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FH101RF DEVELOPMENT KIT

APPLICATION NOTE: FH101RF EVALUATION

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EDITION 2
REVISION 2

0
Content

1
Introduction

This document describes the essential components and steps of an evaluation. These are functions, tools and possible examples of an evaluation of the RFicient® radio receiver using FH101RF development kit. The development kit provides all the necessary evaluation tools and combines them in a graphical software application "WakeUpEvalSuite". This simplifies the interaction with the FH101RF radio receiver.

The main features of the software application are configuring the receiver, generating and sending data, creating and managing configurations, receiving and evaluating the data. The following chapters explain the main functions of WakeUpEvalSuite.

2
Getting Started

The structure of the application consists of a main window shown in the Figure 1, which opens at application startup. The main window shows all FH101RF development boards connected to the PC and recognized. The display is done by symbols and line entries with the information about the respective development board. The symbols in the upper area of the main window represent the buttons. A mouse click on the respective button starts the window of the application corresponding to the symbol name. The menu bar in the upper part of the main window represents additional functions like: Update devices and Change mode of the respective development boards.

The Eval firmware distinguishes between two types of modes.

1. TX(Tx-Kit): generation and parameterization of the transmission data as well as setting of the data rate, transmission power and periodicity of the telegrams
2. RX(FH101RF): parameterization of the FH101RF receiver as well as reception and evaluation of the transmitted data.

The current mode is displayed by the board mode leds attached to the development board. Additionally it is displayed in the main window of the application by the first two symbols of the firmware information.

Changing the mode is done as follows. We recommend, to connect only one development board to the PC to change the mode.

- Open WakeUpEvalSuite main window, select the “Devices” menu item, in the upper menu bar of the main window. Devices detected by the tool are displayed with their serial number. To change the mode the "change device mode" menu must be activated under the corresponding entry.
- The status led acknowledges the change
- The firmware reboots for about 2 seconds. Then press the refresh button, lower left corner, in the main window to update the devices. Mode is changed.

Figure 1: WakeUpEvalSuite Main Window

Note: Only one instance of a device mode (TX or RX) can be displayed in the main window. If it is necessary to run two development boards in same mode and PC, a second instance of WakeUpEvalSuite must be started.

3
TX-Mode

As already mentioned, the TX mode offers all necessary tools for signal generation and transmission via radio. In the TX mode, shown in the Figure 2 of the WakeUpEvalSuite, all important parameters of the transmitter are available for setting. These are the radio band, data rate, data word, transmission power periodicity and number of telegrams. The available settings especially the radio band, frequency and transmission power are dependent on the respective development board firmware. These can differ depending on the firmware implementation.

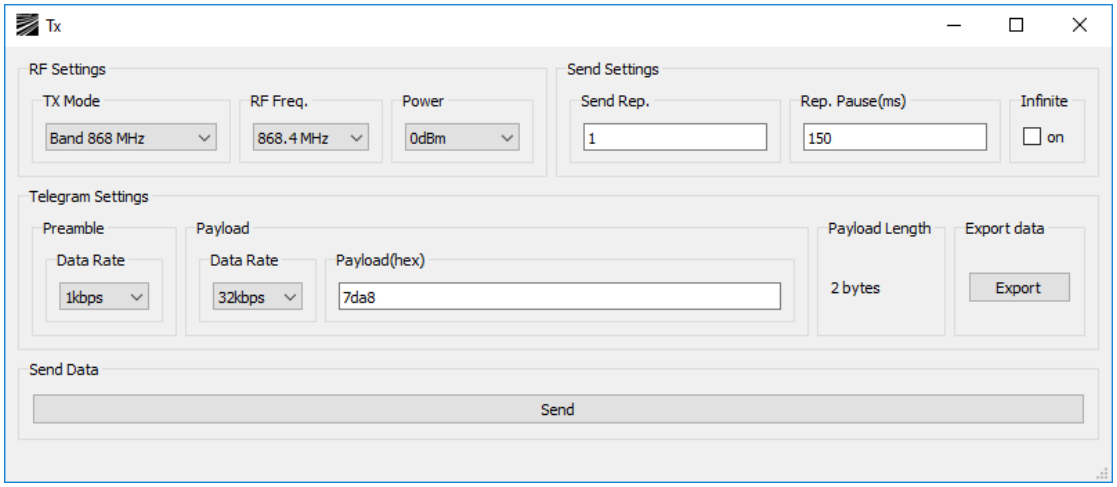

Figure 2: TX-Mode

The following is a brief description of the TX mode settings:

