Agilent Technologies
S800 Training, Fall 2013
Lab guide

Santa Rosa, CA: MODIN_S13_Lab3.2
Lab Title: Creating User Corrections
Duration: 25min

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Objectives of lab

The prime objective is to understand a method for performing stepped-tone 1-ch wideband IF magnitude and phase correction. The method described herein was chosen due to the generally accepted algorithms used and ability to share the demo source code. This method entails stepping a tone across the correction range of the receiver to produce a measured magnitude response. Then we rely on the use of the Hilbert transform to deduce the phase from the magnitude response.

For more information on using the Hilbert transform to extract minimum phase response from magnitude response, please see: http://en.wikipedia.org/wiki/Minimum_phase. Also, refer to the appendix at the end of this document to see MATLAB specific code.

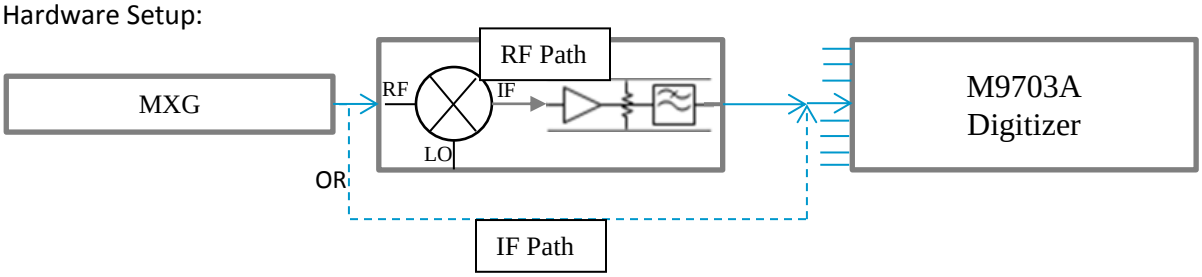
The lab procedure is presented in an extended table as shown below.

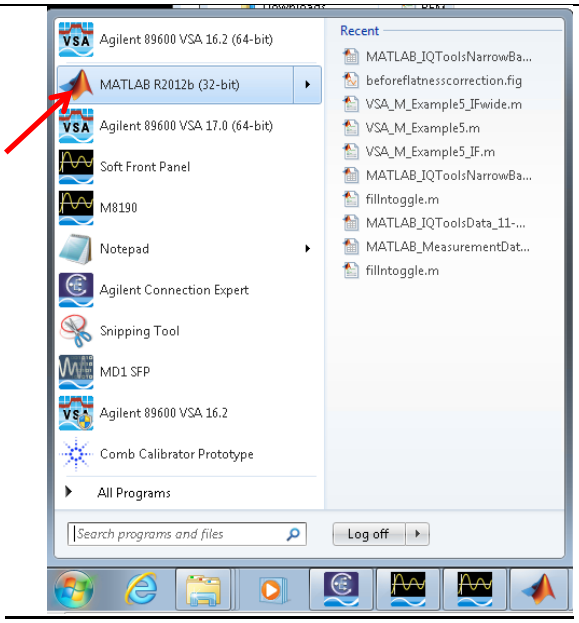
- Left side is the **Procedure -** Follow these steps to execute the lab.
- Right side is **Results/Explanation -** Explanation of the results of each procedure step.

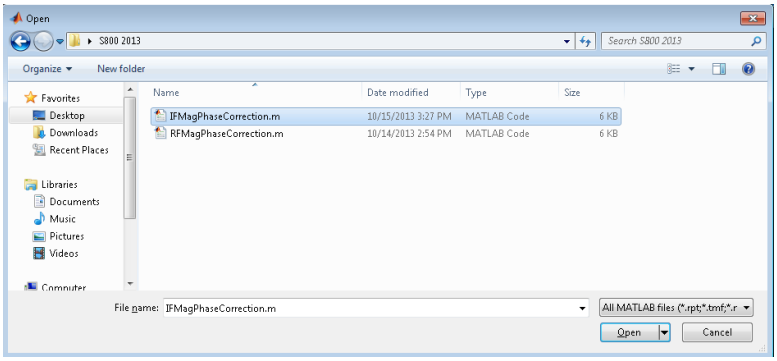
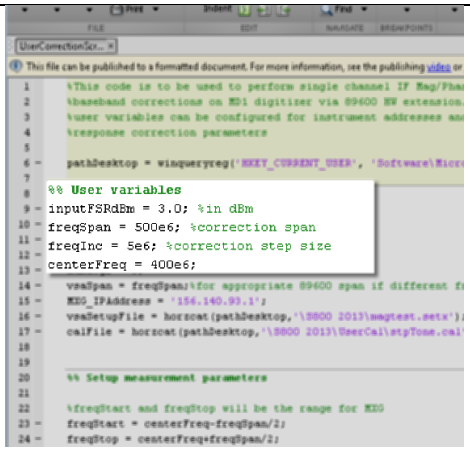
Procedure	Results / Explanation
This side contains the lab process to follow	This side contains graphics and explainations to help understand the process step

