Introduction

The Function Generator is the instrument that creates input signals used to test circuits and systems in the laboratory. This section will show you how to create some basic waveforms commonly used in the lab: sine, square, triangle and pulse waveforms, including DC offset.

The 33220A has a large number of capabilities beyond measuring these basic waveforms; consult the Agilent User's Guide for information on capturing and using "arbitrary" waveforms, noise, signals with AM, FM and FSK modulation, sweeping signals over a range of frequencies. Operation of this "AWG" is easily learned, and fairly intuitive, as each front panel "hardkey" and "softkey" (the buttons right under the display window in the picture below) when pressed for 2 seconds will provide context-sensitive "help" on the display.

Output Voltage and the Load Resistance

Since this is a very important consideration, let's address it right now. Basic concepts:
You can easily set the amplitude and DC offset of the output waveform.

The output resistance of the AWG is always 50 Ω - this can't be changed.

If the AWG output connector is connected to a load (device under test) with a 50 Ω resistance, then the amplitude and DC offset voltage values you set will be the values across the load.

If the AWG output connector is connected to a load (device under test) with a high resistance, then the amplitude and DC offset voltage values you set will NOT be the values across the load. The output voltage will be twice what you set. This may damage certain circuits (i.e. logic gate inputs).

You can tell the AWG that the load resistance is not 50 Ω. This will make the displayed voltage (the one you set) and the open-circuit voltage the same.

We will practice using 50 Ω and "high Z" load resistances very soon.

The Front Panel Controls
Refer to the diagram below as you perform the procedures that follow.
Step One - Creating a Sinewave With No DC Offset Voltage, High Z Load Resistance

1. A basic waveform you will now produce is a 1 kHz, 100 mVpp sine wave with no DC offset. Connect the Output (a BNC connector on the front panel) to the vertical input of an oscilloscope.

2. Turn the power on by pressing the white button at the lower left of the front panel. You are reminded that you can get Help for any key by holding it down.

3. The display says 1.000,000,0 kHz, with a picture of a sinewave on the right. It also says "Output Off", so the first thing we need to do is press the Output button. Press it now.

4. Press AutoScale on the mixed-signal oscilloscope (MSO) (or adjust its controls manually) to display the sinewave. Press QuickMeas on the MSO to measure the frequency and peak-to-peak voltage (should be very close to 1.000 kHz and 200 mVpp). You may want to turn on Averaging on the MSO to minimize noise and get more accurate readings.

5. Now, press the Softkey labeled Ampl; it should say 100.0 mVpp. Wait a minute! What's going on here - we just measured 200 mVpp? The reason for this discrepancy is that the oscilloscope input resistance is 1M Ω (High Z), not the 50 Ω the AWG assumed was the load resistance connected to the AWG output connector. How do we fix this discrepancy?

6. Since we are going to be using the MSO as our "Device Under Test" (i.e. the load connected to the AWG), and the MSO resistance is 1M Ω, not the 50 Ω the MSO "expected", we will tell the AWG what its load is.

7. Press the Utility hardkey, then the Output Setup softkey, and the Load softkey. This changes the AWG to "High Z" mode, and it will now display the correct output amplitude.

8. Press the Sine hardkey; the amplitude now displayed is 200.0 mVpp, which agrees with the amplitude as measured on the oscilloscope.

Be aware of the load resistance of the circuit or instrument you connect to the AWG. If you were connecting the AWG output to a logic circuit (which could be damaged by an input voltage that is too big) and did not change the AWG to "High Z" mode, the actual AWG output voltage can be twice what the AWG display indicates.

Step Two - Creating a Sinewave With DC Offset Voltage, High Z Load Resistance

1) Leave the AWG in "High Z" mode. Now we will add some DC offset to our 1 kHz sinewave, 200 mVpp. This can be done two ways.

2) Method 1: Press the Offset softkey. Use the right "Navigation Arrow Key" to move the cursor one place to the right on the amplitude display. Rotate the
**Knob** one click **clockwise**; this will add +100 mVDC to the 200 mVpp sinewave. See the display below.

3) In the display to the right we can see that our 200 mVpp sinewave now has a minimum value near 0 V (-400 uV = -0.4 mV), and a maximum value of 200.3 mVpp. Note the ground symbol on the display.

4) Remove the 100 mV DC offset using the **Knob**. Our sinewave is still 200 mVpp.

