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FH101RF DEVELOPMENT KIT

APPLICATION NOTE: SENSOR NETWORK

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EDITION 2
REVISION 2

0 Content

1 Introduction

The document describes an example application of an ultra-low power network of sensors using RFicient technology. The application is based on the hardware of the FH101RF development kit. It presents a possible implementation of a radio sensor network, which allows the user to evaluate or parameterize one or more autonomous ultra-low power sensors via radio using the FH101RF radio receiver. A possible use of such a network is e.g. an application that requires asynchronous radio telemetry with low latency and very long runtime.
Such as reading temperature, energy or smoke sensors during asynchronous events.
The basic functionality of this application provides the reading of battery voltage, runtime as well as the temperature of the sensor module. The following nomenclature is defined below:

- Gateway: A development kit board flashed with appropriate firmware and connected via USB to computer.
- Sensor-Node: A development kit board, flashed with appropriate firmware, equipped with CR2032 battery.
- Node-ID: A 16-bit identification number of the sensor node.
- Broadcast-ID: A 16-bit identification number which corresponds to the broadcast type.

Note: The implementation is for demonstration purposes only. In the following chapters, the important functions of the application are explained.

2
How it works

The basic principle behind this application is based on functionality of the FH101RF receiver. A radio network whose nodes are permanently available and yet very power efficient. While the wireless network is idle, the sensor nodes are in a very low power state. By means of the FH101RF receiver, they can be woken up with very short latency and subsequently read out or parameterized. The WakeUp can take place addressed or per broadcast via gateway.

The awakened sensor node(s) responds to the gateway. Figure 1 shows how a broadcast message is sent by the gateway. All sensor nodes that receive this message send out a response with the respective node ID. The response to a broadcast message is time-delayed and is calculated based on the respective node ID.

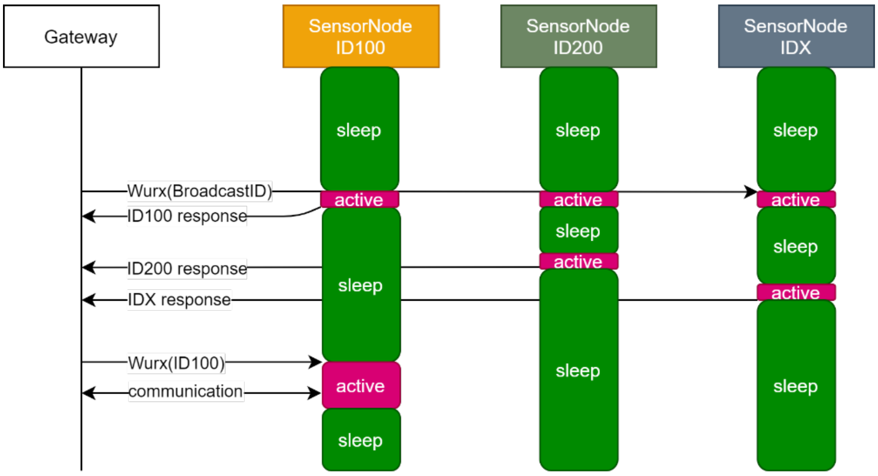

Figure 1: Addressed and broadcast wake up

The gateway receives the response. Thus, the gateway scans all sensor nodes in its radio range. If the Node-IDs are known, an addressed WakeUp can take place. For this purpose, the WakeUp telegram must be coded with the node ID according to the specifications of the FH101RF data sheet. An addressed WakeUp puts the addressed sensor node into communication state. The communication is done with a proprietary message format. After communication, the sensor node puts itself into the low-power sleep state. This happens even if there is no communication after a time out.

3
FH101RF NetworkTool

The management, control and configuration are done in the FH101RF Network Tool see Figure 2. This offers the option of parameterizing the transmission power of the gateway, a list of sensor nodes as well as functions for communication and signal generation. When closed, an entry provides information about the node ID, radio field strength of the received signal at the gateway and time stamp of the last communication.

