

System Testing and Debugging

EEC 134

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## Summary/ Important Tips

To make testing and debugging easier, it is important that you test each individual part or block first before combining the whole system together. In this way, you can have a clear idea where errors might occur, or fix some errors before anything is burned or damaged when testing the whole system.

## Baseband PCB Testing

Our baseband PCB is very similar to the quarter one PCB1, except that we used different components, such as the amplifier. After we finished soldering our baseband PCB below are the steps we took to test its functionality:

1. Check connectivity between components to see if the soldering is done correctly or if your design is correct. We didn't do this first for our testing which latter cause a lot of errors and troubles.
2. Check the voltage supplies! Voltage supplies including voltage output from the battery to the system, the voltage output of the voltage regulator (LM317 in our case), also the voltage output of the precision voltage reference (LT 1009 IC). This is very important because, many components are powered by those voltages, and if they are not correct, it might burn/damage the components. When doing this step, just connect the voltage regulator and the precision voltage reference component to the PCB to avoid any burning.
3. Check the waveform at the output of the DAC IC (Microchip MCP4921). Program teensy with the triangle wave, and then connect the output of the DAC IC to the oscilloscope to see if the output is a expected triangle wave.
4. Check the LPF and Gain stage. Start with inputting a low frequency (~100 Hz) and small amplitude(100 mV) sine wave to the gain stage input, then observed the waveform at the the LPF output. The sine wave you observed should have a amplitude greater than 100 mV, and when you adjust the pot that determine the gain of the amplifier, you should see the wave increasing its amplitude as well. Then, slowly increase the frequency of the input sine wave, until you see a distorted sine wave at the output to test the functionality of the LPF.

When we tested our LPF and gain stage, we see a slightly distorted sine wave at the output even when the frequency is low, we noticed that there might be some errors. We replace our amplifier with new components, but still the same result. As I mentioned before, we didn't do step 1 at first, actually we spending a lot of time trying to figure out what is wrong with our LPF and gain stage. Then, we checked the connectivity according to our schematic, and found that 2 resistors are suppose to connect to 2.5V, but didn't get connected because of the minor design error.

## RF PCB Testing

Our RF board and components are extremely small, which make soldering much more difficult. Because being afraid that our components' pins might be connected all together, the first thing we do even before testing is to look at the components on the PCB very carefully, to see if there is any noticeable connection errors.

**\* Very important.** The checking DC connectivity step doesn't work in the RF board, because many components work only with high frequency, so checking DC connectivity doesn't help.

Below are the steps for testing RF PCB:

### 1. Test the transmitting side/route.

Input a constant DC voltage at the vco input. According to the VCO datasheet, you can find out at frequency you should expect to see your output, and the power output of the VCO. For example, when inputting a 5V DC voltage to the ROS-2490+ VCO, we should expect to see the output at 2386.2 MHz, and the VCO output voltage should be 8.02 dBm (refer to figure 1).