- TX Mode: Radio band setting, 433/868/915/2G4
- RF Freq: Frequency setting for the respective band, important is the observance of the respective radio regulatory domain.
- Power: Tx power setting for the respective band and frequency, important is the observance of the respective radio regulatory domain
- Send Rep: Number of telegrams to be sent, without effect if Infinite is set
- Rep: Pause between the telegrams
- Infinite: Infinite sending until stop is activated
- Preamble DR: Preamble data rate, if enabled sends a WurX codeA with selected data rate
- Payload DR: Payload data rate, if enabled sends the data from the Payload(hex) encoded in Wurx format with selected data rate.
- Payload(HEX): The data to be sent, these are encoded before sending in WurX(A/B) format, these can be saved by Export button in a *.c/*.h file.
- Send Data: Starts the data transfer.

Note: If the settings of the preamble and payload data rate are different, the preamble (codeA) is spread to the payload data rate.

Note: If selective addressing of the wakeup is desired, the payload data rate must be set and the ID must be entered in the first two bytes of the data in the payload(HEX). If required, further data can be entered after the ID, max 6 bytes exclude the ID. The ID is evaluated and discarded by the receiver, i.e. it is not stored in the FIFO register of the receiver.

4
RX-Mode

In RX mode, WakeUpEvalSuite provides all necessary tools for parameterization of the receiver. Important functions such as data reception and evaluation are available to the user of the application. Furthermore, WakeUpEvalSuite offers the possibility to store and manage user configurations. These are conveniently loaded from the application into the receiver IC with a mouse click. An export function is also available to the user. This saves the loaded configuration in a *.c/*.h file.

The current flow and power consumption at the FH101RF receiver is displayed in the window title of the RX window. These are measured values of the current measuring circuit of the development boards. Thus, the power consumption for the loaded configuration of the receiver is immediately visible.

