WIRELESS COMMUNICATION SYSTEM
NB-IoT

NB-PLE

Revision 1.0

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1 Introduction

This document describes features, parameters and setting possibilities of the NB-PLE module, which is used for reading of Elster BK-G series gas-meters and for radio-broadcasting of the data from the gas-meter to the superior remote reading system via NB-IoT services of GSM operator.

1.1 NB-IoT mobile data services

Mobile data services NB-IoT are global data services provided by some operators of GSM services. The services are focused on the communication with a huge quantity of devices, that transfer only an extremely limited volume of data. Networks with such purpose and features are commonly labeled as „Internet of Things", or by its acronym "IoT". NB-IoT ("Narrow Band Internet of Things") is an open standard developed by 3GPP organization (3rd Generation Partnership Project) which is concerned with standardization in the GSM network development. NB-IoT is a cellular technology based on the LTE, that was developed specially for wireless communication with terminals of IoT category, that produces only limited volume of data, but they are miniature, inexpensive, with a very low energy consumption and they are commonly installed in the places with high demands on the signal coverage. Typical example of such device is a reading module of the water/gas/electro-meter installed in the basement without electricity, that should be able to run reliably many years on the internal battery even in weak signal conditions, where other services fail.

NB-IoT technology maximally utilizes technological infrastructure of LTE data services in licensed radio band. Combination of narrow frequency band and the most advanced modulation techniques enable increasing of receiver sensibility to the -135 dBm level, so that an existing infrastructure of mobile operator provides global coverage with high signal penetration even in build-up urban areas. Thus, the service is available in the places, where IoT category devices are typically installed - in shafts, distribution boards and cellars.

Terminal devices are identified in the network by standard SIM of GSM operator. Global system of SIM evidence and single communication standard enable providing of international services (roaming). Bi-directional communication is carried by standard Internet protocol with UDP transport layer. Messages are transferred from the GSM operator network to the IoT-terminal operator through the designated data gateway (Access Point - AP) either to public Internet, or to operator's private IP network (i.e. same way as any similar mobile data services). Addressing and routing details depend on the network configuration and policy of particular GSM operator. Typical example of addressing and routing is a solution, when the GSM network automatically assigns private IP addresses to IoT terminals, IP-packets with messages are routed through the private IP network to a single Access Point, where they are re-addressed and resend through a single pre-arranged public IP-address to the public Internet. The IoT terminal assigns packets by target server public IP-address, that is preset in its configuration. Target system can identify original source of the message by using of device unique identifier (IMEI), which is a requisite part of the message content.

1.2 Module usage

The NB-PLE module can be used for remote reading of Elster BK-G series residential gas-meters that are equipped with special slot („lock") for external remote reading modules (e.g. IN-Z61) in the lower side of its counter. The module is equipped with one magnetic sensor for registration of gas-meter counter revolution, and (on the special order) it could be equipped with a sensor for detection of detachment from gas-meter („Tamper"). The module continuously registers revolving of gas-meter pivotal wheel into its internal counter and broadcasts info-messages with the status of gas-meter counter and tamper in form of radio-messages of NB-IoT service provided by GSM operator (hereinafter „INFO-message").

Content of INFO-messages is configurable, it could contain current statuses of connected meters/sensors, current statuses of embedded temperature/humidity sensors, as well as previously measured "historical" readings stored in the module memory. One message can contain **up to 24 historical readings**. Each message always carries identification and operational data of the module (processor temperature, battery voltage, signal strength information).

These messages are handed over to the application server with using of NB-IoT service of GSM provider. The data are transferred in form of standard IP/UDP packets, that are routed to the server of remote reading application operator through the designated Access Point of GSM provider. Application server receives the messages and performs their decoding, storing and further processing.

The NB-PLE module supports **bi-directional communication** and it is able to receive through the network messages of "SET" type, generated by remote computer. These messages can be used for setting of module parameters from the remote server.

1.3 Hardware features and power supplying

The module is enclosed in plastic casing designed for mounting directly to the Elster BK-G series gas-meter counter slot reserved for remote reading modules. The device is not suitable for using in exteriors without additional protection.

The module is power supplied by internal battery with up to 10 years lifetime for frequency of two broadcastings per day (one message can contain up to 24 readings). Battery lifetime can be negatively influenced by shorter broadcasting period, or by storing and operation in sites with the temperatures exceeding the recommended range.

The module is equipped with an embedded SIM (eSIM) of chosen GSM operator (as per the customer demand).

The module can be controlled and configured either by configuration cable, or wirelessly - by infra-red remote control with using of optical converter. To make configuration by optical converter easier, the module is equipped with the special circular aperture ("peephole") for magnetic fixing of the converter.

The module can be configured also remotely, with using of back channel of bi-directional communication.

External appearance of the NB-PLE module is shown in the figure 1.

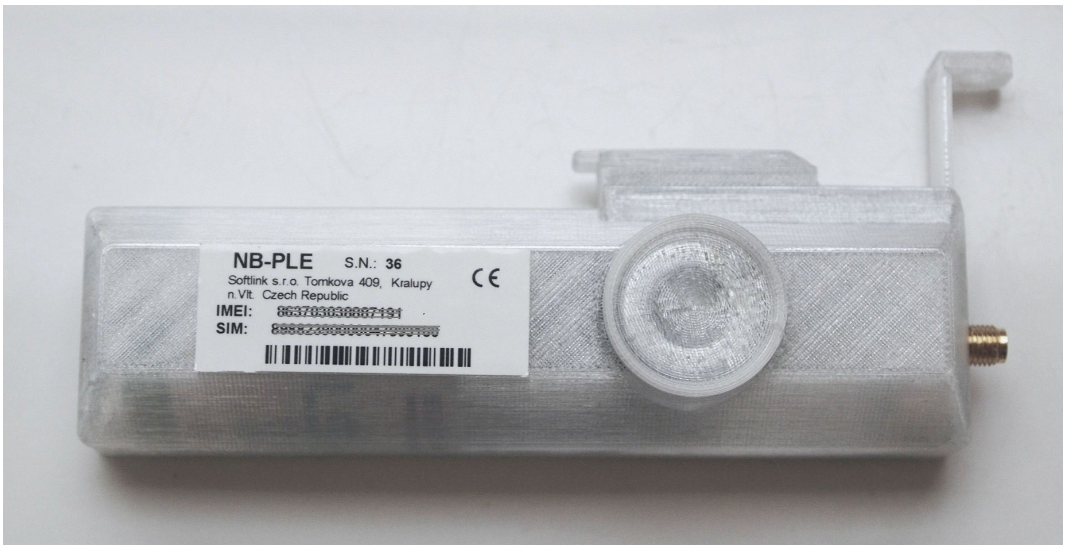


Figure 1: View of the NB-PLE module

2 Technical parameters overview

Overview of NB-PLE module technical parameters is shown in the Table1 below.

Table 1: Overview of NB-PLE module technical parameters

RF subsystem parameters		
Frequency band 800 MHz (RX/TX)	791-821 / 832-862	MHz
Frequency band 850 MHz (RX/TX)	869-894 / 824-849	MHz
Frequency band 900 MHz (RX/TX)	925-960 / 880-915	MHz
Modulation	GMSK, 8PSK	(adaptive)
Bandwidth	180	KHz
Transmitting power	200	mW
Receiver sensitivity	135	dBm
Communication protocol	NB IoT	(bi-directional)
Transmission speed	0,35 ÷ 240	Kbps (adaptive)
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 band	870	nm
Optical interface specification	IrPHY 1.4 standard	
Inputs		
Magnetic sensor of pivotal wheel revolving	index ”0”	
„Tamper” sensor	index ”1”	
Power supplying		
Lithium battery voltage	3.6	V
Lithium battery capacity	5.8	Ah
Weight and dimensions		
Length (w/o antenna connector)	84	mm
Width (w/o sealing protrusion)	40	mm
Height	29	mm
Weight	cca 70	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	IP20	

3 Configuration of the NB-PLE module

Configuration parameters of the NB-PLE 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 NB-PLE 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 „IRDA" converter".

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

3.1 Setting of NB-PLE module parameters by configuration cable

In following part of the document there is a description of these parameters of the NB-PLE module, that can be displayed and examined from PC connected to the module by configuration cable. Some of the parameters can be changed by configuration commands entered „from the console".

