Oscilloscopes
Spring 2003

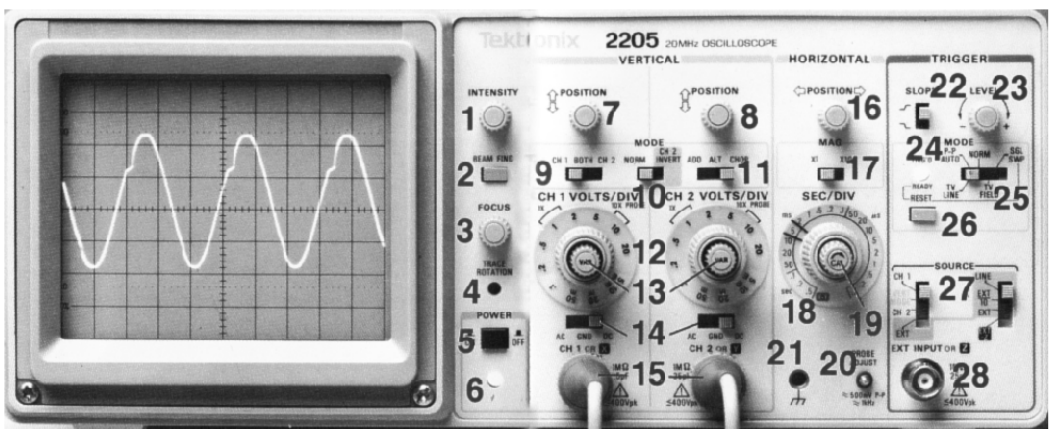
Introduction

The purpose of this lab is to become familiar with the oscilloscope as a voltage-measuring device. You should experiment freely with different combinations of control settings; so long as you do not force any of the knobs, or drop the oscilloscope on the floor, you can do it no harm. In your report, use words and sketches to describe what you have observed at each step. Exercise your curiosity!

The control panel is divided into four major functions (see picture below):

- CH1 - Left vertical channel (gives horizontal deflection in x-y mode)
- CH2 - Right vertical channel
- Time Base (labeled as Horizontal)
- Trigger options

In addition, there is a section containing **intensity** (1) and **focus** (3) knobs, and a useful button labeled **Beam Find** (2). Press and hold this button to locate the spot if it has been moved off screen.



Experiment

I. *X-Y Voltage Measurements ("Etch-a-Sketch mode")*:

1. Turn the oscilloscope on by pressing the **Power** button (5).
2. Turn the *time base* (also referred to as *sweep*) knob (18) fully counterclockwise to **x-y** and turn both *volt/div* knobs (12) to **1** volt/div ("1" on the dial should be aligned with "1x" on the faceplate). This way, a voltage across the CH1 (15 – left) leads displaces the spot horizontally one centimeter for a one-volt potential difference. Voltage across the CH2 (15 – right) leads displaces the spot vertically.
3. Check that the switches (14) under each volt/div knob are set to **DC**.
4. Short out the input leads on CH1 (i.e. connect them directly together); do the same on CH2, and focus the spot (3). Adjust the intensity (1) so the spot will not burn the screen. Now move the spot horizontally with the **horizontal position** knob (16), and vertically with the CH2 **vertical position** knob (8) so that the spot is centered at the origin. When the spot is centered, remove the shorts from CH1 and CH2.

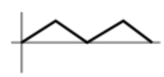
5. Hold the CH1 leads across the terminals of a 9-volt battery and observe the movement of the spot (note that the red connector on CH1 is the positive terminal, and black is the negative terminal). With the leads still connected to the battery, change the sensitivity with the CH1 vertical sensitivity knob (12) to see how it works. Make sure that the **cal** knob (13) is turned fully clockwise, then measure the battery voltage by interpreting each centimeter mark as a number of volts equal to the "volts/div" setting on the sensitivity knob. Use a voltmeter to measure the terminal potential of the battery, and see if the scope agrees with the voltmeter. Reverse the battery and repeat your measurements

6. Now repeat with the CH2 leads, and verify the calibration for vertical displacements.

II. *Voltage as a function of time*:

1. Connect the CH2 leads to the *red* and *green* (ground) connectors on the lab bench (***do not** use the **black** connector; use the **green** ground connector!*). The red connector provides a low frequency *sine wave*. The spot should go up and down as the voltage oscillates. You can see its sine shape if you 'drag' the spot horizontally by turning the horizontal position knob (16) back and forth rapidly. Disconnect the CH2 leads from the lab bench, connect the CH1 leads to the red and green connectors, and observe the horizontal motion when you put the sine function on the x-axis.


Sine Wave


Sawtooth Wave


Square Wave

2. Now connect the CH1 leads to the *black* and *green* connectors; this will provide a low frequency *sawtooth wave*. The spot should move to the right and snap back - just like when you 'dragged' it by hand. So, reconnect the sine wave (red connector) to CH2 and let the sawtooth voltage drag it - revealing the sine wave.

