LimeRFE 0v3

- 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
12/07/2019	1.0.0	Initial version created.
15/07/2019	1.0.1	Figure 6 and found text errors were corrected.
24/07/2019	1.0.2	Descriptions for J3 and J5 are modified.
01/08/2019	1.0.3	Chapters ‘Block Diagram’ and ‘Absolute Maximum Ratings’ added.

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.

A link to download all necessary software is given in Chapter 2.

Chapter 3 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 4.

In Chapter 5 is explained how to change bias currents for some power amplifiers in transmitter block of the LimeRFE board.

Chapter 6 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.

API functions for LimeRFE control are described in Chapter 7.

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 145	2 m		
HAM 435	70 cm		
Wideband 1000	1 – 1000 MHz		
HAM 1280	23 cm	20	
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 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	This value will be > 10 dBm in 1v0 version
HAM 3500	/	5	TBC
Wideband 4000	1 – 4 GHz	5	TBC
Cellular Band 1	LTE Band 1	-10	This value will be > 10 dBm in 1v0 version
Cellular Band 2	LTE Band 2/ PCS-1900	-10	This value will be > 10 dBm in 1v0 version
Cellular Band 3	LTE Band 3/ DCS-1800	-10	This value will be > 10 dBm in 1v0 version
Cellular Band 7	LTE Band 7	-10	This value will be > 10 dBm in 1v0 version
Cellular Band 38	LTE Band 38	-10	This value will be > 10 dBm in 1v0 version

3

Installing the Control Software

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

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 I2C bus − Communication if established through the LimeSDR board.
- Through USB − Direct communication via USB.

In this document the LimeRFE board will be controlled through USB communication, so no additional LimeSDR board is 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, I2C, Configuration, Synchronize, Configure, Power Meter and Message Display panel.
- In Communication panels, chose one of two possible options, I2C or USB.
  Keep in mind that for I2C communication, an additional LimeSDR board must be connected. For I2C, a default LimeRFE board address is 0x51. If any other device on I2C bus has the same address one of these two devices should change its address. LimeRFE address can be changed in its firmware.
  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.

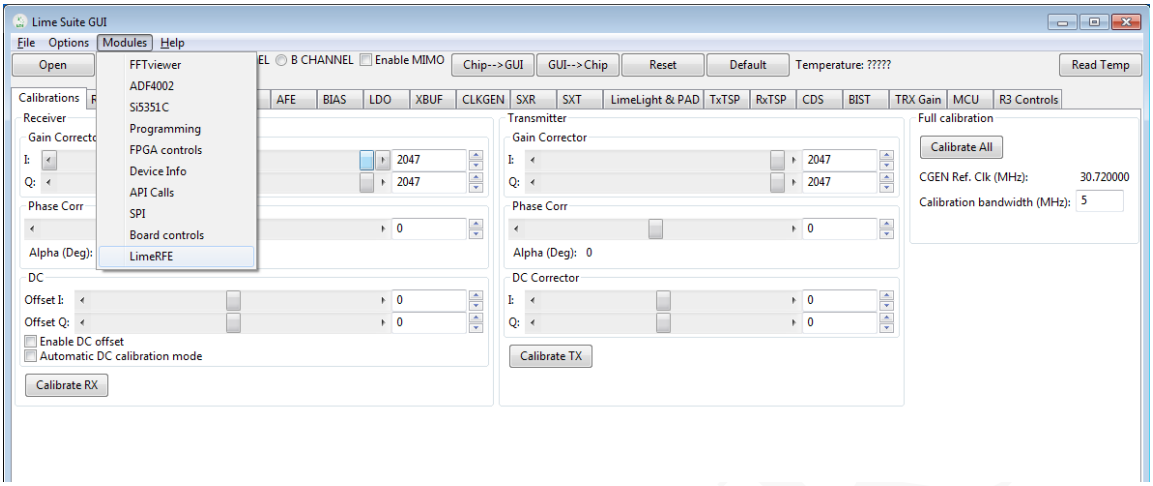

Figure 1: Lime Suite GUI window

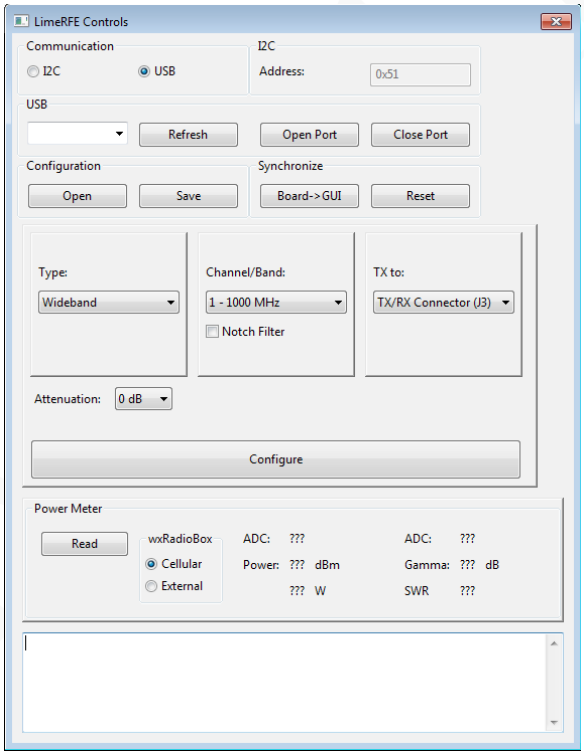

Figure 2: LimeRFE Controls window

- 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.

