How to Connect Two or More Signal Generators to Create a Multi-Channel Waveform Generator

Application Note 1426

Introduction

A single-channel function generator or arbitrary waveform generator meets the needs of most engineers most of the time. But occasionally you face a measurement challenge where you need to have two or more source channels locked together in frequency and phase.

To deliver maximum performance at a reasonable price, test-equipment manufacturers design most function generators with a single channel. Single-channel instruments can be simpler and easier to use than multi-channel instruments. In an environment where engineers tend to share test equipment, it makes sense to purchase single-channel sources and use two single-channel sources in tandem when you need multiple channels, rather than spending a limited budget on a single, dual-channel instrument. With single-channel sources you can disconnect the units and use them separately again when you are finished.

This application note describes the steps you need to take to connect two or more signal generators to create a multi-channel waveform generator.

Connecting two or more function generators

The primary advantage of a dual-channel source is that both waveforms are generated from the same clock source. As a result, both waveforms have the same reference (clock) frequency and are phase-locked together. Phase-locked waveforms maintain a constant phase offset from one another and do not drift. You can use an oscilloscope to observe this constant phase offset. If the two waveforms are not phase-locked, the oscilloscope will only be able to freeze (trigger on) one of the waveforms; the other waveform will appear to "walk."

To phase-lock two or more single-channel sources, you need a common clock signal, often called an "external reference."

Agilent Technologies offers two models of single-channel function/arbitrary waveform generators: the 33120A, an economical 15-MHz source, and the 33250A, an 80-MHz higher-performance generator.

If you want to combine multiple 33120As, you need to add optional external reference and BNC connectors (Option 001) to each generator so they will accept the external reference. If you already own a 33120A, you can look at the rear panel and determine if it has the optional BNC connectors below the labels "Ext Ref In" and "Ref Out." If your 33120A does not have Option 001 installed, usually it
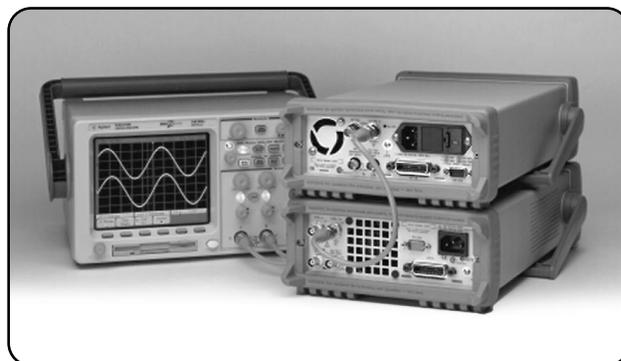

Figure 1: A 33120A (top) receiving an external reference signal from a 33250A (bottom).

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can be retrofitted. You can read more about retrofitting the option on Agilent's Web site. Use the site search engine to find part number 33120-80001.

The higher-performance 33250A includes external reference capabilities as a standard feature.

External clock frequencies may vary slightly, and both the 33120A and 33250A can synchronize to a signal that is not perfectly calibrated. The table below shows the acceptable frequency range for the generators.

	Lowest External Reference Frequency	Highest External Reference Frequency
33120A	10 MHz - 50 Hz	10 MHz + 50 Hz
33250A	10 MHz - 35 kHz	10 MHz + 35 kHz

Table 1: Acceptable frequency ranges

The 33120A function generator's datasheet has more details about the external reference signal. The good news is that if you are using multiple 33120As or 33250As, you can use one unit to supply the external clock signal to the other units with a BNC cable. Once the generators are locked, you can set the actual phase difference between the two generators.

Typically, you start by determining the phase difference between the signals. And, then adjust the
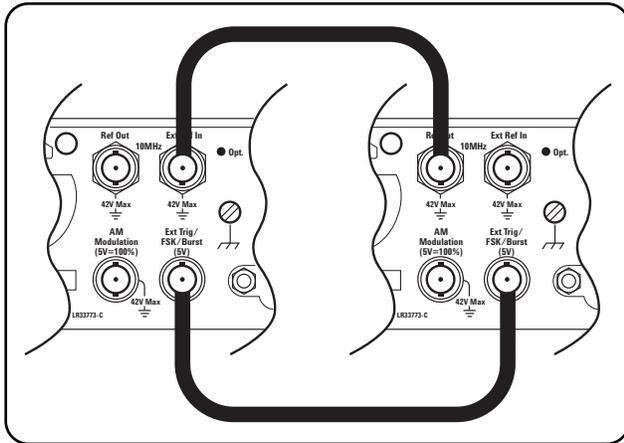

Figure 2: Two phase-locked 33120A generators. The generators are using a common clock signal and a common trigger signal.

