

Cornerstone Electronics Technology and Robotics I Week 20 Oscilloscope Lesson 1

- Administration:
 - Prayer
 - Turn in quiz
- Electricity and Electronics, **Section 10.5**, Oscilloscope, Measuring Voltage:
 - Basic Information: An oscilloscope is like a graphing machine; it plots voltage (y-axis, the vertical axis) as it varies with respect to time (x-axis, the horizontal axis).
 - Oscilloscopes measure voltages only; they do not measure currents or resistances. We will be using the oscilloscope to plot an input signal voltage vs. time. The trace on the screen moves up and down on the y-axis as the input signal voltage increases and decreases. The trace sweeps across the x-axis in a linear motion at a speed set by the operator.
 - If the operator is measuring a constant direct current (dc) signal, the trace will remain level across the screen at a value equal to input dc voltage. When a varying dc signal or an alternating current (ac) signal is measured, the trace will follow the voltage level as it changes in time producing a graph of the input signal voltage with respect to time. This displays the form of the ac voltage wave, or the waveform.
 - Display constant dc voltage – battery output
 - Display waveform from contact mic.
 - Our oscilloscopes can simultaneously display two waveforms on the screen from two separate inputs.
 - See:
<http://www.schulphysik.de/ntnujava/oscilloscope/oscilloscope.html>
 - Types:
 - Analog
 - The voltage amplitude deflects a beam of electrons that strike the oscilloscope screen.
 - The time sweep is generated internally by the oscilloscope.
 - Our oscilloscopes are the analog type.
 - Digital
 - Improved amplitude and time measurements
 - Safety: General Test Instrument Safety Guidelines: Normal use of the equipment exposes you to a certain amount of danger from electrical shock because testing must often be performed where exposed high voltage is present.
 - Measurements that the oscilloscope can make:
 - DC voltage
 - AC voltage
 - Waveform duration
 - Waveform frequency
 - Waveform shape

- Oscilloscope Screen:
 - Definition: graticule - a network of fine lines, dots, cross hairs, or wires in the focal plane of an optical instrument.
 - The screen of the oscilloscope or scope is divided into 10 major horizontal divisions and 8 major vertical divisions. Each of these major divisions is subdivided into 5 equal minor divisions by short lines on each axis.

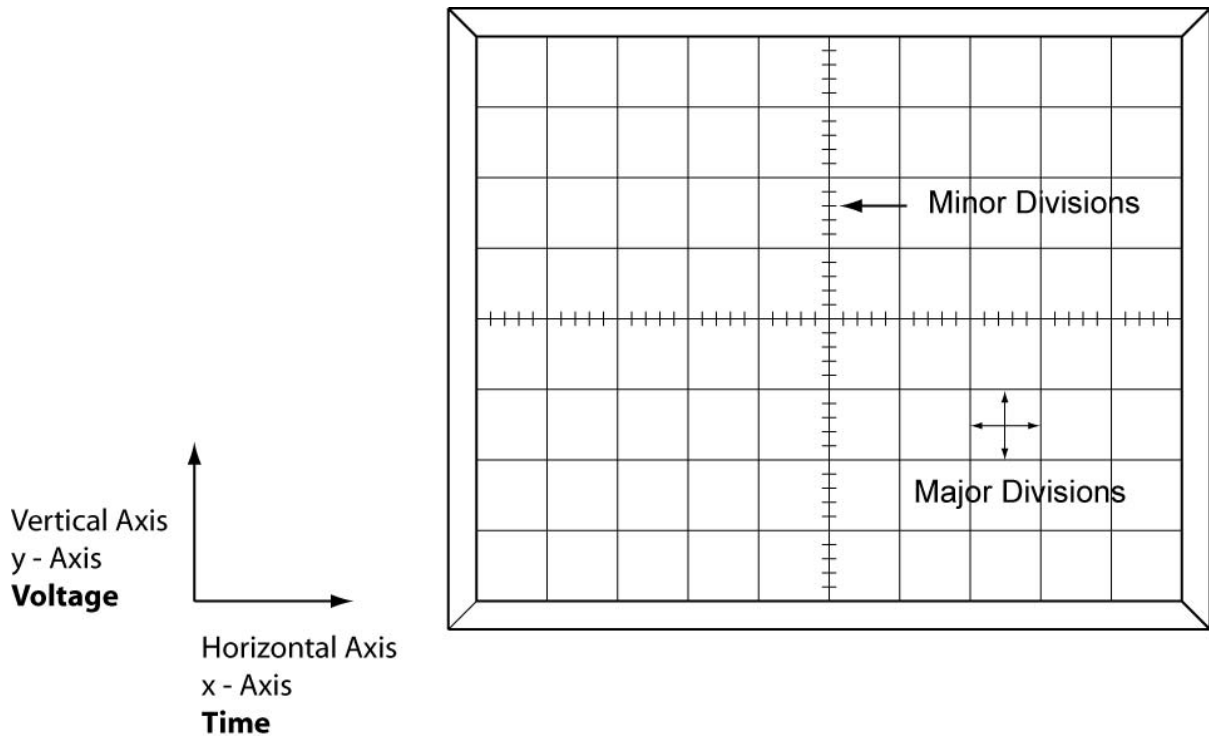
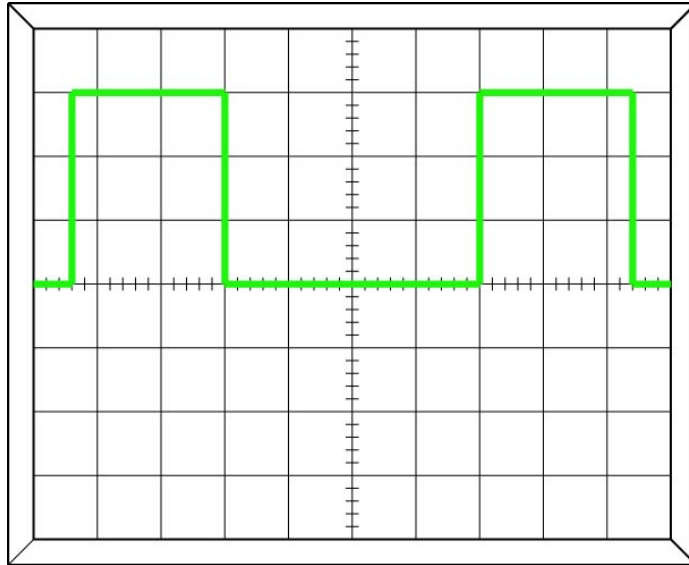


