Electronics Lab

UOS Sub Campus Bhakkar

Experiment No: 1

Study of CRO & Measurement of Voltage Amplitude & Frequency

Aim:

1. Study of CRO and to find the Amplitude and Frequency using CRO.
2. To measure the Unknown Frequency & Phase difference using CRO.

Components and Equipments Required: Cathode-ray oscilloscope, Function Generator (2), Decade Resistance Box (DRB), Capacitor, CRO Probes and Bread Board.

Theory:

An outline explanation of how an oscilloscope works can be given using the block diagram shown below.

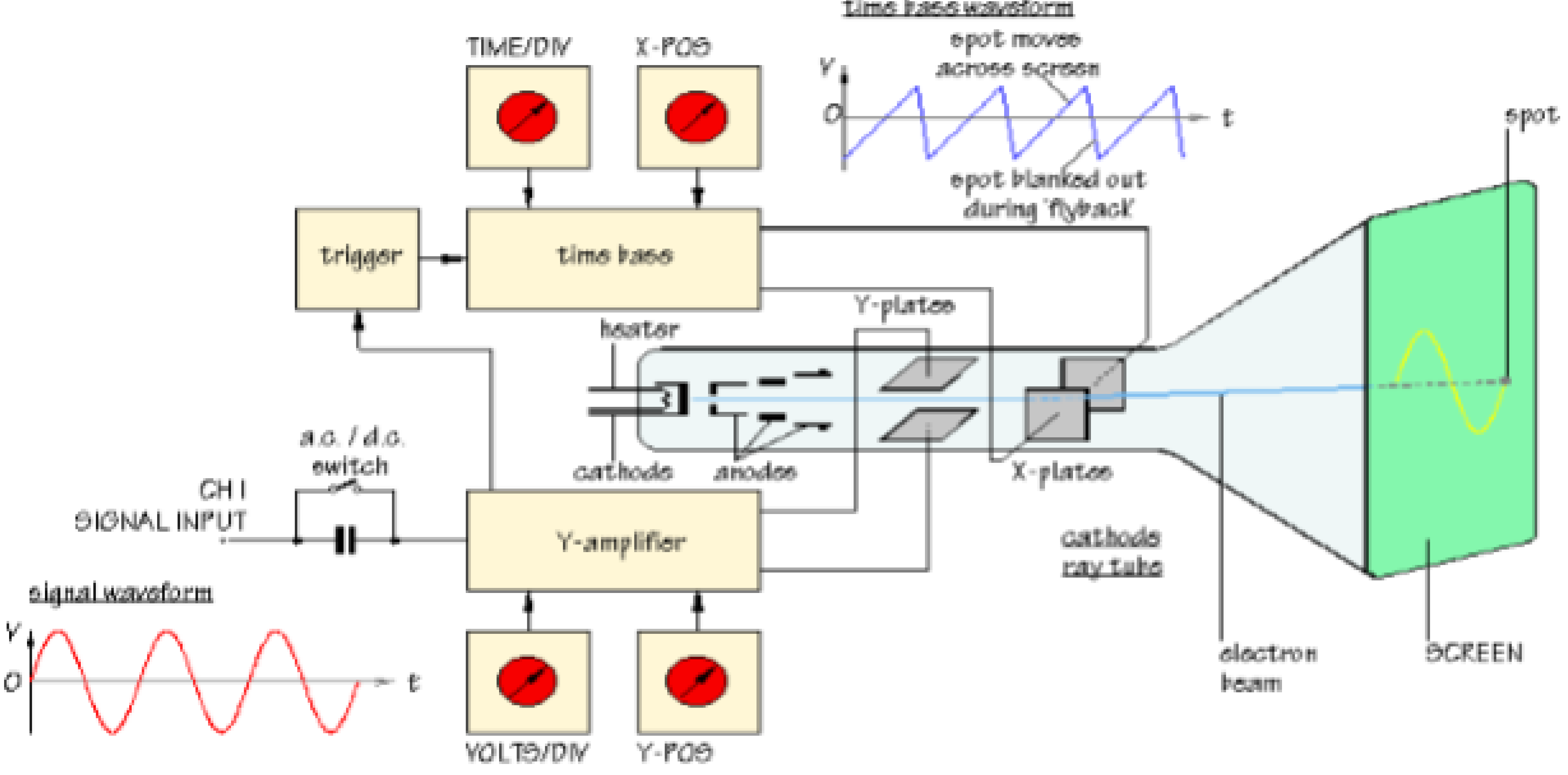
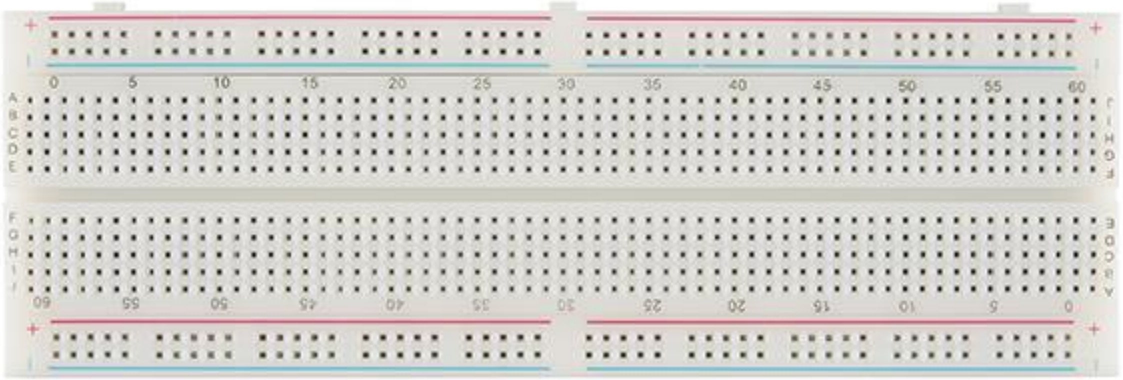


