Agilent
Improving Throughput with Fast RF Signal Generator Switching

Application Note

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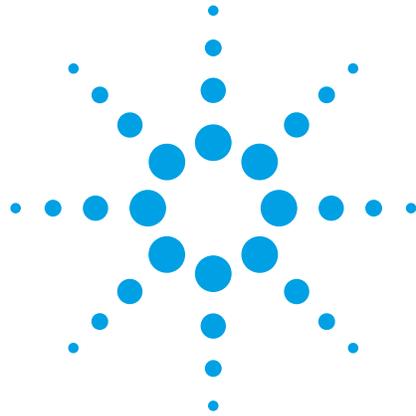
Agilent Technologies

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Introduction

Today's manufacturers of wireless components, devices, and systems face significant pressure to increase throughput and lower the cost of test. Improving the speed of automated test equipment (ATE) can be an important factor in reducing overall test times. This note describes techniques for optimizing RF signal generators within ATEs to reduce test times and improve throughput. Although these concepts can be applied to any signal generator, the examples shown in this note apply to the Agilent N5181A MXG analog and N5182A MXG vector signal generators (250 kHz to 6 GHz). When equipped with the fast switching capability (Option UNZ), these signal generators can switch frequency, amplitude, or waveform in less than 1 millisecond in most cases.

Motivation for faster tests

Wireless manufacturers face significant business challenges. Increased competition and price pressures can result in reduced margins for manufacturers of base stations, mobile units, and RF integrated circuits (RFICs). Test engineers are continuously searching for ways to improve test throughput while management looks for better ways to manage test system assets for higher returns. Despite these efforts, in many cases, the cost of test has actually increased as a percentage of the overall cost.

At the same time, more and more functionality is integrated into wireless systems, requiring more tests with more setups under more conditions. Connectivity methods are expanding to include not just voice and data through GSM and CDMA, but a variety of data connections such as RFID, *Bluetooth*®, WiMAX, and UWB. New broadcast functions are also being supported, such as FM radio, Mobile TV, and Assisted GPS. These modes require testing and verification, over multiple channels, and different power levels, and with realistic waveforms. This can make the efforts to reduce test time and test cost even more challenging.

Application Examples

Shown here is a list of example measurements where source switching time may have a significant impact on reducing measurement time in manufacturing.

- **Test system calibration** – test system calibration may be done weekly or daily and often requires many CW measurements at thousands of frequency and power settings.

- **Device calibration** – many wireless components and devices are designed to store correction factors in on-board programmable memory. Measuring correction factors may require many channels, many levels, and multiple waveforms. Some wireless device manufacturers are now specifying test waveform sequences to be used for calibration of GSM and CDMA devices.

- **Broadcast receiver measurements** – wireless devices incorporating receivers for broadcast signals such as FM Stereo, GPS, or digital video require performance verification. In some cases, this may be a simple receiver sensitivity measurement, and in others bit-error-rate (BER) measurements may be required. In either case, rapid switching of frequency, amplitude, and waveform may be required.

- **Multiple waveform testing** – many automated test procedures require multiple waveforms, for example, to measure distortion through an amplifier with different waveform types or to verify functionality of a variable adaptive data rate system, e.g. 8PSK and QPSK.

- **Gain compression testing** – amplifier gain compression can be measured by varying the power in. Exact gain compression points, such as 1 dB gain compression can be measured using iterative measurements to zoom in on the specific gain compression point.

This note provides general guidance on how to program the source for these applications. Implementation-specific details may require additional sources; see References or contact your Agilent sales representative for more information.

Understanding the Role of the Signal Generator

To optimize a signal generator, it is important to understand its role in the ATE system and how it is programmed in relation to other elements in the system.

Throughput versus switching speed

Figure 1 represents a typical ATE system and the steps needed to make a typical measurement. Overall throughput is normally stated per measurement or per device, and is determined by many factors besides the signal generator settling shown in step 5. However, in highly repetitive test sequences, the signal generator may be stepped to hundreds or thousands of points becoming a significant factor in overall test time. In these cases, it is critical not only to choose a source with fast switching capabilities, but also to implement test programs that take advantage of this speed.
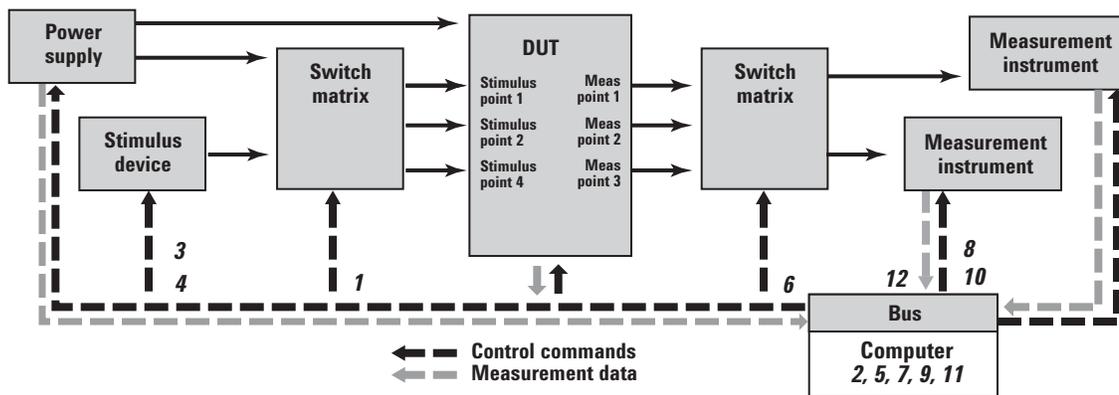
Steps
1. Tell system where to connect the stimulus
2. Wait for switch to settle
3. Tell stimulus instrument what signal to send to DUT (parameter, range)
4. Tell stimulus to send signal
5. Wait for stimulus to settle
6. Tell switch to send DUT signal to measurement instrument
7. Wait for switch to settle
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 measurements with a typical ATE system

