Oscilloscope the most useful instrument

Food & Diet

INTRODUCTION

Cathode Ray Oscilloscope (CRO):

An oscilloscope is easily the most useful instrument available for testing circuits because it allows you to see the signals at different points in the circuit. The best way of investigating an electronic system is to monitor signals at the input and output of each system block, checking that each block is operating as expected and is correctly linked to the next. With a little practice, we will be able to find and correct faults quickly and accurately.

The symbol for a CRO:

The screen of a CRO is very similar to a TV, except it is much simpler. We will not go into the similarities except to say that the “ picture tube” on a TV and the “ screen” on a CRO are both a special type of valve called a Cathode Ray Tube.

It is a vacuum tube with a cathode (negative electrode) at one end that emits electrons and anodes (positive electrodes) to accelerate the electron beam up/down and left/right to hit a phosphor coating at the end of the tube, called the screen.

The electrons are called cathode rays because they are emitted by the cathode and this gives the oscilloscope its full name: Cathode Ray Oscilloscope or CRO.

CRO IN DETAIL

The main part of the C. R. O. is a highly evacuated glass tube housing parts which generates a beam of electrons, accelerates them, shapes them into a narrow beam, and provides external connections to the sets of plates for changing the direction of the beam.

Internal Components

1. K, an indirectly heated cathode which provides a source of electrons for the beam by “ boiling” them out of the cathode.
2. P, the anode (or plate) which is circular with a small central hole. The potential of P creates an electric field which accelerates the electrons, some of which emerge from the hole as a fine beam. This beam lies along the central axis of the tube.
3. G, the grid. Controlling the potential of the grid controls the number of electrons for the beam, and hence the intensity of the spot on the screen where the beam hits.
4. F, the focusing cylinder. This aids in concentrating the electron beam into a thin straight line much as a lens operates in optics.
5. X, Y, deflection plate pairs. The X plates are used for deflecting the beam left to right (the x direction) by means of the “ ramp” voltage. The Y plates are used for deflection of the beam in the vertical direction. Voltages on the X and Y sets of plates determine where the beam will strike the screen and cause a spot of light.
6. S, the screen. This is coated on the inside with a material which fluoresces with green light (usually) where the electrons are striking.

As well as this tube, there are several electronic circuits required to operate the tube, all within the C. R. O. along with the tube:

1. A power supply, operated from the 110 volt 60 cycle per second electrical “ mains”. This supply provides all the voltages required for the different circuits within the C. R. O. for operation of the tube.
2. A “ sawtooth”, or “ ramp” signal generator which makes the spot move left to right on the screen. External controls for this circuit allow variation of the sweep width, and the frequency of the sweep signal. Because of the persistence of our vision, this sweep is often fast enough that what we see on the screen is a continuous horizontal line.
3. Amplifiers for the internally generated ramp signal, and for the “ unknown” signal which we hook up to the C. R. O. for the purpose of displaying it.
4. Shift devices which allow us to control the mean position of the beam; up or down, or left to right.
5. The synchroniser circuit. This circuit allows us to synchronise the “ unknown” signal with the ramp signal such that the resulting display is a nice clear signal like a snapshot of the unknown voltage vs. time.

C. R. O. Operation: Typical front-panel controls

Front Panel

1. On-off switch.
2. INTENS. This is the intensity control connected to the grid G to control the beam

   intensity and hence the brightness of the screen spots. Don’t run the intensity too high, just bright enough for clear visibility. Always have the spot sweeping left to right or the beam may “ burn” a hole in the screen.

3. FOCUS allows you to obtain a clearly defined line on the screen.
4. POSITION allows you to adjust the vertical position of the waveform on the screen. (There is one of these for each channel).
5. AMPL/DIV. is a control of the Y (i. e. vertical) amplitude of the signal on the screen.(There is one of these for each channel).
6. AC/DC switch. This should be left in the DC position unless you cannot get a signal on-screen otherwise. (There is one of these for each channel).
7. A&B/ADD switch. This allows you to display both input channels separately or to combine them into one.
8. +/- switch. This allows you to invert the B channel on the display.
9. Channel A input
10. Channel B input
11. X POSITION these allow you to adjust the horizontal position of the signals on the screen.
12. LEVEL this allows you to determine the trigger level; i. e. the point of the waveform at which the ramp voltage will begin in time base mode.
13. ms/µs This defines the multiplication factor for the horizontal scale in timebase mode. (See 15 below.)
14. MAGN The horizontal scale units are to be multiplied by this setting in both timebase and xy modes. To avoid confusion, leave it at x1 unless you really need to change it.
15. Time/Div This selector controls the frequency at which the beam sweeps horizontally across the screen in time base mode, as well as

whether the oscilloscope is in timebase mode or xy (x VIA A) mode. This switch has the following positions:

16. (a) X VIA A In this position, an external signal connected to input A is used in place of the internally generated ramp. (This is also known as xy mode.)

    (b) . 5, 1, 2, 5, etc. Here the internally generated ramp voltage will repeat such that each large (cm) horizontal division corresponds to . 5, 1, 2, 5, etc. ms. or µs depending on the multiplier and magnitude settings. (Note also the x1/x5 switch in 14 above.)

17. The following controls are for triggering of the scope, and only have an effect in timebase mode.
18. A/B selector. This allows you to choose which signal to use for triggering.
19. -/+ will force the ramp signal to synchronise its starting time to either the decreasing or increasing part of the unknown signal you are studying.
20. INT/EXT This will determine whether the the ramp will be synchronised to the signal chosen by the A/B switch or by whatever signal is applied to the EXT. SYNC. input. (See 21 below.)
21. AC/TV selectors. I’ve never figured out what this does; find whichever position works.
22. External trigger input

INTRODUCTION

FUNCTION GENERATOR

A function generator is a device that can produce various patterns of voltage at a variety of frequencies and amplitudes. It is used to test the response of circuits to common input signals. The electrical leads from the device are attached to the ground and signal input terminals of the device under test.

Most function generators allow the user to choose the shape of the output from a small number of options.

- Square wave – The signal goes directly from high to low voltage.
- Sine wave – The signal curves like a sinusoid from high to low voltage.
- Triangle wave – The signal goes from high to low voltage at a fixed rate.

The amplitude control on a function generator varies the voltage difference between the high and low voltage of the output signal.

The direct current (DC) offset control on a function generator varies the average voltage of a signal relative to the ground.

The frequency control of a function generator controls the rate at which output signal oscillates.

On some function generators, the frequency control is a combination of different controls.

One set of controls chooses the broad frequency range (order of magnitude) and the other selects the precise frequency.

This allows the function generator to handle the enormous variation in frequency scale needed for signals.

The duty cycle of a signal refers to the ratio of high voltage to low voltage time in a square wave signal.

FUNCTION OF FUNCTION GENERATOR

Analog function generators usually generate a triangle waveform as the basis for all of its other outputs. The triangle is generated by repeatedly charging and discharging a capacitor from a constant current source. This produces a linearly ascending or descending voltage ramp. As the output voltage reaches upper and lower limits, the charging and discharging is reversed using a comparator, producing the linear triangle wave. By varying the current and the size of the capacitor, different frequencies may be obtained.

A 50% duty cycle square wave is easily obtained by noting whether the capacitor is being charged or discharged, which is reflected in the current switching comparator’s output. Most function generators also contain a non-linear diode shaping circuit that can convert the triangle wave into a reasonably accurate sine wave. It does so by rounding off the hard corners of the triangle wave in a process similar to clipping in audio systems.

The type of output connector from the device depends on the frequency range of the generator. A typical function generator can provide frequencies up to 20 MHz and uses a BNC connector, usually requiring a 50 or 75 ohm termination. Specialised RF generators are capable of gigahertz frequencies and typically use N-type output connectors.

Function generators, like most signal generators, may also contain an attenuator, various means of modulating the output waveform, and often the ability to automatically and repetitively “ sweep” the frequency of the output waveform (by means of a voltage-controlled oscillator) between two operator-determined limits. This capability makes it very easy to evaluate the frequency response of a given electronic circuit.

Some function generators can also generate white or pink noise.

More advanced function generators use Direct Digital Synthesis (DDS) to generate waveforms. Arbitrary waveform generators use DDS to generate any waveform that can be described by a table of amplitude values.

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