LORAWAN NB-IOT MODEM

VEGA SH-02

User manual

Document Information

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This document applies to the following products:

Product line	Product name
End devices	Vega SH-02

Revision History

Revision	Date	Name	Comments
01	25.03.2019	KEV	Document creation date
02	05.04.2019	KEV	Case dimensions are changed
03	15.07.2019	KEV	Minor changes
04	09.10.2019	KEV	Description of data collection and transmission settings through the LoRaWAN was supplemented
05	22.10.2019	KEV	Device operates only as LoRaWAN class A device, communication protocol changed
06	06.07.2020	KEV	Scheduled revision of the document, minor changes

CONTENTS

INTRODUCTION

This manual is designated for Vega SH-02 modem (hereinafter – the modem) manufactured by Vega-Absolute OOO and provides information on powering and activation procedure, control commands and functions of the modem.

This manual is targeted at specialists familiar with installation work fundamentals of electronic and electrical equipment.

> **To provide the stable radio between the gateway and the end device it is recommend avoiding the device installation in the places which are barriers for the radio signal getting through like a reinforced floors and walls, a basement, an underground facilities and wells, a metal case etc. The necessary stage for the network deploying including a big quantity of end devices is a radio planning work with nature experiments**

Vega-Absolute OOO reserves the right to make changes to the manual related to the improvement of equipment and software, as well as to eliminate typos and inaccuracies, without prior notice.

1 DESCRIPTION AND OPERATION

DEVICE DESCRIPTION

Vega SH-02 modem is designed for collection the data from external connected devices, further accumulating and transmitting of this information in the LoRaWAN or LTE NB-IoT network.

The modem collects the data from the external devices with configurable period of 5, 15, 30 minutes, 1, 6, 12 or 24 hours. Collected data is saved in modem memory as a packet with specified time of collect and transmitted at the next communication session with LoRaWAN network. Memory can hold up to 100 packets.

The modem has two digital inputs which may be configured as pulse or security. Besides the device has two analog inputs, 1-Wire and RS-485 interfaces.

Communication period can be equal to 5, 15, 30 minutes, 1, 6, 12 and 24 hours. While communication session the modem transmitting saved packets from the earliest to the latest.

The modem is powered by a one or two 6400 mAh built-in battery or an external power supply 4.5...55 V.

The internal clock is set automatically when device connected to the "Vega LoRaWAN Configurator" via USB, also adjustable via LoRaWAN.

The modem can transmit collected data via LoRaWAN or LTE NB-IoT technology (see part 4).

2 SPECIFICATION

Main

Digital inputs	2
Analog inputs	2
Interface	1-Wire / RS-485 (modbus)
USB-port	micro-USB, type B
Operating temperatures	-40...+85 °C
Communication channels	LTE NB-IoT or LoRaWAN
Internal temperature sensor	yes
Communication period	5, 15, 30 minutes, 1, 6, 12 or 24 hours
Data collection period	5, 15, 30 minutes, 1, 6, 12 or 24 hours
Memory amount for storing packets	100 packets

Cellular

Supported cellular standards	LTE Cat NB1
Communication protocol	MQTT
Battery life up	3 years with one battery and communication period 24 hours
LTE NB-IoT antenna type	external

LoRaWAN

|	
LoRaWAN class	A
Quantity of LoRaWAN channels	16
Frequency plan	RU868, EU868, IN865, AS923, AU915, KR920, US915, KZ865, custom (EU868 based)
Activation type	ABP or OTAA
Type of the LoRaWAN antenna	external
Sensitivity	-138 dBm
Radio coverage in restrained urban conditions	up to 5 km
Radio coverage within line of sight	up to 15 km
Transmitter power by default	25 mW (configurable)
Maximum transmitter power	100 mW
Battery life up	10 years with one battery and communication period 24 hours

Power

Built-in battery	6400 /12800 mAh
External power supply	4.5...55 V

Case

Housing dimensions (without cable gland and SMA-connector)	95 x 95 x 50 mm
Ingress protection rating	IP65

3 OPERATION

CONTACTS
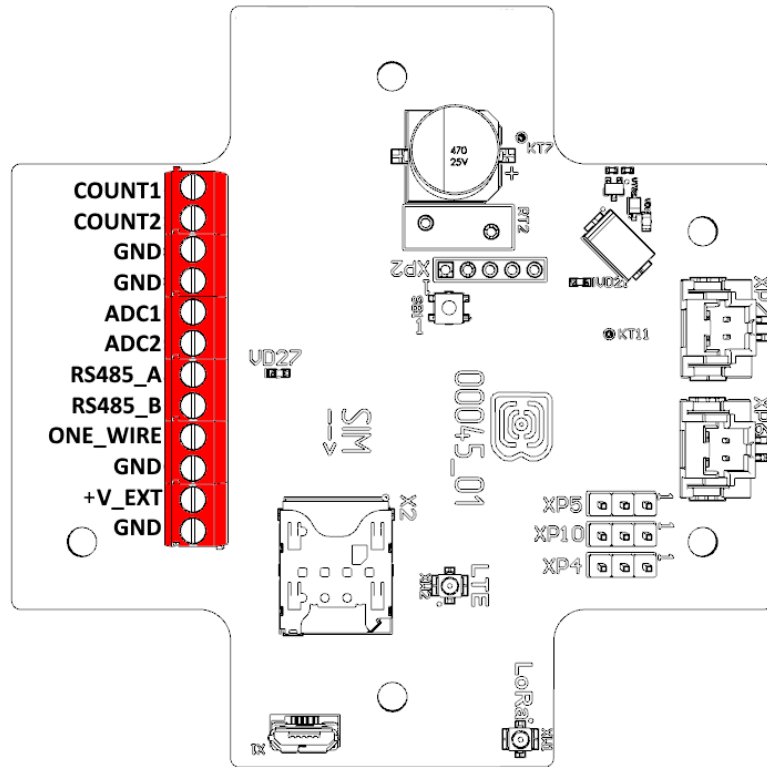
Description of contacts in the table below.

Contact	Name on the board	Description
1	COUNT1	Digital input 1
2	COUNT2	Digital input 2
3	GND	Ground
4	GND	Ground
5	ADC1	Analog input 1 (0...21 B)
6	ADC2	Analog input 2 (0...21 B)
7	RS485_A	RS-485 Interface A
8	RS485_B	RS-485 Interface B
9	ONE_WIRE	1-Wire Interface
10	GND	Ground
11	+V_EXT	External power +
12	GND	External power -

Digital inputs COUNT1 and COUNT2 may operate in pulse or security mode. If the input has not connected there is a logic '1'.

In the pulse mode the modem counts the number of pulses at the input. Fixation is by the impulse slump. In the security mode the modem monitors the input state change and send an alarm message into the network by the one of events: security circuit close, unclose or both of it. You can choose the event for security input triggering via the "Vega LoRaWAN Configurator" application.

Analog inputs ADC1 and ADC2 may be used for measuring an external voltage from 0 to 21 V.

RS-485 (modbus) and 10Wire interfaces cannot connecting at the same time. Switching between two interfaces carried out with jumpers on the XP4 and XP5 connectors on the board.

1-Wire interface allows to connect is up to 10 external thermistors (see part 4).

