Time Varying Voltages and Currents

Motivation:

In this lab, we will work with the oscilloscope to observe and measure time varying voltages and currents.

Related Lecture Content:

- Practical Sources and Superposition

Before you start:

The Function Generator

A function generator is an electronic equipment used to generate different forms of time varying voltages over a wide range of frequencies. Some of the most common time varying voltages produced by the function generator are sine, square, triangular and sawtooth. Each lab station is equipped with two function generators: Topward 8110 and Topward 8120P. Both function generators are similar and can be used interchangeably.

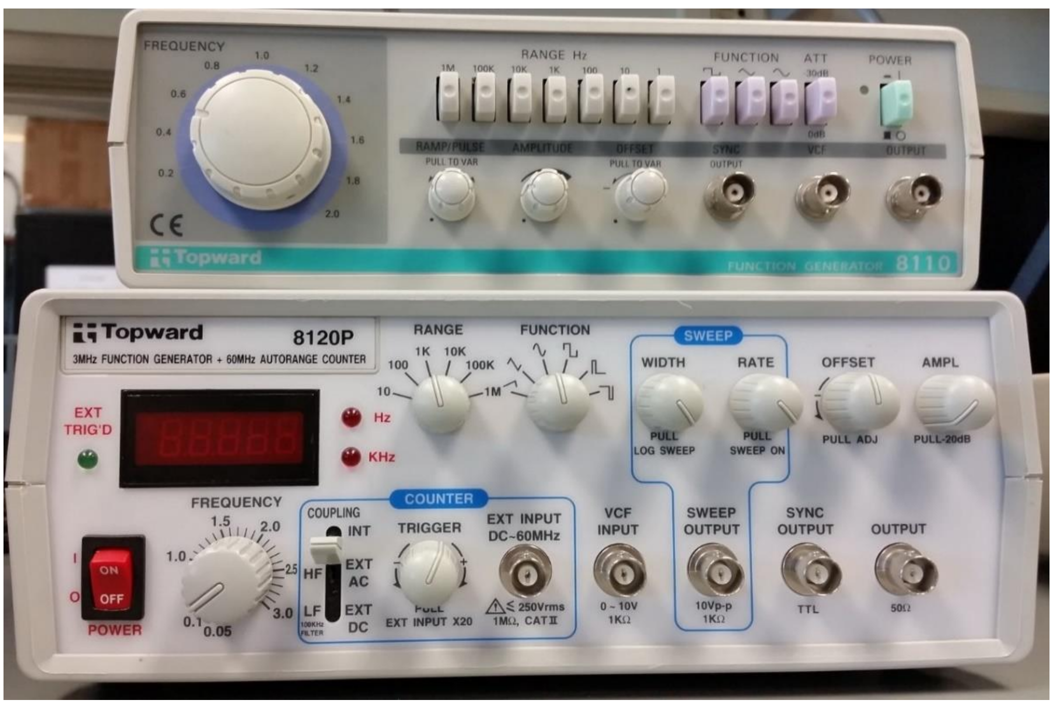

Figure 1: Function Generators Available in the Lab

The function generators have a knob to change the frequency, and either a knob or bank of interlocked switches to select the frequency range. You can also select the waveform and its amplitude. Both generators also have a knob that allows a variable DC voltage to be added to the output. Note that the knob must be pulled out for the offset to be applied to the signal. When the knob is pushed in, no offset voltage is added. The output is provided via a BNC connector. Always use a BNC to BNC cable when connecting the function generator to the breadboard. The rest of the knobs and buttons are not important for this lab, but feel free to read more about them in the manual.

