

CATHODE RAY OSCILLOSCOPE



The cathode ray oscilloscope (CRO) is a device which converts electrical energy into a graphic image, called the trace. The heart of the device is a glass tube with a screen like a TV. When an alternating current (AC) is applied to the CRO inputs, it shows up as a simple wave form on the screen; direct current (DC) is displayed as a straight line. A voice, which has been converted to an electrical signal by a microphone, is shown on the screen as a complex wave form. The CRO is also a good device for measuring voltage because it has a very high internal resistance ($> 1 \text{ M}\Omega$) and does not interfere very much with the operation of the circuit under investigation. The trace can be analysed in terms of voltage (vertical axis measurements) and time (horizontal measurements).

SETTING UP AND USING THE CATHODE RAY OSCILLOSCOPE

X Extra equipment for the suggested learning experiences (numbers refer to appropriate experiences) includes:

- 2 power packs (2, 6, 8, 9)
- a small loudspeaker (readily available at Dick Smith's) (7)
- an audio oscillator/amplifier (5, 7, 8, 9)
- musical instruments such as guitar, violin, etc.
- a demonstration electric generator (1)
- a microphone (3, 7)
- leads
- 1.5V dry cell (1)
- tuning forks
- organ pipes (7)
- 1 metre of aerial wire (4)

- 1. an air-core solenoid (10)
- 2. a powerful magnet (10)

Setting up the Oscilloscope

Shortcut Method to obtain a trace on the machine.

1. Turn the machine off.
2. Turn all knobs with a CAL or AUTO setting to CAL or AUTO.
3. Turn all other knobs to the mid position.
4. Turn the brightness knob to maximum.
5. Switch the machine on and WAIT for about 20secs to 1 minute as most machines need time to warm up.
6. If the trace does not appear as a straight green line or a moving spot, follow the detailed setup instructions below.

Detailed Method to obtain a trace.

1. Identify the POWER switch, often coupled with the brightness control and turn it OFF.
2. Turn the FOCUS control to the mid-way position.
3. Rotate the TIME-BASE selector switch (coarse control) to a suitable setting. This adjusts the time taken for the spot to move 1 cm across the screen. The **frequency** of the waveform will be the reciprocal of the time taken for one complete cycle. For a 50 Hz signal from a power pack choose the 5ms/cm setting on the TIME-BASE Selector so that 1 cycle will take 20ms and cover 4cm of the screen. Only select EXT or HOR INPUT when you are feeding in a signal to the horizontal axis as well as the vertical axis.
4. Rotate the fine control TIME-BASE knob to CAL (calibrated) which is necessary if accurate voltage readings are to be taken from the screen.
5. Set the DC/AC switch to DC and leave it there. (AC is only used when trying to view the small varying component of a DC voltage)
6. Turn the X-SHIFT and Y-SHIFT knobs to the mid-position.
7. Switch the X-GAIN to the CAL (calibrated) position.
8. Adjust the Y-GAIN to a mid-way setting such as 1 V/cm.
9. Set the TRIG level to the auto position.
10. Set the TRIGGER +/- switch to the + position and set the TRIGGER source to the input selected for use; CH1 or CH2.
11. Turn ON the power and allow for a 2 minute warm-up period.
12. Rotate the BRIGHTNESS control to a maximum.
13. Adjust the STABILITY control so that the trace just starts to appear on the screen.

Further Setting up Procedure

- Connect the voltage to be measured by the CRO to the Y-INPUT (VERT INPUT) consisting of 2 sockets, the lower one of which is earthed (—).
- In order to connect a microphone directly to the Y-INPUT terminals, wrap a short piece of wire around the 'live' end of the microphone plug and connect it to the upper, positive terminal of the CRO. Connect a second piece of wire from the external casing of the plug to the earth input terminal of the CRO (see figure 1).
- When connecting a DC power supply to the Y-INPUT of the CRO always connect the **negative** terminal of the power source to the **earth** input socket of the CRO.

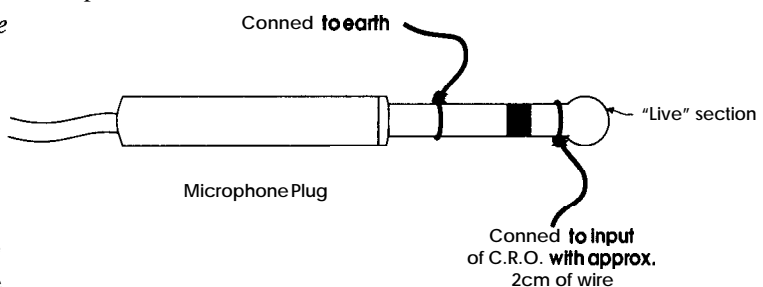


figure 1

HANDY HINT

- In order for all students to see the small CRO screen set up the video camera focusing on the trace and connect it up directly to a TV screen. (*See notes on using a video, page 52*).
- Once the machine is turned on leave it on and avoid switching it on and off.

AN OSCILLOSCOPE GLOSSARY

There are many different types of Cathode Ray Oscilloscopes used in schools. Although the principles are the same, the labels on the controls differ. Some of the alternative terms are set out below.