3.1.1 List of NB-PLE module configuration parameters and commands

List of all configuration parameters of the module 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
 Server IP : '92.89.162.105'
 Server port : 4242
 Reply to server : no
 My src port : 2000
 APN : '' "
Max session time 172800 sec - 2d, 0:00:00
  Input[0] ,multiplier 1,divider 1,mode falling, quick, alr:none,
   Leak detection periode 12 hour(s), zero periode 30 minutes
  Input[1] ,multiplier 1,divider 1,mode falling, quick, alr:none
Send periode : 120 min.
 Hist. periode : 15 min.
   in message 8 records, max. is 24 recs
 Send mask is 1 : I1

 Data will be unencrypted
 Next send : 88 min.
  No. sent : 11 msg(s)
  No. recv : 0 msg(s)

-- Modem status --
Modem state : 0
Session count : 1
Session timeout : 172796 sec - 1d, 23:59:56
Modem IMEI : 863703038894247
  SIM CCID : 89882390000037252304
  SIM IMSI : 901288001028645
 Last RSSI : -61 dBm

 Conf. version : 12
 SW version 1.07, date May 27 2020
mon#
```

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

```
mon#?
 Help :
 --- System commands ---
deb               : Show or set debug level
ta                : Show tasks
mb                : Show mail boxes
du addr           : Dump memmory
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 configation and load defaults
 --- Inputs ---
val               : Show or set counters values[0-1]
mul               : Set multiplier of value[0-1]
div               : Set divider of value[0-1]
det               : Detection 0 - falling, 1 - rising
dmode             : 0 - quick, 1 - slow
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)
 --- Utils ---
ekey              : Set encrypt key, point '.' no encrypt
periode           : Send periode 0 - disable, >0 periode in minutes
sendp             : Send x NB messages
send              : Send data
smask             : Send mask bits, 0 - I1, 1 - I2, 2 - temp. 3 - hum. ,default 3 - I1 and I2
hist              : History periode 0 - disable, >0 periode in minutes
hdata             : Show history data
server            : Server IP address
sport             : Server UDP port
sreply            : Send reply to server
apn               : Access Point Name
sess              : Set max session time in minutes
tshort            : Set modem short timeout
tlong             : Set modem long timeout
tconn             : Set modem connetion timeout
info              : Show or set manuf. info string (0-30 chars)
tz                : Time offset in hours
ppm               : Set RTC ppm
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
reset             : Reset device
at                : Test modem
?                 : Show this help
mon#
```

Overview of configuration parameters with short description of their meaning can be also found in table 2 on the page 24. The meaning of individual parameters and detailed description of their usage can be found in the following part of chapter 3.1.

3.1.2 „System commands" group for control of module basic functions

This group of commands enables control of basic functions of the module. There are following commands:

reset	*command for module reset*
send	*immediate sending of radio message*
sendp	*immediate sending of series of messages*
sens	*show current values of internal sensors (temperature, voltage..)*
uptime	*show system uptime from last reset*
info	*setting of individual module description*

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 3.1.3). 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 ..
mon#
```

The command **"send"** can be used for immediate („out of turn") transmitting of the standard information message with measured values. This command can be used for checking of radio signal availability during the system installation, or for any adjustments and testing of the module. 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. Example:

```
cfg#send
Sending ...
send [1] msg 255
mon#
```

The command **"sendp"** can be used for immediate transmitting of series of standard messages with 1-minute interval. This command can be used for checking of radio signal availability during the system installation. It could enable checking of connection also after closing of mounting rack, or after leaving of watemeter shaft. Number of transmitted messages is set by parameter (number) after command, the first message is transmitted immediately after command. Example of sending of series of 5 messages:

```
cfg#sendp 5
sending 5 msgs
mon#
```

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 : 3.003 V
VBAT : 3.561 V
Sensor type 0
mon#
```

The **"uptime"** parameter value shows the time interval passed from the last device reset in seconds so that the exact moment of the last module reset can be recognized by this parameter. The parameter is of „read only" type. Example:

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

The **"info"** command can be used for setting of individual description/label of the module. Up to 30 alphanumeric characters can be entered. The label will be displayed in the „Info text" field of the optical configuration form. The label can contain any identification data (installation site code, customer code, meter serial number. Example of module individual text setting:

```
cfg#info NB-X 123456
Change manuf info from :  ''  to :  'NB-X 123456'
mon#
```

3.1.3 „Configuration" group of commands for writing of configuration

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 into FLASH memory (after finishing a work the 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 FLASH.

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 13
mon#
```

Reading of the configuration from FLASH memory can be done by using of **"cread"** command:

```
cfg#cread
Reading config ...  OK, version 13
mon#
```

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

```
cfg#clear
Clearing config ...  OK, version 13
mon#
```

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 consultation with the manufacturer.

3.1.4 „System commands" group for general diagnostics

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

3.1.5 „Inputs" group parameters

This group of parameters and commands enables setting of gas-meter counter revolution register and (as an option) for setting of „tamper" function.

The NB-PLE module is equipped with two inputs (port 1 and 2), that are connected to the corresponding registers (index 0 and 1). The first register serves for registration of gas-meter counter revolution, its value goes up one unit with every turn of measuring (scanned) wheel of counter. Second register is not used for standard module modification (without „tamper" function) and its setting is not needed. For the special module modifications with integrated „tamper" function the second input is used as a register of tamper status. Detailed description of „tamper" setting can be found in the separate paragraph 3.1.6 below.

Below listed commands are used for settings of the initial counter value, multiplier, and divisor, that can be used for adjusting of the output status to required value and for setting of special function „leak" and „burst" for detecting of anomalies in the course of consumption (see detailed description in the paragraph 3.1.7 and 3.1.8).

Setting of counters 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)*
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)*
alr[index]	*setting of alarm mode (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)*

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 turn of gas-meter scanned wheel. 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" that suits for the relation (ratio) of one turn of scanned wheel for 1 m^3 of consumed gas. If there is a different ratio, it is necessary to adjust the counter value by 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#
```

The **„det[index]"** and **„dmode[index]"** commands are intended for setting of trigger edge and smoothening (equalizing) filter of the counter. Both parameters are preset to optimal values and it is not recommended to change them needlessly.

3.1.6 Description and setting of „Tamper" function

If the gas-meter is equipped with the system for detection of detachment of reading module from gas-meter („Tamper") on the magnetic principle, the NB-PLE module can be fitted by magnetic tamper sensor. Such modification of the module must be tested and adjusted by producer in advance and ordered separately. In this modification the second register serves as tamper register and must be switched by **alr[index]** command into the alarm mode. In this mode the counter only changes its status (goes from "0" to "1" or vice versa) after each change of input and the module transmits the message immediately with the change of status.

In factory setting the alarm mode is switched off, value of "alr" parameter is "0". Second register can be switched on for the second port by setting of „alr[1]" parameter to the 1, 2 or 3 value. If **"1"** value is entered, the module generates alarm after connecting module with the meter, if **"2"** value is entered, the module generates alarm after the module is disconnected (detached) from the meter. If **"3"** value is entered, the module generates alarm in both transitions (e.g. when the module is attached to the meter as well as when it is detached).

Example of setting of tamper counter (index "1") to "2" value, where the module reports detachment of reading module from gas-meter, and follow-up checking of settings of both ports:

```
cfg#alr1 2
Alr[1] = 2 - rising
cfg#alr
Alr[0] = 0 - none
Alr[1] = 2 - rising
cfg#
```

Checking of both ports status can be performed by using of "alr" command without index. As shown in the example, gas-meter status counter has alarm mode switched off, while the tamper counter is set to "2" value, when the module reports detachment from the meter.

3.1.7 Description and setting of „Leak" alarm function

„Leak" function is used for detection of such situations in the gas consumption, 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 meter measuring wheel), 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 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 the meter generates one metering pulse for 0,1 m^3 of gas, minor leak could become evident even after several hours, when such quantity will leak).

„Leak" function principle is shown in the figure 2. 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 2). 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 2).

„Leak" function can be activated for gas-meter status 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.

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#
```

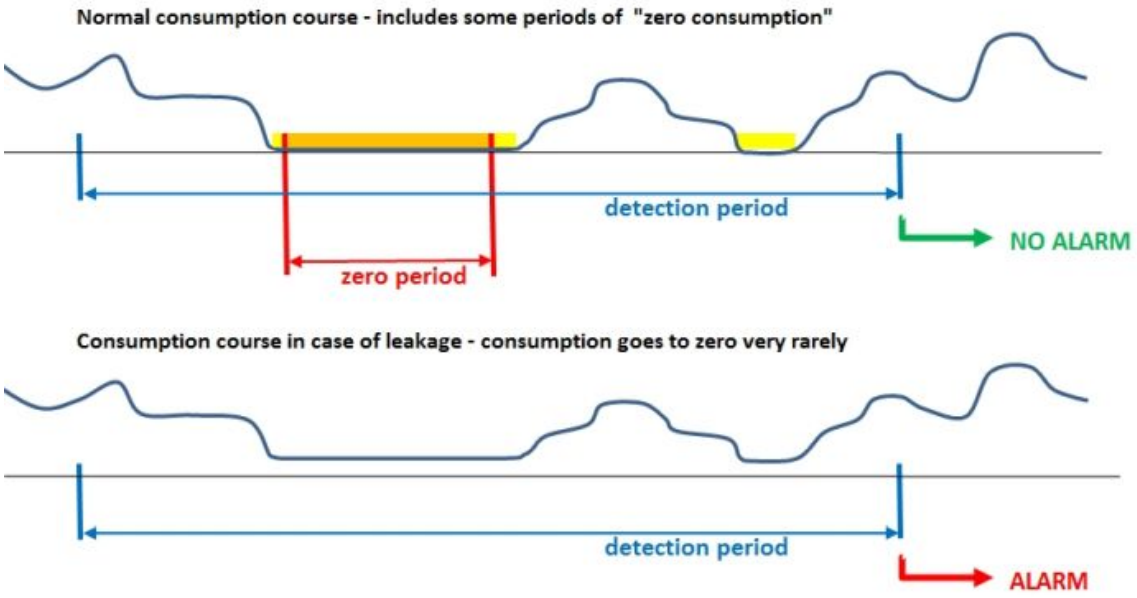


Figure 2: „Leak" alarm function principle

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 gas-meter status counter (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:

```
Input[0] ,multiplier 10 ,divider 1 ,mode falling, quick, alr: none
  Leak detection periode 24 hour(s), zero periode 90 minutes
```

