

EE105 Lab Experiments

Agilent 33220A Function Generator Tutorial

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1 Introduction

The Agilent 33220A is a voltage waveform generator. It can be used to apply periodic voltage waveforms to a circuit (e.g., sinusoids, square waves, triangle waves, and pulses). You will use the function generators to supply time-varying input to circuits for transient or frequency analysis (e.g., to characterize a filter or an amplifier).

This tutorial starts with quick notes on the most vital information, so if you feel somewhat familiar with the function generator you can check over the quick notes and figure out the details yourself. The later sections include more detailed descriptions of the Agilent 33220A interface.

2 Quick Notes (to get started fast)

- Make sure the “Output” button is lit (in the lower-right corner).
- Set parameters in Ampl/Offset mode, not in HiLevel/LoLevel mode. If HiLevel/LoLevel mode is selected, push the blue buttons below HiLevel/LoLevel until Ampl/Offset mode is selected instead.
- The Ampl parameter sets the peak-to-peak amplitude, not the peak amplitude. See Figure 1.
- **Delivered voltage varies with output load impedance.** With an infinite load impedance at the output, the voltage amplitude delivered to the load will be double the panel setting. See Section 3.
- Choose parameters to adjust via the blue buttons that are below the screen. Change the parameter values using the top-right knob as well as the arrow keys; an alternative is to use the numbered keys to input the desired value. If you do use the numbered keys, note that after punching in the numbers, you must select the proper units and order of magnitude using the blue buttons below the screen.

- Offset is the voltage offset for the waveform. You can use it to add a constant voltage (DC component) to the wave (e.g. if you want to have a cosine vary around 2 V).
- The function generator's ground is **earth-grounded**, i.e. the black lead from the BNC cable is not a floating ground. Since the oscilloscope is earth-grounded as well, the function generator and oscilloscope grounds are connected.

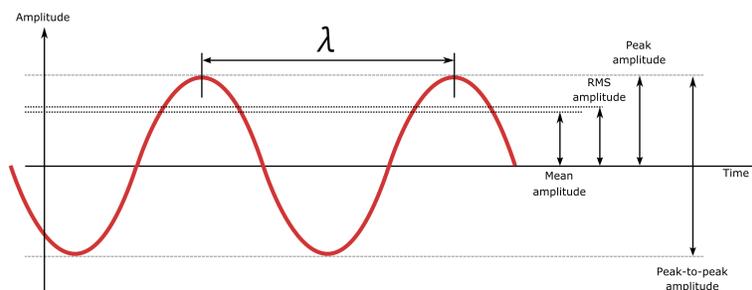


Figure 1: Definitions of various wave parameters

3 Voltage Divider Discussion

When displaying voltage value settings (e.g. the Ampl parameter displaying V_{pp}), the function generator panel displays the voltage that will be delivered to the load at the output under the assumption that the total load impedance is $50\ \Omega$. The function generator also has an internal impedance of $50\ \Omega$, and so the load impedance forms a voltage divider with the internal impedance of the function generator. The equivalent voltage divider is shown in Figure 2.

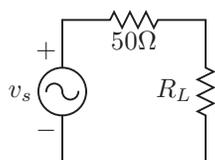


Figure 2: Function generator panel displays voltage values for $R_L = 50\ \Omega$

Under the assumption that the load impedance is $50\ \Omega$, the voltage delivered to the load (the effective voltage output) is half the generated voltage of v_s . Loading the output with an impedance much greater than $50\ \Omega$ (such as connecting the output directly to an oscilloscope) will drop the majority of the voltage across the load, and thus the measured output voltage can be up to double the panel setting. Loading the function generator with $R_L < 50\ \Omega$ will cause the voltage delivered to be less than the panel setting.

The function generator is often used to create an input signal to amplifiers. Voltage amplifiers often have a high input impedance (e.g. an effectively infinite input impedance for a MOS amplifier), and so the function generator will often be loaded with an infinite R_L . Thus the voltage delivered to the amplifier input will often be double the panel setting.

4 Interface Details

To begin, you should know where the power button, output port, and sync port are located on the function generator. The power button is in the lower-left corner of the front panel. The output port is in the lower-right corner and requires a special cable. In contrast, the sync output port is located in the back of the function generator and is used to send a triggering signal to an oscilloscope. The trigger allows the oscilloscope to synchronize its measurement with the function generator's output (e.g. so as to capture a

short pulse). Notice that after turning on the function generator, the display shows the value of the currently selected parameter as well as the units and order of magnitude (e.g. mV V).

The notes below correspond to the button groups shown in Figure 3. They are generally in the order that you would use them to set up an output waveform.



Figure 3: Agilent 33220A Front Panel

4.1 Bottom-Right Buttons

The **Output** button turns on the output voltage, which should be off when the function generator is initially turned on. So, press the button once to turn on the output voltage. The **Trigger** button is used to enable the sync port, which is a feature used in conjunction with another equipment (e.g. an oscilloscope). However, in general, you will not need to use triggering in these labs.