Fig. 1: Cathode Ray Oscilloscope

Basic Structure and Operation

Like a television screen, the screen of an oscilloscope consists of a **Cathode Ray Tube**. Although the size and shape are different, the operating principle is the same. Inside the tube is a vacuum. The electron beam emitted by the heated cathode at the rear end of the tube is accelerated and focused by one or more anodes, and strikes the front of the tube, producing a bright spot on the phosphorescent screen.

Components and equipment required



Basic Structure and Operation

The electron beam is bent, or deflected, by voltages applied to two sets of plates fixed in the tube. The horizontal deflection plates or **X-plates** produce side to side movement. As you can see, they are linked to a system block called the **time base**. This produces a saw tooth waveform. During the rising phase of the saw tooth, the spot is driven at a uniform rate from left to right across the front of the screen. During the falling phase, the electron beam returns rapidly from right ot left, but the spot is 'blanked out' so that nothing appears on the screen. In this way, the time base generates the X-axis of the *V*/*t* graph.

Basic Structure and Operation

The slope of the rising phase varies with the frequency of the saw tooth and can be adjusted, using the TIME/DIV control, to change the scale of the X-axis. Dividing the oscilloscope screen into squares allows the horizontal scale to be expressed in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV). Alternatively, if the squares are 1 cm apart, the scale may be given as s/cm, ms/cm or µs/cm.

The signal to be displayed is connected to the **input**. The AC/DC switch is usually kept in the DC position (switch closed) so that there is a direct connection to the **Y-amplifier**. In the AC position (switch open) a capacitor is placed in the signal path. The capacitor blocks DC signals but allows AC signals to pass.