- In *Configure* panel, in *Type* sub-panel there are three different options. Depending of selected type, different Channel/Band options will appear. Also, in some configurations, a third sub-panel will be given, where the output port for transmitter mode can be selected. All possible states are given in table bellow.
  Keep in mind that after choosing one of options, button *Configure* must be pressed to apply all changes in configuration.

Table 3: All possible states of the LimeSDR board

Type	**Channel/Band**	**TX to**
Wideband	1 – 1000 MHz	TX Connector (J4)
		TX/RX Connector (J3)
	1000 – 4000 MHz	TX Connector (J4)
		TX/RX Connector (J3)
HAM	30 MHz (HF)	*(not shown, but TX to J5)*
	144 – 146 MHz (2m)	TX Connector (J4)
		TX/RX Connector (J3)
	430 – 440 MHz (70cm)	TX Connector (J4)
		TX/RX Connector (J3)
	1240 – 1325 MHz (23cm)	TX Connector (J4)
		TX/RX Connector (J3)
	2300 – 2450 MHz (13cm)	TX Connector (J4)
		TX/RX Connector (J3)
	3300 – 3500 MHz	TX Connector (J4)
		TX/RX Connector (J3)
Cellular	Band 1	*(not shown, but TX to J3)*
	Band 2/PCS – 1900	*(not shown, but TX to J3)*
	Band3/DCS – 1800	*(not shown, but TX to J3)*
	Band 7	*(not shown, but TX to J3)*
	Band 38	*(not shown, but TX to J3)*

- 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 its basic configuration, *Power Meter* panel gives power 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.

Important note: It is important to keep the impedance controlled on all output connectors (J4, J5, and J6, 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 3. CON1 connector is in bottom layer, in the upper-right part of the LimeRFE board.

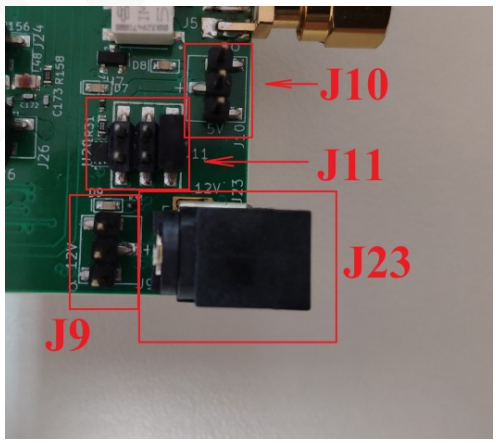

Figure 3: Photo of J9, J10, J11 and J23 connectors

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	External 5 V power supply	5 V is obtained from J10
Centre	Internal 5 V from USB	5 V is obtained from USB cable
Right	5 V from external 12 V power supply	5 V is obtained from DC – DC convector which is supplied from 12 V. 12 V is obtained from J9 or J23

Preferred configuration of J11 connector is at jumper position – right, where 5V is obtained from the 12 V 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 4. The bottom view of the LimeRFE board is shown in Figure 5.

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 which is removed for better view of all bottom components.

