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FH101RF DEVELOPMENT KIT

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1 Introduction

The FH101RF development kit is the evaluation and development environment for the FH101RF radio receiver developed by Fraunhofer IIS. It allows the user to evaluate all functionality of the FH101RF receiver in a time-saving way, to create application-specific configurations and to verify them with WakeUp sequences or data transmission.

The development kit consists of two RFicient® FH101RF development boards, antennas, software, documentation and connecting cables.

The RFicient® FH101RF development board combines the Fraunhofer RFicient® technology in the form of the FH101RF radio receiver and a powerful SOC from SiliconLabs on one board.
At the same time, it provides the radio bands supported by the FH101RF: 433/868/915/2400MHz for receiving and transmitting. Furthermore, there is the possibility of self-sufficient operation with a coin cell CR2032, depending on the configuration of the firmware, the current consumption for the module ready to receive is less than 4 µA.

The FH101RF development board is a unified board that can act as a transmitter (TX), receiver (RX) or as a stand-alone radio node. The function is assigned by the firmware of the microcontroller. The user can define the function himself by choosing the provided firmware as well as by developing it himself. Furthermore the development board offers a programming interface. Requests for custom firmware solutions should be sent to the following email address: contact@lze-innovation.de.

Sample applications and software tools for evaluating the RFicient® FH101RF receiver are included in the scope of delivery. These are described in separate application notes. Each application note contains an assembly and function matrix. It describes the assembly as well as the operating state of the development boards and must be strictly adhered to.

2
Purpose of application

Disclaimer

The Evaluation Kit can be operated within the specified operating voltages, the rated operating temperatures and other conditions as specified. The Evaluation Kits are prototypes which are fabricated for evaluation towards potential system application. They are not intended for use in products at this stage of development AND must always be supervised in a laboratory environment by trained personnel.

The Evaluation Kit is designed for application e.g. in

Smart Home	e. g. intelligent lighting, building automation.
Logistics	e. g. indoor localization, plant tracking.
Industrial	e. g. condition monitoring, wireless remote control.
Retail	e. g. location-based marketing, in-store navigation.
Health	e. g. body area networks, fitness monitoring.

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3 Disclaimer

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4 Fraunhofer RFicient® FH101RF receiver

The RFicient® FH101RF radio receiver constantly monitors the radio channel and responds within a few milliseconds with current consumption below 3 µA. It can thus activate any IoT and sensor node as needed, providing long-lasting maintenance-free operation. RFicient® wireless sensor technology offers many new possibilities through continuous, wide-area wireless monitoring without standard or frequency restrictions. RFicient® therefore represents a key technology for the Internet of Things.

5
Protocol and data transmission

As a rule, a radio application consists of a bidirectional radio channel. In the following consideration, such a radio channel is assumed.
The radio protocol is divided into the WakeUp and the Main sequence. The WakeUp sequence is received, decoded and evaluated by the FH101RF receiver. This serves as wakeup signal for the module. Depending on the configuration the following functionality can be realized with the WakeUp sequence: WakeUp, WakeUp addressed, WakeUp addressed with user data. Further information like data rate, modulation sensitivity can be found in the FH101RF data sheet.
The Main Sequence is the main data transmission. Here different standards as well as proprietary protocols can be used. The SOC from SiliconLabs offers a wide range of radio protocols as well as modulation types for selection.

Figure 1 shows a typical communication flow between a transmitter and receiver. The receiver is equipped with RFicient technology. The receiver remains in low-power mode until it receives the WakeUp sequence. Once the WakeUp sequence is received, the FH101RF receiver generates an interrupt and wakes up the system or the microcontroller (MCU active). The MCU then exchanges data with the transmitter using the selected radio protocol. As soon as the data exchange has taken place, the microcontroller is set to the power-saving sleep mode (MCU sleep).