Jumpers disposition for RS-485 interface operating

Jumpers disposition for 1-Wire interface operating
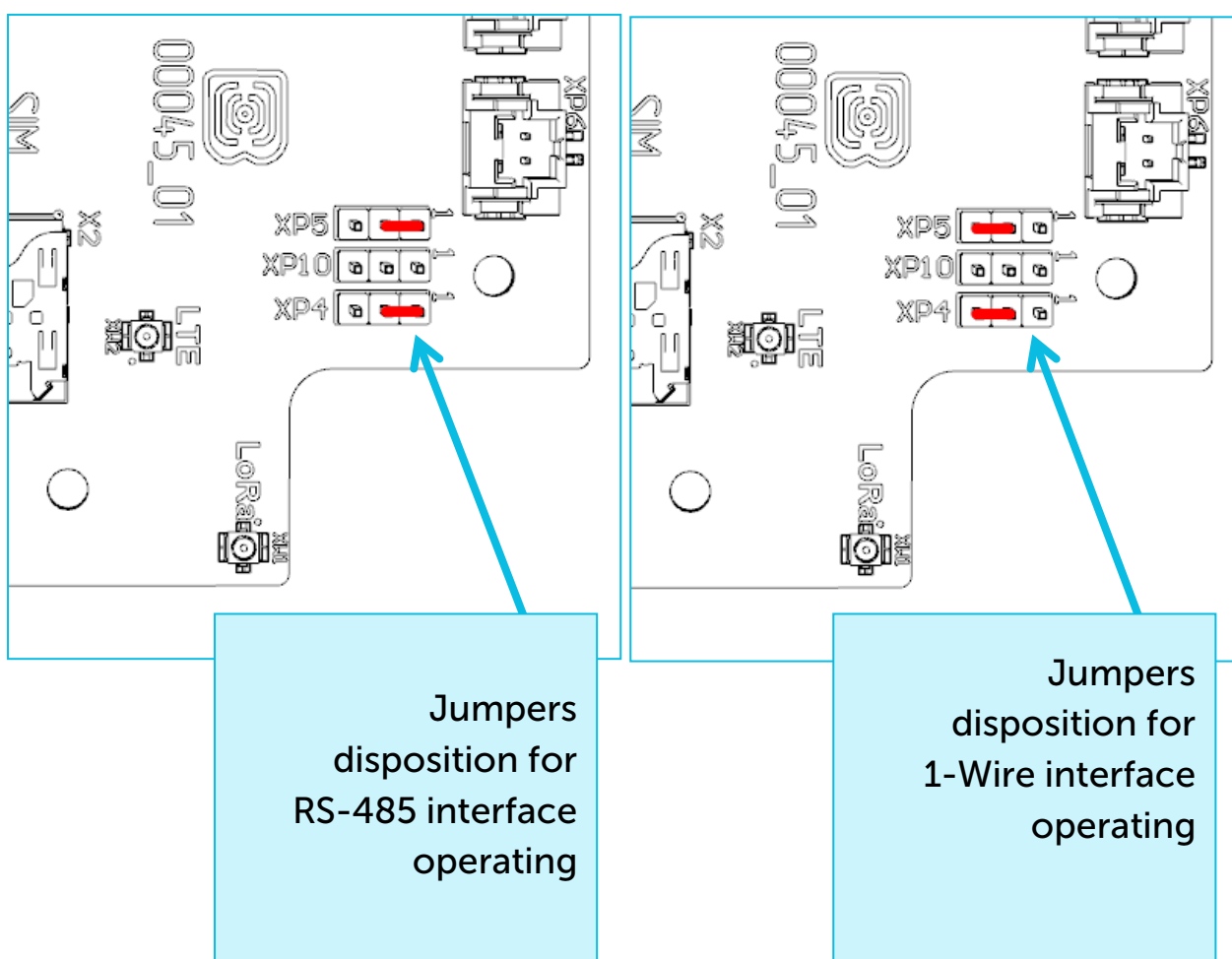
INDICATION

There is a red LED on the board. The indication is only used when the device is activated in the LoRaWAN network, when data transmitting via NB-IoT technology and when the operating modes are changed. Also, there is a green LED which used only for configuring during manufacture.

Red LED on the board
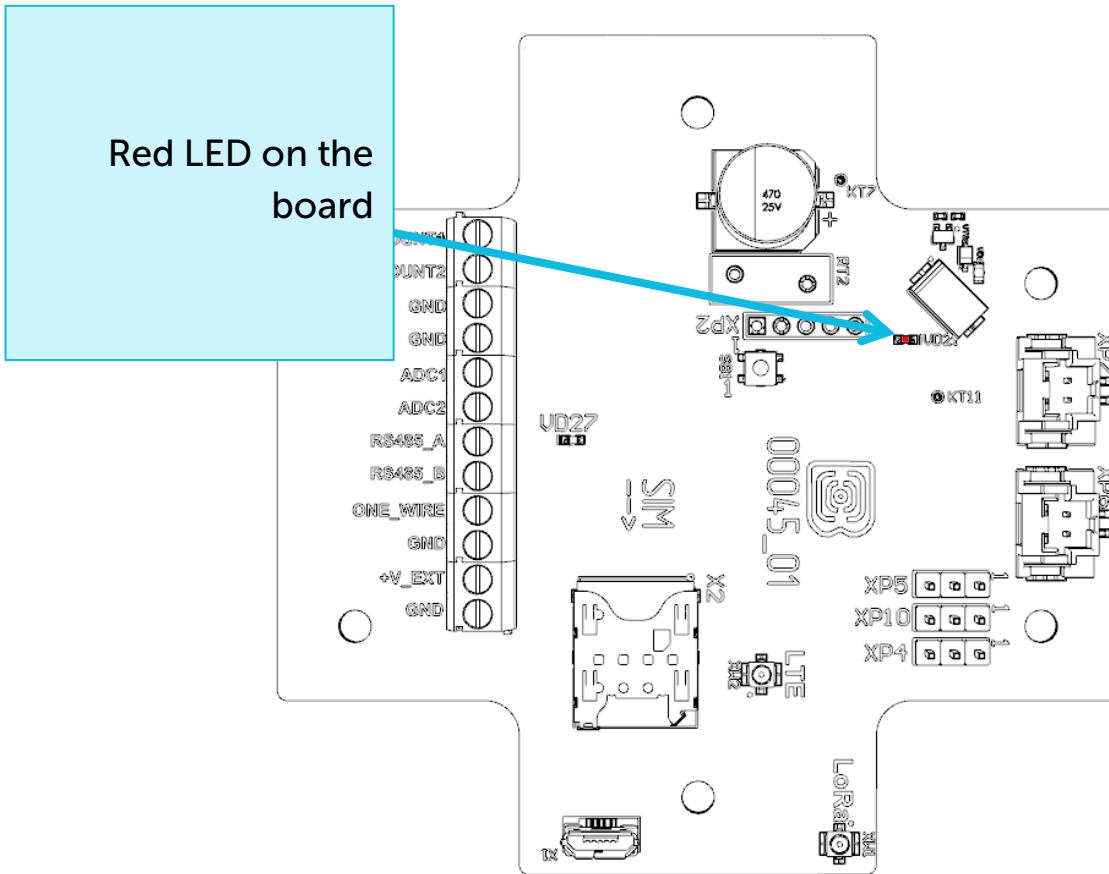
LED signal		Meaning
	Flash every 5 seconds	Device not sleeping/USB connection
	LoRaWAN technology	
	Series of short flashings	Linking to the LoRaWAN network
	One long flashing	The device connected to the network and is in active mode
	Three long flashings	Device switched to the «Storage» mode

NB-IoT technology

|		
	Two short flashings every 2 seconds	Linking to the NB-IoT network
	Three short flashings every 2 seconds	The device connected to the network and transmits the data on the server
	Short flashings for 1.5 seconds	Successful data transmitting

INITIAL STARTUP

The SH-02 modem can be powered from either an external power source or built-in battery. To operate from the built-in battery, you must connect the battery connector to the one of power connectors on the board which XP7 or XP6 marked. In case of operation with two batteries you should use the both connectors.

Connectors for batteries
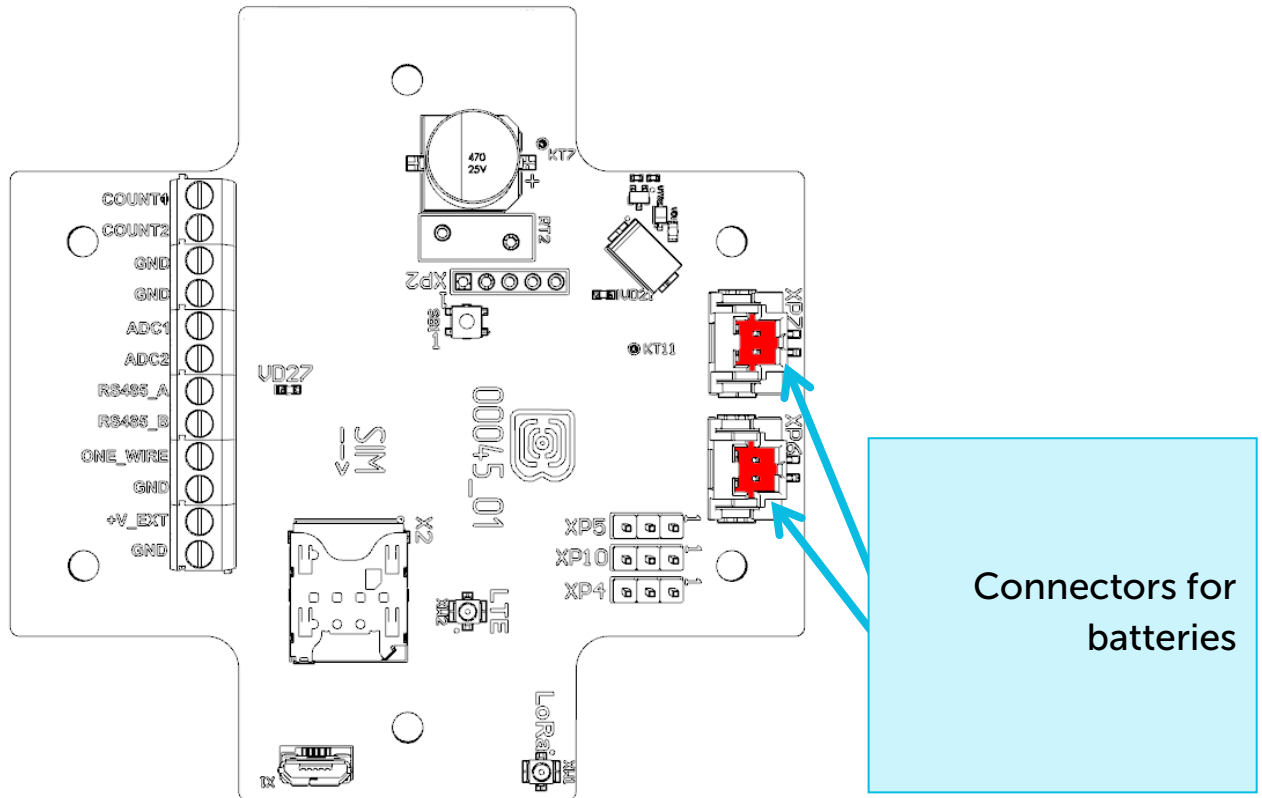
The modem can operate through one of two technologies - LoRaWAN or LTE NB-IoT what is choose via the "Vega LoRaWAN Configurator" application (see part 4).

