RF Lab Module #10 — Radio Frequency Mixers

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***Abstract*—Overall, In this lab overall familiarity with the key parameters and performance of practical RF mixer was gained. The importance of Conversion Loss was shown to be of tantamount significance. The non idealities of mixer's was evident through these precise lab measurements.**

I. Introduction

THIS lab utilizes the spectrum analyzer, signal generator, and VNA acting as a signal generator to determine the conversion loss of the mixer under test. The VNA is also used to characterize the Mixer's Return Loss. An important aspect of this lab entails accounting for the cable loss present between the signal generator and the mixer LO. This Loss is calculated given the direct measurement with the spectrum analyzer.

II. Procedure

1) Characterize Mixer Return Loss
   a) Setup Signal Generator as LO
      i) f = 1GHz
      ii) AMP = 7dBm + amount adjusting for cable loss
   b) Setup VNA as RF
      i) Frequency sweep from 100kHz-4GHz
      ii) perform SOLT calibration
   c) Connect Test equipment to mixer
      i) VNA to Mixer RF
      ii) Signal Generator to Mixer LO
      iii) Connect 50 Ohm Load to mixer
      iv) Save S11 parameters
2) Conversion Loss Measurement
   a) Setup VNA Port 1 as RF
      i) AMP = -15dBm
      ii) F =
      iii) 3 GHz
   b) Setup Signal Generator as LO
      i) f = 1GHz
      ii) AMP = 7dBm + amount adjusting for cable loss
   c) Connect Test Equipment to mixer
      i) VNA to Mixer RF
      ii) Signal Generator to Mixer LO 3. Spectrum Analyzer to Mixer IF
   d) Turn on Signal Generator RF POWER ON
   e) Record Significant Peaks
      i) Record Magnitude of Peak at IF = 30MHz
      ii) Record Magnitude of Peak at RF = 1GHz
   f) Repeat with Carrier frequencies of 800Mhz, 600Mhz
3) Power Sweep Measurements
   a) LO Power Sweep
      i) Set RF Power to -15dBm with f=1.03GHz
      ii) Sweep LO Power w/ -2,3,7,10 dBM
      iii) Record Conversion Loss
   b) RF Power Sweep
      i) Set LO Lower to 7dBm + amount adjusting for cable loss,‘ GHz
      ii) Sweep RF Power w/ -15,10,-5,0
      iii) Record Conversion Loss

III. Analysis

Our cable loss throughout this lab procedure was measured to be 0.8 dBm. While the lab procedure calls for the RF VSWR, analysis showed data collected during the lab resulted in only the S11 only being taken at 1 single frequency. The data displayed was taken from Jason's group and a appears to be from the Mixer's LO Port instead of the RF Port. This is shown in Fig. 1 with the corresponding datasheet graph being shown in Fig. 2. Th

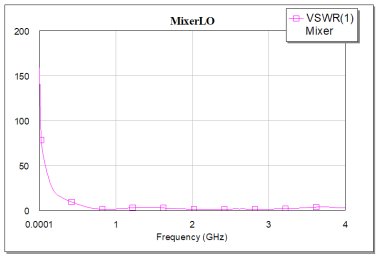

Fig. 1. Measured Mixer S11. Data taken from Jason's Group

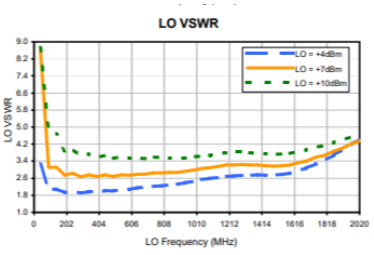

Fig. 2. Datasheet LO VSWR Graph

1) How does your measured performance of conversion loss and isolation of the mixer compare to the data sheet? (better, worse or about the same?)
   a) The Conversion Loss of the measured is 6.6dB at Lo 7dBm 1GHz, IF=30MHz. The Datasheet has the Conversion Loss at around 7.25. The Measured Result is slightly better.