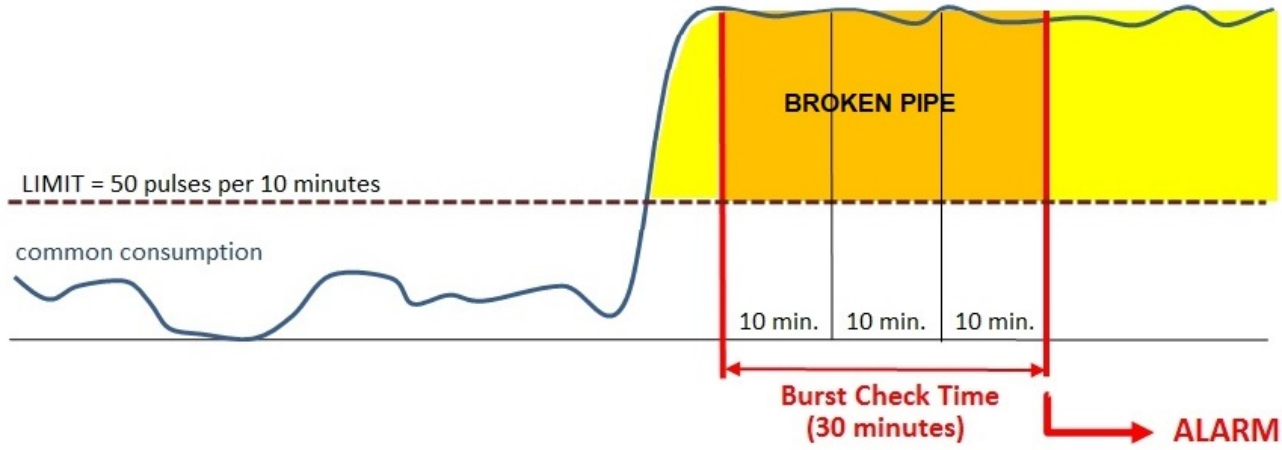
Structure of alarm message of „LEAK" type is described in the paragraph „Description of TRAP type message".

3.1.8 Description and setting of „Burst" alarm function

„Burst" function is used for detection of such situations in the gas consumption, when the burst consumption caused by broken pipe (or similar fatal failure of distribution system) occurs. If the consumption of gas is abnormally huge for some period of time, the module transmits to superior system „Broken Pipe" alarm message.

„Burst" function principle is shown in the figure 3.. „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 „Broken pipe" alarm.

In view of the fact that different gas-meters connected to the module could have different conversion rate of volume per one turn of measuring wheel, consumption limit is delimited universally as **number of registered pulses per 10 minutes time period**. Conversion table between the number of measuring wheel turns per 10 minutes' and consumption per minute for frequently used conversion rates is available in the figure 4.



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 3: „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 4: Conversion table between "LIMIT" value and corresponding minute flow

Burst" function can be activated for gas-meter status port (index "0") by using of **burstp[index]** command that defines required consumption limit in number of measuring wheel turns („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", „Burst" function is deactivated.

Example of setting **„LIMIT"** parameter for gas-meter status port (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 gas-meter status port (index "0") to 40 minutes value:

```
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, 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 („show" command), in the section of the first port:

```
Input[0] ,multiplier 1 ,divider 1 ,mode falling, quick, alr: none
  Broken pipe min. 15 pulse/10 min. during 40 minutes
```

Structure of alarm message of „BURST" type is described in the paragraph „Description of TRAP type message".

3.1.9 Commands for message content setting

This group of commands serves for setting of content of NB-PLE module information message. There are following commands:

smask	*setting of content (selection of transferred information)*
hist	*historical readings storing period*
hdata	*displaying records in memory of historical readings*

The **"smask"** command can be used for setting of information message content. Message structure is described in "mask" table (see figure 5), 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, Input 1 and Input 2) put together four-bit binary number. Decimal form of this number can be used as "smask" command parameter.

Mask	Humidity	Temperature	Input 1	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 5: Table for selection of message content („mask")

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
mon#
```

As it is clear from the example, in the messages with mask number "3" there will be transferred only values of both counters (gas-meter counter status and tamper).

As NB-IoT services are typically charged per volume of transferred data, it is important to set appropriate message structure, that transfers only data that are really useful. If, as an example, the module is not equipped by tamper sensor, it is senseless to transfer status of second counter in each message. Standard modification of NB-PLE module is not equipped by humidity and temperature sensors, thus it has no sense transferring these values either.

Due to decreasing of broadcasting frequency (saving of battery lifetime) the module enables transfer of higher number of before read values in one message. In this case the message does not contain current values of meters, but it contains an array of previously performed readings, that were stored in module internal memory (hereinafter „historical readings"). Each set of historical readings is accompanied by the time of reading („timestamp") and this timestamp is also transferred to the central system. Memory volume enables storing **up to 24 historical readings**. Historical readings are stored into the memory with adjustable period, that should be proportionate to broadcasting period so as the message would contain no more than 24 historical readings. Memory of historical readings is cleared out after each message transmission

Example: *If broadcasting period is set to 240 minutes (4 hours) and historical readings storing period is set to 30 minutes, there will be 240/30 = 8 readings that will be stored during whole broadcasting period. In this case the transmitted message will contain an array of 8 historical readings.*

Current setting of historical readings will display in the configuration statement as follows:

```
Send periode : 60 min.
 Hist. periode : 10 min.
   in message 6 records, max. is 24 recs
 Send mask is 3 : I1, I2
```

It is clear from the abstract, that broadcasting period is 60 minutes, historical readings are stored every 10 minutes and each message contains only 6 historical readings.

The **historical readings storing period** can be preset by using of **"hist"** command followed by parameter. The parameter is required number of minutes. Allowed values of the parameter are 10, 15, 30 and 60 minutes (if other value entered, system will store nearest value). If the parameter is set to "0" (default setting), no historical readings are stored and only current values are transferred.

Example of setting of historical readings storing period to 30 minutes value:

```
cfg#hist 30
History changed from 0 to 30 min.
cfg#
```

The **"hdata"** command can be used for displaying of currently stored historical readings. Example:

```
cfg#hdata
History data :
2018-01-04, 13:30:00+01
 I1 : 1233
 I2 : 7
2018-01-04, 13:40:00+01
 I1 : 1249
 I2 : 7
2018-01-04, 13:50:00+01
 I1 : 1251
 I2 : 7
cfg#
```

As seen in the example, from last message transmitting there are three sets of historical readings stored in the memory.

3.1.10 Commands for setting of message broadcasting system

This group of commands enables setting of system for radio-broadcasting of the information messages. There are following commands:

ekey	*setting of encryption key ("." - encryption disabled)*
periode	*setting of regular messages broadcasting period*
server	*setting of target server IP-address*
sport	*setting of target server port number*
sreply	*redirection of replies to target server*
apn	*setting of private network Access Point Name (APN)*
sess	*maximum session time*
tconn	*connection setup timeout*
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)*

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 encryption 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 paragraph 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 .*

„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 (theoretically up to 65535 minutes) after „periode" command.

Example of displaying, and setting of broadcasting period:

```
cfg#periode
Periode is 60 min.
cfg#periode 120
Periode changed from 60 min. to 120 min.
cfg#
```

The module broadcasts messages wrapped into UDP packets of Internet Protocol to the pre-configured **target server**, where the remote reading application is running. Following commands are intended for setting of **target server IP-address and target application port number** and for setting of the **name of communication gateway** between the GSM operator network and Internet (so called "APN" = Access Point Name).

IP-address of target server can be pre-configured by using of **"server"** command. The address can be entered in commonly used decimal format.

Example of setting of the target server IP address to "92.89.162.105" value and follow-up checking of the setting:

```
cfg#server 92.89.162.105
Server changed from '0.0.0.0' to '92.89.162.105'
cfg#
cfg#server
Server is : '92.89.162.105'
cfg#
```

Number of UDP port can be pre-configured by using of **"sport"** command. The UDP port number should correspond with the remote reading application port number. Example of setting of UDP port number to value "2000" and follow-up checking of the setting:

```
cfg#sport 2000
UDP port changed from 0 to 2000
cfg#sport
UDP port : 2000
cfg#
```

The **"sreply"** command can be used for specification of **back channel communication** settings (see paragraph 3.3 „Setting of module parameters from remote computer by using of back channel"). In some NB-IoT networks/services

there is possible to send back channel messages only from different IP address, than preset standard IP address of target server used for sending of INFO messages. If the setting is "Reply to server : no", the module reply to back channel requests regularly - that means send answers to the address from which the request came. If the setting is "Reply to server : yes", the module always replies to the preset IP address of target server (see "server" command setting). For setting "yes" use "1" parameter, for setting "no" use "0" parameter of the command.

Example of setting back channel communication and follow-up checking of the setting:

```
cfg#sreply
Reply to server : no
cfg#sreply 1
Reply to server : yes
cfg#
```

If the GSM operator providing NB-IOT services transfers data from the modules to the IoT service provider through the virtual network, the **name of the communication gateway** between GSM and Internet (Access Point Name - APN) should be entered to the module configuration by using of **"apn"** command. APN is assigned by GSM operator. Setting of APN can be deleted by entering of "." value (dot).

Example of setting of APN-name to "cms.softlink" value:

```
cfg#apn cms.softlink
APN changed from '' to 'cms.softlink'
cfg#apn
APN is : 'cms.softlink'
cfg#
```

Current setting of target server and communication gateway displays in the configuration summary as follows:

```
 Server IP : '92.89.162.105'
 Server port : 2000
 My src port : 2000
 APN :  'cms.softlink'
```

The "My src port" value is a number of module UDP port. This value is read only and cannot be changed.