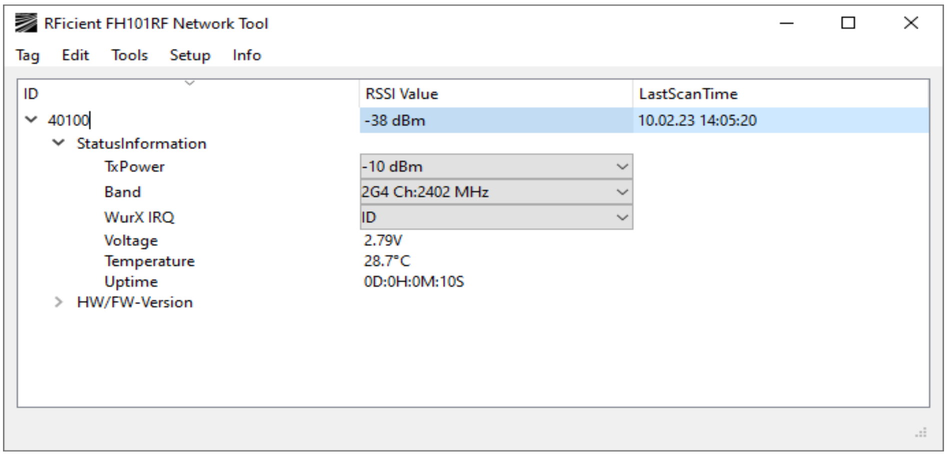

Figure 2: FH101RF Network Tool

The status information of the respective sensor node is displayed in the StatusInformation menu. Access to the menu is via the arrow next to the sensor node entry. If a menu is expanded by the arrow, the data of the respective menu is updated automatically. To update the data when a menu is closed, it must be closed and expanded again by clicking on the arrow. In addition, some menu entries have a drop-down menu which can be opened by clicking the right mouse button. Figure 2 shows a sensor node entry with the ID 40100 it supports the parameters like:

- TxPower: TX power setting, this setting determines the transmit power of the PA amplifier of the sensor node. Important: Please observe the respective regulator guidelines, in CR2032 button cell operation transmitting powers > -10 dBm are not recommended.
- Band: Band and Frequency setting of the Sensor node.
- WurX IRQ: IRQ setting of the FH101RF receiver. Supported options ID for selective wake up and CodeA/B**Fehler! Textmarke nicht definiert.**. CodeA/B**Fehler! Textmarke nicht definiert.** is fault tolerant and should be used in highly disturbed radio environments.
- Voltage: Voltage of the CR2032 battery during the active phase of the module. Important: Voltage at the battery differs depending on the state of the battery, significantly, between the active and passive phase.
- Temperature: Temperature of the MCU, 8bit resolution, manufacturer specifies a deviation of ±3°C.
- Uptime: Runtime after start of the module is zeroed after power up or reset of the module.
- HW/FW-Version: Firmware information of the sensor node.

Note: the menu entries may vary depending on the equipment, e.g. plug on sensors and FW version of the sensor nodes.

[1] No broadcast is available.

Note: If the connection is disturbed during the reading of the sensor node, the corresponding menu remains closed. The status of the node is displayed as offline under RSSI Value. To read out again, click on the arrow symbol.

Note: When changing the sensor node settings in the StatusInformation menu, the set settings are not checked by the radio return channel. To check that the settings have been adopted by the sensor node, the StatusInformation menu must be read out again. This is done by closing and opening the StatusInformation menu with the arrow.

4
Getting started

For the operation of the application, the driver requirements as well as the Assembly and Function Matrix must be fulfilled. If this is the case, connect the gateway to the PC and start the FH101RF Network Tool application. This is part of the development kit and is included in the scope of delivery.
The detected gateway is displayed under Menu Setup/GateWay/UsbDevice. Figure 2 shows the corresponding gateway menu entries . If there is no entry in the menu, the requirements and the PC<->gateway connection must be checked.

