# LimeRFE 1v0

## *- Quick Starter Manual -*

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# Contents

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# Revision History

The following table shows the revision history of this document:

| Date | Version | Description of Revisions |
|---|---|---|
| 20/11/2019 | 1.0.0 | Initial version created. |

# 1

# Introduction

The scope of this document is a quick start with the LimeRFE board. Additional board, the LimeSDR can be used, but also a quick and easy start of the LimeRFE can be done without the LimeSDR. In this document, a method without LimeSDR will be described in details.

Absolute maximum rating are given in Chapter 2.

A link to download all necessary software is given in Chapter 3.

Chapter 4 describes how to run a control software and make a quick start with the LimeRFE board.

A list of all connectors and their brief description are given in Chapter 5.

In Chapter 6 is explained how to change bias currents for some power amplifiers in transmitter block of the LimeRFE board.

Chapter 7 gives a step by step procedure which describe how to quickly and easy startup the LimeRFE board, where the board is setup for HAM 144 – 146 MHz (2 m) band in transmitter mode.

Chapter 8 gives short description how to set bias currents in amplifiers which have that option.

API functions for LimeRFE control are described in Chapter 9.

# 2

# Absolute Maximum Ratings

Table 1 shows the maximum no damage input powers for RX mode (applied to connectors J3 or J5).

Table 1: Maximum input signals for RX

| Channel | Channel Description | RF Input Power [dBm] | Comment |
|---|---|---|---|
| HAM 30 | HF | 10 | |
| HAM 50 and 70 | 6 and 4 m | | |
| HAM 145 | 2 m | | |
| HAM 220 | 1.25 m | | |
| HAM 435 | 70 cm | | |
| Wideband 1000 | 1 – 1000 MHz | | |
| HAM 915 | 33 cm | 20 | |
| HAM 1280 | 23 cm | | |
| HAM 2400 | 13 cm | | |
| HAM 3500 | / | | |
| Wideband 4000 | 1 – 4 GHz | | |
| Cellular Band 1 | LTE Band 1 | 20 | |
| Cellular Band 2 | LTE Band 2/ PCS-1900 | | |
| Cellular Band 3 | LTE Band 3/ DCS-1800 | | |
| Cellular Band 7 | LTE Band 7 | | |
| Cellular Band 38 | LTE Band 38 | | |

**Note:** The received signal will be amplified at the connector SDR RX (J1), care must be taken about that the maximum input RF power of the SDR connected is not exceeded.

Table 2 shows the maximum no damage input powers for TX mode (applied to connectors J2).

Table 2: Maximum input signals for TX

| Channel | Channel Description | RF Input Power [dBm] | Comment |
|---|---|---|---|
| HAM 30 | HF | 13 | TBC |
| HAM 50 and 70 | 6 and 4 m | 13 | TBC |
| HAM 145 | 2 m | 15 | TBC |
| HAM 435 | 70 cm | 13 | TBC |
| Wideband 1000 | 1 – 1000 MHz | 0 | TBC |
| HAM 1280 | 23 cm | 5 | TBC |
| HAM 2400 | 13 cm | 10 | TBC |
| HAM 3500 | / | 5 | TBC |
| Wideband 4000 | 1 – 4 GHz | 5 | TBC |
| Cellular Band 1 | LTE Band 1 | 10 | TBC |
| Cellular Band 2 | LTE Band 2/ PCS-1900 | 10 | TBC |
| Cellular Band 3 | LTE Band 3/ DCS-1800 | 10 | TBC |
| Cellular Band 7 | LTE Band 7 | 10 | TBC |
| Cellular Band 38 | LTE Band 38 | 10 | TBC |

# 3

# Installing the Control Software

Support for LimeRFE control has been integrated into the LimeSuite software.

All necessary software can be downloaded from:
https://wiki.myriadrf.org/Lime_Suite

Latest source can be downloaded from LimeSuite GitHub repository:
https://github.com/myriadrf/LimeSuite
Branch: LimeRFE

# 4

# Getting Started with the Control Software

In this chapter the basic information regarding the LimeRFE board and control software will be presented. The purpose is to get the LimeRFE up and running with as little effort as possible, emphasizing the essential information. Detailed information on the board and the control software will be provided in the following chapters.

## 4.1 Required libraries and tools

There are 2 possible ways to run the LimeRFE board:

- Through SDR board − Communication if established through the LimeSDR board using I2C. In this document this type of communication will be denoted SDR.
- Directly through USB − Direct communication via USB.

In this document the LimeRFE board will be controlled through USB communication, so no additional LimeSDR board will be required.

## 4.2 Basic Software Setup

Basic setup procedure is described in a few steps bellow:

- Open Lime Suite GUI and then go to Modules/LimeRFE, Figure 1.
- LimeRFE Controls window should appear, Figure 2. This window consists of several panels: Communication, Configuration, Synchronize, RX Channel, TX Channel, Mode, SWR (to display this pannel go to View/Power Meter) and Message Display panel.
- In Communication panels, chose one of two possible options, SDR (this is standard I2C communication) or USB.
  Keep in mind that for SDR (I2C) communication, an additional LimeSDR board must be connected. For SDR (I2C), a default LimeRFE board address is 0x51. If any other device on SDR (I2C) bus has the same address one of these two devices should

change its address. LimeRFE address can be changed in its firmware. After connection the board on I2C bus, button Open Port enables communication. Button Close Port terminates SDR (I2C) communication.
For USB communication an appropriate COM port should be chosen. In USB panel, by clicking Refresh button, LimeRFE Controls software will automatically display available COM ports. Also, all available COM ports (under Windows OS) can be checked in the Windows Device Manager tool.

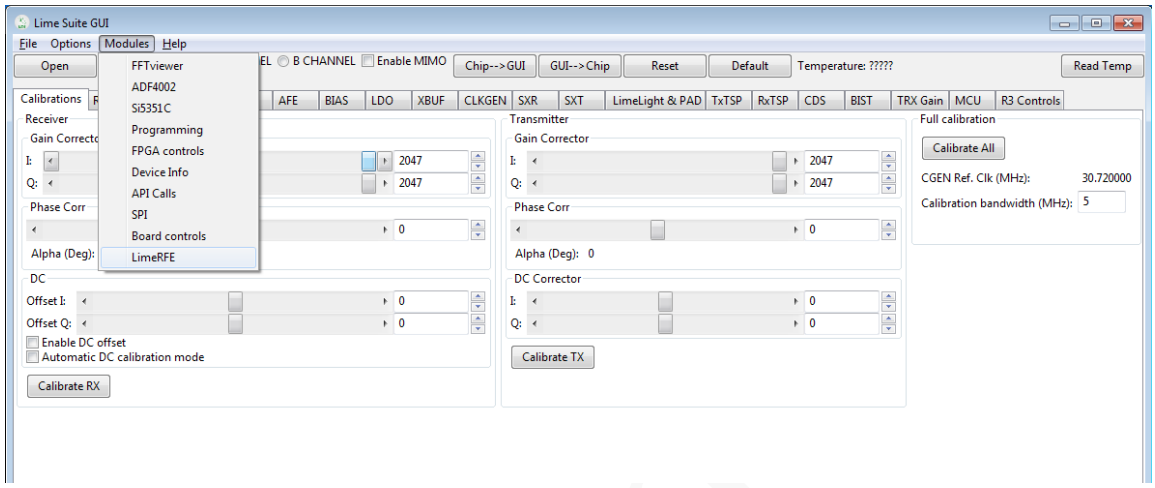


Figure 1: Lime Suite GUI window

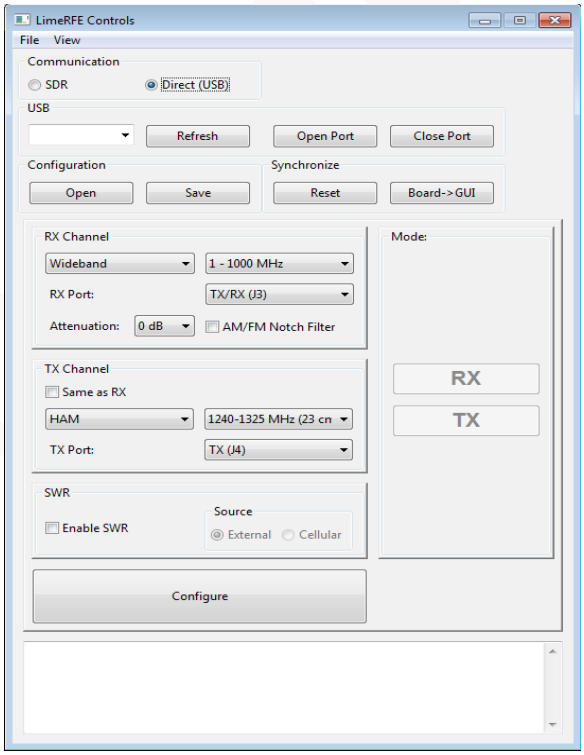


Figure 2: LimeRFE Controls window
(To display SWR pannel go to View/Power Meter)

- From a drop menu select appropriate COM port and click Open Port button to open communication between the LimeRFE board and PC. Text message in *Message Display* panel will be shown after a successful port opening.
- In *Configuration* panel, current configuration can be saved into the **.ini* file (Save button) and previously saved configuration can be loaded from the **.ini* file (Open button).
- In *Synchronize* panel, any current configuration can be changed to default, by clicking Reset button. Button Board→GUI is used to sinhronize Lime RFE Controls software parameters with current board configuration.
- In *RX Channel* panel, in *Type* sub-panel there are three different options (in Fig. 2 an option "Wideband" is shown) .
  Depending of selected type, different Channel/Band options will appear (in Fig. 2 an option "1 – 1000 MHz" is shown).
  The third sub-panel shows selected input port for receiver mode (in Fig. 2 an option "TX/RX (J3)" is shown). RX signal get out from the board at connector J1.
  All possible states are given in Table 3 bellow.
  In the same panel, from *Attenuation* drop menu, attenuation level can be changed for signal in receive mode. Given attenuation values are: 0, 2, 4, 6, 8, 10, 12 and 14 dB (in Fig. 2, 0 dB is selected attenuation level).
  In the same panel, AM/FM Notch filter can be enabled or bypassed in check in box.
  (in Fig. 2 this AM/FM Notch filter has been bypassed, box is not checked).
  Keep in mind that after choosing one of options, button Configure must be pressed to apply all changes in configuration.
- In *TX Channel* panel, in *Type* sub-panel there are three different options (in Fig. 2 an option "HAM" is shown) .
  Depending of selected type, different Channel/Band options will appear (in Fig. 2 an option "1240 – 1325 MHz" is shown).
  The third sub-panel shows selected input port for receiver mode (in Fig. 2 an option "TX (J4)" is shown). TX signal get in into the board at connector J2.
  All possible states are given in Table 3, bellow.
  In the same panel, check in box same as RX can be checked. If it is checked than Type and Channel/Band options will be the same as it was chosen in RX menu, but TX must be selected manually.
  Keep in mind that after choosing one of options, button Configure must be pressed to apply all changes in configuration.
- In Mode panel the board can be configured to operates in RX or TX mode, but for some bands it can be in both modes at the same time or both modes turned off at the same time. All possible states are given in table bellow.