Figure 20 – 1 The Oscilloscope Screen Grid

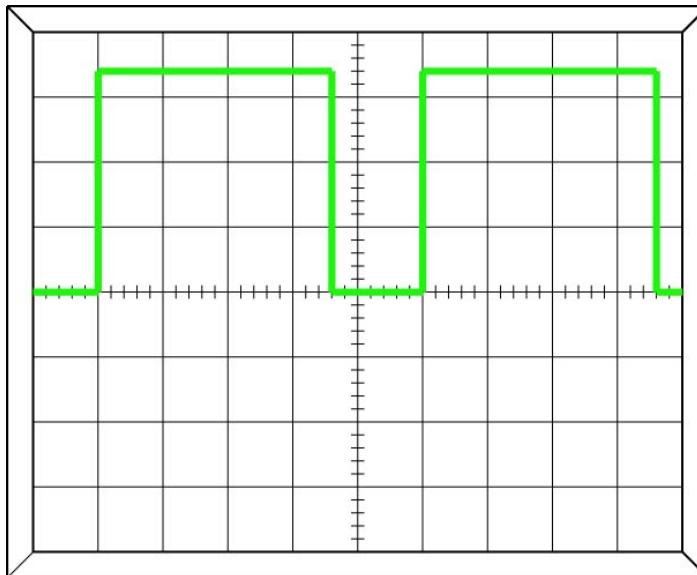
- Controls:
 - See Figures 20-2 & 20-3 in Lab 1 and Figures 20-5 & 20-6 in Lab 2 for the images of the front panel controls (pages 5 & 7).
 - General Controls:
 - POWER button: Turns power on/off.
 - INTENSITY: Adjusts brightness of trace.
 - TRACE ROTATION: Adjusts to maintain trace in a horizontal position. This is a screwdriver-type adjustment.
 - FOCUS: Adjusts trace focus.
 - GND: Oscilloscope chassis ground jack and earth ground via three-wire ac power cord.
 - CAL: Terminal provides 2 volt peak-to-peak, 1 kHz square wave signal.
 - Vertical Controls:
 - CH1/CH2 INPUT JACKS: Vertical inputs (signal inputs) for channels 1 and 2.
 - CH1/CH2 AC-GND-DC:

- AC: Blocks dc component of the signal, allowing only the ac component through.
 - GND: Grounds the input signal, which eliminates trace deflections. This provides a zero-volt baseline which can be used as a reference when performing measurements.
 - DC: Displays both ac and dc components of the input signal.
 - CH1/CH2 VOLTS DIV: Provides step adjustment of vertical (voltage) sensitivity. When the variable control knob is set to CAL'D, the vertical sensitivity is calibrated in 10 steps from 5V to 5mV.
 - CH1/CH2 POS: Adjusts the vertical position of the channels 1 and 2 traces.
 - VERT MODE:
 - CH1: Displays channel 1 by itself.
 - CH2: Displays channel 2 by itself.
 - DUAL: Displays channels 1 and 2 simultaneously.
 - ADD: Displays the sum of the inputs from channels 1 and 2.
 - Horizontal Controls:
 - TIME DIV: Provides step selection of sweep rate for the main time base (x-axis).
 - VAR SWEEP: Adjusts the vernier sweep rate. If the control is fully clockwise, the sweep rate is calibrated to the setting on the TIME DIV control.
 - POSITION: Adjusts the horizontal position.
 - Triggering Controls:
 - TRIG LEVEL: Stabilizes the waveform on the screen.
 - Automatic-Normal Trigger Control: Set control to auto. This automatically creates a time sweep across the display.
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- Start-up: Perform Oscilloscope 1 Lab 1 – Initial Start-up Procedure
 - Displaying a Signal: Perform Oscilloscope 1 Lab 2 – Displaying a Signal
 - See applet: <http://www.csupomona.edu/~pbsiegel/www/idm/oscope.html>
Calculate amplitude and frequency of several waveforms.

