Summary - Lime RX Proxy

Name	lime_rx_proxy
Worker Type	Proxy
Version	v1.4
Release Date	February 2018
Component Library	ocpi.assets.devices
Workers	lime_rx_proxy.rcc
Tested Platforms	xilinx13_3, CentOS 7 (via ALST4/Zipper), CentOS 6/7 (via ML605/Zipper for HPC and LPC FMC slots)
Slave Worker	lime_rx.hdl

Functionality

This control proxy is designed to allow the user of the proxy to set more user friendly properties than the register map on the LMS6002D Transceiver. Only the control of the RX portion of the LMS6002D Transceiver is encompassed in this worker.

Worker Implementation Details

lime_rx_proxy.rcc

A diagram of the receiver in the Lime Microsystems LMS6002D can be seen in Figure 2. It consists of a single channel with three separate inputs each with a dedicated LNA. Post LNA, the RF signal is then mixed with a PLL output to directly down convert to baseband. Post mixing, there an programmable gain amplifier, a lowpass filter, and an another programmable gain amplifier. Furthermore, DC offset is applied at the input of the second programmable gain amplifier. The resulting analog receive IQ signals are converted into the digital domain using the on chip ADCs and are provided as an output.

The features described above are controllable via a SPI interface on the LMS6002D. This proxy is responsible for translating its properties (as described in the Lime datasheet) into the required SPI reads and writes and controlling the worker which performs the SPI transactions.

Block Diagrams

Top level

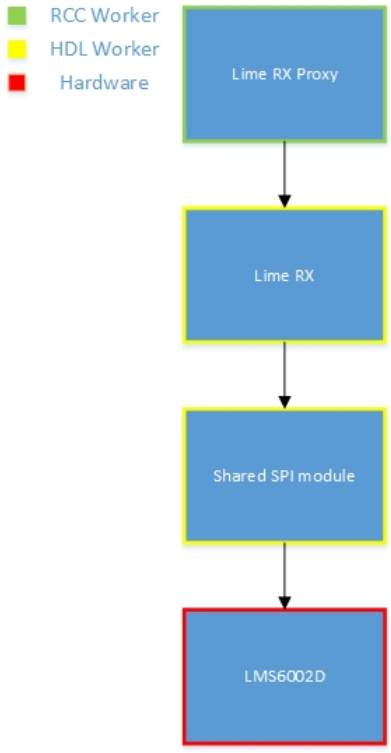

Figure 1: Top Level Block Diagram

Hardware

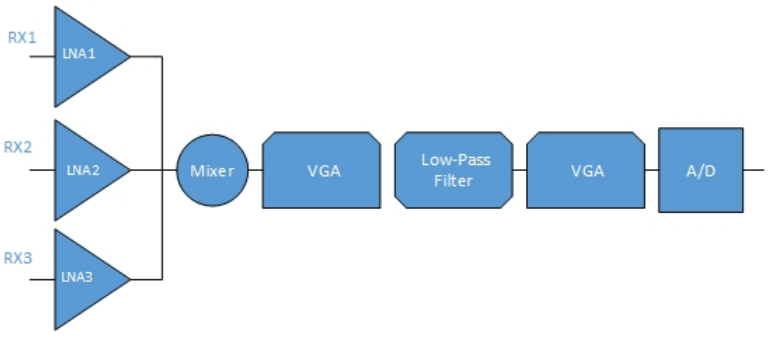

Figure 2: Hardware Block Diagram

Source Dependencies

- assets/hdl/devices/lime_rx_proxy.rcc/lime_rx_proxy.cc
- assets/hdl/devices/lime_rx_proxy.rcc/lime_shared.h

Component Spec Properties

Name	Type	Sequence Length	Array Dimensions	Accessibility	Valid Range	Default	Usage
ninputs	UChar	-	-	Readable, Parameter	1-3	1	The number of hardware inputs that are available to this RX.
input_select	UChar	-	-	Writable, Readable	-	-	This is the hardware selection of which input to pass to the mixer. Input 1 rated from 300MHz to 2.8GHz, input 2 rated from 1.5GHz to 3.8GHz, and input 3 rated from 300MHz to 3GHz.
input_gain_db	Short	-	-	Writable, Readable	-	-	The gain value in the input LNA.
center_freq_hz	Double	-	-	Writable, Readable	-	-	The value of the tuned center frequency of the receiver.
post_mixer_dc_offset_i	UChar	-	-	Writable, Readable	-	-	The register value used to tune the DC offset of the received signal to close to zero on the I path. This is generally set to a close value and then a VHDL component is used to tun this to be exact. The mapping of this is described in the Lime documentation.
post_mixer_dc_offset_q	UChar	-	-	Writable, Readable	-	-	The register value used to tune the DC offset of the received signal to close to zero on the Q path. This is generally set to a close value and then a VHDL component is used to tun this to be exact. The mapping of this is described in the Lime documentation.
pre_lpf_gain_db	Short	-	-	Writable, Readable	-	-	The gain value for the VGA in before the low pass filter.
lpf_bw_hz	Float	-	-	Writable, Readable	-	-	The low pass filter that is used to filter out any noise on the received signal.
post_lpf_gain_db	Short	-	-	Writable, Readable	-	-	The gain value for the VGA in after the low pass filter. The value is in dB and can only be set in multiples of 3.