It must be ensured that the gateway and the sensor node are set to the same band and frequency. The band setting of the gateway is done under the menu item Setup/GateWay/FreqBand. The band setting of the sensor node is explained in the following chapter. Once the GateWay is detected and the band setting is complete, the gateway can scan the sensor nodes within range. This can be done by a broadcast message or by inserting the CR2032 battery into the sensor node. The sensor node will automatically send out a "HELLO" message when the battery is inserted. If the gateway receives this, an entry is made in the NetworkTool with the corresponding node id.

A scan of the sensor nodes in the range of the gateway is done in Menu: Tools/Broadcast or by pressing the B key on the keyboard, the focus must be on the application.
The sensor nodes appear in the overview. If this is not the case or if the sensor nodes are out of range, the transmission power of the gateway can be increased in the menu Setup/GateWay/TxPower.
Here the regulations of the respective radio regulators are to be considered.

The sensor nodes recorded in the Network Tool list can be read out and parameterized.

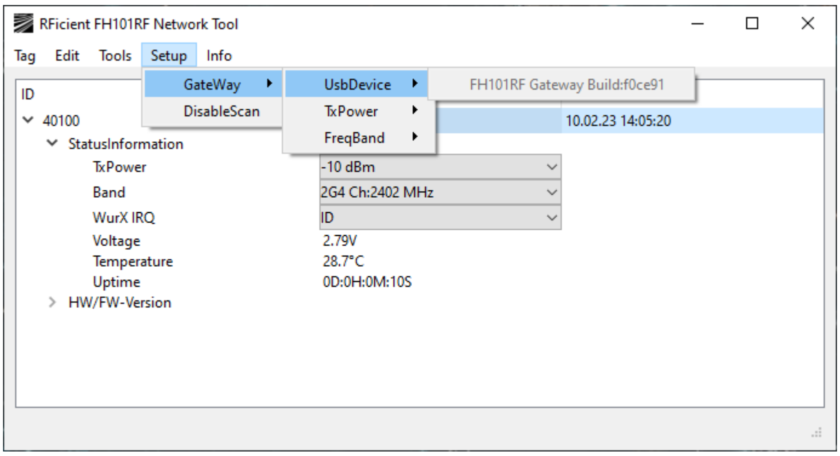

Figure 3 FH101RF Network Tool GateWay menu

5
Frequency and band setting

As mentioned in the previous chapter, the band setting of the gateway and the sensor node must match. In the delivery state, the band setting of the sensor node is 2G4, the radio channel is 2402 MHz. This setting can be changed by flashing configuration templates, see APP note RFicient® Boot loader. The flashed configuration template is loaded from the MCU memory into the corresponding runtime variable during power up of the node. The following matrix shows the band allocation of the *.hex configuration templates.

Table 1 configuration templates eu version

	band 433 MHz	band 868 MHz	band 2402 MHz	band 2480 MHz
conf433eu.hex	x			
conf868eu.hex		x		
conf2g4eu_l.hex			x	
conf2g4eu_h.hex				x

Table 2 configuration templates non eu version

	band 433 MHz	band 915 MHz	band 2402 MHz	band 2480 MHz
conf433.hex	x			
conf915.hex		x		
conf2g4_l.hex			x	
conf2g4_h.hex				x

Furthermore, the band setting of the sensor node can be changed at runtime in the band menu of the Network Tool application. It is important to observe the sequence. First the band setting of the sensor node has to be done and only then the band setting of the GateWay.

Note: sometimes it can happen that the configuration message to the sensor node is overlaid and disturbed by a radio interferer. This is especially the case with band 24xx. To avoid this, the distance between gateway and node should be reduced or the gateway transmit power should be increased.