Table 3: All possible states of the LimeSDR board (Type, Band/Channel, Rx and Tx connectors, Modes)

| Type | Channel/Band | RX Port | TX port | Mode |
|---|---|---|---|---|
| Wideband | 1 – 1000 MHz | *TX/RX (J3)* | TX/RX (J3) | None, RX, TX |
| | | | TX (J4) | None, RX, TX, RX&TX |
| | | *TX to 30 MHz TX/RX (J5)* | TX/RX (J3) | None, RX, TX, RX&TX |
| | | | TX (J4) | None, RX, TX, RX&TX |
| | 1000 – 4000 MHz | TX/RX (J3) | TX/RX (J3) | None, RX, TX |
| | | | TX (J4) | None, RX, TX, RX&TX |
| HAM | 30 MHz (HF) | *TX/RX (J3)* | *TX to 30 MHz TX/RX (J5)* | *None, RX, TX, RX&TX* |
| | | *TX to 30 MHz TX/RX (J5)* | | *None, RX, TX* |
| | 50 – 70 MHz (6 & 4m) | *TX/RX (J3)* | *TX to 30 MHz TX/RX (J5)* | *None, RX, TX, RX&TX* |
| | | *TX to 30 MHz TX/RX (J5)* | | *None, RX, TX* |
| | 144 – 146 MHz (2m) | *TX/RX (J3)* | TX/RX (J3) | *None, RX, TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| | | *TX to 30 MHz TX/RX (J5)* | TX/RX (J3) | *None, RX, TX, RX&TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| | 220 – 225 MHz (1.25m) | *TX to 30 MHz TX/RX (J5)* | TX/RX (J3) | *None, RX, TX, RX&TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| | | *TX/RX (J3)* | TX/RX (J3) | *None, RX, TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| | 430 – 440 MHz (70cm) | *TX to 30 MHz TX/RX (J5)* | TX/RX (J3) | *None, RX, TX, RX&TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| | | *TX/RX (J3)* | TX/RX (J3) | *None, RX, TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| | 902 – 928 MHz (33cm) | *TX/RX (J3)* | TX/RX (J3) | *None, RX, TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| | 1240 – 1325 MHz (23cm) | *TX/RX (J3)* | TX/RX (J3) | *None, RX, TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| | 2300 – 2450 MHz (13cm) | *TX/RX (J3)* | TX/RX (J3) | *None, RX, TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| | 3300 – 3500 MHz | TX/RX (J3) | TX/RX (J3) | *None, RX, TX* |
| | | | TX (J4) | *None, RX, TX, RX&TX* |
| Cellular | Band 1 | TX/RX (J3) | TX/RX (J3) | *RX&TX* |
| | Band 2/PCS – 1900 | TX/RX (J3) | TX/RX (J3) | *RX&TX* |
| | Band3/DCS – 1800 | TX/RX (J3) | TX/RX (J3) | *RX&TX* |
| | Band 7 | TX/RX (J3) | TX/RX (J3) | *RX&TX* |
| | Band 38 | TX/RX (J3) | TX/RX (J3) | *RX, TX* |

- When the LimeRFE Controls GUI is opened, its default view doesn't show *SWR* panel. To display *SWR* panel go to View/Power Meter.
  In its basic configuration, S*WR* panel gives signal powers measured at SMA connectors J17 and J18. *Source* sub-panel gives two options. *Cellular* option enables ability to measure forward power at the output of currently active power amplifier, from cellular block of the board. In *External* option, RF output of LimeRFE board (conectors J3, J4 or J5) can be connected to antenna or other amplifier device through a directional coupler. Forward and reverse ports of the directional coupler are connected back to LimeSDR board to connectors J18 (forward) and J17 (reverse), where RF powers are measured and displayed in the *Power Meter* panel.
  It is possible to correct the values by a constant coefficient, by performing calibration. Namely, if the exact value for the power and/or reflection coefficient (gamma) is known, it can be entered in the fields *Calibration Power* and *Calibration Gamma*. By clicking *Calibrate* button, coefficients are calculated, and will be used in subsequent calculations. These coefficients are included in the configuration file, and can be saved/loaded.
- *Message Display* panel prints all important information related to the communication with the LimeRFE board (displays info massages if port is opened, closed, if the board is configured for specific band, if there was an error in communication…)

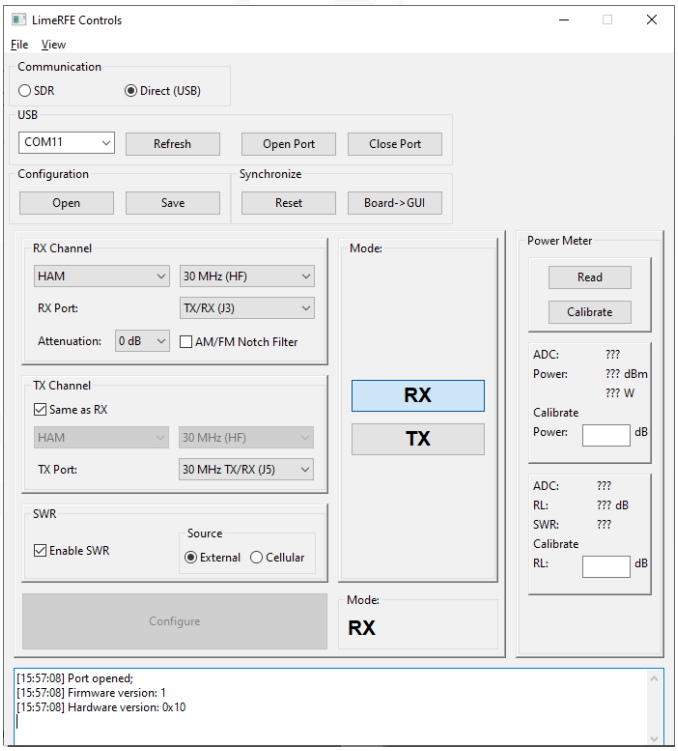


Figure 3: LimeRFE Controls window with opened SWR pannel and enabled SWR

**Important note:** It is important to keep the impedance controlled on all output connectors (J3, J4, and J5, see the next Section for detailed description of the connectors). In the very unlikely situations that the impedance on those ports is very reflective, the power amplifier oscillations might occur, which may damage the board. Hence, it is recommended to connect 50 Ω matched loads/sources, and to terminate the unused ports with 50 Ω terminations.

# 5

# LimeRFE Connectors and Options

## 5.1 Supply Options

Supply option is chosen by properly configuring and connecting connectors J9, J10, J11, J23 and CON1 (this is micro USB type B connector). All of these connectors except CON1 are placed in top layer, in the lower-right part of the LimeRFE board, shown in Figure 4. CON1 connector is in bottom layer, in the upper-right part of the LimeRFE board.

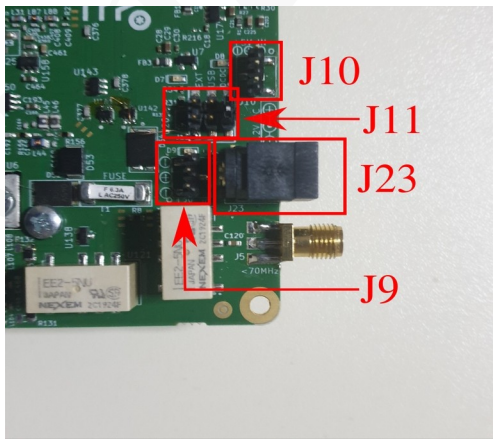


Figure 4: Photo of J9, J10, J11 and J23 connectors

There are three ways of providing 5 V supply to the board. It is possible to select one of these ways by placing a jumper at connector J11, Table 4.

Table 4: Power supply options with connector J11

| Jumper position | Selected option | Comments |
|---|---|---|
| Left (Pins 5-6) | External 5 V power supply | 5 V is obtained from J10 |
| Centre (Pins 3-4) | Internal 5 V from USB | 5 V is obtained from USB cable |
| Right (Pins 1-2) | 5 V from external 12 V power supply | 5 V is obtained from DC – DC convertor which is supplied from 12 V. 12 V is obtained from J9 or J23 |

Preferred configuration of J11 connector is at jumper position – right (Pins 1-2), where 5V is obtained from the 12 V power supply. In this configuration either J9 or J23 are connected to external 12 V power supply.

## 5.2 Introduction to the LimeRFE Connectors

This section describes the various connectors available on the LimeRFE.

The top view of the LimeRFE board is shown in Figure 5. The bottom view of the LimeRFE board is shown in Figure 6.

Please, pay attention that in top view connectors J1, J2, J3, J4 and J5 are terminated with 50 Ohm and that all jumpers are set in position for quick start.

