BME 1070 Introduction to Biomedical Engineering - Lab 3
Introduction to Cathode Ray Oscilloscopes and Signal Generators

Topics:

Basic Usage of Signal Generator

Basic Usage of Oscilloscope

Required Equipment and Components:

CRO (Cathode Ray Oscilloscope)  Resistors
Breadboard  Ac Signal Generator
DC power supply

Information:

Signal Generators

A signal generator is an electronic instrument that generates repeating voltage waveforms. An ideal signal generator can be simply modeled as a voltage source as shown in figure 2.1.1.

![Figure 2.1.1](image1.png)
![Figure 2.1.2](image2.png)
where $V_s(t)$ is a specified function of time. A practical signal generator is modeled as an ideal signal generator connected to a series source resistance (output resistance) $R_s$ as shown in figure 2.1.2. The terminal voltage, $v(t)$, is the output of the signal generator and depends on the terminal current, $i(t)$, and $R_s$.

A sine wave oscillator is the heart of the generator. It generates a sine wave of fixed amplitude and adjustable frequency, which is set by the external frequency control, by attenuator. The output of attenuator I is a sine wave with desired amplitude and frequency.

Figure 2.2 (The heart of the signal generator)

**Cathode Ray Oscilloscope (CRO)**

An analog oscilloscope displays the voltage waveforms by deflecting an electron beam generated by an electron gun inside a cathode-ray tube on to a fluorescent coating. Because of the use of the cathode ray tube, analog oscilloscopes are also known as cathode ray oscilloscopes.

Electron beam generated by the electron gun first deflected by the deflection plates, and then directed onto the fluorescent coating of the CRO screen, which produces a visible light spot on the face plane of the oscilloscope screen.
Electron gun provides a sharply focused electron beam directed toward the fluorescent-coated screen. The thermally heated cathode emits electrons in many directions. The control grid provides an axial direction for the electron beam and controls the number and speed of electrons in the beam.

The deflection system consists of two pairs of parallel plates, referred to as the vertical and horizontal deflection plates. One of the plates in each set is permanently connected to the ground (zero volt), whereas the other plate of each set is connected to input signals or triggering signal of the CRO.

In numerous applications it will be required to display a periodical voltage waveform as a function of time. By applying the voltage to be displayed on the CRO, to the vertical deflection plates \( (V_y) \), the vertical deflection of the beam spot will be proportional to the magnitude of this voltage. It is then necessary to convert the x axis (horizontal deflection) into a time axis. If the signal to be observed is periodic, then a periodic voltage waveform that varies linearly with time, as shown in figure below, is applied to the horizontal deflection plates. This type of waveform is called the sawtooth waveform.
Preliminary Work:

No preliminary work this week.

Procedure:

1) Switch the power of CRO on. If a trace is not yet visible, use the horizontal and vertical controls (marked with the labels vertical position and horizontal position) to bring the trace into view. Then, set the straight line to central position. If a trace is not clearly visible, then rotate the INTENSITY control. Also adjust FOCUS for trace sharpness.

2) Now, the CRO is ready for single trace operation. Restore the input coupling of Channel 1 to AC. Connect the positive lead of the probe of Ch. 1 to the CAL. 2V eyelet of the CRO and leave the ground lead of the probe unconnected. CAL. 2V eyelet of the CRO provides a square wave voltage waveform of 1 kHz frequency, and 2 V peak-to-peak (2 Vpp in short) amplitude.

3) To observe the square wave you may need to adjust the VOLT/DIV and TIME/DIV controls of Ch. 1. (1 volts for volt/div and 1mS for time/div). Then sketch the wave on figure 2.5. Please write the units, time division and voltage division to the graph.

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\text{Figure 2.5} 
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4) Set the output of the signal generator to a sinusoidal waveform of 4 Vpp amplitude and 500 Hz frequency. Connect the probe of channel 1 to the signal generator. Be sure that the grounded lead of the CRO is connected to the negative (black) lead of the signal generator. Set the TIME/DIV control to 1 ms/div and VOLT/DIV control to 0.5 V/div. Sketch the wave on figure 2.6.

![Figure 2.6](image)

5) Construct the network in figure 2.7 and measure the voltage on $R_1$ with oscilloscope. What can you say about this value?

![Figure 2.7](image)
6) Construct the network in figure 2.8 and measure the voltage value at node $x$ ($V_x$) with oscilloscope and sketch the wave on figure 2.9. For this measurement, do we have to use DC coupling or AC coupling, why?

7) Construct the network in figure 2.10 and measure the node voltages $V_x$, $V_y$ with oscilloscope in dual mode. Sketch the wave on figure 2.11.
8) For figure 2.10, measure node voltages $V_x, V_y$ in X-Y mode; what can you say about this shape.