# WIRELESS COMMUNICATION SYSTEM NB-IoT

# NB-IR-V

*Revision 1.0*

**SOFTLINK s.r.o., Tomkova 409, 278 01 Kralupy nad Vltavou, Czech Republic**
Phone.: +420 315707111, e-mail: sales@softlink.cz, www.softlink.cz

# Contents



# List of Tables

## List of Figures

# 1 Introduction

This document describes the configuration options of the NB-IR-V radio module, which is used for remote reading of electricity meters with IrDA optical interface according to the IEC 62056 standard. The module reads the status of connected electricity meters and forwards the read data to the remote reading system (Automatic Meter Reading - AMR) via NB-IoT services of the GSM mobile service 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-IR-V module is used for local data collection from electricity meters equipped with IrDA optical interface and communication according to the IEC 62056-21 (DLMS) protocol. Electricity meters are connected to the module using the IR15 optical head, which is placed on the optical output of the electricity meter. The module checks the status of preset electricity meter registers at adjustable intervals and, depending on the set mode (transmission mode), sends the detected values to the superior remote reading system (AMR) in the form of radio messages via the NB-IoT service of the mobile operator (hereinafter "INFO message").

The NB-IR-V module can be used for reading **up to 6 electricity meters** located in its vicinity (up to a maximum cable length of 3 meters). From each electricity meter, the content of up to four registers can be read, whose addresses are preset according to the conditions of the distributor or market regulator. For each electricity meter, serial communication parameters can be individually set to suit the given type of electricity meter. The reading period can also be set separately for each electricity meter. The module performs reading of the register contents of the given electricity meter with the set period and either sends a radio message with the read values immediately (online mode) or stores the read values in memory for later bulk sending (history mode). The module has dedicated memory for storing up to 100 variables that can be sent in one summary message. This way, for example, messages from four electricity meters can be sent in bulk for six past reading periods (4 electricity meters * 4 variables * 6 measurement intervals = 96). This method of communication is optimal both from the point of view of minimizing electricity consumption (the module is powered by a built-in battery) and from the point of view of minimizing the costs of NB-IoT services.

The module has a configuration table for introducing up to six electricity meters, which are distinguished by bus identifiers according to the IEC 62056 standard. When querying the status of registers, the module uses these identifiers. If the electricity meters do not support bus addressing, the module only queries using a multicast address and cannot distinguish which electricity meter the response came from. In this case, its use is limited to connecting one electricity meter. The module allows data transmission **in both open and encrypted mode**.

Messages are transmitted to the module operator's application server via the NB-IoT service in the form of standard IP packets routed to the user's IP network through an Access Point contractually defined between the GSM network operator and the module operator. The device operator's application server decodes the messages and further processes the data contained in them.

The NB-IR-V module is equipped for **bidirectional communication** and is capable of receiving messages with commands in NEP format from a remote server via the GSM network. These messages can be used to set module parameters remotely, from a remote server.

## 1.3 Module Features

The NB-IR-V module is enclosed in a moisture-resistant plastic box (IP65 protection) and is suitable for use in both indoor and outdoor environments. The box is designed for wall mounting or mounting on any structural element (beam, pipe...). The module can be equipped with additional moisture protection (to IP68 degree) by sealing with high-adhesion silicone filling. If this modification is required from the manufacturer, it must be ordered with a special order code.

The module is powered by an internal battery with a very long life. When reading data from one electricity meter with a period of 15 minutes and a data sending interval with a period of 6 hours, the battery life is longer than 10 years. Battery life can be negatively affected by frequent reading and sending of messages (for example, when operating in "online" mode), sending long INFO messages (for example, when sending data from multiple electricity meters), but also by operating the device in buildings with temperatures outside the recommended operating temperature range.

The module is equipped with a SIM card holder for use with a "Micro-SIM" (3FF) format SIM card with dimensions of 15 x 12 x 0.76 mm. The SIM holder is located inside the module on the main board. The module can be manufactured to order with an integrated SIM module (chip-SIM) of a specific GSM operator.

The module can be controlled and configured using a configuration cable, or wirelessly, using an optical converter. For optical configuration, the module is equipped with a circular "peephole" to support magnetic attachment of the optical converter. The module can also be configured remotely, using the reverse channel of bidirectional communication. The appearance of the NB-IR-V module is shown in Figure 1.

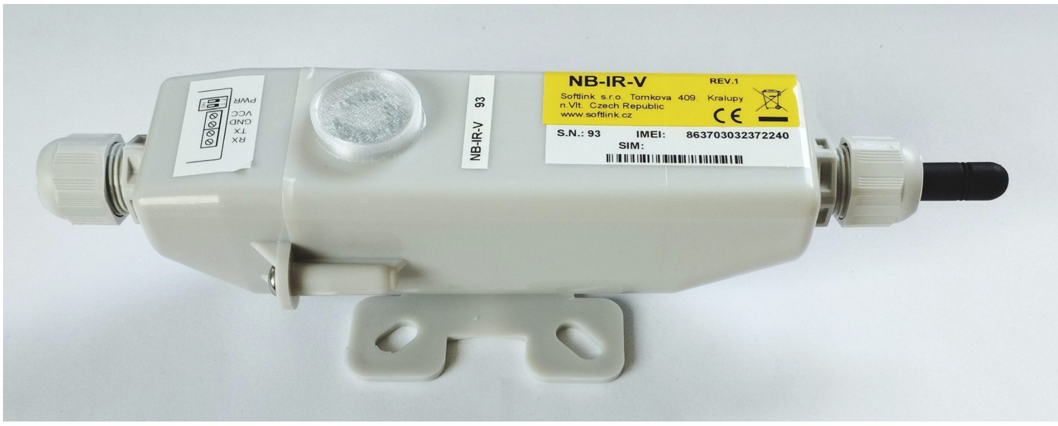


Figure 1: Appearance of the NB-IR-V module

## 2 Overview of Technical Parameters

An overview of the technical parameters of the NB-IR-V module is given in Table 1.

Table 1: Overview of technical parameters of the NB-IR-V module

| | | |
|---|---|---|
| **NB-IoT Transmitter 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 type | GMSK, 8PSK | (adaptive) |
| Bandwidth | 180 | KHz |
| Transmit power | 200 | mW |
| Receiver sensitivity | 135 | dBm |
| Communication protocol | NB-IoT | (bidirectional) |
| Transfer rate | 0.35 ÷ 240 | Kb/s (adaptive) |
| Antenna input characteristic impedance | 50 | Ω |
| Antenna connector | SMA female | |
| **Data Interface** | | |
| Serial interface | InfraRed (according to IEC 62056-21) | (terminals GND, RX, TX |
| Transfer rate | 300 ÷ 19200 | Baud |
| Operation mode | asynchronous | |
| Transfer parameters (basic setting) | 7 data bits, 1 stop bit, even parity | |
| Signal level | CMOS 3.5 | V |
| Optical head power supply | CMOS +3.5V/0.1A | terminal "VCC" |
| Max. number of connected IR15 optical heads | 6 | |
| **RS-232 Configuration Interface** | | |
| Transfer rate | 9600 | Baud |
| Operation mode | asynchronous | |
| Transfer parameters | 8 data bits, 1 stop bit, no parity | |
| Signal level | TTL/CMOS | |
| **Optical Configuration Interface** | | |
| Transfer rate | 115 200 | Baud |
| Optical wavelength | 870 | nm |
| Optical interface specification | complies with IrPHY 1.4 standard | |
| **Power Supply Parameters** | | |
| Lithium battery voltage | 3.6 | V |
| Lithium battery capacity | 17 | Ah |
| **Mechanical Parameters** | | |
| Length (without antennas) | 200 | mm |
| Width | 70 | mm |
| Height | 60 | mm |
| Weight | approx. 250 | g |
| SIM card dimensions | (15x12x0.76)mm) | "Micro-SIM" |
| **Storage and Installation Conditions** | | |
| Installation environment (according to ČSN 33 2000-3) | normal AA6, AB4, A4 | |
| Operating temperature range | (-20 ÷ 40) | °C |
| Storage temperature range | (0 ÷ 40) | °C |
| Relative humidity * | 95 | % (without condensation) |
| Protection rating * | IP65 or IP68 | |

* modules with additional sealing by silicone filling are waterproof, with IP68 protection rating.

# 3 Configuration of the NB-IR-V module

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

- with using of **„USB-CMOS”** converter and configuration cable connected to the module;
- wirelessly, with using of **„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-IR-V 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 reverse channel** can be found in paragraph 3.3 „Remote setting of module parameters through the NB IoT reverse channel”.

## 3.1 Setting NB-IR-V module parameters using a configuration cable

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

### 3.1.1 Listing of NB-IR-V module configuration parameters

We perform a listing of configuration parameters by entering the **”show”** command into the command line and pressing the ”ENTER” key. The following parameter listing will appear in the terminal window:

```
----- Configuration -----
 Timezone : 1
 Server IP : '192.168.0.20'
 Ping IP : '10.0.0.1'
 Server port : 4242
 Reply to server : yes
 My src port : 2000
 APN : ''
 Band : 20
 Ping IP : '10.0.0.1'
 Max session time 172800 sec - 2d,
 0:00:00
 Error restart time : 24 hours
 Main Send periode : 1440
 Data will be unencrypted

---- Configuration 0 ------
  OPTO mode
  Uart init speed 300 7E1
  Max speed : 9600
  Meter address :
 -- Register 1 --
   Reg value : C.1.0
 -- Register 2 --
   Reg value : 1.8.1
 -- Register 3 --
   Reg value : 1.8.2
 -- Register 4 --
   Reg value : 2.8.0
  RT : 4 * 50ms
  FT : 1 * 50ms
  Resp : 200 * 50ms
  iDel : 10 * 50ms
  Repeat : 2
  Send history : 60 min.
---- Configuration 1 ------
---- Configuration 2 ------
---- Configuration 3 ------
---- Configuration 4 ------
---- Configuration 5 ------

-- Narrow band modem --
 Next send : 1381 min.
  No. sent : 1 msg(s)
  No. recv : 0 msg(s)
Modem state : 4 - ready
Session count : 1
Session timeout : 169323 sec - 1d, 23:02:03
Restart timeout : 0 sec
Modem IMEI : 864700048156442
  SIM CCID : 89882390000398957020
  SIM IMSI : 901288910070695
 Last RSSI : -51 dBm
 Last IP   : 10.0.82.101

 Conf. version : 2
 SW version 1.07, date Jan 10 2023
```

The initial section of the configuration parameter listing displays information about the module's communication system settings and some other setting parameters, the meaning of which is described below.

The middle section of the listing shows the configurations of individual inputs (electricity meters). The module allows connection of up to six electricity meters, so the configuration listing contains 6 sections (”Configuration 0” to ”Configuration 5”). Each section contains settings for communication via the optical head (communication protocol, initial and maximum data rate, meter identification) and settings for reading individual registers from which the required values are read. The registers are fixed to read only the values approved by the owner/operator of the electricity meters. For operation in the Czech Republic, these registers are set:

- electricity meter serial number (C.1.0)
- current state of active consumption counter according to tariff T1 (1.8.1)
- current state of active consumption counter according to tariff T2 (1.8.2)
- current state of active reverse supply counter (2.8.0)

In case of a request to read other registers according to the IEC 62056 (DLMS) standard, contact the module manufacturer, who can set the reading of any four parameters according to the specified standard for the ordered production series.

The last section of the module configuration parameter listing displays some **identification and operational data of the module**. At the beginning of this section are statistical data on message transfer via the NB-IoT network. The **”Next send”** data is the time until the next regular message is sent. The **”No. sent”** and **”No. recv”** data contain statistics of received/sent messages.

This is followed by information about the NB-IoT subsystem settings - current GSM modem status **”Modem state”**, GSM modem identification data **”IMEI”**, inserted SIM card number **”SIM CCID”** and unique SIM card user number **”SIM IMSI”**. The **”Last RSSI”** row shows the signal strength with which the last message from the GSM network was received, the **”Last IP”** row shows the last assigned IP address from the NB-IoT network. It also displays the number of connections established since the last reset **”Session count”**, time until the maximum connection time expires **”Session timeout”** and time until GSM modem restart in case of connection loss **”Restart timeout”**.

At the end of the listing, the configuration parameter set number **”Conf. version”** is displayed, which increases with each new configuration save to memory (it is reset by erasing the FLASH memory) and the software version **”SW version”** with its release date.

