# Agilent Technologies
# S800 Training, Fall 2013
# Lab guide

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|---|---|
| Santa Rosa, CA: | MODIN_S13_Lab3.3 |
| Lab Title: | Channel characterization using Cross-channel FRF in 89600 VSA |
| Duration: | 25min |

## Table of contents



## Objectives of lab

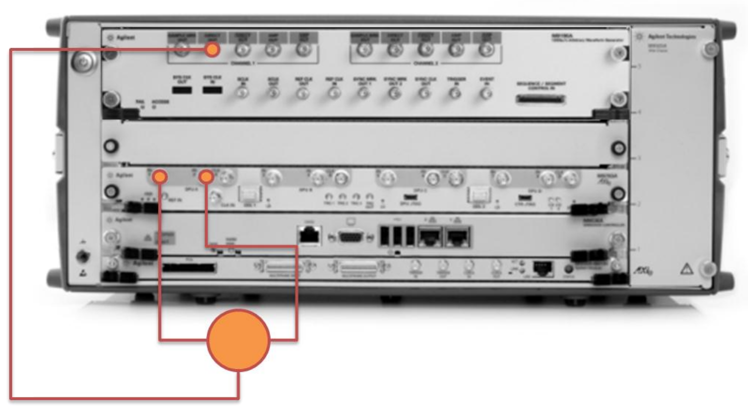
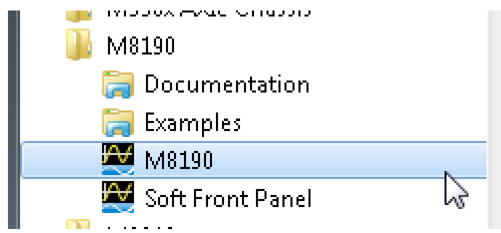
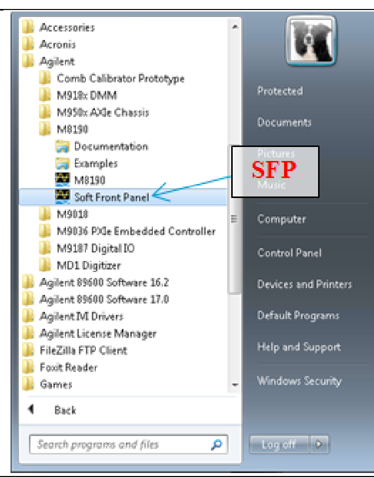
The objective of this lab is to introduce the student to one of the methods that can be used to characterize and correct the channel frequency response, using the cross-channel performance of the digitizer where one of the channels has already been corrected. In this lab you will be using the M8190A AWG for signal generation, and 89600 VSA software to acquire and calculate the cross-channel frequency response of one channel with respect to another.

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 3 part 1 – System set up.

| Procedure | Results / Explanation |
|---|---|
| **Review System cabling**<br>• The Direct output of the AWG should be split into two paths and connected to two channels of the M9703A.<br>• Use Channel 1 as your reference, and Channel 2 as your test channel. | <br>We are using a passive wideband power divider that has proven performance for equal division of the input signals. |
| **Launch M8190A Firmware application**<br>• From the start menu launch the M8190 application. | <br>M8190A requires a firmware interface application to communicate with the hardware. Before launching the M8190A SFP the firmware application must be active. |
| **Launch M8109A SFP**<br>• From the start menu launch the M8190A Soft Front Panel (SFP) |  |

<table>
<tr><th>Procedure</th><th>Results / Explanation</th></tr>
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- Confirm connection with the hardware from the VISA address and slot.

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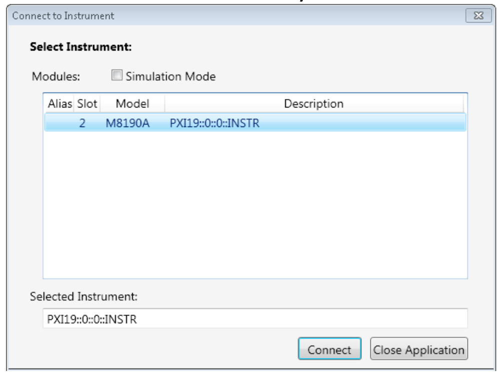
Connection to the AWG hardware is simple when there is only one unit in the chassis. If multiple units are present in the chassis, each module can be identified by the slot that it occupies




The M8190A SFP can be used to drive the basic functions of the AWG, including loading and generating specific waveforms, as well as adjusting output signals.