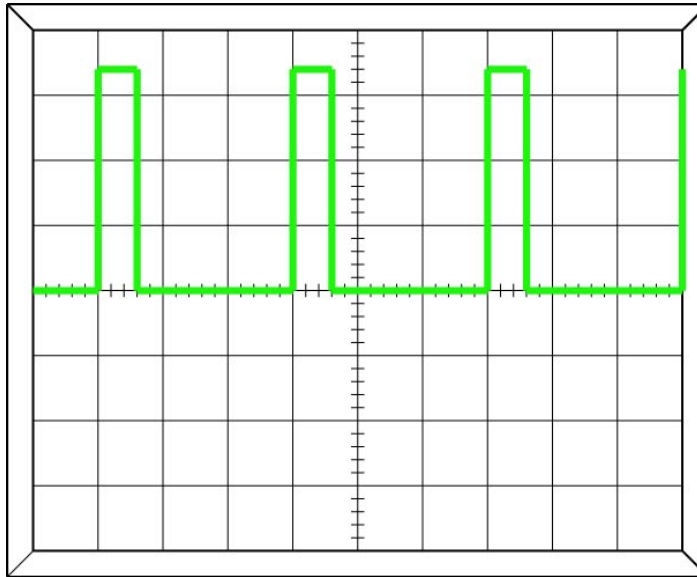
- Sample Voltage and Period Displays:



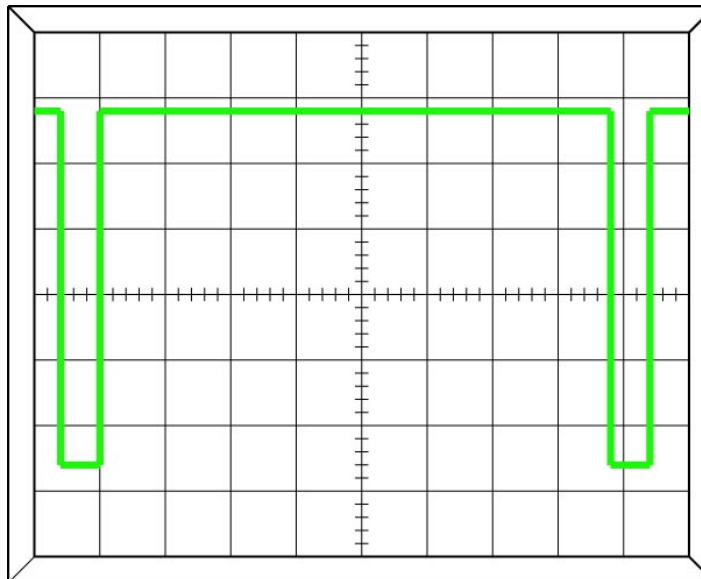
If the Volts/Div Setting is at 1 volt, what is the voltage displayed?
If the Volts/Div Setting is at 0.5 volts, what is the voltage displayed?



If the Volts/Div Setting is at 5 millivolts, what is the voltage displayed?
If the Volts/Div Setting is at 0.2 volts, what is the voltage displayed?



If the Time/Div Setting is at 10 ms, what is the period of the waveform displayed?
 If the Time/Div Setting is at 0.1 ms, what is the period of the waveform displayed?
 If the Time/Div Setting is at 0.2 ms, what is the period of the waveform displayed?



If the Time/Div Setting is at 1 ms, what is the period of the waveform displayed?
 If the Time/Div Setting is at 50 us, what is the period of the waveform displayed?

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Oscilloscope Lab 1 – Initial Startup Procedure

- **Purpose:** The purpose of this exercise is to perform the startup procedure for an oscilloscope.
- **Apparatus and Materials:**
 - 1 – Oscilloscope
- **Procedure:**
 - Set the basic controls as follows: These settings prepare the scope for a single-trace display of a zero-volt base line, centered vertically and horizontally. At this point, no signal is applied.
 - **Vertical Mode Control (O13):** CH1 (See the next page for the location of the controls on the oscilloscope.)
 - **CH 1 Input Coupling Switch (O9):** GND
 - **CH 1 Vertical Position Control (O5):** centered.
 - **Horizontal Position Control (O8):** centered.
 - **Trigger Coupling Switch (O6):** AUTO
 - **Intensity Control (O3):** minimum intensity.
 - **Time/Div Control (O14):** 0.5 ms/Div
 - Plug in the oscilloscope and turn the **Power Switch (O1)** on. Allow the unit a few seconds to warm up.
 - Slowly bring the **Intensity Control (O3)** up. You should see a horizontal trace near the center of the screen.
 - Adjust the trace sharpness with the **Focus Control (O4)**, and adjust the trace tilt with the **Trace Rotation Control (O2)**.
 - Follow the same process for a single trace on channel 2. Start by setting the **Vertical Mode Control (O13)** to CH2.