An overview of configuration parameters with a brief description of their meaning is given in table **??** on page **??**. The procedure for setting individual parameters and detailed explanation of their meaning can be found below.

### 3.1.2 Overview of NB-IR-V module configuration commands (”HELP”)

We display an overview of configuration commands (”HELP”) and their parameters by entering the **”?”** command into the command line and pressing the ”ENTER” key. The following listing will appear in the terminal window according to the example below.

```
 Help :
 --- System commands ---
deb              : Show or set debug level
ta               : Show tasks
mb               : Show mail boxes
du addr          : Dump memory
rb addr          : Read byte from addr
rw addr          : Read word from addr
rd addr          : Read dword from addr
sb addr val      : Set byte on addr
sw addr val      : Set word on addr
sd addr val      : Set dword on addr
port             : Show port [a,b,..]
 --- Configuration ---
show             : Show info
info             : Show module info
write            : Write configuration to flash
cread            : Read configuration from flash
clear            : Clear configuration and load defaults
...
```

```
...
 --- All profiles [0 - 5] ---
ispeed           : Communication speed
parity           : Parity N,O,E (bits)
periode          : Send periode in minute, 0 - disable
irt              : rising time * 50ms
ift              : falling time * 50ms
iresp            : response time * 50ms
idel             : delay time * 50ms
irep             : Repeat readout
iread            : Readout BUS device
 --- Opto protocol commands per meter [0 - 5] ---
oid              : Meter ID (0 - 99999999)
mspeed           : Communication max. speed
 --- Narrow band ---
server           : Server IP address
sport            : Server UDP port
testip           : Ping IP address
sreply           : Send reply to server
apn              : Access Point Name
sess             : Set max session time in minutes
errtime          : Set restart time on error in hours
band             : Set NB band, default 20 - Europe
tshort           : Set modem short timeout
tlong            : Set modem long timeout
tconn            : Set modem connection timeout
sping            : Send ping
at               : modem command
 --- Utils ---
tz               : Time offset in hours
ppm              : Set RTC ppm
xmco             : Enable/disable Xtal on MCO
xtset            : Set Xtal freq for ppm
hsical           : Calibrate HSI
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
vbat             : Show or set vbat for alarm (vbat min)
uptime           : Show uptime
sens             : Show sensors
sendp            : Send x NB messages
send             : Send NB message
periode          : Send periode 0 - disable, >0 periode in minutes
hist             : History periode 0 - disable, >0 periode in minutes
ekey             : Set encrypt key NEP, point '.' no encrypt
mint             : ADC measure interval in sec.
loca             : Show or location (0-30 chars)
reset            : Reset device
hdata            : show data for send
?                : Show this help
```

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

### 3.1.3 „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.**

### 3.1.4 „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.**

### 3.1.5 „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:

| | |
|---|---|
| **?** | *show list of configuration commands („Help”)* |
| **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** | *show module info* |

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

The command **”reset”** performs the module reset. After each reset the system starts with the parameters that are stored in FLASH memory. If the current configuration should be used after reset, it is necessary to store it into the

FLASH before reset (see paragraph 3.1.4). Example of using of "reset" command:

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

By using of **"info"** command the basic identification information of the module can be displayed (including SIM info). The content of module label QR-code information displays in the "QRCODE" section. This command can be used during initial setting and module diagnostics. Example:

```
cfg#info
-- Info --
 Name : NB-IRDA
 SN : 308
 Type     : 850
 SubType  : 12
NB modem
     IMEI : 864700048156442
  SIM CCID : 89882390000398957020
  SIM IMSI : 901288910070695
QRCODE :
https://mod.softlink.cz?type=850&subt=12&sn=0&imei=864700048156442&ccid=89882390000398957020
```

#### 3.1.6 Commands for setting communication with electricity meters

The NB-IR-V module reads data from the internal registers of the connected electricity meter through the optical interface of the meter, to which it connects via the IR-15 optical head. The optical head is connected with a four-wire cable to the input terminal block of the module. The module can read up to 6 electricity meters this way, which are connected to the input terminal block in parallel via a four-wire bus.

For setting the parameters of the optical interface, there is a group of parameters listed in the configuration commands list in the sections **"All profiles"** and **"Opto protocol commands per meter"**. These are the following commands:

| | |
|---|---|
| **ispeed** | *initial communication speed of the optical interface* |
| **parity** | *setting the parity bit of serial communication (none/odd/even)* |
| **periode** | *setting the reading/transmission period* |
| **irt** | *setting the time interval for turning on the bus "rising time"* |
| **ift** | *setting the time interval for turning off the bus "falling time"* |
| **iresp** | *setting the timeout for response "response time"* |
| **idel** | *setting the minimum gap between commands "delay time"* |
| **irep** | *setting repeated reading* |
| **iread** | *command for immediate data reading* |
| **oid** | *setting the meter identifier on the bus* |
| **mspeed** | *setting the maximum communication speed of the optical interface* |

For each connected electricity meter, these commands are set separately, so when entering them, it is always necessary to specify the serial number of the electricity meter ("index") as the first parameter.

Using the command **"ispeed [index] [value]"** we set the initial bit rate of the optical interface. The module sends a data connection request to the electricity meter at this speed. Based on data exchange, the transmission speed can automatically increase to a value supported by the given type of electricity meter (the electricity meter "agrees" with the module on a higher transmission speed). Using the **"mspeed"** command, we limit the automatic speed increase to the maximum transmission speed allowed by the currently used optical head model. Example of checking current values and then setting the initial and maximum transmission speed for an electricity meter with index "2":

```
mon#ispeed 2
Init speed [2] : 300 bps
mon#ispeed 2 600
Init speed [2] changed from 300 to 600 bps
cfg#mspeed 2
Max speed [2] : 4800 bps
cfg#mspeed 2 9600
Max speed [2] changed from 4800 to 9600 bps
cfg#
```

The commands **"irt"**, **"ift"**, **"iresp"**, **"idel"** and **"parity"** are used to set the parameters of serial data transmission via the optical interface. They are factory set to be suitable for connecting electricity meters commonly found on the market. We recommend changing their settings only in specific cases, based on the documentation of the connected device. Parameter changes should always be made only by a qualified person with knowledge in the field of serial data transmission.

Using the command **"irep [index] [value]"** we set the number of attempts to read data from the given electricity meter. The value of this parameter is preset to "2" from the factory, which means that if the data completeness check fails after the first data reading, the module will repeat the data reading attempt once more. This significantly increases the probability of obtaining a correct reading. Increasing the number of repetitions results in extending the bus activation time, which can have a slight impact on battery life. Example of checking current values and then decreasing the number of data reading attempts for an electricity meter with index "0":

```
mon#irep
Repeat[0] : 2
Repeat[1] : 2
Repeat[2] : 2
Repeat[3] : 2
Repeat[4] : 2
Repeat[5] : 2
mon#irep 0 1
Repeat[0] changed from 2 to 1 * 50ms
cfg#
```

The command **"iread [index]"** is used for immediate reading of current values from the electricity meter registers. Using this command, we can immediately test the functionality of the connection after connecting the electricity meter to the module and check the status of the read variables. Example:

```
cfg#iread 1
Reading configuration 1 ...
Reading opto...
 Enable uart on speed 300 7E1
 Send init id '' .. Recv 18 bytes : '/ZPA4ZE110.v30_012'
 ack 4 (4800)
 set 4 (4800)
 Set uart speed to 4800
: 'F.F(000000)'
: 'C.1.0(05837224)'
 *Mid : 05837224
: 'C.90(837224)'
: '1.8.1(0000008.9#kWh)'
 *Reg1 : '1.8.1' -> 8.900
: '2.8.1(0000000.0#kWh)'
: 'C.9.3(19-10-17 08:23)'
: 'C.7.0(0074)'
: '0.3.3(00250.000*i\kWh)'
: '0.2.1(ZE110_DE_30)'
: 'C.8.1(00000096:16#h:min)'
: 'C.82.1(00000000:00#h:min)'
: 'C.50(00000583:32*h:min)'
: '31.6.0(002.382*A)'
: '21.6.0(00.371*kW)'
: '!'
 BCC 0x43 (0x43)
Flags 80
Recv end, 290 bytes
```

In the listing, values that are loaded into the sent message are marked with an asterisk. In this case, these are only the values "Mid" (register C.1.0, value 05837224) and T1 (register 1.8.1). The electricity meter does not provide values for registers for active consumption according to tariff T2 (1.8.2) and active reverse supply (2.8.0).

Using the command **"oid [index] [value]"** we set the unique bus identifier (OID) of the electricity meter according to the IEC 62056-21 standard for the given index. This command associates the electricity meter index from the range (0 to 5) in the NB-IR-V module configuration with a specific electricity meter. The module uses the OID identifier to address the query to a specific electricity meter.

**IMPORTANT NOTE!** If the OID value is not entered for a given index, the module queries using a broadcast address and stores the response it receives. If multiple electricity meters are connected to the module, the module cannot distinguish which one the response came from. Therefore, if multiple electricity meters are connected to the NB-IR-V module and bus identifiers are not entered for all of them, data cannot be read. **In case the bus identifiers are unknown or the electricity meter does not respond to them (i.e., they are not stored in the electricity meter configuration), only one electricity meter can be connected to the NB-IR-V module.**

*We can find out the bus identifier from the electricity meter documentation or by querying its manufacturer. It is often identical to the serial number, or it is a designated part of the serial number (but this is not a rule). In the above register listing, the "oid" value (837224) is stored in register C.90, but for other types of electricity meters, it may be in a different register (or in none).*

Example of setting a unique bus identifier for an electricity meter to index "1" and checking data reading using OID:

```
cfg#oid 1 837224
Meter ID [1] changed from  to 837224
cfg#iread 1
Reading configuration 1 ...
Reading opto...
 Enable uart on speed 300 7E1
 Send init id '837224' .. Recv 18 bytes : '/ZPA4ZE110.v30_012'
 ack 4 (4800)
 set 4 (4800)
 Set uart speed to 4800
: 'F.F(000000)'
: 'C.1.0(05837224)'
 *Mid : 05837224
: 'C.90(837224)'
: '1.8.1(0000008.9#kWh)'
 *Reg1 : '1.8.1' -> 8.900
: '2.8.1(0000000.0#kWh)'
. . .
```

It is clear from the example that the OID is introduced correctly because the electricity meter responds to a specific query using the entered OID.

The command **"periode [index] [value]"** is used to set the period for reading the status of the electricity meter with the given index and sending a message with the read values (the module sends the message immediately after reading). A different reading/sending period can be set for each of the six read electricity meters (with index 0 to 5), when **value "0"** is entered, the given electricity meter is **not read**. The zero value is factory set for all electricity meters.

The "periode" command **with index "6"** is used to set the transmission period of operational messages that the NB-IR-V module sends for itself. The content of these messages is operational data of the module (uptime, processor temperature, battery voltage...) and data from the history table (see description of the "hist" command). From the factory, the period for sending operational messages is also set to zero (transmission turned off).

Example of checking the setting of all transmission periods, setting the period of the first electricity meter to 1 hour, and subsequent checking of the transmission period of the first electricity meter:

```
mon#periode
Periode [0] is 0 min.
Periode [1] is 0 min.
Periode [2] is 0 min.
Periode [3] is 0 min.
Periode [4] is 0 min.
Periode [5] is 0 min.
Periode [6] is 0 min.
mon#periode 0 60
Periode [0] changed from 0 to 60 min.
cfg#periode 0
Periode [0] is 60 min.
```

### 3.1.7 Commands for setting communication with the NB-IoT network

This group of commands is used to set up the message sending system. These are the following commands:

| | |
|---|---|
| **server** | *setting the IP address of the target server* |
| **sport** | *setting the port number of the target server* |
| **testip** | *setting the IP address for control ping* |
| **sreply** | *redirecting the response to the target server* |
| **apn** | *setting the name of the private network access point (Access Point Name)* |
| **sess** | *maximum time for establishing a connection with the server* |
| **errtime** | *time interval for modem restart after entering an error state* |
| **band** | *setting the NB frequency band (default "20" = Europe)* |
| **tconn** | *maximum waiting time for a response from the server* |
| **sping** | *sending a control "ping" to the specified address* |

The module sends messages wrapped in UDP packets of the Internet protocol to a preset **target server**, on which the remote data collection application is running. The following commands are used to **set the IP address and target port number** and to set the **name of the communication gateway** between the GSM operator's network and the Internet (so-called "APN" = Access Point Name).

