC time : 18:25:55 2019-01-30
 systime 1548869155 : 2019-01-30, 18:25:55+01
cfg#date 0x190128
RTC time : 18:26:58 2019-01-28
 systime 1548696418 : 2019-01-28, 18:26:58+01
cfg#
```

As it is clear from the example, "time" value should be entered in "0x**hhmmss**" format, "date" value should be entered in 0x**RRMMDD** format.

NOTE: *setting of RTC (including time zone setting) is not important for the module common operation. No current module application requires RTC setting.* By using of **"uptime"** command the time since last module restart (switch on or reset) can be displayed. Using of this command can help with module diagnostics. From current „Uptime" value it is clear, when the module went through the last restart. The variable is of „read only" type. Example:

```
cfg#uptime
Uptime 0d, 0:13:26
cfg#
```

The **"sens"** command can be used for displaying of current values of A/D converters measuring physical quantities (battery voltage, temperature...). This command is intended only for module checking and diagnostics.

```
cfg#sens
-- Sensors --
CPU : 25.8 °C
VDA : 3.586 V
VIN1 :  3.524 V
VIN2 :  3.566 V
Sensor type 0 - none
mon#
```

The "CPU" value is a module processor temperature, the "VDA" value is an internal battery voltage, the "VIN1" and "VIN2" values are voltage levels on the inputs. The last figure "Sensor type 0" is an external sensor value, that have no meaning for this module modification. The command **"send"** can be used for immediate („out od turn") transmitting of the standard information message with current status of broadcasted variables. This command can be used for example for checking of radio signal availability during the system installation, or for any adjustments and testing of the module, connected meter, or receiving device. The command makes possible to send the information message anytime without necessity to change the transmission period or without waiting until the message will be sent spontaneously within the pre-set period.

An example of the command for immediate sending of the information message:

```
mon#send
Sending ... 73
mon#
```

Similar command **"sendp [number]"** can be used for transmitting of series of several info-messages with one minute period, when the first message is transmitted immediately. Number of messages in the series is set by "number" parameter after command, where maximum number of messages in series is 30. This command can be used during installation and testing of the module.

An example of the command for sending of series of 5 messages:

```
mon#sendp 5
 send 5 msgs
mon#
```

The command **"reset"** performs the module reset. After each reset the system starts with the parameters that are stored in FLASH memory. If the current configuration should be used after reset, it is necessary to store it into the FLASH before reset (see paragraph 3.1.4). Example of using of "reset" command:

```
cfg\#reset
 -- Reset code 0x14050302 --
 PIN Reset
 SFT Reset
 SW version 0.01, date Jan 18 2019
Monitor started ..
cfg#
```

By **"?"** command the list of all configuration commands with their brief description ("Help") can be displayed. Example of using this command can be found in the initial part of section 3.1.

3.1.13 Overview of module configuration parameters

Overview of configuration parameters that can be used for user settings of the WB169-SI2 module is shown in the Table 2 below. The parameters are presented in the same order as they appear in the List of configuration parameters (see paragraph 3.1.1

In **„Value"** column there are allowable ranges of parameter values. If there is a „code" indication in the „Value" column, it means that the value is displayed in hexadecimal code (where couple of hexadecimal characters represents one Byte).

In **„Default"** column there are default (factory) settings of the parameter. Colour marking of this field has following meaning:

- green colour - commonly used parameters that should be setup in reliance on the specific usage

Table 2: Overview of WB169-SI2 module configuration parameters

Item	Name	Value	Description	Default.
1	Timezone	1 - 11	Setting of time zone	1
2	MBUS ID	0 - 99999999	Serial number (M-Bus address)	read only
3	MBUS Version	0 - 255	Generation or version (M-Bus address suppl.)	read only
4	MBUS Manufacturer	code	Device producer (M-Bus address suppl.)	read only
5	MBUS Medium	code	Medium (M-Bus address suppl.)	07
6	MBUS Manuf. info	0 - 29 char.	Device name	SI4
7	Multiplier	1 - 65535	Counter value multiplier	1
8	Divisor	1 - 65535	Counter value divisor	1
9	DIF	code	Data field format (M-Bus)	84 0n
10	VIF	code	Measured quantity and unit (M-Bus)	13
11	Mode	desc.	Filter and trigger edge setting	falling, quick
12	Analog	desc.	Analog mode setting	digital
13	Alarm	desc.	Alarm mode setting	none
14	Leak period	0 - 1090	Leak detection period („Leak” function)	0
15	Leak zero time	0 - 1090	Zero consumption period („Leak” function)	0
16	Burst limit	0 - 65535	Alarm limit value („Burst” function)	0
17	Burst periode	0 - 1090	Burst check time („Burst” function)	0
18	Radio Power	1 - 5	Transmitting power	5
19	Comm. mode	1 - 2	Communication mode	1 (N1)
20	Channel	1 - 7	Frequency channel	1
21	Periode	1 - 65535	Broadcasting period in minutes	60
22	Send mask	1 - 15	Setting of info message content	3
23	Encryption	code	Encryption key	individuální
24	Next send	curr. status	Time to broadcasting of next info-message	read only
25	No of sent msgs	curr. status	No of sent messages since last reset	read only
26	No of recv. msgs	curr. status	No of received messages since last reset read only	
27	Config. Version	curr. status	No of stored images since last FLASH erasure	read only
28	SW Version	curr. status	Software version and date of issue	read only

- red colour - parameters that are not recommended to change
- grey colour - values that cannot be changed („read only”)

Yellow colouring of the „Item” number highlights the parameters, that can be configured by **USB-IRDA optical converter** as described in chapter 3.2 „Setting of parameters by using of optical „USB-IRDA” converter”.

3.2 Setting of parameters by using of optical „USB-IRDA" converter

The module is equipped with the „IRDA" infrared optical interface, that can be used for configuration through the **„USB-IRDA"** converter (USB-to-optic) or through the **„BT-IRDA"** converter (Bluetooth-to-optic).

All parameters that is necessary to set-up during common operation can be configured by **„USB-IRDA"** converter. The settings can be performed through the transparent casing without necessity to open the module's cover. This is the significant advantage especially if the module is used in humid environment and has been sealed by additional silicon filling (additional adaptation for IP-68 proofing).

Any changes in module's settings can be performed in **Module configuration table** that opens by click on the „Read device" button in "WACO OptoConf" program window. View of configuration table is depicted in figure 9.

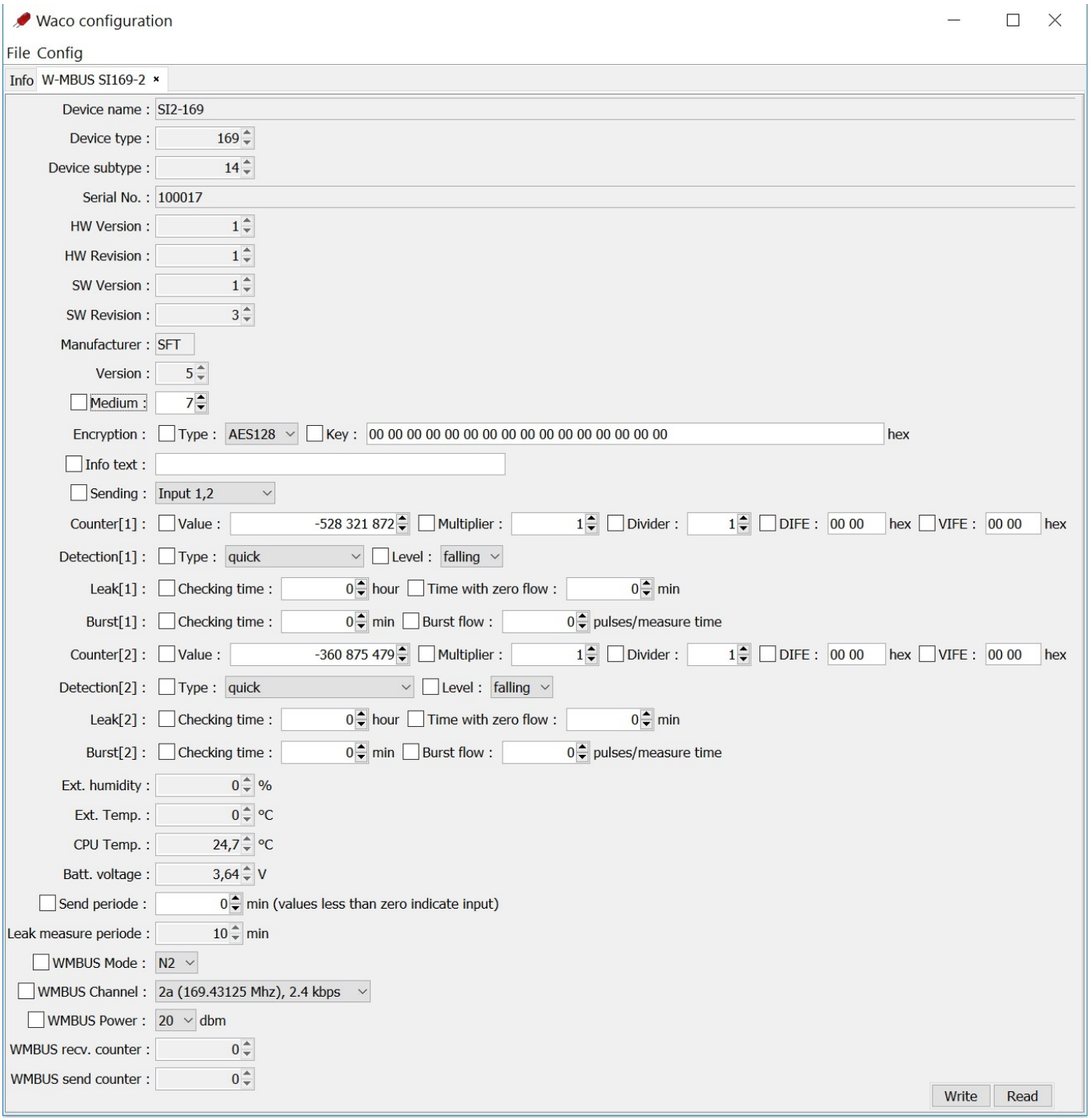


Figure 9: WB169-SI2 module configuration table

In the **upper section of the table** there are „read only" type of parameters (factory settings) that refer to the identification of the module and its components.

