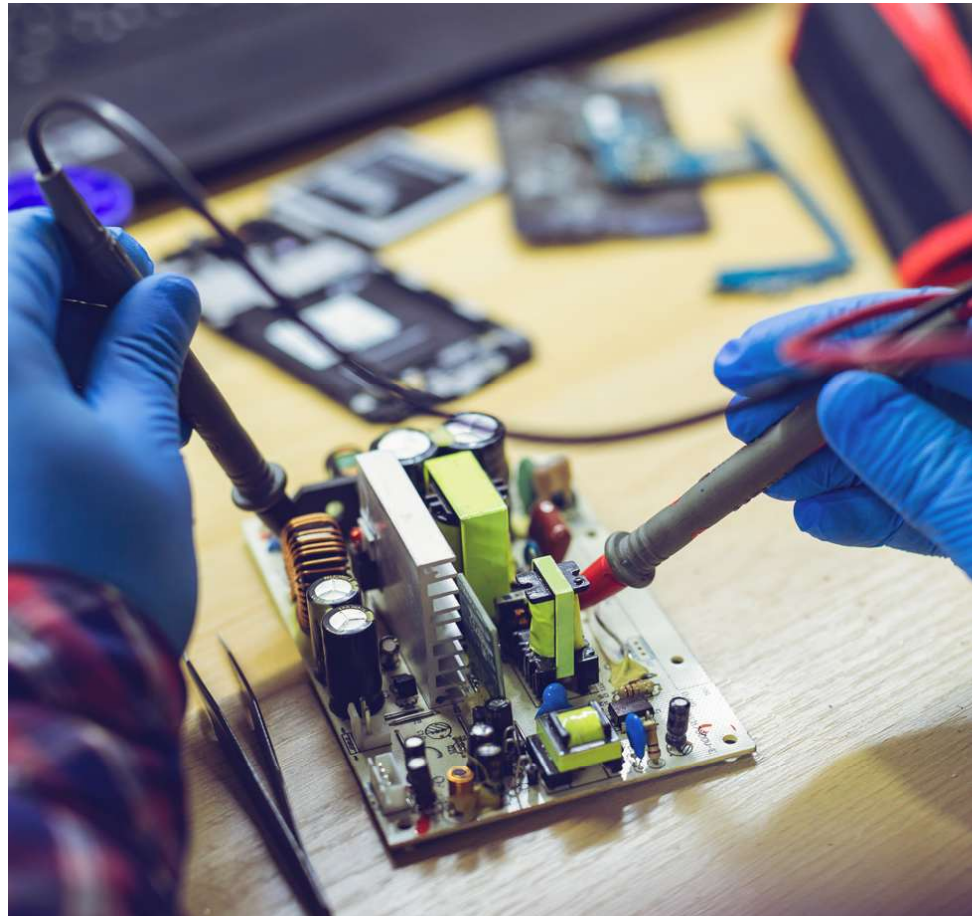




# Introduction

Generating the signals to characterize, test, or troubleshoot electrical designs or systems can be tedious and time-consuming. Keysight engineering experts came up with four tips to help you more efficiently generate simple or complex waveforms.