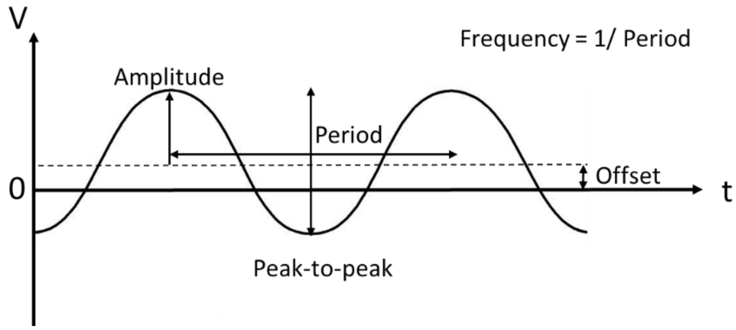

Figure 2: Time Varying Voltage

The Oscilloscope

An oscilloscope is an electronic test instrument that allows the observation of time varying voltages, as a two-dimensional plot of one or more voltages as a function of time. The electrical signal is continuously graphed against a calibrated time scale and the observed waveform can be analyzed for properties such as amplitude, shape and frequency. Each station is equipped with a Tektronix TDS 2002B oscilloscope. This lab will teach you the basics of oscilloscope operation, but feel free to read more about oscilloscope in the manual.

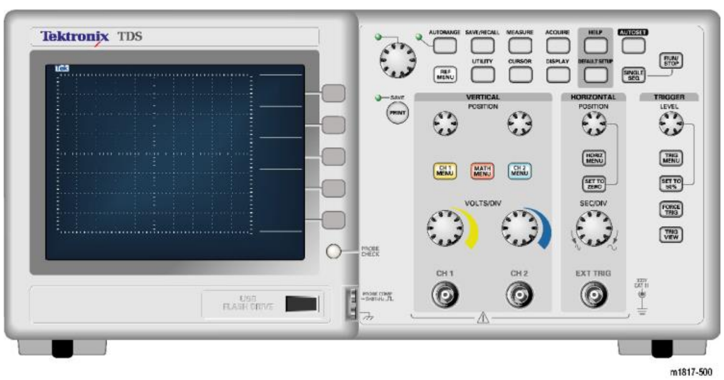

Figure 3: Tektronix Oscilloscope

The Probe

The probe is used to connect the oscilloscope to your circuit on the breadboard. The alligator clip is always connected to the reference node in your circuit, while the probe tip is connected to the point you want to measure. Never connect the tip directly to the breadboard, instead connect it to a wire, and then place the wire at the node you want to measure.

The probe also has two different settings, 1X and 10X, make sure your oscilloscope setting matches the probe setting to ensure an accurate measurement.

Figure 4: Oscilloscope Probe

Experiment:

Please fill out the experimental report while going through the lab and submit it to the TA by the end of the lab for grading.

Part 1

- Turn on the oscilloscope, by pressing the power button; it is on the top of the box, above the word Tektronix.

Once it is on, the display area can display up to two signal waveforms via its two input channels CH1 and CH2. In addition to displaying waveforms, the display will also show details about the waveform and the oscilloscope control settings. A complete list of these details can be found on pages 10-12 in the manual on MyCourses, or pages 12-14 in the manual beside the equipment.

- Connect a BNC cable from the output of one of the function generators to CH1 of the oscilloscope. Turn on the function generator and select a sine function with a frequency of around 100 Hz. Vary the amplitude to see changes on the oscilloscope display.

Each channel has its own menu, and when you push a front-panel button, the oscilloscope displays the corresponding menu on the right side of the screen. The menu shows the options that are available when you push the unlabeled option buttons directly to the right of screen. The math menu will allow you to manipulate the input channels mathematically.

- Press channel 1's menu and go through some of the possible options. Set the coupling to DC.

The position of the signal on the display can be controlled with the vertical position knob and the vertical scale factors with the VOLTS/DIV knob. The vertical scale factor can be seen at the bottom left of the display You can also adjust the horizontal position of the all the channel waveforms, as well as the horizontal SEC/DIV scale factor.

- Vary channel 1's horizontal position and vertical position and scale factors with the knobs.

