Using a Function/Arbitrary Waveform Generator to Generate Pulses

Engineers typically use pulse generators to create pulses for characterizing digital devices. A pulse generator is well-suited for applications that require fast transition times, high accuracy, or frequencies higher than 50 MHz. A dedicated pulse generator may offer multiple channels, pattern generation, double pulses, RZ (return-to-zero) pulses, and the ability to add jitter to the pulse train. When testing complex logic, these features give you the capabilities you need to complete the job.

However, if your application does not require the performance of a dedicated pulse generator, you can use a relatively inexpensive general-purpose function generator to create pulses. These applications include creating trigger signals, clock signals, and controlling logic.

This white paper explains several techniques you can use to create pulses with a function generator. We will use a Keysight Technologies 33600A modern function/arbitrary waveform generator to create a single pulse, a burst of pulses, or a steady pulse train with high bandwidth, up to 100 MHz.
Some function generators now offer robust pulse functionality. Look for a pulse button on the front panel that allows you to define primary pulse characteristics, or check the instrument’s specifications. The instrument’s data sheet should specify the parameters for a pulse:

1. Shortest and longest period
2. Shortest and longest pulse width expressed in either seconds or duty cycle percentage
3. Shortest and longest variable edge time
4. Percentage overshoot
5. Jitter, expressed as a percentage or ppm (parts per million)

**Methods for Creating Pulses with a Function Generator**

A function generator offers several methods for generating pulses:

1. **Vary the duty cycle of a square wave**
   The most common way to create a pulse is varying the duty cycle of a square wave. By definition, square waves have 50 percent duty cycle, meaning the square wave is high for half the period and low for the other half. Typically, a function generator varies the duty cycle from 20 percent up to 80 percent. Burst mode lets you achieve an even lower duty cycle.

2. **Use the built-in pulse capability of newer function generators**
   This method is easy and provides lots of flexibility, but not all function generators have this built-in capability.

3. **Use arbitrary waveforms**
   You can create a wide variety of custom pulses and patterns using the arbitrary waveform capabilities of a function/arbitrary waveform generator to define the desired shape and parameters. While this is not the easiest approach, it does offer lots of flexibility (limited only by memory depth). Most function generators have the required arbitrary waveform capability.
Using a Function Generator’s Pulse Generation Capability

Having pulse generation capability built into a function generator makes it easy to create pulses. You simply specify the main parameters of a pulse: period, pulse width, and edge time (rise/fall time).

![Pulse waveform parameters](image)

On the 33600A function generator, the pulse is specified in almost the same way as it is in a dedicated pulse generator. A dedicated pulse generator describes pulse width as the time from the leading edge to the beginning of the falling edge. Because it uses this definition, you can set the rise and fall times independently without affecting the time between the leading edge and the beginning of the falling edge.

The 33600A function generator also allows you to vary the edge time without affecting the pulse width by using the same edge time for both rise and fall times. The 33600A sets the pulse width between the 50 percent level on the rising and falling edge. Because the edge times are the same, the pulse width value will be the same whether it is measured from the beginning of the edges or between the midpoints of the edges. Oscilloscopes also measure pulse width from the 50 percent level of the edges. If you use a pulse generator to create a pulse with different rise and fall times, the oscilloscope measurement of pulse width will not match the setting on the pulse generator.

A function generator’s ability to accurately produce a specified pulse depends on the instrument. Function-generator hardware reproduces a variety of waveforms — everything from sine waves to arbitrary waveforms. On the other hand, a pulse generator is designed specifically for pulse waveforms.
Many modern function generators typically generate waveforms through direct digital synthesis (DDS). A DDS function generator has the ability to seamlessly change the frequency of a waveform by using more or fewer points, effectively sampling the stored data to output the waveform. While DDS works well for waveforms that have smooth transitions, it does not always work well for pulses. DDS technology can sample the data in memory differently each time the waveform is output, causing jitter. To overcome these issues, Keysight’s 33600A uses an exclusive digital sampling technique called Trueform technology, to overcome the drawbacks of DDS technology.

Trueform and DDS technology are quite similar, but Trueform builds on the foundation of DDS allowing generators using this technology to create a much closer approximation of a signal. Improved performance is achieved by interpolating the samples stored in waveform memory in real time through DSP in conjunction with a low pass filter. The resulting waveform can be reproduced accurately by the DAC.

Jitter is a key instrument’s specification for pulse wave. A 100 MHz DDS based function generator may typically have <200 ps edge jitter specification. A Trueform function generator will have <1 ps edge jitter specification. Trueform offers a 200X improvement over DDS technology.
Using Arbitrary Waveforms

You also can create pulses using arbitrary waveforms. At low frequencies, the DDS technology does not present a problem. However, at higher frequencies, transition time and cycle-to-cycle jitter that are equivalent to one period of the sample clock can begin to impact overall performance.

Creating a pulse or train of pulses in arbitrary waveform memory allows endless possibilities — limited only by memory depth — for the shape of the pulse. For best results, you generally want to use all the available points to describe the pulse. Using more points will provide better time resolution. Using a PC and application for generating arbitrary waveforms helps simplify the task. Keysight offers BenchVue Function Generator application and BenchLink Waveform Editor application specifically for creating and downloading arbitrary waveforms. The Waveform editor can create pulses with variable rise/fall times. Rise/fall time shapes can be linear, exponential, half-cosine, or Gaussian.

![Figure 3: BenchVue waveform editor to create pulses](image)

Once you have configured the function generator to generate the desired pulse or pulse train, you can use triggering to further define the output. You can create a single pulse or a burst of pulses using triggering. Most function generators accept an external trigger as input and also provide an external trigger signal. You can set a delay programmatically or from the front panel to offset the pulse from the external trigger.
Summary

Function generators offer flexibility to create pulses from simple modified square waves to arbitrary waveforms. Not all function generators are the same.

For high-speed pulse applications, a dedicated pulse generator is necessary which offers additional features for creating pulses.

To learn more about Keysight’s Trueform function generators, please visit our website: www.keysight.com/find/function-generators.

To find out more about Direct Digital Synthesis (DDS) Generators versus Trueform Waveform Generators, please click on literature number: 5991-0852EN

Learn more at: www.keysight.com

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