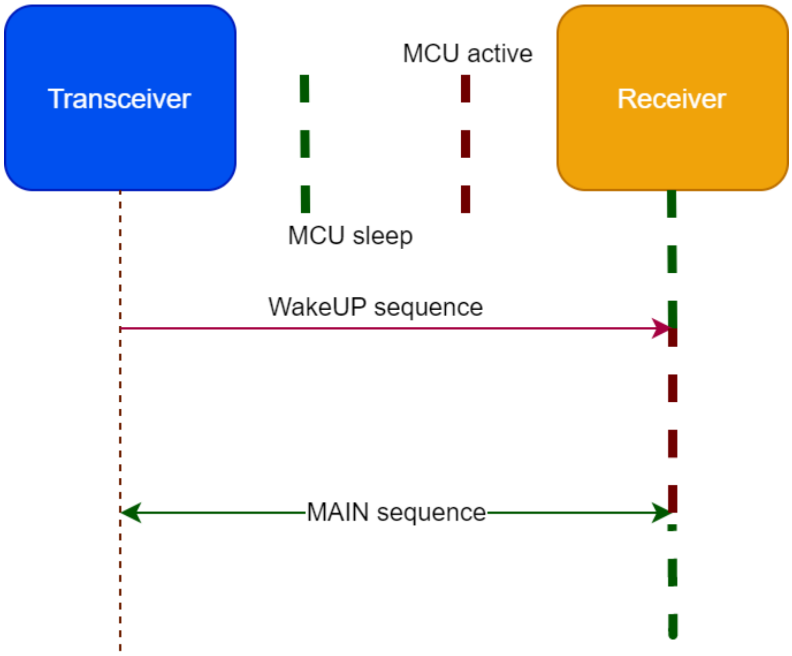

Figure 1: Typical transmitter/receiver sequence with FH101RF

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FH101RF development board

Figure 2 shows the development board from the top/bottom view. Key components and antenna connectors are labeled. The FH101RF DUT pin header is equipped with jumpers that cannot be removed during normal operation. If the application requires the FH101RF receiver to be controlled externally, the jumpers must be removed. This separates the development board and the FH101RF receiver. To avoid damage to the development board, only the pins on the FH101RF side of the FH101RF DUT pin header should be externally driven. The level diagram can be found in the data sheet of the FH101RF.