There are following parameters:

Device name	*device name by manufacturer*
Device type	*device type by manufacturer*
Device subtype	*device subtype by manufacturer*
Serial No.	*device serial number (as well MBUS-ID in M-Bus address)*
HW Version	*hardware version by manufacturer*
HW Revision	*hardware revision by manufacturer*
SW Version	*software version by manufacturer*
SW Revision	*software revision by manufacturer*
Manufacturer	*MBUS Manufacturer code*
Version	*MBUS-Version in M-Bus address*

Meaning of **"Serial No."** (MBUS-ID), **"SW Version"** (MBUS Version) and **"Manufacturer"** (MBUS Manufacturer) parameters is more precisely described in section 3.1.5 **„Commands for WMBUS messages settings"**. The rest of parameters contain information about specific identification of production series and software version of the device and are intended only for manufacturer's use.

In the **middle section of the table** there is a group of commonly used configurable parameters of the WB169-SI2 module. There are following parameters:

Medium	*MBUS-Medium code in M-Bus address*
Encryption	*encryption key setting*
Info text	*device type information*
Sending	*setting of message content*
Value	*counter initial value*
Multiplier	*multiplier of the counter (output value = counter value * multiplier)*
Divider	*counter's divisor (output value = counter value / divisor)*
DIFE	*DIF code setting (= type and coding of the data)*
VIFE	*VIF code setting (= unit and the multiplier code)*
Detection Type	*setting of equalizing filter and alarm mode*
Detection Level	*setting of trigger edge of the counter*
Leak check. time	*setting of „detection period" of the „Leak" function in hours*
Time with zero flow	*setting of „zero period" of the „Leak" function in minutes*
Burst flow	*setting of „LIMIT" of the „Burst" function (pulses per 10 minutes)*
Burst check. time	*setting of „burst check time" of the „Burst" function in minutes*

The **"Medium"** parameter is an international code of measured energy, water or other medium according to the M-Bus coding system. The value of the parameter is editable for the WB169-SI2 (it is an editable part of full meter/sensor M-Bus identification), the default value of the „Medium" parameter is 07 („Water"). More detailed description of the variable and possibilities of its setting are explained in details in section 3.1.5 „Commands for WMBUS messages settings".

The **"Encryption"** parameter is used for entering of the encryption key for AES-128 encryption of transmitted messages. If there is "AES-128" selected in the „Type" field then the encryption key of 16 bytes length should be entered to the „Key" field (always in hexadecimal format). If there is "none" selected in the „Type" field, then the encryption is switched off.

The **"Info text"** parameter is used for setting of the device name. Entered device name is thus a part of each information message (see paragraph 3.3). Default setting of this variable is „SI2". More detailed description of the variable and possibilities of its setting are explained in details in section 3.1.5 „Commands for WMBUS messages settings".

The **"Sending"** parameter command can be used for setting of information message content in order to transfer only useful information. The initial (factory) setting of this parameter is "Input 1,2", where the only values of both counters are transferred (without temperature and humidity information). More detailed description of this parameter and possibilities of its setting are explained in details in paragraph 3.1.12 „Commands of „Utils" group for setting of module common functions".

In the following part of this section there is a group of parameters **Value**, **Multiplier**, **Divider**, **DIFE** and **VIFE**, that are intended for setting of individual counters and their outputs. The module WB169-SI2 is equipped with two inputs (ports No 1 and 2), connected to two corresponding pulse counters. Each counter always increases its status by one with every incoming measuring pulse. The following variables are used to set initial values of counters, for setting of constants that enable adjust desired output values (multipliers and divisors), and for setting of „DIF" and „VIF" codes that allow the correct decoding of measured values according to the M-Bus standard

(especially for correct decoding of measuring units) in collecting data device („Master"). More detailed description of these variables and possibilities of their setting are explained in details in section 3.1.6 „Commands for setting of inputs parameters". Editable fields are arranged to two blocks, each of them is intended for setting of one counter („Counter[1]" and „Counter[2]"). In each block there are also variables for setting of criteria for „Leak" and „Burst" alarms for individual inputs.

The **"Value"** parameter is used for setting of the initial (or current) value of the counter. After this setting the initial value increases by one unit with each incoming measuring pulse.

The **"Multiplier"** and **"Divider"** parameters are used for settings of multiplier and divisor of the counter. The default setting of both parameters is "1". If it is required to adjust the output value of the counter by some constant (coefficient), enter the appropriate combination of the multiplier and divisor.

The **"DIFE"** parameter describes the character of the variable, the number of „storage" and a format of the data field according to the M-Bus standard. The variable should be always entered in hexadecimal format.

The **"VIFE"** parameter describes the kind of the measured value (whether the volume, temperature, voltage, etc.) and the measuring unit (including its multiplier) in which the value is presented (whether m^3, °C, mV, kWh, etc.). Examples of settings can be found in section 3.1.6. The variable should be always entered in hexadecimal format.

The **"Type"** parameter in „Detection" section is used for setting of equalizing filter on the counter input as well as for setting of alarm mode for the input. Parameter can be setup as follows:

- „quick" - equalizing filter disabled
- „slow" - equalizing filter involved for the input
- „slow+alarm falling" - involved filter, alarm message in "1-0" transition
- „slow+alarm rising" - involved filter, alarm message in "0-1" transition
- „slow+alarm both" - involved filter, alarm message in both transitions

Detailed description of these settings can be found in paragraph 3.1.6 („Inputs" group of parameters") and in paragraph 3.1.9 („Setting of sensor inputs").

The **"Level"** parameter in „Detection" section can be used for setting of counter trigger edge. „Falling" option means that the counter value will increase with falling edge of measuring pulse (i.e. short-circuiting of mechanical contact, or "1-to-0" transition of electronic pulse generator). „Rising" option means that the counter value will increase with rising edge of measuring pulse (i.e. releasing of contact, or "0-to-1" transition).

Variable **"Leak Checking time"** is used for setting of the length of „detection period" related to the „Leak" alarm function. Length of the detection period should be entered in hours. Variable **„Time with zero flow"** is used for setting of the minimal length of period with zero consumption related to the „Leak" alarm function. Length of the zero consumption period should be entered in minutes rounded to tens (e.g. 10, 20, 30...). More detailed description of these variables and possibilities of their settings are explained in section 3.1.7 „Description and setting of the „Leak" function".

Variable **„Burst flow"** is used for setting of the upper consumption limit for the detection of broken pipe purpose („Burst" function). This limit should be entered in number of measuring pulses per 10 minutes (=constant measuring interval). Variable **„Burst Checking time"** is used for setting of minimal duration of over-limit consumption related to the „Burst" function. Length of this interval should be entered in minutes rounded to tens (e.g. 10, 20, 30...). More detailed description of these variables and possibilities of their settings are explained in detail in section 3.1.8 „Description and setting of the „Burst" function".

In the **lower section of the table** there are current values of internal sensors and variables for setting of transmitting parameters.

There are following parameters:

Ext. humidity	*current humidity measured by external sensor (read only)*
Ext. temp.	*current temperature measured by external sensor (read only)*
CPU Temp.	*current processor temperature (read only)*
Batt. voltage	*current battery voltage (read only)*
Send periode	*setting of info-messages transmitting period*
Leak measure periode	*basic measuring interval of leak/burst functions (read only)*
WMBUS Mode	*setting of WMBUS communication mode*
WMBUS Channel	*setting of WMBUS RF channel*
WMBUS Power	*setting of transmitting power*
WMBUS recv. counter	*current number of received messages (read only)*
WMBUS send counter	*current number of transmitted messages (read only)*

In the non-editable fields **"Ext. humidity"** and **"Ext. temp."** there are displayed current values of external sensors. As this modification of the module is not equipped by external sensors, the values are always "0".

In the non-editable fields **"CPU Temp."** and **"Batt. voltage"** there are displayed current values of processor temperature and battery voltage of the module. These values are transmitted in each info-message (see description of information message in section 3.3 „Structure of WB169-SI2 module data message").

The **"Send periode"** parameter is used for setting of broadcasting period of regular information messages. Value of the period should be set in minutes; default setting is 60 minutes. For switching to external synchronization mode, it is required to enter the number of synchronization port with "-" (minus) sign. Broadcasting is disabled by setting this parameter to zero value. More detailed description of this variable and possibilities of its setting are explained in details in section 3.1.5 „Commands for WMBUS messages settings".