By using of **"sess"** command the **maximum session time** with GSM network server can be set. The timeout should be set in minutes. As some operators charge each creating of session, setting of session before each transmitting of message could significantly increase service expenses (and it also increases broadcasting time). On the other hand, if the network server interrupts (loses) session, the module is not notified about it and all broadcasted messages after that moment are lost. By setting of "sess" parameter the session time is limited and after that limit the module closes pending session and sets up new one with broadcasting of next message. Factory setting of this parameter is **two days** (172800 seconds, 2880 minutes), what is reasonable compromise between expenses and reliability of message delivery. If GS operator does not charge each session, the parameter can be set to lower value (even to zero, when the session is set-up before each broadcasting), but it is recommended to keep factory setting always in this situation because creating of session increases broadcasting time.

Current setting of maximum session time appears in the in the configuration summary as follows:

```
Max session time 172800 sec - 2d, 0:00:00
```

Example of setting of maximum session time to 2880 minutes:

```
cfg#sess 2880
Max session time : 2880 min.
cfg#
```

By using of **"tconn"** command the **connection setup timeout** can be set. If the GSM network server does not react on the module's session setup request, the GSM sub-module is switched to idle mode and next attempt of session setup is performed before next broadcasting. Factory setting of this parameter is **5 minutes** (300 seconds). It is recommended to change this parameter only if the GSM operator guarantees significantly different response of its network.

Example of changing of connection setup timeout from 200 to 300 seconds (5 minutes):

```
mon#tconn
Connection timeout is 200 sec
mon#tconn 300
Connection timeout is 300 sec
cfg#
```

Both above described parameters ("sess" and "tconn") have significant influence on the energy consumption and ***battery lifetime****. If, as an example, the module sets up connection before each broadcasting, it increases broadcasting period when the GSM sub-module is in active mode and consumes lots of energy. If the connection setup timeout is too long, the internal modem is pointlessly active during waiting for connection setup. From this point of view the best solution is setting of long "sess" time and short "tconn" time. But such setting could* ***decrease the reliability of message delivery****, because in case of session interruption on the network side all the messages are lost until expiration of "sess" timeout, and too short "tconn" timeout can cause that the module did not manage to setup session and the message is not transmitted. Setting of both parameters should be reasonable compromise between energy consumption and reliability of message delivery.*

As the NB-PLE module can broadcast not only current values, but also „historical" values from internal memory, its internal timer Real Time Clock (RTC) must be synchronized with Coordinated Universal Time (UTC) to register exact time of each historical reading. GSM networks usually provide this synchronization automatically after the device is connected to network. For setting and checking of UTC and Time Zone there is a special group of commands described below.

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 is automatically computed by module as UTC value (obtained from the GSM network) plus Time Zone value (preset by user). RTC value can be entered also manually 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. After connecting to the GSM network, RTC value will be automatically corrected by GSM network.

3.1.11 Displaying of other operational entries in the list of parameters

In the lower part of the list of all configuration parameters there are some additional **identification and operational parameters of the module.**, that are of „read only" type. There are following parameters:

```
 Next send : 88 min.
  No. sent :  11 msg(s)
  No. recv : 0 msg(s)
-- Modem status --
Modem state : 0
Session count : 1
Session timeout : 172796 sec - 1d, 23:59:56
Modem IMEI : 863703038894247
  SIM CCID : 89882390000037252304
  SIM IMSI : 901288001028645
 Last RSSI : -61 dBm
 Conf. version : 12
 SW version 1.07, date May 27 2020
```

In the first part there is an information about sent messages. Parameter **"Next send"** means remaining time to the next broadcasting of info message. **"No. sent"** and **"No. recv"** indicate numbers of transmitted and received messages from last module reset.

In the **"Modem status"** section there are identification data of internal GSM-submodule (IMEI), unique number of inserted SIM-card (SIM CCID) and unique number of SIM-card user (IMSI). In the **"Last RSSI"** row there is an information about the signal strength of the last message received from the GSM network. In the **"Session count** row there is a number of sessions since last reset, in the **"Session timeout** row there is a current remainder of session timeout.

In the **"Conf. version"** row there is a current version (number) of configuration set, that increases with each storing of the configuration into the FLASH memory. The number is cleared by erasure of FLASH memory. In the **"SW version"** row there is a module software version and release date.

3.2 Setting of parameters by using of optical converter

The module i 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 already connected to the gas-meter and sealed.

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 6.

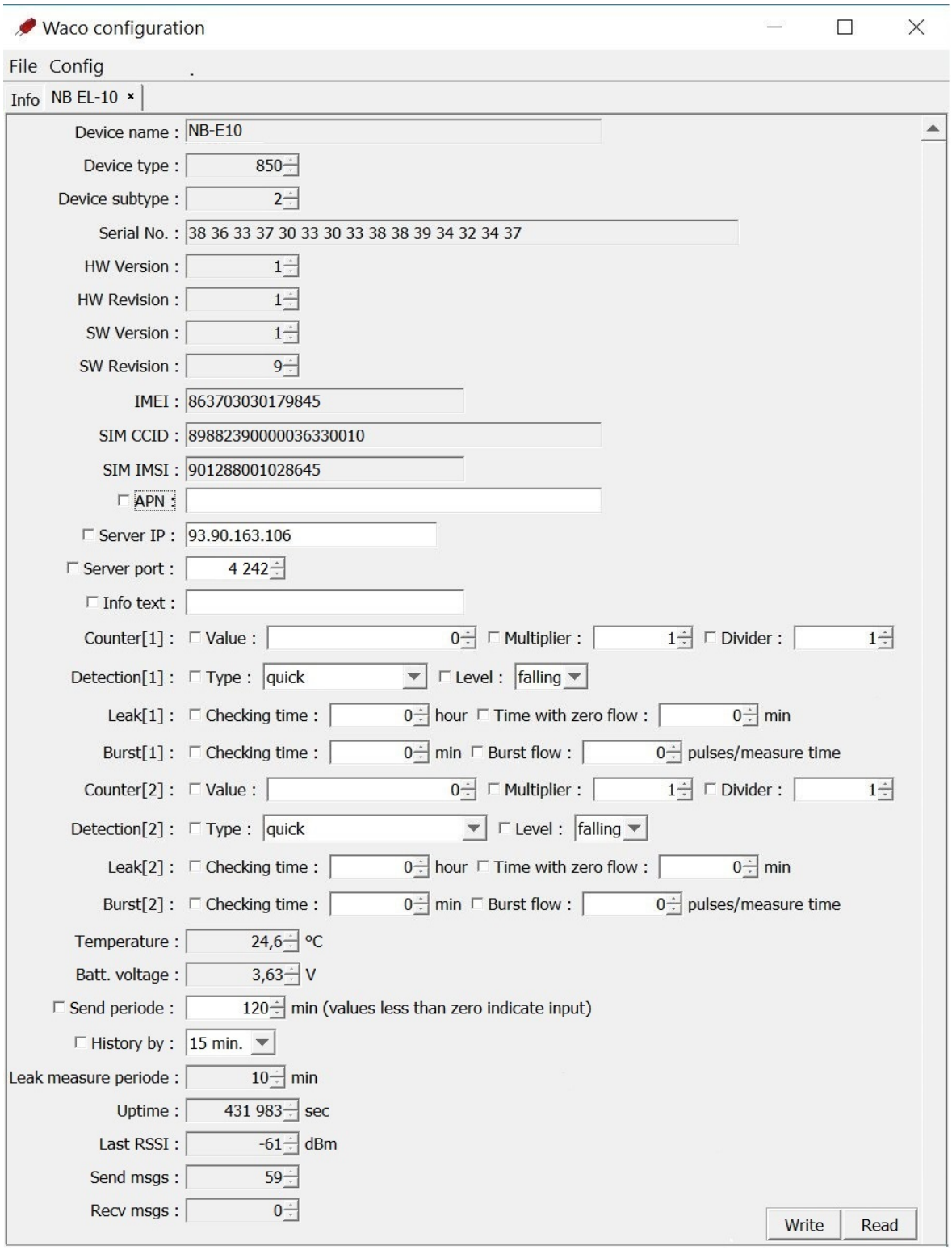


Figure 6: NB-PLE module configuration table

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*
EMEI	*unique identifier of internal GSM sub-module*
SIM CCID	*unique number of inserted SIM-card*
SIM IMSI	*unique number of SIM-card user*

All the parameters contain information about device identification, series and hardware/software version 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 NB-PLE module.

There are following parameters:

APN	*name of network GateWay (Access Point Name)*
Server IP	*target server IP-address*
Server port	*target application port number*
Info text	*user defined device name*
Value	*counter initial value*
Multiplier	*multiplier of the counter (output value = counter value * multiplier)*
Divider	*counter's divisor (output value = counter value / divisor)*
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 check. time	*setting of "burst check time" of the "Burst" function in minutes*
Burst flow	*setting of "LIMIT" of the "Burst" function (pulses per 10 minutes)*
Send periode	*setting of info-messages transmitting period*
History by	*setting of historical readings storing period*

The first part of configurable parameters (**"APN", "Server IP"** and **"Server port"**) are parameters for setting of **route to target server and application**. More detailed description of these parameters can be found in the paragraph 3.1.10.

The **"Info text"**parameter is intended for setting of device user name/description. This setting is optional and has no influence on the module function. Value of this parameter displays only in this configuration table.

In the next part of the table there is a group of parameters for setting of internal counters, output values and alarms: **"Value"**, **"Multiplier"**, **"Divider"**, **"Detection"**, **"Leak"** and **"Burst"**. Editable fields are arranged into two sub-sections, each of them is intended for setting of one counter („Counter[1]" and „Counter[2]").

