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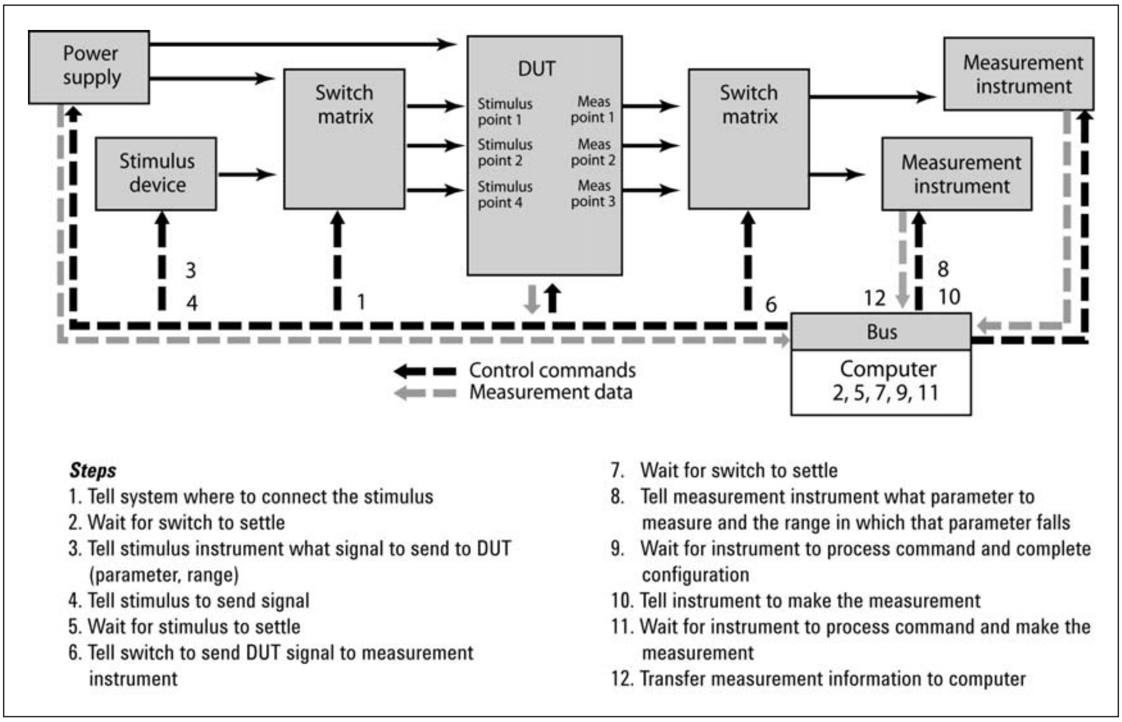
Improving Test Times with Fast Frequency, Amplitude and Waveform Switching

By Heather Lane
Agilent Technologies

The ability of modern test equipment to quickly change test signal parameters helps keep test times manageable with increasingly complex wireless products

Pressure to reduce test costs and increase throughput continues to rise in RF automated test environments (ATEs). One way system designers look to manage costs is to reduce test times. This is commonly done by eliminating unnecessary tests; however, this is becoming increasingly difficult in an industry where more and more functionality is integrated into wireless systems, requiring more tests with more setups and more conditions. Wireless receiver testing, including receiver sensitivity measurements like bit-error-rate (BER), may require multiple broadcast signals such as FM Stereo, GPS or digital video to verify performance. Test complexity carries through to the component level, resulting in performance requirements for multiple communications formats even for components like power amplifiers. Additionally, the convergence of multiple connectivity methods into a single wireless device works against efforts to reduce test times.

Aside from eliminating unnecessary testing, the simplest way to reduce test times is by improving measurement speed. Measurement speed can be improved by optimizing the



Steps
1. Tell system where to connect the stimulus
2. Wait for switch to settle
3. Tell stimulus instrument what signal to send to DUT (parameter, range)
4. Tell stimulus to send signal
5. Wait for stimulus to settle
6. Tell switch to send DUT signal to measurement instrument
7. Wait for switch to settle
8. Tell measurement instrument what parameter to measure and the range in which that parameter falls
9. Wait for instrument to process command and complete configuration
10. Tell instrument to make the measurement
11. Wait for instrument to process command and make the measurement
12. Transfer measurement information to computer

Figure 1 · Steps involved in making a measurement with a typical ATE system.