Please, pay attention that in bottom view there are no terminations on J1, J2, J3, J4, J5 connectors. Also, there is no heat sink and RD16HHF1 transistor which are removed for better view of all bottom components.

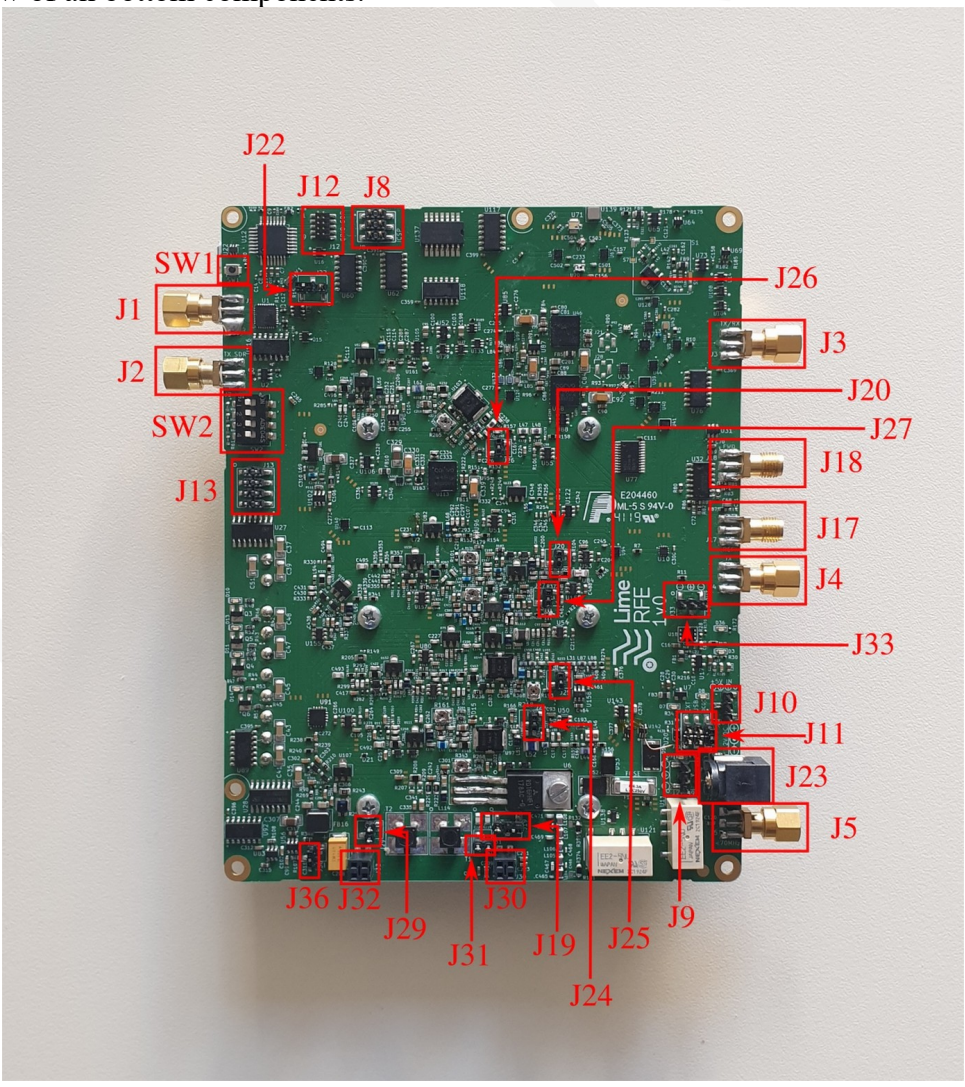


Figure 5: LimeRFE Connectors – Top View
(Connectors J1, J2, J3, J4 and J5 are terminated with 50 Ohm terminations)

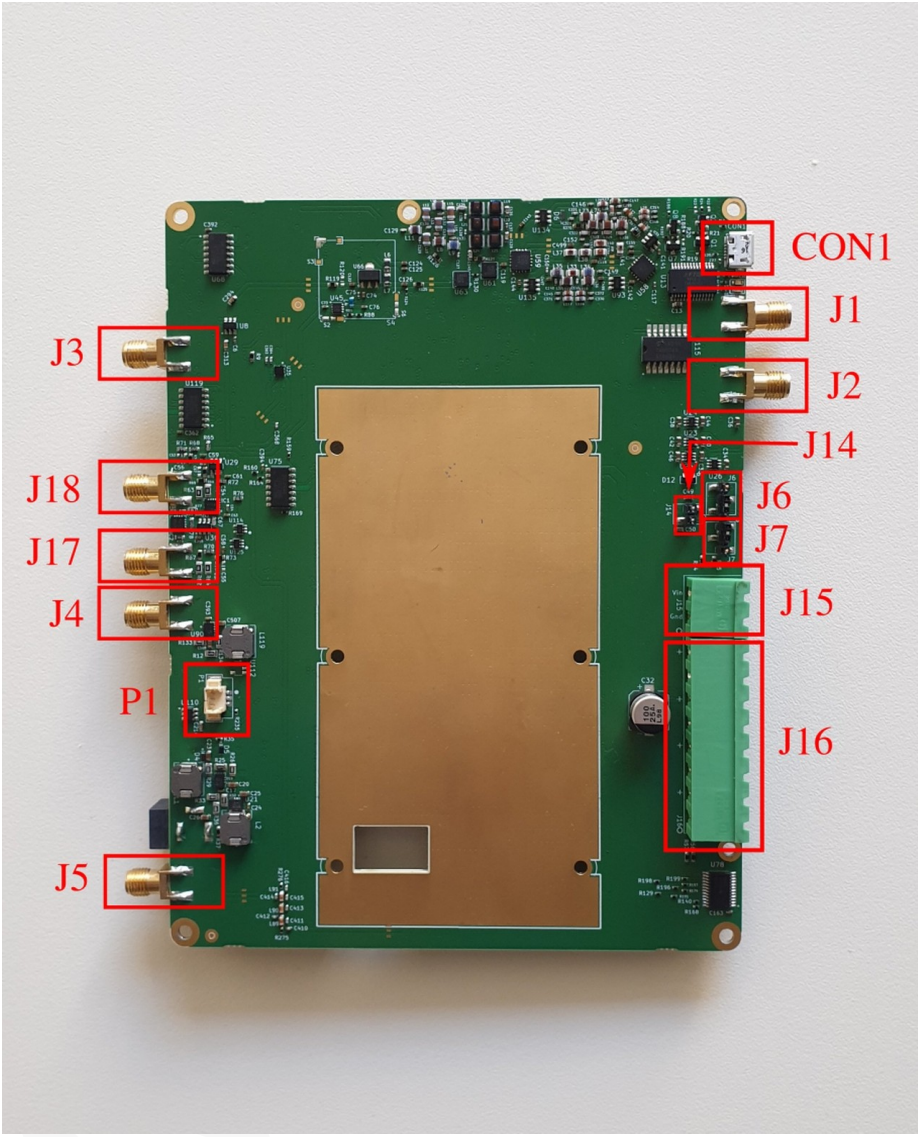


Figure 6: LimeRFE Connectors – Bottom view
(Heat sink and RD16HHF1 transistor were removed, for better view)

Table 5 describes the high level pin assignment for each connector on the design kit.

Table 5: Design kit connectors and switches

| Connector | Description |
|---|---|
| J1 | RF output – in RX mode |
| J2 | RF input – in TX mode |
| J3 | RF input – in RX mode, for all frequency bands<br>RF output – in TX mode, for all frequency bands except 30 MHz (HF) band and 50 – 70 MHz (6 & 4 m) band |
| J4 | RF output – in TX mode, for all frequency bands except 30 MHz (HF) band and 50 – 70 MHz (6 & 4 m) band and all Cellular bands (Band 1, 2, 3, 7 and |

| | |
|---|---|
| | 38) |
| J5 | RF input – in RX mode, for 30 MHz (HF), 50 – 70 MHz (6 & 4 m), 144 – 146 MHz (2 m), 220 – 225 MHz (1.25 m) and 430 – 440 MHz bands<br>RF output – in TX mode, only for 30 MHz (HF) band |
| J6 | Connects the output of log detector to ADC7 input, in order to measure forward power – jumper between pins 1 and 2<br>External signal (connected to J13-PIN3) to ADC7 input – jumper between pins 2 and 3 |
| J7 | Connects the output of log detector to ADC6 input, in order to measure reflection coefficient – jumper between pins 1 and 2<br>External signal (connected to J13-PIN6) to ADC6 input – jumper between pins 2 and 3 |
| J8 | ICSP bus – MISO (PIN1), SCK (PIN3), MOSI (PIN4), RESET (PIN5), PWR (PIN2), GND (PIN6) |
| J9 | External 12 V connection – GND (PINs 1, 3), 12 V (PIN 2) |
| J10 | External 5 V connection – GND (PINs 1, 3), 5 V (PIN 2) |
| J11 | 5 V source selection –<br>5 V is obtained from DC-DC connector supplied from external 12 V (PIN connection 1-2, jumper position – right)<br>5 V is obtained from USB (PIN connection 3-4, jumper position – center)<br>5 V is obtained from external 5 V supply unit (PIN connection 5-6, jumper position – left) |
| J12 | This 10-header enables the communication between the SDR and LimeRFE.<br>Such 10-pin GPIO headers are available in all Lime Microsystems' SDR platforms.<br>• GPIO – GPIO0 (PIN1), GPIO1 (PIN2), GPIO2 (PIN3), GPIO3 (PIN4),<br>These pins are connected to the GPIO sub-system of the LimeRFE. This sub-system provides level shifters and relay drivers, and enables communication/control between SDR and other hardware (e.g. additional PA). This sub-system enables the same functionality as the *LimeSDR GPIO Board* (https://wiki.myriadrf.org/LimeSDR_GPIO_Board), but with the number of GPIO pins reduced to 4.<br>• GPIO – GPIO4 (PIN5), GPIO5 (PIN6)<br>These 2 pins provide the 2-way communication between the SDR and the microcontroller on LimeRFE.<br>• SCL (PIN7), SDA (PIN8)<br>These pins enable I2C communication between SDR and LimeRFE.<br>• GND (PIN9), VDD_CON (PIN10)<br>These are supply pins. |