The **gas-meter counter** is labeled as **"Counter[1]"**. In this sub-section it is necessary to perform setting of initial value, multiplier and divisor to get correct output values, corresponding with the values of physical counter. In the same block there is a "Detection[1]" sub-section that is recommended not to change. When using „Leak" and „Burst" alarm functions, use relevant editable fields ("Leak[1]" a "Burst[1]") of the first block.

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 turn of gas-meter measuring wheel.

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.

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".

Register of „Tamper" function is labeled as **"Counter[2]"**. If this function is exploited, perform setting of „Level" and „Type" parameters in „Detection" section of second input. On the contrary, setting of initial value, multiplier and divisor in this section has no sense, just as setting of „Leak" and „Burst" functions.

The **„Level"** parameter is intended for setting of counter trigger edge. "Falling" option means that the counter value will increase with falling edge of input signal (i.e. short-circuiting of tamper sensor). "Rising" option means that the counter value will increase with rising edge of input signal (i.e. releasing of tamper contact).

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 „Description and setting of „tamper" function.

The **„Send periode"** parameter is used for setting of broadcasting period of regular information messages. Value of the period should be set in minutes. More detailed description of this variable and possibilities of its setting are explained in details in paragraph 3.1.10 „Commands for setting of message broadcasting system".

The **„History by"** parameter is used for setting of historical readings storing period. The parameter is set in minutes, allowed values of the parameter are 0 (=disabled), 10, 15, 30 and 60 minutes. More detailed description of this variable and possibilities of its setting are explained in details in paragraph refsection:param-msg „Commands for message content setting".

In the **lower section of the table** there are current values of internal sensors (temperature, voltage...) and other operational "read only" parameters.

There are following parameters:

Temperature	*current value of processor temperature (read only)*
Batt. voltage	*current value of battery voltage (read only)*
Leak measure periode	*measuring period of "leak" function (read only)*
Uptime	*elapsed time from last module reset in seconds (read only)*
Last RSSI	*signal strength of last message from GSM network*
Sent msgs	*number of transmitted messages from last reset*
Recv msgs	*number of received messages from last reset*

All these parameters are intended mainly for examination of module function and operation and for module 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 NB-PLE module supports configuring all parameters, that are necessary for module installation on the site, as well as performing basic tests.

In the figure 7 there is an identification form of NB-PLE module (bordered by grey colour), form selection window (bordered by yellow colour) and administration form (bordered by blue colour).

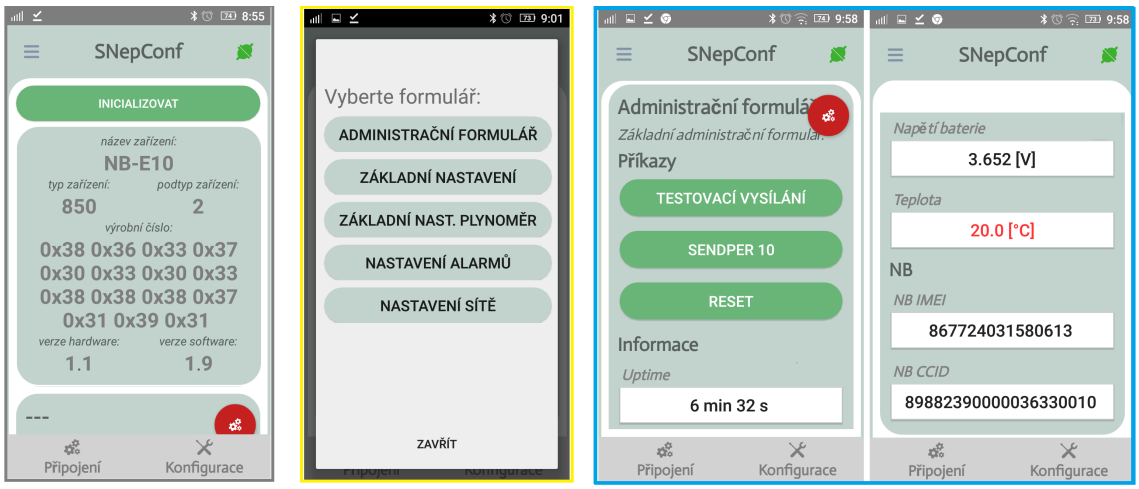


Figure 7: Basic forms of NB-PLE module in „SOFTLINK Configurator" application

In the figure 8 there is a basic form for setting of inputs and outputs (bordered by red colour), reduced form for typical necessary „in-field" setting (bordered by violet colour), and NB-IoT network communication setting form (bordered by green colour).

Figure 8: Input/output setting form and NB-IoT network configuration form

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

- setting of initial value, multiplier and divisor of gas-meter counter
- setting of Leak and Burst function parameters
- setting of trigger edge and mode of „tamper" input
- setting of message content (transferred value selection mask)
- setting of transmitting period of INFO messages
- setting of maximum session time with NB-IoT server
- setting of period of storing of historical readings
- setting of target server IP-address
- setting of target server UDP port number
- displaying of source UDP number
- setting of private network Access Point Name (APN)
- starting of one-time testing transmission
- starting of multiple (10 times) transmission series (SENDPER 10)
- sending of RESET command to the module

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

3.3 Remote setting of module parameters through the NB IoT back channel

NB-IoT network uses standard Internet Protocol (IP) that naturally enables data communication in **both directions**. The NB-PLE module can use bi-directional communication for setting of its parameters from so called **"back channel"**, that is (for the reason of saving battery) opened only during two second period after transmitting of each message (INFO, TRAP, or RESPONSE). In this period the module's receiver is switched on and the module is able to receive message from remote server.

Messages in reverse direction can be used for setting of module parameters. As these **"setting messages"** are also coded by NEP protocol, they have in fact same structure, as the messages transmitted by module (i.e. set of NEP-coded individual variables inside UDP packet).

The first variable in each setting message is always **Message type**. Setting messages are always of **"SET"** type (OiD 63 = **"1"**). This variable is followed by one or more variables, that are requested to change.

The NB-PLE module performs setting of requested parameters (update requested variables) and sends back a message of the **"RESPONSE"** type (OiD 63 = **"4"**), that contains set of variables after requested update. The message is addressed either to the IP-address of the server from which the SET request came, or to the preset IP address of target server (depending on the setting of "Reply" parameter by "sreply" command).

Remote setting of parameters through the back channel can be used for setting of same parameters that can be set by optical interface (because both systems work on the same principle). More details about the back-channel communication can be obtained from the producer upon request.

3.3.1 Overview of module configuration parameters

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

Table 2: Overview of NB-PLE module configuration parameters

Item	Name	Type	Description	Default.
1	Timezone	number	Time zone (time from UTC)	1
2	Server IP	code	target server IP-address	
3	Server port	number	target application port number	2000
4	Reply	yes/no	setting of reply from NB-IoT network	no
5	My src port	number	port number of source application	read only
6	APN	text	private network Access Point Name	
7	Max session time	number	Session timeout	2 days
8	Multiplier	1 - 65535	Counter value multiplier	1
9	Divisor	1 - 65535	Counter value divisor	1
10	Mode	desc.	Filter and trigger edge setting	falling, quick
11	Alarm	desc.	Alarm mode setting	none
12	Leak period	0 - 1090	Leak detection period („Leak" function)	0
13	Leak zero time	0 - 1090	Zero consumption period („Leak" function)	0
14	Burst limit	0 - 65535	Alarm limit value („Burst" function)	0
15	Burst period	0 - 1090	Burst check time („Burst" function)	0
16	Send period	0 - 65535	Broadcasting period in seconds	3600
17	Hist. period	number	historical readings storing period	0
18	Send mask	number	number of message content mask	3
19	Encryption	code	Encryption key	indiv.
20	Next send	curr. status	Time to next message in minutes	read only
21	No. sent	curr. status	No of sent messages from reset	read only
22	No. recv	curr. status	No of received messages from reset	read only
23	Modem state	curr. status	internal GSM module status	read only
24	Session count	curr. status	number of sessions from rese	read only
25	Session timeout	curr. status	time to closing of current session	read only
26	Modem IMEI	curr. status	internal GSM module unique ID	read only
27	SIM CCID	curr. status	unique number of inserted SIM-card	read only
28	SIM IMSI	curr. status	unique number of SIM-card user	read only
29	Last RSSI	curr. status	signal level of last received message	read only
30	Version	curr. status	No of stored images since last FLASH erasure	read only
31	SW version	curr. status	version number and date of issue	read only

In the **„Type"** column there is a data type of the parameter. „Code" indication in this field means that the value is displayed in hexadecimal code (couple of hexadecimal characters means 1 Byte) with one exception - IP-address is indicated in common form (four decimal octets separated by dots). "Curr. status" indication means that the field contains current value of operational parameter that cannot be influenced. Range of numbers means that there could be a number from mentioned range.

In the **„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 set in reliance on the specific usage
- 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 using of **USB-IRDA optical converter** as described in details in chapter 3.2 „Setting of parameters by using of optical converter". These parameters can be set also remotely (from remote server) with using of NB-IoT back channel.

3.4 The NB-PLE module data messages

3.4.1 Structure and types of data messages

The NB-PLE module is intended for reading of data from gas-meter and broadcasting of readings to the superior system via NB-IoT services of GSM operator.