Basic Structure and Operation

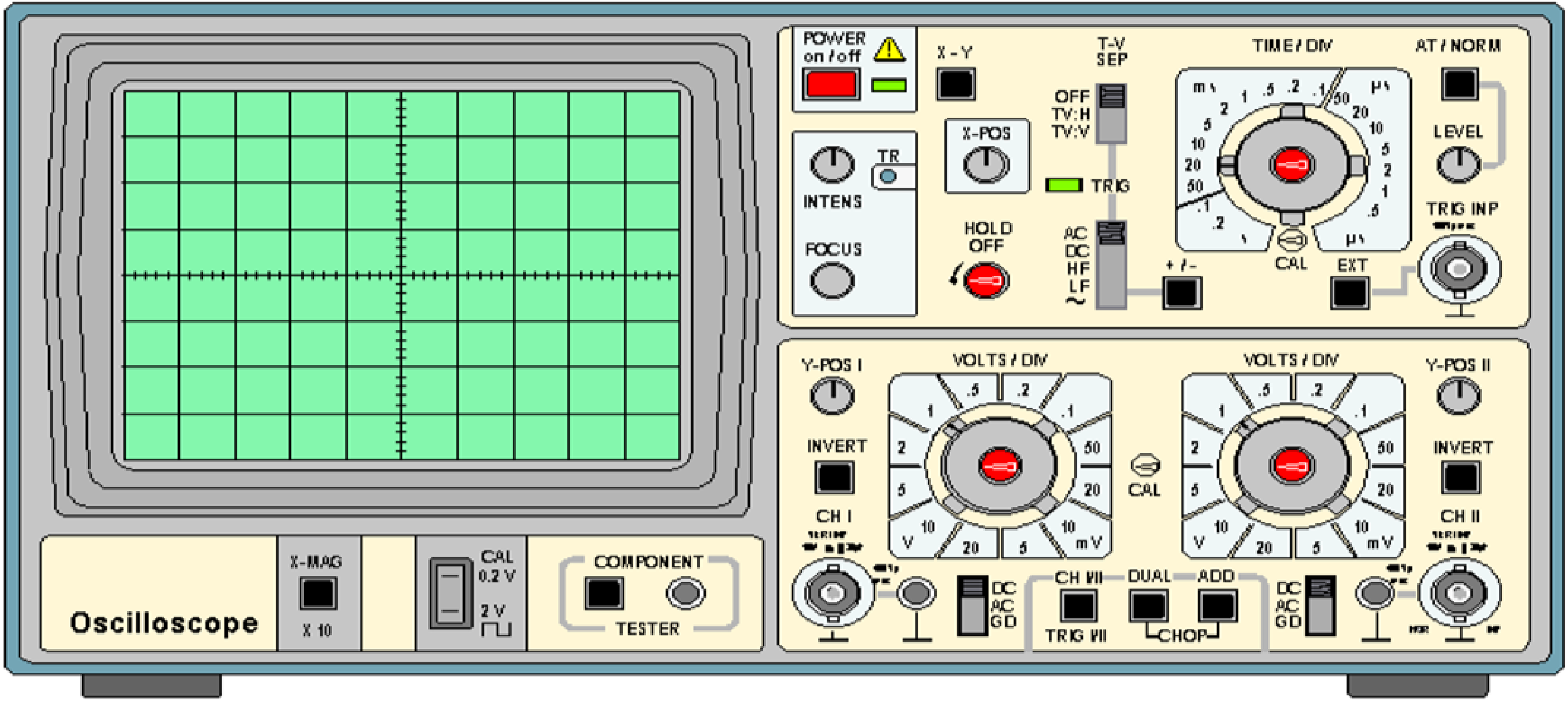
The Y-amplifier is linked in turn to a pair of **Y-plates** so that it provides the Y-axis of the the *V*/*t* graph. The overall gain of the Y-amplifier can be adjusted, using the VOLTS/DIV control, so that the resulting display is neither too small nor too large, but fits the screen and can be seen clearly. The vertical scale is usually given in V/DIV or mV/DIV.