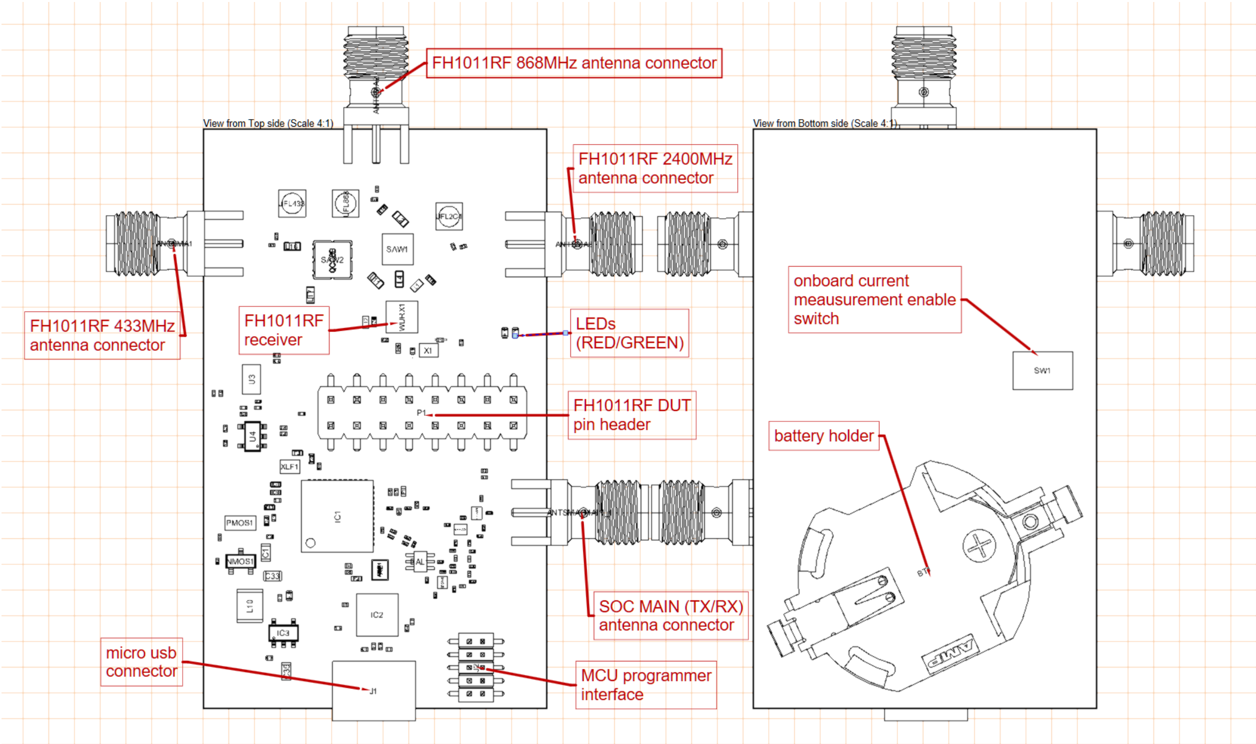

Figure 2: Development board (V3.02) TOP/BOTTOM view

Figure 3 shows a simplified block diagram of the development board. For programming the MCU, a programmer is required that supports the SWD protocol.

The programming connector is assigned as follows: 1(VDD3V3), 2(GND), 3(DBG_RESETn), 4(VCOM_RX), 5(VCOM_TX), 6(DBG_SWO), 7(DBG_SWDIO), 8(DBG_SWCLK), 9(PTI_FRAME), 19(PTI_DATA). The programming connector can also be used to connect sensors or other systems. The pins can be configured as SPI/I2C/GPIO.

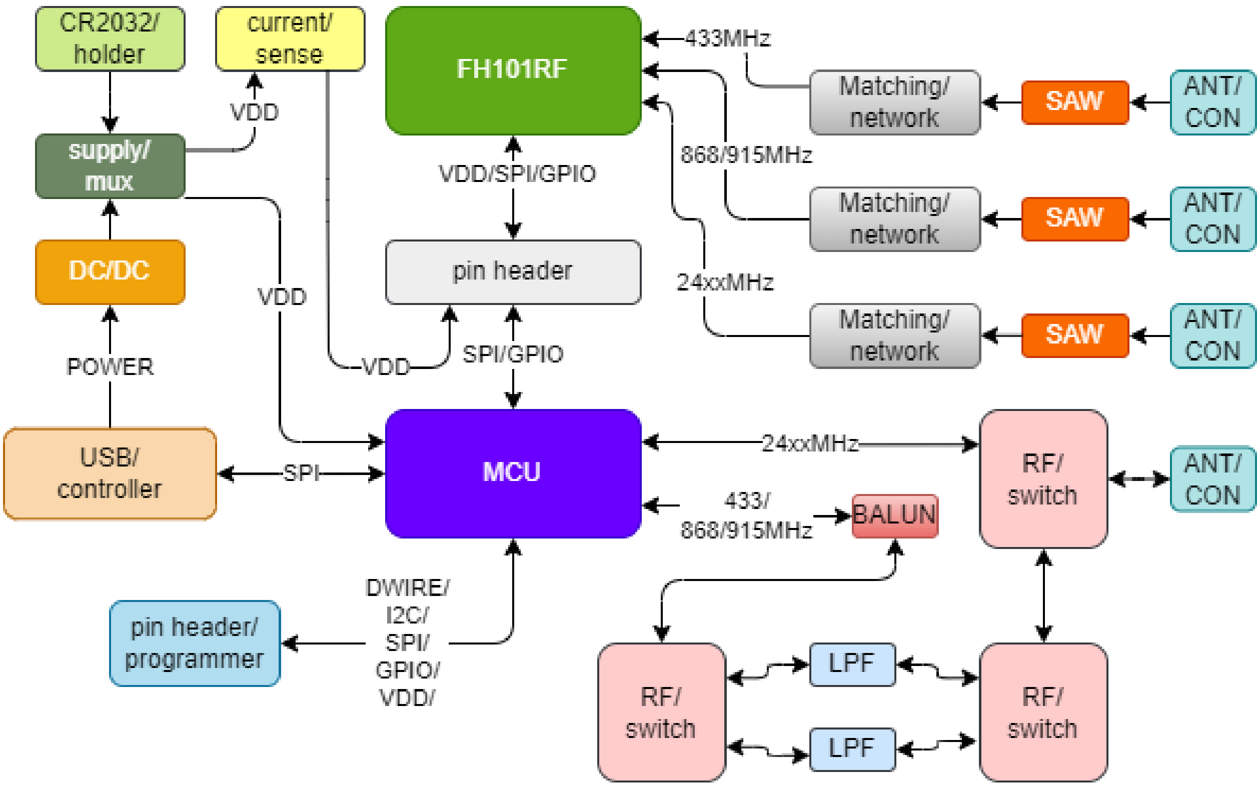

Figure 3: Development board (V3.03) block diagram
Note: saw filter in FH101RF 24xx MHz path since board version 3.03