| | |
|---|---|
| J13 | • GPIO0_LS (PIN1), GPIO1_LS (PIN2), GPIO2_LS (PIN3), GPIO3_LS (PIN4)<br>These pins are part of the GPIO sub-system.<br>• ADC7 (PIN3), ADC6 (PIN6)<br>These pins can be connected to the ADC inputs of the LimeRFE microcontroller by properly setting jumpers on J6 and J7.<br>• VDDA (PIN5), GND (PIN4)<br>These are supply pins. |
| J14 | • VDDA (PIN1), VDD_CON (PIN2)<br>Jumper connection only in case that VDDA = VDDA_CONN (For use in relay only mode) |
| J15 | DC supply for RELAY signals – VCOM (PIN2), GND (PIN1) |
| J16 | RELAY signals – RELAY_0 (PIN7), RELAY_1 (PIN5), RELAY_2 (PIN3), RELAY_3 (PIN1), GND (PINs 2, 4, 6, 8) |
| J17 | Reverse power RF input (for SWR operation) |
| J18 | Forward power RF input (for SWR operation) |
| J19 | This connector connects drain of RD16HHF1 to the either on board soldered baluns T1 and T2 or to the external balun (LimeRFE add-on balun board).<br>In default configuration (T1 and T2 are used), J29 should be shorted by jumper, as well as connector J31. Also pins 1 and 2 of connector J19 should be shorted by jumper for this configuration (jumper in left possition).<br>If external balun is used (LimeRFE add-on balun board), then connectors J29 and J31 should be left opened and pins 2 and 3 of connector J19 should be shortered by jumper (jumper in right possition). Externall balun is connected to the board through connector J30. Connector J32 is dummy and it serves only for mechanical support. All four pins of J32 are connected to ground. |
| J20 | This connector enables the measurement of the bias current in power amplifier for 1240 – 1325 MHz (23 cm) band. In normal mode, where this current is not measured, pins of this connector should be shorted by jumper. |
| J22 | Connects GPIO3_CONN to GPIO3 (PIN connection 2-3) or<br>GPIO5 to GPIO3 (PIN connection 1-2)<br>The intention is to enable on of the level-shifters/relay-drivers to be controlled directly from the LimeRFE microcontroller. |
| J23 | External 12 V connection |
| J24 | This connector enables the measurement of the bias current in power amplifier for 144 – 146 MHz (2 m) band. In normal mode, where this current is not measured, pins of this connector should be shorted by jumper. |
| J25 | This connector enables the measurement of the bias current in power |

| | |
|---|---|
| | amplifier for 220 – 225 MHz (1.25 m) band. In normal mode, where this current is not measured, pins of this connector should be shorted by jumper. |
| J26 | This connector enables the measurement of the bias current in power amplifier for 430 – 440 MHz (70 cm) band. In normal mode, where this current is not measured, pins of this connector should be shorted by jumper. |
| J27 | This connector enables the measurement of the bias current in power amplifier for 902 – 928 MHz (33 cm) band. In normal mode, where this current is not measured, pins of this connector should be shorted by jumper. |
| J29 | This connector connects drain of RD16HHF1 to the on board soldered baluns T1 and T2. In default configuration (T1 and T2 are used), J29 should be shorted by jumper, as well as connector J31. Also pins 1 and 2 of connector J19 should be shorted by jumper for this configuration (jumper in left possition).<br>If external balun is used (LimeRFE add-on balun board), then connectors J29 and J31 should be left opened and pins 2 and 3 of connector J19 should be shortered by jumper (jumper in right possition). Externall balun is connected to the board through connector J30. Connector J32 is dummy and it serves only for mechanical support. All four pins of J32 are connected to ground. |
| J30 | This connector connects externall balun wich will be used instead of on board soldered baluns T1 and T2.<br>In default configuration (T1 and T2 are used), J29 should be shorted by jumper, as well as connector J31. Also pins 1 and 2 of connector J19 should be shorted by jumper for this configuration (jumper in left possition).<br>If external balun is used (LimeRFE add-on balun board), then connectors J29 and J31 should be left opened and pins 2 and 3 of connector J19 should be shortered by jumper (jumper in right possition). Externall balun is connected to the board through connector J30. Connector J32 is dummy and it serves only for mechanical support. All four pins of J32 are connected to ground. |
| J31 | This connector connects the on board soldered baluns T1 and T2 to the exit of the board (connector J5). In default configuration (T1 and T2 are used), J31 should be shorted by jumper, as well as connector J29. Also pins 1 and 2 of connector J19 should be shorted by jumper for this configuration (jumper in left possition).<br>If external balun is used (LimeRFE add-on balun board), then connectors J29 and J31 should be left opened and pins 2 and 3 of connector J19 should be shortered by jumper (jumper in right possition). Externall balun is connected to the board through connectors J30 and J32. |
| J32 | This connector is dummy connector and serves only for mechanical support of external board (LimeRFE add-on balun board) when an externall balun is used instead of on board soldered baluns T1 and T2. All four pins of J32 connectors are connected to ground.<br>In default configuration (T1 and T2 are used), J29 should be shorted by jumper, as well as connector J31. Also pins 1 and 2 of connector J19 should |

| | |
|---|---|
| | be shorted by jumper for this configuration (jumper in left possition).<br>If external balun is used (LimeRFE add-on balun board), then connectors J29 and J31 should be left opened and pins 2 and 3 of connector J19 should be shortered by jumper (jumper in right possition). Externall balun is connected to the board through connector J30. Connector J32 is dummy and it serves only for mechanical support. All four pins of J32 are connected to ground. |
| J36 | This connector enables the measurement of the bias current in power amplifier for 30 MHz (HF) band. In normal mode, where this current is not measured, pins of this connector should be shorted by jumper. |
| SW1 | LimeRFE microcontroller RESET push-switch |
| SW2 | GPIO to/from Level shifted GPIO –<br>When the switches are in position closser to PIN1 (marked with dot), direction signal is at high logic level, directron is GPIO → GPIO_LS<br>When the switches are in position away from PIN1 (marked with dot), direction signal is at low logic level, directron is GPIO_LS → GPIO. |
| CON1 | Micro USB type B connector |
| P1 | 3-pins fan connector for external fan |

# 6

# Block diagram

The scope of this chapter is in detailed explanation of the block diagram of the LimeRFE board. The above mentioned block diagram is shown in Figure 7. Please keep in mind that this block diagram depicts only RF part of the board.

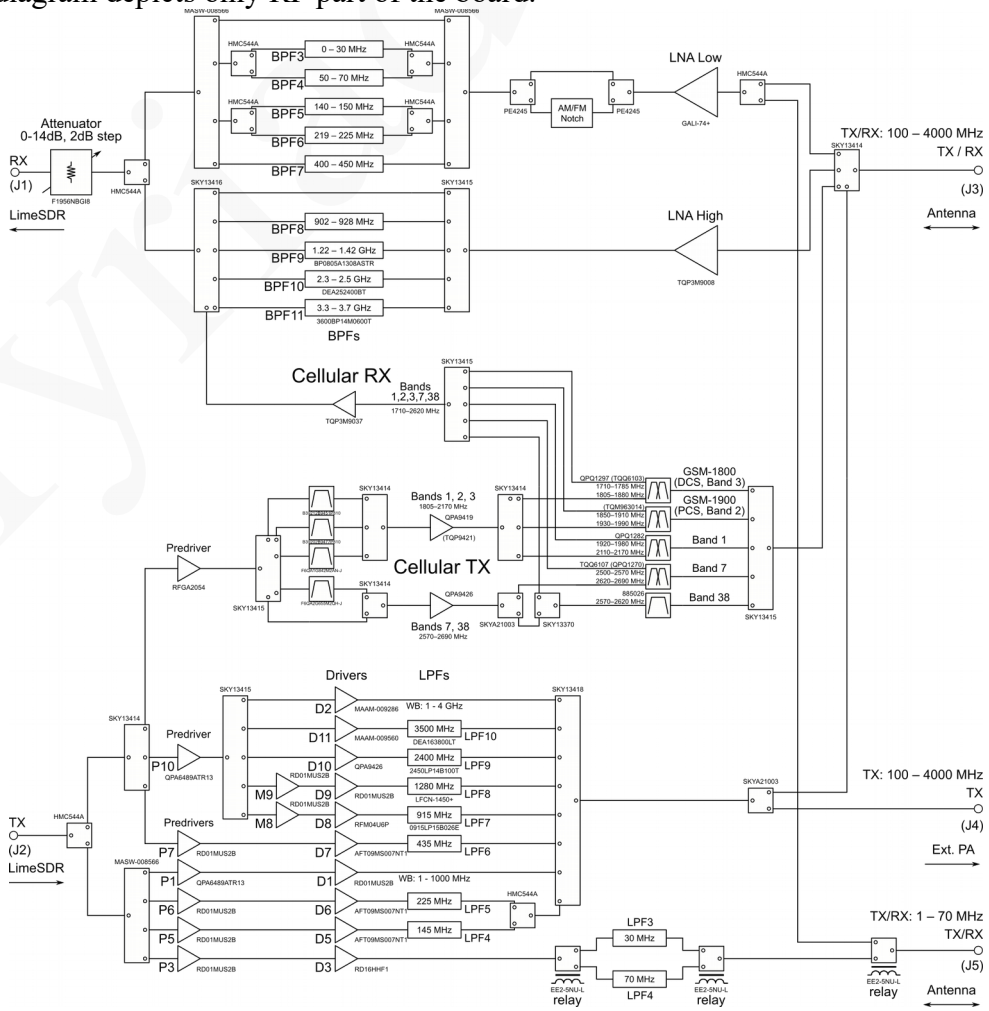


Figure 7: Lime RFE block diagram (RF part only)

Basically, the board comprises receiver and transmitter blocks, where both of them have Wideband, HAM and Cellular sub-blocks. These sub-blocks are not stricly devided and separated, for example HAM and Wideband have been realised under the same hardware. Photo of the LimeRFE board, with marked most important RF blocks is shown in Figure 8 and in Figure 9.