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**<u>Launch 89600 VSA</u>**

- Launch the 89600 VSA software (64b).
- A connection with the hardware will be made, if not then connect through Utilities > Hardware > Configurations

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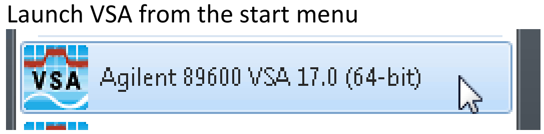
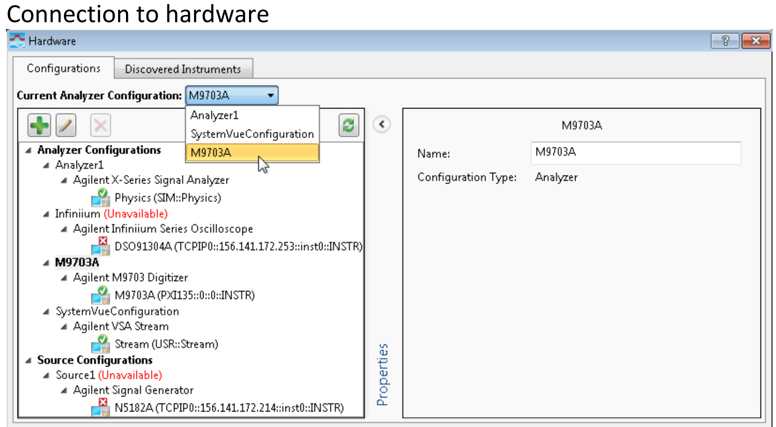
Launch VSA from the start menu




Connection to hardware




The M9703A is seen in the VSA software as any other hardware. It can be configured with 8 independent channels, tuned over 1.6 GHz using the on-board DDC functionality

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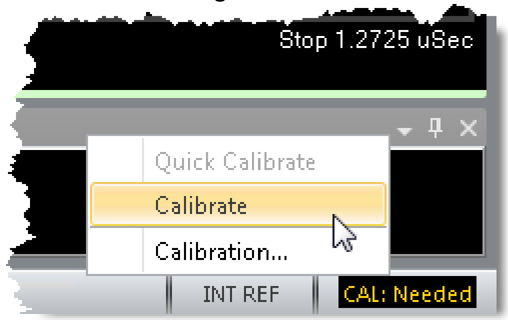
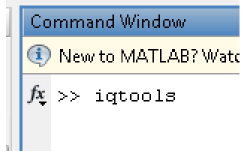
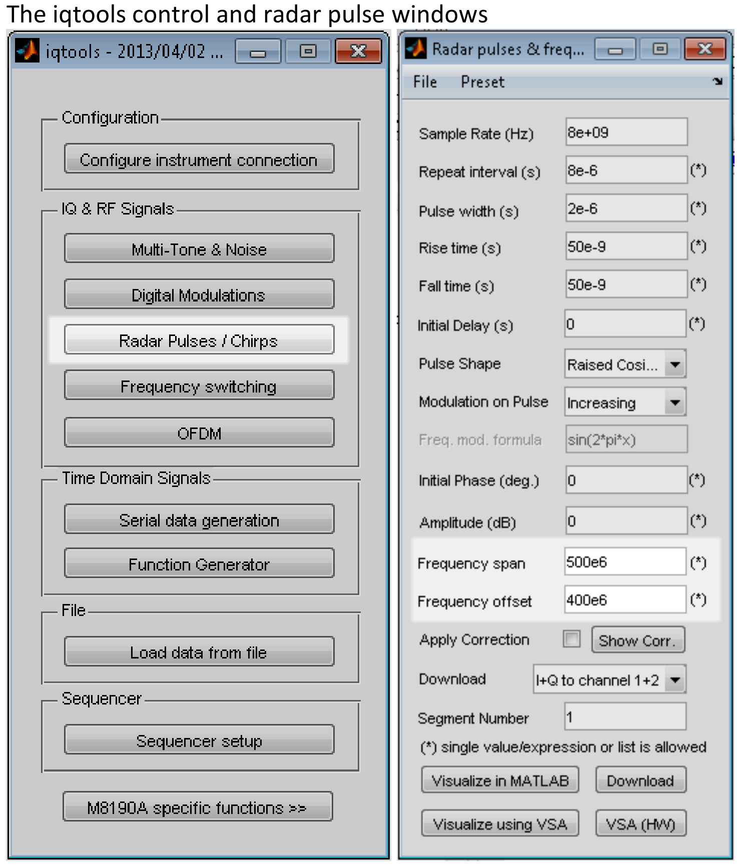
| Procedure | Results / Explanation |
|---|---|
| • Perform a Self-Cal, either from the menu **Utilities > Calibration…**, or from the bottom right of the 89600 VSA window. It will take 2 minutes for the hardware to perform its self-calibration routine.<br>• Whilst the system calibrates move on to the next step | From the bottom right of the 89600 VSA window<br><br><br><br>The self-calibration of the digitizer uses a number of internally generated signals to align the timing and offsets of the eight input channels for all settings. In 89600 VSA it is not yet possible to launch a "quick" or "fast" calibration, so this process will take a couple of minutes. |