7 Current measurement

The development board is equipped with a current measurement circuit that measures the current flow to the FH101RF chip. The accuracy of the current measurement at room temperature is in the range of approx. ±300 nA. Saturation is reached at approx. 300 µA, the circuit is not temperature compensated.
The circuit for current measurement can be switched on and off by setting the switch on the back of the board to the appropriate position. Make sure that both sliders are in the same position.
If the board is operated in stand-alone mode with the battery, the current measurement should be switched off to reduce the current flow and thus achieve the best possible battery lifetime.

It is possible to measure the FH101RF current with an external measuring device. To do this, the VDD jumper on the pin header must be removed and the external current measuring device connected instead. The internal resistance of the current meter should not be higher than 10 Ohm when powering up the FH101RF receiver. After power up, the internal resistance can be increased.

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Latency measurement

To measure the latency of the FH101RF receiver, the TX trigger signal is fed out on the TX module (TX-Mode) at pin RESETn of the pin header. When the transmitter starts the buffered transmission, an inverted pulse is generated at this pin. The rising edge of the pulse defines the transmission start time t(tx). The time t(rx) of the triggering/reception of the FH101RF receiver, at the RX module (RX-Mode), is defined by the rising edge at pin GPO1 of the PinHeader.

Note: The measurement of the latency is only available in the evaluation application.

