ME1000 RF Circuit Design

Lab 5

Mixer Characterization using Spectrum Analyzer (SA)

Objectives:

i. To measure some important characteristics of the Frequency Synthesizer and Frequency Mixer with a Spectrum Analyzer.
ii. To understand the frequency conversion principles of the frequency mixer.

Equipments and Accessories Required:

i. Spectrum analyzer
ii. Signal generator
iii. ME1000 Receiver unit
iv. SMA m-m coaxial cables
v. USB cable
vi. PC/Notebook with RF Trainer Control Panel installed

Note: Turn off the transceiver trainer kit when not in use. The trainer will turn off automatically when no mouse or keyboard action is detected for more than 10 minutes. Always ensure that the casing is grounded to earth and the cover is latched up before powering up the device.

Lab 5 – Mixer Characterization using Spectrum Analyzer

Basic Equipment Setup

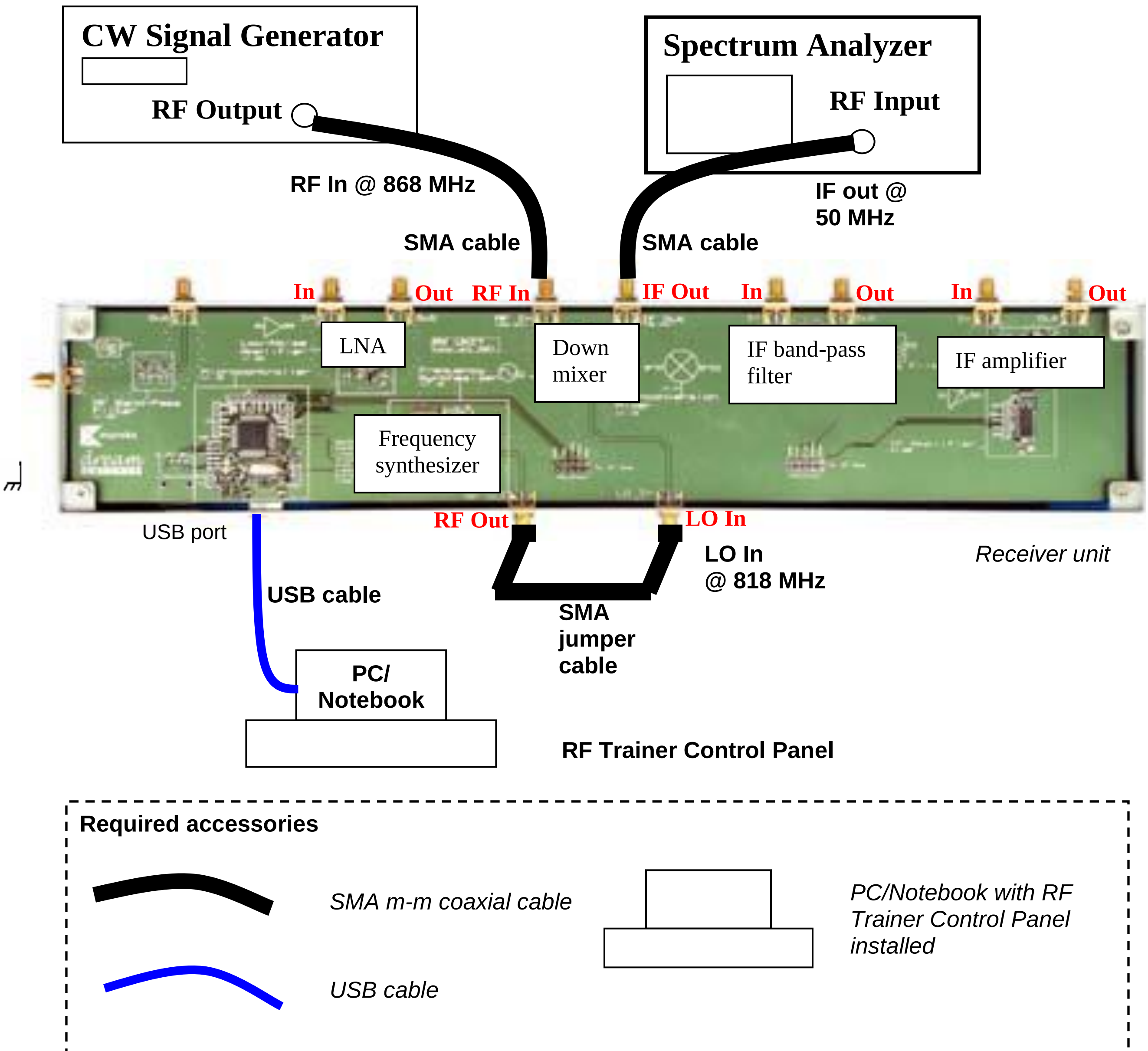


Figure 1 General equipment configuration for mixer measurement using SA

Task 1: Frequency Synthesizer Characterization

Frequency Synthesizer Specifications:

Frequency Synthesizer	Min	Typical	Max	Unit	Remarks
Power Supply Voltage	3	3.3	3.6	V	
Output frequency	816	-	880	MHz	
Output power	-6	-4.5	-2	dBm	into 50 Ohm load
1st harmonic suppression	15	-	45	dB	
2nd harmonic suppression	20	-	50	dB	
Frequency resolution	-	0.1	-	MHz	

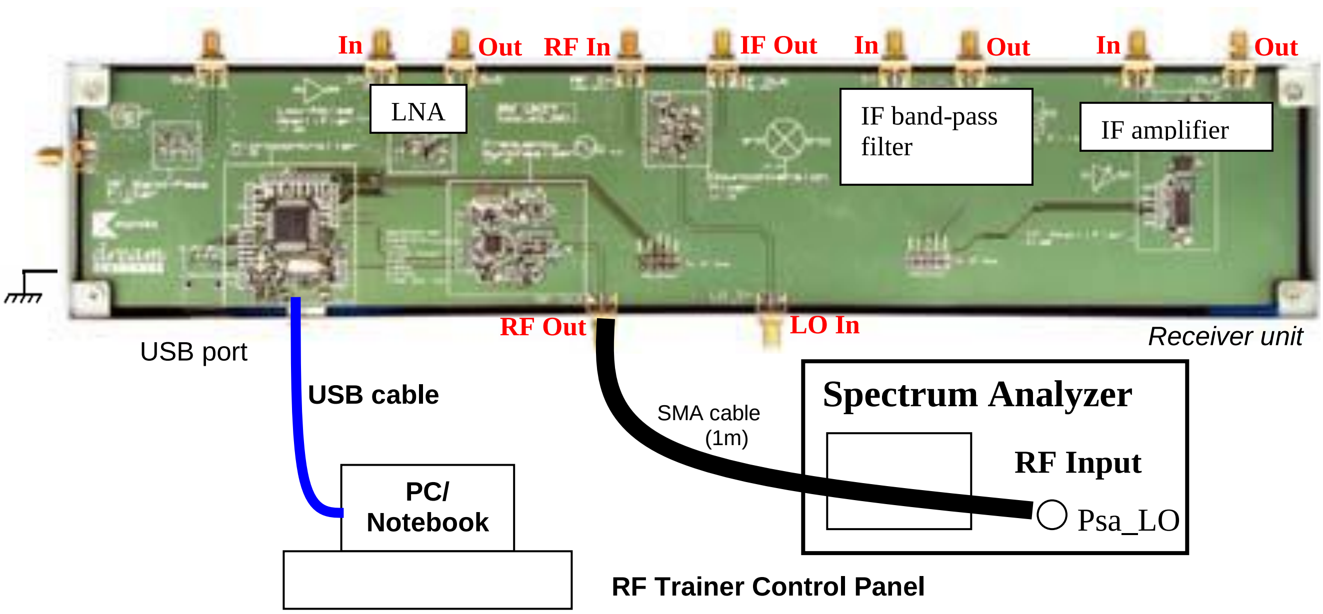


Figure 2 Equipment setup

1. Connect the output of the frequency synthesizer module directly to the SA.

2. On the PC, click **"Frequency Synthesizer Off"** to power up the synthesizer. Set the frequency to **818MHz**. You will see the frequency synthesizer PCB LED light up on the trainer, and the button text change to **"Frequency Synthesizer On"**.