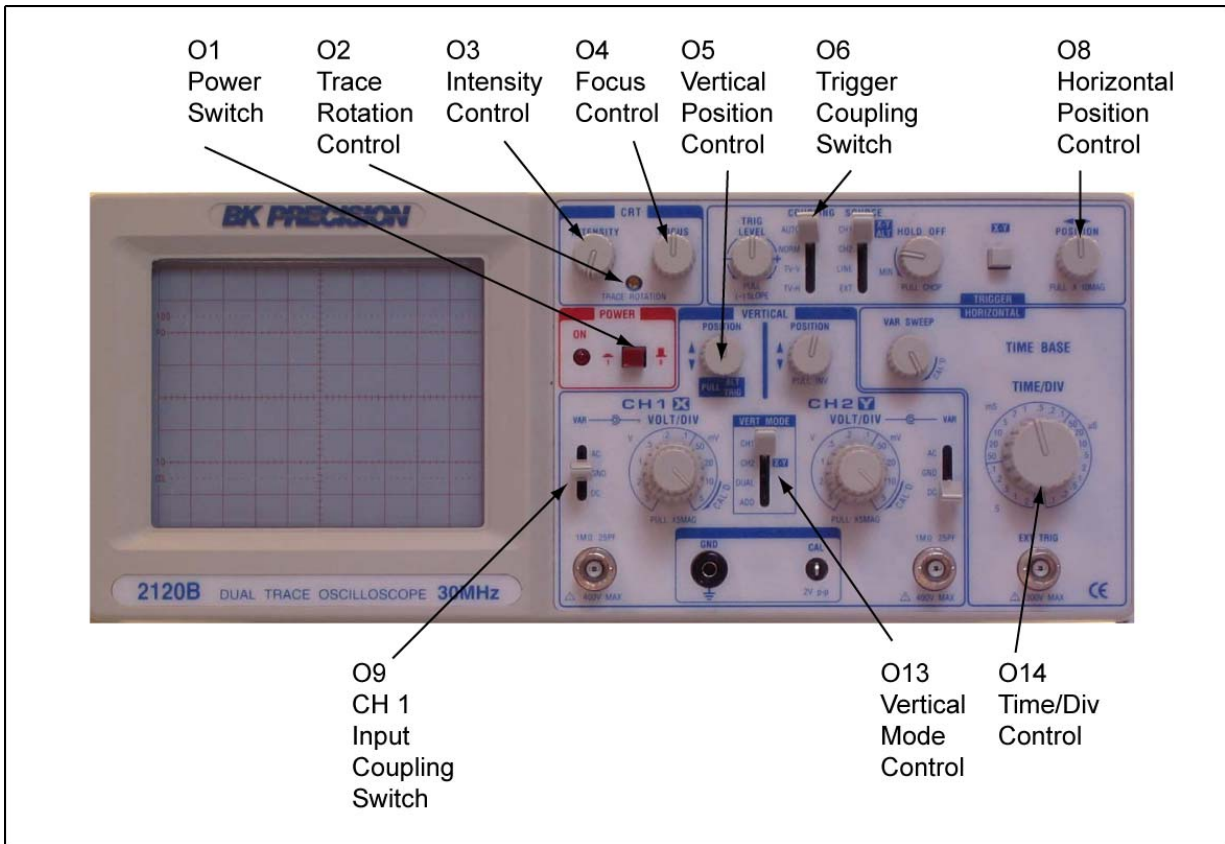


Figure 20 - 2 BK Precision 2120B Controls for Lab 1

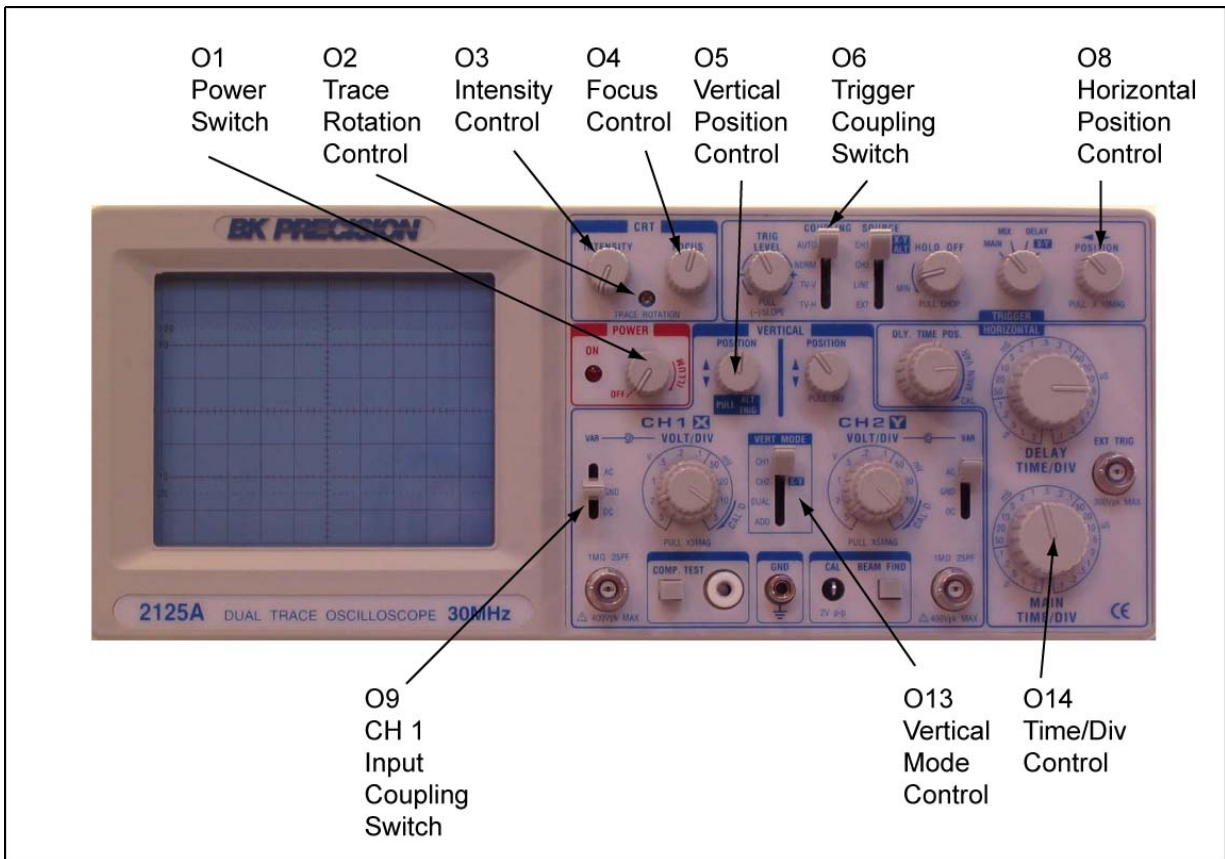


Figure 20 - 3 BK Precision 2125A Controls for Lab 1

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Oscilloscope Lab 2 – Display a Signal

- **Purpose:** The purpose of this exercise is to display a signal on an oscilloscope.
- **Apparatus and Materials:**
 - 1 – Oscilloscope
 - 1 – Solderless Breadboard with 9 V Power Supply
 - 1 – 25 K Tripot
 - 2 – 1 K Resistors
 - 1 – 220 Ω Resistor
 - 1 – 2.2 μ F Capacitor
 - 1 – 2N2222A NPN Transistor
 - 1 – 555 Timer IC
 - 1 – LED
- **Procedure:**
 - Wire the 555 timer LED flasher circuit below.
 - Connect the scope probe to the **CH 1 Input Jack (O10)**. (See the next page for the location of the controls on the oscilloscope.)
 - Adjust the **CH 1 Variable Attenuator (O11)** to the full clockwise position. This assures that the screen's vertical divisions for the voltage scale are in calibrated.
 - Set the **CH 1 Volts/Div Control (O12)** to 5.
 - **CH 1 Input Coupling Switch (O9):** DC

