THE UNIVERSITY OF BRITISH COLUMBIA
Department of Electrical and Computer Engineering

ELEC 391 – Electrical Engineering Design Studio II

Lab Orientation

1 Introduction

This short lab assignment will follow the Safety Briefing and provide ELEC 391 students with opportunities:

- to become familiar with the test and measurement equipment that will be used during subsequent lab sessions,
- to verify some of the fundamental principles introduced in the self-paced tutorial on *Spectrum Analyzer Basics,*
- to meet their lab partners and to begin preparing for their lab sessions.

The lab orientation session is fairly short. It is also fairly free-form so that students have maximum opportunity to explore the capabilities of the equipment.

1.1 Performance Objectives

Upon completion of this lab assignment, ELEC 391 students will be able:

- to operate the Agilent RF signal generator, the Rigol function generator, the Rigol spectrum analyzer, and the Tektronix dual-channel oscilloscope to be used in subsequent lab assignments, and,
- to demonstrate how adjusting the frequency span, resolution bandwidth, video bandwidth, RF attenuation, and sweep time affects the noise floor and accuracy of a spectrum analyzer, including the ability to distinguish closely spaced signals.

1.2 Tasks

Completing this lab assignment will involve the following steps:

1. Review the lab assignment and begin the pre-lab assignment in Section 2. Locate copies of the equipment manuals online and review using SQ3R
2. Work with your lab partners to complete the three experiments described in this lab assignment handout. Please ensure that everyone has equal opportunity to use the equipment and participate in the work. Please record your results in a group laboratory log book. Please do not record your results on loose or scrap paper!
3. Within a specified period, each group should submit a short technical memorandum (a few pages, at most) that summarizes their results and accomplishments during the Lab Orientation session.

1.3 Test and Measurement Equipment

The following test and measurement equipment from the communications bench will be used in this lab session. Where applicable, please record the serial numbers of each item.

1. RF Signal Generator (Agilent, model 8648B, 9 kHz – 2 GHz)
2. Function/Arbitrary Waveform Generator (Rigol, model DG1022, 2 Channel, 20 MHz, 100 MSa/s)
3. Spectrum analyzer (Rigol, model DS 815), 9 kHz-1.5 GHz) or
4. Dual-channel oscilloscope (Tektronix, model TDS 2012, 100 MHz)
5. 2-input combiner (Mini-Circuits, model ZSC-2-1, 0.1-400 MHz)
6. 20 dB attenuator (MiniCircuits, CAT-20 (DC-1.5 GHz) or HAT-20 (DC-2 GHz))

In order to protect the input of the spectrum analyzer, please make absolutely certain that the signal levels applied to the input will not exceed the limit marked on the front panel.

2 Pre-lab Assignment

Before you come to the lab, please complete Agilent Technologies' self-paced tutorial on *Spectrum Analyzer Basics,* review *Application Note 150 – Spectrum Analysis* (available through the ELEC 391 course web site), and complete this pre-lab assignment.

Next, review the three experiments in Sections 3, 4, and 5 of this assignment and devise a test plan that will meet the objectives of each.

Finally, answer the following set of pre-lab questions. Please submit them to your TA upon arriving at the lab:

1. Give definitions for the following measures:

   a. dB b. dBm c. dBW d. dBμV

2. Draw a block diagram of a swept-frequency spectrum analyzer and *briefly* explain the function and operation of each of the component parts.
3. Define and explain the significance of each of the following settings or modes of operation of a swept-frequency spectrum analyzer:

   a. Start frequency
   b. Stop frequency
   c. Center frequency
   d. Span
   e. Resolution bandwidth
   f. Video bandwidth
   g. Zero span mode
   h. Swept frequency mode
   i. RF attenuation

4. What is the noise floor? What is another name for the noise floor?
5. What is LO feedthrough? What is its significance?
6. How do the settings of the resolution bandwidth, video bandwidth, span, sweep time, and RF attenuation affect the noise floor?
7. If the resolution bandwidth is halved, how should the sweep time be adjusted to compensate? What will happen to the noise floor?
8. What limits our ability to distinguish closely spaced signals on the spectrum analyzer display?
9. What are the principal advantages and disadvantages of the swept frequency spectrum analyzer architecture?
10. What are the alternatives to the swept frequency spectrum analyzer architecture? What are their advantages and disadvantages?
11. How does the resolution bandwidth setting affect the appearance of a single carrier signal? How does it affect the appearance of a wideband signal?
12. Why is it desirable to sweep as quickly as possible? What sets the limitations on minimum sweep time?