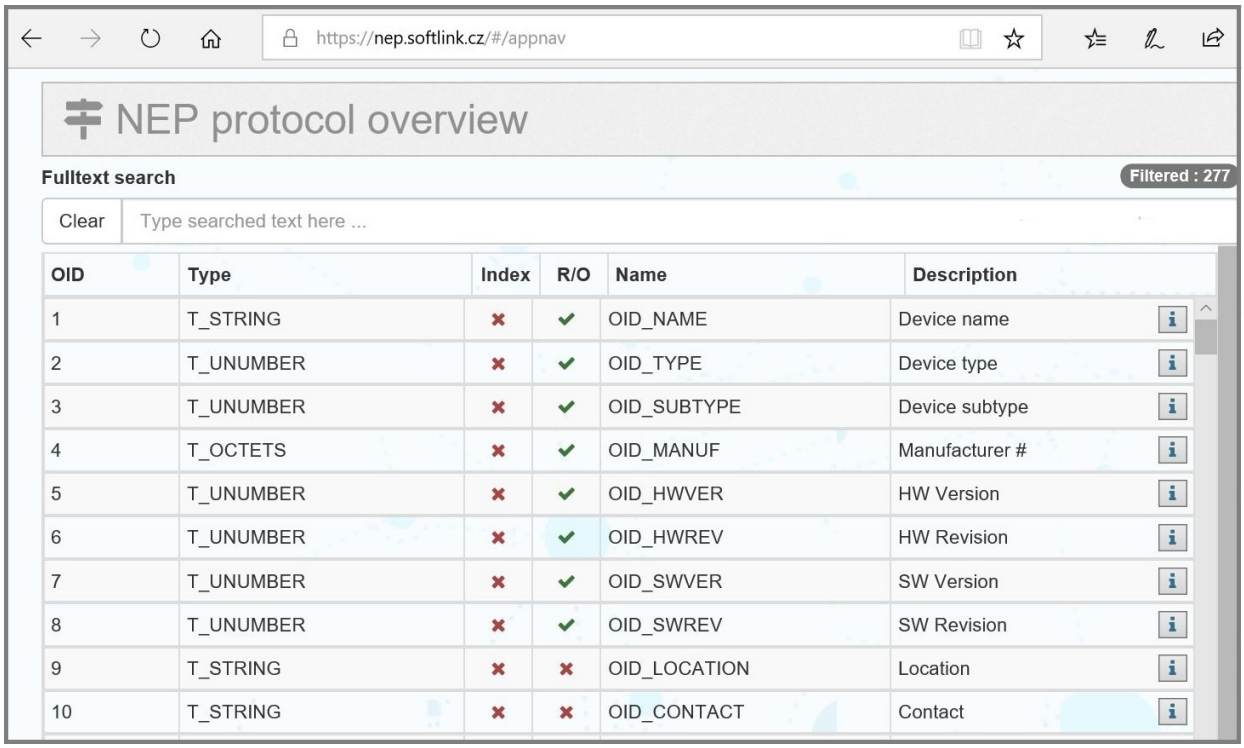
NB-IoT service utilizes for transfer of messages packets (datagrams) of UDP protocol (UDP = User Datagram Protocol), that is a transport layer of the Internet Protocol (IP).

Header of UDP datagram of the NB-PLE module consists of three fields:

- source port (16 bits) - constantly preset to "2000"
- destination port (16 bits) - set by "Server port" parameter
- length (number of Bytes) of UDP packet (16 bits)

UDP header is followed by data content with all transferred variables.

Individual variables are coded into the data content of the message by using of "NEP" proprietary coding system invented by SOFTLINK. In this system each type of variable has its own designation called "OID" (Object ID), which determines meaning, character and data type of the variable. These variables, that could be used multiple times (as multiple inputs, temperatures, voltages...) must be used jointly with order number of the variable called „Index". „NEP coding table" is centrally maintained by SOFTLINK and it is available on the public WEB address NEP Page. Preview of „NEP coding table" for coding of variables in the WACO system is shown in the figure 9.



OID	Type	Index	R/O	Name	Description
1	T_STRING	✖	✔	OID_NAME	Device name
2	T_UNUMBER	✖	✔	OID_TYPE	Device type
3	T_UNUMBER	✖	✔	OID_SUBTYPE	Device subtype
4	T_OCTETS	✖	✔	OID_MANUF	Manufacturer #
5	T_UNUMBER	✖	✔	OID_HWVER	HW Version
6	T_UNUMBER	✖	✔	OID_HWREV	HW Revision
7	T_UNUMBER	✖	✔	OID_SWVER	SW Version
8	T_UNUMBER	✖	✔	OID_SWREV	SW Revision
9	T_STRING	✖	✖	OID_LOCATION	Location
10	T_STRING	✖	✖	OID_CONTACT	Contact

Figure 9: Preview of „NEP coding table" for coding of variables in WACO system

Each variable is transferred together with its decoding information „Type" and „Length" that enables decoding of the information (i.e. determine variable's OID, index and value) on the receiving side even without knowledge of variable meaning. More detailed description of the NEP protocol can be downloaded in PDF format at the NEP Page.

The NB-PLE module message data content contains fixed part with identification and operational data and variable part with measured values. The module generates two basic types of messages:

- periodically transmitted **"INFO"** messages with readings (counter values and temper statuses)
- spontaneous alarm messages of **"TRAP"** type, generated immediately at alarm status (event)

The module generates these messages either in open, or in encrypted mode. Besides these basic types the module can generate also acknowledgment messages of „RESPONSE" type, as a response for setting messages from remote server (see paragraph 3.3).

3.4.2 Description of INFO message

Principal content of INFO message are statuses (readings) of gas-meter monitored by the module. Together with these readings there are also some identification and operational information of the module itself. The INFO messages are broadcasted in regular intervals preset by "periode" parameter (see paragraph 3.1.10).

Fixed part of the message is comprised of the first nine variables, that are contained in each message. In the table below there are marked in the OID field by yellow colour.

Variable part of the message contains set of measured values that depends on setting of the **message mask** by "smask" command. If only **current values** are transferred, the message contains only one set of measured values, without timestamps. If **historical readings** are transferred (see setting of "hist" parameter in paragraph 3.1.9 „Commands for message content setting"), the message contains several sets of measured values with appropriate **"timestamp"** before each set.

One set of measured values contains variables selected by "smask" command. Following variables can be selected:

OID 100/1 - gas-meter status (input 1)
OID 100/2 - tamper register status (*)
OID 105/2 - temperature of embedded sensor (*)
OID 90/1 - humidity of embedded sensor (*)

(*) Only special custom-tailored modifications of the module are equipped with tamper, temperature and humidity sensors.

Example of INFO message data content of NB-PLE module with **current values** and transferring only gas-meter status value:

OID	Index	OID Name	Description	Example
63		Message type	Message of DATA/INFO type	6
2		Device Type	Type name by manufacturer	850
3		Device Subtype	Device modification	2
4		Manufacturer No.	Device identification (IMEI)	
12		Uptime	Time from last reset (sec)	186552
61		Sequence No	unique message number	
105	1	Temperature	Processor temperature in 0.1 °C	223
106	1	Voltage	Battery voltage in mV	3765
462	1	RSSI	Last RSSI value	-61
100	1	Input value 1	Gas-meter counter current value	1996

Example of INFO message with **historical data** transferring data from both inputs (counter and tamper):

OID	Index	OID Name	Description	Example
63		Message type	Message of DATA/INFO type	6
2		Device Type	Type name by manufacturer	850
3		Device Subtype	Device modification	2
4		Manufacturer No.	Device identification (IMEI)	
12		Uptime	Time from last reset (sec)	186552
61		Sequence No	unique message number	
105	1	Temperature	Processor temperature in 0.1 °C	223
106	1	Voltage	Battery voltage in mV	3765
462	1	RSSI	Last RSSI value	-61
*TimeStamp and data of the **first** historical reading*				
17		Timestamp	Reading time (Epoch Unix Time Stamp)	1549031954
100	1	Input value 1	Gas-meter counter value	1984
100	2	Input value 2	Tamper counter value	4
99	2	Input value level 2	Tamper status	0
*TimeStamp and data of the **second** historical reading*				
17		Timestamp	Reading time (Epoch Unix Time Stamp)	1549032854
100	1	Input value 1	Gas-meter counter value	1989
100	2	Input value 2	Tamper counter value	4
99	2	Input value level 2	Tamper status	0

As it is clear from the example in the table, each historical reading creates its sequence of variables in the message. The first variable in the sequence is reading date and time (TimeStamp) and this record is followed by read values valid for that reading.

Number of sequences depends on the number of historical readings stored in the module memory from the last message transmission, where there could be up to 24 historical readings (24 readings is a maximum limit done by memory volume).

Tamper input is set into the **alarm mode** (see using of "alr" command in paragraph 3.1.5). In this mode the module sends in INFO-message input counter status (OID 100) as well asi **input current level** (OID 99), that is "1" or "0". Counter status indicates number of changes (how many times the module was detached from gas-meter since last reset), tamper input status indicates whether the module was attached ("0") or detached ("1") to/from gas-meter in the reading moment.

3.4.3 Description of TRAP message

Messages of TRAP type are used for immediate transmitting of information about event detected by the NB-PLE module. The information contains type of detected event (e.g. „Processor temperature exceeded limit") that can be followed by one or several variables with parameters of the event (e.g. „Temperature" and „Temperature limit"). This way the message recipient get information about limit exceeding, accompanied by current temperature value and value of the limit.

Type of detected event is encoded into the **„Alarm code"** variable (OID 60 - TRAP CODE), where value of variable determines event type. Current version of the NB-PLE module supports sending of events generated by „Leak" and „Burst" functions, events generated by „tamper" function, as well as its own events (module reset).

Fixed part of the message is comprised of the first six variables, that are the same as in INFO message. The only difference is that "Message type" (OID 63) is set to **"5"** value, what is a flag of **TRAP** type of message.

