Wireless Communication Systems Laboratory

Lab #2: Understanding test equipment

Objective

The students will be familiar with the following items:

- Signal generation and analysis tools
- Description of the laboratory equipment, internal blocks and functions
- Measurement instruments: Understanding the operation and internal structure of generic measurement instruments in relation with SDR and cognitive radio concepts.
- Use of the equipment (VSA/SA and VSG) to generate and analyze digital waveforms.
- Controlling ESG and VSA using MATLAB®.

Pre-lab

- Go through the following files posted on the blackboard: "Digital Modulation Measurements", "Agilent Signal Generator", "Agilent Spectrum Analyzer"
- Write down the ranges of frequencies allocated to GSM and PCS 1900 (for both uplink and downlink signals)
- Read about the FCC frequency spectrum allocation in the USA
- Read about spectrum allocation for the IEEE standard 802.11b/g. (You can only focus on the channels allocated for 802.11b)
- Read about the following MATLAB® functions: *scatterplot(), downsample().*

Procedure

A. WIRED COMMUNICATION

1. Connect the VSG to the VSA through the provided cable (perform this step with the supervision of the TA).

2. Open the VSG and VSA programs through the start menu.

3. Generate an unmodulated carrier at the assigned central frequency (refer to TA), and with an amplitude of -30 dBm through the following steps (**please notice that you should NEVER change the Power of the signal without the supervision of the TA**).

    a- Select frequency from the VSG front panel interface.

    b- Input 915 and choose MHz as the unit.

    c- As the amplitude part is very critical, please call the TA. (the TA should set the amplitude to -30 dBm).

    d- Press “RF on\off” button to activate the RF.

    e- Adjust the central frequency of the VSA spectrum window to the same frequency that you generated by the ESG.

    f- Adjust the span to 1 MHz (in the VSA control panel).

4. Observe the signal and record:

    a- What are the peak and the center frequencies of the signal? Is the signal power the same as you generated? Comment.

    b- Evaluate the noise floor (in dBm/Hz).

    c- Apply the averaging techniques by going to the “MeasSetup” menu. From this menu select *average*, from the average tab, choose “RMS(video)” as averaging type, and check the box “Repeat Average” and close the window.

    d- Observe and comment on the time domain signal from the time domain window.

B. WIRELESS COMMUNICATIONS

A unique central frequency for each bench will be assigned to use.

1. Turn the RF off from the VSG control panel.
2. Replace the cable with the provided antenna (**please call the TA to perform this step**).
3. Turn the RF on.
4. Repeat step A.4 (above) and comment on the path loss effect.

C. ANALYZING AN NADC SIGNAL

1. Turn the RF off
2. Make sure that the central frequency of the ESG is still 915 MHz.
3. From the ESG control panel,

   a- Adjust amplitude to -30 dBm (refer to the TA for this step).

   b- Select “Mode” then, select “Custom”, and choose “Arb Waveform Generator”.

   c- Select the option “Setup Select”.

   d- Choose “NADC” then press return.

   e- Select the “Digital Modulation” on.

   f- Now we will change the digital modulation through the following steps:
   - Click on “Digital Mod Define”
   - Click “Modulation Type”
   - Choose PSK as the modulation, then select QPSK

   g- Activate the modulation by pressing “MOD On/Off”.

4. Using the VSA control panel:

   a- Set the center frequency to 915 MHz

   b- Set the span to 100 kHz

   c- Set the range (if you did not have an OVD you can decrease the range further, refer to the instructor) d- Observe and comment on the spectrum

e- Repeat steps b to d with a span of 80 MHz and try to identify the signals in the spectrum using FCC regulation for spectrum usage

5. Calculate the Bandwidth and the power of the signal by applying the following steps:

   a- From “Marker” menu choose “Calculations”.

   b- Select “Band power”, change the center frequency to 915 MHz.

   c- Close the window, and manually adjust the window marker and record most of the bandwidth power and bandwidth.

