Introduction

The cathode ray oscilloscope is an electronic test instrument; it is used to obtain waveforms when the different input signals are given. In the early days, it is called as an Oscillograph. The oscilloscope observes the changes in the electrical signals over time, thus the voltage and time describe a shape and it is continuously graphed beside a scale. By seeing the waveform, we can analyze some properties like amplitude, frequency, rise time, distortion, time interval and etc. The applications of CRO's mainly involve in the radio, TV receivers, also in laboratory work involving research and design. In modern electronics, the CRO plays an important role in the electronic circuits.

Theory

1. Construction of Cathode Ray Oscilloscope

The main structure of the C.R.O. is a highly evacuated cathode ray tube (C.R.T.) which emits an electron beam known as cathode ray beam. The cathode ray tube consists of three main components: (a) The electron gun (b) The deflection system (c) The fluorescent screen. Their parts are explained below in details.

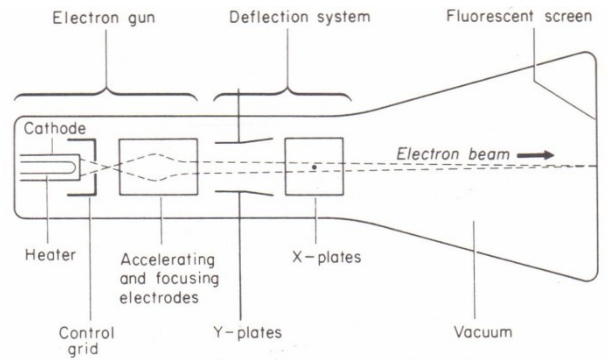

Figure 1. The Construction of Cathode Ray Oscilloscope

1) Electronic Gun Assembly

The electron gun emits the electrons and forms them into a beam. The electron gun mainly consist a heater, cathode, a grid, a pre-accelerating anode, a focusing anode and an accelerating anode. For gaining the high emission of electrons at the moderate temperature, the layers of barium and strontium is deposited on the end of the cathode.

After the emission of an electron from the cathode grid, it passes through the control grid. The control grid is usually a nickel cylinder with a centrally located co-axial with the CRT axis. It controls the intensity of the emitted electron from the cathode.

The electron while passing through the control grid is accelerated by a high positive potential which is applied to the pre-accelerating or accelerating nodes.

The electron beam is focused on focusing electrodes and then passes through the vertical and horizontal deflection plates and then goes on to the fluorescent lamp. The pre-accelerating and accelerating anode are connected to 1500v, and the focusing electrode is connected to 500 v. There are two methods of focusing on the electron beam. These methods are Electrostatic focusing and Electromagnetic focusing. The CRO uses an electrostatic focusing tube.

2) Deflecting Plate

The electron beam after leaving the electron gun passes through the two pairs of the deflecting plate. The pair of plate producing the vertical deflection is called a vertical deflecting plate or Y plates, and the pair of the plate which is used for horizontal deflection is called horizontal deflection plate or X plates.

If no input voltage or potential difference is applied between the X-plates and Y-plates, the electron beam does not experience any force. No deflection occurs and the bright spot is at the centre. When a positive voltage or potential difference is applied to the Y-plates, the electrons in the beam will experience a force acting upwards causing the electron beam to deflect upwards. The bright spot moves to the top of the screen. When a positive voltage or potential difference is applied to the Y-plates, the electrons in the beam will experience a force acting upwards causing the electron beam to deflect upwards. The bright spot moves to the top of the screen. When an a.c. voltage is applied to the Y-plates, the electron beam deflects up and down. The bright spot moves up and down rapidly to form a bright vertical trace on the screen. Thus we can conclude that the function of the Y-plates is to move the electron beam up and down the screen when an input voltage is applied across it. The function of the X-plates is to sweep the electron beam across the screen horizontally from left to right at a steady speed. The X-plates are usually connected to a time-base circuit that generates a time-varying voltage. Therefore, by applying appropriate voltages to the deflection plates, the position of the bright spot on the screen can be controlled.

3) Fluorescent Screen for CRT

The front of the CRT is called the face plate. It is flat for screen sized up to about 100mm×100mm. The screen of the CRT is slightly curved for larger displays. The face plate is formed by pressing the molten glass into a mould and then annealing it.

The inside surface of the faceplate is coated with phosphor crystal. The phosphor converts electrical energy into light energy. When an electronics beam strike phosphor crystal, it raises their energy level and hence light is emitted during phosphorous crystallisation. This phenomenon is called fluorescence.

2. Working of Cathode Ray Oscilloscope

The key to the versatility of the CRT is two sets of electron deflection plates with deflect the electron beam in the vertical Y-plates and horizontal X-plates directions as a function of the voltage applied to each set of plates. In normal operation, an internally generated sawtooth sweep voltage is applied to the X-plates, causing the beam to be deflected horizontally at a constant rate in a repetitive fashion. This result in a horizontal line across the screen if on voltage is applied to the Y-plates. If a time-verying voltage is applied to the Y-plates, the electron beam is deflected by the resulting electric field, thus giving a display of voltage versus time on the screen, see Figure. 2.

In practice, the sawtooth sweep voltage set up only when a trigger input allows it. This trigger control makes it possible to start each sweep on the same part of a repetitive signal so that each successive sweep overlaps the previous sweep. Otherwise a sine wave, for example, would start at random phases each time. On the screen you might see a jumble of 100 sine waves all shifted randomly with respect to each other.