Some quick calculations can help determine the impact of source switching time on system throughput. For a given measurement, the total source switching time can be estimated by multiplying the point switching time by the number of source settings. Many measurements may require changes in frequency, amplitude, and waveform settings, and each type of change may have a different switching time specification.

Switching speed specifications

There are a variety of techniques for measuring and specifying switching speed. Important considerations are typically step size constraints; limitations on the size of the step, and the settling window; that is how close to the desired value the source is before it is considered finished switching.

It is important to consider the times for frequency, amplitude, and waveform switching, depending on the application. Agilent MXG frequency and amplitude settling times for LIST sweep and SCPI modes are shown in Table 1.

Table 1. Source settling times for the N5182A Agilent MXG vector signal generator with Option UNZ

Switching Mode/conditions	Frequency	Amplitude	Waveform
Digital Modulation OFF			
SCPI mode	1150 µs	750 µs	N/A
Sweep mode	900 µs	500 µs	N/A
Digital Modulation ON			
SCPI mode	1150 µs	1150 µs	1200 µs (typ)
Sweep mode	900 µs	900 µs	900 µs (typ)

Notes:

• The values shown in the table are worst case. Typical switching times are up to 40% faster. The typical values can be measured on an oscilloscope by monitoring the TRIG OUT line during a sweep.

• The Agilent MXG source frequency is considered settled when the frequency is within 0.1 parts per million (ppm); the specification applies when switching to or from frequencies >500 kHz.

• The amplitude is considered settled when the amplitude is within 0.2 dBm; the specification applies when switching to or from amplitudes <+5 dBm.

• The SCPI switching times shown in the table include the command processing time, but do not include the time for sending the command over the bus. This additional delivery time may be 0.5 to 1.5 ms or more, depending on the I/O configuration, PC performance, PC load, LAN traffic, and other factors.

• Without Option UNZ, all switching speeds are 5 ms typical. See *Agilent N5182A MXG Vector Signal Generator Data Sheet*, Aug 17, 2006 5989-5261EN for complete specifications.

Optimizing nested loops

A test sequence may require that the DUT be tested with different frequency, amplitude, and waveform conditions. For example, a GSM/GPRS/EGPRS device calibration may require 10 channels in 4 bands (40 frequencies), 8 power levels, and 2 waveforms, for a total of 640 stimulus conditions. Applications like this require nested loops in the program, as represented in Figure 2. Planning how to nest the loops may have an important impact on throughput.

The switching interval of the inner loop, loop 3 in the diagram, is exercised most frequently, since the number is multiplied by the number of repetitions in loop 2 and then multiplied again by the number of repetitions in loop 1. For optimal time, the fastest switching characteristic should be placed in loop 3, and the slowest in loop 1. Note that LIST sweep mode, discussed later, allows up to 1601 points with arbitrary frequency, amplitude, and waveform settings, and fast switching less than 1 ms per point. Multiple loops can be embedded in a single LIST.

Test flow diagram — nested programming loops

Loop 1
    Contains stimulus conditions that take a long time
    to change or set up.

Loop 2
    Contains test variables that take less time to
    change or set up.

Loop 3
    Contains test variables that take the least time
    to change or set up.
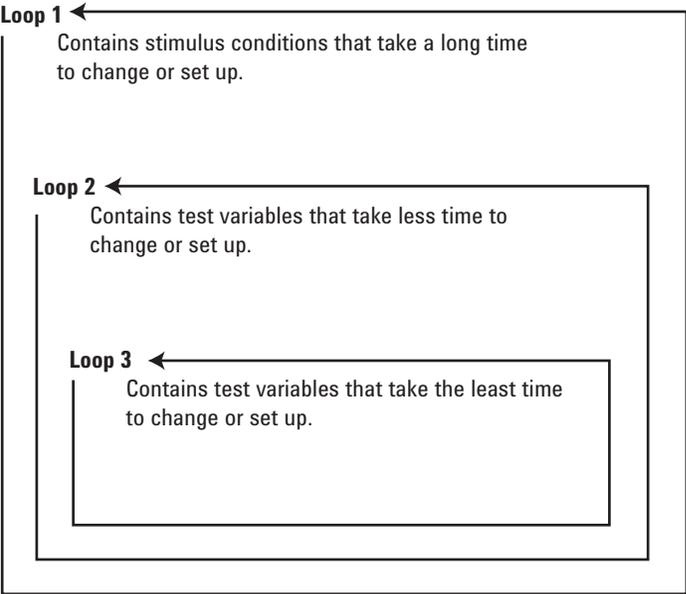
Figure 2. Nested programming loops for changing RF signal generator conditions