The **"Leak measure periode"** parameter is basic measuring interval of leak and burst functions. Its value is factory set to 10 minutes and cannot be changed. Values of counters for „Leak" and „Burst" functions are checked with this period.

Editable variables **"WMBUS Mode"**, **"WMBUS Channel"** and **"WMBUS Power"** are used for settings of radio-frequency subsystem of the module. More detailed description of these variables and possibilities of their setting are explained in details in section 3.1.11 „Modem group commands".

The **"WMBUS Mode"** parameter can be used for selection of the module's WMBUS communication mode. Factory setting is "N1" mode, variable is entered by choosing from pre-set relevant options.

The **"WMBUS Channel"** parameter can be used for selection of the module's frequency channel. Frequency channels within particular frequency bands are defined by the M-Bus standard. Variable is entered by choosing from pre-set relevant options (there are 7 options for WB169-SI2 module).

The **"WMBUS Power"** parameter can be used for selection of the module's transmitting power. Factory setting is 100 mW (moderate power), variable is entered by choosing from pre-set relevant options.

In the non-editable fields **"WMBUS recv. counter"** and **"WMBUS send counter"** there are displayed current numbers of received and transmitted messages from the last reset of the module. These data can be used for module's diagnostics.

Some of the module parameters can be configured also by using of **„BT-IRDA"** converter and **„SOFTLINK Configurator"** mobile application. Current version of the WB169-SI2 module supports configuring all parameters, that are necessary for module installation on the site, as well as performing basic tests.

In the figure 10 there is an identification form of WB169-SI2 module (bordered by grey colour), form selection window (bordered by yellow colour) and form for setting of „Leak" and „Burst" functions (bordered by blue colour).

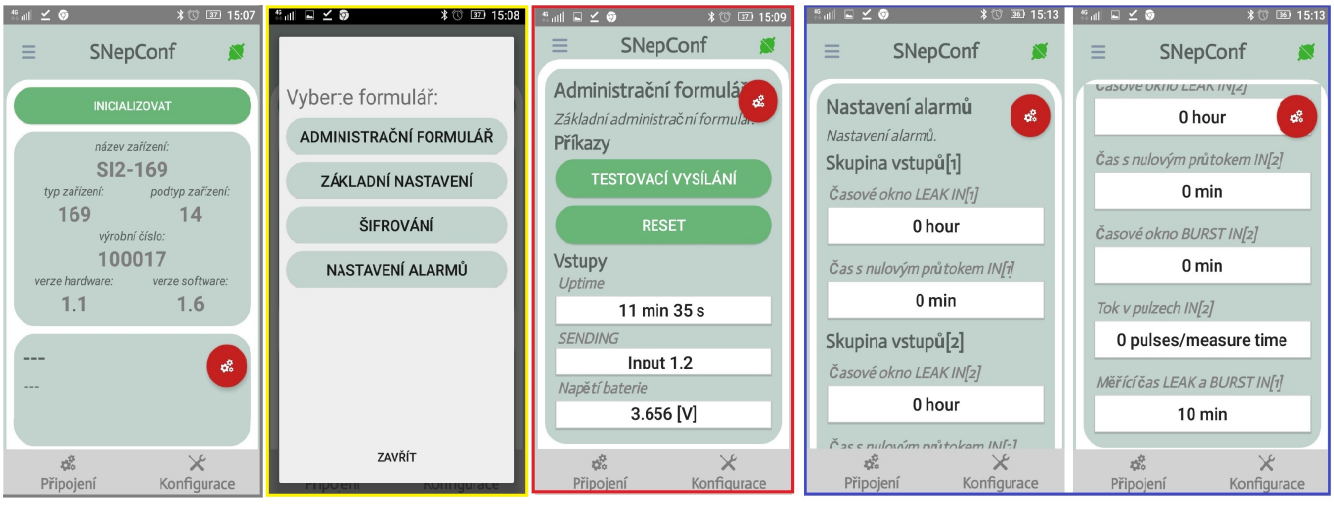


Figure 10: Basic forms of WB169-SI2 module in „SOFTLINK Configurator" application

In the figure 11 there is a form for setting of inputs and outputs (bordered by violet colour) and encryption setting form (bordered by green colour).

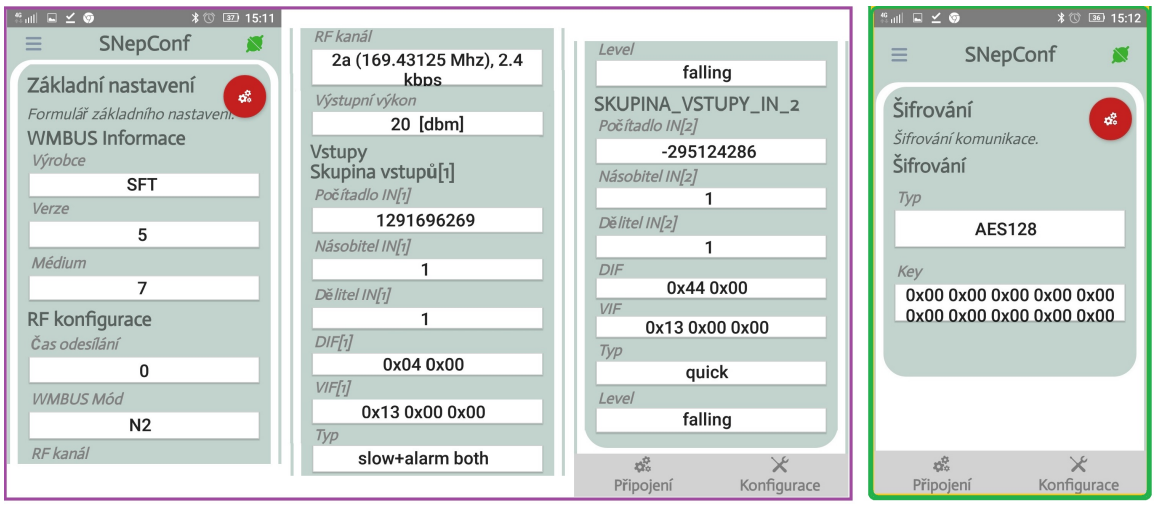


Figure 11: Input/output setting form and form for setting of encryption

As evident from the pictures, the application enables performing of following settings:

- setting of WMBUS message (manufacturer, version, medium)
- setting of broadcasting (period, mode, channel, transm. power
- setting of initial value, multiplier and divisor of inputs
- setting of measured value auxiliary information (DIF/VIF)
- setting of trigger edge and mode of pulse inputs
- encryption activation and entering of encryption key
- setting of message content (transferred value selection mask)
- setting of Leak and Burst function parameters
- starting of one-time testing transmission
- sending of RESET command to the module

As the „SOFTLINK Configurator" application is continuously developed and improved, the screen previews of WB169-SI2 module configuration forms can vary in time.

3.3 Structure of module data messages

The WB169-SI2 module transmits following two types of messages:

- standard **information message** with status of all variables, broadcasted periodically
- short **alarm message** sent immediately when alarm status has been detected

3.3.1 Iinformation message

Information message of the module consists from the Wireless M-BUS header, short 4 Byte M-Bus header and a data block with minimum six data segments with length of at least 31 Byte (it could vary in reliance on configuration).

Structure of Wireless M-BUS message header of the WB169-SI2 module is described in the Table 3.

Table 3: Structure of Wireless M-BUS message header of the WB169-SI2 module

Name	Length (Byte)	Description/meaning
Length (L)	1	Message length in Byte
Type (C)	1	"Spontaneous User Data"
Manufacturer ID (M)	2	"SFT" (manufacturer code of Softlink)
Address (A)	4	M-BUS Device ID (configurable)
Version (V)	1	M-BUS Version/Generation (configurable)
Medium (T)	1	M-BUS type of medium (configurable)
Application type (Cl)	1	"Slave to Master, 4-Byte header, variable data format"

Wireless M-BUS header contains full identification of the device according to the M-Bus specification (manufacturer/medium/version/serial number) and also message type and format of content.

Short 4-Byte M-Bus header of the message application layer contains following data:

- item "Access No" that increases by one with each sent message;
- item „Status" that is normally "00", value "04" („Low Power") signalizes low battery volatge;
- item „Signature" contains encryption type and parameter ("00 00" means no encryption).

If the message has been re-transmitted (repeated), item „Signature" is modified by Wireless M-Bus repeater to "01 XX" (low bit of the first Byte changes from "0" to "1"). Basic data block consists of six or seven (*) data segments, each of them carries data of one variable. List of variables transmitted in the information message of WB169-SI2 module can be found in the Table No. 4:

Table 4: Description of variables of WB169-SI2 module info-message data block

Order	Variable (description)	Unit	Type	Data format
1	INFO (text)	Fabric. No.	Inst.	Variable
2	Current consumption (counter 1)	m^3 (10^{-3})	Inst.	32 bit Integer
3	Current consumption (counter 2)	m^3 (10^{-3})	Inst.	32 bit Integer
4	Internal battery voltage	V (10^{-3})	Inst.	16 bit Integer
5	Transmitting power setting	W (10^{-3})	Inst.	16 bit Integer
6	Processor temperature	°C (-1)	Inst.	16 bit Integer
7	"Uptime" from last reset	seconds	Inst.	32 bit Integer

(*) Length of „INFO" data segment depends on the number of characters in „Info" string (see paragraph 3.1.5). If the „Info" string is not set, the "INFO" data segment is removed from the message and in this case the data bock consists only from 6 segments.

