Testing broadband CATV amplifiers with true wideband channel rasters

Simple test system saves time and enhances amplifier characterization

Application Note

Overview

Since the mid-1990s, cable access television (CATV) providers have been pushing to offer more services and greater bandwidth. Within any such CATV system, bidirectional broadband amplifiers are the key to carrying high quality video and audio signals to and from every subscriber.

A typical CATV amplifier provides the following functions:

- Supports multi-channel transmission by amplifying signals over a wide bandwidth
- Ensures signal quality by minimizing distortion and frequency fluctuation
- Provides variable gain to compensate for changing conditions

These amplifiers must be capable of handling both analog and digital signals. For digital signals that carry complex modulation schemes, the key measures of signal quality are either error vector magnitude (EVM) or the closely related modulation error ratio (MER)[1]. The most efficient way to measure amplifier EVM or MER is to apply a complex wideband signal and measure the resulting output with a signal analyzer and vector signal analysis (VSA) software. Creating highly realistic input signals requires the use of an arbitrary waveform generator (AWG) such as the 12 GSa/s Agilent M8190A.

1. *MER and EVM are used to quantify the quality of complex modulation, with MER being expressed in decibels while EVM is expressed as a percentage*

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M8190A Wideband Arbitrary Waveform Generator

Agilent Technologies

Problem

Without a wideband AWG, the process of estimating a wideband amplifier's performance requires multiple steps. For example, the first step may be to perform a series of measurements at various signal levels using a vector network analyzer such as the Agilent ENA or PNA. The resulting S-parameter models will describe normal or linear operation while the X-parameter models will describe compressed or nonlinear operation.

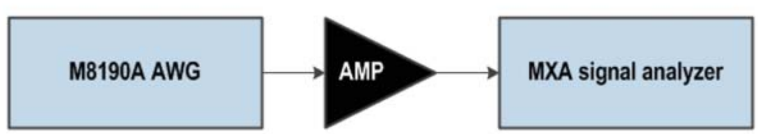
The next step is simulating the amplifier's behavior when a wideband stimulus such as a CATV channel raster is applied. This requires that you transfer the S-parameter models to a software application such as SystemVue or ADS from Agilent. Within the software environment you can apply a wideband stimulus to the simulation and observe the estimated amplifier performance.

This multi-step approach has two noteworthy shortcomings. First, it can be time consuming to make all the necessary narrowband measurements, capture the associated models and transfer those models to the simulator. Second, a series of narrowband measurements made at different operating points will lead to simulations that provide only an approximation of an amplifier's actual operating behavior when handling wideband signals.

Solution

As an alternative to the issues described above, you can produce more accurate results—and check your simulations—by applying a simulated broadband stimulus directly to the amplifier and then measuring the analog and digital characteristics of its output signal. This can be done by creating a true wideband stimulus in software and downloading it to an AWG. An example system configuration, as created by members of Agilent's application engineering organization, is shown in Figure 1.

Figure 1. Basic block diagram of the test system.



The key elements are a signal analyzer and an AWG—but not just any AWG will suffice. For example, some wideband units produce artifacts that add unwanted distortion to arbitrary signals. A source of greater fidelity is required for accurate, informative testing of broadband amplifiers.

The Agilent M8190A AWG delivers high resolution and wide bandwidth simultaneously: 14-bit resolution at 8 GSa/s and 12-bit resolution at 12 GSa/s. It also generates signals with spurious-free dynamic range (SFDR) of up to 80 dBc (typical) and harmonic distortion as low as –72 dBc (typical). With analog bandwidth of 5 GHz (via direct DAC output), the M8190A can handle CATV applications with direct RF output, no upconversion required.

To test an example amplifier, the responsible application engineer created a simulation of a CATV signal based on an RF channel plan with 84 QAM64-modulated carriers. This was done with IQtools, an Agilent-provided piece of freeware for MATLAB, and the signal characteristics are shown in Figure 2. The simulated signal was an 800 MHz-wide channel plan with five active CATV channels followed by two inactive channels (Figure 3).

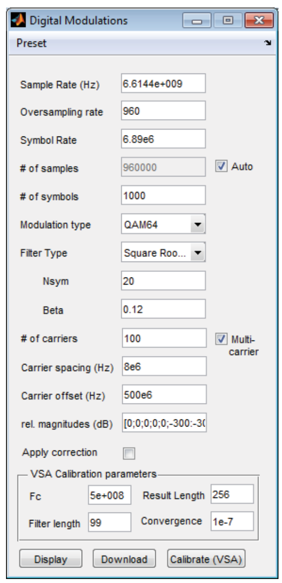


Figure 2. Configuration screen from IQtools freeware showing setup for generating 84 QAM64 signals.