Traditionally for signal generators, waveform switching has been the slowest, and has therefore been in loop 1. When switching between waveforms in the internal baseband generator, the Agilent N5182A vector signal generator waveform switching times are very close to the amplitude and frequency switching times. This may enable the programmer to switch waveforms to loop 2 or loop 3, while maintaining or improving throughput, depending on the application.

Downloading waveforms

When using the N5182A vector signal generator, waveforms can be stored within the internal 64 Megasample (MS) baseband generator or 100 MS of non-volatile memory. Downloading the waveforms from the computer or from the non-volatile memory can take seconds or even minutes; a typical transfer rate over LAN into the baseband generator is 270 kilosamples per second. This can therefore become a significant part of throughput for some applications. Waveform loading should therefore be done as infrequently as possible. This may be difficult when using very large waveforms such as video waveforms used in Satellite Digital Multimedia Broadcast (S-DMB). See the *Agilent MXG Programming Guide and SCPI Reference Manual* for more information.

Source switching speed background

RF signal generators have advanced to include many modern digital features. But switching characteristics and limitations are often inherent in the RF architecture. A typical signal generator block diagram is shown in Figure 3.
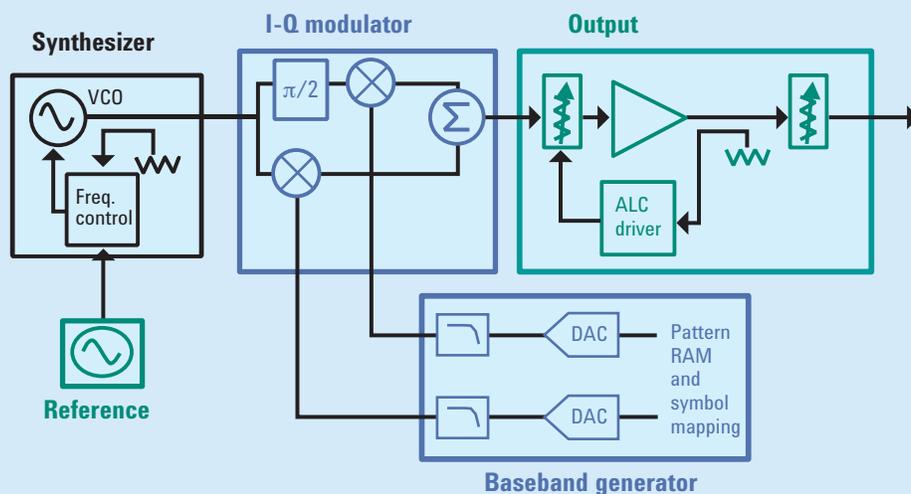
Figure 3. Typical signal generator block diagram showing frequency generation, power control, and baseband digital waveform generation

Whenever the signal generator is set to a new frequency, the frequency synthesis loop is used to phase lock the voltage controlled oscillator (VCO). Whenever a new power level is set, the automatic level control (ALC) loop is used to set the power versus a precise reference. The switching behavior depends on step size and is subject to inherent bandwidth limitations and settling times.

For digital waveforms the I/Q data must also be computed and downloaded into the playback memory. The sample rate and digital-to-analog converter (DAC) values must be computed and stored with the file for accurate playback. The N5182A vector signal generator has 64 Megasamples of playback memory.

More information about Signal Generator basics can be found in *Signal Sources Back to Basics Seminar* at **www.agilent.com/find/sources.**

Choosing the Signal Generator Control Method

There are various ways to control the signal generator's output (frequency, amplitude, waveform) in an automatic system. For each measurement or set of measurements, one method may have significant advantages over the others. The Agilent MXG has the following methods available.

• SCPI programming each point
• SWEEP mode (LIST or STEP)
• Waveform sequencing

These methods will be discussed in further detail, along with a summary of their benefits to facilitate comparisons.

SCPI programming each point

SCPI commands are very flexible and can be used to set not only frequency and amplitude in the signal generator's range, but also to play back any waveform in the playback memory. Example SCPI commands for setting frequency, amplitude, and waveform are shown below.

• FREQuency:FIXed <value><unit> sets the RF signal generator frequency.
• POWer:AMPLitude <value><unit> sets the RF power level.
• RADio:ARB:WAVeform "WFM1:file_name" selects a waveform file or sequence, for the dual ARB player to play. The file must be present in volatile memory, WFM1.

