Application Note

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Amplifier EVM Characterization Using Aeroflex PXI

Amplifier circuits used in the transmission of vector modulated signals are required to provide acceptable Error Vector Magnitude (EVM) performance over a specified range of power levels and frequencies. Characterization of EVM performance is necessary to ensure proper operation of amplifier circuits used in digital communication applications. When performing amplifier EVM characterization, it may be necessary to make EVM measurements at a number of incremental power level steps and then verify that each measured value falls within a specified range. Graphical presentation of EVM versus output power makes it easy for the designer or test engineer to see the EVM performance of a particular device over a range of power levels.

Characterization can be very time consuming. Conventional instrumentation tends to be slow even when automated. This application shows how using high speed PXI modular RF instruments can accelerate test speed and produce accurate results.

As an amplifier's output power increases towards its' gain compression point, the corresponding EVM performance can be degraded due to non linearity. Characterizing this behavior is an important part of the design process. This information allows users of the device to select their operating point.

A typical plot of EVM versus output power is curved like the one shown in figure 1. The bold dots on the graph represent measured output power values in dBm versus their corresponding EVM values, shown in percent. The plot is relatively flat or rises slightly from left to right as the amplifier's output power is increased within its' specified operating range. The curve then rises sharply once the amplifier's output power nears its' gain compression region.

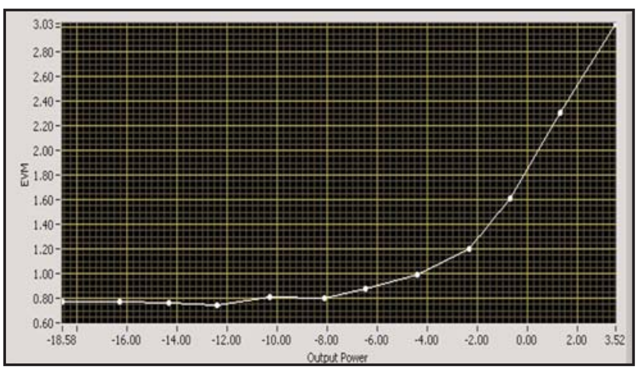

Figure 1. Amplifier EVM vs Output power

It is desirable to repeat this measurement at more than one carrier frequency. Figure 2 shows an example of a family of EVM vs output power curves for a device with each curve representing a different carrier frequency. To produce such a family of curves requires a very large number of iterative measurements. This data collection and calculation can take a lot of time, depending on the method and the equipment used.

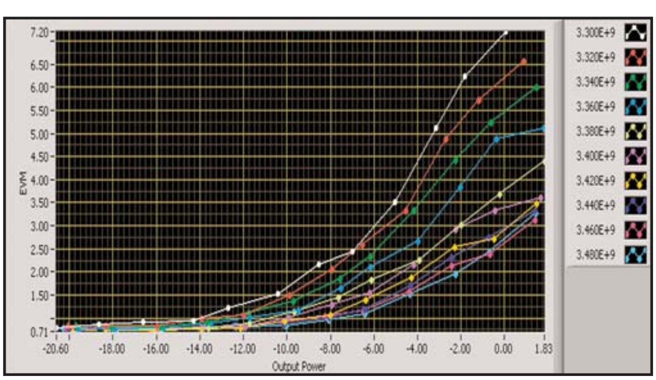

Figure 2. Amplifier EVM vs Output power plotted iteratively at ten frequency steps.

Aeroflex PXI Solution

The widely adopted Aeroflex 3000 Series of RF modular instruments configured for this application have been proven as an accurate, high speed solution for performing the many iterative measurements necessary for EVM characterization. The characterization curves shown in figure 2 are the result of calculations made at 12 power level steps, iteratively performed at each of 10 frequency steps. The resulting measurement time was only 4.3 seconds, 10 x faster than the solution it replaced. In this example, 8192 IQ sample pairs were captured at each power level step. EVM and amplifier output power were calculated for each captured sample set. This capture/calculation process was repeated 120 times on a total of 120 x 8192 or 983040 captured samples.