View of information message with default setting, received and decoded by *WMBUS AN4* Wireless M-BUS signal analyzer, is shown in the figure 12. **If the AES-128 data encryption is switched on**, there are two additional

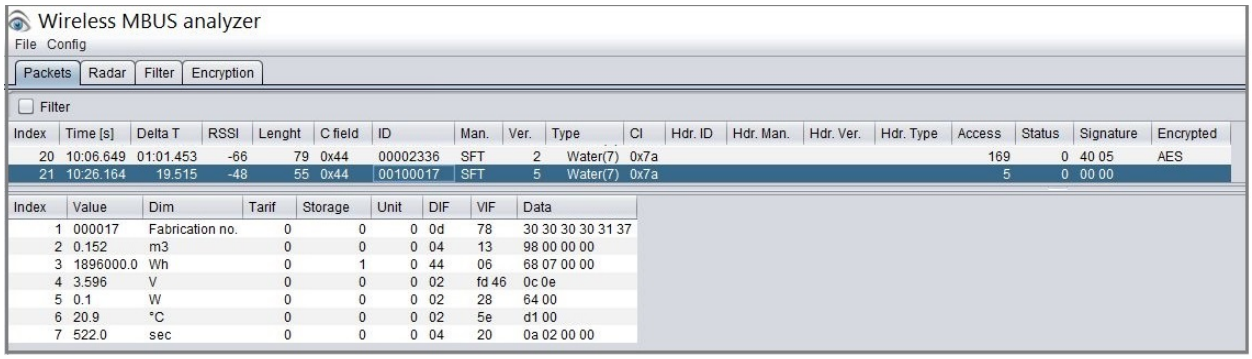


Figure 12: View of WB169-SI2 module information message received by *WMBUSAN4* analyzer

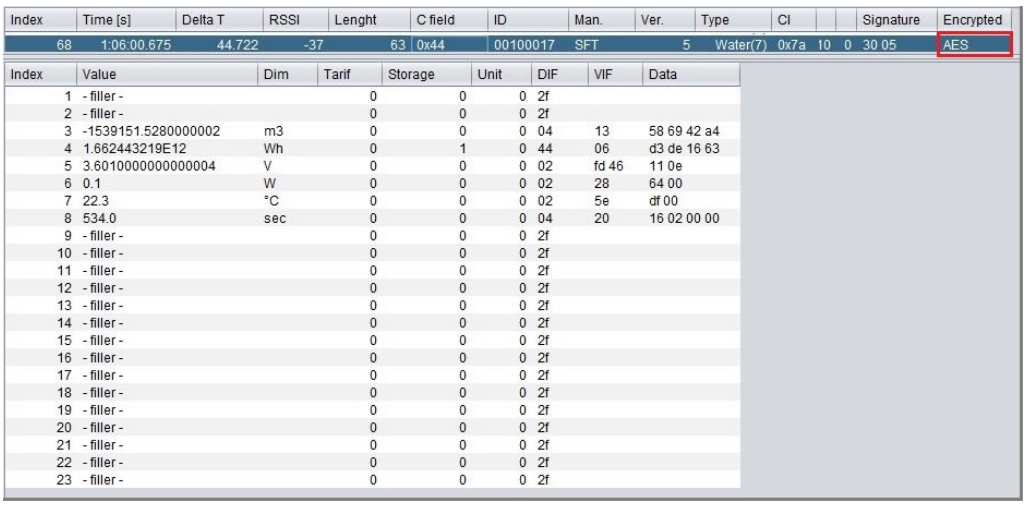
„control segments" inserted before data segments of the message. These "2F" segments serve only for checking of correctness of the decryption. If using encryption, the total number of data block bytes must be „rounded" into integer multiple of 16 Byte (i.e. 16, 32, 48, 64...etc. Bytes). Rounding of the message is performed by inserting of required number of "2F" blocks.

Decoded encrypted message of the WB169-SI2 module with two control segments at the beginning and several other "2F" blocks at the end is shown in the Figure 13. This way the length of message data block is rounded to 64 Byte.

If there is a sensor connected to some module's input and its counter is preset into **alarm mode** (see paragraph 3.1.9 „Setting of sensor inputs"), there is another data segment inserted after the last „normal" data segment. The inserted segment carries an information about actual status of the sensor input. Thus, if there are both ports preset into the alarm mode, standard information message (including "INFO" segment) contains 7+2= 9 data segments in total.

Decoded message of the WB169-SI2 module with two additional data segments carrying statuses of sensors in alarm mode is shown in the Figure 14. Additional data segment with status of sensor input in alarm mode carries an information about the current port status and its structure is same as a structure of alarm message (see paragraph 3.3.2 „Alarm message" below).

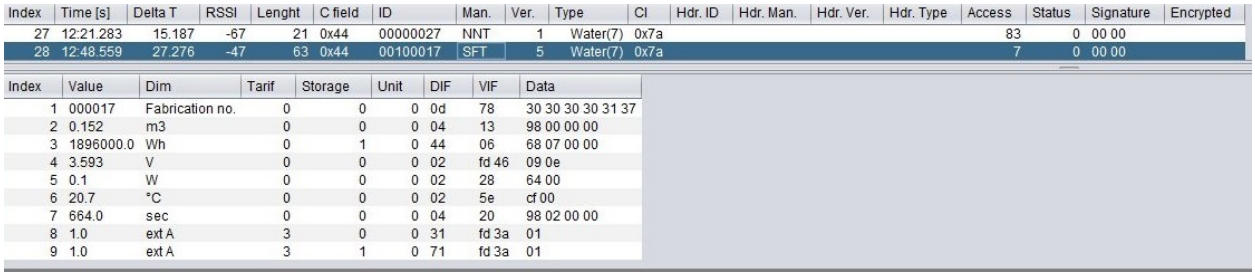
If some of the inputs is set to **analog mode**, message data format is always „4-Byte Integer", VIF value is configurable. Variable value always contains voltage on given input in mV (e.g. value "d2 0d 00 00"=3538 mV).



Index	Time [s]	Delta T	RSSI	Lenght	C field	ID	Man.	Ver.	Type	CI			Signature	Encrypted
68	1:06:00.675	44.722	-37	63	0x44	00100017	SFT	5	Water(7)	0x7a	10	0	30 05	AES

Index	Value	Dim	Tarif	Storage	Unit	DIF	VIF	Data
1	- filler -		0	0	0	2f		
2	- filler -		0	0	0	2f		
3	-1539151.5280000002	m3	0	0	0	04	13	58 69 42 a4
4	1.662443219E12	Wh	0	1	0	44	06	d3 de 16 63
5	3.6010000000000004	V	0	0	0	02	fd 46	11 0e
6	0.1	W	0	0	0	02	28	64 00
7	22.3	°C	0	0	0	02	5e	df 00
8	534.0	sec	0	0	0	04	20	16 02 00 00
9	- filler -		0	0	0	2f		
10	- filler -		0	0	0	2f		
11	- filler -		0	0	0	2f		
12	- filler -		0	0	0	2f		
13	- filler -		0	0	0	2f		
14	- filler -		0	0	0	2f		
15	- filler -		0	0	0	2f		
16	- filler -		0	0	0	2f		
17	- filler -		0	0	0	2f		
18	- filler -		0	0	0	2f		
19	- filler -		0	0	0	2f		
20	- filler -		0	0	0	2f		
21	- filler -		0	0	0	2f		
22	- filler -		0	0	0	2f		
23	- filler -		0	0	0	2f		

Figure 13: Encrypted and decrypted message of the WB169-SI2 module



Index	Time [s]	Delta T	RSSI	Lenght	C field	ID	Man.	Ver.	Type	CI	Hdr. ID	Hdr. Man.	Hdr. Ver.	Hdr. Type	Access	Status	Signature	Encrypted
27	12:21.283	15.187	-67	21	0x44	00000027	NNT	1	Water(7)	0x7a					83	0	00 00	
28	12:48.559	27.276	-47	63	0x44	00100017	SFT	5	Water(7)	0x7a					7	0	00 00	

Index	Value	Dim	Tarif	Storage	Unit	DIF	VIF	Data
1	000017	Fabrication no.	0	0	0	0d	78	30 30 30 30 31 37
2	0.152	m3	0	0	0	04	13	98 00 00 00
3	1896000.0	Wh	0	1	0	44	06	68 07 00 00
4	3.593	V	0	0	0	02	fd 46	09 0e
5	0.1	W	0	0	0	02	28	64 00
6	20.7	°C	0	0	0	02	5e	cf 00
7	664.0	sec	0	0	0	04	20	98 02 00 00
8	1.0	ext A	3	0	0	31	fd 3a	01
9	1.0	ext A	3	1	0	71	fd 3a	01

Figure 14: Structure of WB169-SI2 module message with both inputs in alarm mode

3.3.2 Alarm message

Alarm message of the module is transmitted immediately after some of the supported alarm types arises. Current modification of WB169-SI2 module supports sending of following types of alarm messages:

- OID 60 - value"0" - event of "RESET" type
- OID 60 - value "4" - input in "OK" status - normal status (*)
- OID 60 - value "5" - input in "Error" status - alarm status (*)
- OID 60 - value "15" - input in "LEAK" status - alarm status
- OID 60 - value "16" - input in "NO LEAK" status - normal status (**)
- OID 60 - value "17" - input in "BURST" status - alarm status
- OID 60 - value "18" - input in "NO BURST" status - normal status (**)

(*) These types of events indicate alarm statuses on the pulse interface. Default values "4" and "5" generally indicate whether the port status is alarm or normal. With using of "alarm" couple of commands it is possible to make the event interpretation more specific according to the sensor real function (see setting of "alcok" and "alcerr" in paragraph 3.1.9 „Setting of sensor inputs".