Alternative LABELS on the Control	SETTINGS on the Control	FUNCTION of the Control
Controls for Moving the Spot Across the Screen		
TIME-BASE TIME/DIV TIME/CM	finecontrol variablecontrol CAL = Calibrated (to read accurately from the screen)	controls the speed of the spot across the screen in s/cm, ms/cm or μ s/cm
Controls For Releasing The Spot		
TRIG TRIGGER SWEEP	AUTO • trace always triggers NORMAL (AUTO OFF) • trace only triggers if level is correctly set and signal large enough	controls the release of the spot for each pass across the screen
TRIG LEVEL LEVEL		sets the starting level of the spot
COUPLING	DC • used for most experiences AC • blocks DC signal and lets you see a small AC ripple	
SOURCE	INTERNAL, CH 1, CH 2 • looks at the signal on channel 1 or 2 EXTERNAL (EXT) • looks at external input LINE • 240V power line • useful when you want triggering at 50 Hz	causes the trigger to look for a signal
Control for moving the Spot Horizontally		
X POSITION ↔ POSITION		controls the horizontal position of the whole image
Controls for Moving the Spot Vertically		
VERTICAL AMPLIFIER VOLTS/DIV VOLTS/CM	CAL = calibrated to read accurately voltages from the screen	controls height of the image in volts/cm
Y • POSITION ↑↓ POSITION		controls vertical position of the image

SUGGESTED LEARNING EXPERIENCES

TOPIC: Electricity

- 1. Investigate the nature of AC and DC voltages.** To demonstrate DC, connect a 1.5V dry cell to the Y-INPUT terminals of the CRO. Adjust the Y-GAIN to 0.2V/cm and the TIME-BASE Selector to 1s/cm. To demonstrate AC, connect the demonstration electric generator to the Y-INPUT terminals of the CRO. Set the Y-GAIN on 5 V/cm and the TIME-BASE Selector on 100ms/cm. Note the waveforms and amplitude.
- 2. Investigate both the AC and DC voltage outputs from a school power supply.** Connect the AC terminals of a Power pack unit to the Y-INPUT terminals of the CRO and adjust the setting to 'B'. Set the Y-GAIN on 2 V/cm and the TIME-BASE Selector on 10ms/cm. Switch to the DC terminals of the power pack and observe that the so-called DC current is really rectified AC - it is not a smooth consistent voltage output but contains a ripple effect.

TOPIC: Waves

- 3. Investigate the properties of periodic sound waves.** Connect a microphone to the Y-INPUT sockets of the CRO as described in the setting up procedure. Set the Y-GAIN to 0.1 V/cm and the TIME-BASE Selector to 1ms/cm. Experiment with speech patterns, whistling, tuning fork, organ pipe, guitar and other musical instruments. Discover the relationship between pitch, frequency and wavelength, and also between loudness and the amplitude of the wave.
- 4. Radio wave reception.** Connect a 1 metre long aerial wire to the Y-INPUT terminals of the CRO. Set the Y-GAIN to 0.1 V/cm and the TIME-BASE Selector to 10ms/cm. Measure the frequency of the main component of the electromagnetic radiation and suggest a source for this. Switch the TIME-BASE Selector to 1 s/cm, adjust the stability control and measure the frequency of one of the components now apparent.
- 5. Discover the sensitivity of the human ear.** Connect the audio oscillator/amplifier to the Y-INPUT terminals of the CRO. Start with a low frequency and gradually increase the pitch, showing the changing pattern on the screen, until the sound can no longer be heard. The CRO clearly demonstrates the production of a sound. Discuss.
- 6. Demonstrate the superposition of waves.** Connect the AC terminals of 2 power pack units in series to the Y-INPUT terminals of the CRO. Set the output from each power pack at setting 'A' (2 volts), the TIME-BASE Selector on the CRO to 10ms/cm and the Y-GAIN control to 2V/cm. (For further details see page 29 in the Year 12 Senior Physics Prac Manual)
- 7. Demonstrate the nature of standing waves in an open organ pipe.** Connect a microphone directly to the Y-INPUT terminals of the CRO as described in the setting up procedure. Place a small loudspeaker connected to an audio oscillator at one end of the open pipe and the microphone at the other. Starting with a low frequency, increase the pitch of the oscillator till you locate the fundamental for the tube (the lowest frequency which will cause a standing wave pattern in the pipe). Continue increasing the frequency till harmonics are heard and at this point move the microphone along the length of the tube, observing the nodes and antinodes.
- 8. Demonstrate the phenomenon of beats.** Connect the DC terminals of a power pack and HI output terminals of an audio oscillator in series to the Y-INPUT terminals of the CRO. Adjust the Y-GAIN control to 2 V/cm and the TIME-BASE Selector to 10ms/cm. Adjust the audio oscillator to almost 50 Hz and observe the characteristic pattern of the beats.
- 9. Demonstrate the Lissajous figures** to see the effect produced by a particle subjected to simultaneous periodic motions at right angles to each other. To do this, connect the audio oscillator powered by a transformer, to the Y-INPUT as before. Connect a power pack to the X-INPUT (sometimes located at the back of the machine). Switch the TIME-BASE Selector to EXT or HOR INPUT. Set the Y-GAIN at 2 V/cm. (For further details see page 34 in the Year 12 Senior Physics Prac Manual)

Topic - Electromagnetism

- 10. Demonstrate the production of an induced *emf* in a solenoid.** Connect an air-core solenoid, such as the one used in the current balance kit, to the Y-INPUT terminals of the CRO. Adjust the Y-GAIN control to 0.01 V/cm and the TIME-BASE Selector to 1 s/cm for maximum sensitivity. Move a powerful magnet into the centre of the solenoid and note the effect on the screen. Experiment with different types of relative movement of the magnet and the coil.