6. Measure and calculate the 10 dB and 90% power values.

7. Adjust the VSA to modulation analysis mode through the following steps:

   d- From “MeasSetup” select “Demodulator”, then select “Digital Demod”.

   e- From “MeasSetup”, select “Demod properties” and adjust modulation type, symbol rate, reference filter and the factor alpha considering the properties of the transmitted signal.

   f- From the “Display” menu change the layout to “Grid2x2”.

   g- From “MeasSetup” menu go to “Demodulator” and choose “Digital Demod” (you should see the polar diagram and the spectrum and the EVM)

   h- How many constellation points do you have?

   i- Change the spectrum span to 50 KHz. What are the changes in the polar diagram and the EVM? Comment on the effect.

   j- Change the span again to 20 KHz and observe the changes on the polar diagram and EVM. Comment and explain.

8. Change the digital modulation type to 8 PSK (refer to step C.3.f) and comment on the polar diagram and the EVM.

9. **Turn the RF and Mod Off in the ESG.**

D. FM SPECTRUM ANALYSIS

1. Adjust the central frequency in the VSA to 100 MHz, with the span of 20 MHz.

2. Could you comment on the signals you have on your display? (hint: you can use a digital radio)

3. Identify at least three frequencies, and interpret them.

4. For the three signals that you identify: record the central frequency. Also, calculate bandwidth and power for one of the strongest stations.

E. GSM SPECTRUM ANALYSIS

1. Using the VSA, adjust the central frequency and span considering the uplink band of PCS.

2. Call 813-974 3935, and observe and comment on the spectrum changes in the VSA.

3. Move the cell phone away from your bench, and observe the changes in the frequency spectrum of your signal. Comment on the results and explain the reason(s).

F. USING SWEEP/LIST FEATURE

This feature is used to simulate a predefined hopping sequence, or a sweeping frequency with predefined start, end, step.

1. Turn the RF off if it is not.

2. Make sure the central frequency of the ESG is still 915 MHz.

3. Generate an NADC signal as you did in the previous steps (refer to step C.3).

4. Select Sweep/List from the control panel of the ESG.

   a- In the Sweep Section select Freq & Ampl.

   b- In the sweep type Section change to list.

   c- In the sweep repeat section change to continuous.

   d- In the Configure list sweep section add three rows with the following values:
   - 915 Hz -20dBm 3Sec Dwell
   - 915.2 Hz -10dBm 2Sec Dwell
   - 915.4 Hz -15dBm 3Sec Dwell.

   k- Activate the modulation by pressing "MOD On/Off".

5. Using VSA control set the span to 1 MHz, and set up the rang and central frequency to an appropriate values to tune to the generated signal.

6. Describe your observation, and comment.

G. WiFi SPECTRUM ANALYSIS

1. Use the information you have in the prelab, and adjust your VSA settings considering the 802.11b signals.

2. For the WiFi signal, estimate the central frequency as well as the null-to-null bandwidth.

H. ANALYZE A CAPTURED DATA FROM THE VSA USING MATLAB®

1. Refer to Section (Analyzing a NADC) to generate an NADC signal with the following parameters:

   a- Symbol rate: 10 ksps

   b- Modulation type: QPSK

2. To capture and record the data in the VSA internal memory, do the following steps:

   a- Choose an appropriate value for the span of the VSA to capture the generated signal with 16samples per symbol (Please note that VSA sampling frequency is 1.28xSpan)

   b- From the input menu, make sure that the “hardware” option is chosen

   c- From input menu go to “Recording”, adjust the length of the recording to 1 second.

   d- Start recording my pressing the “record” button.

   e- Upon recording, go to the “File” menu, from the “Save” option choose “Save Recording” selecting .mat as the type of the file.

3. Load the data that you captured to MATLAB® work space.

4. Plot the logarithmic magnitude of the time domain signal versus time for the captured data. Compare the plot with the time signal displayed on the VSA

5. Plot the power spectral density of the signal using psd() command (Adjust the x-axis to the corresponding frequency values) and compare it with the one displayed in VSA. Calculate the approximate null-to-null bandwidth.

6. **Optional Step:** Use *scatterplot()* command to plot the constellation diagram of the captured signal. (Hint: use only one sample per symbol)