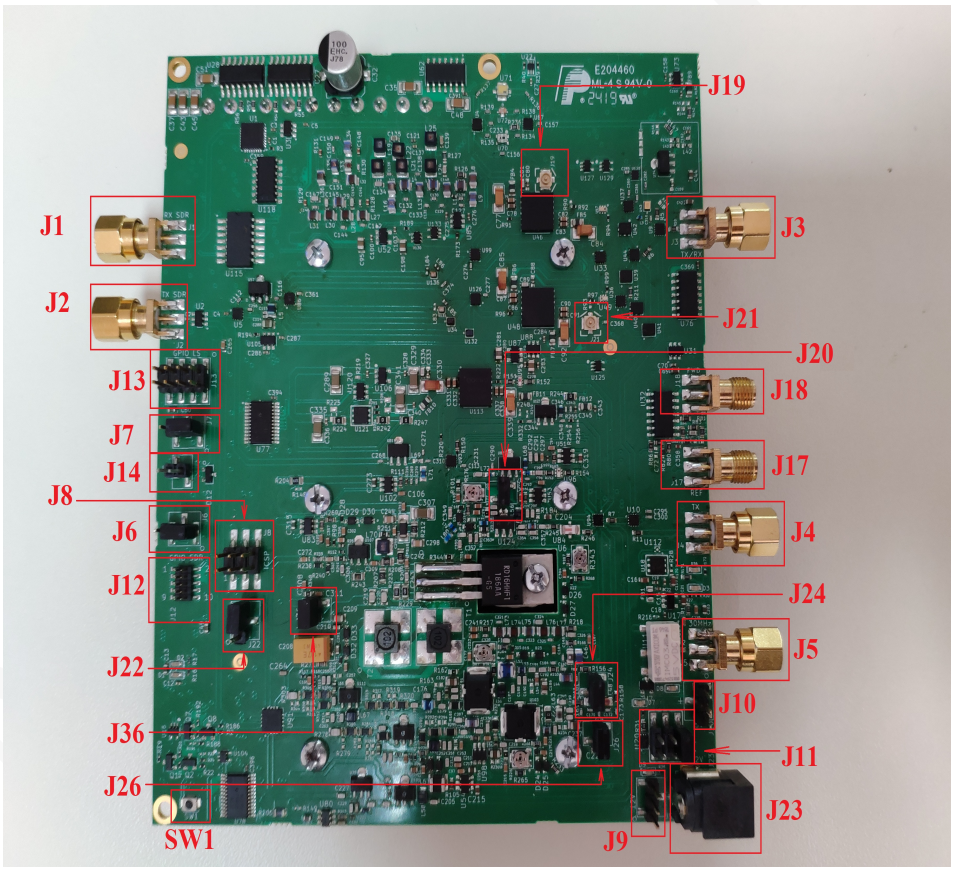

Figure 4: LimeRFE Connectors – Top View

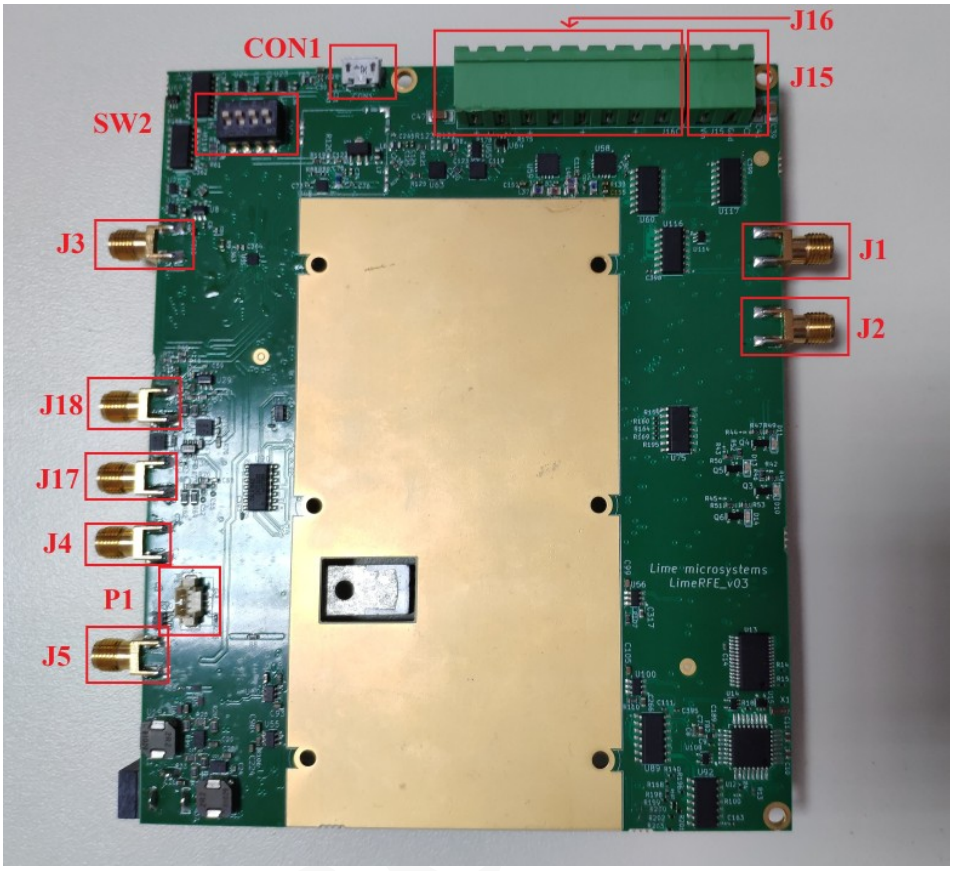

Figure 5: LimeRFE Connectors – Bottom view

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 except 30 MHz (HF) band RF output – in TX mode, for all frequency bands except 30 MHz (HF) band
J4	RF output – in TX mode, for all frequency bands except 30 MHz (HF) band
J5	RF input – in RX mode, only for 30 MHz (HF) band 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 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 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 – 5 V is obtained from DC-DC connector supplied from external 12 V (PIN connection 1-2, jumper position – right) 5 V is obtained from USB (PIN connection 3-4, jumper position – center) 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. Such 10-pin GPIO headers are available in all Lime Microsystems' SDR platforms. • GPIO – GPIO0 (PIN1), GPIO1 (PIN2), GPIO2 (PIN3), GPIO3 (PIN4), 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. • GPIO – GPIO4 (PIN5), GPIO5 (PIN6) These 2 pins provide the 2-way communication between the SDR and the microcontroller on LimeRFE. • SCL (PIN7), SDA (PIN8) These pins enable I2C communication between SDR and LimeRFE. • GND (PIN9), VDD_CON (PIN10) These are supply pins.