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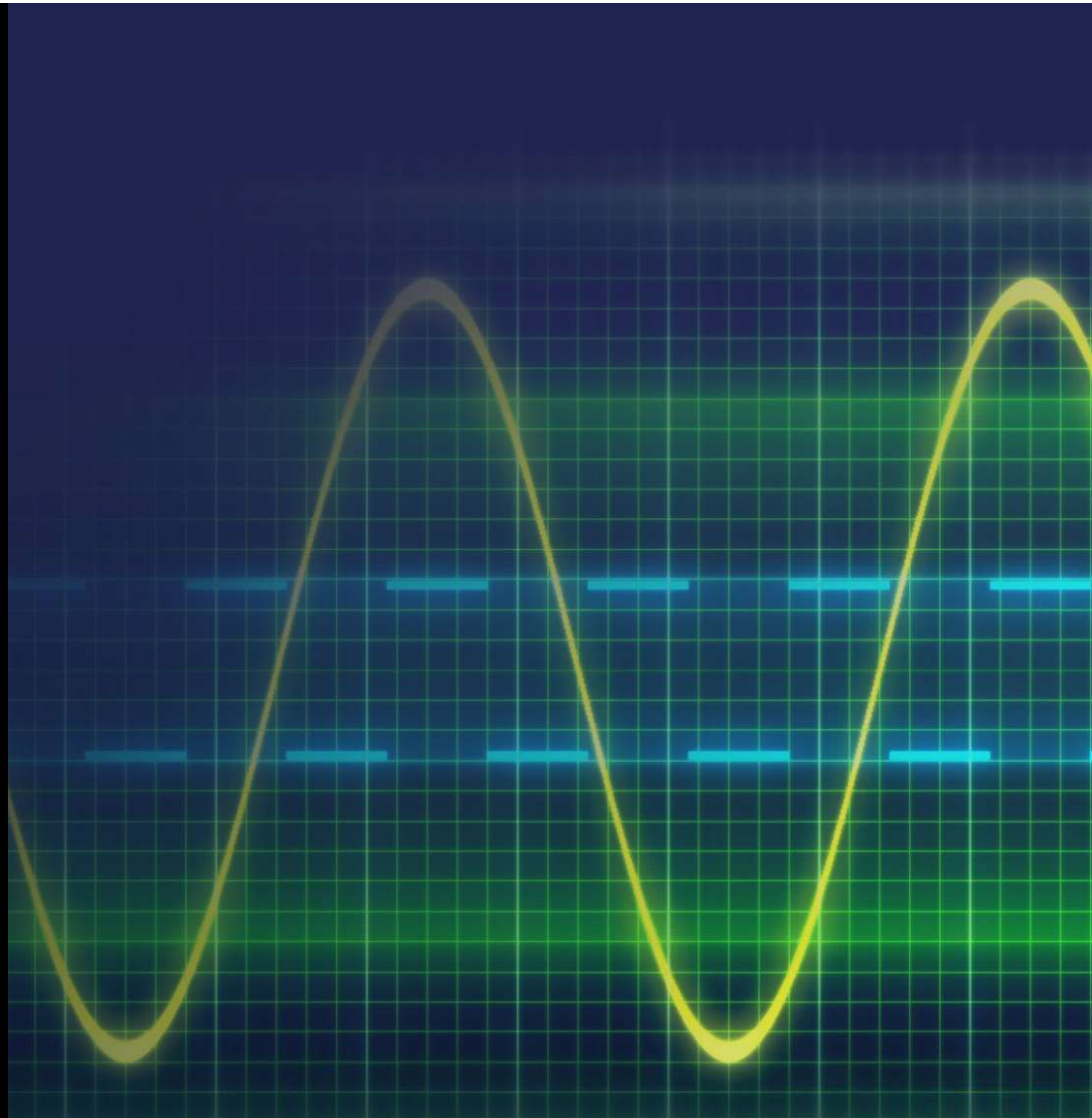
Learn More About  
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**TIP 1**

# Get Started with Pure Sinewaves



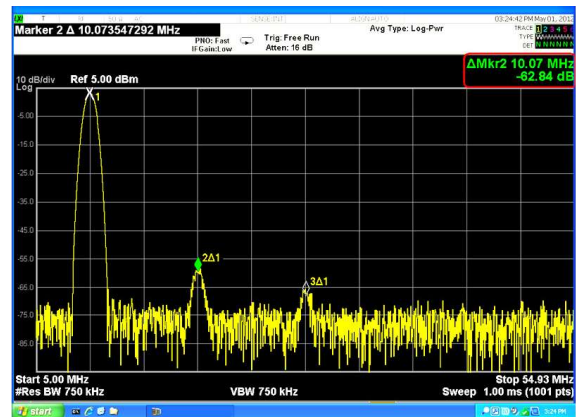
# Tip 1: Get Started with Pure Sine Waves

## Check clarity of waveform generator output

When creating circuits that amplify or mix or modulate signals, it makes sense to test them using pure sine waves with low harmonic distortion. Using a waveform generator with the cleanest output can help you troubleshoot a design to identify the sources of error, mainly when working on transmitters, receivers, and phase-locked-loops.

Starting with the generator's bandwidth, check your waveform generator's noise level by using a spectrum analyzer. Check if the specified bandwidth is a 3 dB point, or if the generator can output sine waves or even square waves up to the specified bandwidth. The energy ratio in the fundamental frequency compared to the sum is the total harmonic distortion (noise).

Figure 1 shows an example of noise at 0.04 THD generated by a Keysight Trueform Series waveform generator. The screen capture, taken from a spectrum analyzer, shows the fundamental 10 MHz (tallest peak) and the harmonics (smaller peaks), which occur at even multiples of the fundamental frequency.



The Keysight Trueform Waveform Generator produces less than 0.04 THD noise output.