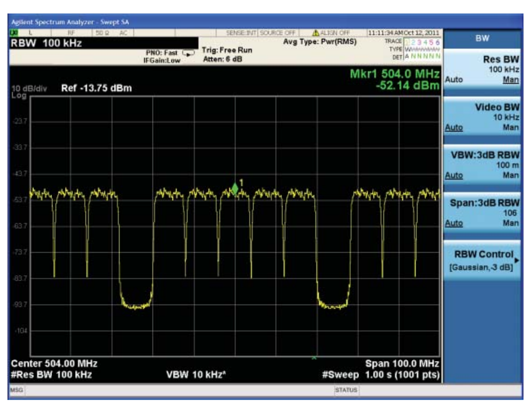


Figure 3. This zoomed measurement from an MXA signal analyzer shows the active and inactive channels.

Results

At this point, the key question was, "How good is this channel plan?" The question actually has two parts, namely the analog and digital performance of the signal. On the analog side, the key characteristics are flatness, signal-to-noise ratio (SNR), dynamic range, and SFDR. As shown in Figure 4, the generated signal is spurious-free from 10 MHz to 1 GHz, which is consistent with the –70 dBc SFDR typical performance.

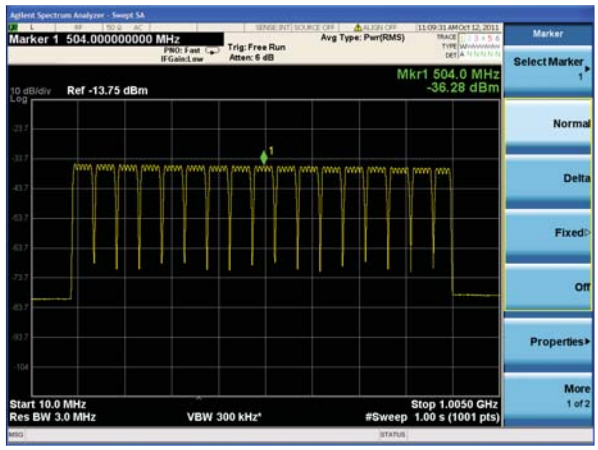


Figure 4. The analog characteristics of the full channel plan show no spurs between 10 MHz and 1 GHz.

As noted earlier, EVM and MER are key indicators of digital performance. These can be measured and viewed with an MXA equipped with either the N6152A digital cable TV app, which provides DVB-C demodulation and analysis, or the Agilent 89600 VSA software with option AYA, vector modulation analysis. As shown in Figure 5, a single channel within the 84 QAM64 signals has an EVM better than 0.5% and an MER of 43 dB.

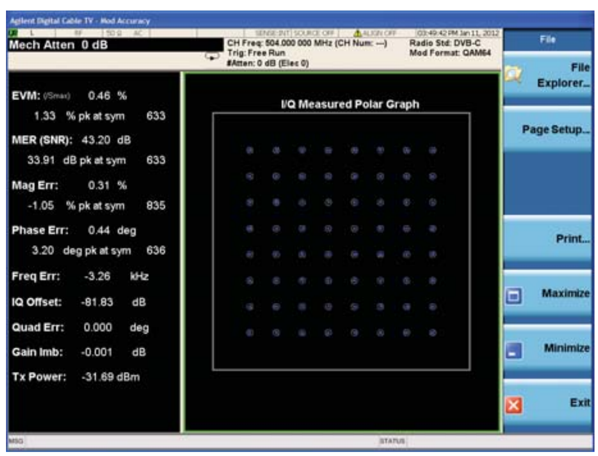


Figure 5. The digital characteristics of one channel within the 84-channel QAM64 signal show excellent results for EVM, MER and more.

Conclusion

Specific to CATV applications, the two-instrument system configuration reduces complexity, saves time and provides thorough characterization of wideband amplifiers. With its high resolution and wide bandwidth, the M8190A AWG is capable of producing virtually any channel plan for the testing of CATV devices.

Taking a more general view, the example system has the flexibility to address a variety of wideband applications at RF and, with upconversion, microwave applications. What's more, ultra-wideband (UWB) applications can be addressed by adding a high-performance oscilloscope such as the Agilent 90000 X-Series, which can run the 89600 VSA software.

Related literature

Type of Document	Title	Publication Number
Data sheet	*M8190A 12 GSa/s arbitrary waveform generator*	5990-7516EN
Brochure	*N9020A MXA signal analyzer*	5989-5047EN
Brochure	*X-Series signal analyzers*	5990-7998EN
Brochure	*89600 vector signal analysis software*	5990-6553EN

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