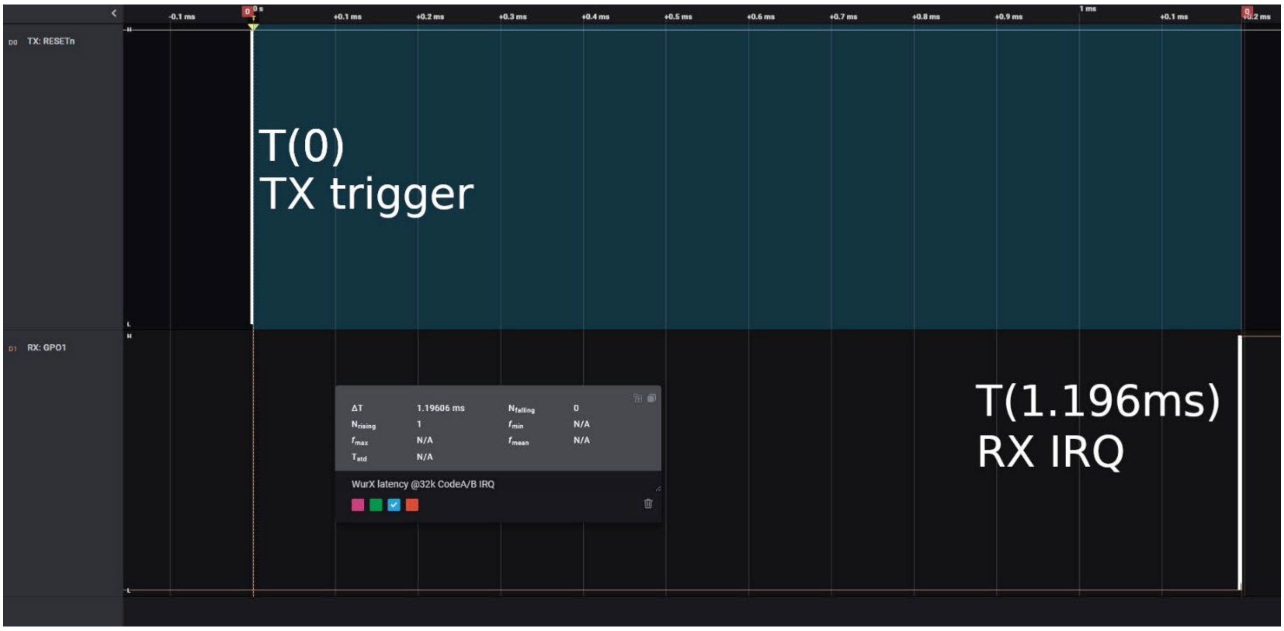

Figure 4: Latency measurement

The Figure 4 shows a latency measurement with logic analyzer. The TX module is connected to logic analyzer channel D0 TX:RESETn and the RX module to channel D1 RX:GPO1. At time t(0) the inverted pulse occurs at D0 and at time t(1.196ms) the receiver triggers. The time delay is marked in blue in the figure.

Table 1: TX delay vs data rate

TX data rate [bps]	TX delay [us]
256	6880
512	3485
1k	1795
2k	944
4k	520
8k	308
16k	202
32k	149

To calculate the exact FH101RF latency, the time between the TX pulse, SoC tx buffer filled, and the physical start of the WakeUp pattern must be subtracted from the measured delay. This delay is caused by the SoC transmitter and its configuration. It depends on the transmitter data rate and can be taken from the Table 1.

Note: If the payload data is activated in Tx-Mode, the payload data rate must be used to determine the TX delay.

The FH101RF latency from the example shown is calculated as follows:
MeasuredTimeDelay(1196us) – TxDelay@32k(149us)=Latency(1047us)