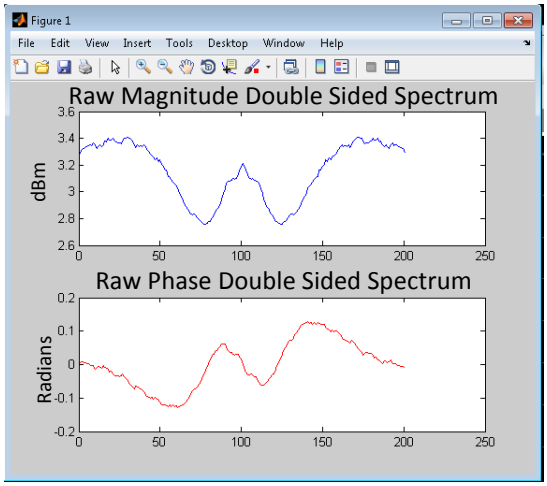
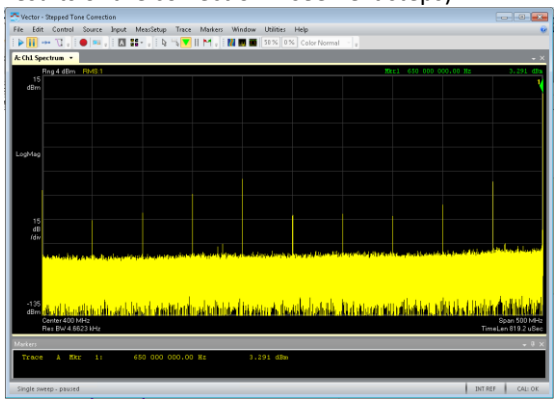
Lab part 1 – Using MATLAB IF Correction Script to Produce Mag and Phase Response

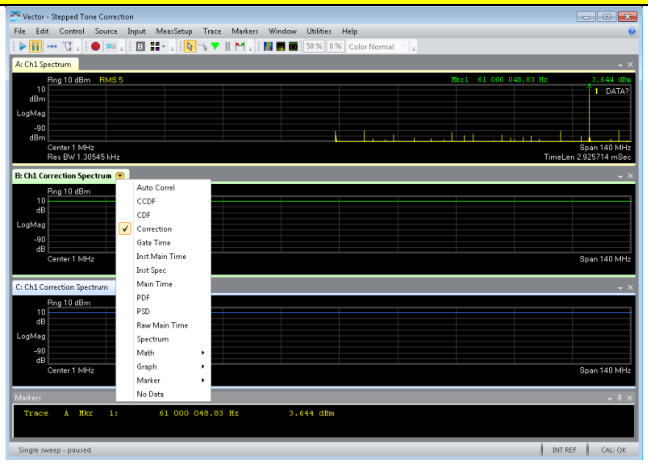
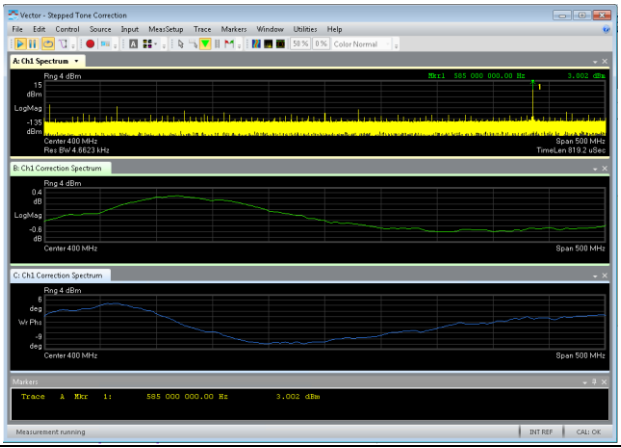
Hardware Setup:

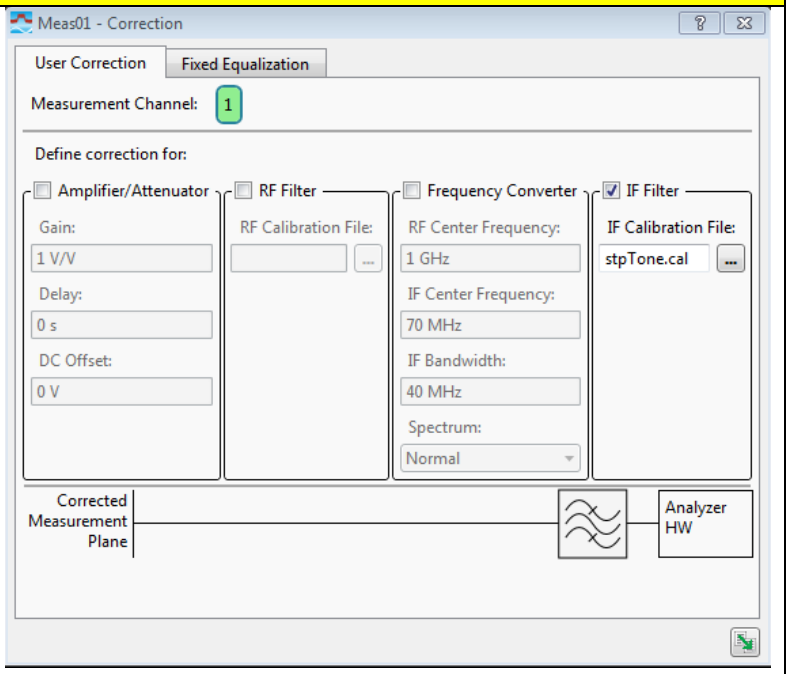


Procedure	Results / Explanation
Cabling for the IF Measuerment • Review the cabling of the hardware in the system. The RF output of the MXG should be connected to channel 1 (Ref CH) of the digitizer. A power sensor was used to perform a flatness correction on the MXG before we measure the response of the digitizer (loaded into a flatness correction file we call from the script).	
Open MATLAB Launch MATLAB R2012b (32-bit).	

Procedure	Results / Explanation
Open MATLAB • Open <Desktop>/S800 2013/**UserCorrectionScript_IF.m**.	
Set Test Parameters • Change only the following user variables if necessary: inputFSRdBm = **3.0** dBm freqSpan = **500e6** freqInc **= 5e6** centerFreq **= 400e6**	 In this experiment the M9703A will be set to 1V FSR or +4.0 dBm (later in the code). So, to allow for some margin in the digitizer's response we drive the MXG output at a somewhat lower level than the max digitizer input level (3 dBm).

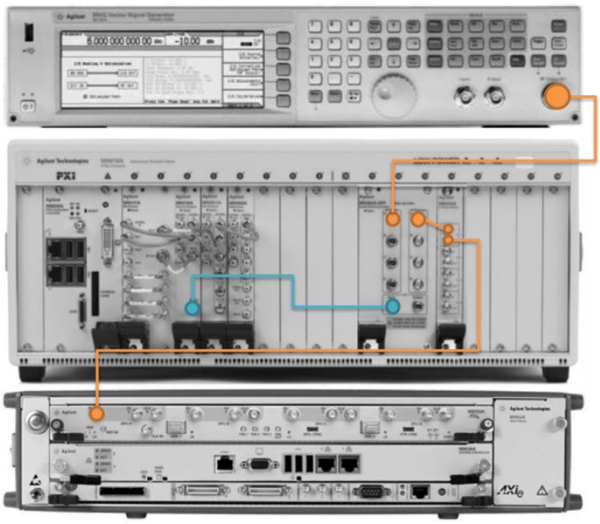
Procedure	Results / Explanation
Run Correction • Run the script  **Note:** The script launches 89600 VSA and then performs an initial self-calibration of the digitizer which takes 2 minutes. Please be patient and only click Run once. You are welcome to read through the Results/Explanation while the script starts. Also, FYI when you see the dialog pop-up indicating that calibration has begun, you do not need to click OK (it will only disappear after the calibration is done anyway).	Note: Prior to the lab we performed the user flatness correction on the MXG and stored it into a file for use by our script. UserCorrectionScript_IF measures the magnitude response by stepping the MXG across frequency steps equal to freqInc (user variable you set in last step) step size. Then, from the creation of a double-sided magnitude response (dBm) it computes the phase response using the Hilbert Transform. The results (below) are plotted before the generation of the user correction file for 89600 VSA as a simple check.  When the magnitude and phase response are finally computed, the final step is for the MATLAB script to properly formulate the 89600 VSA correction file. The script processes the data and forms an I and Q complex value (I+j*Q) per frequency point using the formulas I = r*cos(θ) and Q = r*sin(θ) where r is the normalized magnitude response and θ is the phase response value at each respective frequency. 89600 VSA after MATLAB correction script (note correction was enabled at the very end so you have to run the 89600A now to see the results of the correction – see next steps): 