(**) Positive events of "NO LEAK"/"NO BURST" type are generated in that case, when after one or several "alarm" periods a period without alarm status came around.

Each alarm message has Wireless M-BUS header („WMBUS Header") and short 4-Byte M-Bus header. The only difference between regular information message header and alarm message header is in setting of **"CI" field** (Application Type), where the field in alarm message is always set to **"74"** value („Alarm from meter with short transport layer").

Each alarm message has at least two data segments, that contain **alarm category and type** according to the *wacoSystem* categorization. All alarm messages from WB169-SI2module are in "0" category (Generic) and can be of different type as described in the list of supported alarm messages above. Complete code-list of supported types of alarms is available on the public WEB address NEP Page.

These two segments are always the first and can be followed by one or more other segments carrying additional information relevant to the alarm (typically current status in time of its arising).

Alarm message about a **change of sensor input status** is transmitted only in that case, when a two-state sensor is connected to the module input, equalizing filter is set to "1" status (slow mode) by "dmode" command, and the

input is set to alarm mode by "alr" command. The message is transmitted immediately after change of port status (out of regular broadcasting period) and contains only information relevant to the port, on which the status was changed. The message has four data segments:

The first data segment carries alarm category information. Its DIF/VIF values are always set to is set either to "02" and "7A" (storage 0, 16-bit Integer, unspecified content). Common meaning of "7A" value (unspecified content) within WB169 product range is always **„Alarm Category/Type"**. Data value of the first segment is always "0" (all alarms supported by the module are of "Generic" category).

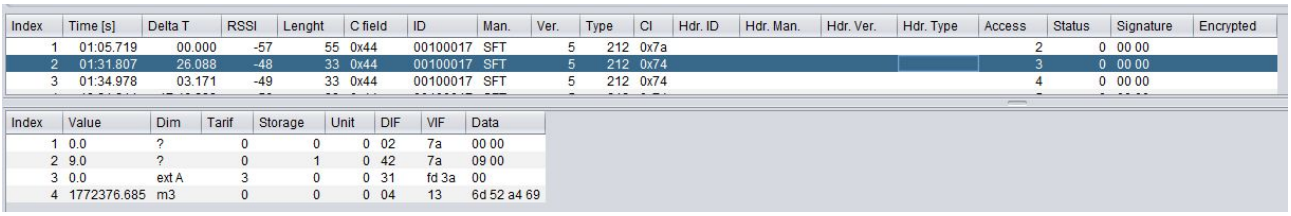
The second data segment carries alarm type information. Its DIF/VIF values are always set to is set either to "42" and "7A" (storage 1, 16-bit Integer, unspecified content). Data value of the second segment means number of alarm type, that is for this type of message either "5" (if the sensor turned from normal to alarm status = rising of alarm), or "4" (transition from alarm to normal status = end of alarm).

The third data segment carries information about the status of sensor input after change of status, so its value is either "0", or "1". Decoding information DIF/VIF are set as follows:

DIF = 31 for 1. input (average value, 8-bit integer, storage "0")
DIF = 71 for 2. input (average value, 8-bit integer, storage "1")
VIFE = FD 3A for all inputs (dimensionless value "NO VIF")

The fourth data segment carries information about the current status of sensor input counter (i.e. number of transitions since last counter reset). The DIF and VIF values correspond with setting of given input, transferred data value (Value) is counter current status.

Decoded alarm message about the change of sensor status on the first input is shown in the figure 15: Alarm message

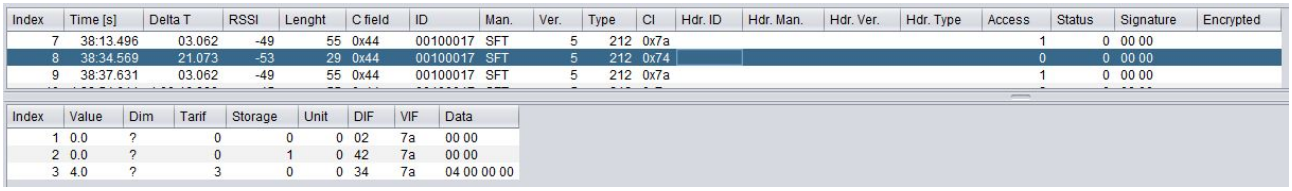


Index	Time [s]	Delta T	RSSI	Lenght	C field	ID	Man.	Ver.	Type	CI	Hdr. ID	Hdr. Man.	Hdr. Ver.	Hdr. Type	Access	Status	Signature	Encrypted
1	01:05.719	00.000	-57	55	0x44	00100017	SFT	5	212	0x7a					2	0	00 00	
2	01:31.807	26.088	-48	33	0x44	00100017	SFT	5	212	0x74					3	0	00 00	
3	01:34.978	03.171	-49	33	0x44	00100017	SFT	5	212	0x74					4	0	00 00	

Index	Value	Dim	Tarif	Storage	Unit	DIF	VIF	Data
1	0.0	?	0	0	0	02	7a	00 00
2	9.0	?	0	1	0	42	7a	09 00
3	0.0	ext A	3	0	0	31	fd 3a	00
4	1772376.685	m3	0	0	0	04	13	6d 52 a4 69

Figure 15: Structure of alarm message about the change of sensor status on the port of WB169-SI2 module

about a **module reset** is transmitted after each module switching on and after each module reset. The message has three data segments, the obligatory „alarm category" and „alarm type" segments are followed by segment with reset code. Decoded alarm message about the module reset with "4" („Power Reset") reset code is shown in the figure 16: **Alarm messages of „LEAK" and „BURST" functions** are transmitted immediately after the alarm status is



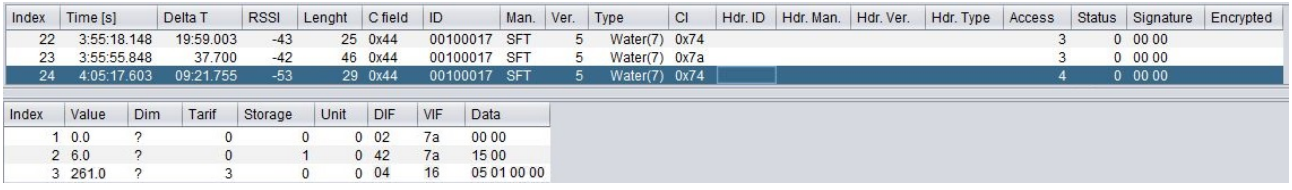
Index	Time [s]	Delta T	RSSI	Lenght	C field	ID	Man.	Ver.	Type	CI	Hdr. ID	Hdr. Man.	Hdr. Ver.	Hdr. Type	Access	Status	Signature	Encrypted
7	38:13.496	03.062	-49	55	0x44	00100017	SFT	5	212	0x7a					1	0	00 00	
8	38:34.569	21.073	-53	29	0x44	00100017	SFT	5	212	0x74					0	0	00 00	
9	38:37.631	03.062	-49	55	0x44	00100017	SFT	5	212	0x7a					1	0	00 00	

Index	Value	Dim	Tarif	Storage	Unit	DIF	VIF	Data
1	0.0	?	0	0	0	02	7a	00 00
2	0.0	?	0	1	0	42	7a	00 00
3	4.0	?	3	0	0	34	7a	04 00 00 00

Figure 16: Structure of alarm message about the reset of WB169-SI2 module

detected on some input (see description of „Leak" function in paragraph 3.1.7 and description of „Burst" function in paragraph 3.1.8). Messages of "NO LEAK"/"NO BURST" type are generated in that case, when "non-alarm" period comes after one or several "alarm" periods.

The messages have three segments, the first two segments with alarm category and alarm type (15, 16, 17, or 18) are followed by segment with current status of affected port counter. Decoded alarm message about the rising of „Leak" alarm on the first input (index 1) at the counter status 261 m3 is shown in the figure 17:



Index	Time [s]	Delta T	RSSI	Lenght	C field	ID	Man.	Ver.	Type	CI	Hdr. ID	Hdr. Man.	Hdr. Ver.	Hdr. Type	Access	Status	Signature	Encrypted
22	3:55:18.148	19:59.003	-43	25	0x44	00100017	SFT	5	Water(7)	0x74					3	0	00 00	
23	3:55:55.848	37.700	-42	46	0x44	00100017	SFT	5	Water(7)	0x7a					3	0	00 00	
24	4:05:17.603	09:21.755	-53	29	0x44	00100017	SFT	5	Water(7)	0x74					4	0	00 00	

Index	Value	Dim	Tarif	Storage	Unit	DIF	VIF	Data
1	0.0	?	0	0	0	02	7a	00 00
2	6.0	?	0	1	0	42	7a	15 00
3	261.0	?	3	0	0	04	16	05 01 00 00

Figure 17: Structure of WB169-SI2 module alarm message about the „Leak" type of alarm

4 Operational conditions

This section of the document describes basic recommendations for transportation, storing, installation and operation of WB169-SI2 radio modules.