J13	• GPIO0_LS (PIN1), GPIO1_LS (PIN2), GPIO2_LS (PIN3), GPIO3_LS (PIN4) These pins are part of the GPIO sub-system. • ADC7 (PIN3), ADC6 (PIN6) These pins can be connected to the ADC inputs of the LimeRFE microcontroller by properly setting jumpers on J6 and J7. • VDDA (PIN5), GND (PIN4) These are supply pins.
J14	• VDDA (PIN1), VDD_CON (PIN2) 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
J18	Forward power RF input
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 GPIO5 to GPIO3 (PIN connection 1-2) 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.
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.
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 – When the switches are in position closser to PIN1 (marked with dot), direction signal is at high logic level, directron is GPIO → GPIO_LS 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	External fan connector

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 6. Please keep in mind that this block diagram depicts only RF part of the board.

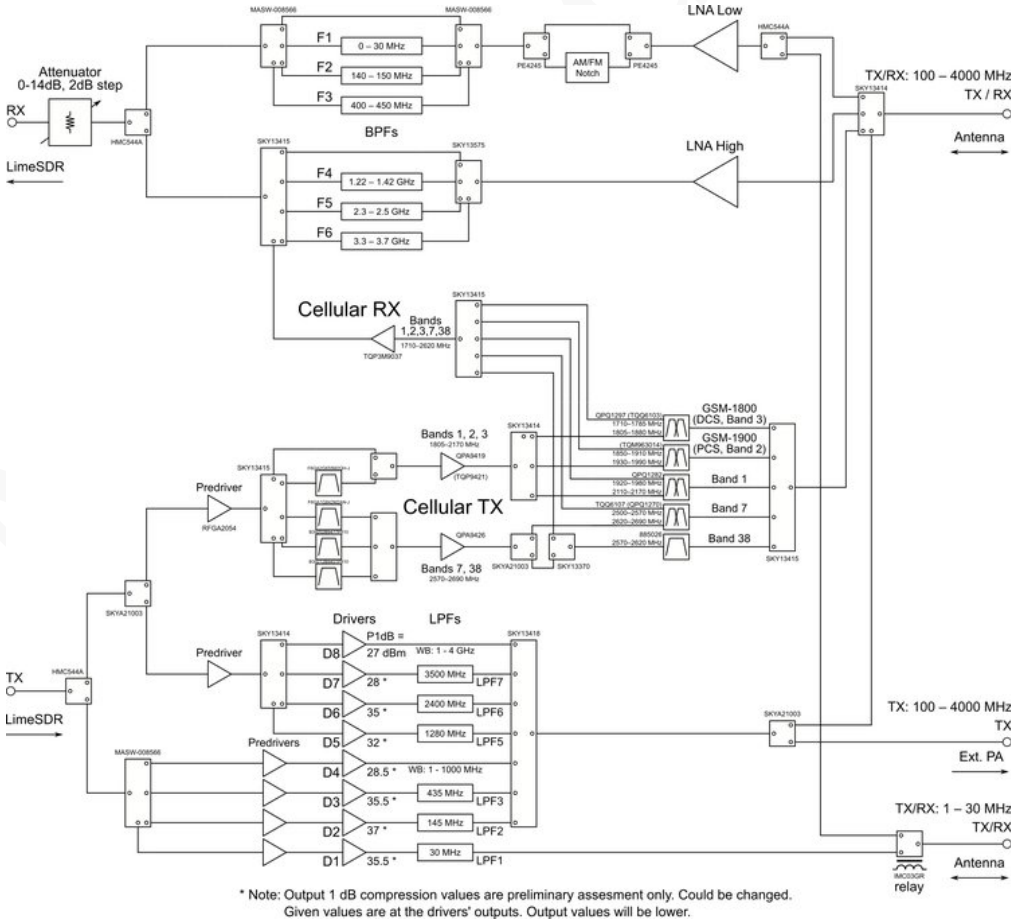

Figure 6: Lime RFE block diagram (RF part only)

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 7 and in Figure 8.