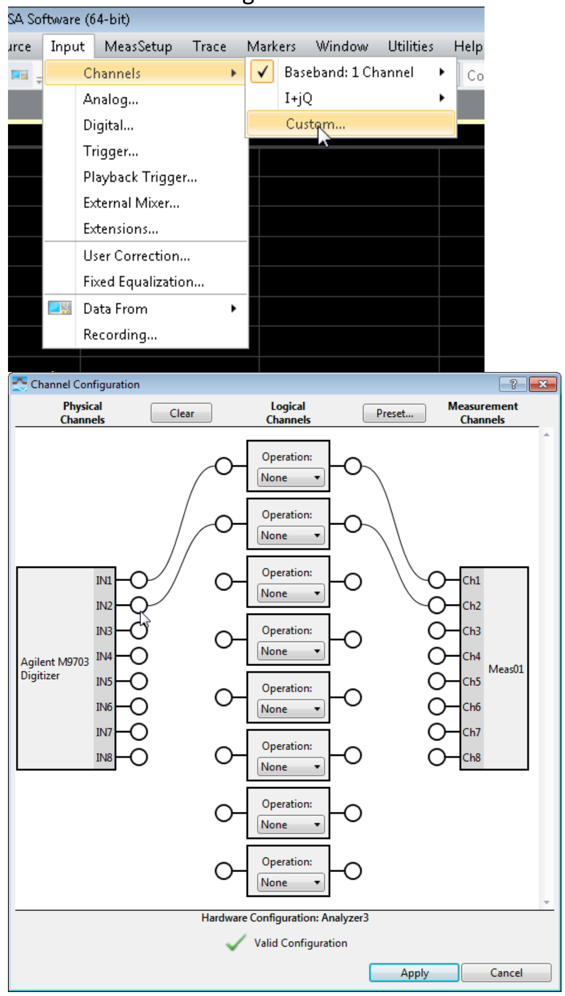
## Lab 3 part 2 – Characterize frequency response using wideband chirp

| Procedure | Results / Explanation |
|---|---|
| **<u>Open MATLAB</u>**<br>• Launch MATLAB R2012b (32-bit).<br>• Launch **iqtools** from MATLAB prompt - type “**iqtools”** in to the command window and press **enter**.<br>• Using the “Radar Pulses / Chirps” window of iqtools, configure a radar chirp:<br>Frequency span 500e6<br>Frequency offset 400e6<br>(see image on right)<br>• “Download” the waveform to the AWG and generate the chirp. | <br><br>iqtools is a MATLAB application available with the M8190A. It allows simple set up and generation of complex waveforms for not only the M8190A but for other Agilent AWG’s such as the N6030 too.<br><br>The iqtools control and radar pulse windows<br><br><br>The wideband chirp used here in UHF could also have been down converted from higher frequency bands. IF the reference path is calibrated, we would split the signal as close to the antenna as possible to calibrate the secondary path. |

**<u>In 89600 VSA</u>**

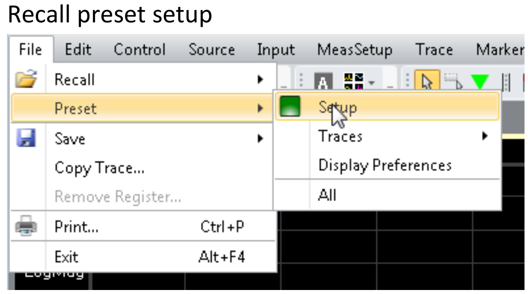
- Set up custom 2 channel system **that corresponds to the connections to the M9703A.**