Using SCPI programming to set each point is especially useful when the frequency/amplitude/waveform states are not initially known. For example, some measurement algorithms use iterative commands to set new conditions based on measured results. For example, to measure the exact 1dB compression point, the power is set, then the gain is measured, and based on that result, a new power setting is calculated and then the value is sent to the signal generator via SCPI. In this case, the software did not have prior knowledge of the power setting, so the flexibility of SCPI programming is needed.

Due to SCPI command sending, parsing, and processing, there is overhead time when using SCPI commands before the switching can begin. A typical timing diagram is shown in Figure 4. Note that each of the SCPI commands uses a command to set either frequency or amplitude or waveform. Traditionally, if more than one parameter needs to be changed, e.g. frequency and amplitude, multiple SCPI commands are required and therefore additional switching time is needed. However, a new prototype SCPI command implemented in the MXG signal generators enables both frequency and amplitude switching with a single SCPI command. This choice of units streamlines processing and can cut switching time in half. The command is:

FPFAST freq, power
where freq is the frequency in milli-Hertz and power is the power in milli-dBm.

If the frequency/amplitude/waveform combination is known beforehand, then using STEP or LIST sweep, which can switch multiple parameters simultaneously, will be significantly faster.

Computer I/O considerations

The choice of computer I/O can also impact throughput when using SCPI programming. GPIB (IEEE-488-2) has the shortest latency; commands are transferred very quickly, up to 500 KBytes/sec for a 1-meter cable. USB and LAN have longer transfer periods, and a typical command may take up to 1.5 ms to transfer. However, USB and LAN provide faster data throughput and offer better performance for larger data transfers such as when downloading waveforms or LIST sweep parameters. GPIB offers better speed performance when programming every point via SCPI, and faster triggering for sweep mode using group execute trigger (GET). See the section, "Choosing the Best Triggering Method" for more information on triggering the Agilent MXG signal analyzers over the bus.

Note that the LAN interface on the Agilent MXG provides full SCPI remote programming functionality, and is LXI class C compliant. For more information, see *Application Note 1465-2, Test-System Development Guide, Computer I/O Considerations* and *Applicatioan Note 1465-22, Transitioning from GPIB to LXI, Examining Similarities, Differences and Best Practices*. The Agilent MXG LAN interface is also used to access the internal web server and FTP server, for example to display the MXG user interface on the computer.
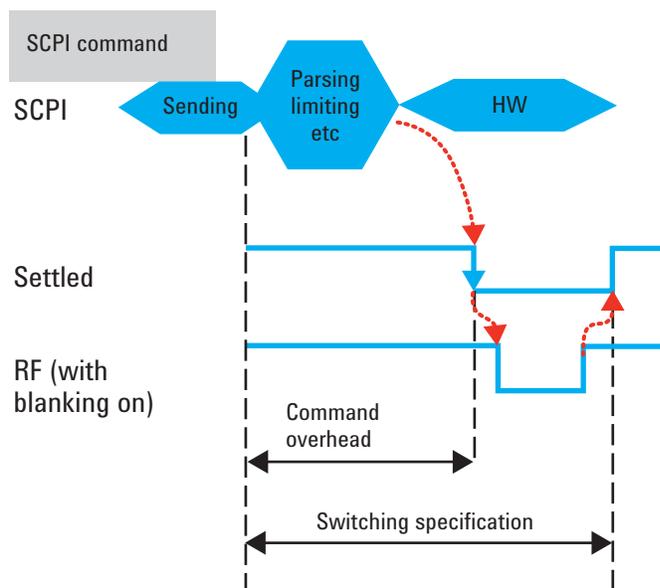
Figure 4. SCPI command processing - time for processing is significant compared to time for switching

Sweep mode (STEP/LIST)

In sweep mode, either STEP or LIST, the frequency/power/waveform states are known in advance, and are downloaded to the signal generator. The program can then sequence through the states in rapid succession. STEP sweeps are for fixed steps of frequency or amplitude only and the steps are fixed in either linear or log format. In the case of LIST sweeps, frequency, amplitude, and waveform can be set in the predefined list with switching time between points typically less than 600-800 µsec. Taking advantage of this switching time will depend upon the triggering method used.

Agilent MXG SWEEP types

The Agilent MXG has two methods of sweeping through a pre-defined set of signals:

- **Step sweep** provides a linear or logarithmic progression from one selected frequency/amplitude setting to the next, pausing at linearly or logarithmically spaced points (steps) along the sweep base. The sweep can progress forward, backward, or manually. The number of steps in a STEP sweep can be from 2 to 65,535. An example of the Step Sweep menu on the Agilent MXG is shown in Figure 5.

Figure 5. N5182A Agilent MXG vector menu showing Step Sweep, and start/stop values of frequency and amplitude as well as number of points, dwell time, and other settings

- **LIST sweep** enables the user to enter frequencies and amplitudes at unequal intervals, in nonlinear ascending, descending, or random order. Like waveform sequencing, list sweep also lets you to jump to any waveform stored in the playback memory. But list sweep also can accommodate different sample rates and DAC settings in the waveform, and allows frequency and amplitude settings to be set at each point. The number of steps in a LIST sweep can be from 1 to 1601. An example of the list sweep menu on the Agilent MXG is shown in Figure 6.