LORAWAN TECHNOLOGY OPERATION

The modem supports two activation methods in the LoRaWAN network - ABP and OTAA. Select one of the methods using "Vega LoRaWAN Configurator" application (See part 4).

1. ABP. After power supply connection, the device immediately begins to operate in the "Active" mode.

2. OTAA. After pressing the start button, the device makes three attempts to connect to the network within the set frequency plan. After the activation in the LoRaWAN network is confirmed, the device sends a signal (LED flashing for 3 seconds) and switches to the "Active" mode. If all attempts fail, the converter will continue to accumulate data and will attempt to connect to the network every 24 hours.

NB-IOT TECHNOLOGY OPERATION

Before starting it is necessary to configure data transmitting via "Vega LoRaWAN Configurator" application (see part 4) and set SIM card in the slot on the board.


SIM card slot for micro-SIM format
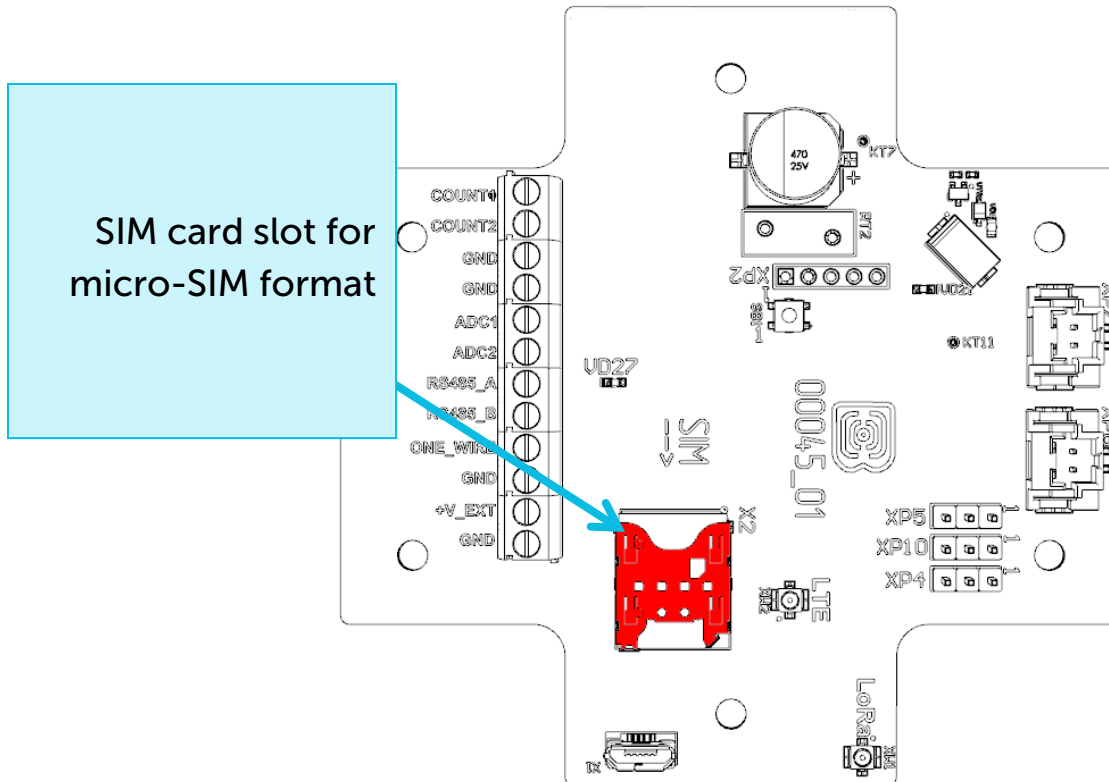
When some event occurs (schedule time, alarm etc.) the modem begins registration in the network. After registration and data transmitting or if the data transmitting is unsuccessful the modem switch to the lower power consumption mode until the next communication session according to the schedule.

CONNECTING VIA USB

The modem can be adjusted with the "Vega LoRaWAN Configurator" application (See part 4). The modem must be connected to the computer via USB for that.

Before connecting the device to the computer for the first time, you must install the driver for the COM port **stsw-stm32102**, which can be download from iotvega.com. After running the executable file **VCP_V1.4.0_Setup.exe**, the installer window will appear:
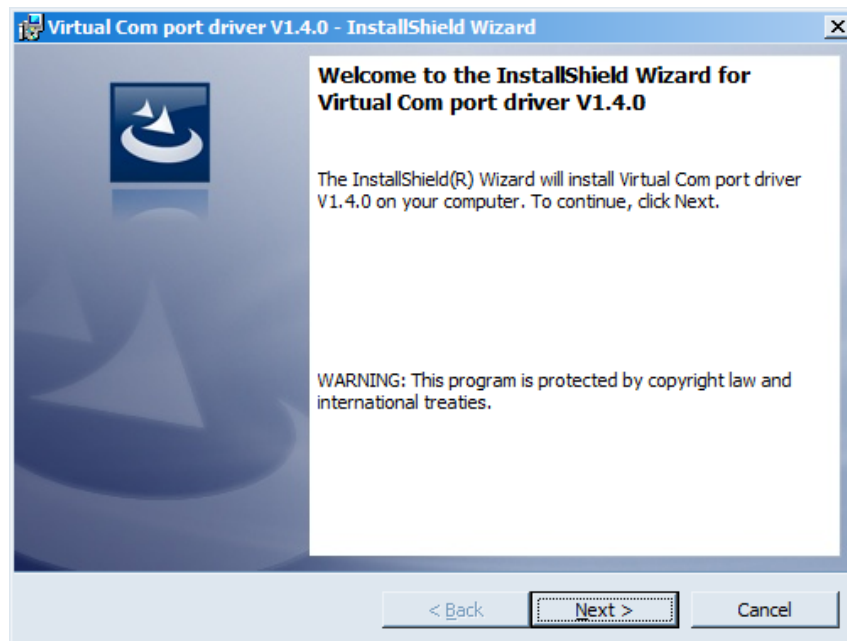
In this window, you need to click **Next**, then **Install**, and then the installation will begin. When the installation complete successfully, the following screen appears:
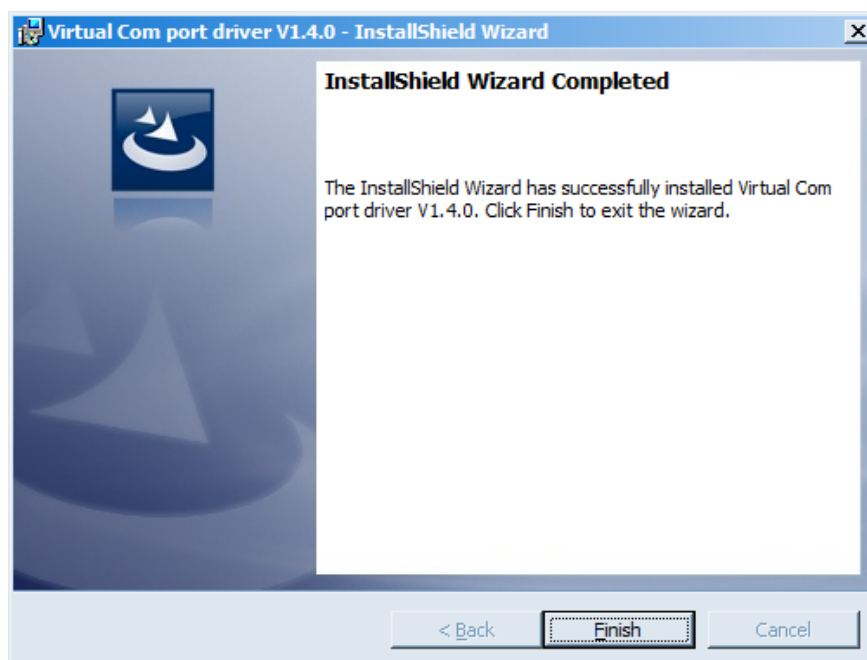
After pressing **Finish** the driver is ready for operation, - it is possible to connect the modem via USB.