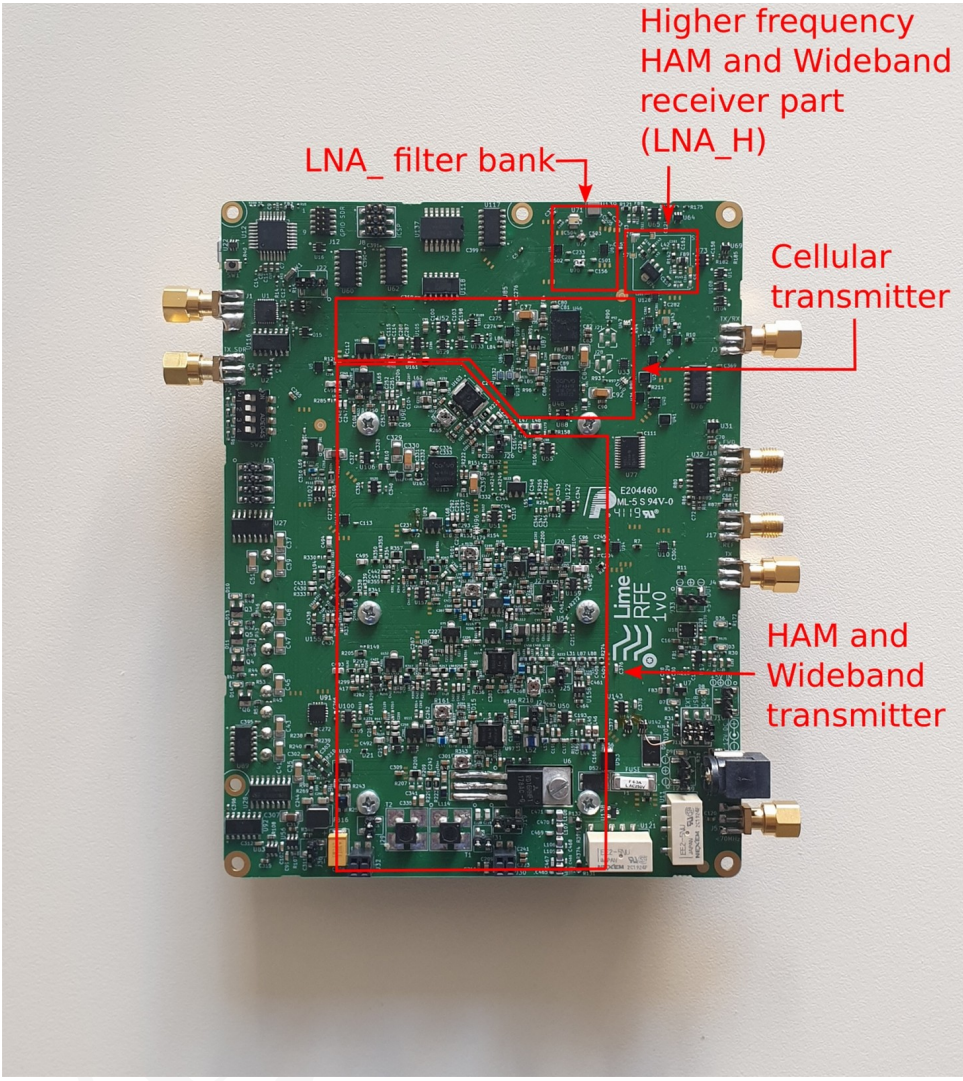


Figure 8: Receiver and transmitter sub-blocks – Top view

(Connectors J1, J2, J3, J4 and J5 are terminated with 50 Ohm terminations)

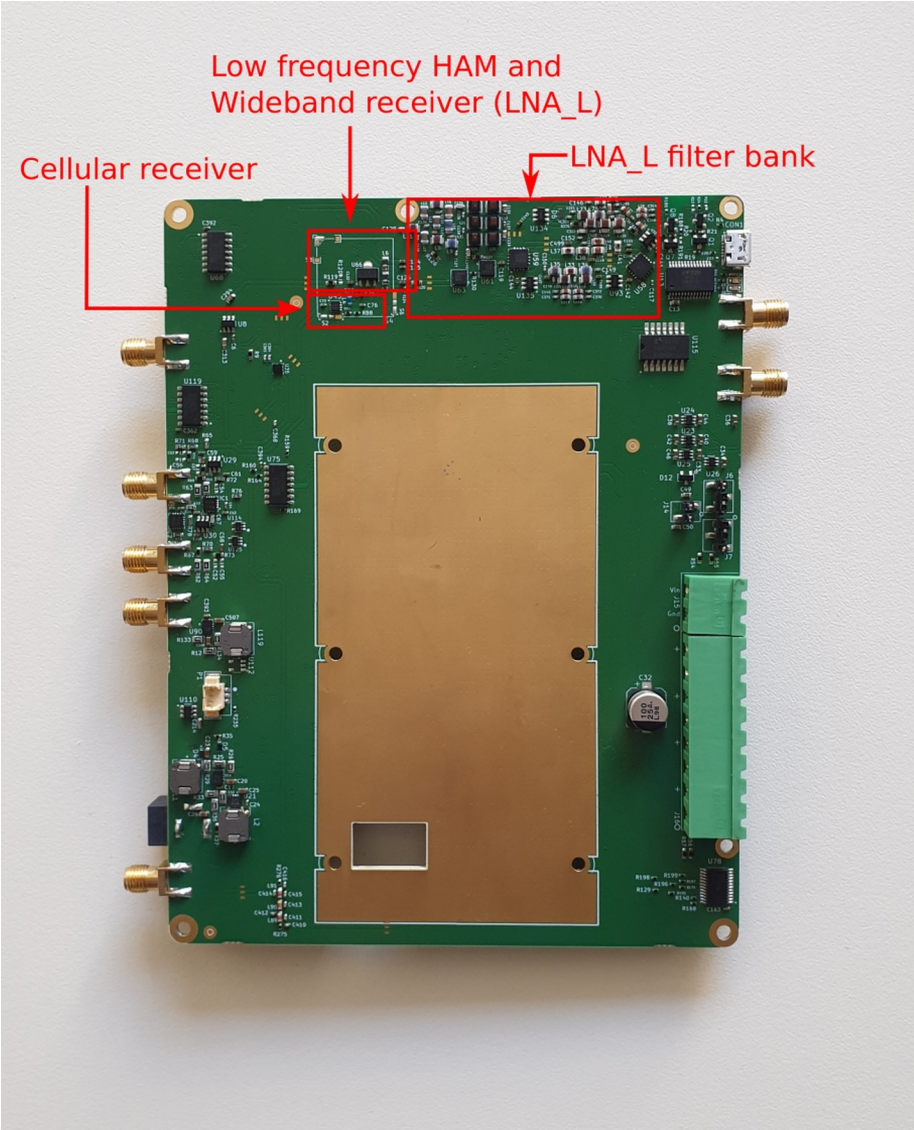


Figure 9: Receiver and transmitter sub-blocks – Bottom view
(Heat sink and RD16HHF1 transistor were removed, for better view)

Receiver block uses connectors:

- J3 as input connector for all bands
- J5 as input connector, but without bands:
  HAM 902 – 928 MHz (33 cm), HAM 1240 – 1325 MHz (23 cm), HAM 2300 – 2450 (13 cm), 3300 – 3500 MHz, Cellular Band1, Cellular Band 2/PCS-1900, Cellular Band3/DCS-1800, Cellular Band7 and Cellular Band 38.
- J1 as output connector for all bands

Receiver block consists of 2 sub-blocks:

- Cellular receiver
- HAM/Wideband receiver

From the RX input of the LimeRFE board, the signal is guided to Cellular or HAM/Wideband receive sub-blocks. Once again, depending on selected configuration (primarily regarding the frequency of received signal), the signal is guided through various switches, filters and duplexers to the amplifier units. After amplification, the signal passes again through various switches and filters and is brought to the variable attenuator. This software controlled

attenuator can change attenuation 0 − 14 dB in steps of 2 dB. Table 6 gives full, in details, description of signal paths, depending on chosen RX configuration.