Custom channel configuration



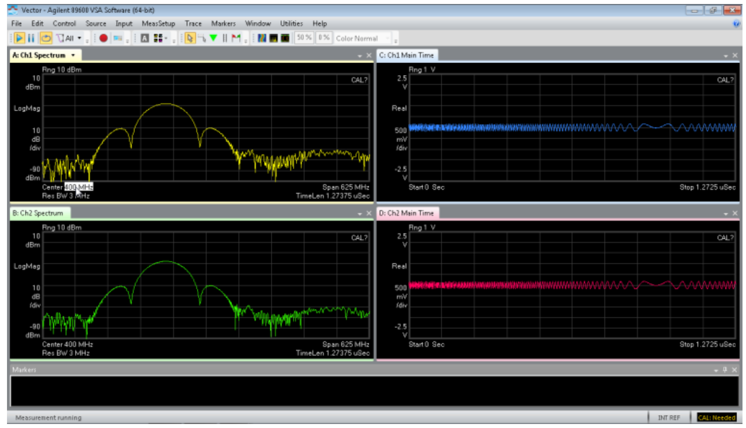

- Preset the standard 2 channel setup.
- Set the center frequency of each channel to 400 MHz.
- The bandwidth will be set to the maximum 625 MHz, which will allow you to observe the 500 MHz chirp.

Recall preset setup

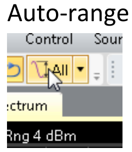


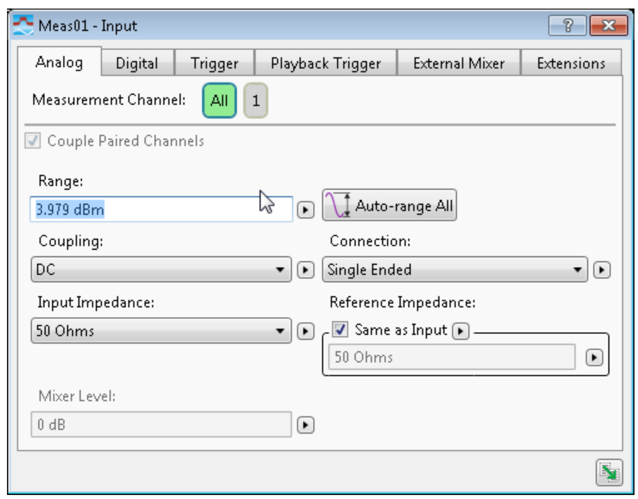
- **IMPORTANT**: Make sure the full-scale range is correctly set for the signal. Hit Auto range All. Or check the **Input>Analog…** menu. The Digitizer has two full scale range settings 10dBm and 3.979dBm.
- ANY Frequency Response Function calibration is specific to the front-end settings. **For these measurements make sure both channels 1 and 2 are set to 3.979 dBm. Both now and when testing your correction later.**

Set the center frequencies of both channels



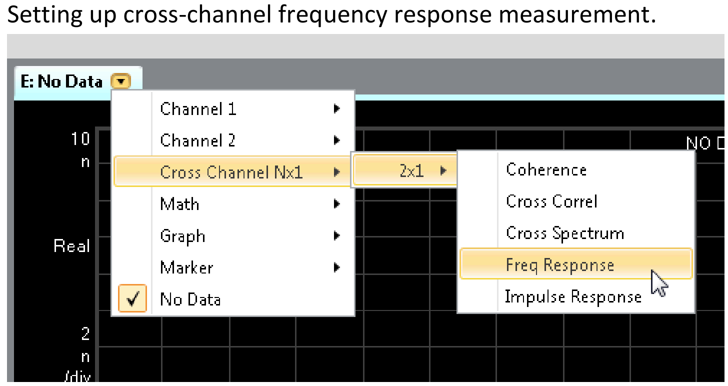
Auto-range or Analog menu




- Change the display in 89600 VSA to a 2x3 grid
- Set up Cross Channel Freq Response measurement, in windows E and F.
- By default, the scale in window E will be in Log Mag
- Adjust the scale so that F shows Wr Phase (wrapped phase).

Setting up cross-channel frequency response measurement.