3. The time base and trigger will do all this automatically and synchronize it as well. Slide the trigger mode switch (25) to **P-P Auto** and the channel mode switch (9) to **CH2**, then turn the time base (sweep) knob (18) clockwise a click or two. This removes the "x-y" mode and instead sweeps the spot repetitively across the screen. Play with the sweep and sensitivity (12) knobs to get a sense of how to view a sine voltage.

4. Move the channel mode switch (9) to **CH1** to look at the sawtooth wave. Display both the sawtooth and the sine waves by changing the mode switch (9) to **BOTH** and (11) to **CHOP**, and using both CH1 and CH2 leads. With (9) set to **BOTH**, move (11) to **ALT** and then to **ADD** to see the difference in these settings.

5. Disconnect *both* CH1 and CH2 leads from the lab bench, then connect either channel to the **probe adjust** terminal (20) and observe a *square wave*. Practice by measuring its period and amplitude. Use the **cal** knob (19) on the sweep knob (18) to "freeze" the square wave.

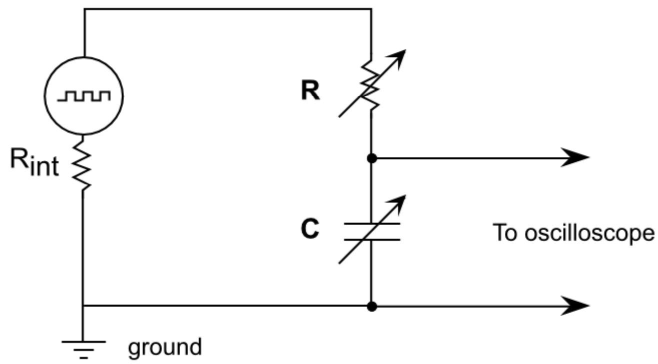
III. *Examining Sound Waves*:

1. Connect either channel to an audio oscillator set for 1000 Hz (set the amplitude on the oscillator to anything other than zero) and measure the period (there are three connectors on the audio oscillator – one black, and two red. Use the black connector, and the red connector on the right). The period *should* be T = 1/1000 sec (1.00 ms).

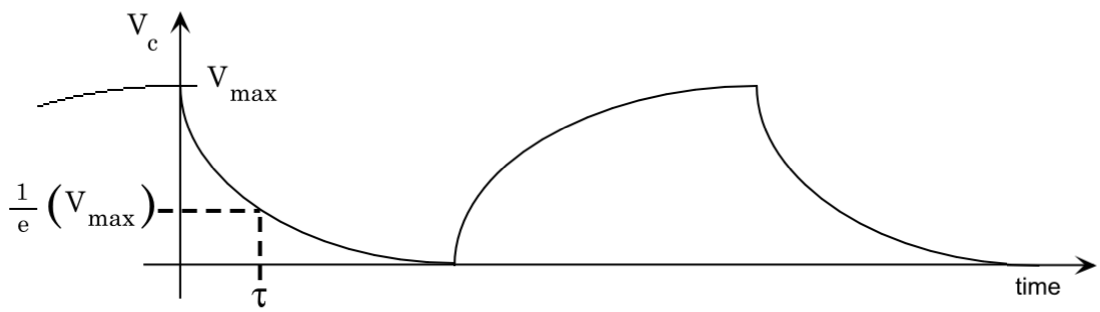
2. Disconnect the audio oscillator, and connect a small speaker to either channel, and use it as a microphone. Sing the various vowel sounds into the "microphone" and observe what their pressure waves look like. Try singing the vowels at different pitches or whistling.

IV. *Charging & discharging of a capacitor through a resistor*:

1. Connect the *RC* circuit as shown below, using decade boxes for the resistance and capacitance. Use the oscilloscope as a *square wave* power supply (connect wires to the probe adjust (20) and ground (21) connectors). As you would with any voltage-measuring instrument, connect the oscilloscope *last*.



2. Play with the values of *R* and *C* until you can produce a trace that looks something like this (hint: keep *R* high, and *C* low):



The voltage across a capacitor in an *RC* circuit as a function of time is given by the following expression:

$$V(t) = V_{\max} e^{-t/\tau}$$

where the *time constant* $\tau = RC$. When the elapsed time $t = \tau = RC$, then the expression becomes:

$$V(t) = V_{\max} e^{-1}$$

3. Measure on the oscilloscope the time it takes for the voltage to decay to $^{1}/_{e}$ of its maximum value. This will give you the time constant, τ, of the circuit.

4. Disconnect the resistor and capacitor from the circuit, and measure *R* and *C* with a multimeter and a capacitance meter, respectively (don't rely on the "knob" settings on the resistor and capacitor). Use these measured values to find $\tau = RC$. Both values of the time constant should be equal (the internal resistance of the "battery" – the oscilloscopes square wave supply – is around 1.3 kΩ, so you should expect a discrepancy between the two RC measurements).