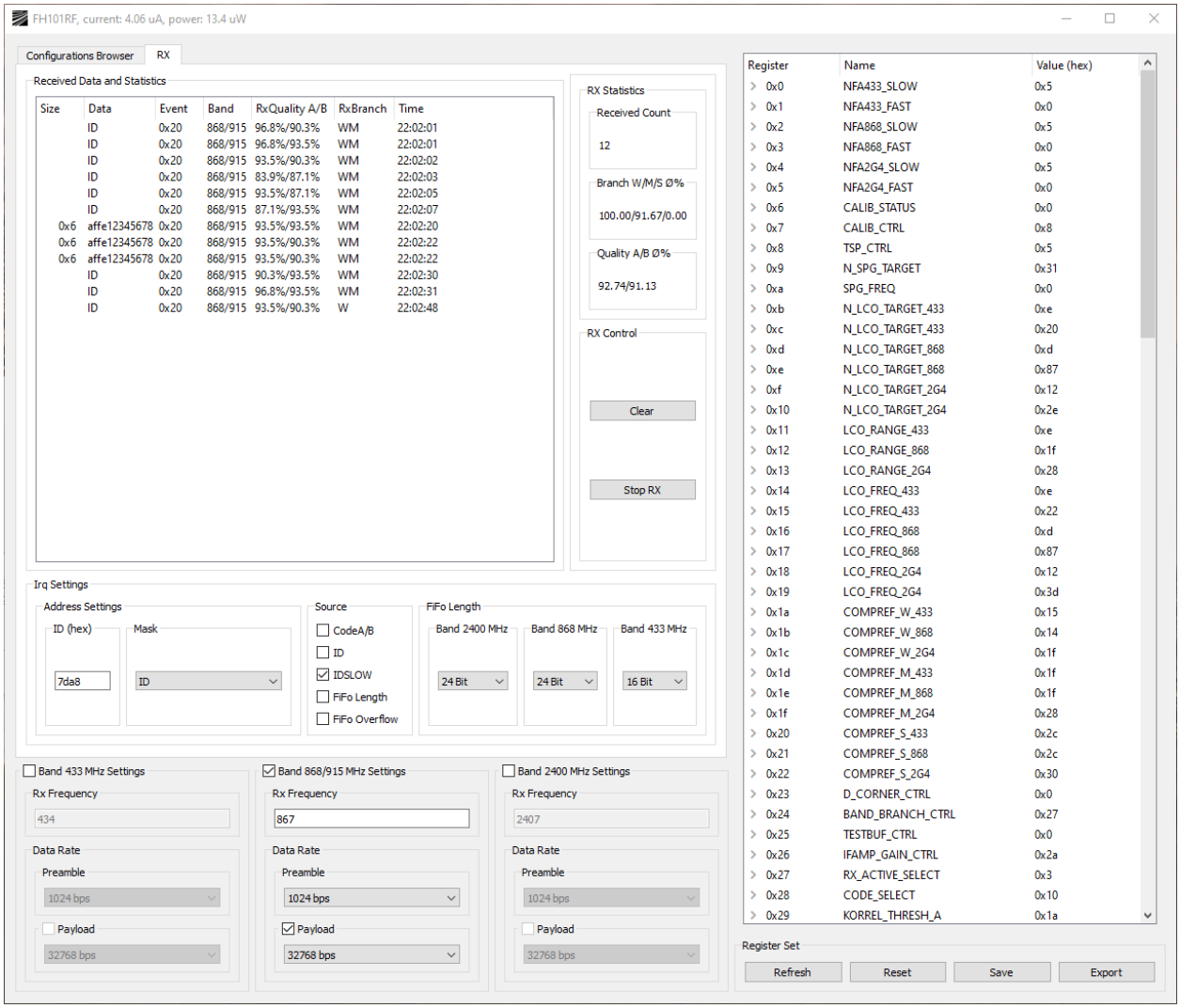

Figure 3: RX-Mode

Figure 3 shows the RX mode of the WakeUpEvalSuite application. In the right window area of the application, the register entries of the receiver are located, these can be parameterized comfortably by direct input or by folding out the respective register. The left part of the application window provides predefined functions of the application. These are settings of RX frequency, data rate, interrupt source, setting of ID and

data reception. They simplify the setting for the users without detailed knowledge about the receiver. Settings that are made using predefined functions are mapped to register entries immediately after the setting. This applies vice versa also for the direct input of the register values.

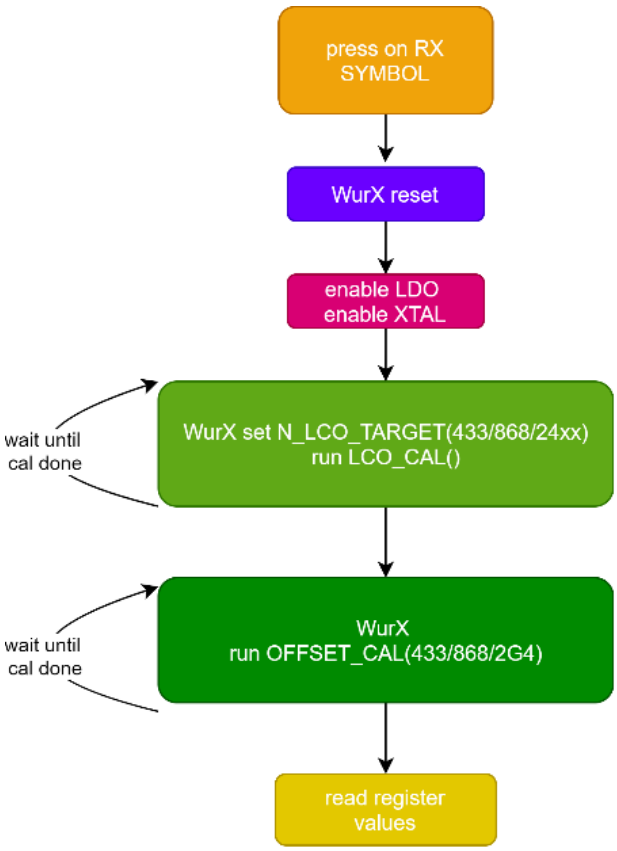

Figure 4: RX Symbol-Trigger sequence

When the RX mode is started by clicking on the RX symbol (FH101RF) of the application, a sequence of defined initialization steps of the receiver takes place see Figure **4**.
This establishes an operational state of the receiver. The initialization sequence can be performed at any time by clicking on the RX symbol (FH101RF) of the application. Even if RX window of the application is already open.