Using the **"server"** command, we set the **IP address of the target server**. The address is entered in decimal format in the commonly used way.

Example of setting the target server IP address to "92.89.162.105" and checking 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#
```

Using the **"sport"** command, we set the **UDP port number** of the target server that corresponds to the remote data collection application. Example of setting the target server UDP port number to "2000" and checking the setting:

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

The **"sreply"** command is used to specify the setting of **communication via the reverse channel** (see paragraph 3.3 "Setting module parameters from a remote computer using the reverse channel"). In some NB-IoT networks/services, it is possible to send return messages to the module only from a different IP address than the standard set IP address of the target server for sending messages. When the module is set to "Reply to server : no", the module responds to messages in a way that is standard for IP networks - i.e., it responds to the address from which the query came. When set to "Reply to server : yes", the module always responds to queries from any server to the set target server address (see the "server" command). We set the module to the "yes" state by entering parameter "1", we set the module to the "no" state by parameter "0".

Example of checking the reverse channel communication setting and then making a change:

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

If the GSM network operator transmits data from modules to their operator in the form of a virtual network, we use the **"apn"** command to set the name of the communication gateway between the GSM network and the Internet (so-called "APN" = "Access Point Name"), reserved for the given virtual network within the GSM network. The APN name is assigned to virtual network operators by the GSM network operator. We cancel the APN setting by entering the value "." (dot).

Example of setting the APN name to "cms.softlink":

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

The current setting of the target server and communication gateway is displayed in the configuration listing as follows:

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

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

Using the **"sess"** command, we set the **maximum time for establishing a connection with the operator's server ("session time")** in minutes. Some GSM service operators charge for each connection establishment ("session"), so establishing a connection before sending each message can be financially disadvantageous (and sending a message takes longer). On the other hand, if the server loses the connection during a permanent connection for some reason, the module does not receive any message about it from the network and the sent messages are lost. The "sess" parameter can be used to set a time after which the module checks the functionality of the connection using the "ping" function (see the use of the "testip" command below). If the functionality of the connection is not verified using the control "ping", the module terminates the connection and establishes it again when sending the next data. By default, this time is set to **2 days** (172800 seconds, 2880 minutes), which is a reasonable compromise between costs and message delivery reliability. If the GSM operator does not charge for connection establishment, the parameter can be set to a shorter time (or even to zero, when a connection is established when sending each message), but for the sake of shortening the communication time, we recommend keeping the default setting even in this case.

The current setting of the maximum connection establishment time is displayed in the configuration listing as follows:

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

Example of setting the maximum connection establishment time to 2880 minutes:

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

Using the **"testip"** command, we set the **IP address for the control ping**. The address is entered in decimal format in the commonly used way. The control ping is sent after the end of the maximum time for establishing a connection with the operator's server (see the previous "sess" parameter). The control ping is addressed to the set address of a suitable computer in an accessible IP network (a computer that reliably responds to control "ping" queries). If a response comes to the ping, the connection with the NB-IoT network is verified and it is not necessary to establish it again.

Example of setting the IP address of the computer for sending a control "ping" to the value "10.0.0.1":

```
mon#testip 10.0.0.1
Test ip changed from '10.0.0.8' to '10.0.0.1'
mon#
```

We can check the availability of the server for the control "ping" message using the **"sping [address]"** command. By entering this command, the system sends a control ping and displays the result.

Using the **"tconn"** command, we set the **maximum waiting time for a network response when establishing a connection**. If the GSM operator's network does not respond to connection requests within this time, the module's GSM modem turns off and attempts to establish a connection when sending the next message. The parameter is set by default to **5 minutes** (300 seconds). We recommend changing the value if the GSM network operator guarantees a significantly different response from the network. Example of changing the setting of the maximum waiting time for a network response when establishing a connection from 200 to 300 seconds (5 minutes):

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

*Both of the above parameters ("sess" and "tconn") affect power consumption and **battery life**. If a connection is established with the server when sending each message, the active state of the modem is prolonged, when it consumes a lot of energy. If too long a waiting time for network response ("tconn") is set, the modem is unnecessarily on for a long time while waiting for connection establishment. From this point of view, it is advantageous to set the longest possible "sess" time and the shortest possible "tconn" time. However, such a setting **reduces the reliability of message delivery**, because in the event of a "session" failure on the operator's side, messages are lost until the "sess" time expires, and with a short "tconn" timeout, it may happen that the connection is not established in time and the message is not sent. The setting of both parameters must be a compromise between energy efficiency and message delivery reliability.*

Using the **"errtime"** command, we set the **modem restart time after an error in establishing a connection**. If a fatal error occurs when attempting to establish a connection, the modem automatically deactivates to avoid unnecessarily draining the battery with repeated connection attempts. The "errtime" parameter sets a timer that restarts the modem after the set time and attempts to establish a connection again. The parameter is set by default to **24 hours** and we recommend not changing this value without reason. Example of checking the "errtime" parameter setting and changing its value to 48 hours:

```
mon#errtime
Error restart time : 24 hours
mon#errtime 48
Error restart time : 48 hours
cfg#
```

Using the **"band"** command, you can set the **NB-IoT modem frequency band**. By default, the most commonly used frequency band B20 in Europe is set (value "20"). The used modem may support multiple frequency bands, in which case it is possible to switch the module to another frequency band. In different production series of the NB-IR-V module, the used modem modification may differ depending on the current availability and price of the modem at the time of production. **If you are interested in using the modem in a band other than B20 (800 MHz), always include this information in the order, or contact the manufacturer**.

In the "Narrow band" section of the "HELP" listing, the commands **"tshort", "tlong"** and **"at"** are also displayed, which are used exclusively for initial setup and module diagnostics. **We strongly recommend against using these commands during device operation.**

### 3.1.8 Commands of the "Utils" group for setting and checking basic module functions

This group of commands is used to set the content and period of message sending and other common module functions. The following commands are used to set the content and period of sending information messages:

| | |
|---|---|
| **periode** | *setting the period of spontaneous message sending* |
| **ekey** | *setting the encryption key ("." - encryption disabled)* |
| **hist** | *setting the data reading period in "history" mode* |
| **hdata** | *preview of the current content of the historical readings table* |

The **"Periode"** variable is used to set the period of spontaneous sending of information messages. For the NB-IR-V module, this parameter is always set with indices 0 to 6, which have the following meanings:

- values **with indices 0 to 5** are used to set message sending **from individual electricity meters** in "online" mode, where each electricity meter is read with its own period and the message is sent immediately;
- the value **with index "6"** is used to set message sending **from the module itself**. These messages have their own repeat period and carry service information related to the module. In **"history" mode** (see description of the "hist" variable below), these messages also carry tables of previously measured values from individual electricity meters.

During production, this parameter is set to "0" for all 6 indices, which turns off transmission. We set the transmission period for a given index by entering the transmission period in minutes as a parameter of the command (theoretically up to 65535 minutes can be set). The **"periode"** command (without a parameter) can be used to display the current setting values.

Example of displaying currently set values of the "periode" parameter for all indices:

```
cfg#periode
Periode[0] is 60 min.
Periode[1] is 120 min.
Periode[2] is 120 min.
Periode[3] is 0 min.
Periode[4] is 0 min.
Periode[5] is 0 min.
Periode[6] is 720 min.
cfg#
```

Example of setting the transmission period for electricity meter with index "2" to 60 minutes and shortening the transmission period of the module's service message to 360 minutes:

```
cfg#periode 2 60
Periode[2] changed from 120 to 60 min.
cfg#periode 6 360
Periode[6] changed from 720 to 360 min.
cfg#
```

With this setting, the electricity meter with index 2 will be read every 60 minutes and the message with its readings will be sent immediately. Every 6 hours, a message with the module's operational parameters will be sent.

***Warning:*** *NB-IoT service operators may charge for this service based on the volume of data transferred. Higher transmission frequency negatively affects battery life and may also negatively affect the cost of the service.*

The **"Encryption code"** variable is used to set the encryption key for encrypting outgoing module messages using the AES-128 key. We enter the 16-byte encryption key using the **"ekey"** command followed by a string of 16 bytes, which can be entered in decimal or hexadecimal form (see examples).

Example of entering the encryption key in hexadecimal form:

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

Example of entering the encryption key in decimal form:

```
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
```

After entering the encryption key, the information about encryption being turned on ***"Data will be encrypted by AES"*** will be displayed in the list of set parameters (see paragraph 3.1.1).

We turn off encryption by entering the parameter "." (dot) after the **"ekey"** command:

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

After turning off encryption, the information ***"Data will be unencrypted"*** will be displayed in the parameter listing (see paragraph 3.1.1).

To reduce the number of transmissions (saving battery capacity), the NB-IR-V module allows sending a larger number of previously read values in one message. Such a message then does not contain current measured values, but a set of previously measured values stored in the internal memory of the module (hereinafter "historical readings"). Each set of historical data contains data from all read electricity meters that are not read in "online" mode, but **in "history" mode**. Each set of historical readings is also assigned the time of their acquisition, which is also transmitted to the central system. To determine the number of transmitted sets of historical data, it is necessary to take into account these limitations:

1. The module's memory size allows storage of **up to 100 historical readings**. The number of historical receive windows that can be transmitted in one transmission session depends on the number of electricity meters read and the number of variables read. With the standard setting, 4 data are read from each electricity meter: serial number, T1 reading, T2 reading and counter reading of supply to the network (in case of production). If we read data in "history" mode from only one electricity meter, we can stack up to 25 readings in memory, which allows, for example, reading the electricity meter every 15 minutes and sending all readings at once in one message sent with a period of 6 hours. After each message is sent, the historical readings table is emptied
2. The size of the NB IoT data message is limited to 512 kB, so data from about 10 variables fit into one IoT data message. If a message with a larger amount of historical data is transmitted, the module divides the transmitted data into several NB-IoT messages. This may affect the charging of the service.

From these dependencies, it follows that setting the reading period and data transmission period when reading a larger number of electricity meters is **always a compromise between information delay, energy consumption and service cost**. To minimize information delay, it is necessary to transmit as often as possible. To minimize energy consumption, on the other hand, it is advantageous to transmit as infrequently as possible. To minimize cost, it is advantageous to fill the transmitted packets as much as possible.

*Determining the parameters of measurement and transmission frequency should always be done on a project basis, taking into account the specific situation, specific tariff and specific needs and requirements of the project.*

***Example:*** *If the total transmission period of the module (see description of the "periode" parameter with index "6") is set to 240 minutes (4 hours), in "history" mode 3 electricity meters are read with a reading period of 30 minutes, each electricity meter generates 240/30 = 8 sets of data over the entire transmission period, which is a total of 8*4 =32 historical readings. All three electricity meters therefore generate a total of 3*32= 96 historical readings, which does not exceed the maximum capacity of the history memory (100 readings).*

We set the **reading period with storing readings in memory** for a given electricity meter using the **"hist [index]"** command. The value is set in minutes, allowed setting values are 10, 15, 30 and 60 minutes (if another number is entered, the nearest of these values is set). When set to "0" (default setting), readings are not stored in memory. Example of setting the period for storing readings for electricity meters with indices "0" and "1" with periods of 15 and 30 minutes:

```
mon#hist 0 15
History[0] changed from 0 to 15 min.
cfg#hist 1 30
History[1] changed from 0 to 30 min.
cfg#
```

One NB-IR-V module can simultaneously connect electricity meters with reading in "online" mode and in "history" mode. If we set the value "periode a x" for the electricity meter with index [a], it is read in "online" mode with period "x". If we set the value "hist b y" for the electricity meter with index [b], it is read in "history" mode with period "y". When making changes, the last setting always applies, so if a new "hist" period is set for an electricity meter with "online" reading, its reading method switches to "history" (...and vice versa). The valid reading method is displayed in the configuration listing, where there is always either the "Send periode" data (for "online" mode) or the "Send history" data (for "history" mode).

Example of a module configuration listing with two electricity meters in "history" mode, two electricity meters in "online" mode and two unoccupied inputs:

```
---- Configuration 0 ------
  Send history : 15 min.
---- Configuration 1 ------
  Send history : 30 min.
---- Configuration 2 ------
  Send periode : 120 min.
---- Configuration 3 ------
  Send periode : 60 min.
---- Configuration 4 ------
  Send periode : 0 min.
---- Configuration 5 ------
  Send periode : 0 min.
```

When listing the settings of all indices, the same situation will be displayed as follows:

```
cfg#periode
Periode[0] is - min.
Periode[1] is - min.
Periode[2] is 120 min.
Periode[3] is 60 min.
Periode[4] is 0 min.
Periode[5] is 0 min.
Periode[6] is 1440 min.
```

```
cfg#history
History[0] is 15min.
History[1] is 30 min.
History[2] is 0 min.
History[3] is 0 min.
History[4] is 0 min.
History[5] is 0 min.
cfg#
```

In "history" mode, the module records data from electricity meters with higher frequency, but sends it with a significantly longer period than the measurement period. The module stores records from performed measurements in the "history" table, which it empties after each message is sent. In the table, each read electricity meter has four records allocated for each measurement performed, one for each read variable. For the electricity meter with index "0", records ID(1) to ID(4) are permanently reserved, for the electricity meter with index "1" records ID(5) to ID(8), etc. We can display the current content of the history table (i.e., the list of readings waiting to be sent) using the **"hdata"** command. Example:

```
cfg#hdata
Show history data :
 ID[1] val 25514787, time 2021-01-01, 0:10:00+01
 ID[2] val 0.152, time 2021-01-01, 0:10:00+01
 ID[3] val 0.000, time 2021-01-01, 0:10:00+01
 ID[4] val 0.000, time 2021-01-01, 0:10:00+01
 ID[1] val 25514787, time 2021-01-01, 0:20:00+01
 ID[2] val 0.188, time 2021-01-01, 0:20:00+01
 ID[3] val 0.000, time 2021-01-01, 0:20:00+01
 ID[4] val 0.000, time 2021-01-01, 0:20:00+01
```

From the history table listing, it is clear that since the last data transmission to the center, two measurement periods have taken place (at "0:10:00" and "0:20:00"), in which one electricity meter (ID 25514787) was read. The value of tariff T1 is 0.152 kWh and 0.188 kWh, the values of the other two variables are zero.

The following commands are used to set other common parameters and functions of the module:

| | |
|---|---|
| **tz** | *setting the time zone (UTC + n)* |
| **time** | *display/set hh:mm:ss of real time RTC* |
| **date** | *display/set YY.MM.DD of real time RTC* |
| **vbat** | *setting the battery threshold voltage for generating an alarm (setting)* |
| **mint** | *setting the measuring interval of AD converters for voltage and temperature measurement* |
| **loca** | *setting individual module designation* |

Given that the NB-IR-V module can send not only the current counter value but also "historical" values stored in memory, it must have the correct real-time value ("RTC") set so that the exact time of measurement can be registered for each stored value. GSM networks usually synchronize time with Coordinated Universal Time UTC automatically, when the device logs into the network and when sending a message. The following group of commands is used to check the RTC setting.

Using the **"tz"** command, we set the **time zone** (Time Zone) in which the remote reading system operates. The module supports **only one** time zone, which is set in hours from UTC. Example of setting the time zone to UTC+1 (Central European Time):

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

In the configuration listing, the set time zone value is displayed as:

```
Timezone : 1
```

Using the **"time"** or **"date"** command, we can display the current RTC setting. By entering either of these commands without parameters, we display the current RTC value of the module. Example:

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

We set the RTC value using the **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 evident from the example, the "time" value is given in the format "0x**hhmmss**", the "date" value is given in the format 0x**YYMMDD**. When the module is put into operation in the GSM network, the RTC value will be automatically set according to the GSM network data.

Using the **"vbat"** command, we can adjust the setting of the battery threshold voltage at which the module sends a "Low Battery" alarm. The factory-set threshold value is 3.1 V (3100 mV). We recommend changing this value only in justified cases, after consulting with the manufacturer. Example of checking the current setting and changing the threshold value to 3.2 V:

```
cfg#vbat
Vbat alarm for 3100 mV
cfg#vbat 3200
Vbat alarm for 3200 mV
mon#
```

Using the **"mint"** command, we can set the interval for measuring analog values (battery voltage, processor temperature) using the AD converter. The factory-set interval value is 120 seconds. We recommend changing this value only in justified cases, after consulting with the manufacturer. Example of checking the current setting and changing the interval to 240 seconds:

```
cfg#mint
Measure interval 120 sec.
cfg#mint 240
Measure interval 240 sec.
cfg#
```

Using the **"loca"** command, we can set an individual designation for the module. Up to 30 alphanumeric characters can be entered. The entered designation will be displayed in the "Info text" field of the optical configuration form. The designation can contain any identification data (installation site code, customer code, serial number...). Example of setting an individual module designation:

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

In the "Utils" section of "HELP" list there are the **"ppm", "xtset"** and **"xmco"** commands, that are intended only for module initial setup and diagnostics. **It is recommended not using these commands during operation.**

## 3.2 Setting module parameters using an optical converter

The module is equipped with an ”IRDA” infrared optical interface, which is used for configuration using the **”USB-IRDA”** converter (from optics to USB cable), or using the **”BT-IRDA”** converter (from optics to Bluetooth radio). For easy attachment of the optical converter, the module is equipped with a circular recess (”peephole”) for attaching the converter with a retaining magnet. The advantage of setting via the optical converter is the possibility of configuration through the ”peephole” in the plastic cover of the module, without the need to open the cover. This is of great importance especially in those cases when we use the module in a humid environment and it is sealed with additional silicone sealing, or by filling with silicone (additional modification to meet the conditions of IP68 protection degree).

Using the **”USB-IRDA”** optical converter, you can display a listing of the current settings of all module parameters. We display the listing of all parameters by clicking on the **”Walk”** button in the ”WACO OptoConf” program window.

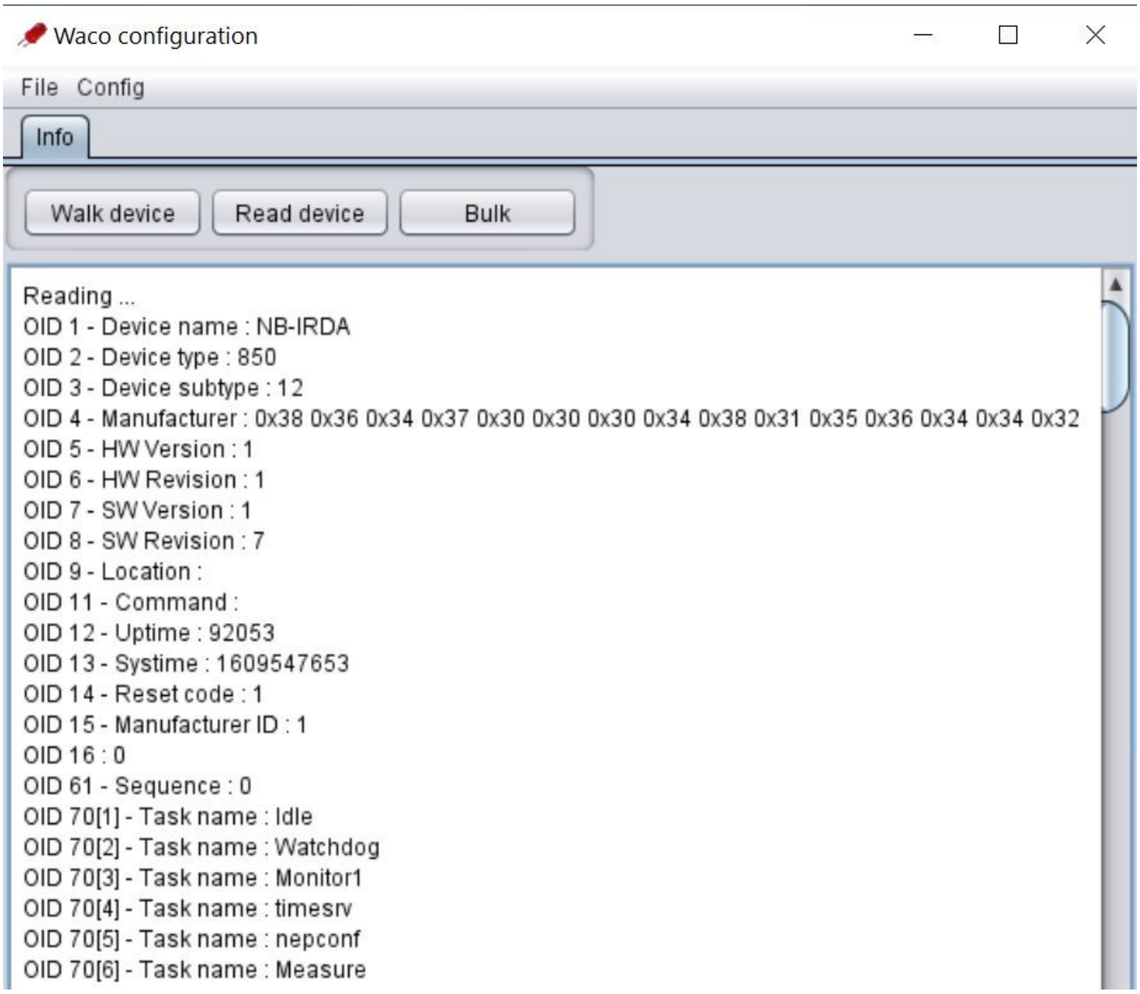


Figure 2: Parameter listing of the NB-IR-V module

The **”Read”** button in the ”WACO OptoConf” program is used to display the module’s configuration table, through which it is possible to make changes to the settings of individual module types. However, this table is not available for all types and modifications of modules and its functionality is being replaced by configuration from a mobile phone via the ”BT-IRDA” converter.

Using the **”BT-IRDA” optical converter**, those parameters that are included in some configuration form of the **”SOFTLINK Configurator”** mobile application can be set. The current version of the ”SOFTLINK Configurator” application supports the configuration of all basic module parameters, as well as performing those basic tests that need to be performed at the installation site. Figure 3 shows the identification form of the NB-IR-V module (in the green frame), the list of available forms (in the yellow frame), the administration form (in the purple frame) and the network settings form (in the red frame).

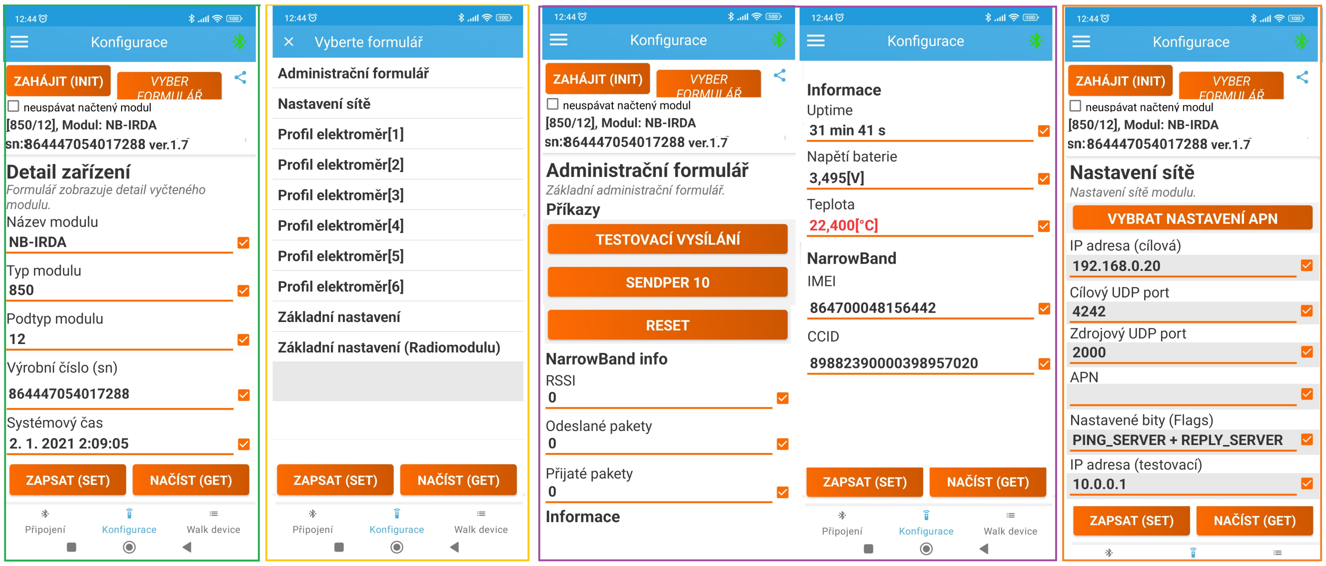


Figure 3: Forms of the NB-IR-V module in the "SOFTLINK Configurator" application

The **identification form** displays basic information about the module (type, modification, serial number, system time) and a button for selecting the configuration form.

The **administration form** displays the module's operational data (uptime, battery voltage, processor temperature). There are buttons for performing a reset and turning on test transmission.

The **network settings** form contains configuration fields for setting communication with the NB-IoT network (IP address, UDP port, APN, address for ICMP tests) and a switch for selecting the IP communication mode ("Flags").

The meaning of individual parameters is described in detail in paragraph 3.1.7 (Commands for setting communication with the NB-IoT network). For the **IP communication mode** selection, you can choose from these options:

- Option "OFF" - the module sends spontaneous messages to the set target IP address, responds to queries to the address from which the query came. After the "session timeout" ends, it does not test the connection, but interrupts and establishes it again;
- Option "PING SERVER" - the module sends spontaneous messages to the set target IP address, responds to queries to the address from which the query came. After the "session timeout" ends, it tests the connection by pinging the set test IP address, if the connection is functional, it extends the connection by another timeout;
- Option "REPLY SERVER" - the module sends spontaneous messages to the set target IP address and sends responses to all queries to this address. After the "session timeout" ends, it does not test the connection, but interrupts and establishes it again;
- Option "PING SERVER + REPLY SERVER" - the module sends spontaneous messages to the set target IP address and sends responses to all queries to this address. After the "session timeout" ends, it tests the connection by pinging the set test IP address, if the connection is functional, it extends the connection by another timeout;

Figure 4 shows the form for setting communication with the electricity meter (in the light gray frame), the form for basic module settings (in the dark gray frame), the parameter listing in "WALK" mode (in the light green frame), examples of editing edit fields (in the brown frame) and the result of test reading of electricity meter parameters via the optical interface using the "TEST INTERFACE" button (in the blue frame).

For setting each electricity meter, a form marked with the serial number of the electricity meter configuration (Electricity meter profile 1 to 6) is used. For each electricity meter, these parameters can be set:

- setting the initial data transfer rate via the optical head
- setting the maximum data transfer rate via the optical head
- setting serial communication parameters (7 data bits / even parity / 1 stop bit)
- electricity meter bus identifier according to IEC 62056 standard
- setting the transmission period, or writing readings to the "History" table

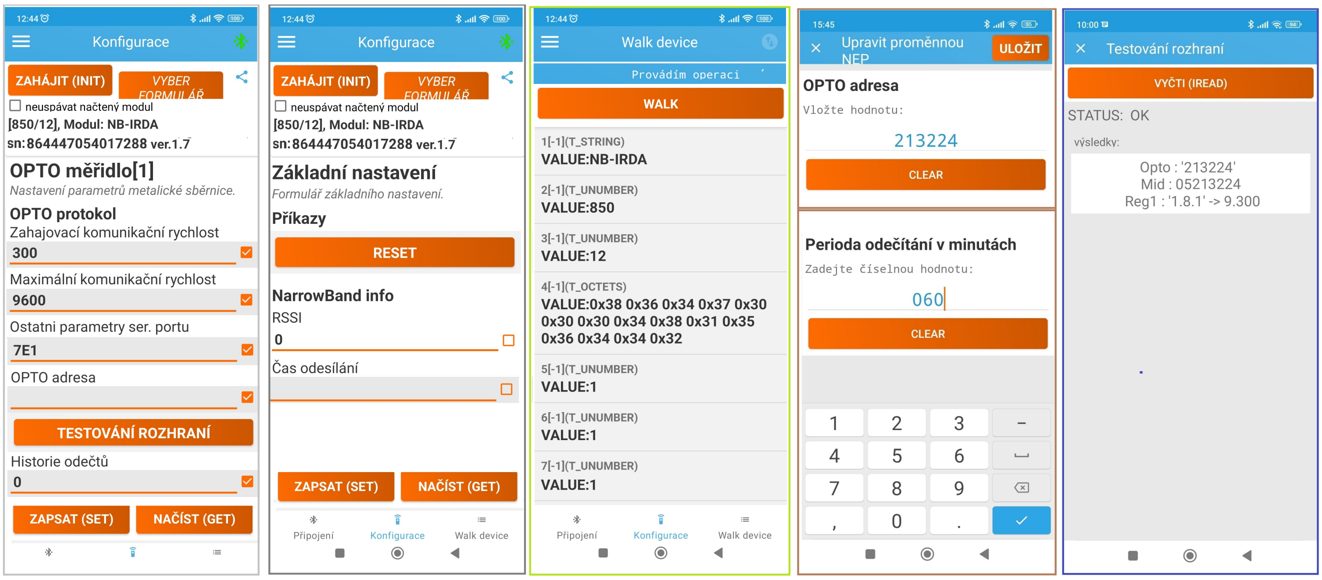


Figure 4: Forms for setting data reading from electricity meters

The brown frame shows the procedure for editing individual items. By clicking on the desired field, an edit window opens in which we set the value and click on the "Save" button in the top bar of the window, which closes the edit window. After editing all fields, we click on the "Write" button at the bottom of the electricity meter setting form. The mobile application sends setting updates to the module and signals confirmation of writing to the configuration by checking the square field on the right.

Using the **"Test interface"** button, you can immediately read the preset registers from the given electricity meter. After clicking on this button, a new window opens with the "Read (IREAD)" button at the top. By clicking on this button, the electricity meter is read and after a few seconds the status of the "OPTO" interface changes to "OK" and the status of the requested registers is displayed. The blue frame on the right shows a preview of the window for reading variables with the read value "Mid" and "Reg 1.8.1".

Using the **"Test transmission"** button, you can immediately send a message with the last read data.

The "SOFTLINK Configurator" mobile application is continuously being developed and improved, so the above previews of information and configuration forms of the NB-IR-V module may change over time.

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

The NB-IoT type network communicates via the standard Internet Protocol (IP), which naturally allows **communication in both directions**. The NB-IR-V module uses the possibility of two-way communication for remote setting of parameters from a remote computer via the so-called **"reverse channel"**, which opens only for two seconds after sending a message (INFO, TRAP, or RESPONSE) to save battery capacity. During this time, the module's receiver is open and the module is able to receive a message from a remote server.

Messages in the reverse direction are used to set module parameters. These **"setting messages"** are encoded by the NEP protocol, so they have essentially the same structure as messages sent by the module (in the data content of the UDP packet, individual variables are transmitted in NEP encoding).

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

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

Using the setting messages of the reverse channel, the same parameters can be set as when setting the module using the optical converter, which communicates with the module on the same principle. More detailed information about the possibilities of communication via the reverse channel can be obtained by inquiring with the module manufacturer.

## 3.4 Overview of module configuration parameters

An overview of the configuration parameters used for user settings of the NB-IR-V module is given in Table ??. The parameters are listed in the table in the same order as they appear in the configuration listing (see paragraph 3.1.1).

| No. | Name | Type | Description | Default |
|---|---|---|---|---|
| 1 | Timezone | number | time zone (time from UTC) | 1 |
| 2 | Server IP | code | target server IP address | |
| 3 | Ping IP | code | IP address for ICMP tests | |
| 4 | Server port | number | target application port number | 4242 |
| 5 | Reply | yes/no | setting response to network message | no |
| 6 | My src port | number | source application port number | read only |
| 7 | APN | text | network access point name | |
| 8 | Max session time | number | maximum connection duration | 2 days |
| 9 | Error restart time | number | connection recovery timeout | 24 hours |
| 10 | Main send period | 0 - 65535 | main transmission period in minutes | 0 |
| 11 | Encryption | code | encryption key | disabled |
| 12 | Next send | curr. state | minutes until next message | read only |
| 13 | No. sent | curr. state | number of messages sent since reset | read only |
| 14 | No. recv | curr. state | number of messages received since reset | read only |
| 15 | Modem state | curr. state | internal GSM module status | read only |
| 16 | Session count | curr. state | number of connections established since reset | read only |
| 17 | Session timeout | curr. state | time until "session timeout" expiration | read only |
| 18 | Modem IMEI | curr. state | unique GSM module identifier | read only |
| 19 | SIM CCID | curr. state | unique inserted SIM card number | read only |
| 20 | SIM IMSI | curr. state | unique SIM card user number | read only |
| 21 | Last RSSI | curr. state | signal level of last received network message | read only |
| 22 | Last IP | curr. state | last assigned IP address from network | read only |
| 23 | Conf. version | curr. state | serial number of stored configuration | read only |
| 24 | SW version | curr. state | software version number and release date | read only |
| *Settings for connected electricity meters 1 - 6* | | | | |
| 25 | Init speed | 300-19200 | Initial bit rate | 300 |
| 26 | Max speed | 300-19200 | Maximum bit rate | 9600 |
| 27 | Parity | code | Serial line parity bit | 7E1 |
| 28 | Meter address | 15 chars | Bus address according to IEC 62056 | - |
| 29 | Register 1 | curr. state | address of read register 1 | read onlyC.1.0 |
| 30 | Register 2 | curr. state | address of read register 2 | read only1.8.1 |
| 31 | Register 3 | curr. state | address of read register 3 | read only1.8.2 |
| 32 | Register 4 | curr. state | address of read register 4 | read only2.8.0 |
| 33 | Rising time | 0 - 255 | Bus power-on timeout | 4 |
| 34 | Falling time | 0 - 255 | Bus power-off timeout | 1 |
| 35 | Response time | 0 - 255 | Timeout for command response | 200 |
| 36 | Delay time | 0 - 255 | Timeout for gap between commands | 10 |
| 37 | Repeat | 0 - 255 | Number of attempts to read data | 2 |
| 38 | Send periode | 65535 | Reading period in minutes | 0 |
| 39 | Send history | 65535 | Storage period in minutes | 0 |

The **"Type"** column shows the type of value for the given parameter. The designation "code" means that the set value is displayed in the form of a hexadecimal code. The designation "curr. state" means that the given data is an operational value that cannot be influenced. A numerical range means that the given value is a number from the specified range.

The **"Default"** column lists the default values set during module production. The color marking of this field has the following meaning:

- green color - most frequently changed parameters, we set them depending on the specific application
- red color - parameters that we do not recommend changing
- gray color - values that cannot be changed ("read only")

**Yellow highlighting** in the "No." column indicates those parameters that can be set using the **USB-IRDA optical converter, or BT-IRDA** as described in detail in section 3.2.

## 3.5 Data Messages of the NB-IR-V Module

### 3.5.1 Structure and Types of Module Data Messages

The NB-IR-V module is used for reading of electricity meters with "IrDA" (InfraRed) interfaces and sending the read data to a superior automatic data collection system via the NB-IOT service of a GSM operator.

NB-IOT services use UDP (User Datagram Protocol) messages for data transfer, which is the transport layer of the Internet Protocol (IP).

The UDP datagram header of the NB-IR-V module consists of three fields:

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

The UDP packet header is followed by the packet data content, in which individual variables are transmitted.

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 5.

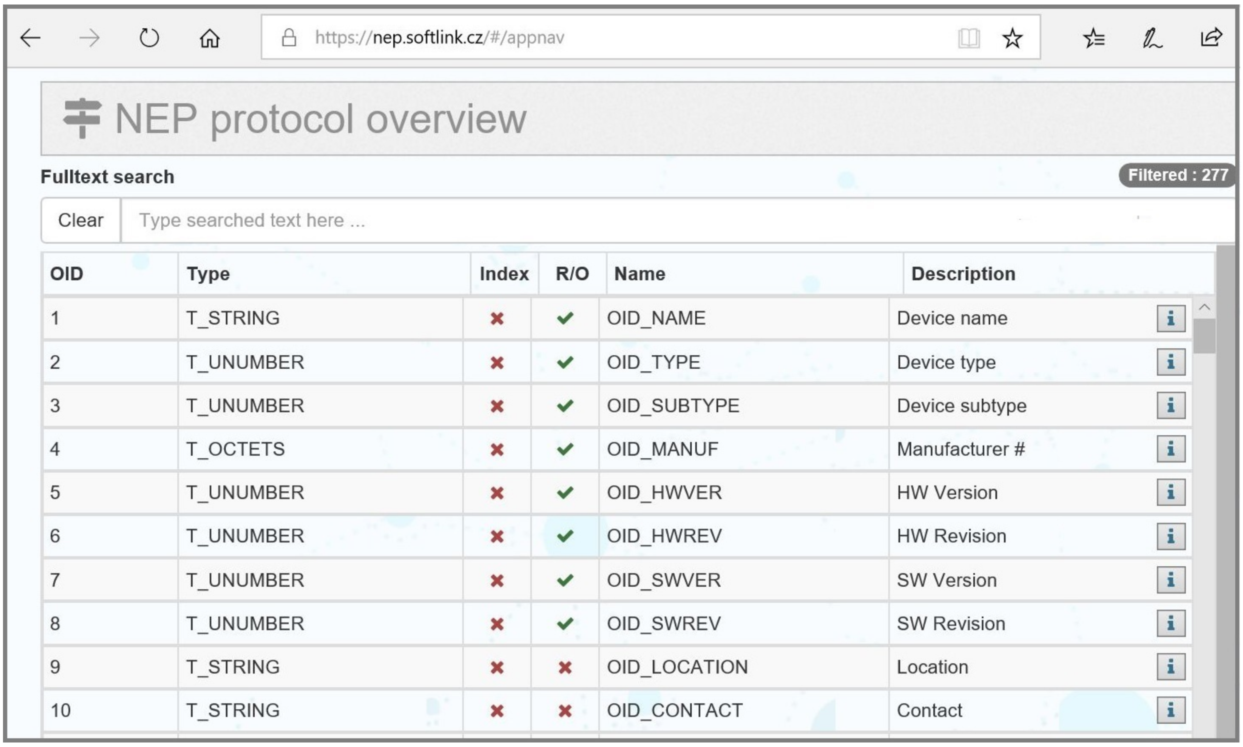


Figure 5: Preview of „NEP coding table" for coding of variables in WACO system