3. Set the following suggested settings for Spectrum Ana;yzer(SA) and record measurements and screenshot the spectrum:

Start Freq.	Start Freq.	Measured Peak #1		Measured Peak #2		Measured Peak #3	
MHz	MHz	MHz	dBm	MHz	dBm	MHz	dBm
10	3000						
800	900						
1600	1700						
2400	2500						

4. You may also want to examine the Frequency Synthesizer(FS) at 816MHz and 880MHz

OBSERVATIONS/DATA RECORDING

a) Observe the measured peaks reading when the SA settings are varied. Which setting of the SA gives a more accurate reading and why ?

b) Are the measured signals meeting the specifications: frequency range & resolution, output power, harmonic suppression?

c) Calculate the LO signal level for 818MHz, **Plo** at the output of the Synthesizer circuit,

Given the following path loss @818MHz from Lab 1 Calibration with Spectrum Analyzer:

1-meter cable connecting “RF Out” to the SA, Lcable_sa= 0.99dB

1. What is the power level displayed on the SA when LO is power on?

   LO level measured at SA, Psa_LO @818 MHz = −3.72 dBm

2. Determine the output power level of the LO at “RF Out”.

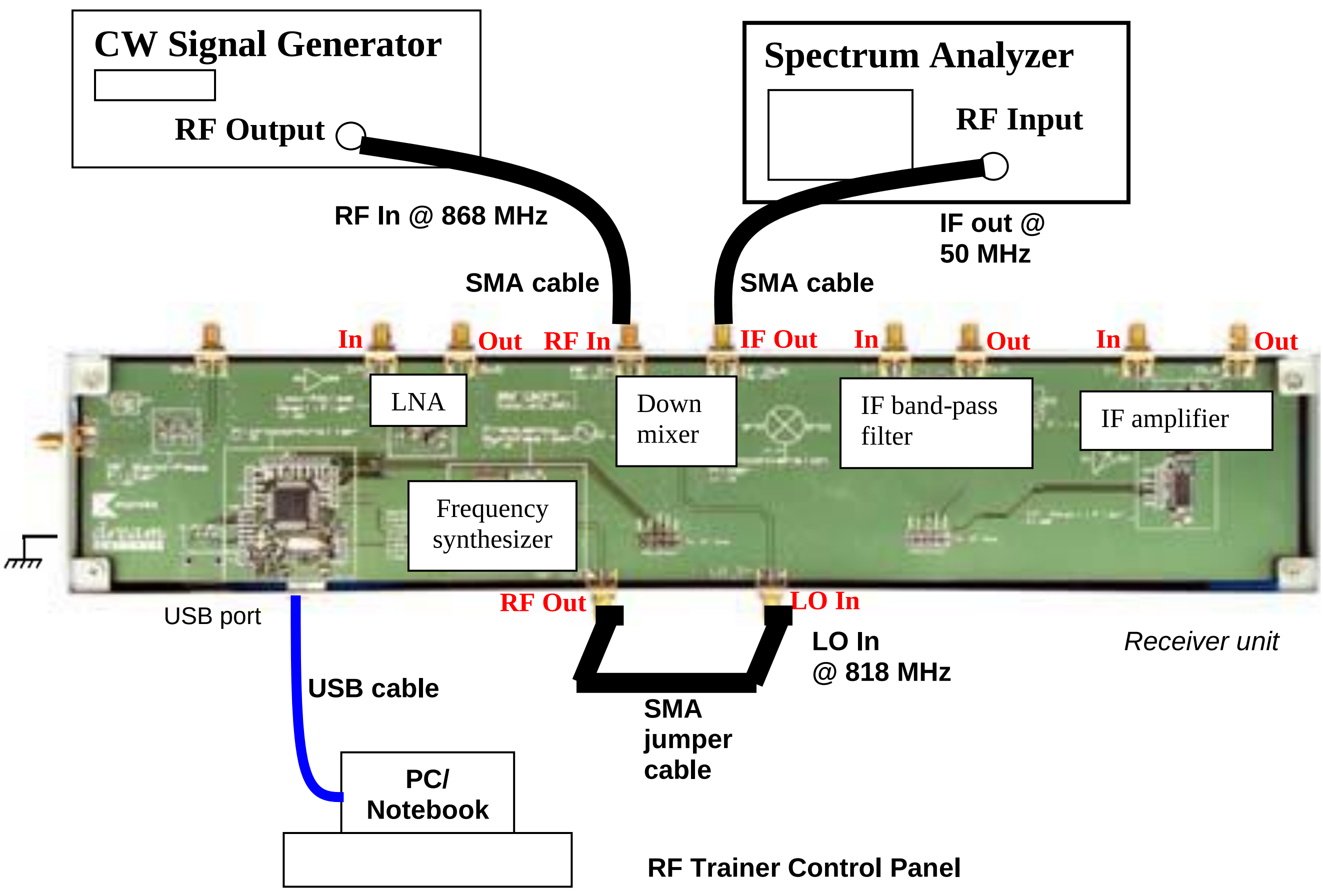
   LO output power, Plo (at RF Out port) = Psa_LO + Lcable_sa