Note: that changing the sensor node band configuration at runtime by the Network Tool is volatile and is not active at the next power up sequence of the module.

Note: after changing the band setting, the antennas on the SoC radio interface (Tx/Rx) must be changed according to the setting. This concerns the gateway as well as the node module.

Note: configuration of the gateway using templates is permitted

6 Measuring the radio range with the Ping/Pong method

Another possibility to measure the radio range is offered by PingTool. This is part of the Network Tool application and allows the user to wake up the selected sensor node cyclically with a periodicity of 1 second. Immediately after waking up the node, the GateWay sends an additional ping message via the SoC transceiver, addressed to the corresponding sensor node. The corresponding sensor node then responds with a pong message. This message is received by the GateWay, evaluated and then forwarded to the Network Tool. Thereby the information like the receive level (RSSI) of the signal as well as FH101RF runtime parameters are determined. The processes are shown in simplified form in Figure 4.

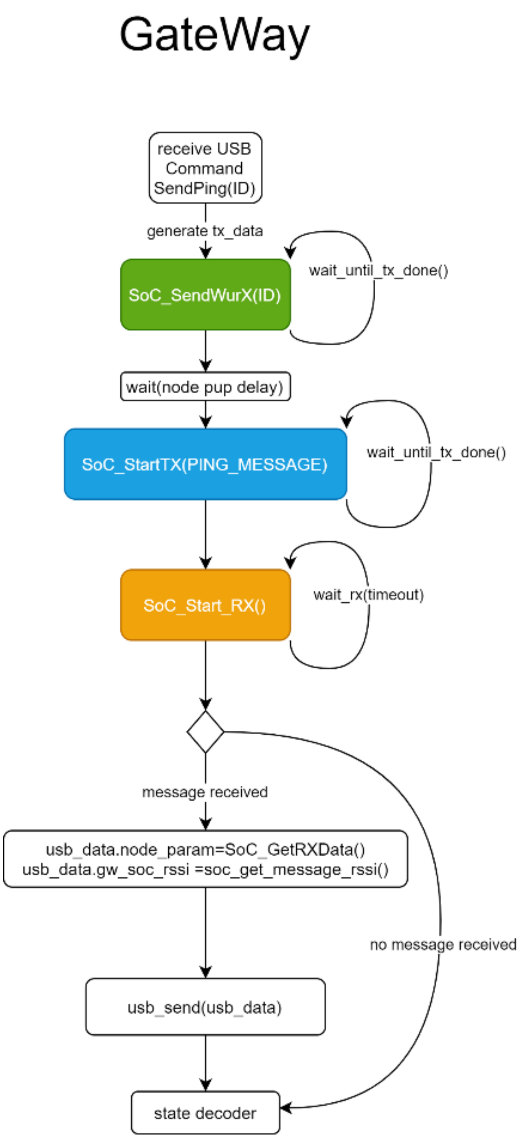

Figure 4: Ping/Pong flow chart

The PingTool is called by a context menu in the Network Tool application. The context menu is displayed by right mouse click below the RSSI Value column. Figure 5 shows the context menu. Clicking on the PingTool menu item starts the corresponding application.