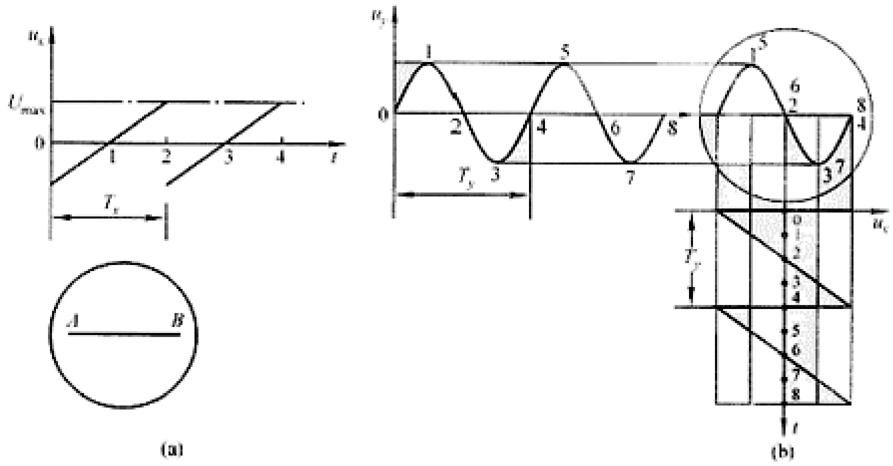

Figure 2. Display a waveform

3. Lissajous Patterns

Besides displaying time varying signal, CRO can display input signal rather than time base on the horizontal axis. This set up is referred as XY mode due to the fact that both X axis and Y axis are tracing input voltage. The resulting waveform due to XY arrangement of two periodic signals having different periods is known as Lissajous Pattern.

From the shape of Lissajous pattern displayed on CRO screen, one can determine information about relative phases of signals and frequency ratio of signals.

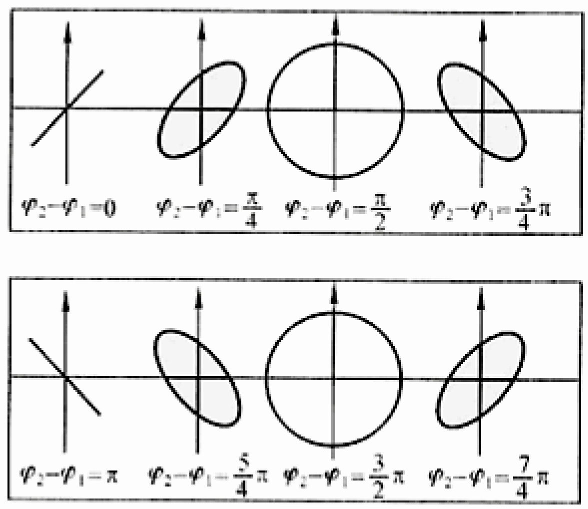

Figure 3 Lissajous pattern at different phase

To determine the ratio of frequencies of signal by using the Lissajous pattern, simply draw arbitrary horizontal and vertical line on lissajous pattern intersecting the Lissajous pattern. Now count the number of horizontal and vertical tangencies by Lissajous pattern with these horizontal and vertical lines.

Then the ratio of frequencies of signals applied to deflection plates,

$$\frac{f_y}{f_x} = \frac{Number\ of\ horizontal\ tangencies}{Number\ of\ vertical\ tangencies} \tag{1}$$

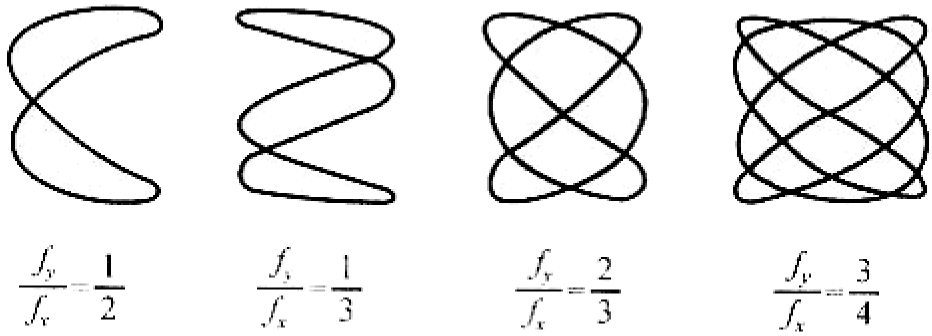

Figure 4. Lissajous patterns with differen ratio of frequencies of signal.

DATA RECORDING AND PROCESSING

(A) Output the Sin signal using the function generator, and use the accurate SWEEP TIME/DIV and VOLTS/DIV to display ~ 3 period on the screen. Measured the vale in the following table.

		100 Hz, Vpp=4V	1 KHz Vpp=4V	10 KHz Vpp=1V	100 KHz Vpp=1V
VOLTS/DIV (V)					
SWEEP TIME/DIV(ms)					
CRO Measurement	*f(Hz)*				
	Vpp (V)				
	virtual value （V）				
Virtual value of Multimeter （V）					

$$\text{Virtual value } U = \frac{\sqrt{2}}{4} \times V_{p-p}$$

(B) Output a DC voltage and measure it using a CRO

Output voltage by Multimeter (V)	
DIV	
VOLTS/DIV	
V_{DC} （V）	

(C) Measure frequency using Lissajous patterns

X frequency	Y frequency	Lissajous patterns
1000 Hz		
1000 Hz		

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