## Performance Data & Curves\*

## ROS-2490+

V TUNE	TUNE SENS (MHz/V)	FREQUENCY (MHz)			POWER OUTPUT (dBm)			Icc (mA)	HARMONICS (dBc)			FREQ. PUSH (MHz/V)	FREQ. PULL (MHz)	PHASE NOISE (dBc/Hz) at offsets				FREQ OFFSET (KHz)	PHASE NOISE at 2385 MHz (dBc/Hz)
		-55°C	+25°C	+85°C	-55°C	+25°C	+85°C		F2	F3	F4			1kHz	10kHz	100kHz	1MHz		
0.00	32.97	2227.6	2218.2	2210.9	7.44	7.64	7.69	30.93	-22.7	-29.7	-43.3	1.37	1.63	-80.3	-103.4	-123.9	-143.8	1.0	-80.04
0.50	30.02	2243.7	2234.7	2227.5	7.46	7.64	7.75	30.98	-23.7	-31.3	-39.1	1.42	0.97	-82.2	-103.6	-124.2	-143.8	2.0	-88.06
1.00	30.15	2259.1	2249.7	2242.6	7.59	7.75	7.84	31.04	-22.3	-28.5	-35.3	1.39	0.30	-82.1	-103.8	-124.4	-144.2	3.5	-93.59
1.50	31.28	2274.2	2264.8	2257.4	7.62	7.83	7.93	31.07	-21.4	-30.1	-36.9	1.42	0.72	-81.5	-103.6	-124.5	-144.3	6.0	-98.85
2.00	32.55	2290.2	2280.4	2272.7	7.58	7.83	7.98	31.12	-22.3	-29.5	-33.4	1.39	1.08	-80.7	-103.7	-124.6	-144.2	8.5	-102.03
2.50	34.34	2306.6	2296.7	2288.7	7.67	7.88	7.99	31.17	-22.3	-30.3	-34.6	1.37	1.21	-80.1	-103.7	-124.5	-144.1	10.0	-103.57
3.00	35.17	2324.0	2313.8	2305.4	7.75	7.92	8.08	31.20	-21.0	-28.7	-33.9	1.40	0.88	-80.3	-104.0	-124.7	-144.4	20.8	-110.64
3.50	36.22	2342.1	2331.4	2322.9	7.83	8.04	8.13	31.25	-20.6	-29.2	-31.8	1.31	0.43	-81.0	-103.8	-124.6	-144.4	35.5	-115.15
4.00	36.73	2360.5	2349.5	2340.5	7.80	8.05	8.18	31.26	-21.3	-30.3	-34.7	1.27	1.49	-80.4	-103.8	-124.5	-144.4	60.7	-119.88
4.50	36.53	2379.1	2367.9	2358.6	7.81	8.08	8.21	31.29	-21.0	-30.1	-34.6	1.20	1.66	-80.5	-103.9	-124.5	-144.2	86.7	-123.09
5.00	36.25	2397.4	2386.2	2376.7	7.81	8.02	8.18	31.32	-19.6	-27.5	-34.1	1.13	0.71	-79.9	-103.4	-124.4	-144.1	100.0	-124.36
5.50	34.86	2415.8	2404.3	2394.4	7.87	8.01	8.11	31.42	-19.4	-28.7	-35.8	1.00	0.93	-79.8	-103.5	-124.3	-144.2	148.1	-127.69
6.00	33.94	2433.0	2421.7	2411.9	8.05	8.15	8.13	31.47	-19.8	-30.3	-34.3	0.92	1.51	-80.1	-103.5	-124.5	-144.3	177.0	-129.37
6.50	33.05	2450.3	2438.7	2428.7	8.32	8.36	8.30	31.53	-20.1	-29.7	-35.1	0.85	1.53	-79.8	-103.4	-124.5	-144.3	211.6	-130.79
7.00	32.48	2466.7	2455.2	2445.1	8.47	8.62	8.49	31.57	-18.9	-29.5	-36.3	0.76	0.79	-79.2	-103.4	-124.4	-144.2	302.4	-134.04
7.50	31.19	2482.9	2471.5	2461.0	8.51	8.66	8.63	31.62	-19.3	-31.3	-33.0	0.72	0.80	-78.5	-103.5	-124.4	-144.1	361.5	-135.22
8.00	30.27	2498.8	2487.1	2476.7	8.56	8.79	8.74	31.70	-19.3	-31.1	-34.2	0.61	1.50	-79.2	-103.2	-124.4	-144.2	507.5	-138.36
8.50	29.64	2513.8	2502.2	2491.8	8.89	8.89	8.82	31.78	-19.0	-30.1	-31.6	0.54	1.73	-78.5	-103.5	-124.6	-144.4	606.7	-139.97
9.00	29.18	2528.9	2517.0	2506.5	9.09	9.01	8.91	31.80	-18.5	-29.7	-33.3	0.49	1.16	-77.9	-103.4	-124.5	-144.6	851.6	-142.92
10.00	28.61	2557.9	2545.9	2534.9	9.47	9.37	9.26	31.81	-18.9	-30.3	-32.0	0.40	0.95	-78.8	-103.0	-124.0	-144.1	1000.0	-144.12