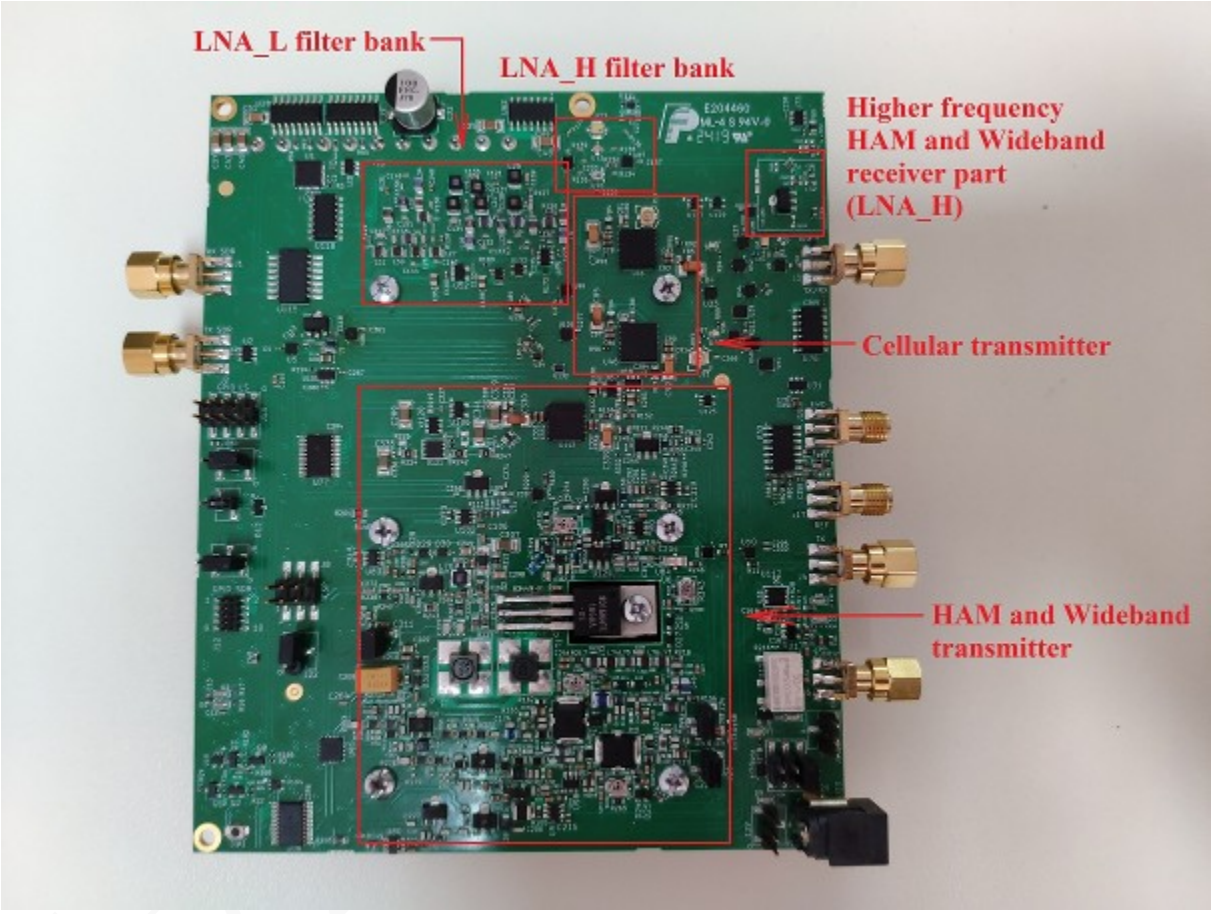

Figure 7: Receiver and transmitter sub-blocks – Top view

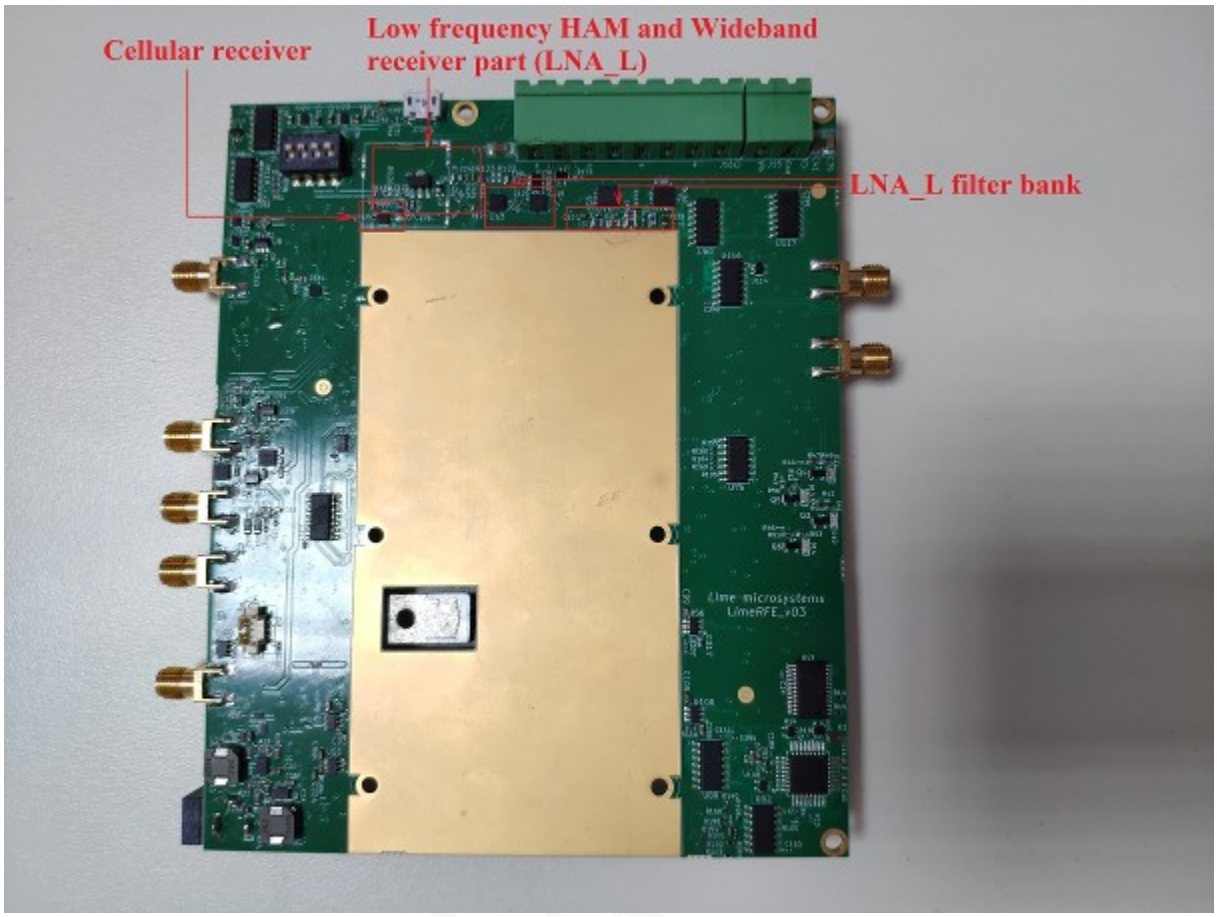

Figure 8: Receiver and transmitter sub-blocks – Bottom view (Heat sink was removed for better view)

Receiver block uses connectors:

- J3 as input connector, without HAM 30 MHz and HAM 50−70 MHz bands
- J5 as input connector, only for HAM 30 MHz and HAM 50−70 MHz bands
- 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 attenuations 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 / 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 / IMC03GR / HMC544A / GALI-74+ / PE4245 / (AM/FM Notch filter or bypass) / PE4245/ MASW-008566 / filter 0−30 MHz / MASW-008566 / HMC544A / F1956NBGI8 / J1
HAM	144−146 MHz (2 m)	J3 / SKY13414 / HMC544A / GALI-74+ / PE4245 / AM/FM Notch filter or bypass / PE4245 / MASW-008566 / filter 140−150 MHz / MASW-008566 / HMC544A / F1956NBGI8 / J1
HAM	430−440 MHz (70 cm)	J3 / SKY13414 / HMC544A / GALI-74+ / PE4245 / AM/FM Notch filter or bypass / PE4245 / MASW-008566 / filter 400−450 MHz / MASW-008566 / 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 / TQP3M9037 / 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 for TX/RX mode, without 30 MHz and 50–70 MHz bands
- J4 as output connector for TX mode only, without 30 MHz, 50–70 MHz and all cellular bands