4.2 Middle Buttons

These six buttons set the shape of the output waveform:

- **Sinusoidal:** A sine or cosine wave; eigenfunctions of LTI systems.
- **Square:** Periodically switches between two values.
- **Ramp:** Also known as a “Sawtooth” wave.
- **Pulse:** A voltage pulse is sent periodically. The pulse width can be tuned separately from the period (the time interval between repeated pulses). The peak value of the pulse can also be set.
- **Noise:** Simulation of voltage noise.
- **Arb:** Create your own waveform.

4.3 Upper-Middle Blue Buttons

These six buttons allow you to select parameters of the output waveform. After selecting a parameter, the parameter value can be adjusted with the numbered keys, arrow buttons, and the knob located in the upper-right corner of the front panel. Depending on the middle button selected, not all of these six upper-middle buttons will be active (i.e. not every waveform will require the use of all six buttons).

Each upper-middle button has two labels above it, with only one of the two labels lit at any given time. The highlighted label corresponds to the parameter that is currently selected, and its value will be shown on the display. You will only need to adjust the Freq, Ampl, Offset, Width, and/or Duty Cycle parameters. If

HiLevel and LoLevel are lit, press the button below LoLevel or HiLevel until Ampl and Offset are selected instead.

Here is a list of the parameter labels and their respective meanings:

- **Freq:** Frequency in repetitions per second. In the case of a pulse, this parameter corresponds to the frequency at which repeated pulses are sent.
- **Ampl:** Amplitude (peak-to-peak), defined as the distance between the highest and lowest voltage points of a waveform.
- **Offset:** DC voltage offset. The time-varying waveform is offsetted (“raised”) by the constant offset component (e.g. if you want a sinusoid of amplitude 1 V centered at 3 V, the offset should be 3 V).
- **Width:** Pulse width (for the pulse waveform).
- **Duty Cycle:** duration of a pulse.

As a reminder, for some waveforms, not all of the parameters are needed. For example, a sinusoidal waveform only has Freq, Ampl, and Offset available for adjustment.

4.4 Upper-Right Buttons

In the upper-right corner of the front panel, there is a knob, two arrow buttons, and a set of numbered buttons. Each of these offers a different way of adjusting the displayed parameter value:

- **Knob:** This can be turned clockwise and counterclockwise to adjust the displayed parameter value. Note that the knob only changes the digit (or number) selected by the blinking cursor.
- **Arrow Buttons:** Press the left and right arrow buttons to manually move the blinking cursor.
- **Numbered Buttons:** An alternative to the knob and arrow buttons is the set of numbered keys. Simply punch in the desired value using the numbered key pad, and when prompted, select the proper order of magnitude. Note that the polarity of the output can be changed with the $+/-$ button.

5 Examples

The following are two examples demonstrating the mentioned features of the function generator.

5.1 Sinusoid

Here are all of the steps necessary to set up a 5 kHz, 1 V_{pp} sinusoid wave with a 1 V offset on a **large load** (i.e. much larger than 50 Ω).

1. Turn on the function generator with the lower-left power button, and enable the output by pressing the “Output” button in the lower-right (so that the “Output” light is lit).
2. Press the sinusoid button in the middle set of buttons.
3. Press the Freq button in the upper-middle set of buttons, and use the upper-right numbered keys, knob, and/or the arrow buttons to select 5 kHz on the display.
4. Now press the Ampl button in the upper-middle set of buttons, and use the upper-right numbered keys, knob, and/or the arrow buttons to select 500 mV_{pp} on the display. However, if the load impedance is much larger than 50 Ω, this step will produce a 1 V_{pp} output waveform instead of 500 mV_{pp}. For further discussion about this discrepancy, please refer to section 3.
5. Next, press the Offset button in the upper-middle set of buttons, and use the upper-right numbered keys, knob, and/or arrow buttons to select a 500 mV offset on the display. This will lead to a 1 V offset if the load impedance is greater than 50 Ω.

5.2 Pulse

Here are all of the steps necessary to set up a 1 V pulse with a 1 μs duration and a repetition every 10 μs on a load impedance much larger than 50 Ω .

1. Turn on the function generator with the lower-left power button, and enable the output by pressing the “Output” button in the lower-right (so that the “Output” light is lit).
2. Press the pulse button located in the middle set of buttons.
3. Press the Freq button in the upper-middle set of buttons. Since we want 10 μs between repetitions, we want $\frac{1}{10\mu} = 10^5$ Hz. Use the upper-right numbered keys, knob, and/or the arrow buttons to select 100 kHz.
4. Now press the Width button in the upper-middle set of buttons. Use the upper-right numbered keys, knob, and/or the arrow buttons to select a 1 μs width.
5. Then, press the Ampl button in the upper-middle set of buttons, and use the upper-right numbered keys, knob, and/or the arrow buttons to select 500 mV on the display. This step will produce a 1 V height pulse if the load impedance is much larger than 50 Ω . If necessary, see section 3 for further discussion about this discrepancy.