Table 6: RX configurations and corresponding RF signal path

| **Configuration:** **Type** | **Channel/Band** | **Signal path** |
|---|---|---|
| Wideband | 1−1000 MHz | (J3 / SKY13414) or (J5 / EE2-5NU-L) / HMC544A / GALI-74+ / PE4245 / (AM/FM Notch filter) or (bypass) / PE4245 / MASW-008566 / bypass / MASW-008566 / HMC544A / F1956NBGI8 / J1 |
| Wideband | 1000−4000 MHz | J3 / SKY13414 / TQP3M9008 / SKY13415 / bypass / SKY13416 / HMC544A / F1956NBGI8 / J1 |
| HAM | 30 MHz (HF) | (J5 / EE2-5NU-L) or (J3 / SKY13414) / HMC544A / GALI-74+ / PE4245 / (AM/FM Notch filter) or (bypass) / PE4245/ MASW-008566 / HMC5444A / filter 0−30 MHz / HMC544A / MASW-008566 / HMC544A / F1956NBGI8 / J1 |
| HAM | 50 – 70 MHz (6&4 m) | (J5 / EE2-5NU-LI) or (J3 / SKY13414) / HMC544A / GALI-74+ / PE4245 / (AM/FM Notch filter) or (bypass) / PE4245/ MASW-008566 / HMC5444A / filter 50−70 MHz / HMC544A / MASW-008566 / HMC544A / F1956NBGI8 / J1 |
| HAM | 144−146 MHz (2 m) | (J3 / SKY13414) or (J5 / EE2-5NU-L) / HMC544A / GALI-74+ / PE4245 / (AM/FM Notch filter) or (bypass) / PE4245 / MASW-008566 / HMC544A / filter 140−150 MHz / HMC544A / MASW-008566 / HMC544A / F1956NBGI8 / J1 |
| HAM | 220–225 MHz (1.25 m) | (J3 / SKY13414) or (J5 / EE2-5NU-L) / HMC544A / GALI-74+ / PE4245 / (AM/FM Notch filter) or (bypass) / PE4245 / MASW-008566 / HMC544A / filter 219−225 MHz / HMC544A / MASW-008566 / HMC544A / F1956NBGI8 / J1 |
| HAM | 430−440 MHz (70 cm) | (J3 / SKY13414) or (J5 / EE2-5NU-L) / HMC544A / GALI-74+ / PE4245 / (AM/FM Notch filter) or (bypass) / PE4245 / MASW-008566 / filter 400−450 MHz / MASW-008566 / HMC544A / F1956NBGI8 / J1 |
| HAM | 902 – 928 MHz (33 cm) | J3 / SKY13414 / TQP3M9008 / SKY13415 / filter 902–928 GHz / SKY13416 / HMC544A / F1956NBGI8 / J1 |
| HAM | 1240−1325 MHz (23 cm) | J3 / SKY13414 / TQP3M9008 / SKY13415 / filter 1.22–1.42 GHz / SKY13416 / HMC544A / F1956NBGI8 / J1 |
| HAM | 2300−2450 MHz (13 cm) | J3 / SKY13414 / TQP3M9008 / SKY13415 / filter 2.3–2.5 GHz / SKY13416 / HMC544A / F1956NBGI8 / J1 |
| HAM | 3300−3500 MHz | J3 / SKY13414 / TQP3M9008 / SKY13415 / filter 3.3–3.7 GHz / SKY13416 / HMC544A / F1956NBGI8 / J1 |
| Cellular | Band1 | J3 / SKY13414 / SKY13415 / QPQ1282 / SKY13415 / TQP3M9037 / SKY13416 / HMC544A / F1956NBGI8 / J1 |
| Cellular | Band 2 / PCS−1900 | J3 / SKY13414 / SKY13415 / TQM963014 / SKY13415 / TQP3M963014 / SKY13416 / HMC544A / F1956NBGI8 / J1 |
| Cellular | Band 3 / DCS−1800 | J3 / SKY13414 / SKY13415 / QPQ1297 (TQQ6103) / SKY13415 / TQP3M9037 / SKY13416 / HMC544A / F1956NBGI8 / J1 |
| Cellular | Band 7 | J3 / SKY13414 / SKY13415 / TQQ6107 (QPQ1270) / SKY13415 / TQP3M9037 / SKY13416 / HMC544A / F1956NBGI8 / J1 |
| Cellular | Band 38 | J3 / SKY13414 / SKY13415 / 885026 / SKY13370 / SKY13415 / TQP3M9037 / SKY13416 / HMC544A / F1956NBGI8 / J1 |

Transmitter block uses connectors:

- J2 as input connector for all bands
- J3 as output connector, but without 30 MHz (HF) and 50–70 MHz (6 & m) bands
- J4 as output connector, but without 30 MHz (HF), 50–70 MHz (6 & 4 m) and all Cellular bands (Band 1, 2, 3, 7 and 38)
- J5 as output connector, only for 30 MHz (HF) and 50–70 MHz (6 & 4 m) bands

Transmitter block consists of 2 sub-blocks:

- Cellular transmitter
- HAM-Wideband transmitter

From the TX input of the LimeRFE board, the signal is guided to Cellular or HAM-Wideband transmitter. Depending on selected configuration (primarily regarding the frequency of received signal), the signal is guided through various switches and filters to the amplifiers units. After amplification, the signal passes again through various switches, duplexers and filters. Table 7 gives full, in details, description of signal paths, depending on chosen TX configuration.

Table 7: TX configurations and corresponding RF signal path

| **Configuration:** **Type** | **Channel/Band** | **Signal path** |
|---|---|---|
| Wideband | 1−1000 MHz | J2 / HMC544A / MASW-008566 / QPA6489ATR13 / RD01MUS2B / SKY13418 / SKYA21003 / (J4) or (SKY13414 / J3) |
| Wideband | 1000−4000 MHz | J2 / HMC544A / SKY13414 / QPA6489ATR13 / SKY13415 / MAAM-009286 / SKY13418 / SKYA21003 / (J4) or (SKY13414 / J3) |
| HAM | 30 MHz (HF) | J2 / HMC544A / MASW-008566 / RD01MUS2B / RD16HHF1 / EE2-5NU-L / filter 30 MHz / EE2-5NU-L / EE2-5NU-L / J5 |
| HAM | 50–70 MHz (6&4 m) | J2 / HMC544A / MASW-008566 / RD01MUS2B / RD16HHF1 / EE2-5NU-L / filter 70 MHz / EE2-5NU-L / EE2-5NU-L / J5 |
| HAM | 144−146 MHz (2 m) | J2 / HMC544A / MASW-008566 / RD01MUS2B / AFT09MS007NT1 / filter 145 MHz / HMC544A / SKY13418 / SKYA21003 / (J4) or (SKY13414 / J3) |
| HAM | 220–225 MHz (1.25m) | J2 / HMC544A / MASW-008566 / RD01MUS2B / AFT09MS007NT1 / filter 225 MHz / HMC544A / SKY13418 / SKYA21003 / (J4) or (SKY13414 / J3) |
| HAM | 430−440 MHz (70 cm) | J2 / HMC544A / SKY13414 / RD01MUS2B / AFT09MS007NT1 / filter 435 MHz / SKY13418 / SKYA21003 / (J4) or (SKY13414 / J3) |
| HAM | 902–928 MHz (33 cm) | J2 / HMC544A / SKY13414 / QPA6489ATR13 / SKY13415 / RFM04U6P / filter 930 MHz / SKY13418 / SKYA21003 / (J4) or (SKY13414 / J3) |
| HAM | 1240−1325 MHz (23 cm) | J2 / HMC544A / SKY13414 / QPA6489ATR13 / SKY13415 / RD01MUS2B / RD01MUS2B / filter 1280 MHz / SKY13418 / SKYA21003 / (J4) or (SKY13414 / J3) |
| HAM | 2300−2450 MHz (13 cm) | J2 / HMC544A / SKY13414 / QPA6489ATR13 / SKY13415 / QPA9426 / filter 2400 MHz / SKY13418 / SKYA21003 / (J4) or (SKY13414 / J3) |
| HAM | 3300−3500 MHz | J2 / HMC544A / SKY13414 / QPA6489ATR13 / SKY13415 / MAAM-009560 / filter 3500 MHz / SKY13418 / SKYA21003 / (J4) or (SKY13414 / J3) |
| Cellular | Band1 | J2 / HMC544A / SKY13414 / RFGA2054 / SKY13415 / B39212B9451P810 / SKY13414 / QPA9419 (TQP9421) / SKY13414 / |

| | | |
|---|---|---|
| | | QPQ1282 / SKY13415 / SKY13414 / J3 |
| Cellular | Band 2 / PCS−1900 | J2 / HMC544A / SKY13414 / RFGA2054 / SKY13415 / B39202B9477P810 / SKY13414 / QPA9419 (TQP9421) / SKY13414 / TQM963014 / SKY13415 / SKY13414 / J3 |
| Cellular | Band 3 / DCS−1800 | J2 / HMC544A / SKY13414 / RFGA2054 / SKY13415 / F6QA1G842M2AN-J / SKY13414 / QPA9419 (TQP9421) / SKY13414 / QPQ1297 (TQQ6103) / SKY13415 / SKY13414 / J3 |
| Cellular | Band 7 | J2 / HMC544A / SKY13414 / RFGA2054 / SKY13415 / F6QA2G655M2QH-J / SKY13414 / QPA9426 / SKY21003 / TQQ6107 (QPQ1270) / SKY13415 / SKY13414 / J3 |
| Cellular | Band 38 | J2 / HMC544A / SKY13414 / RFGA2054 / SKY13415 / SKY13414 / QPA9426 / SKY21003 / SKY13370 / 885026 / SKY13415 / SKY13414 / J3 |

# 7

# Setting up the LimeRFE board – An Example

Here a brief explanation how to configure the LimeRFE board for HAM 144 – 146 MHz (2 m) band is given:

- Before any connection terminate connectors J1, J3 and J5 with 50 Ohm terminations.
- Connect signal generator to J2 connector. It is recommended to use attenuators between signal generator and connector J2. For all our tests we used 6 dB / 2 W attenuators. Also for initial test set power level below –30 dBm. For our test we used –40 dBm of input power. Do not turn on power, yet.
- Connect connector J4 to spectral analyzer. It is highly recommended to use high power high level attenuators between J4 and spectral analyzer in order to protect spectral analyzer from damages. For all our tests we used 40 dB / 50 W attenuators.
- Connect your PC to LimeRFE board through USB cable.
- Place jumper at position – right at J11 (with jumper, connect pins 1 and 2 of the connector J11).
- Connect external 12 V DC power supply to J9 or to J23 and turn on 12 V DC voltage.
- Open LimeSuiteGUI software.
- Go to Modules/LimeRFE to open LimeRFE control window.
- Change communication from SDR (I2C) to USB (in Communication panel).
- Refresh available COM port by clicking Refresh button in USB panel.
- Open port by clicking Open Port button in USB panel. After this a message in Masage Display panel will be printed and after this the LimeRFE board is connected to the PC.
- In Configure panel in Type sub-panel select HAM.
- In Channel/Band sub-panel select 144 – 146 MHz (2 m) band.