- J5 as output connector for TX/RX mode, only for 30 MHz and 50–70 MHz 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 / filter 30 MHz / IMC03GR / J5
HAM	144−146 MHz (2 m)	J2 / HMC544A / MASW-008566 / RD01MUS2B / AFT09MS007NT1 / filter 145 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	1240−1325 MHz (23 cm)	J2 / HMC544A / SKY13414 / QPA6489ATR13 / SKY13415 / RFM04U6P / 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 / QPQ1282 / SKY13415 / SKY13414 / J3
Cellular	Band 3 / DCS−1800	J2 / HMC544A / SKY13414 / RFGA2054 / SKY13415 / F6QA1G842M2AN-J / SKY13414 / QPA9419 (TQP9421) / SKY13414 / QPQ1282 / SKY13415 / SKY13414 / J3
Cellular	Band 7	J2 / HMC544A / SKY13414 / RFGA2054 / SKY13415 / F6QA2G655M2QH-J / SKY13414 / QPA9426 / SKY21003 / TQQ61017 (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
- 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 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 to sub-panel select TX Connector (J4)

- Afer this selection press Configure button
- In Configure panel the forth sub-panel with 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 23 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)	500 mA	J36	R343
144 – 146 MHz (2 m)	200 mA	J24	R161
430 – 440 MHz (70 cm)	200 mA	J26	R226
1240 – 1325 MHz (23 cm)	200 mA	J20	R176

Figure 9 shows possitions of all connectors and trimmers necessary to change power amplifier bias currents.