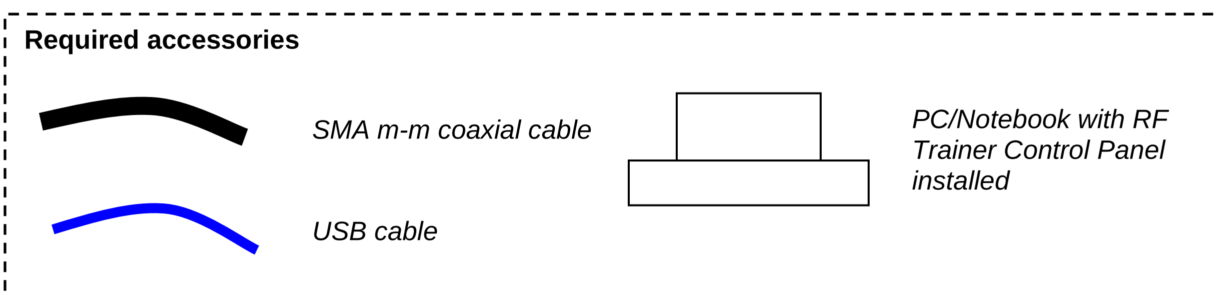
   = −3.72 dBm + 0.99 dB = −2.73 dBm

Task 2: Mixer Characterization

Specifications:

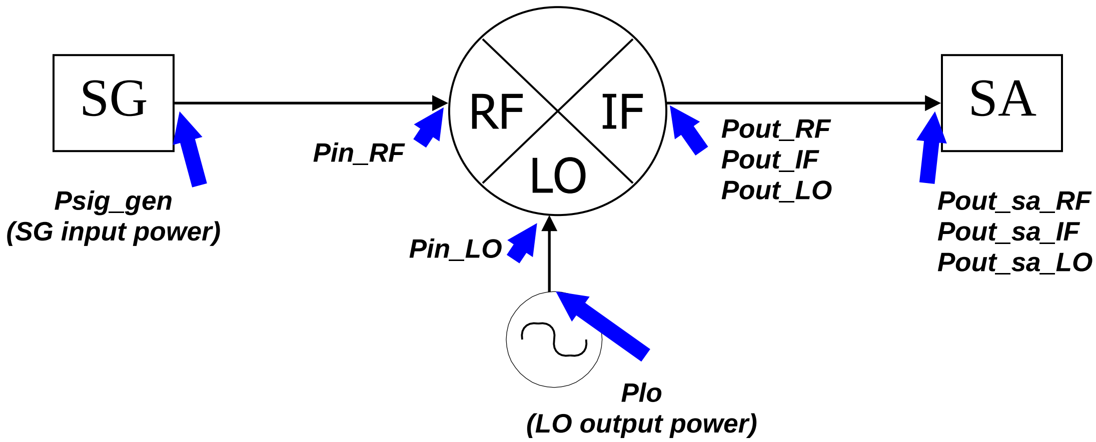
Down Converter Mixer	Min	Typical	Max	Unit	Remarks
Power Supply Voltage	3	3.3	3.6	V	
LO to RF Isolation @ 818 MHz	5	7	9	dB	into 50 Ohm load
LO to IF Isolation @ 818 MHz	13	15.5	18	dB	into 50 Ohm load
Input return loss @ 868 MHz	2	3	5.5	dB	RF
Input return loss @ 818 MHz	1.5	2.5	4	dB	LO
Input return loss @ 50 MHz	2	4	6	dB	IF
RF Feed through	14	15	17	dB	
Conversion loss @ 868 MHz	0.5	2	3.5	dB	RF@-15dBm, 868 MHz; LO @ -4dBm, 818 MHz