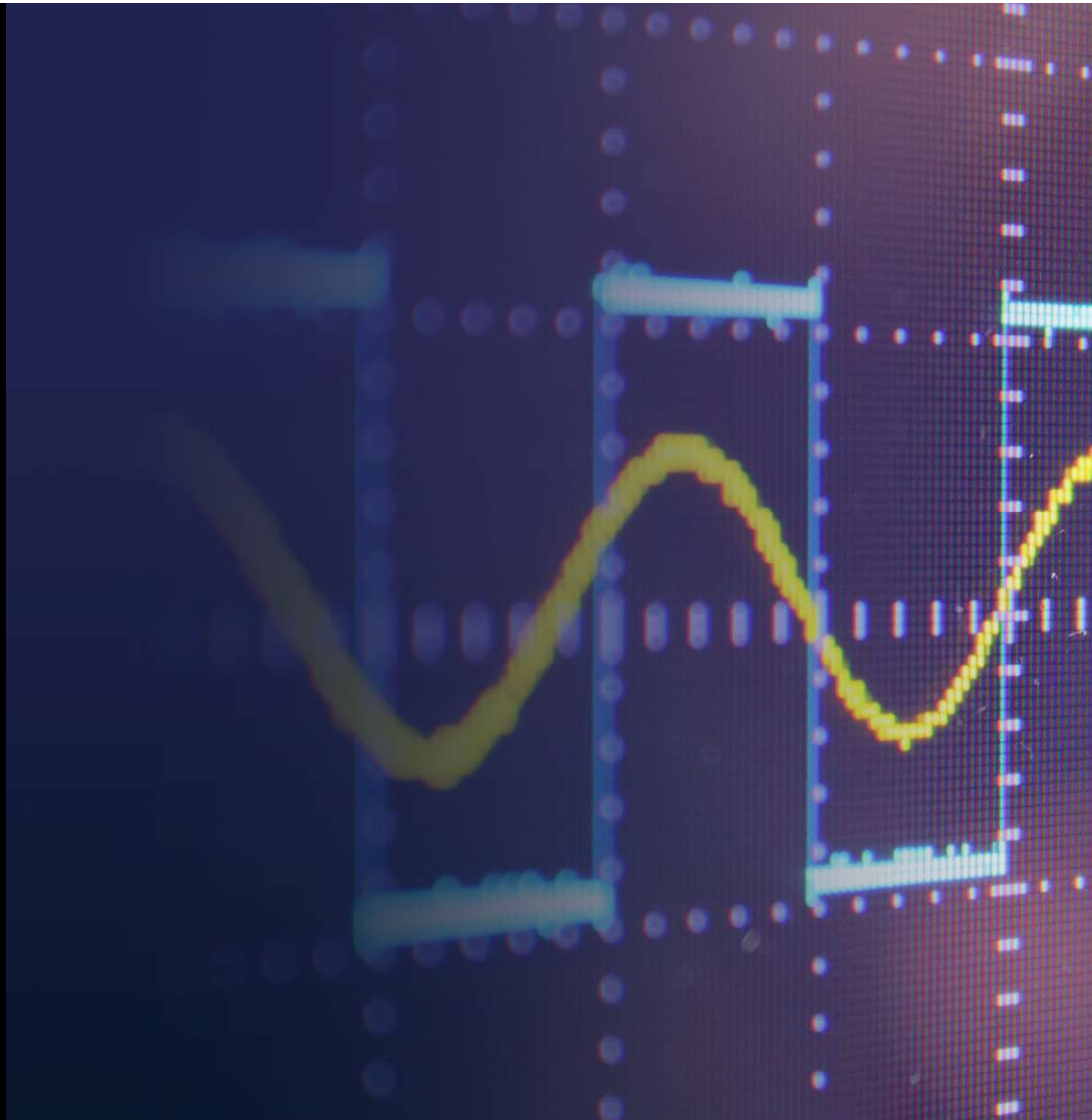
Cabling also has a significant effect on noise. Be sure to use high-quality cables with suitable connectors that deliver only the desired signal to the circuit. A double-shield coaxial cable does an excellent job of keeping unwanted signals from coupling into the source signal. Impedance matching the source, cable, and circuit eliminates reflections and maximizes the power transferred.

The energy ratio in the fundamental frequency compared to the sum is the total harmonic distortion (noise).and remove the border.



