Lab 4: Characterization of RF Mixers

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In this lab, we will learn the techniques for characterizing high frequency mixers.

1 Prelab

1. Read the following materials and pay close attention to the concepts of antenna *conversion gain/loss*, *LO drive*, *LO feedthrough*, *isolation*, *image frequency*,*image rejection*, and *quadrature modulation/demodulation*.
   - EEC 134 Lecture Note 5
   - Bert C. Henderson, "Mixers," WJ Communications Inc. technical notes, 1990.
   - Ferenc Marki and Christopher Marki, "Mixer Basics Primer," Marki Microwave, 2010.
2. Read the Lab 4 procedures.

Pre-lab Assignment 4
Due: Nov. 6th, 2015

Please answer the following questions:

1. What does "Level 10" mean in the specification of the Mini-Circuits ZX05-43LH-S+ mixer?
2. What is the conversion gain/loss of the ADI ADL5363 mixer?
3. What is the power conversion gain/loss of the ADI ADL5801 mixer? What is the voltage conversion gain/loss of this device? Why is there a difference between the power and voltage conversion gain/loss?
4. What is the input IP3 of the Linear LTC5551 mixer? How does it compare with the ADI ADL5365 mixer?
5. A 5.25 GHz RF signal is fed to the input of a mixer driven by an LO signal of 5.20 GHz. What signal do you expect at the output of the mixer?
6. What are the image frequencies of the following systems?

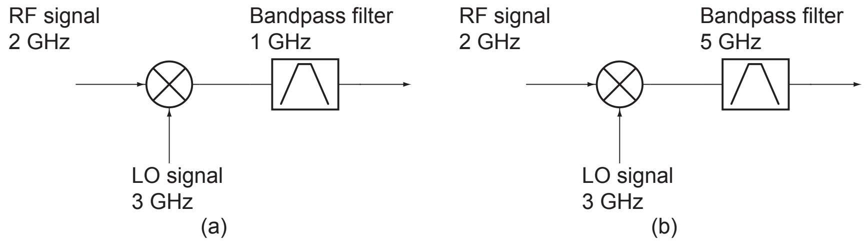
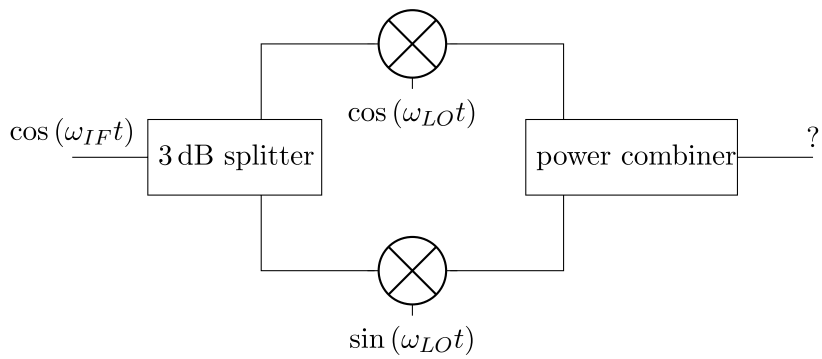


Figure 1: Prelab problem 6.

7. What is the output signal frequency of the following system? Assume that $\omega_{IF} \ll \omega_{LO}$.



8. What is the image reject ratio (side-band suppression) of the TI TRF370417 demodulator?

2 Equipment & Supplies

- 1 × GSP-730 spectrum analyzer;
- 2 × TPI synthesizer;
- 1 × Mini-Circuit ZX05-43LH-S+ mixer;
- 2 × 12” and 2 × 6” SMA cables.

3 Procedures

3.1 Mixer conversion loss

1. Connect the system based on the schematic shown in Fig. 2.
2. Set the output power of the first TPI synthesizer to 10 dBm.
3. Set the output power of the second TPI synthesizer to 0 dBm.
4. Power on the amplifier and spectrum analyzer.
5. Set the frequencies of the TPI synthesizers according to Table. 1 to investigate how the conversion-loss changes with frequency. The conversion loss can be calculated as

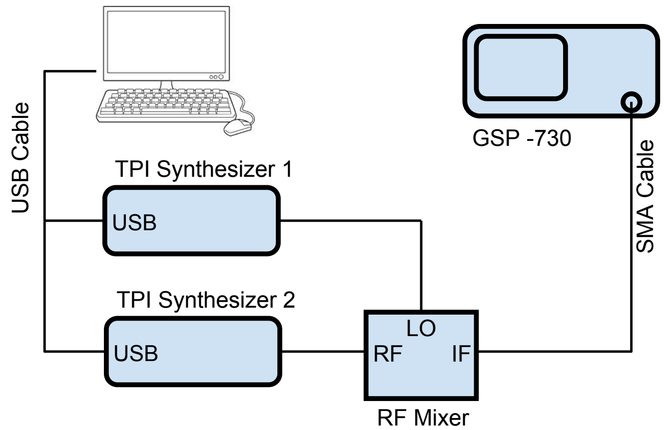


Figure 2: Mixer characterization setup.

$$\textit{Conversion Loss}\ (\text{dB}) = \textit{RF Port Power}\ (\text{dBm}) - \textit{IF Port Power}\ (\text{dBm}).$$

Table 1: RF and LO frequencies for mixer characterization.

RF Port Frequency (MHz)	LO Port Frequency (MHz)
1000	1030
1500	1530
2000	2030
2500	2530
3000	3030
3500	3530
4000	4030

3.2 LO Feed-through

1. Now we use the same setup as in Experiment. 3.1 to measure the LO feedthrough at different frequencies. Set the output power of the first TPI synthesizer (the one connected to the LO port) to 10 dBm. Turn off the second TPI synthesizer to block the RF port of the mixer.

2. Set the output frequency of the first TPI synthesizer from 1 GHz to 3 GHz in increment of 0.4 GHz, and note down the measured IF port power.

3. Calculate the LO feedthrough at those frequencies by the following equation

   $$\textit{LO Feedthrough}\ (\text{dB}) = \textit{IF Port Power}\ (\text{dBm}) - \textit{LO Port Power}\ (\text{dBm}).$$

   How does the measurement compare with the datasheet of the mixer?

3.3 Mixer P1dB

1. Use the same setup as the previous experiments. Set output power and frequency of the first TPI synthesizer to 10 dBm and 2500 MHz. Set the output frequency of the second TPI synthesizer to 2530 MHz.

2. Vary the output power of second TPI synthesizer and measure the IF output power of mixer at each input level. Choose the sample data points wisely (Note: the datasheet says the typical value of 1 dB compression point is 9 dBm).

3. Extract the P1dB of the mixer and compare it with the datasheet.