Worker Properties

lime_rx_proxy.rcc

Type	Name	Type	Sequence Length	Array Dimensions	Accessibility/ Advanced	Valid Range	Default	Usage
SpecProperty	ninputs	-	-	-	-	3	3	The number of hardware inputs that are available to this RX.
SpecProperty	input_select	-	-	-	WriteSync	1-3	-	This is the hardware selection of which input to pass to the mixer. Input 1 rated from 300MHz to 2.8GHz, input 2 rated from 1.5GHz to 3.8GHz, and input 3 rated from 300MHz to 3GHz.
SpecProperty	input_gain_db	-	-	-	WriteSync	-6,0,6	-	The gain value in the input LNA.
SpecProperty	center_freq_hz	-	-	-	WriteSync	232,500 - 3,720,000	-	The value of the tuned center frequency of the receiver.
SpecProperty	post_mixer_dc_offset_i	-	-	-	WriteSync	0x00-0x80	-	The register value used to tune the DC offset of the received signal to close to zero on the I path. This is generally set to a close value and then a VHDL component is used to tun this to be exact. The mapping of this is described in the Lime documentation.
SpecProperty	post_mixer_dc_offset_q	-	-	-	WriteSync	0x00-0x80	-	TThe register value used to tune the DC offset of the received signal to close to zero on the Q path. This is generally set to a close value and then a VHDL component is used to tun this to be exact. The mapping of this is described in the Lime documentation.
SpecProperty	pre_lpf_gain_db	-	-	-	WriteSync	5,19,30	-	TThe gain value for the VGA in before the low pass filter.
SpecProperty	lpf_bw_hz	-	-	-	WriteSync	14e6, 10e6, 7e6, 6e6, 5e6, 4.375e6, 3.5e6, 3e6, 2.75e6, 2.5e6, 1.92e6, 1.5e6, 1.375e6, 1.25e6, 0.875e6, 0.75e6	-	The low pass filter that is used to filter out any noise on the received signal.
SpecProperty	post_lpf_gain_db	-	-	-	WriteSync	0 to 30	-	The gain value for the VGA in after the low pass filter. The value is in dB and can only be set in multiples of 3.

Performance and Resource Utilization

lime_rx_proxy.rcc

Processor Type	Processor Frequency	Run Function Time
TBD	TBD	TBD

Test and Verification

Note: A component unit test does not exist. Reference the applications/ for a hardware-in-the-loop test application.

The testbench for this proxy is meant to exercise the properties of the proxy worker dynamically while the application is running. The sample rate is set low and not changed so that there is less data to deal with at the end. The test requires that there be a signal generator capable of generating a sine wave from 300MHz to 3.005GHz connected to the RX interface of the radio. Amplitude levels are suggested below, but if the test yields all zeros for the I/Q values when plotted, consider increasing the signal generator gain. Also, note that the once the test is started, data is being written to file continuously, so completing the test quickly helps with data consistency.

The following steps are taken in the testbench:

1. Toggle the input select (only when Matchstiq-Z1 container is detected/being used)
2. Change the input gain settings
3. Change pre-lpf gain settings
4. Change filter values
5. Tune the center frequency

Matchstiq-Z1

For Matchstiq-Z1 testing, the sample rate is set at 100 kS/s. The signal generator amplitude should be set to -55 dBm. The results should look like the below images:

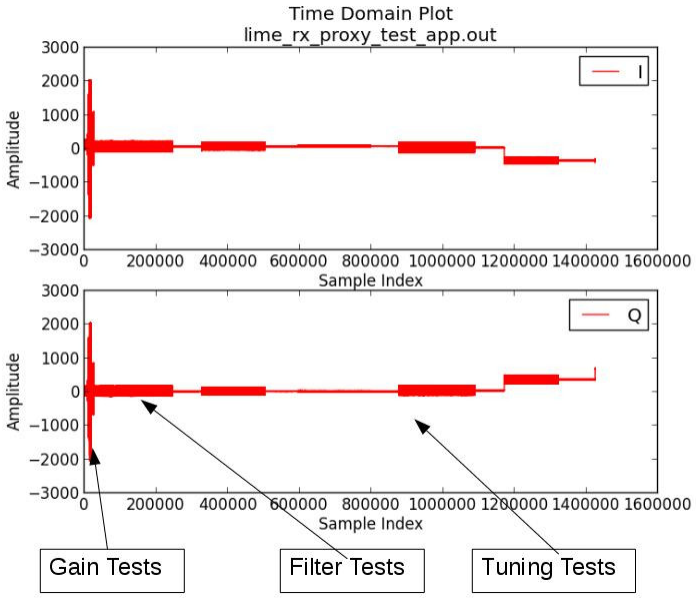

Figure 3: Full Testbench

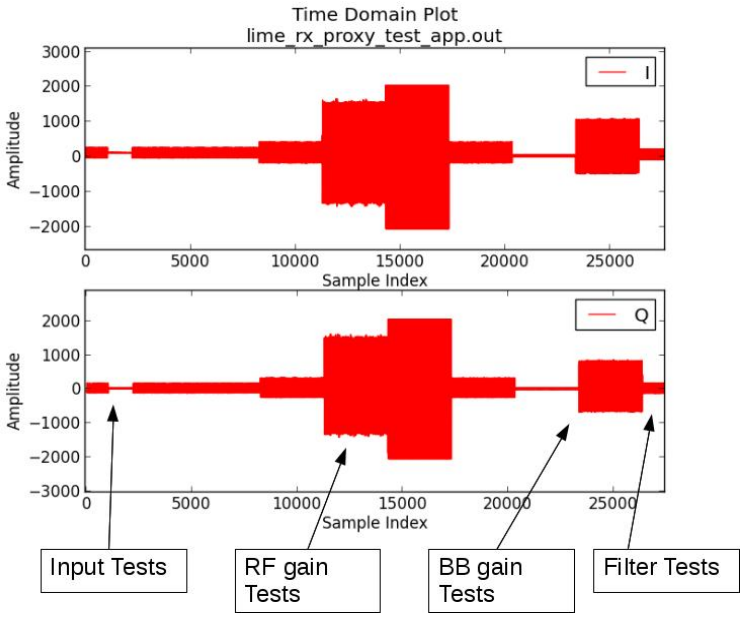

Figure 4: Refined Gain Testing Stage

Zipper Platforms

For Zipper Platform testing, the sample rate is set at 500 kS/s. The signal generator amplitude should be set to -30 dBm. The results should look like the below images:

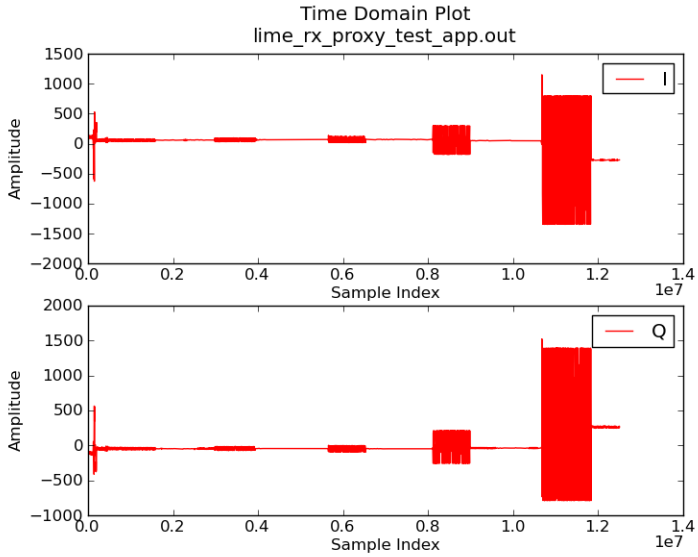

Figure 5: Full Testbench

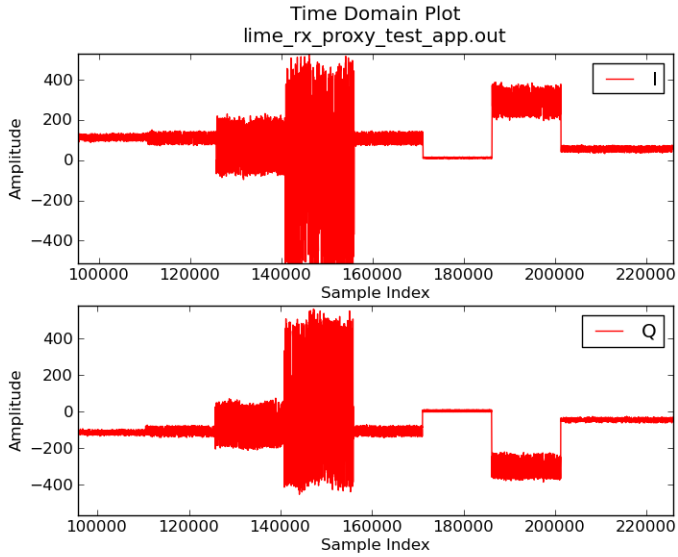

Figure 6: Refined Gain Testing Stage

References

1) LMS6002D Datasheet, www.limemicro.com