4.0.1 Risk of mechanical and/or electric damage

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

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

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

4.0.2 Risk of premature battery discharge

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

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

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

4.0.3 Risk of damage by excessive humidity

Radio modules could be (as any other electronic devices) damaged by water, that could cause a short-circuit among some electronic elements or corrosion of the elements. Correctly assembled plastic box protects the module's printed circuit board against direct penetration of water, but the damage could be caused also by gradual penetration of humid air which can cause corrosion or other damage by condensed water inside the box.

Modules are enclosed in IP65 grade plastic boxes (proof against short-time squirted water) or with additional sealing by high-adhesion silicon filling, that can ensure proof against inundation by water (IP68 grade). Modules, that are delivered with IP68 sealing from factory are clearly assigned by IP68 degree of protection on the manufacturer's production label (e.g.: "WB169-SI2/B13/IP68").

Risks of damage of the device in basic **"IP65"** design caused by penetration of excessive humidity can be eliminated by these precautions:

- install only modules that are correctly assembled, with undamaged box and undamaged rubber seal;
- in case of any doubt perform additional sealing of connection of both parts of the box and both cable bushings by silicon sealant;
- install modules only to the sites where relative humidity exceed value of 95% only occasionally;
- install modules only to the sites where they can be squirted or sprayed by water only occasionally and only for a short time;
- do not install modules to the sites where they can be dipped into the water.

Risks of damage of the device in waterproof **"IP68"** design caused by penetration of excessive humidity can be eliminated by these precautions:

- do not open the module with silicon filling without serious reason;

- if (from some reason) the module was already opened, manipulate with it very carefully or renew its silicon filling by pouring of a few milliliters of special silicon (same as original - consult the technique with manufacturer). **In case the module has been opened, there is no manufacturer's guarantee of IP68 degree of protection.**;
- install modules only to the sites where they can be dipped into the water only occasionally and only for a short time;
- do not install modules to the sites where their antenna could be submerged under water. Antenna must be installed to such place, where there is no possibility to be flooded. **Operating of the module with antenna submerged under water could cause irretrievable damage of the device!**

4.1 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.

4.2 Modules storage

It is strongly recommended to store the modules in dry rooms or halls, in the temperature interval (0 ÷ 30) °C. To prevent the unwanted discharging of internal battery it is recommended storing the modules with batteries disconnected and activate the battery during mounting (with exception of modules with additional sealing by silicon filling - see paragraph 4.1).

4.3 Safety precautions

Warning! Mechanical and electrical installation of the WB169-SI2 module can be provided only by a person with necessary qualification in electrical engineering.

4.4 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.

4.5 WB169-SI2 module installation

WB169-SI2 radio modules are enclosed in plastic casings with an IP65 degree of protection equipped with mounts for mounting on the wall, pipe or any other construction element. In the figure 18 there is displayed the WB169-SI2 module dismantled into individual components.

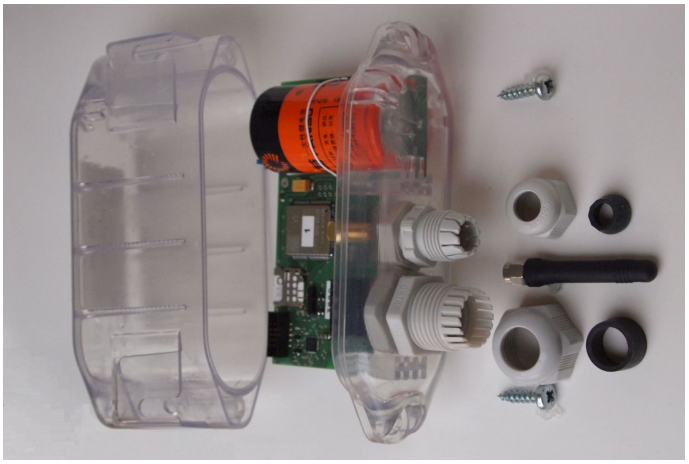


Figure 18: Set of WB169-SI2 module components with stick antenna

Input clamps, battery switch, configuration connector as well as antenna connector are placed on the module's printed circuit board, so that it is necessary to open the casing to access these elements.

Modules with additional silicon filling (IP68 degree of protection) are delivered with battery switched "on" and with both cables connected before silicon filling. **It is recommended do not open the casing during operation until it is really necessary, and if so, do it very carefully**. Configuration of the modules should be performed by USB-IRDA optical converter as described in section 3.2 „Setting of parameters by using of optical „IRDA" converter"

In the figure 19 left there is displayed the detail of WB169-SI2 module printed circuit board with configuration connector marked by violet colour, battery switch marked by red colour, input clamps marked by green colour and antenna connector marked by blue colour. Appearance of the module PCB could slightly vary in dependence on the module modification.

Figure 19: Detail of WB169-SI2 module PCB

In the central part of the figure 19 there is a picture of USB-IRDA optical converter with holding on magnet ("MAGNETIC"), that can be used for module wireless configuration. In the right part of the figure 19 there is a picture of module with attached optical converter.

The case of WB169-SI2 module consists of two parts:

- module base with the printed circuit board attached. It is the where the cable bushings are placed;
- box cap that covers the printed circuit board, with mounts for attaching of the module to the wall or other construction element

When mounting the device follow these instructions:

- attach the module to a suitable firm object (wall, pipe) by two screws or by a clamping tape. There are mounts by the box sides for the attachment. The recommended position of the mounted module is in the way that the base is down, cable bushings are facing to the floor;
- unscrew the screws on the sides of the module base (right beside the cable bushings), loosen the cap of the module and slide the base out of the cap;
- pull the cables with the outputs from the consumption meters or sensors through the cable bushing (**) and connect the individual conductors to the input clamps of the module. The scheme of deployment and polarity of individual clamps is glued inside on the cap of the box. Make sure that the meters are connected to the relevant inputs according to the project materials or write down the diagram of individual connections;
- connect the local antenna (stick or rod type) or an antenna cable from a remote antenna into the antenna connector (coaxial connector on the printed circuit board beside the input clamps). Pull the antenna or the antenna cable through the cable bushings that is just right opposite to the antenna connector;
- switch-on battery by switching of both of the micro-switches („jumpers") placed on the PCB beside the configuration connector into the „ON" position. Some modifications of the module could be equipped with a pair of simple shortening pins, that should be short-circuited by shortening connector;
- perform an elementary module diagnostics and alternatively go through the module configuration (setting of parameters) with using of configuration cable as described in chapter 3 „Module configuration". In case the module has been fully pre-configured in the preparatory phase of installation, at least check and set-up input/output values to ensure that the information sent in the radio-messages will be correct;

- tighten the nuts on the cable bushings to seal them and protect the cables from unwanted pulling out of the clamps;
- insert the base back into the cap and fix with screws. For the mounting in a humid environment it is recommended to apply silicone sealant on the outer perimeter of the seating edge of the base before screwing the box back together;
- if the internal rules or the mounting process needs the antifraud seal to be installed (as the protection from the unwanted influencing), stick the antifraud seal across the joint between the two parts of the box.

(*) ATTENTION! *If the module is sealed by additional silicon filling with IP68 degree of protection do not open its casing during the installation! Meter outputs can be connected to appropriate wires of the input cable (that had been connected to the module before silicon filling) and configuration could be performed by radio or by using of an optical converter USB-IRDA.*

If the module is rated in IP65 or IP68 degree of protection, this declaration is valid only under condition of the proper mounting and sealing. When assembling the modules with IP68 degree of protection that will be placed in the humid environment, it is necessary to follow these rules:

- both cable bushings must be properly sealed;
- the joint of both parts of the box must be properly sealed by original rubber sealing).

After the mounting, write down the counter values of all consumption meters connected to the module into the mounting sheet and alternatively once again check out the module‘s functionality and the correctness of output values (which must correspond to consumption meter mechanical counters). Test the module functionality by „end-to-end” method, that means by checking of the readings directly in the central system of remote reading.

Follow the consumption meter manufacturer’s instructions for determination of the length of the connection cables between the consumption meters and the radio modules.

When locating installation site, selecting antenna type and antenna position it is necessary to take into account conditions for radio signal propagation in the area of installation as well as protection of the device against possible mechanical damage. The radio-signal conditions can be estimated empirically on the base of previous experience, or examined by measuring of the signal strength by the reference transmitter/receiver.

4.6 Module and meter replacement

When there is necessary to replace the module due to the module failure or due to battery discharging follow this procedure:

- check the antifraud seal before dismantling – the antifraud seal damage must be solved according to the internal rules of the customer/project;
- unscrew two screws on the sides of the module base (beside the cable bushings), loosen the cap of the module and slide out the base from the cap;
- disconnect the cables from the consumption meters from the input clamps, alternatively disconnect the cable of the external antenna from the antenna connector;
- by switching of both of the micro-switches („jumpers”) placed on the PCB beside the configuration connector into the „OFF“ position (or replacing of shortening connector from shortening pins) disconnect the module from the battery power supply;
- loosen the fixing screws (or clamping tape) that hold the module on the wall, pipe or other pad and dismantle the cap;
- put both parts of the module back together by screwing the cap together with base (*). Mark the module visibly as „defective”, alternatively you can fill in the form (mounting report) about the module replacement;
- install a new module in the same way as described in paragraph 4.5 above. Pay attention to the correct connection of the input cables (must be the same inputs as they were on the original module) and set up the relevant configuration parameters, namely broadcasting period and input/output values.
- write down the serial number and seal number of the module, alternatively also actual statuses of counters of connected meters;
- if possible, arrange making of all appropriate changes in the database of the remote reading system immediately.

