Edwin Lowery's Modulation Series

Modulation - Fundamentals 1

Modulation and EVM Analysis

Verigy

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Modulation Fundamentals – A New Series in *go/semi*...

Preface to the Series

Modulation analysis is increasingly integral to the test strategies of integrated RF SOC transceivers. The trend is that as the industry gets closer to a single-chip cell phone, more and more mission mode tests need to be performed on the transceivers to make sure that all components of the radio are working together flawlessly. In RF SOC, nothing represents mission mode test better than error vector magnitude (EVM). An acceptable EVM measurement for a complex modulation format implies that a whole host of transmitter or receiver components are within specification.

This article is the first in a series that will appear in *go/semi* over the next months. The goal of these articles will be to go over the fundamentals and challenges of different types of modulation, and show how these challenges are met by the V93000 and SmarTest.

DUT Architecture

TX Architecture and Options

For the transmitter shown in Figure 1, the DUT is expecting an analog I and Q signal on the input ports. The I and Q signals consist of the proper modulation information which is then combined and up-converted to RF, and sent out the transmitter port. Some versions of the transmitter use a DigRF front end at baseband. For this option, data is applied to the DUT in digital format and the DUT then creates the I and Q signals internally, and applies it to the up-converter mixer.

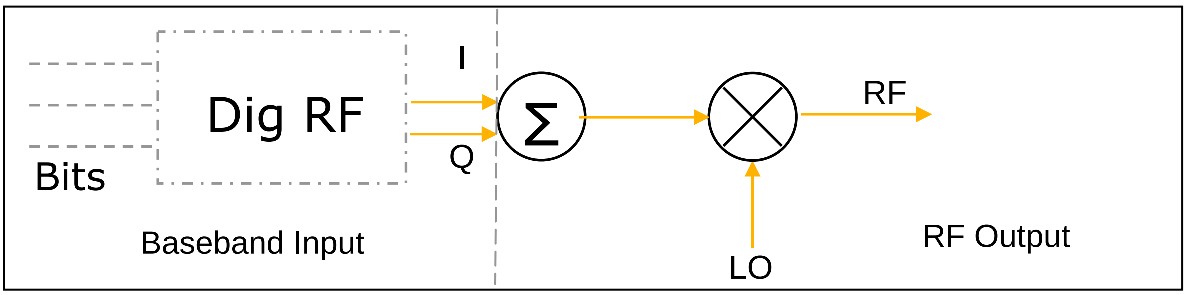

Figure 1. Transmitter block diagram.

RX Architecture and Options

Figure 2 shows the block diagram for a typical ZIF receiver. A modulated signal is applied to the RF port, and then the DUT down-coverts the signal and separates out the I and Q signal. Many RX DUTs output the I and Q signals in analog form, but others employ a DigRF back-end which sends out the demodulated signal in digital format.

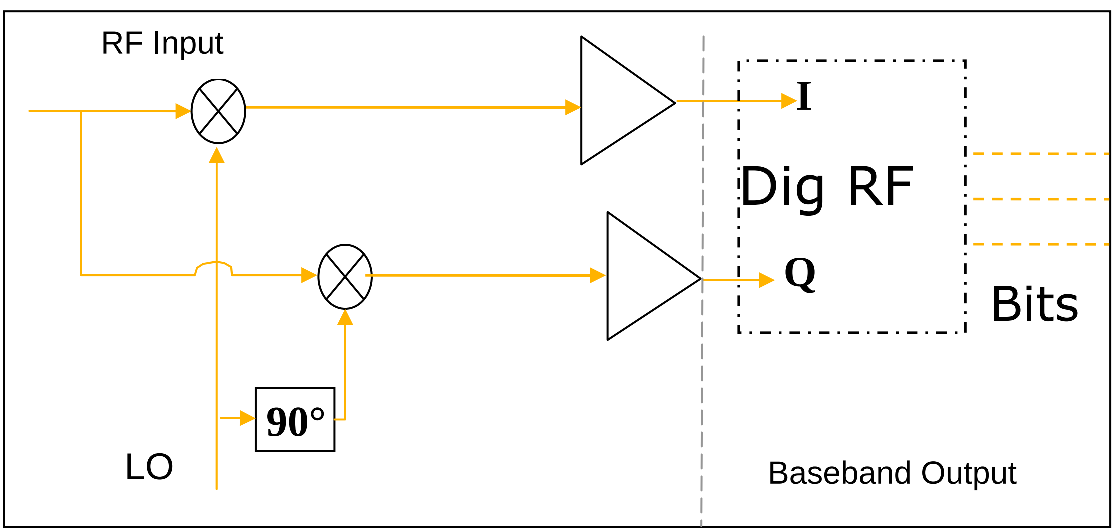

Figure 2. Receiver block diagram.

Ensuring Accurate EVM Analysis:

Although the concept is relatively simple, the implementation of EVM analysis is very complex. There is a whole host of things that have to be done correctly in order for demodulation to give accurate results. If any errors or inaccuracies are introduced at any step of the process, the final EVM results are affected. If we skip for a moment the hardware needs of a system to perform modulation analysis, we are still left with two major components: creating the ideal or reference waveform, and analyzing or calculating EVM from a sampled waveform.

Ideal Waveform

The first and most important step is creation of the reference modulation waveform. This is also called the “ideal” waveform. This is the “gold standard” waveform that will be applied to the DUT and the test equipment. The ideal waveform is used to stimulate the baseband input of the transmitter chain, and also to modulate the RF signal applied to the input of the DUT.