Procedure	Results / Explanation
Verify Correction in 89600 VSA • Set up Stack 3 grid in VSA and set the two new grids to display the correction. • One of the grids should show LogMag on the vertical scale and the other should be Wr Phs (wrapped phase). • Autoscale the corrections by right clicking and then selecting  • Then configure VSA for continuous run ( → ) and turn off averaging (MeasSetup…Average…Type=off). **Manually Stepping the MXG** • Put the MXG in local mode (press Cancel/Esc button) for manual control. • Step the frequency (1MHz steps) of the tone from MXG across the range of corrected frequencies with 89600 in continuous run mode. Watch the top level of the tone and ensure it is flat across the corrected span (we could increase the resolution by making freqInc smaller too). Note: You can also right click on the top plot (Ch1 Spectrum) and move the marker to the peak to display the precise power level.	 You should see something similar to the following while observing the power level at different fequencies after correction (notice that we are measuring within 0.01dB of the expected 3.0 dBm… ☺):  

Procedure	Results / Explanation
89600 VSA: Look at User Correction Menu • Go to Input…User Correction • Observe the setup that our script has made including loading the stpTone.cal file (stored in <Desktop>/S800 2013/UserCal). **END OF PART 1** • In MATLAB Editor close UserCorrectionScript_IF.m. **Note: MATLAB and 89600 VSA can remain open**	

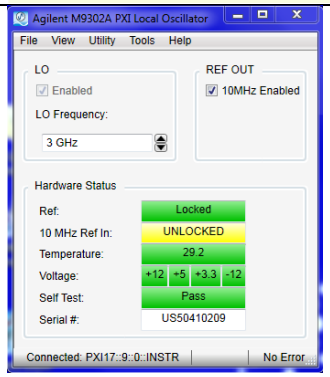
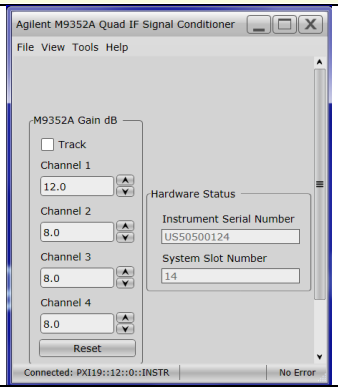
Lab part 2 – Using MATLAB RF Correction Script to Produce Freq Translated Response

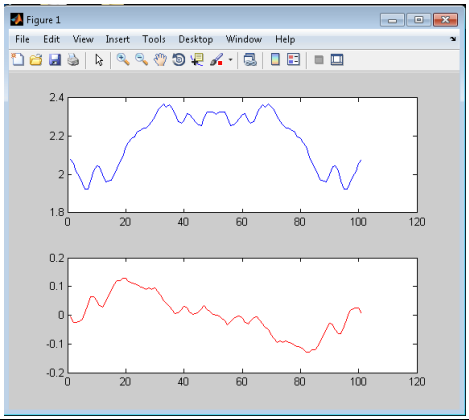
We will now repeat the previous measurements but around 5 GHz

Procedure	Results / Explanation
Setup Instrumentation	The output of the MXG should be connected to channel 1 of the M9362A-D01 PXI quad downconverter. This will be connected to channel 1 of the M9352A PXI amp/attenuator module. The output of this will be connected to channel 1 of the M9703A. The LO signal for our down conversion is provided by a M9302A LO source which should be connected directly to the M9362A-D01 LO input. 
Set Test Parameters • Open <Desktop>/S800 2013/ **UserCorrectionScript_RF.m**. • Set parameters as follows (all others leave default): inputFSRdBm = **-10 dBm** freqSpan = **250e6 Hz** rfcenterFreq = **3.35e9** ifcenterFreq = **350e6** vsaSpan = **300e6** Note: vsaSpan is used for both the vsa span setting as well as the IF BW, so you need to set this to a	We are setting the output power for the optimum performance of the down conversion, however this is much lower than optimum for the M9703A. We will therefore use the M9352A PXI amp/attenuator module to amplify the signal for the digitizer channel. It is also important to provide the rf and if center frequencies so that the script can compensate for the frequency translation of the downconverter. The RF center frequency is the center of the span coming from the MXG and the if centerFreq will be the associated center frequency after the downconverter (i.e. in this example it should be obvious that if we are doing low-side mixing that the LO freq we are using with the M9302A is 3GHz).