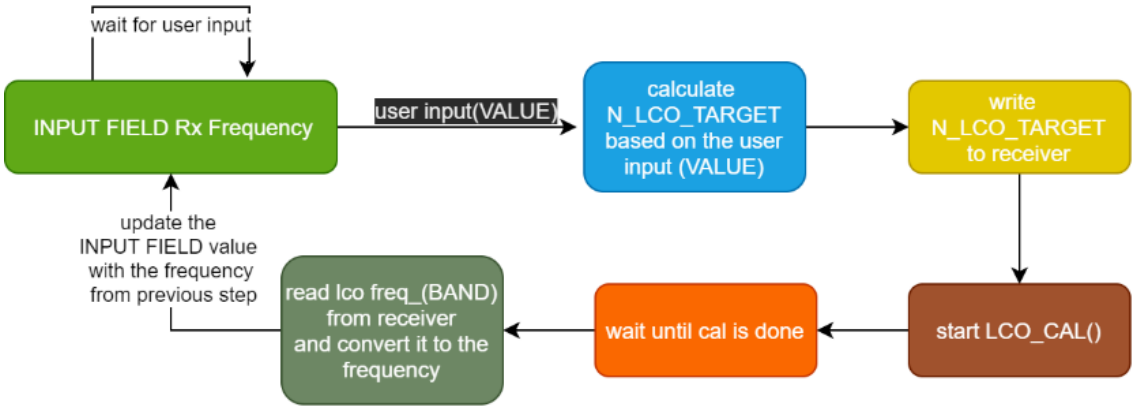

Figure 5: Frequency input sequence

Note: When entering of the receive frequency, frequency of the transmitter, through the Rx Frequency input field, the application executes the sequence as shown in the Figure 5. The LO Target values are calculated based on the following parameters: User input of frequency, Intermediate frequency = 40 MHz, Hi Side LO injection.

Note: It may happen that the displayed frequency differs from the user input by a few units. This is not an error but is due to the granularity of the adjustability of the LO frequency and has no effect on the receiver RF performance.

In the following the predefined functions as well as the parameters of data reception in RX mode are described.

Received Data and Statistics: Shows the entries of the received data.

- Size: These have the number of received payload bytes if available.
- Data: If an address is received without subsequent payload data, only the ID is displayed; if additional payload data has been received, this is displayed instead of the ID. The display shows CodeA or CodeB if they have been received and the interrupt source is set to CodeA/B.
- Event: Shows the event code which has triggered the entry. Details of the event code, see data sheet of the FH101RF.
- BAND: Shows the band on which the telegram was received.
- Signal Quality A/B: Values of the KORREL_VAL register. These indicate how many errors a received CodeA or CodeB had. For further information the data sheet of the FH101RF should be consulted. Important: The value is only an indication and does not give any far-reaching information about reception errors.
- Time: The local time at the time of reception
- Received Count: Number of telegrams received, this is reset to zero after pressing the Clear button.
- Quality A/B avg: Average of all Signal Quality A/B values, this is reset to zero after pressing the Clear button.
- StartRX/StopRX: Starts or stops data reception

Irq Setting: Sets the interrupts and the ID of the receiver.

- ID: Setting the id of the receiver, expects input of a 2-byte hex number
- Mask: Setting of the ID mask, possible settings are ID (Triggers only exactly at the ID), GroupID (Triggers only exactly at the GroupID), BroadcastID (Triggers only exactly at the BroadcastID) and combinations of all.
- Source: Activation of the interrupt sources.
- FiFo Length: Setting of the FiFo threshold for interrupt generation, ineffective without FiFo Length interrupt activation

Band433/(868/915)/2G4 MHz Settings: Sets the frequency and data rate of the respective band.

- Rx Frequency: Reception frequency of the respective band, expects a decimal integer number. Important: The **frequency of the transmitter** must be entered here.
- Preamble: Sets the data rate of the preamble.
- Payload: If an addressed WakeUp or data reception is required, this setting must be activated and the data rate must be set accordingly. Important: For multi-band use, not all data rate combinations are functional, please consult the FH101RF data sheet.

5
Assembly and Function Matrix

Board Mode	Firmware	Red LED (TX)	Green LED (RX)	Antenna TxRx	Antenna RFin433	Antenna RFin868/915	Antenna RFin2G4	D2XX Driver	USB – PC connection	Pin-Header-Jumpers	CR2032	Onboard current meas. switch
RX	evalfw _(vers) _(build).hex	off	on	-	yes, if the Band 433 MHz is used	yes, if the Band 868 MHz or 915 MHz is used	yes, if the Band 24xx MHz is used	yes	yes	Fully equipped	No	on
TX	evalfw _(vers) _(build).hex	on	off	yes according to the transmis-sion fre-quency	-	-	-	yes	yes	Fully equipped	No	-

6
Evaluating FH101RF

With any radio receiver, the question about the reliability of the data reception in a certain radio environment arises or if any data is lost. The ratio between data received and sent determines the average bit error ratio (BER = 1 – received data amount/sent data amount). In the case of the RFicient® FH101RF receiver, data is encoded in bit-error tolerant codeA or codeB sequences, and thus not the erroneous bits but the erroneous code sequences are relevant.
This ratio is referred to as WUER (WakeUp error rate).
This section shows two possible ways to address specific nodes to receive data with FH101RF In different radio environments. Before starting, it must be ensured that the hardware kits are ready, that necessary USB drivers are installed and that the hardware is connected to the computer.