Figure 6. N5182A Agilent MXG vector menu showing LIST sweep, and values of frequency and amplitude and waveform, dwell time, and other settings

Waveform sequencing

The signal generator's on-board playback memory can be loaded with multiple waveform types. Individual playback segments can be repeated and sequenced in predefined patterns and the user can send SCPI commands to switch to different locations in the playback memory. An example sequence is shown in Figure 7.
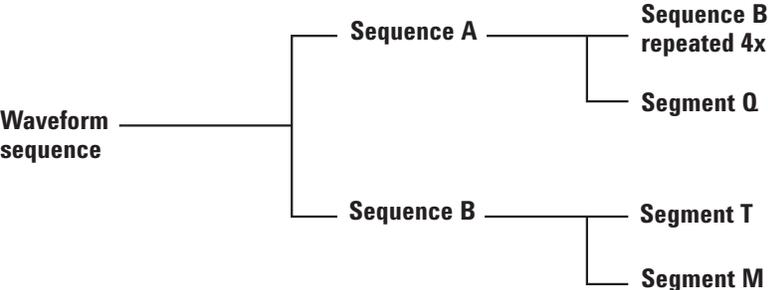
Figure 7. Example of waveform sequencing using multiple segments in the playback memory

Waveform sequencing offers advantages of very fast waveform switching and continuous transitions from one waveform to another. However, waveform sequencing requires that the frequency, amplitude, and sample rate be identical in all segments. ATE applications often require switching signals with different sample rates as well as frequency and amplitude settings. In this case, sweep mode in the Agilent MXG may be preferred. Sweep mode enables the source to jump to any pre-configured frequency, amplitude *and waveform* state, including different sample rates. A brief description of the Agilent MXG sweep modes is provided in the section, "Choosing the Signal Generator Control Method".

A summary of the signal generator programming methods and their key characteristics is shown in Table 2.

Table 2. Signal generator programming methods

	SCPI programming	STEP sweep	LIST sweep	Waveform sequencing
Description	Sends SCPI program commands to set signal generator conditions	STEPs from start to stop value, with increments defined by the number of points	Configures LIST of settings and steps through the list	Sequences through wave-form segments installed in the playback memory
Applications	General automated test, iterative measurements; when settings are not known ahead of time and when fastest source switching is not required	Swept frequency response; gain vs. power measurements, test system calibration. Settings are known in advance	Automated or manual test. Settings are known in advance	R&D; production applications where sample rate flexibility is not required
Frequency/ amplitude/ waveform settings	Frequency or amplitude or waveform (one at a time)	Frequency or amplitude only (one at a time)	Frequency, amplitude, waveform (simultaneous)	Waveform only
STEP types	Arbitrary	Fixed steps, linear or log	Arbitrary	Sets up sequence to loop and repeat
Number of points	Unlimited	2 to 65,355	1 to 1601	N/A
Triggering types	N/A	Free run, key, bus, external, timer	Free run, key, bus, external, timer	Free run, key, bus, external, timer

Choosing the Best Triggering Method

When using STEP or LIST sweeps, sweep triggering can be used to control the start of the sweep, and point triggering can be used to control how the program steps through the points.

Both the sweep trigger and point trigger have the following modes.

- *Free Run* – This mode has no trigger; the sweep is begun whenever the source is ready without waiting for any external trigger. When the point trigger is set to free run, the signal generator pauses for a known "dwell time" prior to proceeding to the next point. Dwell time is set by the programmer, and can be a single value for all points in a STEP sweep or a different value for each point in a LIST sweep. Dwell time can be set from 100 µs to 500 sec.

- *Trigger Key* – Operator manually triggers the sweep or point using the front panel key *Trigger*. This mode is useful either when debugging or trouble-shooting, or when user intervention is required between triggers, for example in reconnections or other settings.

- *Bus Trigger* – Triggers on a remote command, eg. *TRG.

- *External Trigger* – Triggers on a TTL/CMOS signal to the rear panel TRIGGER IN connector. This can be set to positive or negative, ie. high true or low true.

- *Timer Trigger* – Triggers periodically using a timer built into the signal generator. The timer can be set from 0.5 ms to 1000 sec. Note that this is different from free run with dwell time, because *Timer Trigger* is independent of the switching time.

The sweep trigger is most commonly configured to *Free Run* or *Bus Trigger*. Because most sweeps include many points, throughput is often most dependent upon the choice of point trigger mode. Point triggering considerations when using bus and external trigger modes are described in more detail below.

Hardware triggering

Bus triggering each point requires time to process trigger commands and implement them in the hardware of the instrument. Hardware triggering can provide faster responses, not only in setting the source but also in monitoring its condition, thereby minimizing the dead time for waiting or processing commands.

External triggering uses trigger input and output signals to and from the signal generator's rear panel BNC connectors. These signals need to interface with other instruments that are normally also under program control in the ATE system. The programmer must use extra care to ensure that trigger transitions arrive when expected, and that the measurement is not left hanging in an uncertain state.

