**Oscilloscope Tutorial (Keysight EDUX1052A)**

**What is It?**
An oscilloscope measures a circuit's voltage over time, and plots the resulting reading on a graph.

**How Does It Work?**
The oscilloscope graph's horizontal axis measures the time scale, and the graph's vertical axis measures the voltage. The lines of the grid are called divisions. These can be adjusted to "zoom" in or out.

**What Can You Do with It?**
Various types of signals and their resulting waveforms can be measured, including sine waves, rectangular waves/square waves, triangular waves, sawtooth waves, and complex waves (a mixture of wave types, and are not necessarily periodic). Oscilloscopes typically have more than one channel (with corresponding probe connectors), so you can read more than one signal at once.

Here is an example of when you might use an oscilloscope. You have an Arduino and think the oscillator might be bad. You can check this with the oscilloscope. First, connect probe alligator clip to ground on the Arduino. Next, use the probe to touch the output side of the crystal. You should see a 16 MHz oscillation on the oscilloscope. If you see any other value, likely the crystal needs to be replaced.

**Safety**
- **General**- The machine poses no major safety concerns to the user

**Workflow**
- **Power**- Double check the power of your circuit. Oscilloscopes are rated for a maximum power input, which is written on the oscilloscope itself, right next to the channel input. The oscilloscopes in our lab are rated for 1M Ohm = 16 pF, 150V RMS (root-mean-square).
- **Turning On**- Then, Turn the oscilloscope's power on.
- **Setup**- Press "default setup" to use the scope's default settings and to clear out any old settings.
- **Calibrate/Compensate the Probe**- Check 1x-10x slider on probe (usually use 10x setting as it is most accurate setting for most applications). The first time you connect a probe to a oscilloscope channel, you need to impedance match the probe and the scope. Connect the probe to the calibration ports ("Demo/Probe Comp") on the oscilloscope, and get the signal on the screen. We want to see a square wave, so if your squares have peaks or curves, adjust until the signal is square. Use the provided probe adjuster and tweak until you get square waves.

- **Connection**- Now you can connect the probe to your circuit. Connect probe to earth/ground (with alligator clip), then connect probe to the signal output (with regular touch probe or hook probe).
- **Settings**- Oscilloscopes have four main controls that help you change what you see on the screen:
    - Horizontal scaling
    - Horizontal position
    - Vertical scaling
    - Vertical offset per channel
    - You can play with these settings until you are happy with what you see on the screen. When first setting up your signals, you should start at the highest voltage per division setting, and then zoom in until your signal fits on the screen.
    - **Scaling Your Signal**- You will see something on screen, then hit "auto scale" to view your signal properly.
- **Get Measurements**- Press the "Meas" (measure) button to take measurements. Optionally, you can use the "Run/Stop" button to stop the reading if the waveform you want to capture is on the screen. Waveforms can generally be measured in several dimensions:
    - **Amplitude**- the height of a wave from the mean or rest value to peak
    - **Period**- the distance for a wave to complete one full cycle
    - **Frequency**- the number of waves per unit of time; the amount of time for one wave cycle to complete
    - **Phase Shift**- when a wave form is moved horizontally left or right
    - **RMS Voltage**- "root-mean-square" voltage of the waveform is an average of its amplitude, on the basis of which you can calculate the power
    - **Peak-to-Peak Voltage**- the measurement of the difference in voltage between the lowest and highest points of a waveform cycle
    - **Risetime**- the measure of the time needed for a signal's voltage to go from a low to high level
    - **Pulse-Width**- the measurement of a pulse's width

**References**


- **More Information**
    - https://www.bing.com/videos/search?q=keysight+%22digital+storage+oscilloscope%22&&view=detail&mid=54A1C378E87E96BD452854A1C378E87E96BD4528&&FORM=VRDGAR&ru=%2Fvideos%2Fsearch%3Fq%3Dkeysight%2B%2522digital%2Bstorage%2Boscilloscope%2522%26FORM%3DHDRSC3
    - https://saving.em.keysight.com/en/knowledge/oscilloscope-basics