6.1.1 Use Case 1

Requirements:
A network with an abstract main radio is to be set up, that consists of several Ultra Low Power radio sensors nodes that are to be woken up with very low latency when required. Waking up a specific node with a unique ID in form of a network address should be possible.

The network requirements are:

- RF-Frequency: 868 MHz
- WakeUp Latency: Max. 80 ms
- System current consumption: max. 5 µA
- The network is controlled by a master node

FH101RF Configuration, Sensor Node
To meet the requirement, the following setting must be set on the FH101RF:

- Enable the required band 868 MHz: Set the Band to the 868 MHz setting and the payload check box in the FH101RF RX tab. In order to save power, unused bands are switched off and the preamble data rate is set to 1k (1 kbps) and the payload to 32k (32 kbps). A further reduction in the preamble data rate further lowers the current consumption of the FH101RF, but at the expense of latency.
- In order to use the request for the addressed WakeUp, the ID interrupt check-box must be activated, all other interrupts are off. The corresponding check-box can be found in the FH101RF RX tab under irq Settings / Source.

- The ID is set to the default value: 0x7da8. For test purposes, only one node is used in this example. In real world use cases, each node gets its own ID.
- In this case no broadcast or group WakeUps are required, therefore ID-Mask is set to “ID”. It can be found in the FH101RF RX tab irq Settings / Mask.

Figure 9 shows the resulting GUI after setting it up with the aforementioned example.

TX Configuration, Master Node

In order to WakeUp a node which was configured according to the description above, the following settings must be made on the transmitter (TX) side:

- Select the Band 868 MHz on which the network nodes receive. The RF frequency will be set automatically to 868.39 MHz.
- Select the transmit power depending on which range between master and node is required. Higher power equals more range. Please note the regulatory domain requirements regarding TX power in the respective RF band.
- Set the preamble and payload data rate to 1k and 32k.
- Set the Payload to the ID of the node, in this example the ID is 0x7da8.
- “Send Rep.” and “Rep pause(ms)” can remain in the standard setting.

In order to visualize the discussed TX settings, they are shown in Figure 10.