4 VEGA LORAWAN CONFIGURATOR

The "Vega LoRaWAN Configurator" application (hereinafter referred to as the configurator) is intended for setting up the device via USB.

> **For NB-IoT module testing you should to use an additional power – from battery or an external, because USB power is not enough for NB-IoT module operation**

The configurator has two modes of operation - "Simple" and "Expert". In the "Simple" mode, only basic settings are available. In the "Expert" mode, the basic settings, advanced settings and the ability to check the coverage area of the signal from the gateways are available. Next, the work of the application considering in the "Expert" mode.

INTERFACE OF THE APPLICATION

The "Vega LoRaWAN Configurator" application does not require the special installation. When the executable file launching, the window for working with the application appears.
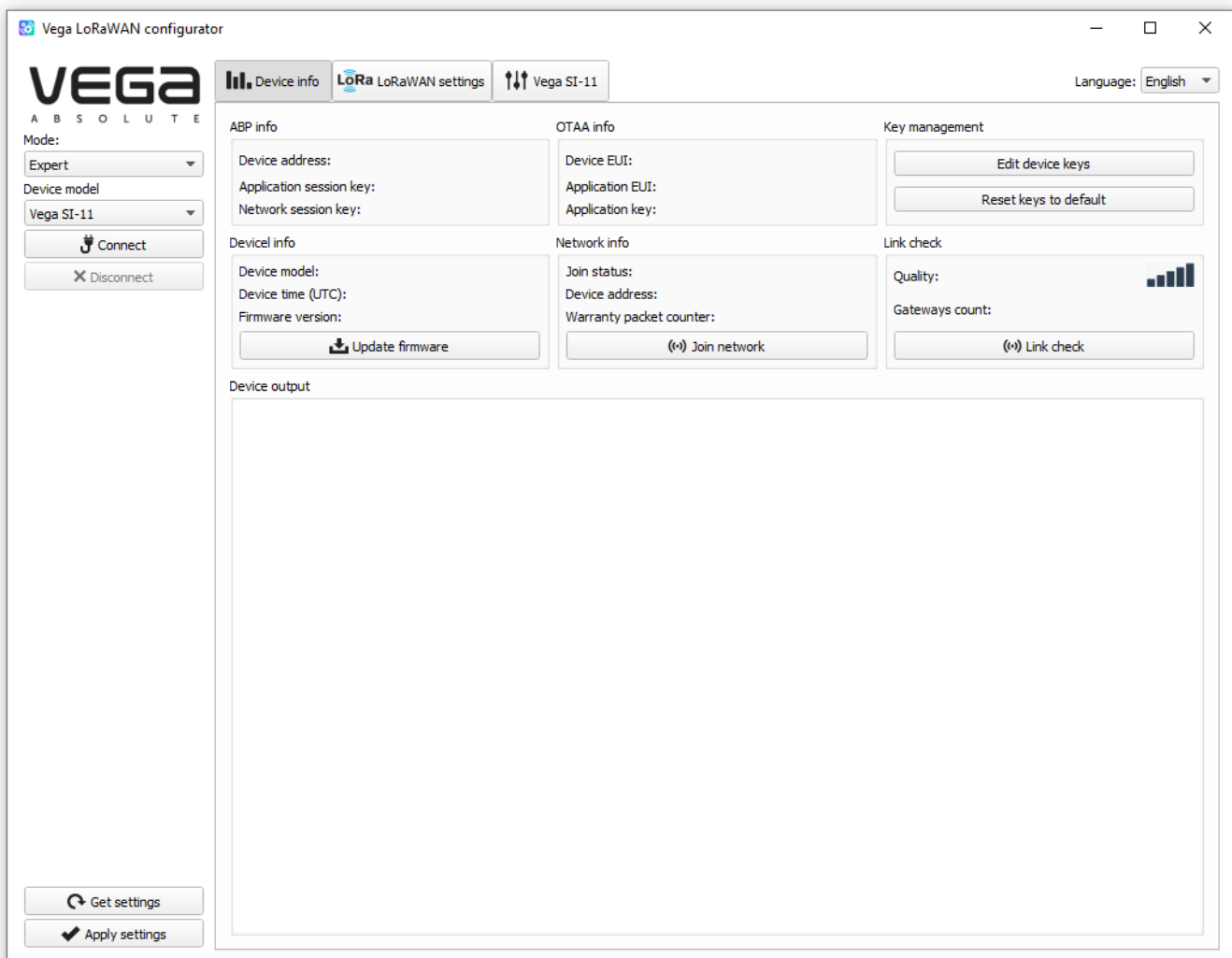
The menu on the left allows you to switch between the "Simple" and "Expert" modes, select the device model, connect to the device, or disconnect from it, get, and apply settings.

The application window contains three tabs – Device info, LoRaWAN settings and device settings.

The language selection menu is in the upper right corner.

CONNECTION TO THE DEVICE

For the connection to the device, perform the following steps:

1. Connect the USB cable to the device.
2. Start the "Vega LoRaWAN Configurator" application.
3. Click the "Connect" button in the menu on the left.