After this part of the message there is always **„Alarm code"** variable (OID 60 - TRAP CODE), carrying information about the event type. Current version of the NB-PLE module supports following types of events:

- 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 (*)

(*) 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.

„Alarm code" variable can be followed by one or several variables specifying event parameters.

„RESET" type of event is followed by variable of **„Reset code"** type (OID 14 - RESET CODE), carrying information about the reset cause. In the NEP coding table there are following types of reset:

- value "0" - Cold start
- value "1" - Warm start
- value "2" - Watchdog reset
- value "3" - Error reset
- value "4" - Power reset

For all other event types is „Alarm code" always followed by **current port status** of the event input.

Example of "TRAP" message with information about the reset of "Warm start" type (caused by command):

OID	Index	OID Name	Description	Example
63		Message type	TRAP type message	5
2		Device Type	Type name by manufacturer	850
3		Device Subtype	Device modification	2
4		Manufacturer No.	Device identification (IMEI)	
12		Uptime	Time from last reset (sec)	0
61		Sequence No	unique message number	
60		Trap code	RESET alarm code	0
14		Reset code	Reset code WARM START	1

Example of "TRAP" type message with information about the "LEAK" alarm on the first input:

OID	Index	OID Name	Description	Example
63		Message type	TRAP type message	5
2		Device Type	Type name by manufacturer	850
3		Device Subtype	Device modification	2
4		Manufacturer No.	Device identification (IMEI)	
12		Uptime	Time from last reset (sec)	186552
61		Sequence No	unique message number	
60		Trap code	LEAK alarm code	15
100	1	Input value 1	Value of gas-meter counter 1	22618

3.4.4 Encryption of messages

Encryption of messages by AES key can be activated by setting of encryption key with using of **"ekey"** command (see paragraph 3.1.10 „Commands for setting of message broadcasting system"). Encrypted message is in its first variable („Message type") designated as „Encrypted message" (OID 63 value is **127** - ENCRYPTED MESSAGE). The first six variables of the message are always sent unencrypted, because they carry data that are necessary for decryption. All other variables are encrypted by **block cipher CFB** and they are transferred in the message as encrypted value of one variable, designated as **„Encrypted part of the message"** (OID 19 ENCRYPTED BLOCK).

Structure of encrypted message has following structure:

OID	Index	OID Name	Description	Example
63		Message type	ENCRYPTED MESSAGE type	127
2		Device Type	Type name by manufacturer	850
3		Device Subtype	Device modification	2
4		Manufacturer No.	Device identification (IMEI)	
12		Uptime	Time from last reset (sec)	186552
61		Sequence No	unique message number	
19		Encrypted block	Encrypted part of the message	rest of variables

In the encrypted part of message there are all other variables encrypted by block cipher. The first variable in the encrypted block is always "Message type" (OID 63 MESSAGE TYPE), that carries an information, whether the type of message is INFO (value 6), or TRAP (value 5). Other variables follow in same order (and structure), as in unencrypted message (starting with seventh variable to the end of message).

4 Operational conditions

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

4.1 General Operation Risks

The radio modules are electronic devices power-supplied by internal batteries that register rotation of gas-meter into the internal counter and broadcast radio-messages with actual gas-meter status.

During their operation be aware mainly of the following risks:

4.1.1 Risk of mechanical and/or electric damage

The devices are enclosed in plastic boxes, so that the electrical components are protected from the direct damage by human touch, tools or static electricity.

The device is intended for using in normal internal environment. The device is designed for mounting directly to the mechanical counter slot of the gas-meter reserved for remote reading modules. In normal operation no special precautions are needed, besides avoiding of the mechanical damage from strong pressure or shocks and protection against excessive humidity.

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. In operation it is necessary to ensure that the antenna cable is not stressed by mechanical tension or bending. 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.

4.1.2 Risk of premature battery discharge

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

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

4.2 The condition of modules on delivery

Modules are delivered in standard cardboard boxes. The modules ordered in basic variant with IP65 degree of protection are delivered with battery switched off. The modules ordered with IP68 degree of protection are delivered in fully operating status with battery switched on. For saving battery energy reasons the long transmitting period (e.g. 1 day) is pre-set in the factory, or transmitting is blocked by setting of "periode" parameter to "0" value.

4.3 Modules storage

The modules should be stored in dry rooms or halls, in the temperature interval (0 ÷ 30) °C. To prevent the unwanted discharging of internal battery it is recommended to keep the long transmitting period configured until the module's installation.

As NB-IoT services are charged by GSM operator, it is recommended to insert SIM and activate the service just before module installation.

4.4 Safety precautions

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

4.5 Environmental protection and recycling

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

4.6 NB-PLE module installation

NB-PLE radio modules are enclosed in plastic casings with IP20 degree of protection. The case consists of two parts:

- back cover with locks for attachment to gas-meter
- front lid with production tag and circular hollow for configuration converter

Both parts are screwed together by two screws and there is no reason to dismantle the casing during normal operation. View of assembled NB-PLE module is displayed in the figure 1. View of all components of disassembled module (left) and view of module printed circuit board inserted into back cover (right) is displayed in the figure 10.

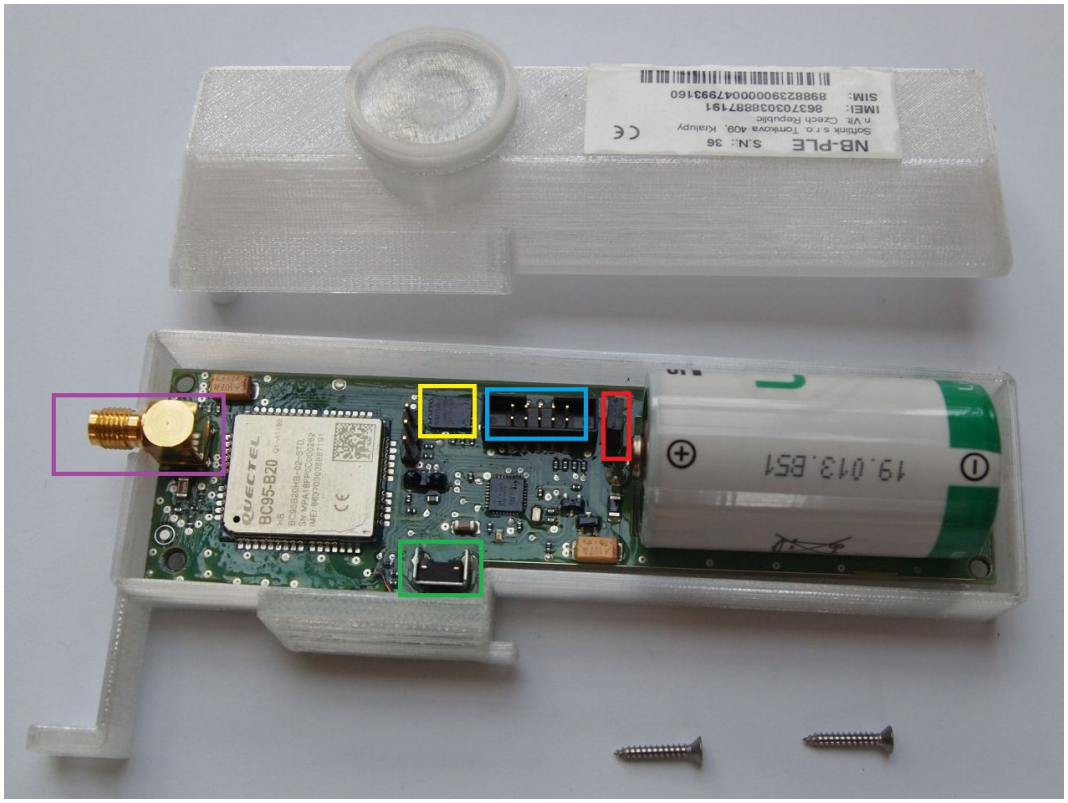


Figure 10: Detailed view of NB-PLE module

The module is equipped with the configuration connector (marked by blue rectangle), battery switch (marked by red rectangle), integrated SIM-module (marked by yellow rectangle) and antenna connector (marked by violet rectangle). If the module is equipped with the tamper sensor, it is placed (together with the measuring wheel rotation sensor) near the locks for attachment to the gas-meter (in the area marked by green rectangle).

The crater-like circular hollow helps for easy positioning of USB-IRDA/BT-IRDA configuration converter. There is an iron segment under the hollow, that enables magnetic fixing of converter equipped with permanent magnet in right position (see figure 11 middle and right).

When mounting the device follow these instructions:

- the module is commonly delivered fully assembled, switched on, and activated. It is no reason to open the casing neither during installation, nor during operation;
- insert the module into the slot under gas-meter counter. L-shaped sealing protrusion should be oriented to the right and must fit in the protrusion on the right side of the counter. Short plastic protrusion on the upper left

side of the module should be locked inside the gas-meter lock. View of NB-PLE module installed to gas-meter is displayed in the figure 11 left;

- connect module sealing protrusion with matching protrusion on the gas-meter by sealing screw or sealing wire (or other prescribed way) and seal the connection by antifraud seal;
- by using of optical converter and „WACO OptoConf' program perform setting of broadcasting period and initial counter value as described in paragraph 3.2 „Setting of parameters by using of optical converter";
- connect antenna (or antenna cable from remote antenna) to the antenna connector. Antenna rod should be oriented in vertical direction and should be situated as far from gas-meter body and other metal objects, as possible. The best way of antenna swiveling is depicted in figure 11;
- if the module is installed with remote antenna, pay attention to secure installation of antenna cable. The cable should be protected against mechanical damage as well as against inundation of cable connector by water;
- check sealing of gas-meter by antifraud seal.