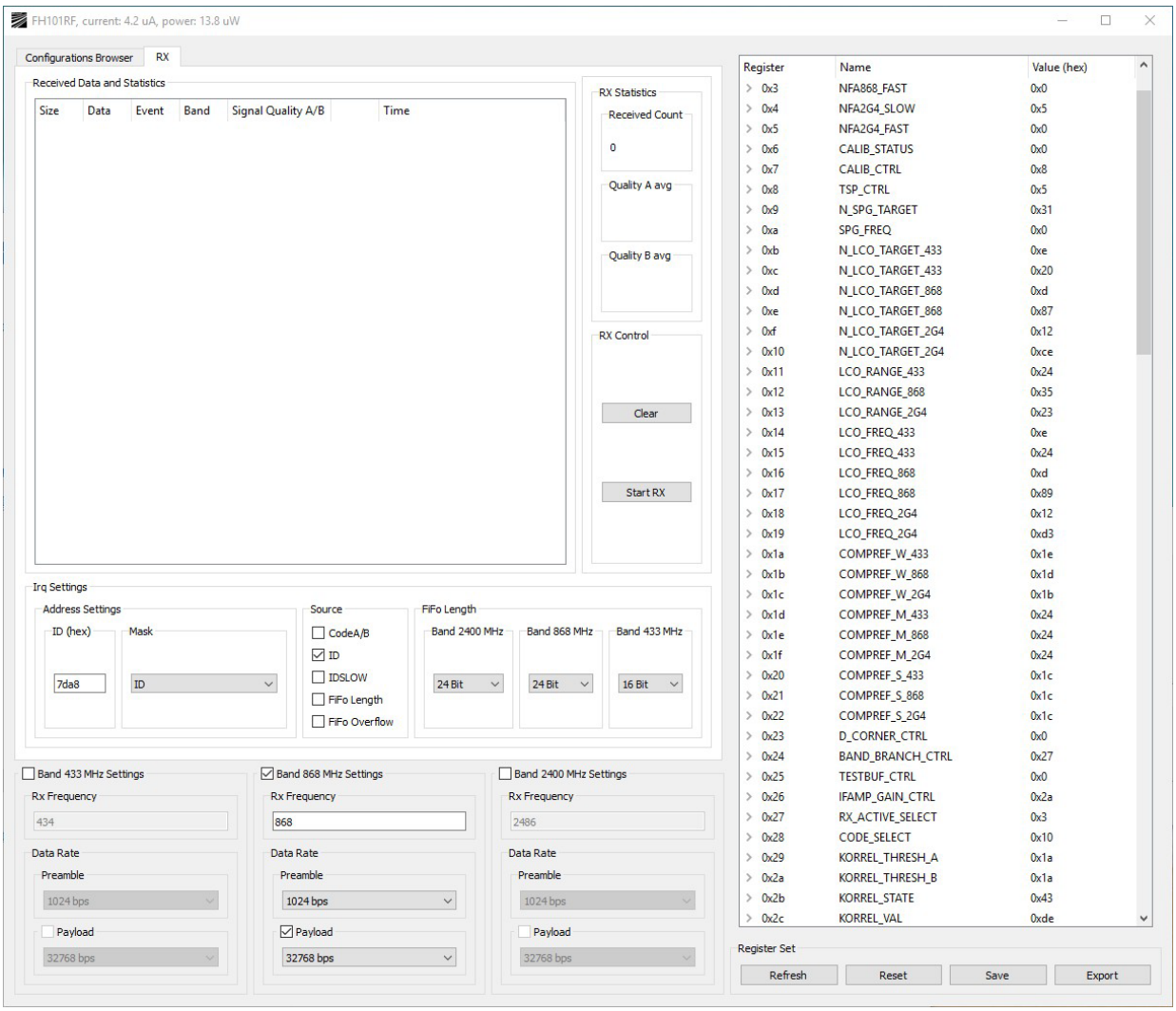

Figure 6: FH101RF RX Settings

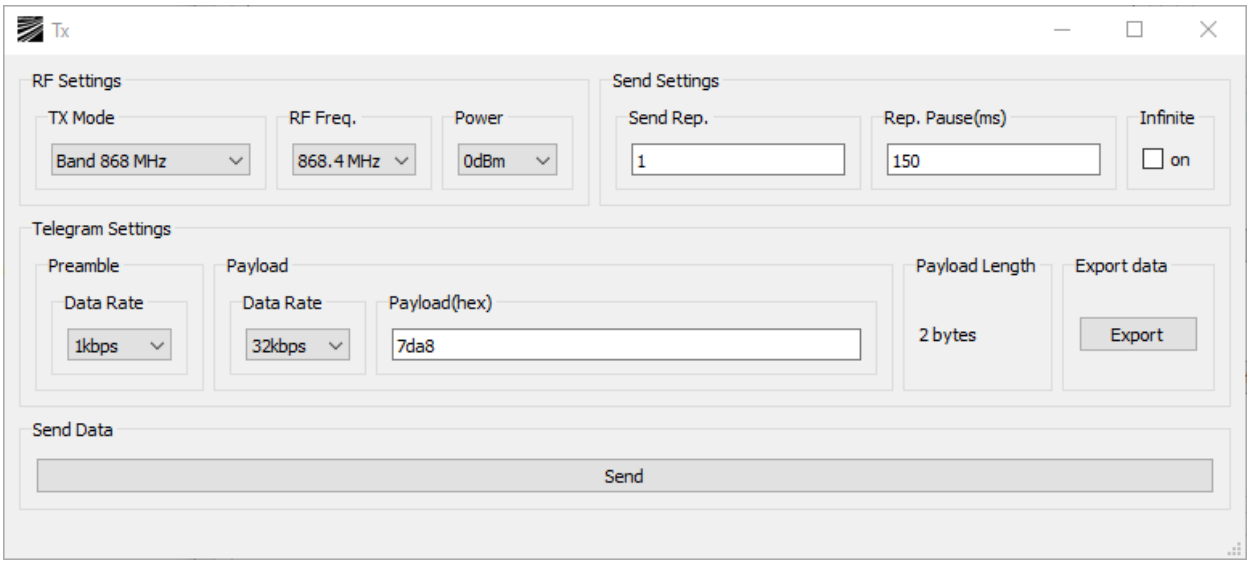

Figure 7: TX Settings

Network Test, Node 0x7da8 WakeUp

To wake up the sensor node, the FH101RF data receiver GUI implementation must be activated. This is done by pressing the Start RX button in FH101RF RX tab RX Control/ Start RX. To send the telegram, the send button must be pressed in the TX-kit. Once this has been done, the telegram received appears in the FH101RF RX tab. The node has awakened, as shown in Figure 11.