The number of IQ sample pairs necessary to make accurate measurement calculations is a limiting factor regarding test time. Another is the hardware response times of the test equipment. Greatest efficiency and test time optimization is achieved when capturing the least number of required samples using the fastest responding test equipment. Sample rate optimization is achieved by determining an appropriate sample rate and overall sampling interval for each type of communications signal. In the case of bursted signals, capture of only one burst is required for the Aeroflex measurement algorithm to make the needed calculations. Hardware response times are technology and manufacturer specific.

An Aeroflex PXI system containing the RF Signal Generator (3010/302x modules), RF Digitizer (3011/303x modules) and embedded host PC is used in the test setup configuration as shown in the block diagram in figure 3. A software application has been developed that utilizes the PXI functionality to iteratively step through the power and frequency levels and measure and plot EVM vs output power for various standards including WiMAX and WLAN. Measurements can be made quickly over a range of power level and frequency steps, saving time and allowing the user to produce results without difficulty.

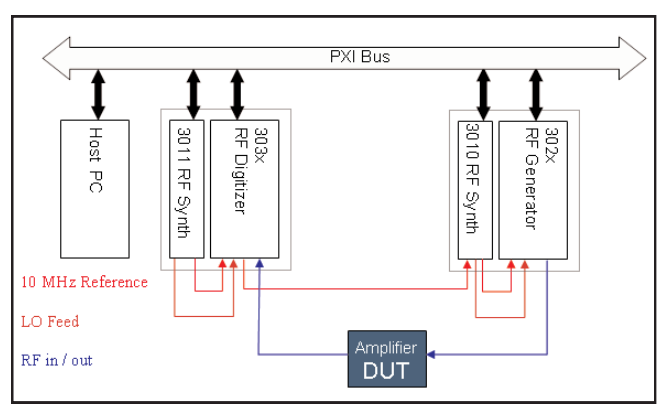

Figure 3. Amplifier test configuration using PXI

EVM Characterization Application Program

The EVM characterization results shown in figure 2 are achieved using a software application that controls the instruments and calculates EVM and amplifier output power. The PXI RF signal generator plays an arb file containing the appropriate signal attributes needed to exercise the amplifier under test with respect to the type of communication standard being characterized. The modulated RF signal is applied to the amplifier input. The signal generator's output power level is automatically stepped through a range of power levels set by the user. These power level steps are repeated over a number of carrier frequency steps. The RF digitizer automatically tracks the signal generator's power level and carrier frequency and captures the selected number of I/Q samples from the amplifier output. The captured I/Q sample arrays are transferred to the host PC where EVM and output power levels are calculated by the software application, using functionality from the appropriate measurement suites.

The user determines the initial power level, step size and number of steps. The application contains a manual operation mode that allows the user to experiment with power, frequency, attenuation and other programmed settings. Experimenting with individual test settings allows the user to verify the test hardware configuration and establish acceptable programmed settings.

Once the initial test settings are established using the manual mode, the settings are transferred to the application's automatic mode, allowing for multiple EVM and power measurements to be made. The auto mode allows the user to experiment with EVM/power measurements at any number of carrier frequency increments. The calculated EVM/output power measurements at each frequency can be written to a file. The resulting graphical plot, like the one shown in figure 2, can be written to a .png file.

The arb file played by the signal generator is formatted to provide a signal for the type of communications standard being measured against. For example, to measure WiMAX 802.16e uplink EVM characteristics, an arb signal with the particular attributes of link direction, bandwidth, guard period, modulation type, etc. would be created using the Aeroflex IQCreator™ software tool. The files created with this tool can be saved in a library as well as loaded into the signal generator arb's memory.

Versions of the EVM characterization program have been implemented for digital communication standards such as WLAN 802.11a, b & g and WiMAX 802.16e. The various versions of the application utilize the same framework and are operated the same way. The difference depends on which measurement function library is used. The application's GUI is divided up under functional windows, selected from tabs across the top of the application. Functional areas include:

"Boot" - for instrument initialization and booting.

"Manual Capture / Analyze" - used to initially setup and check operation of the test configuration manually.

"Auto Measurement" - allows the user to set up the initial power and frequency levels, step sizes, and number of steps. It allows the user to load the desired arb file and apply dBm compensation for losses occurring in the test setup. The user can also write the data or graphic results to a file.