Figure 1. ROS-2490+ VCO Datasheet

Then, go back to the design block diagram, to calculate what power you should get at the transmitting antenna. In our design, shown in figure 2, the output power at Tx antenna will be:

$$8\text{dBm} - 6\text{dBm} + 17.8\text{dBm} - 3\text{dBm} = 16.8\text{dBm}$$

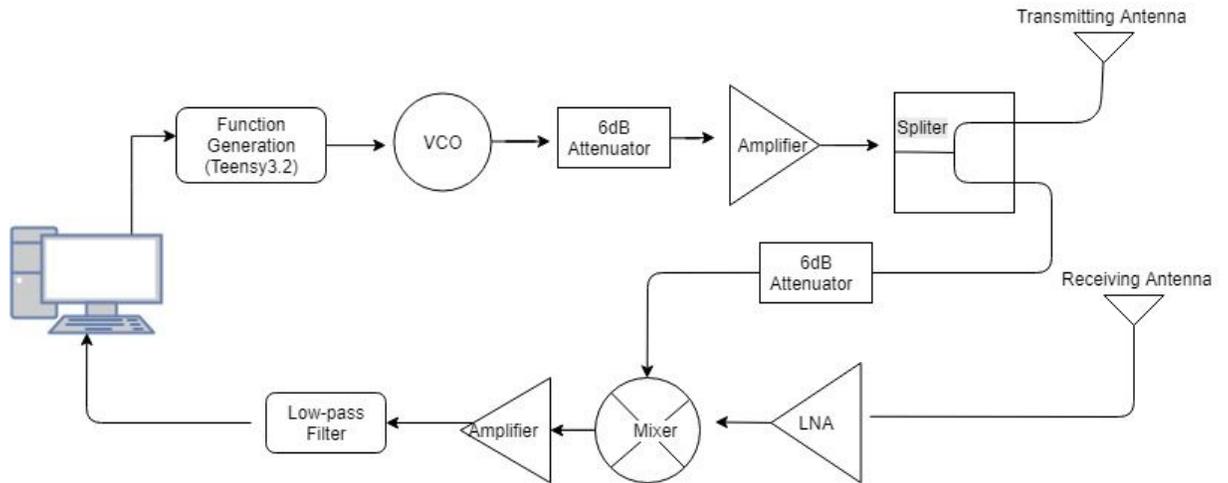


Figure 2. Design Block Diagram

Then, connect the transmitting antenna output to the spectrum analyzer to see if there is a 16.8 dBm signal at around 2386.2 MHz. Figure 3 shown the result we got. (Which is close to the expected output.)