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- Adjust settings of the acquisition so that a full spectrum can be captured.
- Leave the system running with a free-run trigger and set RMS (Video) averaging over 1500 acquisitions.
- Autoscale the displays in windows E and F

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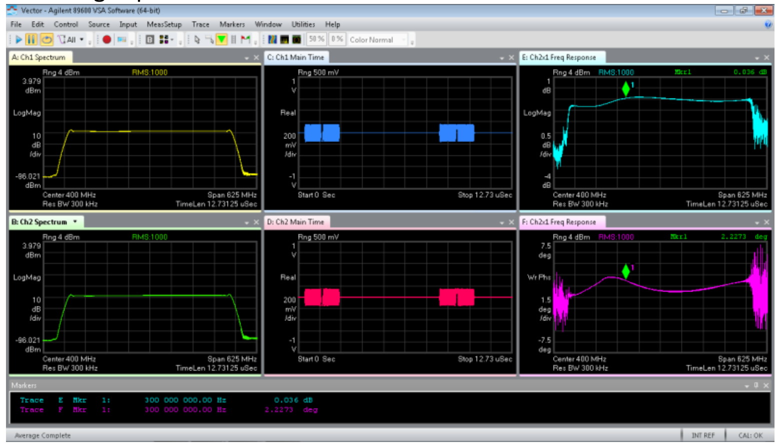
Resulting capture of two channels and the cross-channel FRF



**The resulting FRF data captures the frequency response of channel 2 with respect to channel 1.**

**<u>IF</u> channel 1 has already been characterized and corrected, using a process such as that used in Lab 2, this cross-channel FRF is the wide-band characteristics and corrections for channel2.**

Even without a calibrated reference channel, this process for measuring cross-channel correction will allow us to make comparative measurements in phase and magnitude between these two channels with a high degree of accuracy.

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- Use coupled cursors in windows E and F to measure magnitude and phase differences @ 200MHz, 300 MHz and 400 MHz.

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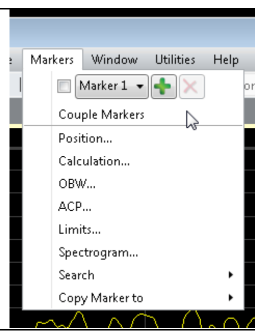


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- With window E or F active, copy the FRF in E to registry “D1”. With window E active use **file>Copy Trace…** and select D1.
It is also possible to save the same FRF to file e.g. “Ch2Corr.mat”.

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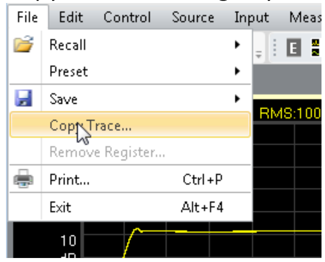
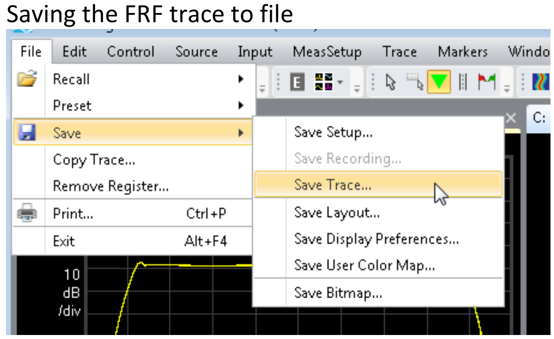
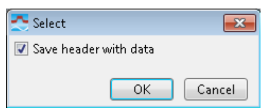
Copy a trace to a registry




Saving the FRF trace to file




NOTE: By saving the FRF to a MATLAB format we can have direct access to the data and can use this in other correction activities.

To remove the effect of any splitter delay we could obtain the FRF function twice, reversing the connections from the power divider to the channels between measurements, and taking an average of the two sets of data.