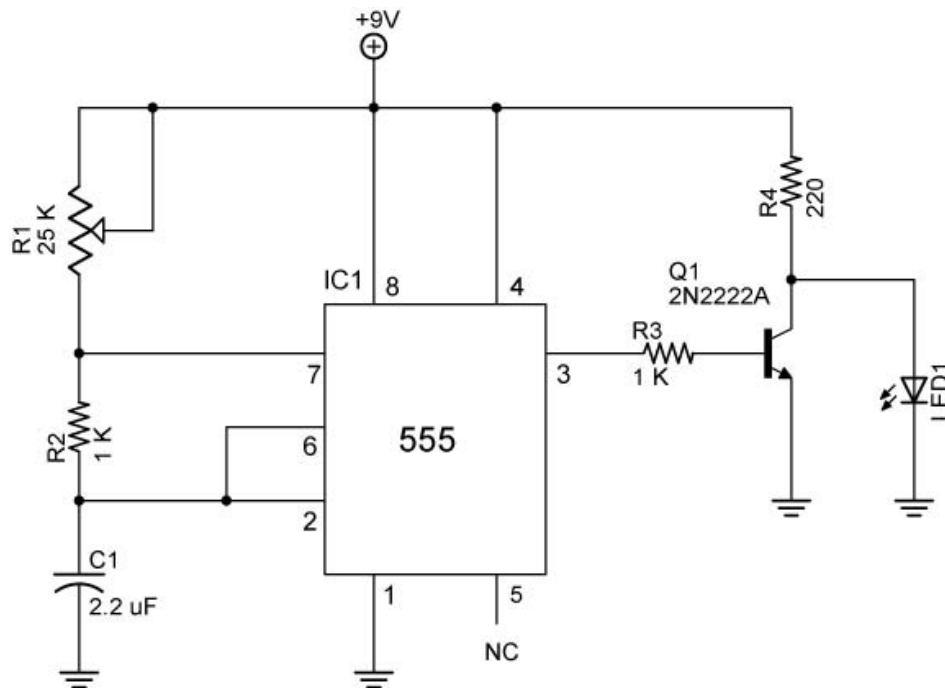


Figure 20 - 4 LED Flasher

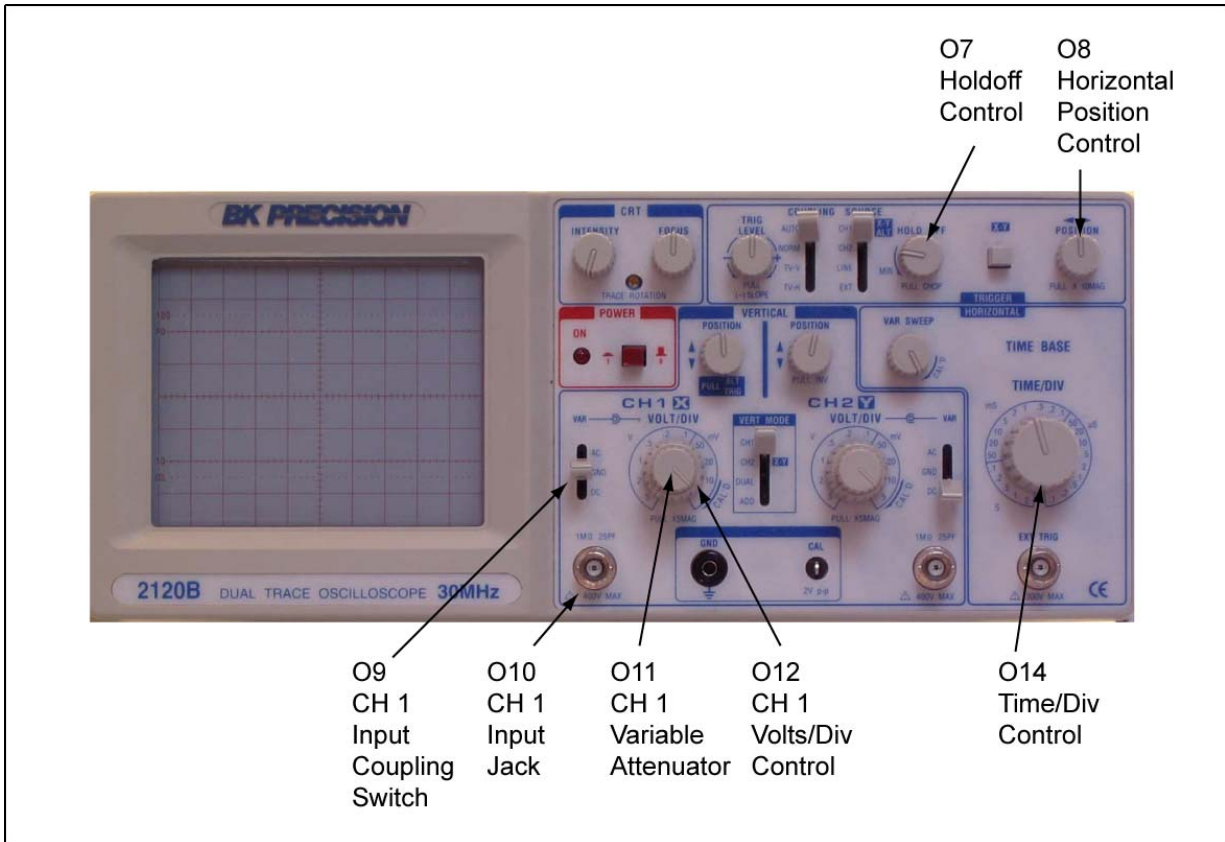


Figure 20 - 5 BK Precision 2120B Controls for Lab 2

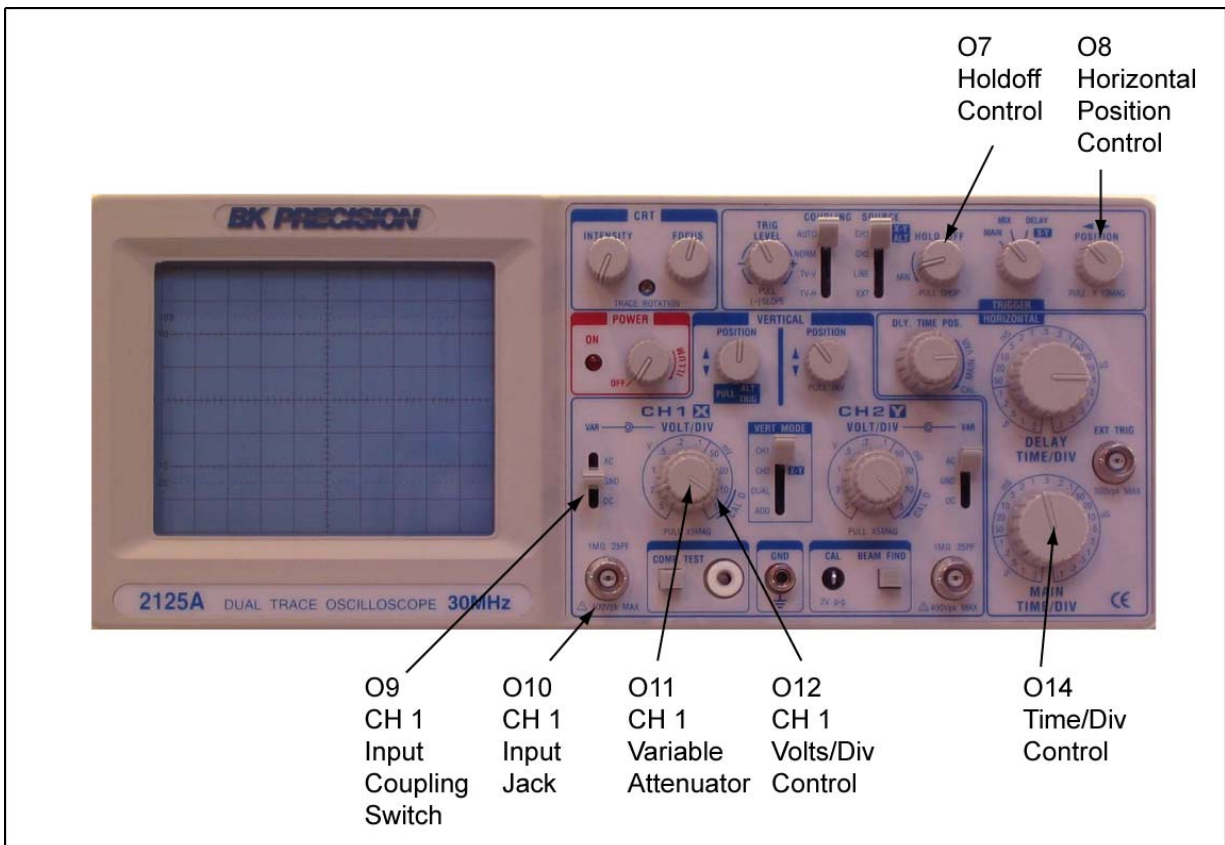


Figure 20 - 6 BK Precision 2125A Controls for Lab 2

- Now connect the probe's ground clip to the circuit ground.
- Set the probe slide switch to x1.

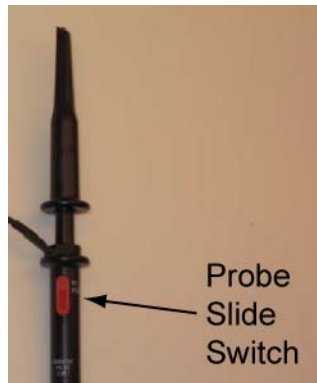


Figure 20 – 7 Oscilloscope Probe

- Display the wave form across the LED by connecting the probe tip to anode of the LED. Adjust the **Holdoff Control (O7)** to help stabilize the waveform.
- Adjust R1 and observe the changes in the waveform.
- Voltage Level of Pulse:
 - Set the **CH 1 Volt/Div Control (O12)** to 1. This means each vertical division on the screen is equal to 1 volt.
 - Calculating the voltage from an oscilloscope:

$$\text{Voltage} = \text{Number of Divisions Tall} \times \text{Volts/Div Setting}$$

For example in Figure 20 – 8, if the Volt/Div Control is set for 2 volts:

$$\begin{aligned} \text{Voltage} &= \text{Number of Divisions Tall} \times \text{Volts/Div Setting} \\ \text{Voltage} &= 3.2 \text{ Divisions Tall} \times 2 \text{ Volts/Division} \\ \text{Voltage} &= 6.4 \text{ V} \end{aligned}$$