## TIP 2

# Generate Basic or Variable Edge Pulses



# Tip 2: Generate Basic or Variable Edge Pulses

## How to Create Pulses with a Waveform Generator

Use a waveform generator to generate trigger signals, clock signals, and logic control instead of a dedicated pulse generator. When designing a control circuit, you can use a waveform generator as an external source to trigger delays and to easily change the delays between triggers.

The following are three techniques that you can use to generate pulses with a waveform generator.

**Square wave:** Create pulses by varying the duty cycle of a square wave, typically between 20% and 80%. If you want higher or lower duty cycles, use burst mode, which lets you output and specify a single-cycle pulse of a square wave waiting period before sending the next pulse.

**Arbitrary waveform:** Define different shapes and parameters with a waveform generator with flexible, arbitrary waveform capabilities if you need a wide variety of custom pulses and patterns. For the best time resolution, use as many points as you can to describe the pulse. Keysight's BenchVue function generator control and automation PC software simplifies the creation of custom arbitrary waveforms.

**Pulse mode:** Keysight's Trueform Series waveform generators have a built-in pulse capability that gives you an easy and flexible method to generate pulses. Simply specify the pulse's main parameters; the period, pulse width, rise, and fall time. You can use burst mode to complex pulse trains in all three classifications. Use trigger delay and burst mode to create precise trigger signals if an external gating signal is available. Keysight's 33600 Trueform Series waveform generators can create pulses with a rise / fall time as fast as 3 ns and jitter lower than 1 ps.

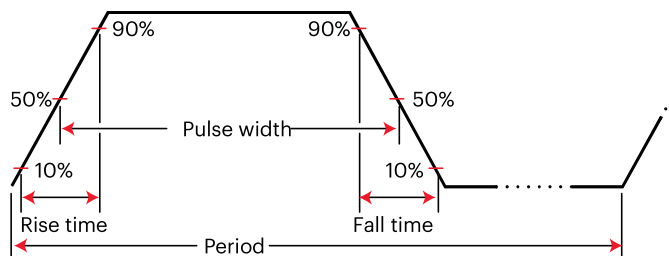


Figure 2. Pulse waveform parameters

### LEARN MORE

[Download Application Note: Using a Function/Arbitrary Waveform Generator to Generate Pulses](#)



**TIP 3**

# Summing Two Signals



Tip 1: Sine Waves

Tip 2: Pulses

Tip 3: Summing

Tip 4: Custom arbs

[Learn More](#)

## Tip 3: Summing Two Signals

### Use additive noise to test a device's immunity to noise

The upper trace is the clean signal. The middle green trace is the additional noise, which is a fraction of the clean signal's amplitude, the lower trace shows the sum of both signals.

### Make one signal from two

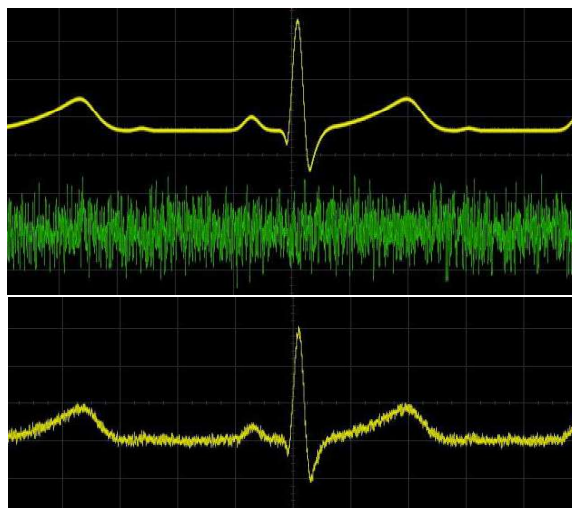
A multitone signal is the superposition of several sine waves or tones, each with a distinct amplitude, phase, and frequency. Many test specifications use this signal to stimulate a circuit or system quickly and efficiently over its entire bandwidth. They can also determine the device's frequency response for a given selection of frequencies or make measurements such as intermodulation distortion. The dial tone in the US is a multitone signal made of 350 Hz and 440 Hz tones.

The following are two methods to create a multitone signal:

**Method 1.** Connect two or more sine wave generators in parallel and add their amplitudes to generate a single waveform. The generators need to have the same clock source and phase control to sync the waveforms.

**Method 2.** Create the waveforms mathematically and download the results to an arbitrary waveform generator. Create a single arbitrary waveform to last the length of the test or create a repeatable waveform segment without any anomalies.