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 data content of the message has a fixed part containing identification data and operational values of the NB-IR-V module itself and a variable part of the message, which contains measured variables. The module generates two types of messages:

- periodically generated messages of type **"INFO"** about the status of variables (electricity meter readings)
- alarm messages of type **"TRAP"** generated by the module immediately after detecting a given event

The module generates these messages either in open or encrypted mode. In addition to these basic types of messages, the module can also generate confirmation messages of type **"RESPONSE"**, which respond to setting messages from a remote server (see paragraph 3.3).

### 3.5.2 Description of INFO Type Message

The main part of INFO type messages are electricity meter readings captured by the module. Along with the readings, identification and operational data of the module are also sent. The module sends INFO messages from each electricity meter either in "online" mode or in "history" mode, with the following rules:

- if the electricity meter is set to "online" mode (i.e., the electricity meter has its own transmission period set), the module sends INFO messages immediately after reading the data with the transmission period of the given electricity meter (see paragraph 3.1.6 "Commands for setting communication with electricity meters"). The message always contains only data from the given electricity meter;
- if the electricity meter is set to "history" mode (i.e., the electricity meter has a period set for storing in the history table), data from this electricity meter is sent with the main transmission period of the module (see "periode" command with index "6"). The message always contains data from all electricity meters that are in "history" mode;
- with combined settings (some electricity meters in "online" mode, some in "history" mode), the module sends messages with several transmission periods simultaneously. Example:

  - electricity meter with index "0" is in "online" mode and has a period set to "60"
  - electricity meter with index "1" is in "online" mode and has a period set to "120"
  - electricity meter with index "2" is in "history" mode and has a period set to "60"
  - electricity meter with index "3" is in "history" mode and has a period set to "30"
  - the module has the main transmission period set to "360" minutes

  With these settings, the module will send data from electricity meter "0" every hour, data from electricity meter "1" every two hours, and a joint message with data from electricity meters "2" and "3" every 6 hours. In the joint message, electricity meter "2" will have six sets of historical readings, electricity meter "3" will have 12 sets of readings in the joint message.

**The fixed part of the message** consists of the first nine variables, which are part of every message. In the examples of messages below, the fixed data are always marked with yellow color in the OID column.

**The variable part** of the message in "online" mode always contains only 4 read variables (without time data). The variable part of the message in "history" mode contains, in addition to the read variables, also **time data** ("Timestamps"), which determine the times of readings of individual variables. The timestamp is always valid for all data that follow it, up to the next timestamp (or to the end of the message).

Variables are assigned to individual electricity meters using the index "x" permanently, as follows: - for electricity meter with index "0", indices 1 to 4 are allocated
- for electricity meter with index "1", indices 5 to 8 are allocated
- for electricity meter with index "2", indices 9 to 12 are allocated
- for electricity meter with index "3", indices 13 to 16 are allocated
- for electricity meter with index "4", indices 17 to 20 are allocated
- for electricity meter with index "5", indices 21 to 24 are allocated

Example of an INFO type message with **current data** from an electricity meter with index "0" in "online" mode:

| OID | Index | OID Name | Description | Example |
|---|---|---|---|---|
| 63 | | Message type | DATA/INFO type message | 6 |
| 2 | | Device Type | Device type | 850 |
| 3 | | Device Subtype | Device modification | 12 |
| 4 | | Manufacturer No. | Device identification | IMEI |
| 12 | | Uptime | Time since last reset (sec) | 186552 |
| 61 | | Sequence No | Unique message number | |
| 105 | 1 | Temperature | Processor temperature in tenths of degree Celsius | 223 |
| 106 | 1 | Voltage | Battery voltage in mV | 3765 |
| 462 | 1 | RSSI | Last RSSI value | -61 |
| 100 | 1 | Input value 1 | Current status of register C.1.0 | 45628533 |
| 100 | 2 | Input value 2 | Current status of register 1.8.1 | 12447 |
| 100 | 3 | Input value 3 | Current status of register 1.8.2 | 0 |
| 100 | 4 | Input value 4 | Current status of register 2.8.0 | 0 |

Example of an INFO type message with **historical data** from two electricity meters with indices "2" and "4" in "history" mode:

| OID | Index | OID Name | Description | Example |
|---|---|---|---|---|
| 63 | | Message type | DATA/INFO type message | 6 |
| 2 | | Device Type | Device type | 850 |
| 3 | | Device Subtype | Device modification | 12 |
| 4 | | Manufacturer No. | Device identification | IMEI |
| 12 | | Uptime | Time since last reset (sec) | 186552 |
| 61 | | Sequence No | Unique message number | |
| 105 | 1 | Temperature | Processor temperature in tenths of degree Celsius | 223 |
| 106 | 1 | Voltage | Battery voltage in mV | 3765 |
| 462 | 1 | RSSI | Last RSSI value | -61 |
| *First TimeStamp and data valid for this timestamp* | | | | |
| 17 | | Timestamp | Reading time (Epoch Unix Time Stamp) | 1549031954 |
| 100 | 9 | Input value 9 | Current status of register C.1.0 | 44832254 |
| 100 | 10 | Input value 10 | Current status of register 1.8.1 | 3257.2 |
| 100 | 11 | Input value 11 | Current status of register 1.8.2 | 2159.3 |
| 100 | 12 | Input value 12 | Current status of register 2.8.0 | 0 |
| 100 | 17 | Input value 17 | Current status of register C.1.0 | 32654487 |
| 100 | 18 | Input value 18 | Current status of register 1.8.1 | 8249 |
| 100 | 19 | Input value 19 | Current status of register 1.8.2 | 0 |
| 100 | 20 | Input value 20 | Current status of register 2.8.0 | 0 |
| *Second TimeStamp and data valid for this timestamp* | | | | |
| 17 | | Timestamp | Reading time (Epoch Unix Time Stamp) | 1549033754 |
| 100 | 9 | Input value 9 | Current status of register C.1.0 | 44832254 |
| 100 | 10 | Input value 10 | Current status of register 1.8.1 | 3259.8 |
| 100 | 11 | Input value 11 | Current status of register 1.8.2 | 2159.3 |
| 100 | 12 | Input value 12 | Current status of register 2.8.0 | 0 |
| 100 | 17 | Input value 17 | Current status of register C.1.0 | 32654487 |
| 100 | 18 | Input value 18 | Current status of register 1.8.1 | 8267 |
| 100 | 19 | Input value 19 | Current status of register 1.8.2 | 0 |
| 100 | 20 | Input value 20 | Current status of register 2.8.0 | 0 |

### 3.5.3 Description of TRAP Type Message

TRAP type messages are used for immediate sending of information about an event detected by the NB-IR-V module. They contain information about the type of detected event (for example, "Processor temperature exceeded limit"), which can be supplemented by one or several parameters of the given event (for example, "Temperature" and "Temperature limit"). In this way, the message recipient receives information that a temperature exceedance has occurred, supplemented by the current temperature reading and the limit that was exceeded.

The type of detected event is encoded into the variable **"Alarm code"** (OID 60 - TRAP CODE), where the variable value determines the event type. The current variant of the NB-IR-V type module supports the following types of events:

- OID 60 - value "0" - event type "RESET"
- OID 60 - value "1" - event type "CONFIGURATION CHANGE"
- OID 60 - value "19" - input in "LOW BATTERY" state - alarm state
- OID 60 - value "20" - input in "BATTERY OK" state - normal state

The "RESET" type event is always generated by the module after it has gone through a reset (immediately after startup).

The "CONFIGURATION CHANGE" type event is generated when a new configuration set is saved to the module's FLASH memory.

The "LOW BATTERY" type event is generated when the supply battery voltage drops below the set threshold value (see the use of the "vbat" command in paragraph 3.1.8). **The fixed part of the message** consists of the first six variables, which are the same as in the INFO type message. However, unlike the INFO type message, the "Message type" variable (OID 63) is set to **value "5"**, which is the flag for a **TRAP** type message. This part is always followed by the variable **"Alarm code"** (OID 60 - TRAP CODE), which carries information about the event type. The "RESET" type event corresponds to **value "0"**. The "Alarm code" variable may be followed by several other variables that specify the event parameters. For example, for a "RESET" type event, there is always one variable of type **"Reset code"** (OID 14 - RESET CODE), which carries information about what caused the reset. In NEP coding, these types of resets are defined:

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

Example of a "TRAP" type message with information that the NB-IR-V module has gone through a "Warm start" type reset (reset given by a regular command):

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

The "CONFIGURATION CHANGE" type event carries the "configuration status" variable (OID 15 - Configuration Status) as additional information. The "LOW BATTERY" type event carries the "battery voltage" variable (OID 106 - Voltage) as additional information.

### 3.5.4 Principle of Message Encryption

Message encryption using an AES key is enabled by setting the encryption key using the **"ekey"** command as described in paragraph 3.1.8 "Commands of the "Utils" group for setting and controlling basic module functions". The message is marked as an "Encrypted message" in the first variable ("Message type") (OID 63 has value **127** - ENCRYPTED MESSAGE). The first six variables of the message are always sent in the clear because they contain identification data and auxiliary data for decryption. The other variables are encrypted using **CFB block encryption** and are transmitted in the message as a single encrypted variable **"Encrypted part of the message"** (OID 19 ENCRYPTED BLOCK). The structure of an encrypted message always looks like this:

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

In the encrypted part of the message, all other variables are block encrypted. The first variable in the encrypted block is always "Message type" (OID 63 MESSAGE TYPE), which determines whether it is an INFO type message (value 6) or a TRAP type message (value 5). Other variables follow in the same composition and order as in an unencrypted message (starting from the seventh variable to the end of the message).

# 4 Operating conditions

This section of the document provides basic recommendations for the transport, storage, installation, and operation of NB-IR-V type radio modules.

## 4.1 General operating risks

NB-IR-V radio modules are electronic devices powered by their own internal battery, which register the status of connected consumption meter counters.

During operation of the device, the following risks are particularly present:

### 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. In normal operation no special precautions are needed, besides avoiding of the mechanical damage from strong pressure or shocks.

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

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

### 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 radio-transmitting.

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

### 4.1.3 Risk of damage by excessive humidity

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

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

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

- install only modules that are correctly assembled, with undamaged box and undamaged rubber seal;
- in case of any doubt perform additional sealing of connection of both parts of the box and both cable bushings by silicon sealant;
- install modules only to the sites where relative humidity exceed value of 95% only occasionally;

- install modules only to the sites where they can be squirted or sprayed by water only occasionally and only for a short time;
- do not install modules to the sites where they can be dipped into the water.

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

- do not open the module with silicon filling without serious reason;
- if (from some reason) the module was already opened, manipulate with it very carefully or renew its silicon filling by pouring of a few milliliters of special silicon (same as original - consult the technique with manufacturer). **In case the module has been opened, there is no manufacturer's guarantee of IP68 degree of protection.**;
- install modules only to the sites where they can be dipped into the water only occasionally and only for a short time;
- do not install modules to the sites where their antenna could be submerged under water. Antenna must be installed to such place, where there is no possibility to be flooded. **Operating of the module with antenna submerged under water could cause irretrievable damage of the device!**

## 4.2 The condition of modules on delivery

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

## 4.3 Modules storage

It is strongly recommended to store the modules in dry rooms or halls, in the temperature interval (0 ÷ 30) °C. To prevent the unwanted discharging of internal battery it is recommended storing the modules with batteries disconnected and activate the battery during mounting (with exception of modules with additional sealing by silicon filling - see paragraph 4.2).