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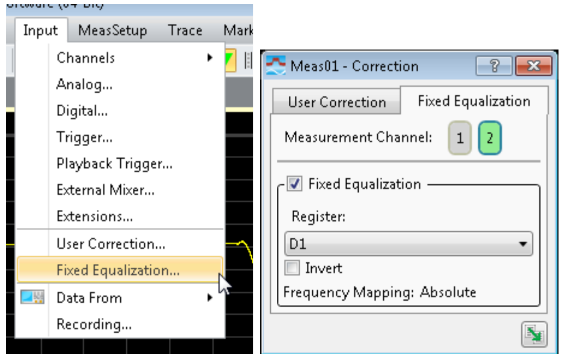
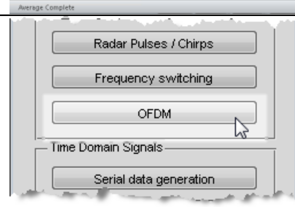
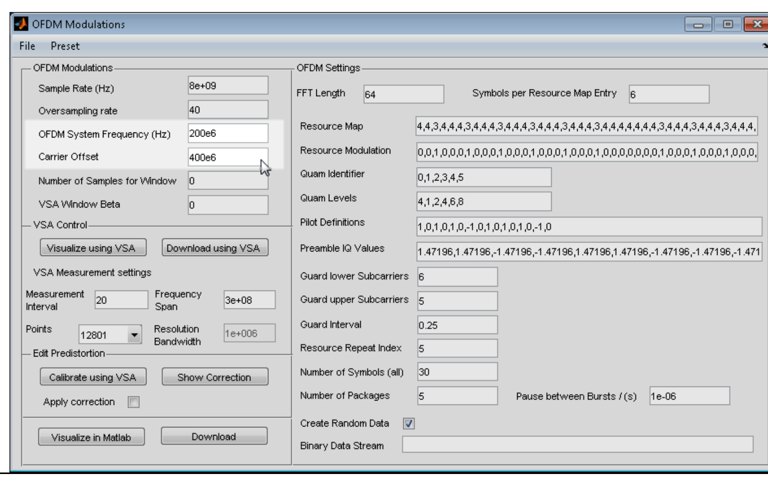
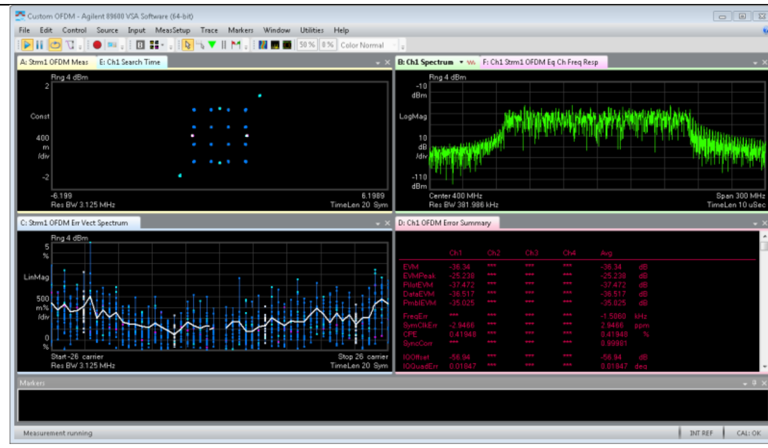
### Lab 3 part 3 – Testing the correction filter

| Procedure | Results / Explanation |
|---|---|
| **<u>Apply a fixed equalization</u>**<br>• Open the fixed equalization window. Input > Fixed Equalization…<br>• Apply fixed equalization **<u>to ch2</u>** using “D1”<br>(if saved, a trace could be recalled from file into register “D1”) | <br> |
| • Repeat the measurement of the chirp using the new correction filter<br>• Measure Mag and phase @ 200MHz, 300 MHz and 400 MHz<br>• How do they compare with the previous measurements? |  |
| **<u>Use different modulation</u>**<br>• In IQ tools click the “OFDM” button<br>• Modify the settings to set up a 200 MHz OFDM at 400 MHz (as shown on the right):<br>OFDM System Frequency (Hz) 200e6<br>Carrier Offset 400e6<br>• Hit the “Download” button to load the waveform into the AWG.<br>• In the 89600 VSA software, observe the cross channel frequency response again over the modulation bandwidth using the correction filter that you constructed for channel 2. | <br><br>< Select OFDM from the iqtools menu.<br><br> |

**Demodulate the signal**

- Load the setup 200MHzOFDM.setx from the desktop.
  This corresponds to the demodulation of the suggested OFDM configuration.
- If using different OFDM parameters adjust the measurement accordingly.