Conversion loss measurement

Take note of the following notation used in mixer measurement:



Pin_RF	***: Input RF power into mixer's RF port***
Pin_LO	***: Input LO power into mixer's LO port***
Pout_RF	***: Output RF power from mixer's IF port***
Pout_IF	***: Output IF power from mixer's IF port***
Pout_LO	***: Output LO power from mixer's IF port***
Pout_sa_RF	***: Output RF power from mixer's IF port measured at SA***
Pout_sa_IF	***: Output IF power from mixer's IF port measured at SA***
Pout_sa_LO	***: Output LO power from mixer's IF port measured at SA***

Figure 3. Notation used in mixer measurement

1. On the **RF Trainer Control Panel**, click **"Frequency Synthesizer Off"** to power up the synthesizer. Set the frequency to **818MHz**. You will see the frequency synthesizer PCB LED light up on the trainer, and the button text change to **"Frequency Synthesizer On"**.

2. Make the connection as shown in Figure 1. Similarly, power on the mixer by clicking **"Mixer Off"**. You will see the mixer PCB LED light up on the trainer, and the button text change to **"Mixer On"**.

3. Use the following settings for signal generator (SG):

CW Frequency	: 868 MHz
Power	: –15 dBm

4. Set the following suggested settings for SA

Start Frequency	: 10 MHz
Stop Frequency	: 900 MHz

Note: You may want to explore expanding the stop frequency setting of the SA to view the other intermodulation signals beyond 868MHz.

OBSERVATIONS/DATA RECORDING

a) Identify all the origin and converted tones (such as LO, RF or RF ± LO) and their respective output power levels.

Output RF power measured at SA @868 MHz, Pout_sa_RF =

Output LO power measured at SA @818 MHz, Pout_sa_LO =

Output IF power measured at SA @50 MHz, Pout_sa_IF =

b) Determine the actual input and output power of the mixer

Given the following cable losses measured using the scalar calibration method in Lab 1

1. Loss of the 1-meter SMA cable connecting SG to the circuit, Lcable_sg
2. Loss of the 1-meter SMA cable connecting the SA to the circuit, Lcable_sa
1. Loss of the 18cm SMA jumper connecting FS to the mixer, Ljumper

Frequency MHz	Lcable_sg dB	Lcable_sa dB	Ljumper dB
50	0.21	0.21	-
818	0.95	0.99	?
868	1.14	1.16	-

Signals	MHz	dBm	Remark
Pin_LO			get Plo from lab 5-1
Pin_RF			get Signal Generator output power
Pout_RF			get Pout_sa_RF
Pout_IF			get Pout_sa_IF
Pout_LO			get Pout_sa_LO

Parameters	dB	Remark
Conversion loss		Actual input RF power (dBm) – Actual output RF power (dBm)
RF-IF isolation		Actual input RF power (dBm) – Actual output RF power (dBm)
LO-IF Isolation		Actual LO input power (dBm) – Actual LO output power (dBm)

c) Verify that the parameters are meeting the specifications

References

- Presentation slides, *“A Seminar on RF Measurement – Spectrum Analysis Basics”*, Agilent Technologies, 2001
- Thomas H. Lee, *“Planar Microwave Engineering”*, Cambridge University Press, 2004.
- David M. Pozar, *“Microwave Engineering”*, 3rd Edition, John Wiley & Sons, 2005.