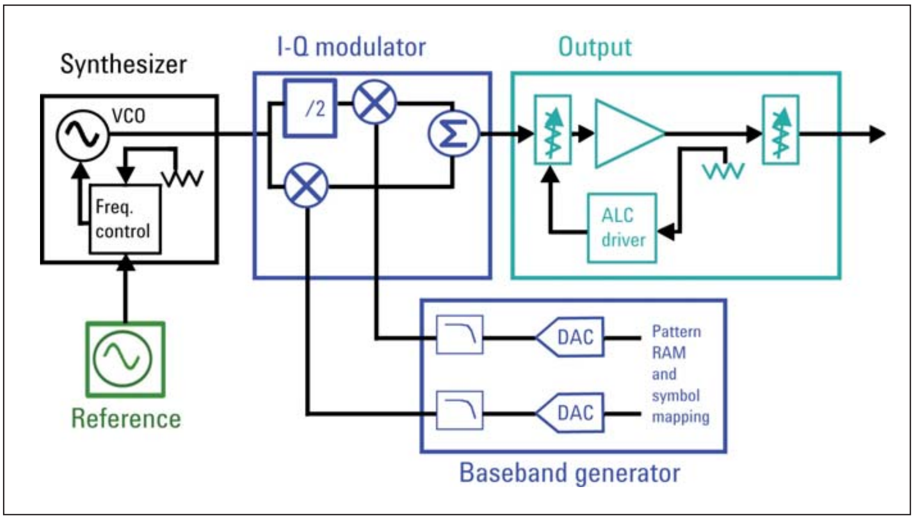


Figure 2 · Typical signal generator block diagram showing frequency generation, power control, and baseband digital waveform generation.

speed of each component within the test system. This article explores the role of signal generators within automated test systems, as well as techniques and trade-offs involved when utilizing fast simultaneous frequency, amplitude, and waveform switching for efficient testing of modern digital communication devices and systems. Whether making gain compression measurements for power amplifiers or calibrating your system, the time required to change your test stimulus contributes to total test time. For a vector signal generator, switching seamlessly not only between amplitude and frequency but from one arbitrary waveform file to another can be critical for optimizing the speed of the test system.

Signal Generators in Automated Test Environments

In order to optimize the speed of a test system it is critical to understand the individual components of the system and how they interact. Figure 1 represents a typical ATE and the steps needed to make a measurement including communicating with each instrument and waiting for commands to be completed. Each component within a test system, from the stimulus to the measurement instrument, incrementally adds to total test time. Steps 3 through 5 represent opportunities where optimizing the use of the signal generator can make an impact on throughput. Many measurements will require the stimulus to change amplitude, frequency and even the baseband signal anywhere from one to hundreds of times, further increasing the contribution from the signal generator to total test time.

Switching time of a signal generator is dependent on both the settling time of the signal and the methods used to programmatically control the instrument. In manufacturing it is important to not only choose a source with sufficient speed in terms of settling time, but to implement programs that best utilize that performance. For example, applications that require the stimulus to change states multiple times often utilize nested loops in the test system program. In nested program loops the inner loop switching time is exercised most frequently. To optimize the program for time, the fastest switching component should be controlled in the inner most loop, as this loop will be exercised in each iteration of the surrounding loops. Improvements in switching speeds that traditionally slow the process, such as waveform switching of a vector signal generator, not only allow system developers to optimize the interaction of the signal generator with other components in the ATE but allow more flexibility when developing the signal generator control programs.

Factors Influencing Signal Generator Switching Time

There are choices users can make when designing and programming the test system that will optimize switching speed of the signal generator. These include defining the sequence of signal generator states, selecting a method to control the instrument, triggering the instrument to change states, and connecting the signal generator within the ATE. Likewise, there are limitations to the ultimate speed of the instrument that are dictated by the architecture of the signal generator, namely the settling time.

There are different methods for measuring and specifying the settling time of a signal generator. The primary consideration when looking at specified settling times of a signal generator is the settling window. The settling window states how close the source is to the desired value before it is considered finished switching. For example, the Agilent MXG signal generators' source frequency is considered settled when the frequency is within 0.1 parts per million (ppm) of the desired frequency. Source amplitude is considered settled when the power is within 0.2 dBm of the desired value.

A block diagram of one type of signal generator is shown in Figure 2; this is similar to the structure of the Agilent MXG signal generators (Figure 3). Two key contributors to settling time are the synthesizer and output sections. Whenever the signal generator is set to a new frequency, the frequency synthesis loop is used to phase lock the voltage controlled oscillator (VCO). Other signal generators use a YIG-based approach for frequency synthesis. While providing a spectrally clean signal this approach results in much slower settling times. When a new power level is set in the Agilent MXG, the automatic level control (ALC) loop is used to set the correct power level by comparing it to a precise reference level. Even when switching one component, frequency or amplitude, both the synthesis and ALC loops need time to settle. Specified switching time of a signal generator takes both these elements into account.