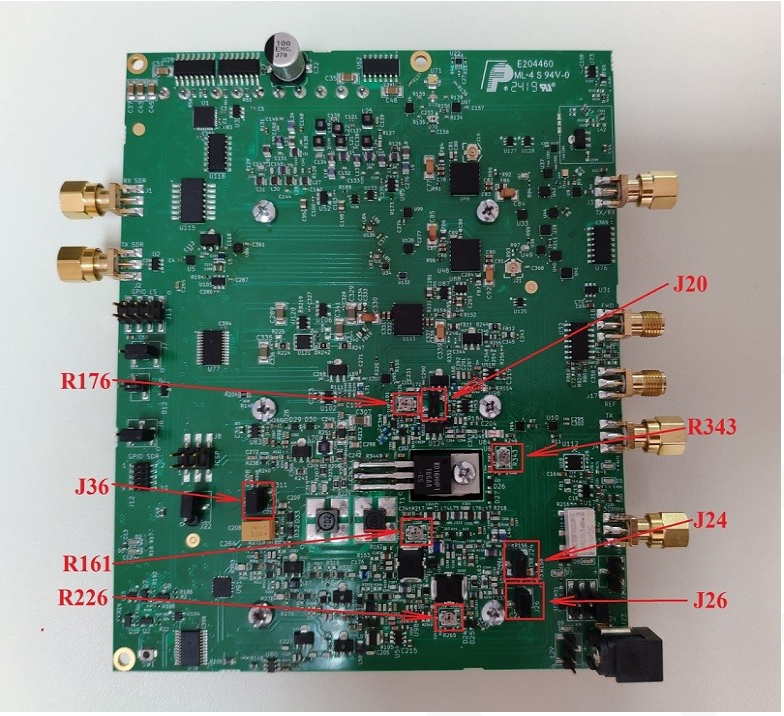

Figure 9: Positions of all necessary connectors and trimmers for bias currents changes

Setup HAM 30 MHz power amplifier drain current

- Choose external DC power supply of 12 V 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 20 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 (R343, R161, R226, R176).
- Connect J36 connector pins through ammeter (set 10 A range in ammeter)
- Turn on 12V 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

- - external DC power supply of 12 V 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 (R343, R161, R226, R176)
- Connect J24 connector pins through ammeter (set 10 A range in ammeter)

- Turn on 12V 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 Connector (J4).
- Turn off Receiver and Turn on Transmitter
- Turn around trimmer R161 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 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 (R343, R161, R226, R176).
- Connect J26 connector pins through ammeter (set 10 A range in ammeter).
- Turn on 12V 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 1240 – 1325 MHz (23 cm) power amplifier drain current

- Choose external DC power supply of 12 V 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 (R343, R161, R226, R176).
- Connect J20 connector pins through ammeter (set 10 A range in ammeter).
- Turn on 12V from external DC supply unit (setup maximum current of 400 mA in external DC power unit if desired bias current is 200 mA).
- 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 R176 in clockwise direction until ammeter shows 0.2 A.

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_constants.h` which is locatedin `<LimeSuite source>/scr/limeRFE/` folder.

9.1 Reference

LIMERFE_Open

```
int LIMERFE_Open(const char* serialport, int baudrate);
```

This functions opens port to LimeRFE in case of USB communication.
In case of I2C communication via LimeSDR, this function is not needed.

Parameters

`const char* serialport`	Serial port name, e.g. “COM3”
`int baudrate`	Baudrate, e.g. 9600. Should match the value in firmware, by default 9600.

Return value
On success it returns the positive value.
In case that port could not be opened, return value is -1.
In case the synchronization with the board could not be performed, the return value is `LIMERFE_HELLO_ATTEMPTS_EXCEEDED`.

LIMERFE_Close

```
void LIMERFE_Close(int fd);
```

This function closes the port previously opened with `LIMERFE_Open`.

Parameters

`int fd`	Port file handle previously obtained from invoking `LIMERFE_Open`.

Return value
None.

LIMERFE_GetInfo

```
void LIMERFE_GetInfo(int commType, lms_device_t *dev, int i2Caddress, int fd, unsigned char* cinfo);
```

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

Parameters

`int commType`	Communication type, I2C or USB. Possible values are: `LIMERFE_I2C` `LIMERFE_USB`.
`lms_device_t *dev`	LimeSDR device obtained by invoking `LMS_Open`. In case of direct USB communication, this value is not used.
`int i2Caddress`	I2C address of the LimeRFE board (0x51 by default). In case of direct USB communication, this value is not used.
`int fd`	Port file handle previously obtained from invoking `LIMERFE_Open`. Used only in case of direct USB communication.
`unsigned char* cinfo`	Board info: `cinfo[0]` – Firmware version `cinfo[1]` – Hardware version `cinfo[2]` – Status (reserved for future use) `cinfo[3]` – Status (reserved for future use)

Return value
None.