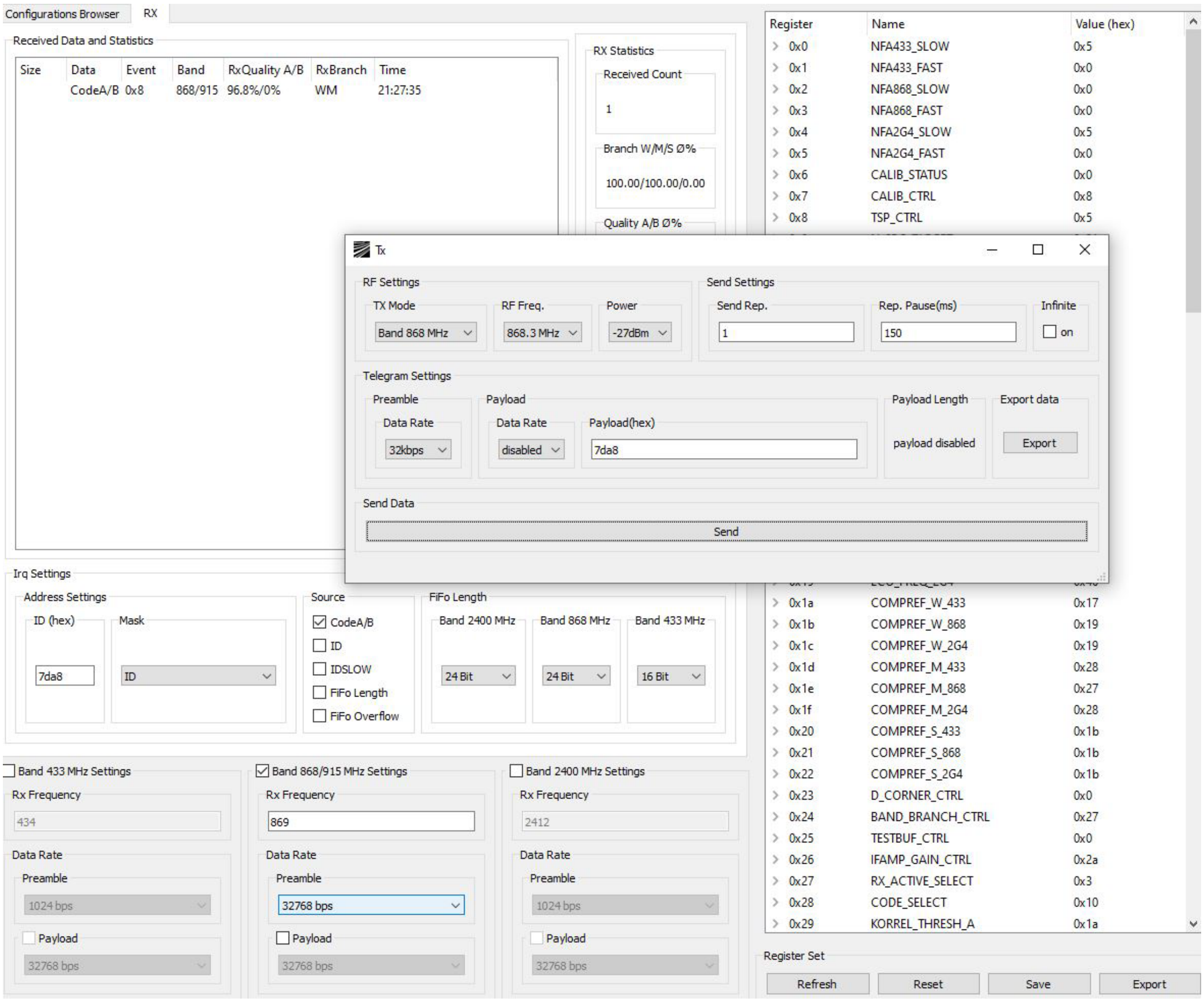

Figure 5: Latency measurement setup

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Antenna chart

Band	Manufacturer	MFG P/N
433	Linx	ANT-433-CW-HWR-SMA
868	Linx	ANT-868-CW-HWR-SMA
915	Linx	ANT-916-CW-HWR-SMA
2400	Linx	ANT-2.4-CW-HWR-SMA

Figure 6: Antennas

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PC Requirements

The following PC requirements must be met:

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

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Technical Data

Electrical	USB supply	Battery holder
Power supply	typ. 5 V	min. 2.6 V : typ. 3 V : max. 3.3 V
Supply current	min. 4 µA : max[1]. up to 500 mA	min. 4 µA : max1. up to 70 mA

Board assembly: FH101RF01FFV3.02	Component
WakeUp	FH101RF
SOC/MCU	EFR32FG13P233F512GM48
USB controller	FT220XQ

RF-Communication: FH101RF01FFV3.02	Frequency (Channel)
FH101RF	433.92 MHz, 868.39 MHz,916.5 MHz, 2400-2480 MHz
SOC/MCU	433.92 MHz, 868.39 MHz, 916.5 MHz 2400-2480 MHz

RF-Communication: FH101RF01FFV3.03	Frequency (Channel)
FH101RF	433.92 MHz, 868.39 MHz,916.5 MHz, 2476-2480 MHz
SOC/MCU	433.92 MHz, 868.39 MHz, 916.5 MHz 2400-2480 MHz

TX power:	Band 433MHz	Band 868MHz/915MHz	Band 24xxMHz
FH101RF01FFV3.02/ FH101RF01FFV3.03	min. -30 dBm/ max. 10 dBm	min. -30 dBm/ max. 17 dBm	min. -30 dBm/ max. 17 dBm

SOC TX Harmonic Emmisions, typical values	2nd	3rd	4th
Frequency: 433.9 MHz @11.4 dBm TX power	-50 dBc	-60 dBc	-84 dBc
Frequency: 868.4 MHz @17 dBm TX power	-48 dBc	-67 dBc	-57 dBc
Frequency: 916.5 MHz @17 dBm TX power	-57 dBc	-67 dBc	-50 dBc
Frequency: 2400 MHz @17 dBm TX power	-50 dBc	-89 dBc	-

[1] depending on the configuration and tx power

12 Physical dimensions

Board: FH101RF01FFV3.02	PCB	PCB + antenna connector
Size (WHT)	33x55x23 mm	55x69x23 mm

Board ordering Information

Order number	MCU	TX band	RX band	Type
FH101RF01FFV3.02 or FH101RF01FFV3.03	EFR32FG13P233F512GM48	433/ 868/ 915/ 24xxMHz	433/ 868 or 915 24xxMHz	development board, board only
FH101RF01FFV3.02KIT or FH101RF01FFV3.03KIT	EFR32FG13P233F512GM48	433/ 868/ 915/ 24xxMHz	433/ 868 or 915/ 24xxMHz	2x development board, cable and documentation. With the corresponding antennas from the order option