"EVM Interpolation" - allows the user to select one of the EVM curves already plotted and apply a best fit interpolation curve to it. The program can then calculate an interpolated EVM value corresponding to a selected power level or calculate an interpolated output power level corresponding to a selected EVM value based on the interpolation curve. See figure 4.

"EVM vs Frequency" - allows the user to select an EVM threshold level and plot the corresponding output power levels at each frequency step. See figure 5.

Figure 4 illustrates an example of the EVM Interpolation functionality. In this example, the smooth red trace on the plot is a best fit curve for the white, piecewise linear plot of EVM vs amplifier output power. The white trace was the initial 3.3 GHz frequency plot shown in figure 2. The best fit curve is created using the Levenberg-Marquardt algorithm to determine the least squares set of coefficients that best fit the set of input data points applied. With a power level of -10 dBm selected by the user, the corresponding EVM value from the red interpolation curve is reported to be 1.83103. With an EVM level of 1% selected, the corresponding power level from the interpolation curve is -15.0966 dBm.

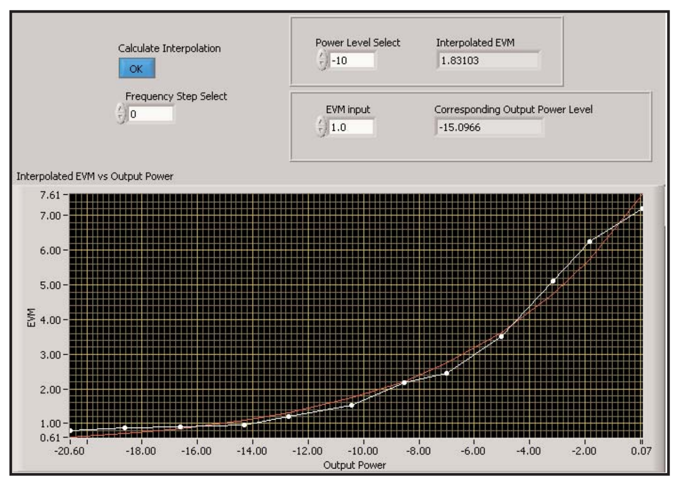

Figure 4. EVM Interpolation function

An example of the EVM vs Frequency functionality is shown in figure 5. This functionality allows the user to plot the output power levels corresponding to an EVM threshold setting for each frequency step curve. This graph allows the user to quickly see the effects of increasing frequency on EVM with regard to output power. In this example, the EVM threshold value is produced at increasing output power levels with increases in frequency.

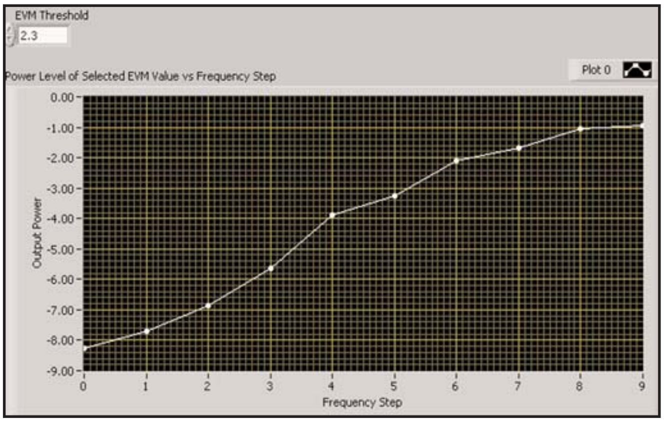

Figure 5. EVM vs Frequency function plot showing the amplifier output power at each frequency step where the selected EVM threshold value was reached.

Conclusion

EVM characterization of amplifiers used in digital communication applications is necessary in order to verify the specified design performance of those devices. To achieve this, extensive data capture and computation must be done iteratively over ranges of many power levels and frequencies. This data capture computation process can be very time consuming, depending on the test methodology, hardware and software used to implement this process. The Aeroflex PXI system does perform this process much faster than traditional rack and stack instrumentation. Test times of seconds or tens of seconds have been compared against methods taking many minutes. Aeroflex PXI is an extremely fast, accurate solution for this type of iterative, data intensive testing.

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Part No. 46891/966, Issue 1, 12/07