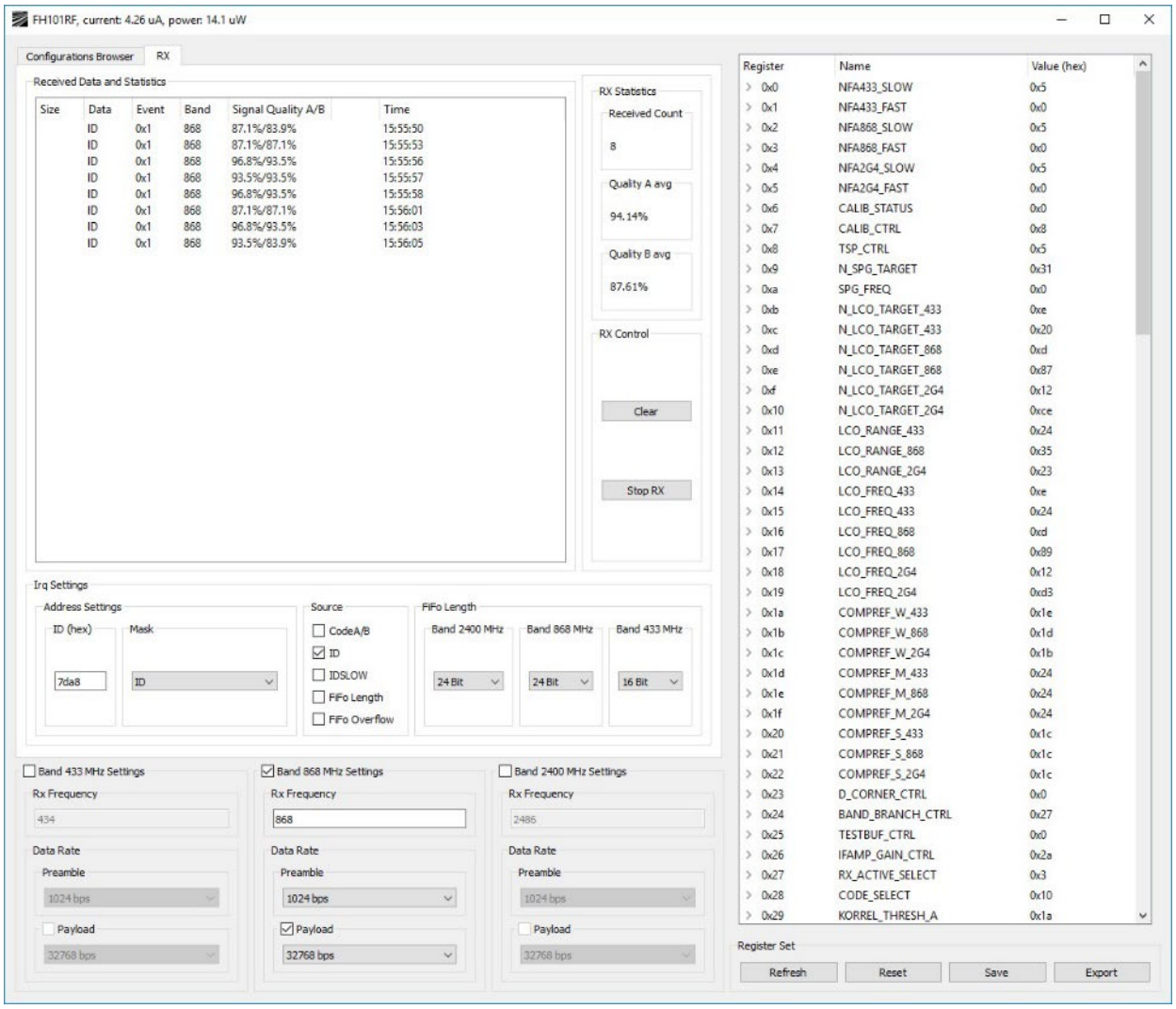

Figure 8: FH101RF received telegram

6.1.2 Use Case 2

In order to expand use case 1, a user-defined data “payload” should now also be transferred with the WakeUp telegram. This provides a low power option to transfer user data.

Requirements

In addition to a WakeUp of the sensor node, it should receive additional data, for example for parameterization and time control. We define the user data in this example to the 6-byte hex string: 0xaffe12345678.

Configuration, Sensor Node

To meet the requirement, the following additional settings must be set on the FH101RF in combination with the settings from the previous example:

- In order to use the request for the addressed WakeUp, the IDSLOW interrupt check-box must be activated, all other interrupts are off. The corresponding checkbox can be found in the FH101RF RX tab under irq Settings / Source.

TX Configuration, Master Node

- In the TX-Kit we add user data to the payload entry. The ID entry in the payload data field remains unaffected, it is only expanded by user data. It must match to 0x7da8affe12345678.

Network Test

To wake up the sensor node, the FH101RF data receiver GUI implementation must be activated. This is done by pressing the Start RX button in FH101RF RX tab RX Control/ Start RX. To send the telegram, the send button must be pressed in the TX-kit. Once this has been done, the telegram received appears in the FH101RF RX tab, see Figure **9**.