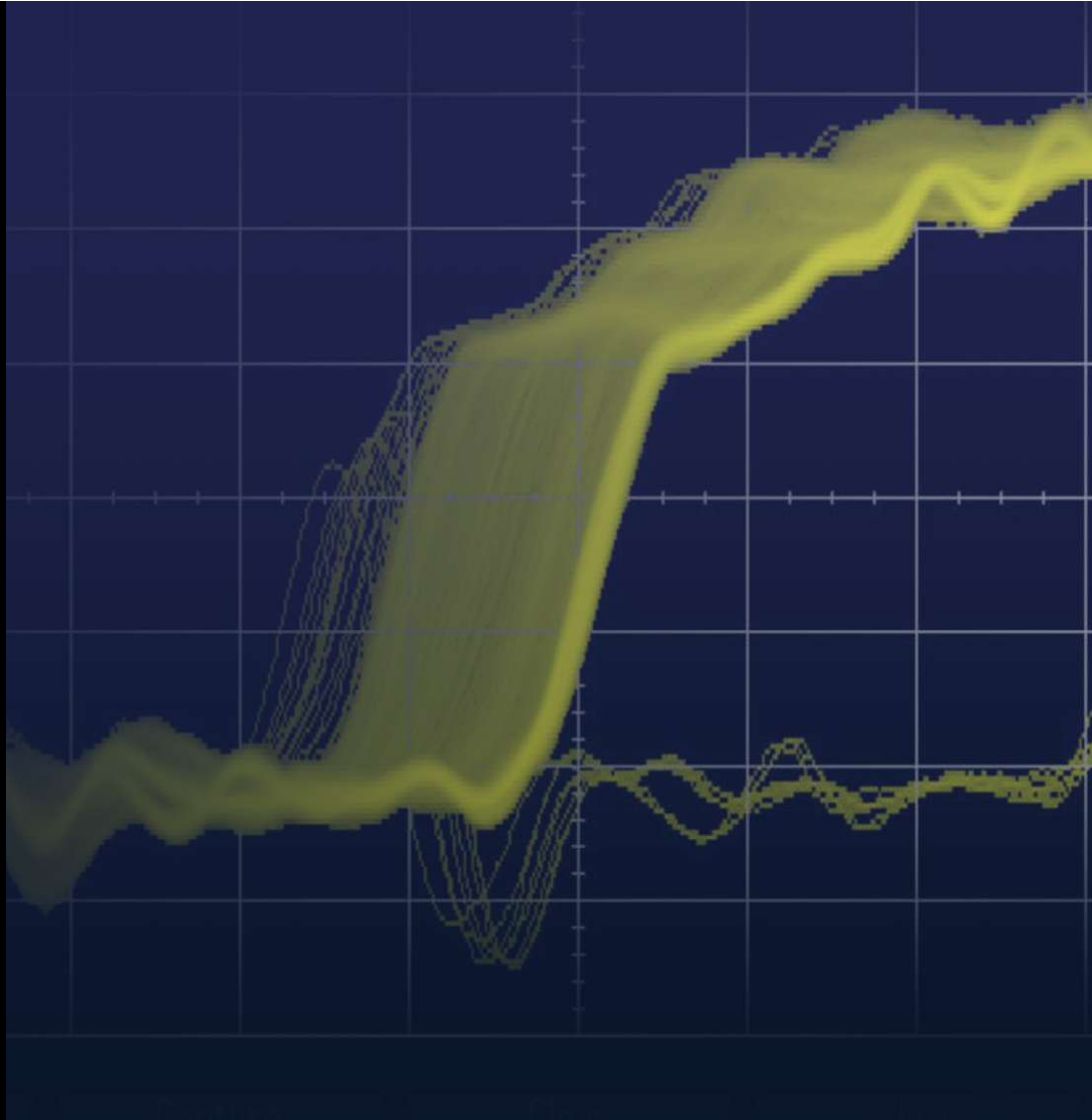
Trueform Series waveform generators produce a dual-tone signal while synchronizing the signals and the phase. They can add signals on a single channel without using a second channel or create an arbitrary waveform. With Trueform Series, you can create complex multitone signals directly from the front panel.





#### TIP 4

## Create Custom Arbitrary Waveforms



# Tip 4: Create Custom Arbitrary Waveforms

## Create custom “mixes” using sequences

A waveform generator typically creates arbitrary or custom waveforms with a list of amplitudes. Once the generator reaches the end of the list, it plays the list again from the beginning. The most common waveform generators use a direct digital synthesis (DDS) technique that skips points based on the desired frequency. The signal complexity limitations are from the sample rate and memory depth.