- In TX port sub-panel select TX (J4)
- Afer this selection press Configure button
- After configuration, in Mode sub-panel two buttons will appear. These two buttons (TX and RX) will turn on and turn off transmitter and receiver independently. Turn on TX mode and turn off RX mode.

- In signal generator turn on the power and amplified signal should appear at the spectral analyzer. The expected gain is of about 33 dB.

# 8

# Changing the bias of power amplifiers

All LimeRFE boards arrive in already preset power amplifier bias currents. Some deviation in bias currents might be possible due to different ambient temperature, some minor changes during the transport, etc.

However, it is possible to change bias current of four power amplifiers on LimeRFE baord. The user must pay attention for any further change of these values and do it on his/her own responsibility. The list of these amplifiers with their default bias currents is given in Table 8.

Table 8: Default power amplifier bias currents which can be changed

| Chanel/Bandband | Bias current | Jumper | Trimmer |
|---|---|---|---|
| 30 MHz (HF) and 50 – 70 MHz (6 & 4 m) | 500 mA | J36 * | R343 |
| 144 – 146 MHz (2 m) | 200 mA | J24 | R161 |
| 220 – 225 MHz (1.25 m) | 200 mA | J25 | R218 |
| 430 – 440 MHz (70 cm) | 200 mA | J26 | R226 |
| 902 – 928 MHz (33 cm) | 100 mA | J27 | R253 |
| 1240 – 1325 MHz (23 cm) | 40 mA | J20 | R176 |

*Jumpers on connectors J29, J31 and J19 (J32 and J30) must be properly placed (for detail description about all these jumpers look at in Table 5)

Figure 10 shows possitions of all connectors and trimmers necessary to change power amplifier bias currents.

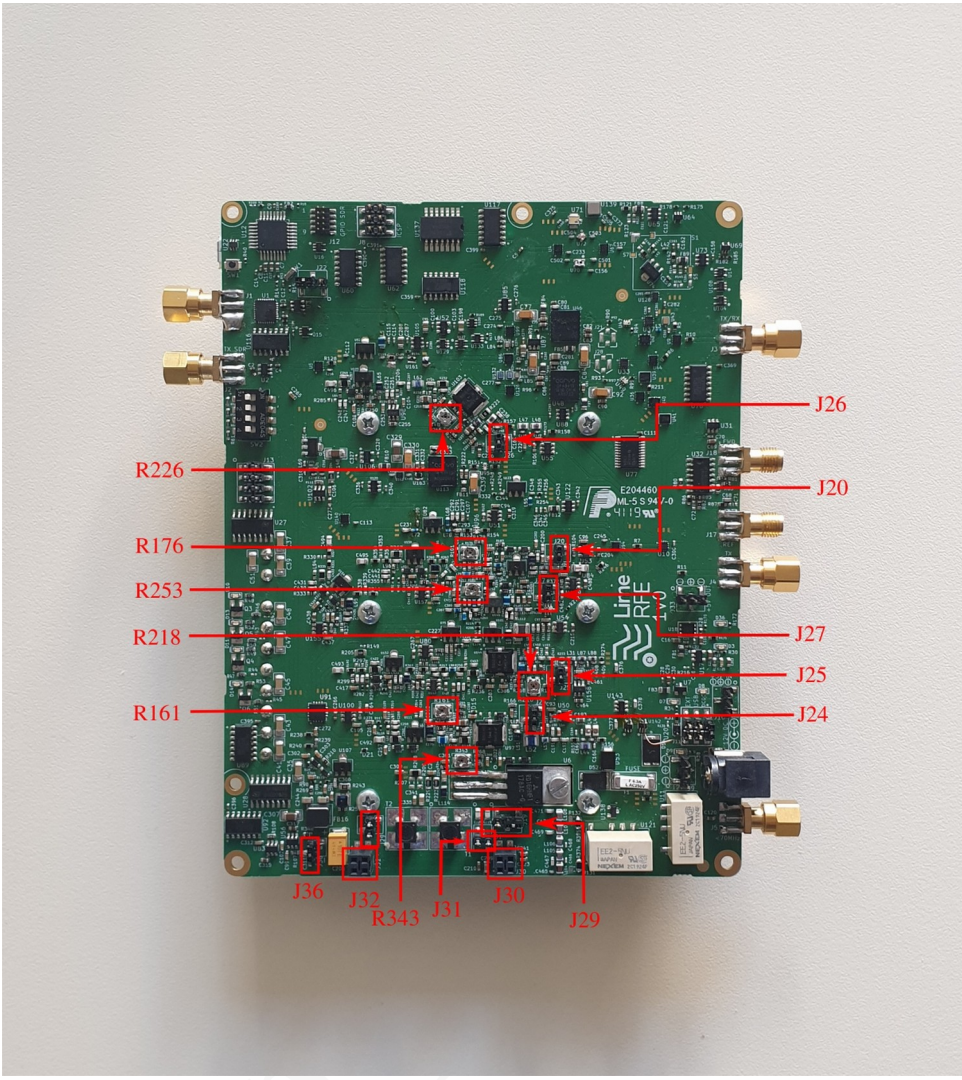


Figure 10: Positions of all necessary connectors and trimmers for bias currents changes

**Setup HAM 30 MHz (HF) and 50 – 70 MHz (6 & 4 m) power amplifier drain current**

- Choose external DC power supply of 12 V and 5 V from on board DC-DC convertor by connecting pin 1 and pin 2 of connector J11 on the board (jumper position – right). Connect external DC supply unit to J9, but do not turn on 12 V from DC supply unit.
- Terminate J1, J2, J3 and J4 SMA connectors with 50 Ohm terminations
- J5 SMA connector (30 MHz out) connect to termination or high attenuation (> 10 dB) capable to endure 10 W of RF power (in our setup we used 40 dB / 10 W attenuator)
- Connect USB cable from computer to the LimeRFE board
- Before external DC supply is turned on, turn around all of trimmers, which are not already set, in counter clockwise directions (R161, R176, R218, R226, R253, R343).
- Connect J36 connector pins through ammeter (set 10 A range in ammeter)
- Also, jumpers on connectors J29, J31 and J19 (J32 and J30) must be properly placed (for all these jumpers look at Table 5 for more detail description)
- Turn on 12 V from external DC supply unit (setup maximum current of 800 mA in external DC supply unit if desired bias current is 500 mA)
- In software, setup the board for HAM, 30 MHz (HF) band.
- Turn off Receiver/Turn on Transmitter mode.

- Turn around trimmer R343 in clockwise direction until ammeter shows 0.5 A

**Setup HAM 144 – 146 MHz (2 m) power amplifier drain current**

- Choose external DC power supply of 12 V and 5 V from on board DC-DC convertor by connecting pin 1 and pin 2 of connector J11 on the board (jumper position – right). Connect external DC supply unit to J9, but do not turn on 12 V from DC supply unit.
- Terminate J1, J2, J3 and J5 SMA connectors with 50 Ohm terminations
- J4 SMA connector connect to termination or high attenuation (> 10 dB) capable to endure 5 W of RF power (in our setup we used 40 dB / 50 W attenuator)
- Connect USB cable from computer to the LimeRFE board
- Before external DC supply is turned on, turn around all of trimmers, which are not already set, in counter clockwise directions (R161, R176, R218, R226, R253, R343)
- Connect J24 connector pins through ammeter (set 10 A range in ammeter)
- Turn on 12 V from external DC supply unit (setup maximum current of 400 mA in external DC supply unit if desired bias current is 200 mA)
- In software, setup the board for HAM, 144 – 146 MHz (2 m) band, with TX (J4).
- Turn off Receiver and Turn on Transmitter
- Turn around trimmer R161 in clockwise direction until ammeter shows 0.2 A

**Setup HAM 220 – 225 MHz (2 m) power amplifier drain current**

- Choose external DC power supply of 12 V and 5 V from on board DC-DC convertor by connecting pin 1 and pin 2 of connector J11 on the board (jumper position – right). Connect external DC supply unit to J9, but do not turn on 12 V from DC supply unit.
- Terminate J1, J2, J3 and J5 SMA connectors with 50 Ohm terminations
- J4 SMA connector connect to termination or high attenuation (> 10 dB) capable to endure 5 W of RF power (in our setup we used 40 dB / 50 W attenuator)
- Connect USB cable from computer to the LimeRFE board
- Before external DC supply is turned on, turn around all of trimmers, which are not already set, in counter clockwise directions (R161, R176, R218, R226, R253, R343)
- Connect J25 connector pins through ammeter (set 10 A range in ammeter)
- Turn on 12 V from external DC supply unit (setup maximum current of 400 mA in external DC supply unit if desired bias current is 200 mA)
- In software, setup the board for HAM, 220 – 225 MHz (1.25 m) band, with TX Connector (J4).
- Turn off Receiver and Turn on Transmitter
- Turn around trimmer R218 in clockwise direction until ammeter shows 0.2 A

**Setup HAM 430 – 440 MHz (70 cm) power amplifier drain current**

- Choose external DC power supply of 12 V and 5 V from on board DC-DC convertor by connecting pin 1 and pin 2 of connector J11 on the board (jumper position – right). Connect external DC supply unit to J9, but do not turn on 12 V from DC supply unit.
- Terminate J1, J2, J3 and J5 SMA connectors with 50 Ohm terminations.
- J4 SMA connector connect to termination or high attenuation (> 10 dB) capable to endure 5 W of RF power (in our setup we used 40 dB / 50 W attenuator).
- Connect USB cable from computer to the LimeRFE board.
- Before external DC supply is turned on, turn around all of trimmers, which are not already set, in counter clockwise directions (R161, R176, R218, R226, R253, R343).
- Connect J26 connector pins through ammeter (set 10 A range in ammeter).
- Turn on 12 V from external DC supply unit (setup maximum current of 400 mA in external DC supply unit if desired bias current is 200mA).