(*) CAUTION! *The type label with RF-address and serial number of the module is always on the cap of the module so the base and the cap of the module must always be one whole unchangeable unit. Always pay attention to the completing of the correct cap with the correct base of the module, that is the reason why it is always necessary*

to replace the whole module – the base and the cap together. The correct module completion can be checked out according to the auxiliary label with the RF-address glued on the PCB (RF-address on the PCB must correspond with the RF-address on the cap of the module).

When there is necessary to replace a consumption meter connected to the module due to the meter failure, expired metrology period or for any other reason, follow this procedure:

- check the antifraud seal before dismantling – the antifraud seal damage must be solved according to the internal rules of each customer/project;
- if the module is sealed by additional silicon filling with IP68 degree of protection do not open its casing! Disconnect replaced meter from the input cable and connect new meter to the same wires;
- if the module is in common IP-65 design, unscrew two screws on the sides of the box (beside the cable bushings), loosen the cap of the module and slide out the base from the cap;
- disconnect the cables from replaced consumption meter from the input clamps, replace the consumption meter and connect its cable back into the input clamps;
- perform setting of input/output values of the relevant input according to the instruction in the chapter 3 „Module configuration". Check out the correctness of output values (which must correspond to consumption meter mechanical counters) by checking of the readings directly in the remote reading system.
- fill in the required documentation for the meter replacement (mounting sheet), precisely write down the value of the mechanical counter of the new meter;
- cover the module and, if needed, apply the sealant according to the instructions in paragraph 4.5. Alternatively wait for the first reading and cover the module afterwards.

***(*) CAUTION!** The new meter might require a different setting of module's input/output even if the meter is the same type and manufacturer. Conversion constants can differ from each other even in various modifications of the same type of the meter.*

4.7 Module dismantling

When dismantling, open the module, disconnect cables and dismantle the cap from the wall, pad or pipe. Switch the battery off and put the module parts back together (put the cap on the base of the module). After the dismantling mark the module as „dismantled" and fill in the relevant documentation, prescribed for this situation by the internal rules. If possible, arrange deactivation of the module in the database of remote reading system immediately.

4.8 Functional check of the module

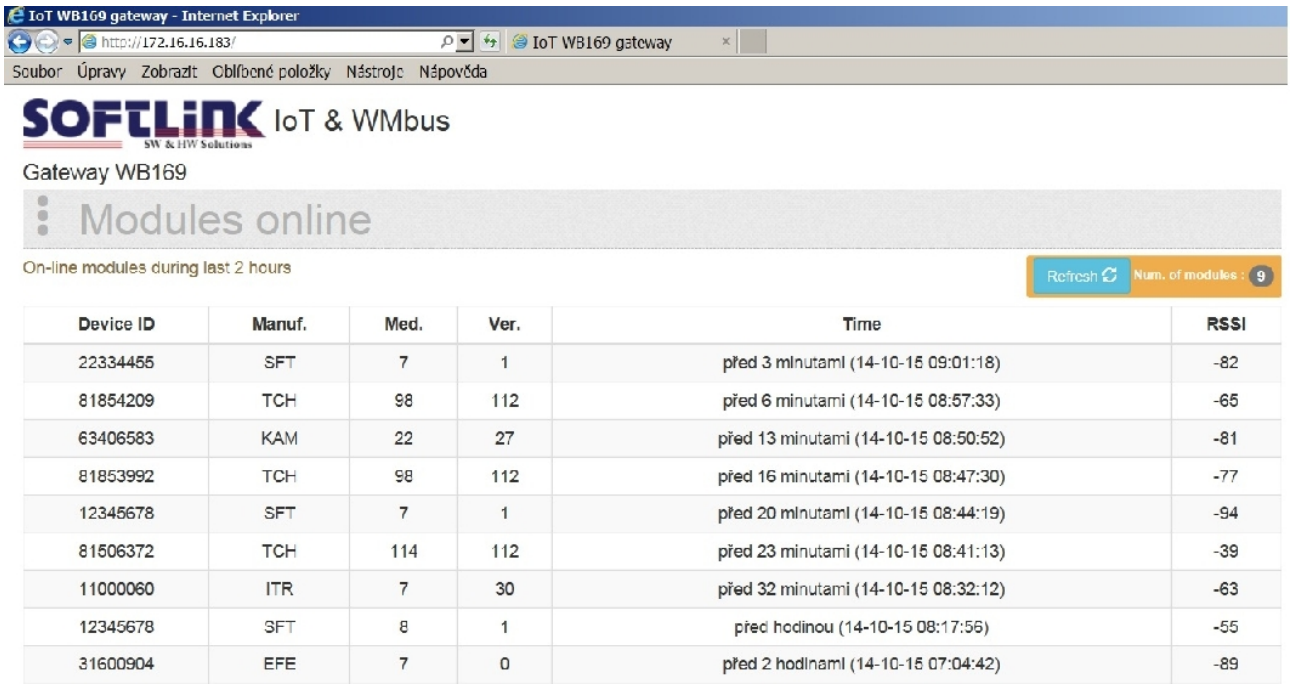
After putting the module into operation (or after each repair and replacing of the module) it is recommended to check functionality of its broadcasting with using of common „Master" receiver, testing (reference) receiver, signal analyzer or any other convenient device.

If the WB169-SI2 module is connected to remote data collecting system with using of WB169-RFE gateway, functionality of its broadcasting could be checked from any computer in **„Radar" mode** by presence of module's signal in the „Radar" application. Open any WEB browser in the computer and enter IP-address of the module's superior WB169-RFE gateway. URL address of the gateway should be entered in „**http://ip_adresa/**" form and search should be started after that. If an IP-connectivity between the computer and gateway is available, the website of „Radar" application opens (see figure 20), where there is a table with last reports from all devices broadcasting in the area of the gateway radio receiving (that work on the same frequency and with same communication mode).

The record of each device registered by gateway is displayed in a separate line where the following data can be seen:

- equipment identification
- receiving time of the last report from the equipment
- indication of radio signal quality of received message (RSSI = Received Signal Strength Indicator)

If the „Radar" table is displayed in a sufficiently long time since the WB169-SI2 module was putting into operation (or since its rebooting), the table should contain reports from meters and sensors connected to the module, including the evaluation of the receiving quality. The „Radar" table displays only records received during last 2 hours.



Device ID	Manuf.	Med.	Ver.	Time	RSSI
22334455	SFT	7	1	před 3 minutami (14-10-15 09:01:18)	-82
81854209	TCH	98	112	před 6 minutami (14-10-15 08:57:33)	-65
63406583	KAM	22	27	před 13 minutami (14-10-15 08:50:52)	-81
81853992	TCH	98	112	před 16 minutami (14-10-15 08:47:30)	-77
12345678	SFT	7	1	před 20 minutami (14-10-15 08:44:19)	-94
81506372	TCH	114	112	před 23 minutami (14-10-15 08:41:13)	-39
11000060	ITR	7	30	před 32 minutami (14-10-15 08:32:12)	-63
12345678	SFT	8	1	před hodinou (14-10-15 08:17:56)	-55
31600904	EFE	7	0	před 2 hodinami (14-10-15 07:04:42)	-89

Figure 20: Example of „Radar" application table

4.9 Operation of the WB169-SI2 module

The WB169-SI2 module performs broadcasting of radio messages fully automatically. Take into consideration that the broadcasting systems according to the Wireless M-BUS standard has no protection against interference during transmission (a signal collision, which occurs when two modules broadcast at the same time), so that temporary loss of data from some modules can commonly occur in case of operating of a large number of modules in one radio network. These losses can last for several hours or days.

The greatest risks of permanent breakdown of module broadcasting are commonly caused by human activities within the installation. It is mainly about the following risks:

- temporary or permanent shading of the antenna (e.g. due to building operations);
- mechanical damage of the module, the antenna cable or the antenna when handling things at the installation site.

To eliminate these risks, it is recommended to pay close attention to selection of the installation site and choice of antenna and antenna location so that to find appropriate compromise between qualities of signal and the level of risk of mechanical damage of the module or antenna. It is necessary to carry out the installation carefully with using of high-quality cables and mounting components.

To prevent an unexpected breakdown, it is recommended to perform regular monitoring of all broadcasting data, i.e. readings, processor temperature and battery voltage. If some of the parameters goes beyond the common steady value, it is recommended to contact the installation site caretaker and ask for the potential cause of the anomaly or perform the physical check on the installation site.

4.10 Using of WB169-SI2 module for remote monitoring of sensors

The WB169-SI2 module can be used also for remote monitoring of any two-state sensors with either isolated contact (e.g. mechanical contact, relay, reed contact...), or solid-state relay, or open collector types of outputs. It is not possible to connect a sensor with its own source of voltage on its output. Convenient types of sensors are displayed in the Figure 21.

When using of sensor with „open collector" output (see „optocoupler" in the Figure 21 left), it is necessary to observe its +/- polarity as marked on the module's and sensor's labels. When using of sensors with solid state relay output (see Figure 21 in the middle), or with isolated contact (see Figure 21 right), the polarity is usually not important.

Sensor output should be connected to the module's input clamps same way, as consumption meter. It is recommended to use shielded cable with minimum length.