The application automatically recognizes the type of device, and the device selection menu becomes inactive.
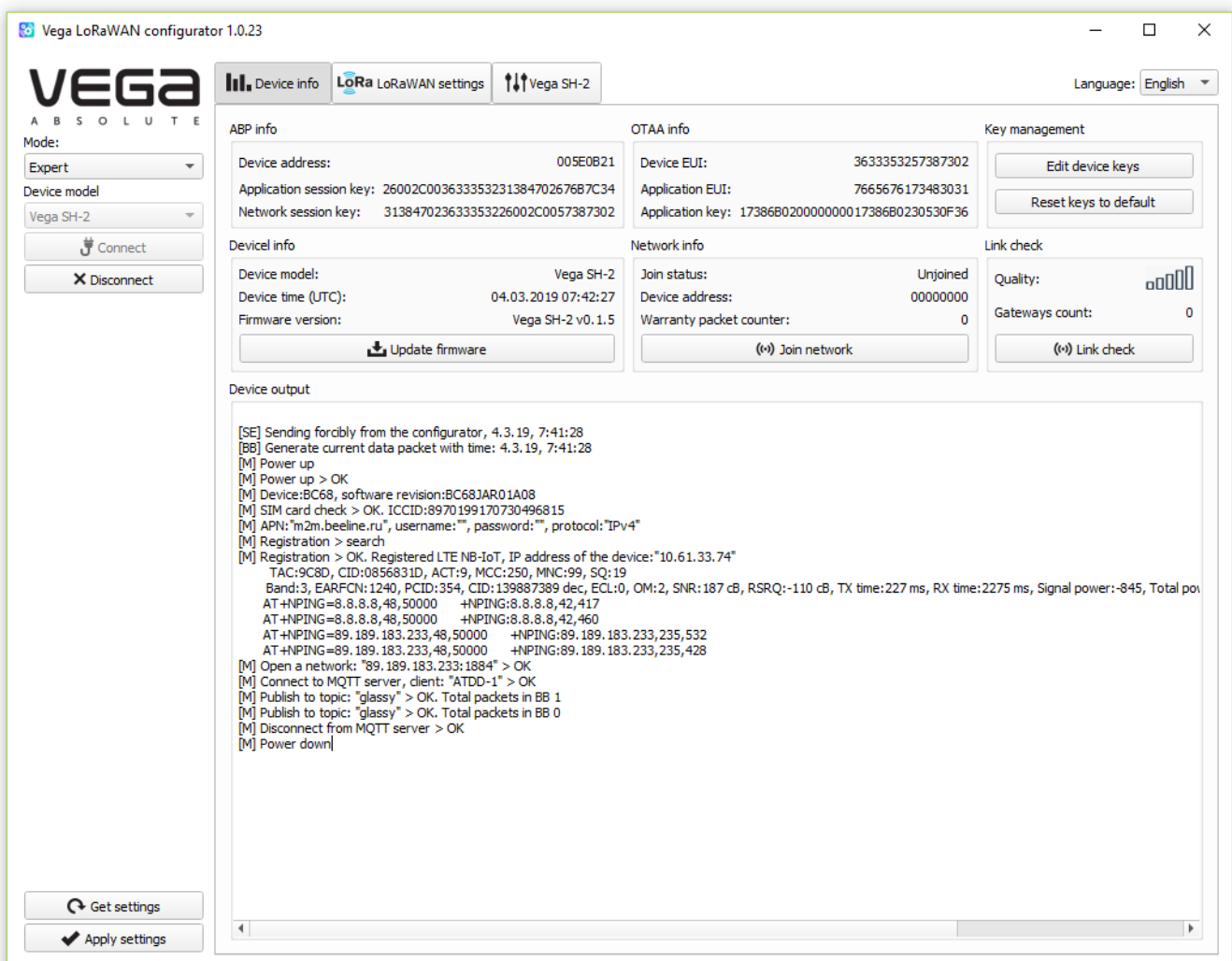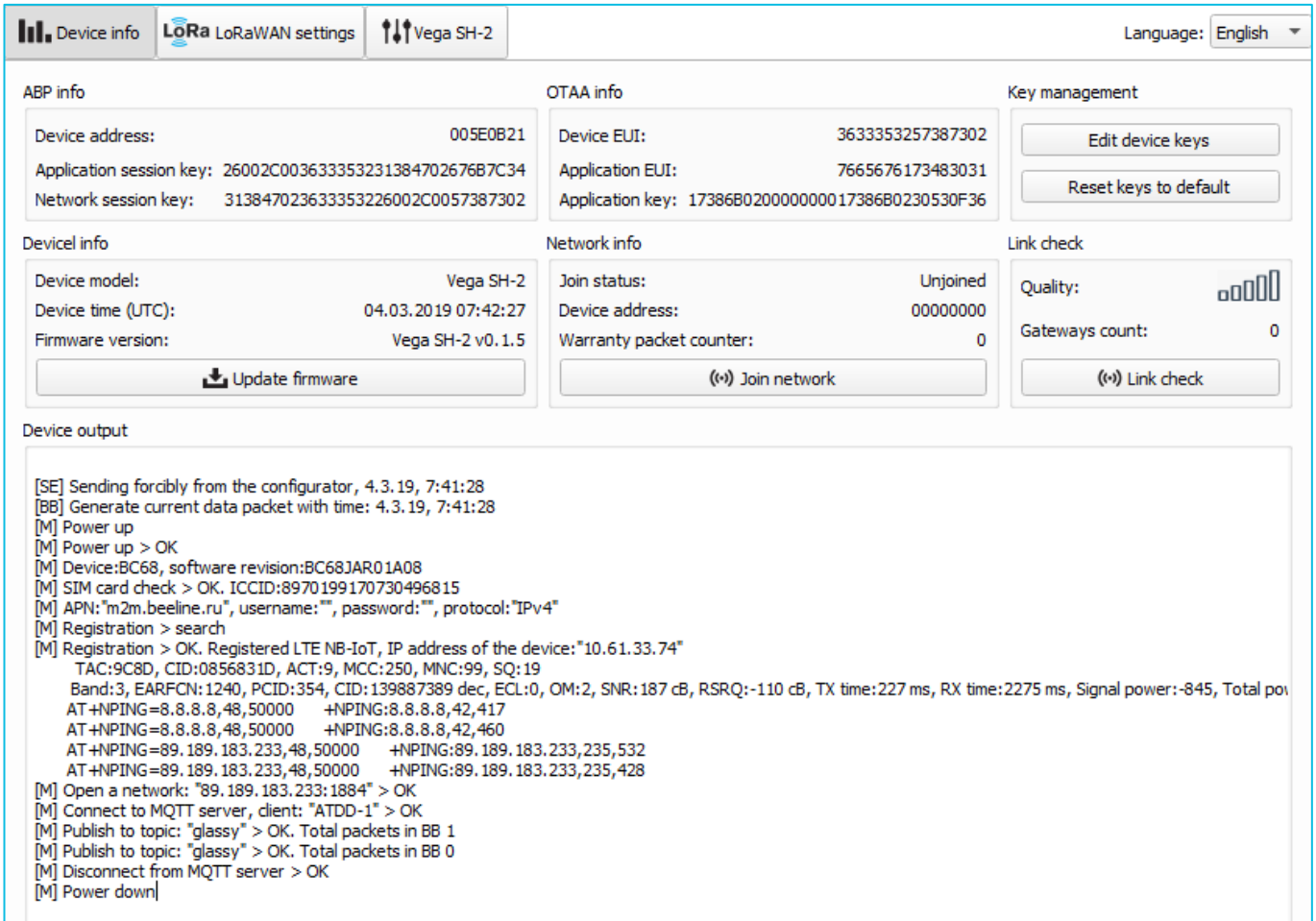

To read the settings from the device, you need to click the "Get settings" button, until this point the application will display the default settings or from the last connected device.

After making the necessary changes to the settings, you should click the "Apply settings" button and only then disconnect from the device with the "Disconnect" button.

"DEVICE INFO" TAB

The "Device info" tab displays information about the device, its status, and also the data needed to register the device in the LoRaWAN network.

ABP info - displays the data necessary to register the device in the LoRaWAN network with ABP method (Activation By Personalization).

OTAA info - the data required to register the device in the LoRaWAN network with OTAA method (Over The Air Activation) is displayed.

Key management (not displayed in the "Simple" mode) - allows you to change the factory keys to register the device on the network and reset the keys back to the factory settings.

Device info - the configurator reads information about the device model, its firmware and automatically corrects the device's time when connected to it.

Update firmware - allows you to select the firmware file from your computer's hard drive and load it into the device. The device will automatically disconnect from the configurator when the download is complete. The current version of the device firmware can be download from iotvega.com.

Network info - shows the device status of connection to the LoRaWAN network and its network address.

Join network button - launch the LoRaWAN network connection procedure with the previously selected ABP or OTAA method. If the device is already connected to the network, reconnection procedure will occur.
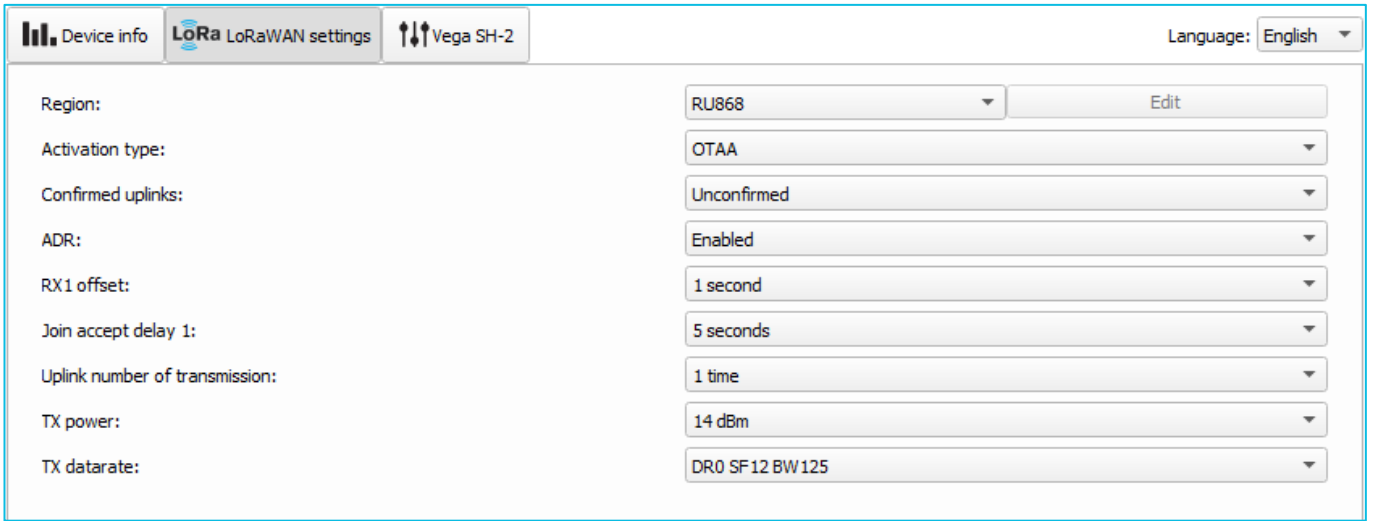
Link check (not displayed in the "Simple" mode) - when pressed, the device sends a special signal to the LoRaWAN network, in response to which the network informs it of the number of gateways that received this signal and the signal quality. This information may be gotten only if the device is connected to the network.
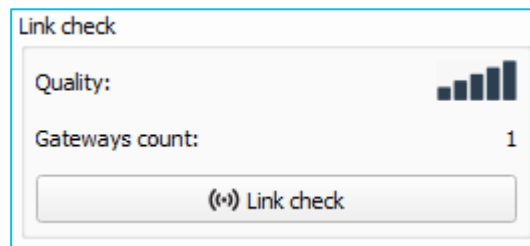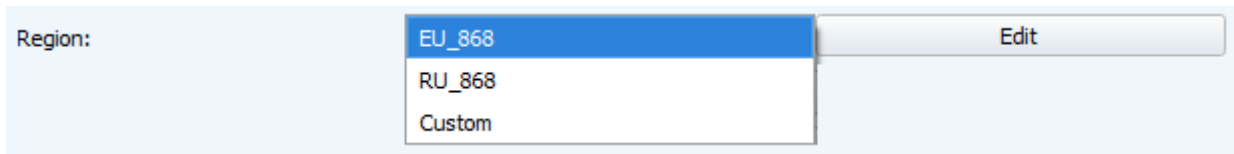

Device output (not displayed in the "Simple" mode) - monitoring the device status, all events in real time are displayed.