## 4.4 Safety precautions

**Warning!** Mechanical and electrical installation of the NB-IR-V 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 Module installation

NB-IR-V radio modules are enclosed in plastic boxes with IP65 or IP68 protection, prepared for wall or pipe mounting. The battery switch, configuration connector, antenna connector, and terminal blocks for connecting optical heads are located on the printed circuit board, so access to them is only possible after opening the box.

**Modules with additional sealing by silicone filling** (protection degree IP68) have antennas connected during production and are supplied with power turned on. **We recommend opening these modules during operation only when absolutely necessary and proceeding with extreme caution**. We recommend performing installation, replacement, or configuration of these modules exclusively using the USB-IRDA optical converter as described in section 3.2 "Setting module parameters using an optical converter".

Figure 6 shows the NB-IR-V module disassembled into individual components.


Figure 6: Assembly of the NB-IR-V module with a rod antenna

Figure 7 shows a detail of the module's printed circuit board with the location of the configuration connector (outlined in red), the 169 MHz radio antenna connector (marked in blue), the terminal block for connecting optical heads (marked in purple), and the battery switch (marked in yellow). The serial number on the module label must always correspond to the serial number on the auxiliary label affixed to the printed circuit board (data marked in orange). The bottom right inset shows a detail of the IR-15 optical head. The appearance of the printed circuit board may vary slightly depending on the module modification.


Figure 7: Detail of the NB-IR-V module printed circuit board

Figure 8 shows a detail of connecting the IR-15 optical head to the module's terminal block.

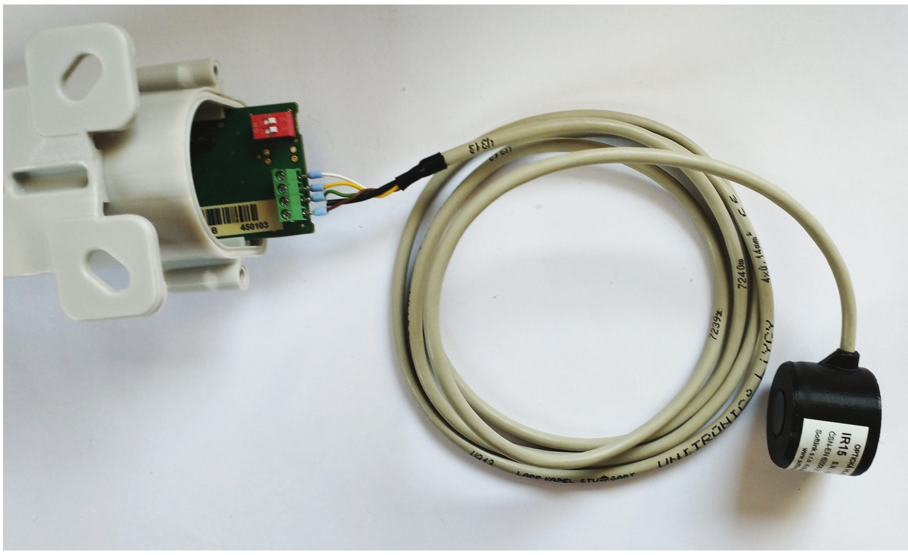

Figure 8: Connecting the optical head to the NB-IR-V module terminal block

The case consists of two parts:

- module housing, into which the printed circuit board is inserted. This part of the case has a label, a window for magnetic attachment of the USB-IRDA/BT-IRDA converter, a cable gland, and mouldings for mounting the module;
- case lid, closing the housing. The lid has a second cable gland.

Installation of a module that is already assembled (including antenna and optical head or bus), pre-configured and turned on, is done as follows:

- attach the module to a suitable fixed object (wall, pipe...) using four screws or a cable tie. The mouldings on the bottom side of the module housing are used for mounting. The recommended mounting position is vertical, with the lid at the bottom;
- attach the optical heads to the electricity meters according to the prepared wiring diagram. **The optical head must be attached to the electricity meter so that the cable to the optical head points straight down**;
- using the USB-IRDA/BT-IRDA converter and the "SOFTLINK Configurator" mobile application, check the module configuration and use the "Read" button to read all connected electricity meters;
- check the tightening of the cap nuts on both cable glands;
- if the installation procedure or the customer's internal rules require sealing of the module (as protection against tampering), seal the module in the specified manner (for example, by gluing a seal over the joint between the two parts of the case).

Before installing a module that is not yet assembled, or is not turned on, or needs to be set up using a cable (*), we must first open the module, assemble it, turn it on and configure it. These operations are performed as follows:

- completely loosen the cap nuts of the cable glands at both ends of the module;
- unscrew the two screws on the sides of the case to release and remove the module lid;
- carefully slide the printed circuit board (PCB) out of the module housing. Either slide the board out completely (if it's necessary to screw on the NB-IoT antenna), or only partially so that the configuration connector is outside the housing (see figure 7). If the NB-IoT modem antenna is already mounted, help yourself when sliding out the PCB by gently pushing the antenna inside the module;
- if the NB-IoT antenna is not mounted on the printed circuit board, screw it to the antenna connector at the end of the module;
- loosen the screws on the terminal block for connecting the optical head, thread the optical head cable through the grommet in the module lid and connect all four wires of the optical head cable to the corresponding terminals of the terminal block. The terminal descriptions are on the top side of the case lid;

- if connecting multiple electricity meters to the module, we recommend connecting only one cable to the input terminal block, which will be used to route the bus to a suitable space near the electricity meters (for example, to the electricity meter cabinet). Connect a more robust auxiliary distribution terminal block to the end of this cable, suitable for connecting multiple cables. Connect the cables from the individual optical heads to the distribution terminal block in parallel (see figure 9;
- switch the micro-switch ("jumper") located on the printed circuit board to the "ON" position to connect power to the module;
- perform basic diagnostics of the module and possibly its configuration (parameter settings) using the cable according to the procedure described in section 3 "Configuration of module parameters". If the module was pre-configured in the preparatory phase of installation, we recommend performing at least a control reading of all connected electricity meters using the "Read" button in the mobile application;
- insert the printed circuit board into the module housing. Insert the board so that the battery micro-switch is on the open side of the housing (i.e. on the side where the lid will be screwed on). The cap nut of the housing cable gland must be completely loosened so that the antenna (or antenna cable) can easily slide out through the grommet from the housing. Push the board all the way in by pressing with your finger on the edge of the PCB (do not press on the terminal block or the micro-switch). In the correct position, the printed circuit board should protrude from the edge of the case housing by only about 7 mm.
- check the integrity of the rubber seal on the edge of the housing and make sure that the cap nut on the lid is completely loosened and the cable to the optical head(s) moves freely through it;
- carefully slide the lid onto the case housing. The cable to the optical head(s) gradually slides out through the lid grommet. Attach the lid to the housing by screwing in and tightening both screws;
- tighten the cap nuts on both cable glands to seal both grommets;
- if the installation procedure or the customer's internal rules require sealing of the module (as protection against tampering), seal the module in the specified manner (for example, by gluing a seal over the joint between the two parts of the case).

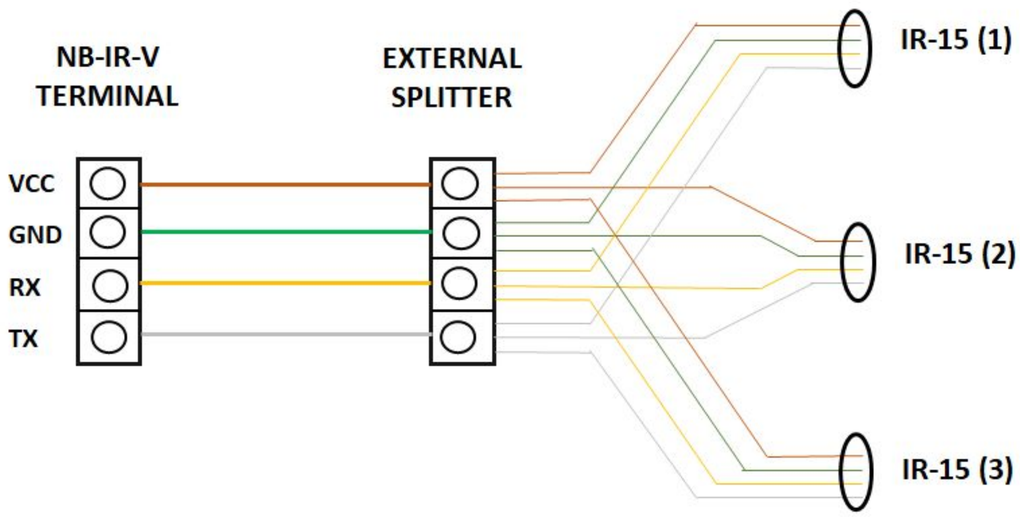


Figure 9: Connecting multiple optical heads using a distribution terminal block

***(*) ATTENTION!*** *For modules with additional sealing using silicone filling with IP68 moisture resistance, do not disassemble the new module during installation under any circumstances! The module configuration must be done using the USB-IRDA/BT-IRDA optical converter*

*In general, the module has the declared degree of moisture resistance (IP65 or IP68) only if it is properly assembled and sealed. Waterproof modules with IP68 protection must be professionally sealed with silicone filling. When installing modules with IP65 moisture resistance, it is necessary to observe these principles::*

*- that the cable glands are properly sealed;*

*- that the joint between the two parts of the case is sealed with an undamaged rubber seal (included in the delivery).*

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

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

## 4.7 Replacement of the module and replacement of the read electricity meter

When replacing the module due to a malfunction of the module, or due to depletion of battery capacity, proceed as follows:

- if the module was sealed, check whether the seal is intact before disassembling the module. Handle seal damage according to the internal rules applicable to the given customer/project;
- loosen the mounting screws (or cable tie) that hold the module to the wall, pipe, or other surface and remove the module;
- if replacing the entire set (module with integrated NB-IoT antenna with already connected optical head or multiple optical heads), simply replace the module "piece-for-piece" and connect the optical heads of the new module to the individual electricity meters;
- visibly mark the original module as "faulty", possibly fill out the appropriate form (installation sheet) or other prescribed documentation for module replacement;
- perform a functionality check on the new module according to the procedure described in section 4.6. Pay particular attention to correctly setting the configuration parameters, especially the transmission period and communication settings with electricity meters;
- write down the serial number and seal number of the new module and possibly the status of the counters of the read electricity meters;
- if possible, immediately ensure the introduction of the new serial number into the collection system database.

If not replacing the entire set (including antenna and optical heads), proceed with the replacement as follows:

- loosen the cap nut on the lid side;
- unscrew the two screws on the sides of the case to release the module lid and carefully slide the lid out of the module. The cable to the optical head(s) slides inside the lid;
- switch the micro-switch ("jumper") located on the printed circuit board to the "Off" position to turn off the module;
- disconnect the cable(s) to the optical head(s) from the module terminal block;
- if the module is equipped with an external 169 MHz antenna, loosen the cap nut on the module housing and carefully slide the printed circuit board out of the housing so that you have access to the antenna connector;
- disconnect the antenna cable from the antenna connector;
- reassemble the original module by screwing the lid to the housing (*). Visibly mark the module as "faulty", possibly fill out the appropriate form (installation sheet) or other prescribed documentation for module replacement;
- attach a new module in place of the original module and proceed further according to the procedure described in section 4.6. Pay particular attention to correctly setting the configuration parameters, especially the transmission period and communication settings with electricity meters;
- write down the serial number and seal number of the new module and possibly the status of the counters of the read electricity meters;
- if possible, immediately ensure the introduction of the new serial number into the collection system database.
- before leaving the installation site, check once more that no optical head has been disconnected or changed position during handling. All optical heads must be attached to the electricity meters so that the cable to the optical head points straight down.

***(*) ATTENTION!*** *When assembling the module, always make sure that the case housing is not swapped, i.e. that we always put the case housing with the correct label on the module PCB. The serial number shown on the module housing must always correspond to the serial number on the auxiliary label that is stuck on the printed circuit board.*

When replacing an electricity meter read by the NB-IR-V module, where the reason for replacement is a malfunction of the electricity meter, expired verification period, or other reason on the meter side, proceed as follows:

- if possible, do not open the module, use the USB-IRDA/BT-IRDA converter and mobile application to rewrite the "OPTO address" identifier of the original electricity meter to the identifier of the new electricity meter and set the reading repeat period;
- use the "Read" button in the mobile application to check whether the new electricity meter responds to queries and whether the read values match the data on the display or counters of the electricity meter;
- if wireless configuration is not possible, check whether the adhesive seal is intact and open the module according to the procedure described in section 4.6;
- connect to the module using the configuration cable and use the "oid [index] [value]" command to set the identifier of the new electricity meter by overwriting the original value (see paragraph 3.1.6 "Commands for setting communication with electricity meters".
- use the "iread [index]" command (see paragraph 3.1.6 to check whether the new electricity meter responds to queries and whether the read values match the data on the display or counters of the electricity meter;
- complete the prescribed documentation for meter replacement (installation sheet), especially carefully record the status of the counters of the new meter;
- cover and seal the module according to the procedure described in section 4.6, or wait for the first reading to be performed;
- If possible, immediately ensure the replacement of the electricity meter identification data in the collection system.

## 4.8 Disassembly of the module

During disassembly, remove the module from the wall (pipe, other surface..), open it, turn off the battery and possibly disconnect the antenna cable. Reassemble the module by putting the lid on the housing, properly mark it as disassembled and fill out the appropriate documentation prescribed for this case by internal regulations. If possible, immediately ensure deactivation of the module in the collection system.

## 4.9 Module functionality check

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