3 Experiment 1: Noise Floor of a Spectrum Analyzer

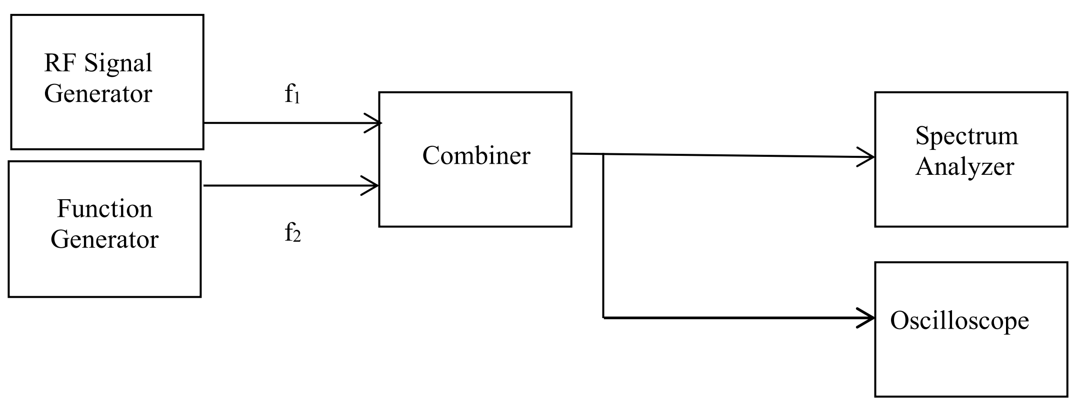
3.1 Objectives

The objectives of this experiment are:

1. to become familiar with the function and operation of the spectrum analyzer, and,
2. to determine how the appearance of the signal and the level of the noise floor are affected by changing the resolution bandwidth, the video bandwidth, and the RF attenuation level.

3.2 Procedure

Set up and configure the test and measurement equipment set up and configured as shown in the following diagram. The combiner is an impedance matching device that allows the outputs from two 50 Ω sources to be connected to a single 50 Ω receiver without causing an impedance mismatch. The oscilloscope has a very high input impedance (> 1 MΩ) so will not load the 50 Ω line.



1. Given the equipment configuration above, and based upon the relevant material presented in Agilent Technologies' self-paced tutorial on *Spectrum Analyzer Basics*, devise and implement a test plan that will meet the objectives of this experiment.
2. Set the output of the signal generator to a sine wave with V_{pp} = 2 V and f_1 = 5 MHz. (You will have to convert this to a power level in dBm in order to configure the instrument.).
3. Adjust the frequency span and amplitude range of the spectrum analyzer as required to view the signal.
4. Observe how the appearance of the signal and the level of the noise floor are affected by changing the resolution bandwidth, the video bandwidth, and the RF attenuation level.

3.3 Issues for Discussion

How do your observations of the relationship the appearance of the signal and the level of the noise floor and the resolution bandwidth, the video bandwidth, and the RF attenuation level compare to what you were taught in the CDROM-based tutorial?

4 Experiment 2: Frequency Resolution of Spectrum Analyzers

4.1 Objective

The objective of this experiment is to determine how: (1) the separation between the signals, (2) the resolution bandwidth setting, and (3) the relative amplitude of the signals affects one's ability to distinguish closely spaced signals.

4.2 Procedure

1. Given the equipment configuration shown on the previous section, and based upon the relevant material presented in Agilent Technologies' self-paced tutorial on *Spectrum Analyzer Basics*, devise and implement a test plan that will allow you to meet the objective of this experiment.
2. With the *signal generator* configured as described in Experiment 1, add a second signal by setting the output of the *function/arbitrary waveform generator* to be a sine wave with V_{pp} = 2 V and f_2 = 5.1 MHz. Is the output impedance of the function generator 50 Ω ?
3. Observe and record how one's ability to distinguish closely spaced signals diminishes as:
   a. the separation between the signals becomes comparable to the resolution bandwidth, and,
   b. the amplitude of one of the signals becomes far less than the other.

4.2 Issues for Discussion

Comment upon the relationship between one's ability to distinguish closely spaced signals and: (1) the separation between the signals, (2) the resolution bandwidth setting, and (3) the relative amplitude of the signals.

5 Experiment 3: Function Generator and Oscilloscope

5.1 Objective

The objective of this experiment is to become familiar with the capabilities and limitations of the function/arbitrary waveform generator and dual-channel oscilloscope.

5.2 Procedure

Devise and implement a short test plan in order: (1) to become familiar with the function/arbitrary waveform generator and dual-channel oscilloscope and (2) to evaluate their capabilities and limitations.

5.3 Issues for Discussion

Comment upon the capabilities and limitations of the function/arbitrary waveform generator and the dual-channel oscilloscope. These might include the minimum and maximum frequencies and amplitudes that the function/arbitrary waveform generator can produce, the stability of the function/arbitrary waveform generator, and the minimum and maximum time spans and amplitude ranges that one can observe using the oscilloscope.