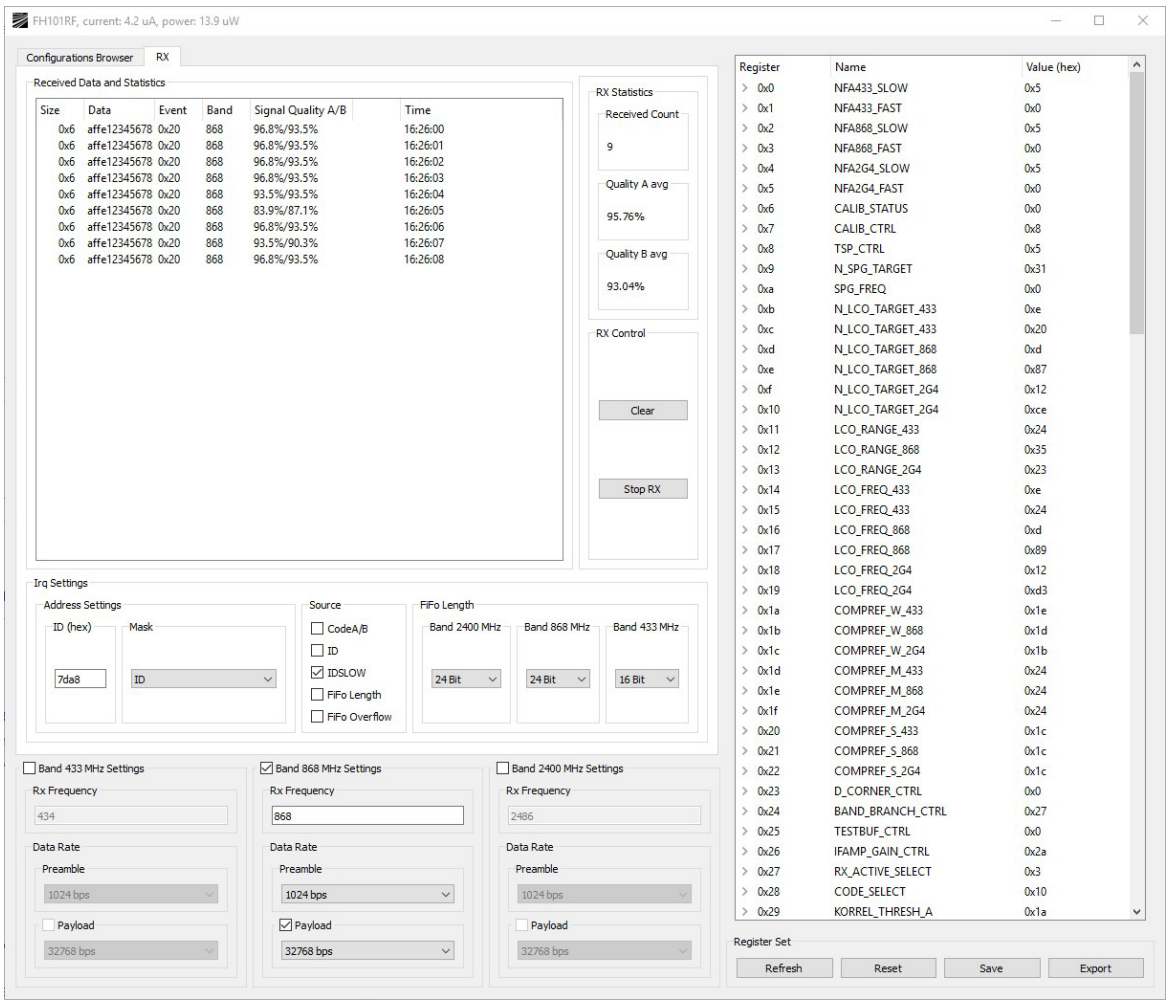

Figure 9: FH101RF received telegram + user data

7
PC Requirements

The following PC requirements must be met::

- OS: Windows 10
- USB Interface: min. USB 1.1
- D2XX Driver: https://ftdichip.com/

8
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The Evaluation Kit uses the following open source libraries under the specified licenses:

9
Software components & licenses

List of Open Source Software

Component	OSS Module Name	Module Version	License
Qt5Core.dll	Qt5Core	5.12.2	LGPL, Vers. 3
Qt5GUI.dll	Qt5Gui	5.12.2	LGPL, Vers. 3
Qt5Svg.dll	Qt5Svg	5.12.2	LGPL, Vers. 3
Qt5Widgets.dll	Qt5Widgets	5.12.2	LGPL, Vers. 3

10
Appendix
Licence text

GNU GENERAL PUBLIC LICENSE

Version 3, 29 June 2007

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