"LORAWAN SETTINGS" TAB

The "LoRaWAN Settings" tab allows you to configure various parameters of the LoRa network.

Region - allows you to select one of installed frequency plans or specify a custom frequency plan. Custom frequency plan is EU-868 based.
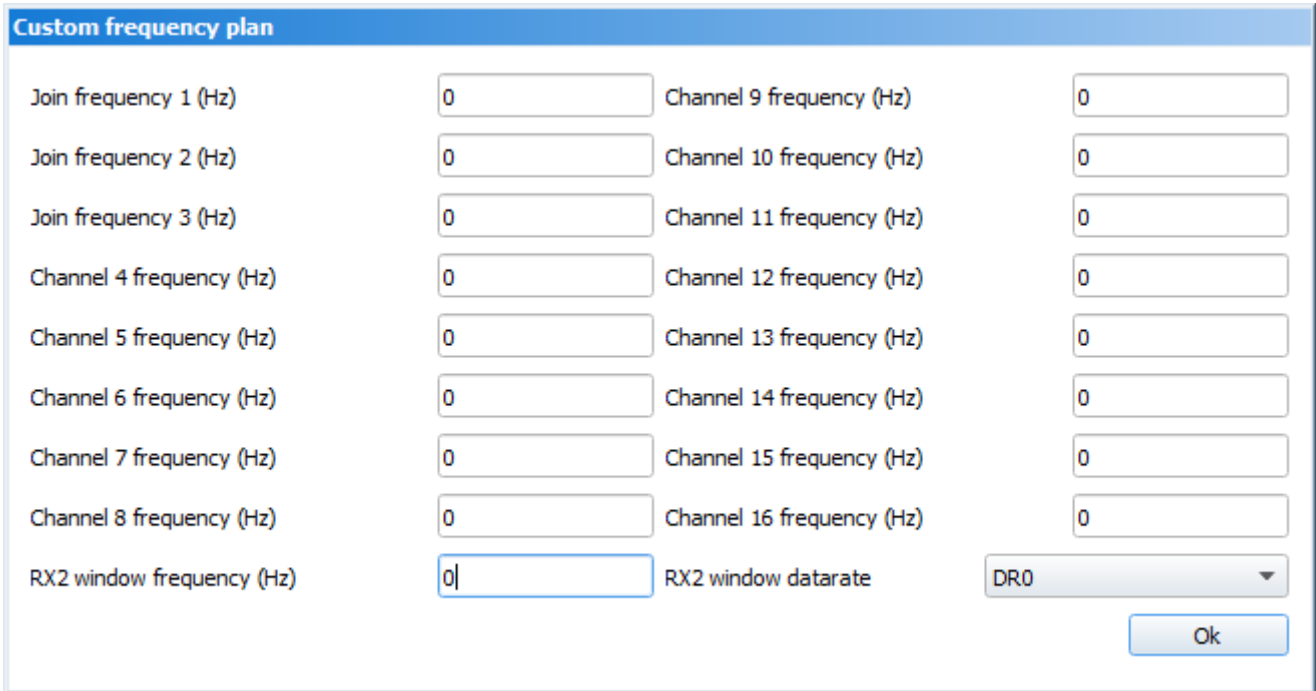

The modem supports the next frequency plans:

Frequency plan[1]	Channel	Frequency	Modulation
EU-868	1	868.1	MultiSF 125 kHz
	2	868.3	MultiSF 125 kHz
	3	868.5	MultiSF 125 kHz
	RX2	869.525	SF12 125 kHz
RU-868	1	868.9	MultiSF 125 kHz
	2	869.1	MultiSF 125 kHz
	RX2	869.1	SF12 125 kHz
Custom		Set up in application	

In the device frequency plan, only those channels are active by default, on which sending requests for connection to the network (join channels). The remaining channels (that the device should use) can be transferring by the LoRaWAN network server during the device activation procedure (only OTAA).

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[1]By default, the device supports only two frequency plans and a custom, however it is able to order the firmware for other frequency plans as: IN865, AS923, AU915, KR920, US915, KZ865

If you select "Custom" in the "Region" field, you must manually specify the frequencies that the device will use. To do this, click the "Edit" button, the channel frequency editing window will appear:

This frequency plan allows you to set up to 16 channels, as well as the frequency and speed of the second receiving window.

> **The first three channels and the second receiving window parameters are mandatory. Without these parameters the custom frequency plan will be considered empty**
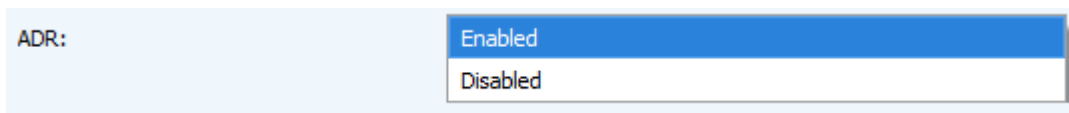
Activation type – displays ABP or OTAA device activation method.

Confirmed uplinks – when you choose "confirmed", the device will retry sending the packet until it receives the server confirmation, or until the "Uplink number of transmission" is over (see below).

> **If you choose to send a packet without confirmation, the modem will not know whether the packet is delivered or not**

ADR – this option activates the Adaptive Data Rate algorithm for automatic control of the data transfer rate from the LoRaWAN network server side. The higher the quality of the signal received by the network, the higher the speed will be installed on the device. This option is recommended only on permanently installed devices.