More on phase-locking

The term "phase-lock" may have several different meanings, depending upon how it is used with instruments. Analog generators tend to have poor stability and rely upon an external phase-lock loop to create additional stability. The function generator could be locked to any signal within its frequency range. Today, lab-quality function/arbitrary waveform generators use built-in clocks and digital circuitry for precise frequency control. These waveform generators can also be referenced to an external source, to which the generator will phase lock.

It is important to note that digital function generators will lock only to cardinal frequencies (for example, 10 MHz, 1 MHz, 1 kHz, etc.). Most generators will be able to lock onto a range of frequencies near the cardinal frequency (±50 Hz). Some will allow harmonics of the cardinal frequency or multiple frequencies.

Once a function generator is phase-locked to another function generator, the two generators will have an unknown phase offset. Usually you can manually adjust the phase or use a common trigger to start the waveforms simultaneously.

phase difference to the desired amount. A scope or universal frequency counter can be used to observe the phase relationship between the two instruments. The phase relationship can be changed via the front panel of the source or programmatically.

Alternately, you could trigger both generators using a common trigger signal. With both the 33120A and the 33250A, there is a second BNC available so you can use the Trig In/Out BNC of one generator to trigger the other generators. Sharing a common trigger will create a phase offset of 25 ns or less when you trigger a 33120A and 1 ns when you trigger a 33250A. However, you can set the phase difference even more precisely with a scope or counter and manually adjusting the offset, as mentioned earlier.

Using different frequencies

In most multi-channel applications, you will use the channels at the same frequencies. However, you can set the function generators independently to any frequencies. For example, you could set one generator to 60 Hz and the other generator to 60.0001 Hz.

More commonly, you would set one generator to an even multiple of the other generator's frequency. You could use this setup to create a trigger at the max and min of a waveform. Use the first generator to create a sine wave at 60 Hz. Use the second generator to create a square wave at 120 Hz. Add a phase offset so that the square wave has a falling edge at the peak and the minimum of the sine wave.
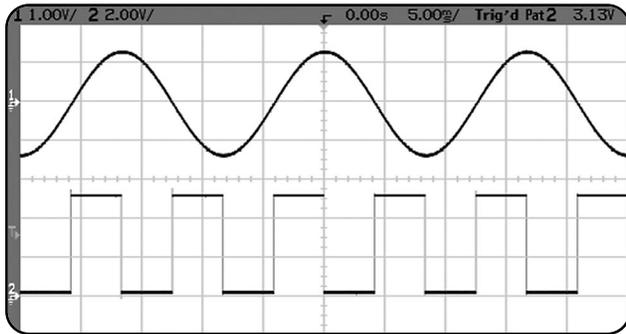

Figure 3: Falling edge of square aligned with max/min points of sine

Summary

It is simple to connect two or more signal generators to create a multi-channel waveform generator. This technique works for all types of waveforms: sine waves, square waves, and arbitrary waveforms. When you need only a single channel you can disconnect the units and use them separately.

Glossary

BNC (Bayonet Neill Concelman) – a type of connector commonly used with coaxial cables, often referred to as simply a bayonet connector

External clock reference – the reference signal used for timing purposes obtained from a source external to the system, or for the purposes of this article, external to the instrument

Frequency lock – The state that occurs when an oscillator is controlled by a frequency-correcting feedback loop for at least one cycle. Note: Phase locked oscillators are also in frequency lock, but oscillators controlled by a frequency lock do not necessarily maintain phase lock.

Phase drift – the change seen during the free run of two signals of slightly different periods. The phase of one signal will vary slightly but consistently in relation to a specific phase angle of the reference signal.

Phase lock – the state that occurs when an oscillator is controlled by a phase-correcting feedback loop for at least one cycle. A constant phase relationship is maintained between the phase of the oscillator and the reference signal of the feedback loop.

Phase offset – the phase difference between two signals; may be defined in phase time (seconds) or phase angle (radians or degrees)

Related Agilent Literature

Data sheet — 33120A Function/Arbitrary Waveform Generator, pub. no. 5968-0125EN

Data sheet — 33250A Function/Arbitrary Waveform Generator, pub. no. 5968-8807EN

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