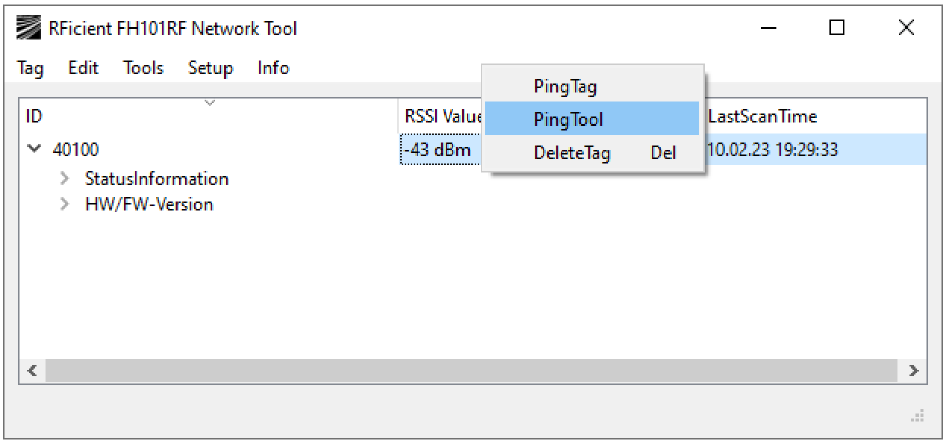

Figure 5: PingTool context menu

By clicking on the menu item PingTool the corresponding tool is started.

The Figure 6 shows the PingTool with the ID (NodeID) of the corresponding sensor node in the window header.

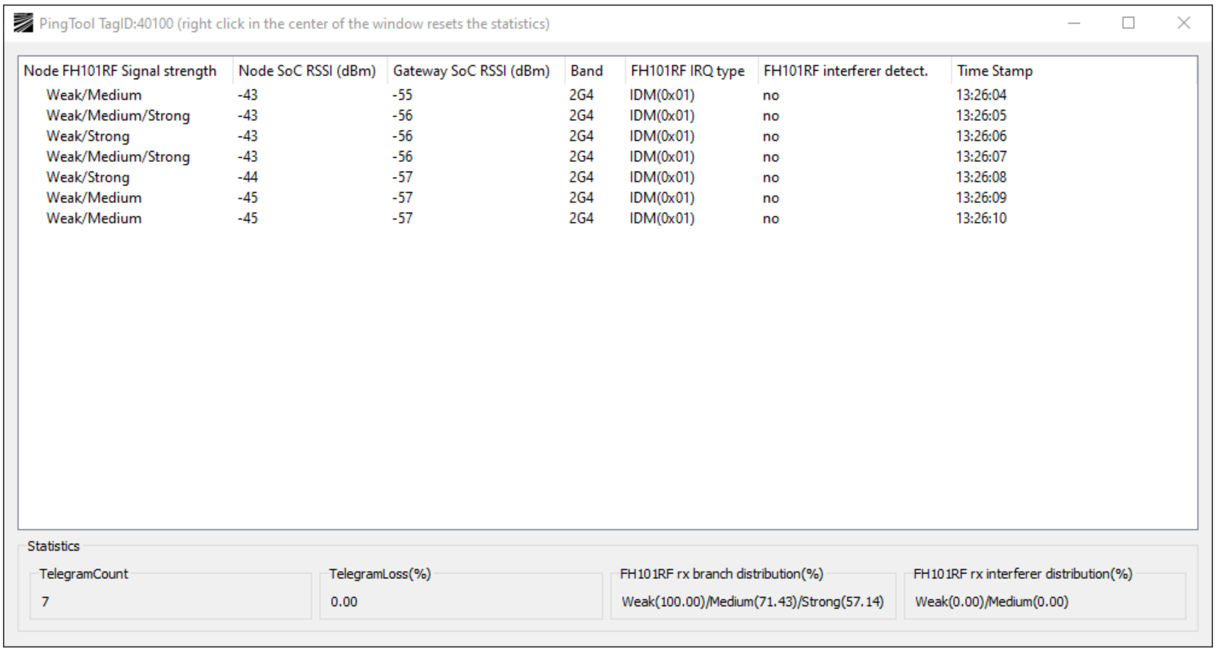

Figure 6: PingTool Application

This contains the following information about the respective telegram.