Here the resulting EVM is around -36 dB

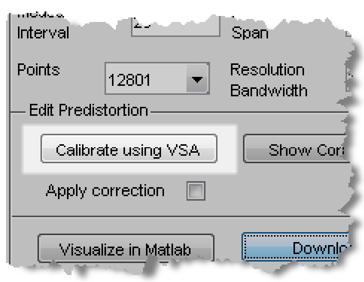
In 89600 VSA the M9703A can be used to measure up to 625 MHz of bandwidth in all 8 channels. The IF of each channel may be tuned independently from DC to 1.6 GHz

In IQ pairs up to 1.25GHz analysis is available

**Calibrate the AWG output**

- In the OFDM waveform setup window, use the "Calibrate using VSA" button to launch the frequency correction of the AWG.
- By default this process recalls a setup that looks to channel 1 of the digitizer as the acquisition channel.
- Wait for the correction to settle. Press ok in the dialog to perform the correction

To make accurate measurements it's important that we calibrate not only the digitizer but also the AWG source. The IQtools predistortion process uses the 89600 VSA software, to generate an FIR filter that is then applied to the waveform data and uploaded to the AWG.  This is used to correct for wideband frequency response.




- Reload the setup 200MHzOFDM.setx to remove the additional windows (or adjust manually).
- 200MHzOFDM.setx will capture data from channel 1 – Our reference channel.  If another channels has been used as the reference channel, adjust accordingly.

After AWG flatness correction the resulting EVM for the same channel is now -41dB

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- Change the channel configuration, as before, **Input > Channels > Custom…** and select Physical Channel 2 as our logical Channel 1 (as shown right).

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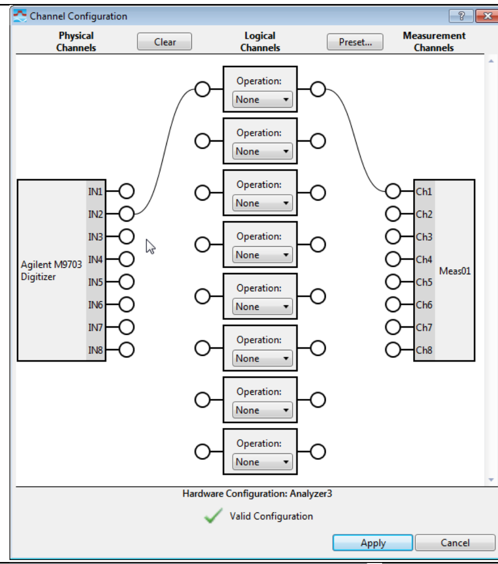


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- Observe the new EVM from the error summary

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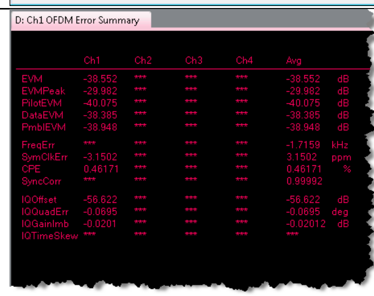


Here the initial EVM on the test channel is -38 dB

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- Apply the fixed equalization, as before **Input > Fixed Equalization…**

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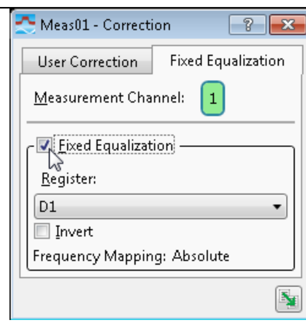


Note that we only have one channel (our test channel)

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- Observe the new EVM from the error summary, after application of the correction filter.

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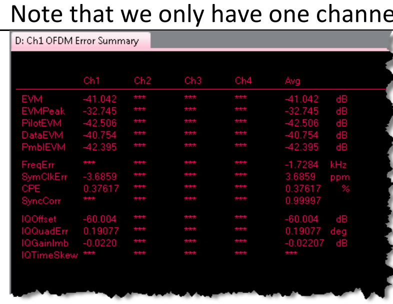


Here the corrected EVM on the test channel is now -41 dB

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## Lab 3 summary – What have we learned?

1) Once we have a corrected channel, this may be used as a reference to characterize and correct other channels in the same module.
2) Even without first correcting the reference channel, this cross-channel correction will allow us to make relatve measurements in phase and magnitude between channels.
3) It is relatively simple to extract the wideband correction using standard 89600 VSA functionality.
4) Correction filters can be saved and applied to individual channels.
5) The wideband performance of the M9703A can be applied to the measurement of many wideband modulations in radar and communications signals.