After module installation make sure the right module is mounted to right gas-meter and fill in the prescribed documentation.

All manipulation with the NB-PLE module during installation is in principle the same, as handling with any other type of authorized remote reading module for Elster BK-G series gas-meter (e.g. IN-Z61).

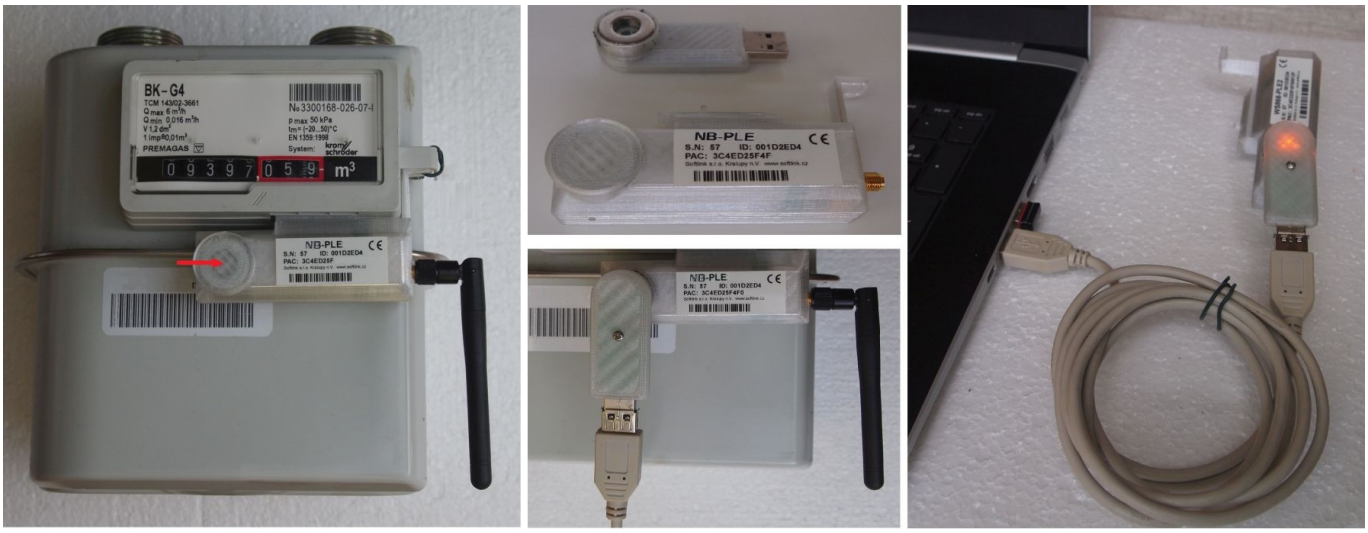


Figure 11: Installation and setting of NB-PLE module

4.7 Module replacement and dismantling

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 antenna or antenna cable from the module;
- remove connecting element (screw, wire...) between the module sealing protrusion and matching protrusion on the gas-meter;
- cautiously pull the module out of gas-meter slot;
- mark the module visibly as „defective";
- install a new module in the same way as described in paragraph 4.6 above (L-shaped sealing protrusion must fit to matching protrusion of the counter, short plastic protrusion on the upper left side of the module should be locked inside the gas-meter);
- connect module sealing protrusion with matching protrusion on the gas-meter and seal the connection;
- check and set broadcasting period and initial counter value as described in paragraph 3.2 „Setting of parameters by using of optical converter";
- connect antenna or antenna cable to the antenna connector and check the antifraud seal;

- write down the new module ID, gas-meter counter status and seal number. Fill in the prescribed service documentation. If possible, arrange making of all appropriate changes in the database of the remote reading system immediately.

When **dismantling** from gas-meter, disconnect antenna cable (if external antenna used), remove sealing connection and detach the module from gas-meter. 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. Take off an external antenna (if used).

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 its basic functionality:

- before installation perform physical check of module, antenna and gas-meter and examine availability of GSM network;
- after installation to the gas-meter check correctness of reading system by repetitive inspection of counter current value ("Value1") by using of optical converter. If there is a real gas consumption in progress, counter value should change in correspondence with changing of mechanical counter value. Values of physical quantities (temperature, voltage..) should correspond with reality;
- check setting of broadcasting period;
- perform complex (end-to-end) check of implementation of the module into the remote reading system by inspection of data rendered by module in reading system database. If the module broadcasting period is quite long, set shorter period for testing. **After testing don't forget to set correct value of broadcasting period (in accordance with service contract!**.

4.9 Operation of the NB-PLE module

The NB-PLE module performs reading of gas-meter and broadcasting of radio messages fully automatically. The greatest risks of permanent breakdown of module broadcasting are commonly caused by human activities within the installation site, especially mechanical damage of the module, excessive humidity or water inundation, or shading the RF signal by metallic object due to building operations.

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.

The risk of **premature battery discharge** could be eliminated by respecting the instructions described in paragraph 4.1.2.

5 Troubleshooting

5.1 Possible causes of module failures

If during operation of NB-PLE 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 1.3 „Hardware features". Battery life can be negatively influenced by circumstances that are described in detail in paragraph 4.1.2 „Risk of premature battery discharge".

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

Battery is soldered into the printed circuit board of the module and the module has to be disassembled for its replacement. Battery replacement can be performed only by qualified and experienced person. Soldering of battery by unskilled person can cause irretrievable damage of the module. There are only top-quality batteries used in the wacoSystem modules, that have been carefully selected and properly tested. In case of battery replacement by

user the new battery parameters should meet same technical requirements (type, capacity, voltage, current load, auto-discharging current...) as the original battery. It is strongly recommended to use for replacement same type of battery as used in production.

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 voltage is correct, 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 4.7 and check functionality of the new module. If the new device works properly, label the original module as „defective" and fill in the appropriate documentation prescribed by internal rules for this case.

5.1.3 Transmitter and receiver failures

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

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

- weak radio-signal of NB-IoT network in installation site. RF signal availability can be influenced by weather conditions (rain, fog..), or by some changes around module installation site as well as around NB-IoT provider base station.
- permanent or occasional shading of radio signal caused by construction works or any construction changes within the premises, or by operation around the installation site (moving of machines, cars, etc.);
- permanent, periodical or occasional interference (jamming) of radio signal from external source (another radio system in the same frequency band, or industrial disturbance);
- low level of transmitting signal caused by transmitter failure;
- low level of receiving signal caused by receiver failure;
- low level of transmitting and receiving signal caused by damage of antenna or antenna cable (if external antenna used).

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

- visually check surrounding of the installation site to find out if there are any changes that can influence radio signal (e.g. new objects, things, machines...). If there are such negative circumstances, solve the trouble by reorganization of the object or by relocation of the module or its antenna (if external antenna used);
- 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 and perform the check of module overall functionality as described in paragraph 4.8;
- replace the module according to the paragraph 4.7 and perform the setting and check of overall functionality of the new module as described in paragraph 4.8 after that;
- if the module is not properly working even after its replacement for proven device and equipment, the trouble can be caused by weak signal of NB-IoT network or interference (jamming) from external source in the installation site. In this case consult actual status of coverage and its future development with your NB-IoT network provider.

5.1.4 Reading system failures

Reading system failures typically appear as „zero consumption" of the gas-meter even though the consumption of the meter is evident, or generally, meter status from remote reading is considerably different than meter status shown in meter's mechanical counter. In this case try to proceed with troubleshooting in following steps:

- visually check whether the module is correctly mounted to gas-meter and whether there are any signs of gas-meter or module damage;

- if the module is correctly mounted to appropriate gas-meter type and there are no signs of damage or unauthorized manipulation, dismantle module from gas-meter and visually check the module and gas-meter again. If everything looks well, without any signs of damage, replace the module according to the paragraph 4.7;
- if the new module (after replacement) does not work properly as well, the trouble is probably caused by defective gas-meter.

5.2 Troubleshooting procedure

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

1. The module communicates normally, gas-meter readings are available, but the data are apparently incorrect. In this case it is recommended to check functionality of the module subsystems in following order:
   - check correctness of central application configuration related to the gas-meter, especially correctness of its ID, and correctness of initial value, multiplier and divisor;
   - check functionality of gas-meter revolving registration system (module input system) as described in paragraph 5.1.4 „Reading system failures".
2. Data from the module are coming irregularly, with periodical breakdowns. In this case it is recommended to check functionality of the module subsystems in following order:
   - check functionality of the transmitter as described in the paragraph 5.1.3 „Transmitter and receiver failures";
   - check functionality of internal battery as described in the paragraph 5.1.1 „Power supplying failures";
3. No data are available from the NB-PLE module. In this case it is recommended to check functionality of the module subsystems in following order:
   - check correctness of setting of the module in the central system database;
   - 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 transmitting as described in the paragraph 5.1.3 „Transmitter and receiver failures".

NOTE: NB-PLE 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 mechanical damage, excessive humidity or discharging of internal battery. 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 NB-PLE RF-modules, designed for operation in NB-IoT network, that are a part of the Softlink's **wacoSystem** product family. More information about all modules of "NB" series (NB-IoT), as well as about WS868 (Sigfox), WM868 (WACO), or WB169 (Wireless M-BUS) series of 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 NB, WS868, WM868, WB169 series or other manufacturer's equipment for telemetry and remote reading of consumption meters, feel free to contact manufacturer:

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