- In software, setup the board for HAM, 430 – 440 MHz (70 cm) band, with TX Connector (J4).
- Turn off Receiver and Turn on Transmitter.
- Turn around trimmer R226 in clockwise direction until ammeter shows 0.2 A.

**Setup HAM 902 – 928 MHz (70 cm) power amplifier drain current**

- Choose external DC power supply of 12 V and 5 V from on board DC-DC convertor by connecting pin 1 and pin 2 of connector J11 on the board (jumper position – right). Connect external DC supply unit to J9, but do not turn on 12 V from DC supply unit.
- Terminate J1, J2, J3 and J5 SMA connectors with 50 Ohm terminations.
- J4 SMA connector connect to termination or high attenuation (> 10 dB) capable to endure 5 W of RF power (in our setup we used 40 dB / 50 W attenuator).
- Connect USB cable from computer to the LimeRFE board.
- Before external DC supply is turned on, turn around all of trimmers, which are not already set, in counter clockwise directions (R161, R176, R218, R226, R253, R343).
- Connect J27 connector pins through ammeter (set 10 A range in ammeter).
- Turn on 12 V from external DC supply unit (setup maximum current of 300 mA in external DC supply unit if desired bias current is 100mA).
- In software, setup the board for HAM, 902 – 928 MHz (33 cm) band, with TX Connector (J4).
- Turn off Receiver and Turn on Transmitter.
- Turn around trimmer R253 in clockwise direction until ammeter shows 0.1 A.

**Setup HAM 1240 – 1325 MHz (23 cm) power amplifier drain current**

- Choose external DC power supply of 12 V and 5 V from on board DC-DC convertor by connecting pin 1 and pin 2 of connector J11 on the board (jumper position – right). Connect external DC supply unit to J9, but do not turn on 12 V from DC supply unit.
- Terminate J1, J2, J3 and J5 SMA connectors with 50 Ohm terminations.
- J4 SMA connector connect to termination or high attenuation (> 10 dB) capable to endure 5 W of RF power (in our setup we used 40 dB / 50 W attenuator).
- Connect USB cable from computer to the LimeRFE board.
- Before external DC supply is turned on, turn around all of trimmers, which are not already set, in counter clockwise directions (R161, R176, R218, R226, R253, R343).
- Connect J20 connector pins through ammeter (set 200 mA range in ammeter).
- Turn on 12 V from external DC supply unit (setup maximum current of 300 mA in external DC power unit if desired bias current is 40 mA).
- In software, setup the board for HAM, 1240 – 1325 MHz (23 cm) band, with TX Connector (J4).
- Turn off Receiver and Turn on Transmitter.
- Turn around trimmer R176 in clockwise direction until ammeter shows 40 mA.

# 9

# API Functions

API functions for LimeRFE control are implemented in LimeSuite shared library.
Communication with LimeRFE is possible using USB, or through LimeSDR using I2C.
In the following API functions for control of the LimeRFE board will be detailed.
Definition of all the constants used are given in the file `limeRFE.h` which is located in `<LimeSuite source>/scr/limeRFE/` folder.

## 9.1 Reference

## RFE_Open

```
rfe_dev_t* RFE_Open(const char* serialport, lms_device_t *dev);
```

This functions opens LimeRFE device. Connection can be direct via USB or through SDR board.

**Parameters**

| | |
|---|---|
| `const char* serialport` | Serial port name, (e.g. COM3) for control via USB. NULL if LimeRFE is controlled via SDR. |
| `lms_device_t *dev` | LimeSDR device obtained by invoking LMS_Open. May be NULL if direct USB connection is used. |

**Return value**
0 on success, other on failure (see error codes in `limeRFE.h`).

## RFE_Close

```
void RFE_Close(rfe_dev_t* rfe);
```

This function closes the device previously opened with `RFE_Open`.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |

**Return value**
None.

# RFE_GetInfo

```
int RFE_GetInfo(rfe_dev_t* rfe, unsigned char* cinfo);
```

This function gets the firmware and hardware version, as well as 2 status bytes (reserved for future use).

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `unsigned char* cinfo` | Board info:<br>`cinfo[0]` – Firmware version<br>`cinfo[1]` – Hardware version<br>`cinfo[2]` – Status (reserved for future use)<br>`cinfo[3]` – Status (reserved for future use) |

**Return value**
0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_LoadConfig

```
int RFE_LoadConfig(rfe_dev_t* rfe, const char *filename);
```

This function loads LimeRFE configuration from an .ini file, and configures the board accordingly.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `const char *filename` | Full path to .ini configuration file. |

**Return value**
0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_Reset

```
int RFE_Reset(rfe_dev_t* rfe);
```

Resets the board. All channels are disabled.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |

**Return value**
0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_Configure

```
API_EXPORT int CALL_CONV RFE_Configure(rfe_dev_t* rfe, char channelIDRX, char channelIDTX, char portRX, char portTX, char mode, char notch, char attenuation, char enableSWR, char sourceSWR);
```

This function configures LimeRFE board.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `char channelIDRX` | RX channel to be acitvated (convenience constants defined in `limeRFE.h`). For example constant `RFE_CID_HAM_0145` identifies 2m (144 – 146 MHz) HAM channel. |
| `char channelIDTX` | TX channel to be acitvated (convenience constants defined in `limeRFE.h`). For example constant `RFE_CID_HAM_0145` identifies 2m (144 – 146 MHz) HAM channel. If -1 then the same channel as for RX is used. |
| `char portRX` | RX port (convenience constants defined in limeRFE.h). |
| `char portTX` | TX port (convenience constants defined in limeRFE.h). |
| `char mode` | Operation mode (defined in `limeRFE.h`). Not all modes all applicable to all configurations. HAM channels using same port for RX and TX are not allowed `RFE_MODE_TXRX` mode. Cellular FDD bands 1, 2, 3, and 7 are always in `RFE_MODE_TXRX` mode. Cellular TDD band 38 can not be in `RFE_MODE_TXRX`. |
| `char notch` | Specifies whether the notch filter is applied or not (convenience constants defined in `limeRFE.h`). |
| `char attenuation` | Specifies the attenuation in the receive path. Attenuation [dB] = 2 * `attenuation`. |
| `char enableSWR` | Enable SWR subsystem. (convenience constants defined in `limeRFE.h`). |
| `char sourceSWR` | SWR subsystem source. (convenience constants defined in `limeRFE.h`). |

**Return value**

0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_ConfigureState

```
int RFE_ConfigureState(rfe_dev_t* rfe, rfe_boardState state);
```

This function configures the LimeRFE board. It's functionality is identical to `RFE_Configure`, with different arguments.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `rfe_boardState state` | Structure containing configuration parameters. |

**Return value**

0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_Mode

```
int RFE_Mode(rfe_dev_t* rfe, int mode);
```

This function sets the LimeRFE mode (receive, transmit, both, or none).

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `int mode` | Operation mode (defined in `limeRFE.h`). Not all modes all applicable to all configurations. HAM channels using same port for RX and TX are not allowed `RFE_MODE_TXRX` mode. Cellular FDD bands 1, 2, 3, and 7 are always in `RFE_MODE_TXRX` mode. Cellular TDD band 38 can not be in `RFE_MODE_TXRX`. |

**Return value**
0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_ReadADC

```
int RFE_ReadADC(rfe_dev_t* rfe, int adcID, int* value);
```

This function reads the value of the speficied ADC.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `int adcID` | Specifies which ADC is to be read (convenience constants defined in `limeRFE.h`). |
| `int* value` | ADC value |

**Return value**
0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_ConfGPIO

```
int RFE_ConfGPIO(rfe_dev_t* rfe, int gpioNum, int direction);
```

This function configures single GPIO pin. Only pins 4 and 5 are configurable.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `int gpioNum` | GPIO pin number. Only pins 4 and 5 are configurable. |
| `int direction` | GPIO pin direction (convenience constants defined in limeRFE.h). 0 - Output; 1 - Input. |

**Return value**
0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_SetGPIO

```
int RFE_SetGPIO(rfe_dev_t* rfe, int gpioNum, int val);
```

This function sets the GPIO pin value. GPIO pin should have been previously configured as output using `RFE_ConfGPIO` function.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `int gpioNum` | GPIO pin number. Only pins 4 and 5 are configurable. |
| `int val` | GPIO pin value. |

**Return value**
0 on success, other on failure (see LimeRFE error codes).

# RFE_GetGPIO

```
int RFE_GetGPIO(rfe_dev_t* rfe, int gpioNum, int* val);
```

This function reads the GPIO pin value. GPIO pin should have been previously configured as output using `RFE_ConfGPIO` function.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `int gpioNum` | GPIO pin number. Only pins 4 and 5 are configurable. |
| `int* val` | GPIO pin value. |

**Return value**
0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_AssignSDRChannels

```
int RFE_AssignSDRChannels(rfe_dev_t* rfe, int rxChan, int txChan);
```

Links LimeRFE Rx and Tx to specific SDR boards channels for automatic band selection and RF switching purposes. By default channel 0 is used, so this function is only needed if different channel is going to be used.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `int rxChan` | Rx channel index. |
| `int txChan` | Tx channels index. |

**Return value**
0 on success, other on failure (see error codes in `limeRFE.h`).

# RFE_Fan

```
int RFE_Fan(rfe_dev_t* rfe, int enable);
```

This function enables/disables the fan.

**Parameters**

| | |
|---|---|
| `rfe_dev_t* rfe` | Handle previously obtained from invoking `RFE_Open`. |
| `int enable` | Fan state: 0 – disable; 1 - enable. |

**Return value**

0 on success, other on failure (see error codes in `limeRFE.h`).

## 9.2 Examples

Examples are available in the `<LimeSuite source>/scr/examples/` folder.
Examples are:

`limeRFE_I2C_example.cpp` – Simple example of configuring LimeRFE using I2C.
`limeRFE_USB_example.cpp` – Simple example of configuring LimeRFE using USB.

In addition one Python example is provided in the same folder:

`limeRFE_Python_example.py` – Simple example in Python