RX1 offset (not displayed in the "Simple" mode) – specifies the time between end of packet transmission and first receiving window opening. The second receiving window always opens after 1 second after the first.
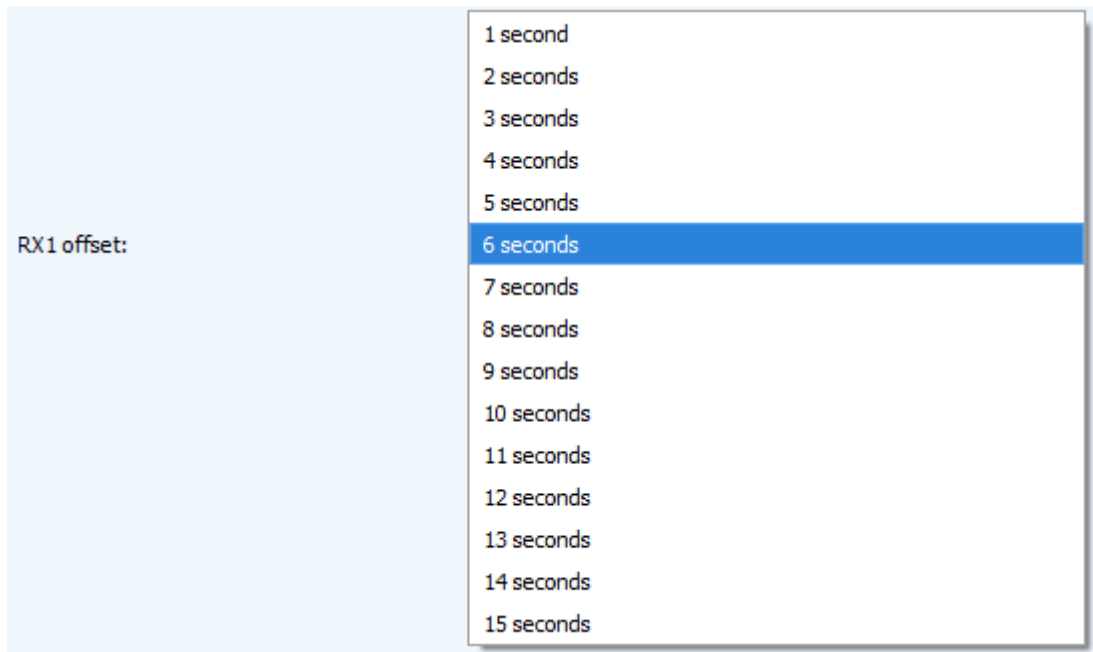
Join accept delay 1 (not displayed in the "Simple" mode) – sets the time that the device will open the first receiving window to receive confirmation for the join request from the LoRaWAN network while OTAA mode active. The second window always opens after 1 second after the first.
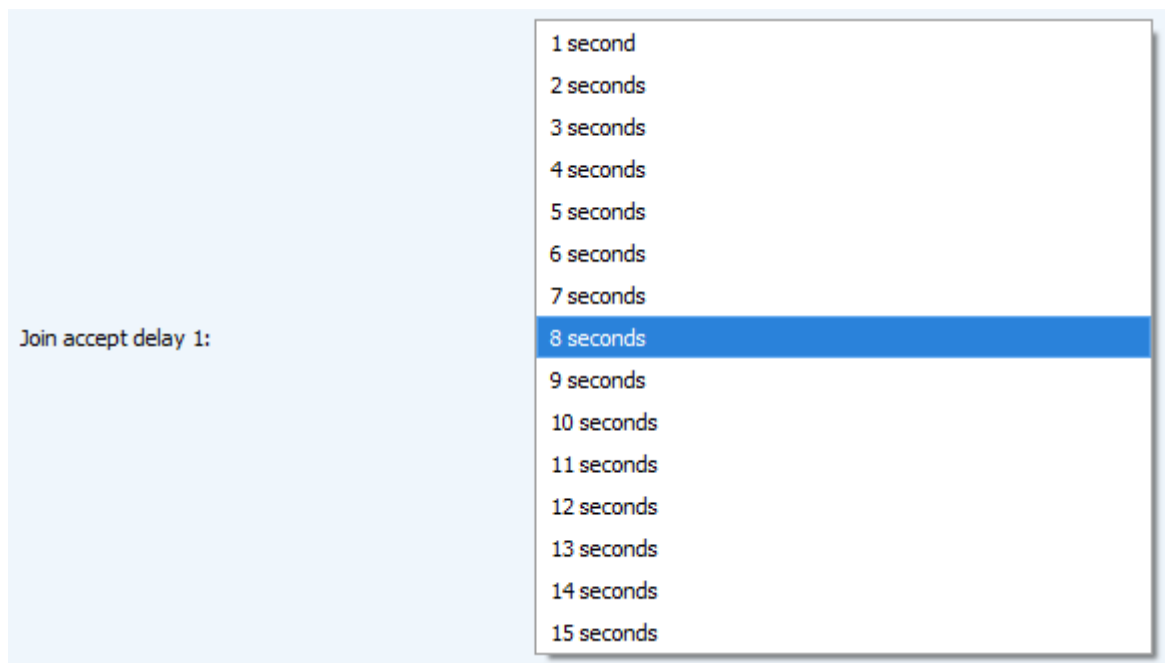
Uplink number of transmission (not displayed in the "Simple" mode) – if the "Confirmed uplinks" function is disabled, the device will simply send each packet as many times as specified in this option. If "Confirmed uplinks" is enabled, the device will send packets until it receives a confirmation or until it sends as many packets as specified in this option.

TX power (not displayed in the "Simple" mode) – the device RF transmitter power is adjusted to this value when sending packets to the LoRaWAN network. This option can be changed by the network server if the ADR algorithm is enabled.
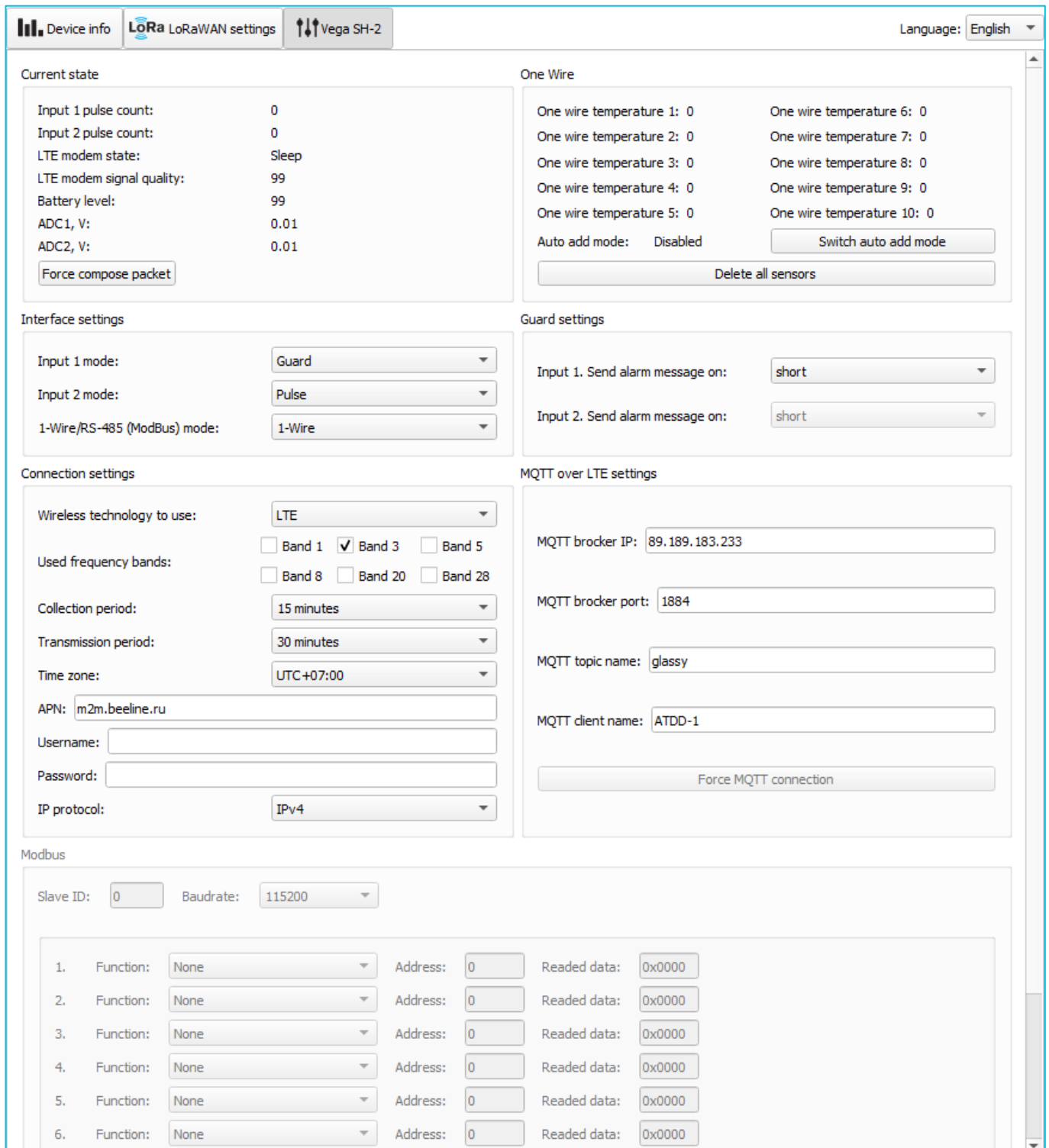
TX datarate (not displayed in the "Simple" mode) – the device transmission datarate at which it will transfer packets to the LoRaWAN network. This speed can be changed by the network server if the ADR algorithm is enabled.

"VEGA SH-02" TAB

The "Vega SH-02" tab contains the settings of the connected device.

Current state – displays the current parameters of the device - the number of counted pulses at the inputs, LTE-modem state and signal quality, the battery level, and the state of analog inputs.

LTE-modem signal quality is from 0 to 31 when there is a connection, but 99 value means that there is no connection. See details in the table below.

Value displayed in application	Signal quality, dBm
0	-113 and lower
1	-111
2…30	-109…-53
31	-51 and more
99	No connection
100	-116 and lower
101	-115
102…190	-114…-26
191	-25 and more
199	No connection

"Force compose packet" button – by pressing the button the device collects readings from all interfaces, forms the packet and put it in the black box.

One Wire – the settings of connection any external temperature sensors and its readings. For adding a temperature sensor, you should switch the auto adding mode on. Every sensor will get a number in order it was connecting. After switching the auto adding mode on, the device search for some new sensors on the bus. If there is a sensor then the device adds it in memory and switch the auto adding mode off. To add the next sensor, you should switch the auto adding mode on again. All sensor removed from the device memory by pressing the button "Delete all sensors".