A typical timing diagram for hardware triggering using the Agilent MXG is shown in Figure 8 including both the source and the measuring instrument. Note that a Source TRIG IN signal is received. The Agilent MXG takes about 50 µsec to process this event and to pull the TRIG OUT line inactive (low). After approximately another 50 µsec the source settled line is pulled inactive (low) and the source begins the process of moving its frequency, amplitude, and waveform to their new setting. After this is completed, the source settled line is made active (high), and then the TRIG OUT line is made active after an interval of about 50 µsec. Either the source settled signal or the TRIG OUT signal can be used to start the measurement. Note, however, that the source is only ready to take a new trigger after the TRIG OUT line is made active (high). Usually the measurement takes more than 50 µsec so that is not usually an issue. Once the measurement is complete, a new Source TRIG IN signal is received, and the cycle is repeated for each point in the list.
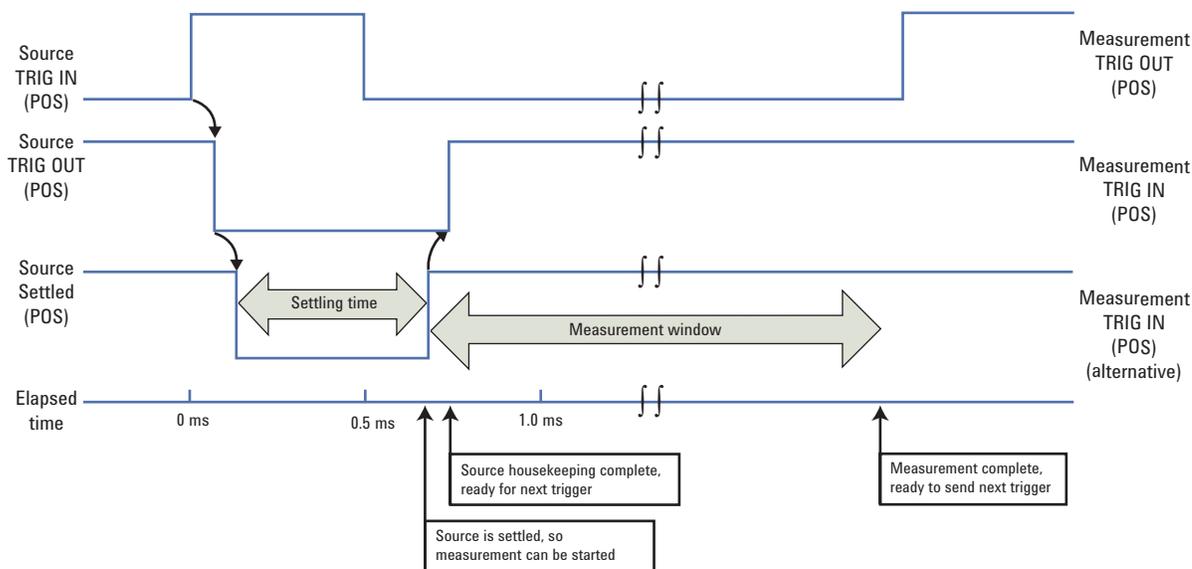
Figure 8. External triggering using the Agilent MXG

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Bus triggering

Using the bus for point triggers is convenient, and does not require synchronization of TTL/CMOS signals. However, due to command processing times, it is slower than external hardware triggering. In Bus Trigger mode, a command such as *TRG is used to step to the first point. The typical Bus Trigger timing diagram is shown in Figure 9.
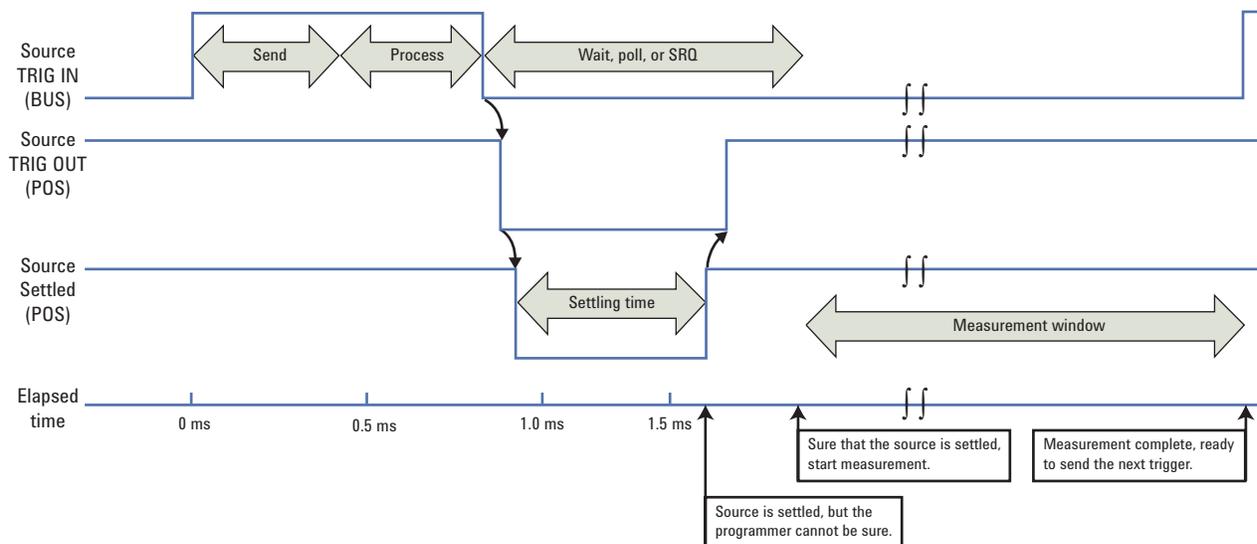
Figure 9. Timing diagram for bus triggering using the Agilent MXG

