

Vector Modulation and Frequency Conversion Fundamentals

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1) **Q:** If you want to measure the noise floor of an IQ Modulator, can you use a signal source analyzer such as E5052 or will that only give you the phase component of the output noise?

A: The E5052B Signal Source Analyzer can measure the AM noise in addition to the phase noise.
www.agilent.com/find/SSA

2) **Q:** What is the effect of frequency error? What is the negligible error for EVM degradation for an OFDM signal with 15 kHz subcarrier spacing?

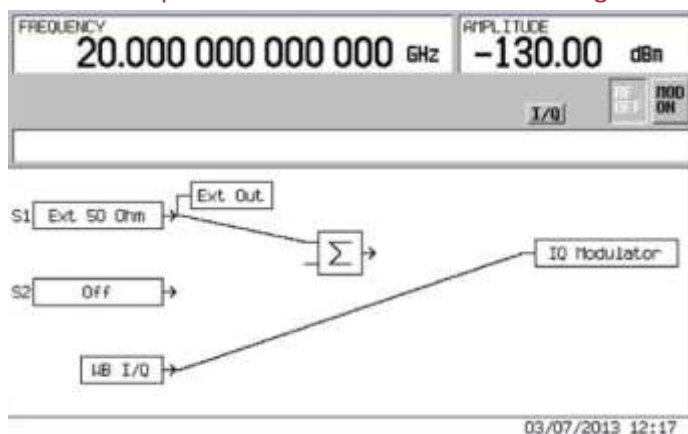
A: Frequency error are not much of an issue in IQ modulator as the LO signal is split from the same source. EVM degradation depends on multiple things about the OFDM waveform including guard time between symbols and the modulation format used.

3) **Q:** Does the Interpolator preserve the phase reference if trying to maintain coherency?

A: Yes it does.

4) **Q:** What is the diff between the S1 and S2 inputs?

A: When "Mux" is selected on the front panel of the PSG signal generator you are given options on how the IQ paths are to be routed. S1 and S2 allow routing of the external narrow band IQ inputs (50 or 600 ohm – user selectable) and the IQ signals from the internal AWG to be routed to the narrowband IQ modulator. We used to allow two internal AWGs inside the generator and the S1 and S2 IQ mux inputs allowed them to be summed together.



5) **Q:** What are the export file formats available for saving and recovering data output?

A: Waveform files created with Agilent Signal Studio are encrypted and can only be used in the signal generator platform for which it is licensed. MATLAB can be used to download waveforms in ASCII and MATLAB file formats.

6) **Q:** Does Agilent have multi-channel Arbitrary Waveform Generators capable of simultaneously generating a multiplicity of waveforms but all referenced to common phase-coherent carrier?

A: Any of Agilent's AWGs can generate signal with multiple modulations or emitters included in a single file. The challenging part is in the creation of the waveform. This can be done in MATLAB or Agilent SystemVue will do this for you with a unique "signal combiner" function. Find more information at the following link:

<http://www.home.agilent.com/agilent/editorial.jsp?cc=US&lc=eng&ckey=2308722&nid=-34878.0&id=2308722>

Multiple AWGs can be connected such that they are phase coherent as well.

7) **Q:** Is the Agilent Proprietary ASIC available for sale?

A: Sorry, no it is not

8) **Q:** Can I use the numerically controlled oscillator to create chirped signals?

A: Yes you can. The NCO has a frequency sweep function that can be used for this. Alternatively, the FM chirp modulation can be included in the waveform file itself.

9) **Q:** Could you be specific about some of the sources of IQ modulation for test. I would assume, at the least, MATLAB.

A: MATLAB is an excellent tool for the creation of waveform files and also offers the "Instrument Control Toolbox" to facilitate the process. There are other tools available that simplify the development of waveforms. Agilent maintains a suite of products call "Signal Studio" that enables the creation of waveforms for nearly any communication standard for mobile phones to wireless LAN. Check out the link below.

www.agilent.com/find/signalstudio

I should note that Signal Studio for pulse building (N7620B) and Signal Studio for multitone distortion have built-in predistortion capability.

Another product from Agilent, SystemVue, a system level simulation tool has a very robust capability for creating waveform. You can find out more at the link below:

www.agilent.com/find/systemvue

Playback of recorded waveforms is also possible.