Interface settings – allows setting up the type of every input – it may be pulse or security mode and choose the input mode 1-Wire/ModBus. If you choose the 1-Wire then ModBus settings does not available, if you choose the ModBus then 1-Wire and temperature sensors settings does not available.

Guard settings – allows setting up the work of security inputs, namely, what kind of security circuit state is reason to send an alarm message: short, open, or both.

Connection settings – a group of parameters that allows you to configure the collection and transmission periods, and the time zone and choose the technology of data transmitting and LTE-modem mode.

Time zone specified for the setting of the internal clock of the device.

Readings collected by the internal device clock at the 0:00 AM if the collection period equal to 24 hours, at the 0:00 AM and 12:00 AM if the period equal to 12 hours and so on. All reading stored in the device memory until the next communication session.

Transmission period may be equal to 5, 15, 30 minutes, 1, 6, 12 or 24 hours. At the next communication session, the device starts sending accumulated packets with readings, from the earliest to the latest. The specific data transfer time cannot be set, it is determined randomly for each device within the selected data transmission period from the moment of

connection to the network. For example, the specified period is 30 minnutes and the device was initialed at the 4:40 PM by the internal device clock. While randomly calculation the device set the time 4:41 PM for packet transmission in half an hour period from the 4:40 PM to 5:10 PM. Thus, packets from this device will be transmitted at the 4:41 PM, at the 5:11 PM, at the 5:41 PM, at the 6:11 PM and so on every 30 minutes by the internal device clock.

While LoRaWAN technology used it necessary to consider the setting of the uplinks' confirmation. With the "Confirmed uplinks" option turned on, the device will send the next packet only after receiving a confirmation of the delivery of the previous one. If such confirmation has not been received after the fulfilled in the settings uplink number, device completes the communication session until the next one according to the schedule. In this case, the device continues to collect data according to the data collection period and store it in memory. Non-transmitted packets remain in the device memory until the next communication session.

With the "Confirmed uplinks" option turned off, the device just sends all accumulated packets to the network in order from the earliest to the latest. There are no checks of package delivery in this mode. There are no non-transmitted messages in the device memory.

> **While LTE NB-IoT technology used the device send all packets with confirmation by default and it does not customize. Uplink number is 5.**

Wireless technology to use – LTE or LoRaWAN technology of data transmitting.

MQTT over LTE settings – setting for connection through LTE-modem.

"Force MQTT connection" button – by pressing the button the device initiates extraordinary communication session through MQTT broker.

Modbus – the part contents settings for data reading via MODBUS protocol from the external device connected to SH-02 through RS-485 interface.

5 COMMUNICATION PROTOCOL

This part describes the SH-02 data exchange protocol with LoRaWAN and NB-IoT network.

> **In fields consisting of several bytes, the little-endian byte order is used**

VEGA SH-02 MODEM TRANSMITS THE FOLLOWING TYPES OF PACKETS

1. Packet with current readings, sent regularly on LoRaWAN port 2

Size in bytes	Field description	Data type
1 byte	Packet type: 01 – if the 1-Wire used 09 – if the ModBus used	uint8
1 byte	Reason for packet was formed: 1 – by the schedule 2 – alarm on input 1 3 – alarm on input 2 4 – pressing the button in application	uint8
1 byte	Battery charge, %	uint8
4 bytes	Reading time for values in this packet (unixtime UTC)	uint32
1 byte	Temperature, °C	int8
20 bytes	Readings of the ten external temperature sensors, 0.1°C Or readings of the ten ModBus registers	int16 uint16
4 bytes	Pulse number on the input 1	uint32
4 bytes	Pulse number on the input 2	uint32
2 bytes	Voltage value on the analog input 1, mV	uint16
2 bytes	Voltage value on the analog input 2, mV	uint16

2. Packet with time correction request, sent every seven days on LoRaWAN port 4

Size in bytes	Field description	Data type
1 byte	Packet type, this packet == 255	uint8
4 bytes	Time of the modem at a moment of the packet transmission (unixtime UTC)	uint32

After receiving this type of package, the application can send to modem the packet with time correction.

VEGA SH-02 MODEM RECEIVES PACKETS OF THE FOLLOWING TYPES

1. Real-time clock adjustment – send by application on LoRaWAN port 4

Size in bytes	Field description	Data type
1 byte	Packet type, this packet = 255	uint8

| 8 bytes | The value in seconds for which you need to adjust the time. Can be positive or negative | int64 |

MESSAGE FORMAT FOR MQTT BROKER SENDING

If the LTE technology used for data transmitting, then the data transmits via MQTT protocol. You should specify in the device settings the address and port of the server where the data will be sent. Those settings specified in application. It must be MQTT broker as a server (received side). You should specify in the device settings the address and port of the broker. Also, you should specify a topic name where the data published and a client name – the name which the device use for publishing. All those settings specified in "Vega LoRaWAN Configurator" in part "MQTT over LTE settings". For watching the data sending by the device you should deploy MQTT broker on a PC and subscribe some application on MQTT broker.

Vega SH-02 sends the message on the server as a text of JSON format. See example below.

```
{
    "Message":{
        "firmware":"SH-02 v0.1.4",
        "num":1,
        "date":"1.3.19",
        "time":"8:43:27"
    },
    "LBS":{
        "TAC":"9C8D",
        "CID":"0856831D",
        "ACT":"9",
        "MCC":"250",
        "MNC":"99",
        "SQ":"21"
    },
    "CellStatus":{
        "EARFCN":1240,
        "PCID":354,
        "RSRP":-775,
        "RSRQ":-108,
        "RSSI":-716,
        "SNR":247
    },
    "Telemetry":{
        "reason":"time",
        "date":"1.1.17",
        "time":"0:0:5",
        "bat":99,
        "pulse1":0,
        "pulse2":0,
        "ADC1":8,
        "ADC2":8,
```

```
            "temp":28,
            "onewire":[28.2, 27.9, 28.3, 0, 0, 0, 0, 0, 0, 0],
      }
}
```

Transcription of the message fields:

Message – part with information about current message.
      firmware – name and version of the device firmware
      num – number of the message sent by the SH-02 device
      date – date of the message sending
      time – time of the message sending

LBS – part with information about the gateway parameters which resend that packet
      TAC, CID, MCC, MNC – gateway identifications
      ACT– technology (9 – LTE Cat.NB1)
      SQ – gateway signal quality

CellStatus – part with information about the cellular state
      EARFCN – the number of radio frequency channel (absolute)
      PCID – physical network address
      RSRP – input signal power
      RSRQ – input signal quality
      RSSI – indicator of the input signal power
      SNR – signal to noise ratio

Telemetry – part with collected data (one packet)
      reason – transmitting reason
      date – date of the data collection
      time – time of the data collection
      bat – battery charge
      pulse1 – pulse number on the input 1
      pulse2 – pulse number on the input 2
      ADC1 – voltage value on the analog input 1
      ADC2 – voltage value on the analog input 2
      temp – temperature of the processor
      onewire – external temperature sensors' readings
      modbus[2] – data from the RS-485 interface from an external MODBUS device (10 values of 16-bit register)

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[2] If the MODBUS mode on, then that data will transmit instead of **onewire** data and vice versa

6 STORAGE AND TRANSPORTATION REQUIREMENTS

Vega SH-02 modem shall be stored in the original packaging in heated room at temperatures +5°C to +40°C and relative humidity less than 85%.

The modem shall be transported in covered freight compartments of all types at any distance at temperatures -40°C to +85°C.

7 CONTENT OF THE PACKAGE

The modem is delivered complete with:

Vega SH-02 modem – 1 pc.

Antenna – 2 pcs.

6400 mAh battery – 1 or 2 pcs. [3]

Factory certificate – 1 pc.

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[3] The number of delivered batteries depends on the order conditions

8 WARRANTY

The warranty period for the device is 5 years from the date of sale.

The manufacturer is obligated to provide repair services or replace the failed device during the entire warranty period.

The consumer is obliged to comply with the conditions and rules of transportation, storage and operation specified in this user manual.

Warranty does not apply to:

- power supplies of devices;

- the device with mechanical, electrical and / or other damages and defects caused by violation of the transportation, storage and operation requirements;

- the device with traces of repair performed not by the manufacturer's service center;

- the device with traces of oxidation or other signs of liquids leaking inside the device.

In the event of a warranty claim, contact the service center:

113/1, Kirova Str., Novosibirsk, 630008, Russia.

Tel.: +7 (383) 206-41-35.

vega-absolute.ru

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