For each point, a trigger command is issued. The programmer must choose a method for determining when the source is ready, that is when the amplitude, frequency, and waveform are settled and measurements can be taken. Common techniques include the following:

- Waiting a fixed time interval – This method is simply waiting for a time equal to the worst case specification of the source settling time before proceeding.

- Enabling interrupts (GPIB) – Using GPIB, the source can be set up to issue an interrupt request over the IEEE-488 bus when the source is settled. This improves speed because it reduces processing time.

- Polling the status register for source settled signal – This is not normally recommended when optimizing switching speed because executing this command typically takes 1.5 msec, which is longer than the worst case switching specification. However, polling does offer a general solution and more comforting reassurance that the source did indeed settle. The Agilent MXG status register includes the source settled status. The programmer can monitor the transitions in individual bits and therefore inquire about the status of source settled.

When the program is sure that the source is ready – verified by using waits, interrupts, or polling – then the program can proceed with the next step, which is usually a measurement sequence using the measurement instrument. Once the measurement is completed, the next source setting in the list can be triggered with a new *TRG command. This "fire when ready" approach is repeated for all the points in the LIST or STEP sweep.

Optimizing bus triggering

Bus triggering can take advantage of VISA drivers to make a general trigger independent of I/O configuration, but which will take advantage of the best method, eg. GET trigger for GPIB. This requires setting up a VISA session and using the AssertTrigger statement. Shown below are the required lines in the program, shown in C# programming language.

First, set up the VISA session:

```
Ivi.Visa.Interop.IResourceManager rmc = new

vi.Visa.Interop.ResourceManagerClass();

Ivi.Visa.Interop.IVisaSession session =
    rmc.Open(visaAddress,Ivi.Visa.Interop.AccessMode.NO_LOCK, 2000, "");

Ivi.Visa.Interop.IMessage msg = (Ivi.Visa.Interop.IMessage)session;
```

Then, to assert a software or hardware trigger, dependent on the interface type e.g. GET with GPIB or *TRG with LXI, send the AssertTrigger:

```
msg.AssertTrigger(Ivi.Visa.Interop.TriggerProtocol.TRIG_PROT_DEFAULT);
```

Implementing the Program

Once the planning is complete, the programmer can begin to write code. This section provides a summary of tips and techniques and a typical process flow. For details about more programming, please refer to the *Agilent MXG Programming Guide and SCPI Reference Manual*.

Agilent MXG switching speed tips and techniques

- Use sweep mode (LIST or STEP) and external point triggering for the fastest results. This avoids SCPI command processing for each point.

- Use the Source Settled signal instead of TRIG OUT to save an additional

  50 µsec per point. To route Source Settled to the TRIG OUT BNC, use the command ROUT:TOUT SETT.

- Use LIST mode when changing waveforms and when changing frequency and amplitude simultaneously.

- Turn off sweep retrace when multiple sweeps are taken, since this adds one additional switch to the ending/beginning of the sweep. The command is LIST:RETR OFF.

- When using bus or hardware triggering, try to avoid polling of status bits for each point, since this typically takes 1.5 msec, which is longer than the worst case switching specification. It is faster to use a delay for the worst case specified switching time expected.

- Turn off SCPI status bits if not used to save an additional 50 µsec per point. The command is STAT:OPER:SUPPRESS ON.

- Use GPIB for the fastest switching of arbitrary frequency and amplitude states, since GPIB has the lowest latency. Use interrupts to coordinate bus triggering on GPIB.

- Store as many of your waveforms as possible in the baseband generator; if downloading from the computer is needed, do it as infrequently as possible to save time. Use USB or LAN for best throughput.