10) **Q:** Can the signal generator run a short waveform in a looped fashion?

A: Yes. The AWGs from Agilent include a sequencing capability which in addition to enabling playback of multiple waveform segments in a specific order (or sequence) allow looping playback of a waveform segment. The playback sequence can also be changed conditionally in real time with dynamic sequencing.

11) **Q:** How accurately can you generate amplitude and phase of a chirp signal with the AWG?

A: Depending on the bandwidth of the signal the amplitude and phase linearity accuracy can be within a few tenths of a dB in amplitude and less than a degree in phase.

12) **Q:** Is the mixing of the IF LO and the I or Q signal a straightforward mixing that would essentially be amplitude modulation?

A: That is correct

13) **Q:** Could we derive RF carrier power data from demodulated I/Q data? Is there any relationship between I/Q data values and carrier RF power?

A: Different modulations will have different peak to average power ratio (PAPR). But an absolute power measurement will depend on many other factors beyond the IQ modulation. These might include at what levels the IQ modulator are driven and any amplification or loss after the modulator.

14) **Q:** Does the DC offset adjustment improve the output spectrum same way if I/Q signals are close to LO frequency, considering that near DC products after the multiplication could raise phase noise of the mixer diodes?

A: Yes, the DC offset adjustment will still reduce the LO feedthrough although it may be slightly less effective.

15) **Q:** Please suggest any good book/material for doing the predistortion you have mentioned.

A: That is a good question but I don't have a really good answer. There are some things that may be of interest on the M8190A AWG page. Here is the link:

<http://www.home.agilent.com/en/pd-1969138-pn-M8190A/12-gsa-s-arbitrary-waveform-generator?cc=US&lc=eng>

16) **Q:** Do you have a block diagram where the predistortion is applied for different I/Q imperfection? I want to know where you implement these ideas inside the MXG

A: Here is a brief description of how the process works:

Baseband correction (calculated at boot-up or when cal is run)

- Grab the 160 MHz worth of I and Q magnitude and phase data interpolated to step size
- Apply EVM or ACP shape to magnitudes (will convolve with RF correction)

RF correction (calculated and/or cached when tuning)

- Grab the 160 MHz worth of RF data in the proper band centered about the RF frequency
- Interpolate to center the 5 MHz stepped data about the actual RF frequency (to kHz precision)
- Convolve with baseband correction
- Mix in impairments (if desired) and I/Q Timing Skew Correction

17) **Q:** Could you describe the complex multiplier function that "simulates" a hardware mixer?

A: The complex multiplier enables upconversion mathematically and programmatically. The following page provides a good source of information on IQ signals and a description of complex multiplication:

<http://whiteboard.ping.se/SDR/IQ>

18) **Q:** You mention the H30 option for the E8267D (wideband mixer option) I don't see that in the datasheet. Is that a new option?

A: The H30 option has been around for several years but is an option for the E8257D analog PSG (not the E8267D vector PSG). You will find it in the E8257D Configuration Guide at the link below:
http://www.home.agilent.com/agilent/redirector.jsp?action=ref&cname=AGILENT_EDITORIAL&cky=473840&lc=eng&cc=US&nfr=-536902342.536894871.00

H30 simply places a mixer inside the PSG with the IF input on the back panel (up to 6 GHz in BW) and the ability to internal route a CW signal to the LO port and the upconverted IF signal to the RF Output (up to 40 GHz) of the signal generator. The signal routing can be done from the front panel or programmatically.

19) **Q:** Can you comment generally on the use of a sequencer to repeat a waveform without adding any artifacts

A: When playing different waveform segments in a sequence it is important to ensure there are no discontinuities between the ending sample of the previous segment and the beginning sample of the next segment. This needs to be taken in to account when creating the waveforms. For pulsed and bursting signal this is made easier by the availability of "off" time during the waveform which can be used at the end and beginning of the waveform file.

20) **Q:** For digital I/Q generation and summing there is one DAC output and then if this is upconverted with an analog mixer how is the phase relation established between the DAC output and the carrier?

A: In this case the phase relationship will initially be random. The phase of the IQ modulated signal can be adjusted by manipulating the waveform file to roll the phase forward or backward relative to the carrier phase.