An oscilloscope's trigger function synchronizes the acquisition of the voltage in time, and it is essential for clear signal characterization. The trigger makes repetitive waveforms appear static on the oscilloscope display by repeatedly displaying the same portion of the periodic voltage. The trigger can be configured to respond to an internal or external event. If your displayed voltage appears unstable, you can change the trigger level with the knob or press the AUTOSET button. The trigger level is displayed at the bottom right of the display

- Change the trigger level with knob until the input signal appears unstable on the display, and then try to re-stabilize the trace.

The AUTORANGE button will activate or deactivate the autoranging function of the oscilloscope. When the autoranging function is active, the adjacent LED light is turned on.

- With the AUTORANGE button deactivated, change the output signal frequency of the function generator from 100 Hz to 1 KHz. Turn on the AUTORANGE, so that you can see the signal better on the display.

The MEASURE button displays the automated measurements menu. You can measure a wide range of useful information such as the peak-to-peak, maximum or mean voltages, as well as frequency. You can navigate between what is measured and displayed using the unlabeled buttons on the right of the screen

- Using the MEASURE button, display the frequency of your signal, the peak-to-peak voltage, and the mean voltage.

- Vary the frequency, the amplitude and the DC offset of your input signal and make sure you are able to see the changes in the measured values on the oscilloscope display.

The rest of the menu buttons are not important for the rest of the lab, but feel free to navigate through them to better understand the wide range of functions on the oscilloscope.

Now that you have learned the basics of the oscilloscope, it is time to design some circuits.

Part 2

2.1 Connect one of the function generators to the breadboard using a BNC cable with three 10 kΩ resistors, as shown in Figure 5. Note that the generator has a 50 Ω resistance. Set the function generator at approximately 400 Hz with a sine wave signal with an amplitude of 1.75 V. Verify the values using the oscilloscope. If you chose to use the oscilloscope probe, be sure that both the probe and the channel menu option are set to 1X, and that you connect the alligator clip to the reference node.

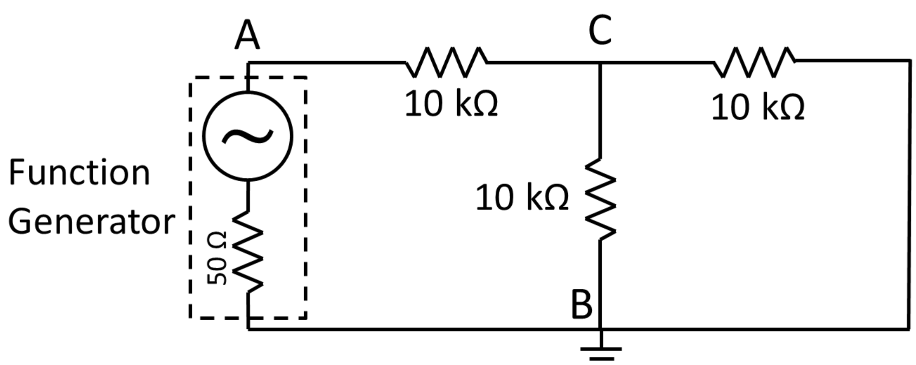

Figure 5: Function Generator with 3 Resistors Network

2.2 What is the AC peak-to-peak voltage between nodes C and B? What is the frequency of the voltage?

2.3 Set the amplitude of the input voltage to 0 V, and the DC offset to -1 V. Measure the DC voltages of both V_{AB} and V_{CB} (note that V_{AB} is the voltage difference between the node A and B; this convention will be used throughout the labs).

2.4 Keep the offset at -1 V, and set the amplitude to 1.75 V again, measure both the AC and DC components of V_{AB} and V_{CB}.