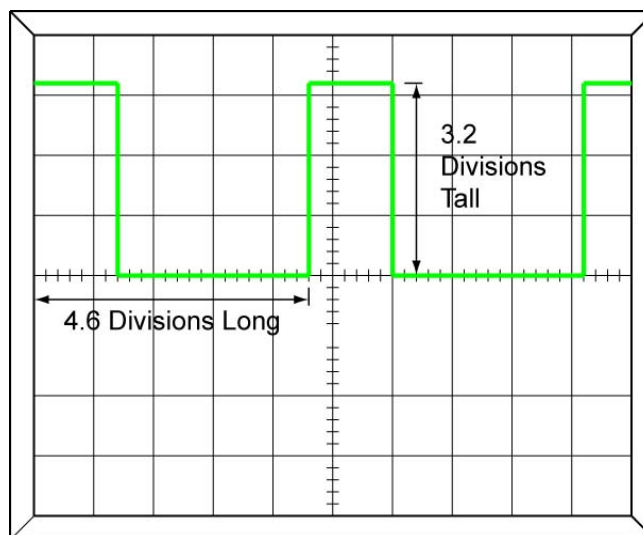


Figure 20 – 8 Calculating Voltages

- Measure the voltage at the anode of the LED and record in the table provided.

- Timing of Pulses:
 - Set the **Time/Div Control** (O14) to 5 ms.
 - Measure the length of time of a positive pulse and record the results. To assist with this measurement, you may want to move the leading edge of the pulse to a division line using the **Horizontal Position Control** (O8).
 - Vary R1 and note the changes in the waveform.
 - Now set R1 to have the longest off time between pulses. You may have to change the **Time/Div Control** (O14) to display two pulses on the screen.
 - Measure and record the maximum time off between pulses.
 - Now set R1 to have the shortest off time between pulses. R1 is set to just before the pulse waveform breaks down. Change the **Time/Div Control** (O14) to achieve greater precision.
 - Measure and record the minimum time off between pulses.
- Period T of a Waveform:
 - Calculating the period from an oscilloscope:

$$T \text{ (Period of Waveform)} = \text{Number of Divisions Long} \times \text{Time/Div Setting}$$

For example in Figure 20 – 9, if the Time/Div Control is set for 0.5 ms:

$$T = \text{Number of Divisions Long} \times \text{Time/Div Setting}$$

$$T = 4.6 \text{ Divisions Long} \times 0.5 \text{ ms/Division}$$

$$T = 2.3 \text{ ms}$$

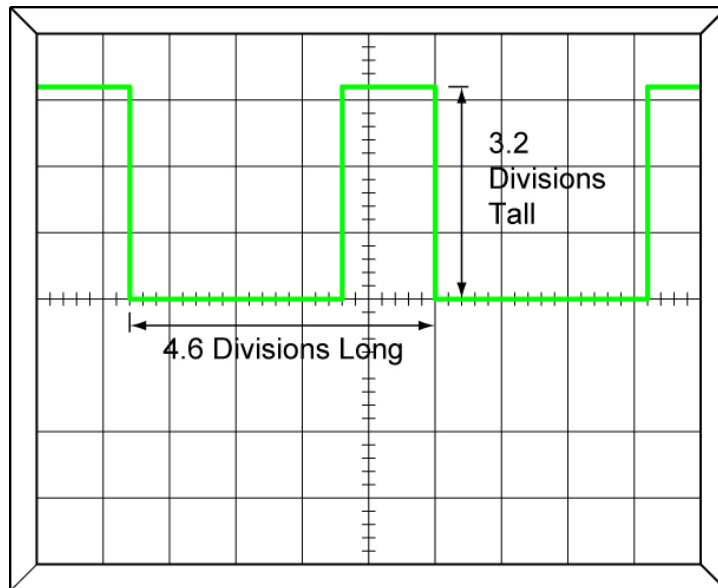


Figure 20 – 9 Calculating the Period

- Set the period (T) of the waveform to 20 ms. Since

$$T = \text{Number of Divisions Long} \times \text{Time/Div Setting}$$

$$\text{Number of Divisions Long} = T / \text{Time/Div Setting}$$

Let Time/Div Setting = 5 ms and T = 20 ms,

$$\text{Number of Divisions Long} = 20 \text{ ms} / 5 \text{ ms}$$

$$\text{Number of Divisions Long} = 4 \text{ Divisions Long}$$

- Have the instructor verify your setting.
- Calculate and record the frequency of this waveform. $F = 1/T$

- Now adjust R1 to the point when the blinking effect appears to become a constant light.
- Measure the period T of this waveform.
- Calculate and record the frequency.

- **Results:**

Voltage at anode of LED	V
Length of time of the positive pulse	ms
Does the pulse width change by varying R1?	Yes / No
Maximum time off between pulses	ms
Minimum time off between pulses	ms
Frequency of waveform w/ period = 20 ms	Hz
Frequency when blinking stops	Hz

- **Conclusions:**

- From the results of the last frequency calculation, why do you think 60 Hz is used to power generation?