Ordering options

Option number (Band)	Included antennas (Band)	Equipped SAW on band 868/915	Equipped SAW on band 2G4
433 MHz	3x 433 MHz	B39871B3744H110 or B39921B3300H110	B39252B7556P810 or no SAW-Filter depending on the board version
868 MHz	3x 868 MHz	B39871B3744H110	B39252B7556P810 or no SAW-Filter depending on the board version
915 MHz	3x 915 MHz	B39921B3300H110	B39252B7556P810 or no SAW-Filter depending on the board version
24xx MHz	3x 24xx MHz	B39871B3744H110	no SAW-Filter
2476 MHz	3x 24xx MHz	B39871B3744H110 or B39921B3300H110	B39252B7556P810
433 MHz+868 MHz	3x (433/868) MHz	B39871B3744H110	B39252B7556P810 or no SAW-Filter depending on the board version
433 MHz+915 MHz	3x (433/915) MHz	B39921B3300H110	B39252B7556P810 or no SAW-Filter depending on the board version
433 MHz+24xx MHz	3x (433/24xx) MHz	B39871B3744H110	no SAW-Filter
433 MHz+2476 MHz	3x (433/24xx) MHz	B39871B3744H110	B39252B7556P810
868 MHz+24xx MHz	3x (868/24xx) MHz	B39871B3744H110	no SAW-Filter
868 MHz+2476 MHz	3x (868/24xx) MHz	B39871B3744H110	B39252B7556P810
915 MHz+24xx MHz	3x (915/24xx) MHz	B39921B3300H110	no SAW-Filter
915 MHz+2476 MHz	3x (915/24xx) MHz	B39921B3300H110	B39252B7556P810
433 MHz+915 MHz+24xx MHz	3x (433/915/24xx) MHz	B39921B3300H110	no SAW-Filter
433 MHz+915 MHz+2476 MHz	3x (433/915/24xx) MHz	B39921B3300H110	B39252B7556P810
433 MHz+868 MHz+24xx MHz	3x (433/868/24xx) MHz	B39871B3744H110	no SAW-Filter
433 MHz+868 MHz+2476 MHz	3x (433/868/24xx) MHz	B39871B3744H110	B39252B7556P810

Board code key

(FH101RF)(01)(FF)(V3.02) (NAME)(TYPE)(BAND)(V)

Name, 8 chars	Type (hex), 1byte	Band (hex) , 1byte	Version
RFicient® WakeUp Tech.	0-0xff	Band feature bitwise coded: 0-0xff	Board version
	0 eval board	Band[7] = ULPRX433; 1=> equipped	
	1 development board	Band[6] = ULPRX433SAW; 1=> equipped	
	>=2 reserved	Band[5] = ULPRX868 or ULPRX915; 1=> equipped	
		Band[4] = ULPRX868SAW or ULPRX915SAW; 1=> equipped	
		Band[3] = RX24xx; 1=> equipped	
		Band[2] = TX433; 1 => equipped	
		Band[1] = TX868/TX915; 1 => equipped	
		Band[0] = TX24xx; 1 => equipped	

(FH101RF)(01)(FF)(V3.03) (NAME)(TYPE)(BAND)(V)

Name, 8 chars	Type (hex), 1byte	Band (hex) , 1byte	Version
RFicient® WakeUp Tech.	0-0xff	Band feature bitwise coded: 0-0xff	Board version
	0 eval board	Band[7] = ULPRX433; 1=> equipped	
	1 development board	Band[6] = ULPRX433SAW; 1=> equipped	
	>=2 reserved	Band[5] = ULPRX868 or ULPRX915; 1=> equipped	
		Band[4] = ULPRX868SAW or ULPRX915SAW; 1=> equipped	
		Band[3] = ULPRX24xx and SAW; 1=> equipped	
		Band[2] = TX433; 1 => equipped	
		Band[1] = TX868/TX915; 1 => equipped	
		Band[0] = TX24xx; 1 => equipped	

Band feature	Description
ULPRXxxx	Board is equipped with an ultra-low power rx path @xxx band
ULPRXxxxSAW	Board ultra-low power rx feed is equipped with a saw filter @xxx band
TXxxx	Board is equipped with an transceiver @xxx band

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Software components & licenses

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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

15 Appendix Licence text

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Version 3, 29 June 2007

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