LIMERFE_Reset

```
int LIMERFE_Reset(int commType, lms_device_t *dev, int i2Caddress, int fd);
```

Resets the board. All channels are disabled.

Parameters
None.

Return value
None.

LIMERFE_Configure

```
int LIMERFE_Configure(int commType, lms_device_t *dev, int i2Caddress, int fd, int channelID, int mode, int selTX2TXRX = 0, int notch = 0, int attenuation = 0);
```

This function configures LimeRFE board.

Parameters

`int commType`	Communication type, I2C or USB. Possible values are: `LIMERFE_I2C` `LIMERFE_USB`.
`lms_device_t *dev`	LimeSDR device obtained by invoking `LMS_Open`. In case of direct USB communication, this value is not used.
`int i2Caddress`	I2C address of the LimeRFE board (0x51 by default). In case of direct USB communication, this value is not used.
`int fd`	Port file handle previously obtained from invoking `LIMERFE_Open`. Used only in case of direct USB communication.
`int channelID`	Channel to be acitvated. Constants presenting channels are gicen in `limeRFE_constants.h`. For example constant `LIMERFE_CID_HAM_0145` identifies 2m (144 – 146 MHz) HAM channel.
`int mode`	Operation mode (defined in`limeRFE_constants.h`): `LIMERFE_MODE_RX` – Receive `LIMERFE_MODE_TX` – Transmit `LIMERFE_MODE_NONE` – None `LIMERFE_MODE_TXRX` – Transmit and receive. Not all modes all applicable to all congfigurations. HAM channels can be in the TXRX mode only if the separate TX output is used. Cellular bands 1, 2, 3, and 7 are always in TXRX mode, since they are using FDD duplexing. Cellular band 38 can not be in TXRX mode since it is using TDD duplexing.
`int selTX2TXRX`	Specifies which connector will be used for transmit: `LIMERFE_TX2TXRX_INDEX_TX` – TX connector `LIMERFE_TX2TXRX_INDEX_TXRX` – TXRX connector.
`int notch`	Specifies whether the notch filter is applied or not: `LIMERFE_NOTCH_VALUE_OFF` – Notch off `LIMERFE_NOTCH_VALUE_ON` – Notch on.
`int attenuation`	Specifies the attenuation in the receive path. Attenuation [dB] = 2 * `attenuation`.

Return value
Returns 0 if successful.

LIMERFE_Mode

```
int LIMERFE_Mode(int commType, lms_device_t *dev, int i2Caddress, int fd, int mode);
```

This function sets the LimeRFE mode (receive, transmit, etc.)

Parameters

`int commType`	Communication type, I2C or USB. Possible values are: `LIMERFE_I2C` `LIMERFE_USB`.
`lms_device_t *dev`	LimeSDR device obtained by invoking `LMS_Open`. In case of direct USB communication, this value is not used.
`int i2Caddress`	I2C address of the LimeRFE board (0x51 by default). In case of direct USB communication, this value is not used.
`int fd`	Port file handle previously obtained from invoking `LIMERFE_Open`. Used only in case of direct USB communication.
`int mode`	Operation mode (defined in `limeRFE_constants.h`): `LIMERFE_MODE_RX` – Receive `LIMERFE_MODE_TX` – Transmit `LIMERFE_MODE_NONE` – None `LIMERFE_MODE_TXRX` – Transmit and receive. Not all modes all applicable to all congfigurations. HAM channels can be in the TXRX mode only if the separate TX output is used. Cellular bands 1, 2, 3, and 7 are always in TXRX mode, since they are using FDD duplexing. Cellular band 38 can not be in TXRX mode since it is using TDD duplexing.

Return value
Returns 0 if successful.

LIMERFE_ReadADC

```
int LIMERFE_ReadADC(int commType, lms_device_t *dev, int i2Caddress, int fd, int adcID, int* value);
```

Reads the ADC value.

Parameters

`int commType`	Communication type, I2C or USB. Possible values are: `LIMERFE_I2C` `LIMERFE_USB`.
`lms_device_t *dev`	LimeSDR device obtained by invoking `LMS_Open`. In case of direct USB communication, this value is not used.
`int i2Caddress`	I2C address of the LimeRFE board (0x51 by default). In case of direct USB communication, this value is not used.
`int fd`	Port file handle previously obtained from invoking `LIMERFE_Open`. Used only in case of direct USB communication.
`int adcID`	Specifies which ADC is to be read: `LIMERFE_ADC1` – ADC #1, this ADC value is proportional to output power in dB. `LIMERFE_ADC2` – ADC #1, this ADC value is proportional to reflection coefficient in dB.

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