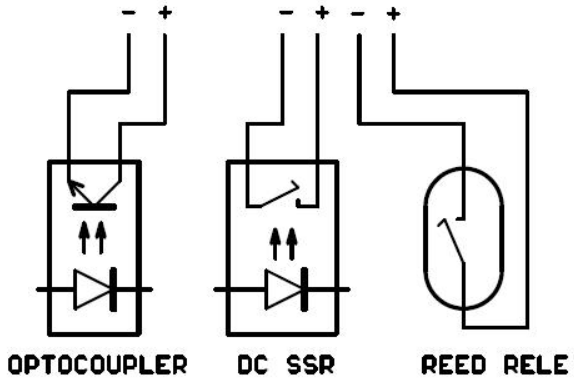


Figure 21: Types of sensor outputs convenient for WB169-SI2 module

Setting of sensor input is described in detail in paragraph 3.1.9 „Setting of sensor inputs". Before setting it is necessary to realize, in which state the sensor output is switched off, and in which state it is switched on, and which status should be propagated as „alarm message". If, as an example, the monitored sensor is a security loop (electronic seal - see Figure refimg:sensor-seal), it is clear, that in „normal" status the contact is switched on, because the contact head is coupled with magnet segment. In this case the primary cause of alarm status should be opening of security loop that causes detachment of contact head from magnet and releasing of reed contact inside the head. Releasing of contact is detected as rising edge ("0-to-1" transition) so that the alarm mode should be set to "2" ("rising") value. If the loop (or cable) is torn, the result would be the same.

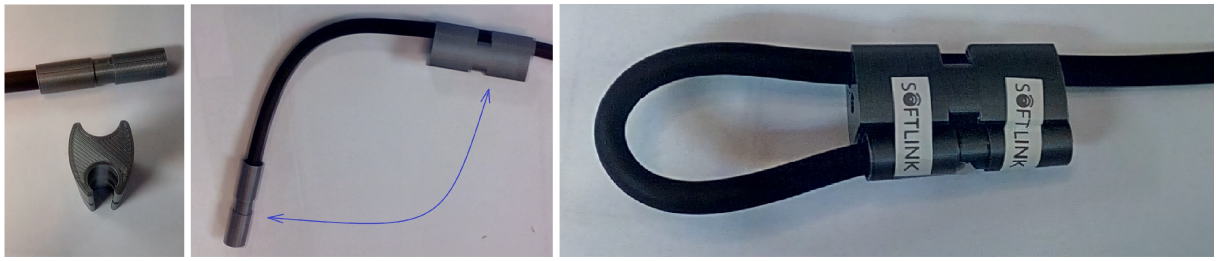


Figure 22: Principle of „electronic seal" sensor

If the subject of monitoring is opening of doors with using of position sensor. (see Figure 23), setting of alarm mode depends on the manner how the sensor was mounted on the door (whether contact head is coupled with magnet when the door is open, or when the door is closed).

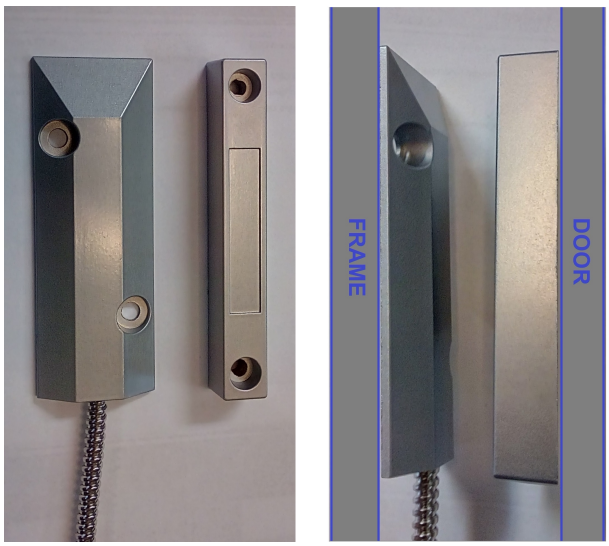


Figure 23: Using of position sensor for door monitoring

5 Troubleshooting

5.1 Possible causes of module failures

If during operation of WB169-SI2 module some anomaly, malfunctions or other troubles are recognized, the possible causes of the failures can be classified by following categories:

5.1.1 Power supplying failures

The module is supplied by electrical power from the long-life internal battery. Approximate battery life is specified in paragraph 1.2 „Modul usage". Battery life can be negatively influenced by circumstances that are described in detail in paragraph 4.0.2 „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.

5.1.2 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 4.6 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.

5.1.3 Transmitter and receiver failures

Transmitting of messages is signaled by flashing of red "TXA" LED on the module's printed circuit board. Flashing of LED during broadcasting can be observed through the transparent casing of the module.

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, when there are repetitive breakdowns in reception data from the module or occasional malfunctions of back channel (if implemented).

The ground of all above described troubles with communication could be unreliable radio-communication caused by one of these reasons:

- incorrect setting of transmitter parameters, mainly frequency channel, mode, 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 externel source (another radio system in the same frequency band, or industrial disturbance);
- low level of transmitting power caused by wrong setting or by failure of transmitter;
- failure of receiver that causes malfunction of back channel;
- 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 3.1.11 and perform the check of module overall functionality as described in paragraph 4.8;
- replace the module according to the paragraph 4.6 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.).

5.1.4 Failures of communication with meters

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

1. Visually check the meter and connecting cable between meter and radio-module, especially whether the meter's pulse generator is correctly mounted on the meter (if it is removable) and whether the meter or cable are not damaged;
2. in case of any doubt check the functionality of cable connection by ohm-meter. If there is a problem with reliability of the connection, or the cable is evidently damaged, replace the cable immediately;
3. check whether the cable is correctly associated with the module input (correct port number, correctness of polarity - if required by meter producer);
4. Visually check if there are not placed any objects or devices radiating a magnetic field (for example a device for water treatment with magnet, electrical installation...) around the consumption meter. The pulse generators of some types of the consumption meters are very sensitive to the magnetic field presence. If such devise is detected, it must be removed or there must be taken necessary measures to eliminate the magnetic field influence on the pulse generator of the consumption meter. To find more about the influence of the magnetic field on a particular consumption meter, you must follow its manufacturer instructions;
5. if there is some possibility of measuring metering pulses, make sure that the meter generates the pulses properly and that these pulses lead up entirely to the radio module input;
6. correctness of generating and transfer of metering pulses can be alternatively checked by short-circuiting of the cable on the meter side. If after each short-circuit the status value of the module's counter goes up, the module and cable are probably correct, and the trouble is probable caused by meter or by its pulse generator;
7. if the module doesn't read the data even the metering pulses are provably brought to the correct radio module input, check the pulse counter parameter settings (counter mode, trigger edge) according to the paragraph 3.1.6 „Internal Counter Setting Commands". In case the setting is correct, the problem is the most probably in the malfunction of the radio module. Replace the module following the instructions in the paragraph 4.6.

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

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

1. visually check the sensor and connecting cable between sensor and radio-module for any damage;

2. check whether the cable is correctly associated with the module input (correct port number, correctness of polarity - if required by sensor producer);
3. visually check if there are not placed any objects or devices around the sensor that can influence its functioning;
4. check correctness of the sensor input by short-circuiting of the cable on the sensor side. If after each short-circuit the value of the module's counter changes, the module and cable are probably correct, and the trouble is with high probability caused by sensor;
5. if the module doesn't register the changes of sensor status even though the changes are provably brought to the correct radio module input, check the counter parameter settings (counter mode, trigger edge) according to the paragraph 3.1.6 „Internal Counter Setting Commands". In case the setting is correct, the problem is the most probably in the malfunction of the radio module. Replace the module following the instructions in the paragraph 4.6.

5.2 Troubleshooting procedure

To identify a reason of device failure or any anomaly in its operation follow this procedure:

1. No data are available from all meters/sensors connected to the WB169-SI2 module. In this case it is recommended to check functionality of the module subsystems in following order:
   - check functionality of power supplying as described in the paragraph 5.1.1 „Power supplying failures"
   - check functionality of the system as described in the paragraph 5.1.2 „System failures"
   - check functionality of the transmitting and receiving of the radio-signal as described in the paragraph 5.1.3 „Transmitter and receiver failures"
   - check functionality of correct reading of pulse/sensor signals on the module inputs as described in the paragraph 5.1.4 „Failures of communication with meters"
2. No data are available from only one meter/sensor connected to the WB169-SI2 module. In this case it is recommended to check functionality of the module subsystems in following order:
   - check functionality of the meter/sensor
   - check correctness of central application configuration related to the meter/sensor, especially correctness of its ID, address and association of the meter/sensor with right port of reading module
   - check functionality of receiving pulse signals on the module's input as described in paragraph 5.1.4 „Failures of communication with meters"

NOTE: WB169-SI2 module is a reliable device with relatively simple and resilient construction, so that any possible failure of the device is very likely caused by external circumstances, especially installation environment, mechanical damage, excessive humidity, discharging of internal battery, or voltage pulses induced to the input cables. After each replacement of the module caused by its failure it is recommended to check the root cause of the failure and take necessary measures to eliminate any persisting troubles.

6 Additional information

This manual is focused on description, parameters and configuration options of radio modules WB169-SI2, operating according to the Wireless M-BUS standard (EN 13757-3 / EN 13757-4 recommendation) for the 169 MHz band, that are a part of the Softlink's **wacoSystem** product family. More information about all WB169 (Wireless M-BUS), WM868 (WACO), 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 WB169, WM868, WS868, 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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