Creating this waveform file can be rather challenging as modulation standards can change rapidly, and most test engineering teams do not have access to the same tools that are available to R&D teams. Any users who decides to create their own waveforms from scratch must consider all of the elements of the standard being applied. On the communication layer side, they must consider the data being sent, data packet size, chip encoding, and any other elements added or modified by the MAC layer of the protocol. On the physical layer side, they must consider modulation type, filtering, training sequences, peak-to-average power ratios, whether or not OFDM is being used, channel allocation, etc. All decisions must conform to the standard and still be representative of whatever modulation type is being used and still be able to correlate to bench equipment.

Calculating EVM

Once the DUT output is captured by the automated test equipment, the single most daunting task is calculating the EVM of the acquired signal. This is difficult because not only must the signal created above be deconstructed and decoded, but the ideal signal must be re-constructed in the I/Q plane, and then compared against the original signal encoded. This effort can take weeks to months to do from scratch for a single modulation reference file. Creating a solution which supports a known standard, is flexible, and can handle the multiple data rates, bandwidths, and modulation types which are required in today’s high-speed data modulation, literally takes many man-years of effort. Even with the tools available in the V93000, being able to make consistent EVM measurements depends on a working knowledge of the standard being tested.

The Modulation Library

The task of reproducing a valid EVM measurement that correlates precisely to the bench can be extremely difficult. Which stimulus settings and data packet sizes must I use to get enough symbols for a proper EVM value? How should I configure my instrumentation to get a valid result? How many sampled points must I take, and at what sample rate? How do I optimize the measurement for speed? To answer these questions, Verigy has created a modulation library that users can access to get the exact setups that are needed.

The library consists of a series of examples that correlate to bench, are throughput-optimized, and conform to industry standards. Since many modulation types, like WiMax, Bluetooth, WLAN and LTE, operate in many different modulation modes, multiple waveform choices will be available depending on what the customer requires.

This library represents a whole host of modulation types and consists of the following:

- Ideal reference waveforms
- Instrument setups
- Demodulation module (code)
- Documentation outlining what the reference waveforms represent, and how to decode them

To be able to easily share and create this, the modulation library architecture (Figure 3) contains first a file demodulation example, which takes the ideal signal and demodulates it without the use of any instruments. Next, it contains an RF-to-RF loopback test of the same signal. Finally it contains a baseband-to-baseband loopback version of the exact same test.

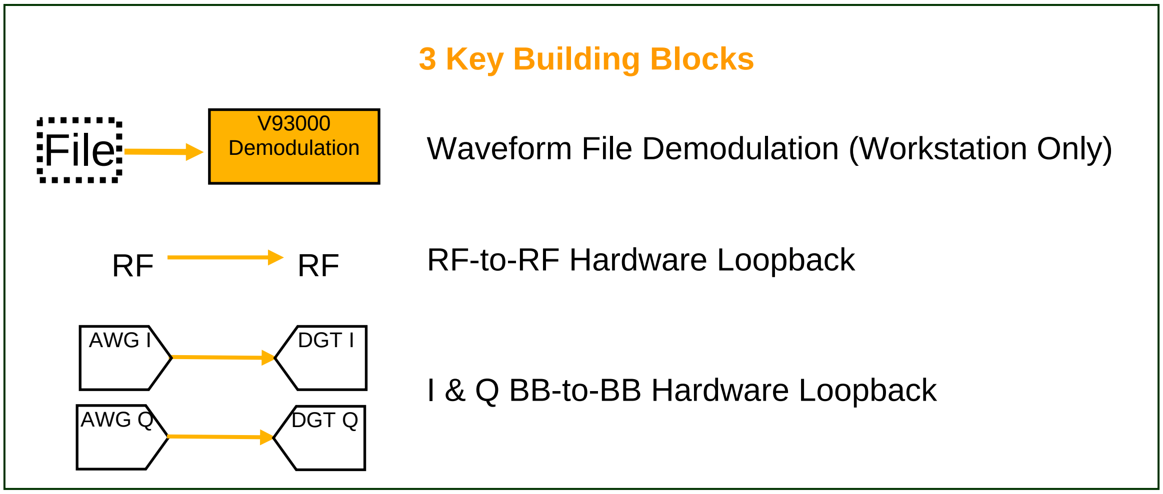

Figure 3. Modulation Library Architecture: 4 critical building blocks.

The structure of this modulation library is based on fundamental building blocks that are needed for any kind of EVM test. The library is structured so that end users can easily leverage into their application:

- RF source setups
- Digitizer setups and demodulation code
- AWG setups
- RF measurement setups and demodulation code

Conclusions and Looking Ahead

As modulation and EVM analysis become more mainstream, it is crucial that test engineers be able to execute these mission mode tests on their target DUTs. Verigy has a host of tools built in to the V93000 SmarTest software to help in this process. In addition, Verigy has a library of reference modulation standards which can be easily leveraged into the end application. Nevertheless, to be successful, test engineers must have a working knowledge of the standard that they are testing.

Over the coming months, we will go several modulation types in detail discussing critical measurements, any quirks of the modulation type, and technical details useful to making the EVM measurements successful. Please contact your local Verigy representative if you have questions regarding modulated device testing.

Next month's topic: Bluetooth