Switching waveforms with a vector signal generator adds more complexity and subsequently more time to the process. In order to change waveforms, the I/Q data must also be computed and downloaded into the playback memory of the vector signal generator. The sample rate and digital-to-analog converter (DAC) values must be computed and stored with the file for accurate playback. This is an area where Agilent MXG vector signal generators have made advances over previous waveform switching techniques. These instruments can switch frequency, amplitude and waveforms in parallel depending on the program control method selected.

Figure 3 · The Agilent MXG signal generator supports the fast frequency and waveform switching required for reduced test times.

Selecting a Signal Generator Control Method

There are various ways to control a signal generator's output in an automated system, each with their own advantages. This article will discuss the drawbacks and advantages of three common control methods.

- SCPI programming each point
- SWEEP mode (list or step)
- Waveform sequencing

SCPI commands are very flexible and can be used to set frequency, set amplitude and playback waveforms loaded in the playback memory of the signal generator. Using SCPI programming to set each point is especially useful when the states are not known prior to testing. For example, some measurement algorithms use iterative commands to set new conditions based on measured results. When measuring the 1-dB compression point of a power amplifier, the amplitude of the signal generator is set, the gain measured, and based on that result a new amplitude setting is calculated. This new value is sent to the signal generator via SCPI and the process repeated. In this example, the software did not have prior knowledge of the setting, so the flexibility of SCPI programming is needed.

One disadvantage of using SCPI control is the time required to send, parse, and process the command before switching can begin. Traditionally separate commands were required to change individual settings, requiring additional time to process two commands when switching both frequency and amplitude for example. However, a new prototype SCPI command implemented in the Agilent MXG signal generators enables both frequency and amplitude switching with a single SCPI command.

Waveform sequencing allows the user to switch between different waveforms loaded in the playback memory of the vector signal generator using SCPI commands. Individual playback segments can be repeated and sequenced in predefined patterns allowing for very fast waveform switching. While waveform switching is seamless it also requires that the frequency, amplitude, and sample rate be the same for all waveforms played back.

Using sweep mode to control the signal generator allows for faster switching speeds than available using SCPI commands, because frequency/amplitude/waveform states are known beforehand. There are various types of sweep modes utilized by signal generators; Agilent MXG offers two of these, step and list. Both require states to be downloaded to the signal generator so the program can sequence through the states in rapid succession. For most signal generators step sweep provides a linear or logarithmic progression from one selected frequency or amplitude setting to the next. List sweep is used to sequence through predefined states at unequal intervals—a random order of frequency/amplitude/waveform states.

Traditionally list sweep could only be used to switch frequency and amplitude. Agilent MXG vector signal generators have added waveform switching capability to list sweep to meet the growing need for testing devices that integrate multiple communications and connectivity technologies. Using list sweep the Agilent MXG vector signal generator can simultaneously switch frequency, amplitude and waveform in less than 900 µs. Unlike waveform sequencing the sample rate of the waveform can differ without impacting switching time.

Summary

As the functionality of modern wireless communication devices expand to cover connectivity methods for voice, data and even video the associated costs, test times, and complexity of verifying those devices increases. To combat these costs and reach throughput goals, test system designers must optimize measurement speed on the production line. Within automated test systems there are many elements that can be the limiting factor in measurement speed, particularly when making complex measurements. While optimizing your system to get the best speed from the signal generator is critical, this is secondary to selecting the correct instrument for your application and system. The signal generator must have the speed, performance and capabilities needed in order for optimization to make a difference. Agilent MXG signal generators offer fast switching speeds and a selection of control methods making them adaptable to different test systems. In addition, they are LXI class C compliant, making integration into modern test systems quick and easy.

There are many approaches for a test system designer to optimize a signal generator for speed. The selection of triggering method, computer I/O and most importantly control method all impact switching speed. Our discussion centers on trade-offs associated with different program control methods available on the Agilent MXG signal generator. For more information on the other factors associated with switching reference Agilent Application note 5989-5487EN, “Improving Throughput with Fast RF Signal Generator Switching,” available at www.agilent.com.

Author Information

Heather Lane is currently a product manager for Agilent Technologies’ Electronic Measurement Group. She joined Agilent Technologies in August of 2004 as a Product Marketing Engineer in the Signal Sources Division. Her expertise is in RF and microwave signal generation. Heather received her BS in Engineering from Harvey Mudd College and her BA in Economics with a focus in macroeconomics from Claremont McKenna College. She can be reached by e-mail at heather_lane@agilent.com