Example program sequence

The typical program sequence is shown in the flowchart in Figure 10, along with a description of the functions and example SCPI commands that may be used.
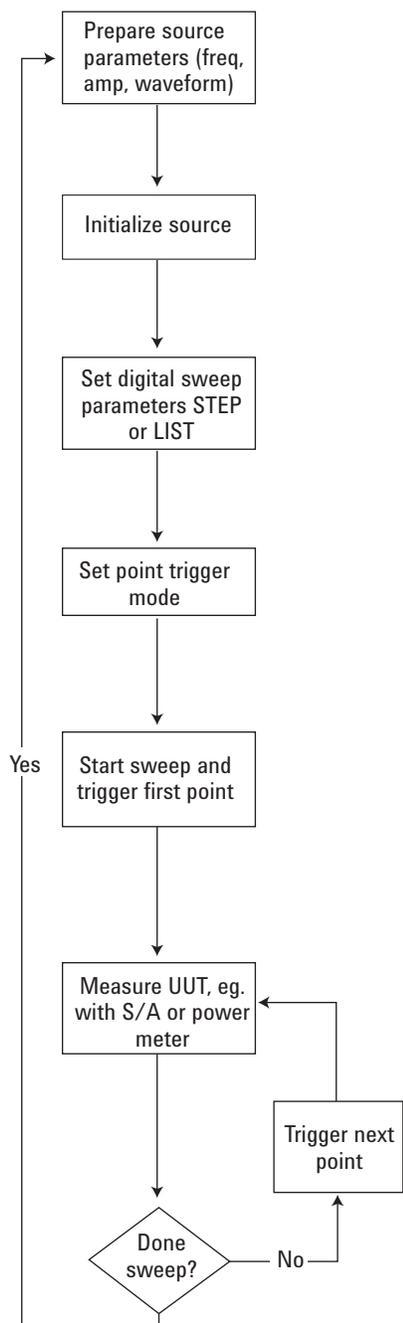
Table 3. Example program flow and typical functions performed[1]

Step	Example program functions	Example SCPI commands
Prepare source parameters	Prepare sweep parameters, eg. start, stop, #points Decide trigger type and method Prepare strings for LIST Download waveforms into baseband generator	

Initialize source	Clear status registers
	Reset to known conditions
	Set display to desired state
	  (OFF is slightly faster)
	Set single or continuous sweep mode
	Turn retrace OFF
	Suppress SCPI status bits
	  (optional for best speed)
		*CLS
		*RST
		DISP:REM ON
		
		INIT:CONT OFF
		LIST:RETR OFF
		STAT:OPER:SUPPRESS ON

Set sweep parameters	STEP mode
	  Select swept frequency mode
	  Start frequency (or amplitude)
	  Stop frequency (or amplitude)
	  Number of points
	  Dwell time (immediate trigger only)
	  Linear or log spacing between steps
	  Set other non-swept parameters
	    E.g. amplitude
	    E.g. waveform
	    Turn on ARB if used
		LIST:TYPE STEP
		FREQ:MODE LIST
		FREQ:START *freqStart* MHz
		FREQ:STOP *freqStop* MHz
		SWE:POIN *freqPoints*
		SWE:DWEL *dwelltime*
		SWE:SPAC LIN
		POW:MODE FIX
		POW *amplSingle* dBm
		RAD:ARB:WAV *waveformSingle*\
		RAD:ARB ON

Set sweep parameters LIST	LIST mode – Preset list
	  List mode
	  Enter powers
	  Download string of amplitudes (and/ or frequencies and/or waveforms)
	  Dwell time (immediate trigger only)
	  Set other non-swept parameters
	    Eg. Frequency
	    Eg. Waveform
	    Turn on ARB if used
		LIST:TYPE:LIST:INIT:PRES
		LIST:TYPE LIST
		POW:MODE LIST
		LIST:POW *amplListString*
		LIST:DWEL dwelltime
		FREQ:MODE FIX
		FREQ *freqSingle* MHz
		RAD:ARB:WAV *waveformSingle*\
		RAD:ARB ON

Set point trigger mode	Set up source point trigger (EXT, IMM, BUS)
	For EXT only
	  Route TRIG OUT to BNC, eg. Settled
	  Set polarity for TRIG IN
	  Set polarity for TRIG OUT
		
		LIST:TRIG:SOUR EXT
		ROUT:TOUT:SETT
		TRIG:SLOP NEG
		TRIG:OUTP:POL POS

Start sweep	Turn on modulation if used Turn on RF Initialize sweep and trigger first point	OUTP:MOD ON OUTP ON INIT
Trigger points	Trigger points Measure with measuring instrument	*TRG (for bus trigger only) Group Execute Trigger, eg. AssertTrigger (GP-IB)
Done?	Check status for end of sweep (loop done or status bit 3 zero?)	STAT:OPER:COND?

1. Example SCPI commands are shown, refer to *Agilent MXG Programming Guide and SCPI Reference Manual* for complete information

Figure 10. Example simplified program flow for source control

References

- *System Throughput and Optimizing System Deployment (Application Note 1465-7)*, December 2004, 5988-9822EN

- *Test-System Development Guide, Choosing Your Test-System Software Architecture (Application Note 1465-4)*, May 7, 2004, 5988-9819EN

- *Test-System Development Guide, Choosing Your Test-System Hardware Architecture and Instrumentation (Application Note 1465-5)*, November 10, 2003, 5988-9820EN

- *Test-System Development Guide, Computer I/O Considerations (Application Note 1465-2)*, September 25, 2003, 5988-9818EN

- *Transitioning from GPIB to LXI: Examining Similarities, Differences and Best Practices (Application Note 1465-22)*, April 3, 2006, 5989-4373EN **http://cp.literature.agilent.com/litweb/pdf/5989-4373EN.pdf.**

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