Complex communication signals, such as those used for robotics or automotive applications, typically do not repeat for several seconds. You can generate a single, long waveform using a generator with a deep memory or divide it into smaller segments. A motion drives the same signal 1,000 times in robotics but with a different beginning for ramp-up and a different ending for ramp down. Using the segmentation approach provides multiple advantages — it’s simpler to set up, uses less memory, and is easy to modify. For example, you might be satisfied with the ramp-up and the drive segment but would only modify the ramp-down segment.

You can use arbitrary waveforms to introduce transients or dropouts to test a circuit’s reaction to infrequent events. A poorly designed circuit could latch-up or reset when a dropout occurs. Segmentation simplifies the process of introducing unique cycles or varying the ratio of good to bad cycles.

### LEARN MORE

[Download Application Brief: Be More Efficient Designing Your Arbitrary Waveforms](#)

Waveform sequencing can greatly improve test efficiency. Sequencing creates several combinations by changing the order and number of cycles of each segment, starting with just a few arbitrary waveforms. You can easily create arbitrary waveforms with Trueform Series waveform generators as shown in Figure 3. With Trueform Series, a sequence can have up to 512 steps, and a total of 32 sequences with up to 1,024 segments can be pre-loaded into the generators’ volatile memory to improve throughput.

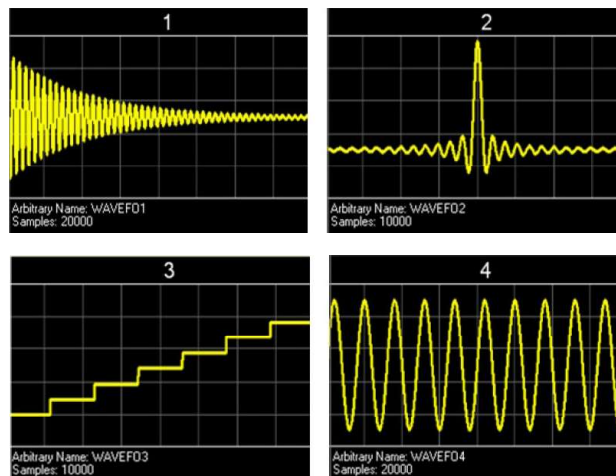
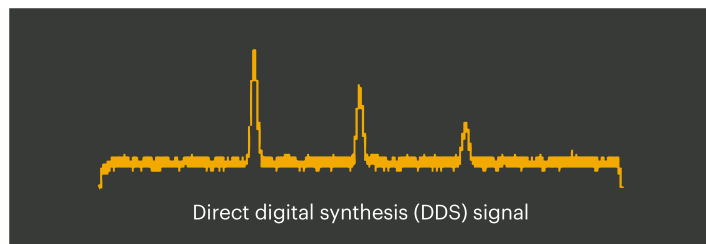
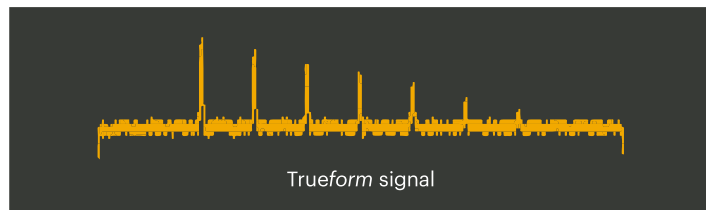
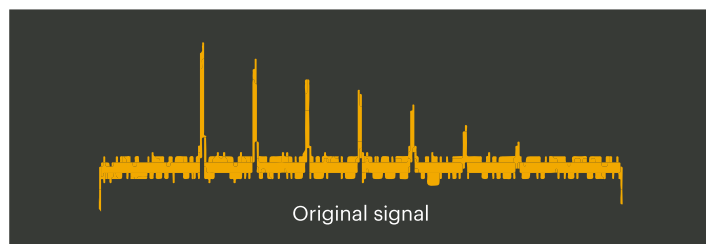


Figure 3. Examples of arbitrary waveforms

# Want to Learn More?

## Get the trueform series advantage

Many waveform generators come with DDS technology that uses a fixed clock to simulate signals. The fixed clock approach adds or reduces points in signals to meet a fixed clock rate and may generate signals that are different than you expected. Trueform Series waveform generators use a proprietary technology that plays every point in your signal precisely as defined.



### LEARN MORE

 Learn more about Keysight's latest Trueform Series



Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at [www.keysight.com](http://www.keysight.com).

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