- Node FH101RF Signal strength: The FH101RF signal strength of the received WakeUp telegram. This shows the FH101RF branches that have received the signal/telegram.
- Node SoC RSSI: Signal strength of the received ping telegram at the SoC receiver of the sensor node.
- Gateway SoC RSSI: Signal strength of the received ping telegram at the SoC receiver of the gateway.
- Band: FH101RF band, which has triggered.
- FH101RF IRQ type: FH101RF IRQ type that has triggered.
- FH101RF interferer detector: Interferer detector this indicates possible interfered receive branches of the FH101RF receiver by radio interferers. It is expected that the telegram be received by all three branches weak/medium/strong at the corresponding strong reception level. If this is not the case, it can usually be assumed that the more sensitive receive branch is disturbed. As an example: with a telegram which was received only by the medium branch it can be assumed that the weak branch is disturbed.
- TimeStamp: Local time at the time of receipt of the telegram.

Additionally in the lower area of the PingTool application statistic information are attached. These show the statistics about all currently displayed telegrams. These can be deleted by right clicking on any telegram.

Note: while the PingTool is running, all settings of the GateWay and the sensor node are still available and can be changed.

7
SoC radio and FH101RF settings

Table 3: SoC-Radio configuration FH101RF pattern sending

Band/Setting	Modulation	Symbol rate (bps)	Frequency (MHz)	Shaping filter
433 Ch:433.9	OOK	33115	433.9	None
868 Ch:868.4	OOK	33115	868.4	None
915 Ch:916.5	OOK	33115	916.5	None
2G4 Ch:2402	OOK	33115	2402	None
2G4 Ch:2480	OOK	33115	2480	None

Table 4:SoC Radio configuration main data channel

Band/Setting	Modulation	Deviation (kHz)	Symbol rate (bps)	Frequency (MHz)	Shaping filter
433 Ch:433.9	FSK2	20	32000	433.9	Gaussian(.5)
868 Ch:868.4	FSK2	20	32000	868.4	Gaussian(.5)
915 Ch:916.5	FSK2	20	32000	916.5	Gaussian(.5)
2G4 Ch:2402	FSK2	20	32000	2402	Gaussian(.5)
2G4 Ch:2480	FSK2	20	32000	2480	Gaussian(.5)

Table 5: FH101RF register settings

Band/Setting	LO Target (MHz)	Preamble data rate (bps)	Data rate (bps)	Desired ZF Frequency (MHz)	OFFSET_CAL Setting COMP_THRESH_S/M/W
433 Ch:433.9	470	1024	32768	36	0x14/0x14/0x09
868 Ch:868.4	906	1024	32768	38	0x14/0x14/0x09
915 Ch:916.5	956	1024	32768	40	0x14/0x14/0x09
2G4 Ch:2402	2350	1024	32768	52	0x14/0x14/0x09
2G4 Ch:2480	2530	1024	32768	50	0x14/0x14/0x09

8 Assembly and Function Matrix

Board Mode	Firmware	Red LED	Green LED	Antenna TxRx	Antenna RFin433	Antenna RFin868	Antenna RFin2G4	D2XX Driver	USB – PC connection	Pin-Header-Jumpers	CR2032	Onboard current meas. switch
Gate-Way	gwfw_(vers)_(build)_.hex	On/Off	On	Yes[1]	-	-	-	Yes	Yes	Yes fully equipped	No	Off
Sensor Node	sensorfw_(vers)_(build)_.hex	Very short On @power up	Off	Yes[1]	Yes[2]	Yes[2]	Yes[2]	-	No	Yes fully equipped	Yes	Off

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[1] Depending on selected band

[2] When corresponding band is enabled

9
Electrical and RF specifications

Sensor-Node	
Voltage (CR2032)	min: 2.6 V / typ. 3.0 V
Current	max: 80 mA Sleep @EM3: typ. 7.2 µA
Gateway	
Voltage	USB 5V / Core typ: 3.3 V
Current	max: 500 mA
Tx Power	min: -30 dBm / max[1]: 17 dBm

[1] depending on the configuration and only on certain bands

10
PC Requirements

The following PC requirements must be met:

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

11
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Component	OSS Module Name	Module Version	License
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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

13 Appendix Licence text

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