Freq. (GHz)	P_IF IF PORT	P_RF RF PORT	Lc	PLO IF PORT	PLO LO PORT	ISO LI
1.03	-21.5	-15	-6	-14.5	7	-21.5
0.83	-22.2	-15	-7.2	-19.25	7	-26.25
0.63	-22.0	-15	-7	-20.60	7	-27.6

TABLE I
CONVERSION LOSS ACROSS FREQUENCY

   b) The measured Isolation is -21.5dB at Lo 7dBm 1GHz, IF=30MHz. The datasheet is much better with -38dB Isolation at the same operating condition
2) What happens to the noise floor on the spectrum analyzer if you reduce the resolution bandwidth? How does it affect the sweep time on the spectrum analyzer?
   a) Reducing the resolution bandwidth increases the noise floor
   b) Increasing the resolution bandwidth decreases the sweep time of the spectrum analyzer
3) Why is it important to provide the nominal LO signal power to the mixer?
   a) The LO Power directly impacts the conversion loss and signal to noise ratio of the output signal on the IF.
4) What should the signal level of the RF signal be compared to the LO signal?
   a) The RF signal should have a lower magnitude than the LO signal.

The simulation was conducted using the schematic shown in Fig. 4 . The output of the IF port is show in Fig. 5. From this graph, the Conversion Gain is -21.7 + 15 = -6.7 dB and the LO/IF isolation is -20 - 7 = -27dBm.

IV. DISCUSSION AND SUMMARY

Overall, In this lab overall familiarity with the key parameters and performance of practical RF mixer was gained. The importance of Conversion Loss was shown to be of tantamount significance. The non idealities of mixer's was evident through these precise lab measurements.

APPENDIX A
PRE-LAB

1) Describe briefly what a microwave mixer is (or does). A mixer's main purpose is to multiply the information signal with a carrier bringing the information to a higher frequency. In a transmit case, this means moving the IF to RF w/ carrier. in the receive case this means bringing the RF without carrier to IF.
2) What do the port names (RF, LO & IF) mean? (Ex: RF=Radio Frequency)
   a) RF = Radio Frequency
   b) LO = Local Oscillator
   c) IF = Intermediate Frequency

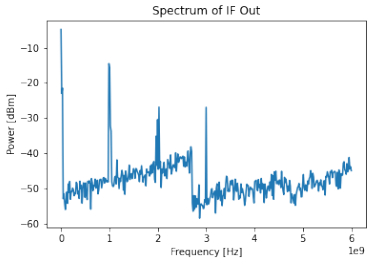

Fig. 3. Measured spectrum at IF port with RF at 1.03GHz

LO power	P_IF IF PORT	P_RF RF PORT	Lc
-2	-24.6	-15	-9.6
3	-22.8	-15	-7.8
7	-21.6	-15	-6.6
10	-21.4	-15	-6.4

TABLE II
F_RF = 1.03 GHZ WITH LO POWER SWEPT

LO power	P_IF IF PORT	P_RF RF PORT	Lc
0	-23.6	-15	-8.6
0	-18.4	-10	-8.4
0	-13.4	-5	-8.4
0	-10	0	-10

TABLE III
F_RF = 1.03 GHZ WITH RF POWER SWEPT

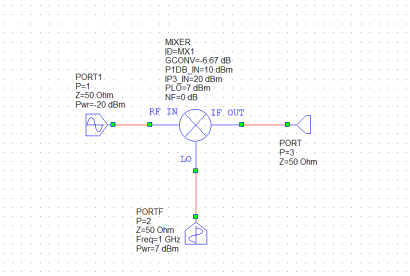

Fig. 4. Mixer Simulation Schematic

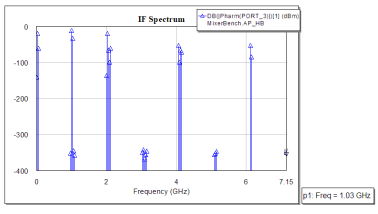

Fig. 5. Mixer Simulation Spectrum

3) When do we use a mixer as a down-converter in an RF system? When do we use a mixer as an up-converter?
   a) a down-converter is for receiving
   b) up-converter is for transmitting
4) What is the definition (equation) for conversion loss of a down-converting RF mixer?
   $P_{\text{out,IF}}/P_{\text{in,RF}}$