5) Method 2: Press the **Offset** softkey, to select **LoLevel**. Raise this to 0.00 V. Now, press the "**HiLevel**" softkey, and use the **Knob** to raise the high level to 200 mV. This accomplishes the same result: a 200 mVpp sinewave, that goes between 0 V and 200 mV.

6) Press the **Graph** hardkey; you can see the waveform you have just created, and can modify the frequency, amplitude and DC offset using the yellow, purple and blue softkeys respectively. Try it. When you are done, press the **Graph** hardkey again.

**Step Three - Creating a Squarewave With DC Offset Voltage, High Z Load Resistance**

1) Create a squarewave compatible with TTL or 5 V CMOS logic by pressing the **Square** hardkey.

2) Press the **Ampl** softkey, which will turn it into **HiLevel** mode. Now use the Numerical Keypad to enter: 5.00, then press the **V** softkey. You now have a 5 Vpp squarewave, which goes between -2.5 V and + 2.5V. Verify this with the MSO.

3) Press the **LoLevel** softkey, and the display will say -100 mV. Change this with the **Knob** to be 000.0 mV. Your 5 Vpp squarewave, now goes between 0.0 V and + 5.0V. Verify this with the MSO.
4) You can turn the squarewave into a pulse train by pressing the **Duty Cycle** softkey. Change the duty cycle to 20% (the range is 20% to 80%), either using the **Knob** or the Numerical Keypad. Your 5 Vpp, 1 kHz pulse train, goes between 0 V and +5 V. Verify that yours looks like the one to the right.

5) If you need a pulse with a duty cycle less than 20% or more than 80%, use the **Pulse** hardkey.

**Step Four - Creating a Triangle or Ramp Waveform, High Z Load Resistance**
1) Press the **Ramp** hardkey. The resulting waveform is a classic sawtooth shape.

2) By varying the **Symmetry**, you can make a triangle waveform, and sawtooth waveforms with different shapes. Try it.

**Other Waveforms and Features to Try**
Noise (white, not pink) is available. Be sure that **Averaging** is turned off if you look at noise.

Arbitrary waveforms are non-standard voltages that either are stored in the AWG memory ("Built-In" waveforms) or that you capture and load into the AWG memory. Try pressing the **Arb** hardkey, then the **Select Wform** softkey, then the **Built-In** softkey, and finally the **Cardiac** softkey. To make it realistic, a human cardiac waveform should vary between approximately 0.33 Hz and 1 Hz (corresponding to 180 and 60 beats per minute). For now, to make it easy to observe on your MSO, set the frequency to 20 Hz (representing, perhaps, a tachycardic hummingbird after a double espresso); see the display below.
Other Useful Information and Review

As covered in the procedure, but of such importance that its repeated again: The output must be terminated by 50 Ω for voltages set on the AWG to be accurate. OR, for loads that are much higher resistance than 50 Ω, you can use the Utility key, then Output Setup softkey, and Load softkey to select High Z.

The Help function tells us that "Load Impedance / High Z / 50Ω Sets the value of the load attached to the [Output] connector (used for voltage settings). The Agilent 33220A has a fixed series output impedance of 50Ω, regardless of the value specified for the parameter. If the actual load is different than the value specified, the displayed voltage levels will not match voltage levels at the device under test."

To get context-sensitive help on any front panel key or softkey menu, press and hold down that key.

You can even get pure DC (like a small power supply) using Utility and DC On. This "power supply" will have a 50Ω output resistance, making its usefulness limited.

You can see a graph of your waveform with all its parts illustrated, in color, with the colors keyed to the controls that adjust those parameters (e.g. for a Pulse waveform, the pulse width, edge time, HiLevel, LoLevel, offset), by pressing the Graph hardkey.

Try using the Mod (modulation), Sweep, Burst, and Help hardkeys. Of course, for complete and detailed information consult the Agilent User’s Guide.

This instrument has a frequency range of 1 µHz to 20 MHz for most waveforms. Think about the frequency of sunlight on the planet Earth: its period is one day. What is that, expressed as a frequency in hertz? Can you think of how to design a circuit to have this generator provide illumination to a plant, using an incandescent lamp, to simulate the period of earth's sunlight?

You may not have been the last person to use the AWG. When first turning the AWG on, be sure to return the AWG to its "factory default values" by pressing the Store/Recall hardkey, then the Set to Defaults softkey, and the YES softkey.