- check the setting of basic module parameters, especially the message sending system parameters (encryption, transmission period, path to the superior server) according to paragraph 3.1.7;
- perform a communication check with electricity meters using the "iread" and "send" commands via the configuration cable, or via the mobile application using the "Test transmission" and "Read" buttons.
- verify sufficient coverage of the installation site with NB-IoT radio signal by sending several test messages using the "send" command according to paragraph 3.1.5 "Commands of the "System commands" group for checking basic module functions" and their successful reception in the central system. An informative data on network signal availability can be obtained by checking the RSSI value in the configuration parameter listing, or in the optical configuration form (value "Last RSSI");
- a comprehensive (end-to-end) check of remote reading functionality can be performed by checking in the reading system whether data from all connected electricity meters are correctly loaded. If the reading period is long, or if it is not possible to wait for the message to be sent at the standard interval, we can use the function of immediate message sending as described in the previous paragraph.

## 4.10 Operation of the NB-IR-V module

The NB-IR-V module performs remote reading of electricity meter status and sending of radio messages with readings completely automatically. The greatest risks of permanent failure of radio module transmission are associated with the activities of the facility user, especially the risk of mechanical damage to modules when handling objects at the installation site, damage to the module by water ingress, or the risk of signal shading by a metal object. A typical consequence of damage is a complete loss of connection with the module.

To eliminate these risks, we recommend paying great attention to the selection of the module installation site and the selection of the type and location of antenna installation so that a suitable compromise is found between the quality of the radio connection via the NB-IoT network and the degree of risk of mechanical damage to the module, the cable between the module and the electricity meter, the antenna cable, or the antenna. The installation itself needs to be carried out carefully, using quality cables and mounting elements.

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

The risk of premature battery discharge can be easily eliminated by respecting the recommendations given in paragraph 4.1.2.

# 5 Troubleshooting

## 5.1 Possible Causes of System Failures

During operation of the NB-IR-V device, failures, functional outages, or other operational problems may occur, which can be categorized according to their cause as follows:

### 5.1.1 Power supply failures

The module is powered by an internal battery with a long lifetime. The approximate battery lifetime is specified in more detail in paragraph 1.3 "Module features". The battery lifetime is influenced by circumstances described in detail in paragraph 4.1.2 "Risk of premature internal battery discharge". Low voltage of the power supply battery initially manifests as irregular data reception failures from the given module, later the radio connection with the module is interrupted completely. The battery is soldered onto the printed circuit board and its replacement requires disassembly of the module. Battery replacement can only be performed by a person with appropriate qualifications and experience; soldering the battery by an unqualified person risks damaging the module's printed circuit board. The "NB" series modules use only the highest quality batteries that have been carefully selected and tested for this purpose. In case of battery replacement by the device user, the new battery must match the original battery as closely as possible in its parameters (type, capacity, voltage, current load, self-discharge current...). The module manufacturer strongly recommends using the same type of battery for replacement as was used in the module during its production.

### 5.1.2 System failures

System failures are considered to be mainly processor failures, memory failures, internal power supply failures, or other fatal failures that cause complete device malfunction. If the device is in a state where the battery has the correct voltage and shows no signs of discharge, yet the device does not communicate through the configuration port, does not respond to any configuration commands, and this state does not change even after performing a module restart, it is likely a system failure. We perform device replacement according to paragraph 4.7 and then perform setup and functionality check of the new (replaced) device. If the new device functions normally, we mark the original module as defective and record the replacement data in the operational documentation according to internal rules.

### 5.1.3 NB-IoT Network Communication Failures

The functionality of transmission to the NB IoT network is indicated by the flashing of a yellow LED on the printed circuit board. If the module's power supply has the correct voltage, the module communicates through the configuration port, responds to configuration commands, and yet no messages are received from it, the cause may be a fault related to radio signal transmission or reception. A typical symptom of transmission and reception faults are also states of "partial" functionality, which manifest especially in frequent dropouts in data reception from the module. The cause of the above-described communication faults of the module may be unreliable radio data transmission, which may be caused by:

- weak NB-IoT network radio signal at the installation site. Network signal availability may change over time depending on weather conditions (fog, rain...), or as a result of changes at the transmission site and its surroundings (for example, change in the location of the base station antenna by the network operator, or construction activity in the vicinity of the base station);

- permanent or temporary signal shading due to construction modifications in the building of the module installation site, or due to operations in the given building (movement of mechanisms, machines, cars near the device);
- permanent, periodic, or irregular radio interference of the radio network by parasitic signal from an external source (operation of another system in the same radio band, industrial interference);
- low level of transmission signal, caused by a fault in the module's transmitter;
- low level of received signal due to a fault in the module's receiver;
- damage to the antenna or antenna cable (only for module types with external antenna).

If the above-described symptoms of unreliable radio transmission occur, we proceed as follows when searching for and eliminating the causes of the problem:

- we perform a visual inspection of the module installation site and determine whether there have been any construction modifications or other changes in the building that could affect the propagation of the radio signal. We address any negative impacts of such changes and modifications organizationally, or (if possible) by changing the location of the device, or by relocating the antenna (for modules with external antenna);
- for modules with external antenna, we perform a visual inspection of the antenna and antenna cable, possibly also replacing these components with other components with verified functionality;
- we check the configuration parameters of the module and check the functionality of the module according to paragraph 4.9;
- we replace the module according to paragraph 4.7 and then set up and check the functionality of the new (replaced) module according to paragraph 4.9;
- if after performing the replacement under the circumstances described in the previous point, the replaced module also does not work correctly, the cause of the problem may be local radio interference, or the cause is insufficient network signal at the installation site. In this case, we consult the current status and possible future development of NB-IoT network signal coverage at the installation site with the service provider.

### 5.1.4 Communication Failures with Electricity Meters

Failures in the functionality of reading data from electricity meters through the optical interface generally manifest as missing readings from some electricity meters in the incoming data. In this case, we proceed to determine the likely cause of the failure as follows:

- If messages from a particular electricity meter are not coming at all, we check whether the identifier (OID) of that electricity meter is correctly entered in the table of read electricity meters (see paragraph 3.1.6 "Commands for setting communication with electricity meters") and whether this setting matches the records in the reading system database;
- We visually check the condition of the connected electricity meter, especially the correct placement of the optical head, the integrity of the cable between the optical head and the module, and the correct connection of the optical head to the module's terminal block or to the distribution terminal block. **The optical head must be placed on the electricity meter so that the cable to the optical head points straight down**;
- We check the reading of the message from the given electricity meter using the "iread" command (see paragraph 3.1.6 "Commands for setting communication with electricity meters"), or using the "Read" command in the mobile application;
- If the module does not read the data using the "iread"/"Read" command, we check the communication parameter settings ("ispeed", "parity", "irt", "ift", "iresp") for the given type of electricity meter. If a different speed is set, we try to reduce the initial communication speed to the minimum (300 bps);
- We visually check if there is a strong interfering light source near the electricity meter. Optical communication can be disrupted by strong light at the installation site, or even sunlight falling on the optical interface sensor. If the presence of such an interfering source is detected, we permanently shade it;
- We make sure that the electricity meter has communication enabled via the optical interface;
- If we fail to read data even after the above checks and actions, we replace individual components (module, cable, electricity meter).

## 5.2 Procedure for Determining the Cause of Failure

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

1. If data is not being read from any electricity meter connected to the NB-IR-V module, we recommend checking the functionality of individual subsystems of the module in this order:
   - check the correctness of the module settings in the remote reading system database;
   - check the power supply functionality according to paragraph 5.1.1 "Power Supply Failures";
   - check the system functionality according to paragraph 5.1.2 "System Failures";
   - check the functionality of data transmission and reception according to paragraph 5.1.3 "NB IoT Network Communication Failures";
   - check the functionality of correct radio message reception according to paragraph 5.1.4 "Communication Failures with Electricity Meters".
2. If data is not being read only from some of the read electricity meters, we recommend checking the functionality of individual subsystems of the module in this order:
   - check the functionality of the electricity meter itself and the correctness of its settings (especially whether communication via the optical interface is enabled);
   - check the correctness of the address setting of the given electricity meter in the configuration of the central data collection system, especially the consistency with the identifier and index settings in the table of read electricity meters of the module;
   - check the functionality of correct radio message reception according to paragraph 5.1.4 "Communication Failures with Water Meters".
3. Data from some connected water meter is incorrect. In this case, we recommend checking the functionality of the given water meter.
4. Data from the module comes irregularly, with periodic outages. In this case, we recommend checking the functionality of individual subsystems of the module in this order:
   - check the functionality of data transmission and reception from the NB IoT network according to paragraph 5.1.3 "NB IoT Network Communication Failures";
   - check the power supply functionality according to paragraph 5.1.1 "Power Supply Failures".

**WARNING: The NB-IR-V module is a reliable device of relatively simple and durable construction, so there is a high probability that any failure is caused by external circumstances of installation, especially mechanical damage, moisture ingress, battery depletion, or radio interference at the installation site. With each module replacement due to failure, we recommend verifying, if possible, whether the cause of the failure was not one of these circumstances and, if necessary, take measures to eliminate it.**

# 6 Additional information

This manual focuses on the description, parameters and configuration options of NB-IR-V type radio modules designed for operation in the NB-IoT network, which are part of the **wacoSystem** product family by SOFTLINK. Further information about the NB (NB-IoT), WS868 (Sigfox), WM868 (WACO), or WB169 (Wireless M-Bus) type series modules can be found on the manufacturer's website:

www.wacosystem.com
www.softlink.cz

If you are interested in any information related to the use of NB, WS868, WM868, WB169 series radio modules, or other SOFTLINK manufacturer's devices for telemetry and remote reading of consumption meters, you can contact the manufacturer:

**SOFTLINK s.r.o.**, Tomkova 409, 278 01 Kralupy nad Vltavou, Czech Republic, Phone: +420 315 707 111, e-mail: sales@softlink.cz, WEB: www.softlink.cz.