Part 3

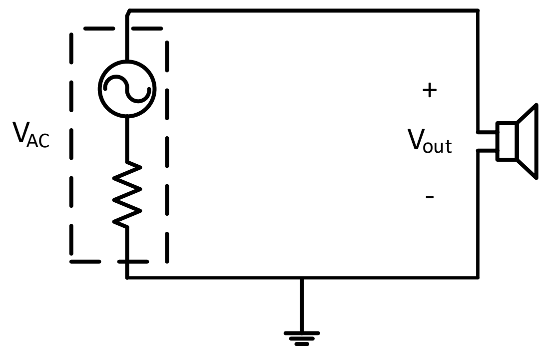

Figure 6: Speaker Connected to a Function Generator

3.1 Connect the speaker to a function generator as shown in Figure 6. Set the signal from the generator to a sine wave with a frequency of 440 Hz (A_4 musical note). Vary the amplitude of V_{AC} until you are able to hear a tone with the speaker (no DC offset is required). Listen to the signal using a sine, square and triangle waveform. Record the frequency and peak-to-peak voltage of V_{AC} (of the sine wave).

3.2 While maintaining the previous amplitude of V_{AC}, change the frequency of the generator. Listen to the signal using a sine waveform. Record the lowest and the highest frequencies at which you are able to hear the tones.

You can find a list of the different musical notes and their frequencies at:
http://www.phy.mtu.edu/~suits/notefreqs.html

Part 4

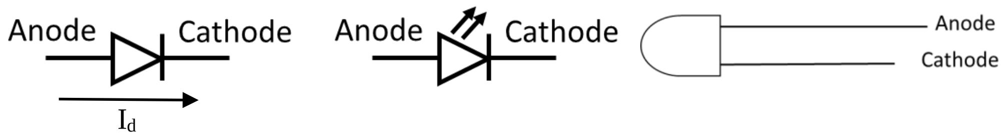

Figure 7: Diode and LED Schematics

In this part you will replace the speaker in the previous circuit with a light-emitting diode (LED). An LED is a semiconductor device that emits light when activated by passing a current through it. LEDs are polarized; they allow the current to pass in one direction from the Anode to the Cathode. The Anode terminal is identified by the longer pin, as shown in Figure 7.

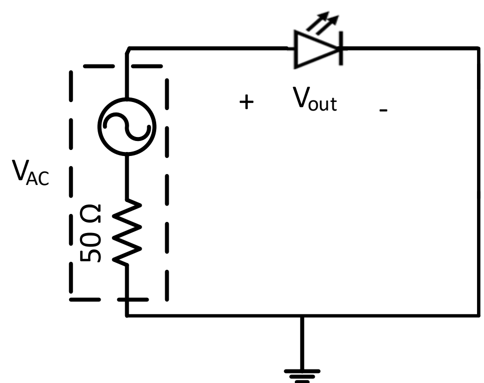

Figure 8: LED Connected to a Function Generator

4.1 Build the circuit shown in Figure 8. Set the signal of the function generator to a square wave of 30 Hz and the DC offset to zero. Starting from an AC input voltage of 0 V, increase the amplitude of the signal gradually until the LED turns on. Do not apply more than 6 V peak-to-peak across the LED to avoid burning the device. Record the minimum amplitude of V_{AC} that activates the LED.

4.2 Change the frequency of the function generator to 0.5 Hz while keeping the DC offset at zero. Record the minimum amplitude of V_{AC} that activates the LED. Observe the blinking pattern of the LED with respect to V_{AC} waveform, which can be displayed on the oscilloscope screen. Record the number of times the LED turns on/off in each period.

Use the RUN/STOP button to follow the trace of the voltage on the screen of the oscilloscope. As explained in Part 1, you can change the scale of the vertical and horizontal axes by adjusting the VOLTS/DIV and SEC/DIV knobs respectively. In case you are unable to directly read the measurements, use the grid (divisions) on the screen to estimate these measurements. The time and voltage represented by each division are displayed at the bottom of the screen. Using these values, you can calculate the voltage signal amplitude, the period, and the frequency (refer to Figure 2).