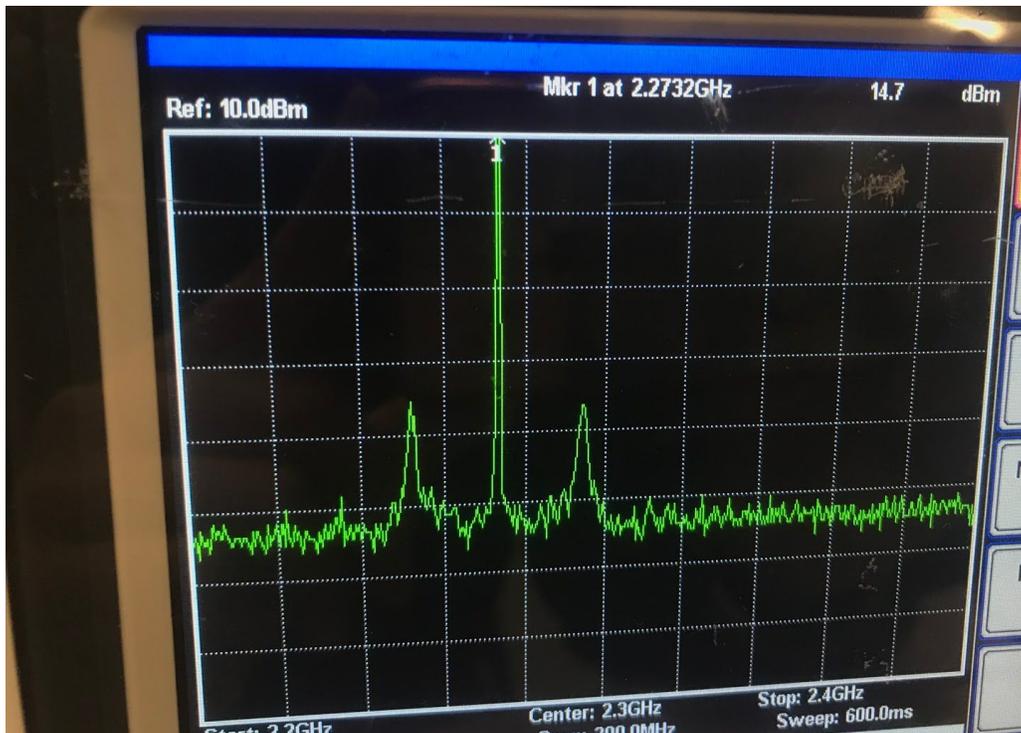


Figure 3. Output at the Transmitting Antenna

## 2. Test the transmitting side/route.

Input a sine wave that is slightly higher than the frequency you observed above (which mean slightly higher than 2.2732 Ghz) into the LNA using the SMA connector

for the Rx antenna. Check the input signal of the LNA using a Probe (this can be difficult and the signal you saw might not be accurate) compare it with the signal at the output of the LNA. If the signal at the output is stronger (higher power) than the input signal, this suggests that the LNA is working. Then check the signal at the mixer output, which it should show a wave with the a frequency that is the difference between the inputs of the mixer. Unfortunately, our mixer is not working and we didn't see any signal at the output. If your mixer has the correct output, you can move on to the next testing.

### Testing the Overall System

If both baseband and RF PCBs are working, now you can move on to test the whole system. When setting up the system be sure to organize the wires to ensure stable connection. It better to test the system in the lab room first. Connect the system output into the oscilloscope, and see if there is a wave. Also, hold the metal plate and walk further or closer to the antenna to see if the wave's frequency change. When the metal plate is closer, the frequency is lower, and when it is far away, the frequency is higher. Figure 4 shown the output we observed in our system. If you don't see a output, here are some debugging tips:

1. Check all the components' operating current and add them up. Look at the current that is shown in your power supply. Does it match with your number? If not, from those numbers, you can figure out which components are not operating.
2. Check the input of the VCO, is that the triangle wave you want?

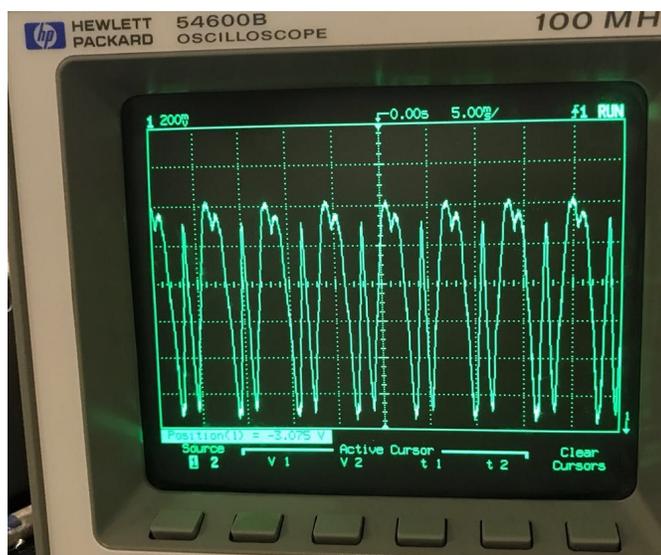


Figure 4. Signal at the System's output

Then, you can connect the output to the audio jack and record the sound wave file. If you look closely to the waveform on your record sound on audacity, you should see a wave that is similar to what you see on the oscilloscope.

After, you can test the system in the hallway to get less distraction and longer distance. If everything is working fine, you are good to test on the field!