Procedure	Results / Explanation

wider span than the freqSpan to allow for the shape of the IF BW filter roll-off	`%% User variables`
	`inputFSRdBm = -10.0; %in dBm, pick an input power where mag respo`
	`freqSpan = 250e6; %correction span`
	`freqInc = 5e6; %correction step size`
	`rfcenterFreq = 3.35e9;`
	`ifcenterFreq = 350e6;`
	`numavgs = 3;`
	`vsaSpan = 300e6;%for appropriate 89600 span, should be wider since`
	`MXG_IPAddress = '156.140.93.1';`
	`vsaSetupFile = horzcat(pathDesktop,'\S800 2013\magtest.setx');`
	`calFile = horzcat(pathDesktop,'\S800 2013\UserCal\stpTone.cal');`

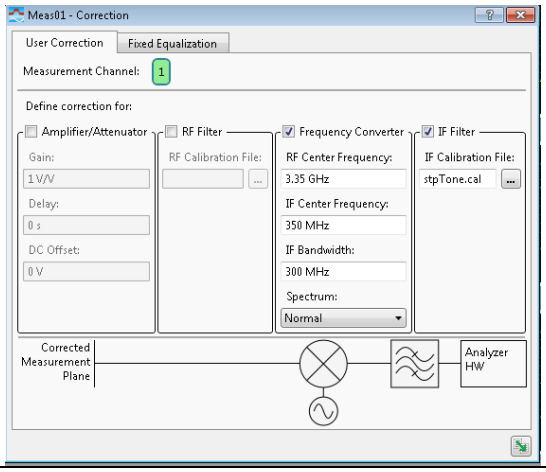
Set up signal down conversion and amplification
• Using the PXI controller
• Launch M9302A **SFP**
  • Set LO to **3e9 Hz**
• Launch the M9352A SFP
  • Set the amplification of channel 1 to 12 dB
	 

Back on AXIe Controller…Run Correction • Run the script  Note: it takes a moment here to start (including opening 89600 VSA if you closed it after the previous experiment). Then there is a 2 min digitizer self-calibration too. Just be patient please and click Run only once. • Observe Raw Results from MATLAB	As before the script will step through the frequencies measuring the amplitude at each step and performing a Hilbert transform to determine the frequency response of the phase over the selected bandwidth. 

Observe User Correction Setup in 89600

- Go to Input…User Correction

For the RF Correction where we are dealing with a down-converter in front of the digitizer, the script uses the information we provide it to set up the frequency converter parameters of 89600 for us too…



Verify the Correction Results

- Set up 3x3 grid in VSA and set the two new grids to display the correction.
- One of the grids should show LogMag on the vertical scale and the other should be Wr Phs (wrapped phase).
- Autoscale the corrections by right clicking and then selecting 

- Then configure VSA for continuous run ( → ) and turn off averaging (MeasSetup…Average…Type=off).

Manually Stepping the MXG

- Put the MXG in local mode (press Cancel/Esc button) for manual control.
- Step the frequency (1MHz steps) of the tone from MXG across the range of corrected frequencies with 89600 in continuous run mode. Watch the top level of the tone and ensure it is flat across the corrected span (we could increase the resolution by making freqInc smaller too).

Note: You can also right click on the top plot (Ch1 Spectrum) and move the marker to the peak to display the precise power level.

Lab summary – What have we learned?

1) Channel phase can be estimated from the absolute magnitude using the Hilbert transform
2) The M9703A can effectively be used as the IF digitizer for multichannel applications requiring wideband multichannel acquisition. And we can optimize the frequency response depending on the application need.

Appendix – supplemental material

Hilbert Transform	http://en.wikipedia.org/wiki/Hilbert_transform http://www.mathworks.co.uk/help/signal/ref/hilbert.html