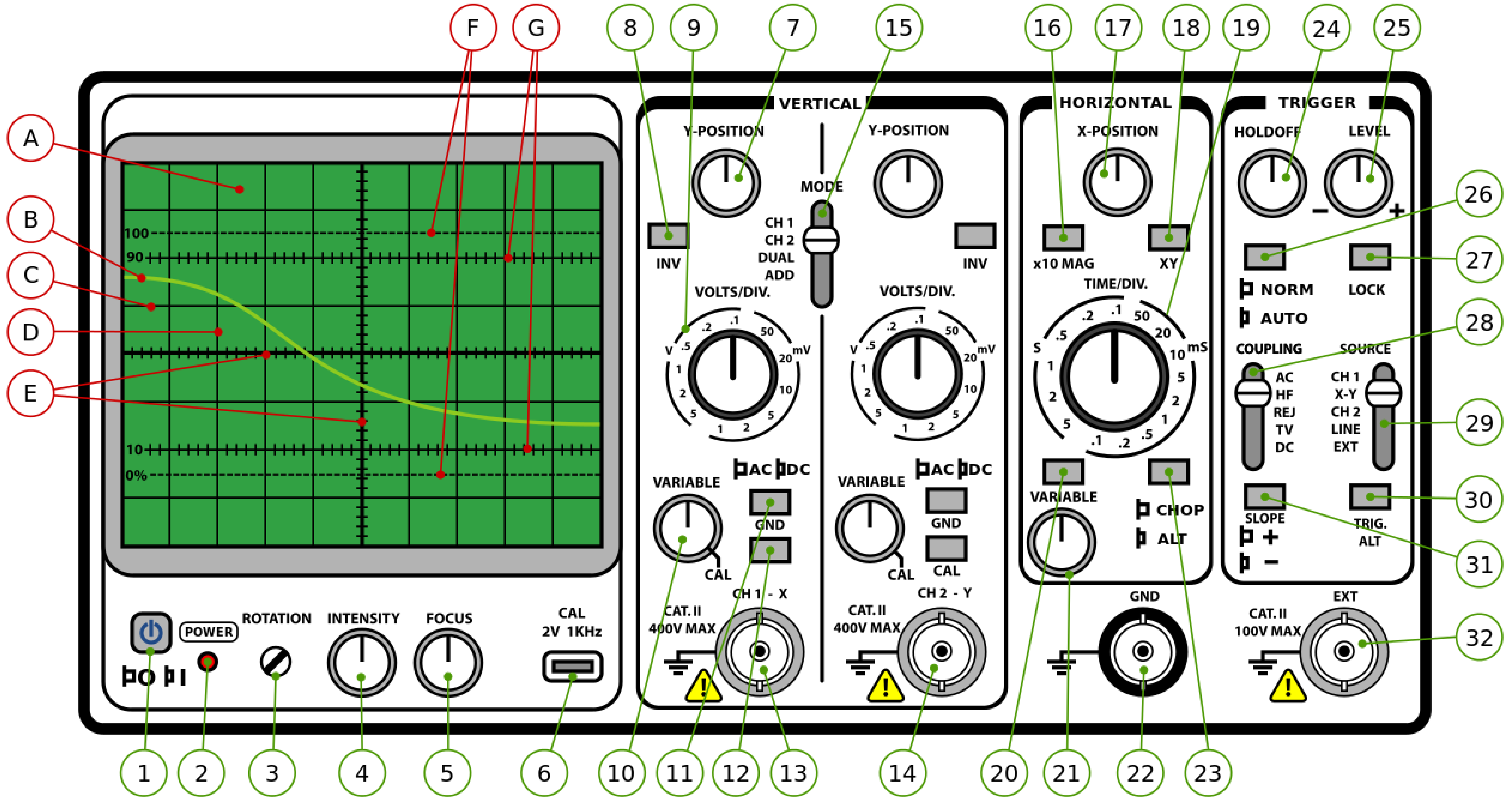
The **trigger** circuit is used to delay the time base waveform so that the same section of the input signal is displayed on the screen each time the spot moves across. The effect of this is to give a stable picture on the oscilloscope screen, making it easier to measure and interpret the signal.

Basic Structure and Operation

Changing the scales of the X-axis and Y-axis allows many different signals to be displayed. Sometimes, it is also useful to be able to change the *positions* of the axes. This is possible using the **X-POS** and **Y-POS** controls. For example, with no signal applied, the normal trace is a straight line across the centre of the screen. Adjusting Y-POS allows the zero level on the Y-axis to be changed, moving the whole trace up or down on the screen to give an effective display of signals like pulse waveforms which do not alternate between positive and negative values.

Diagram of Front Panel of CRO





VERTICAL
HORIZONTAL
TRIGGER
Y-POSITION
MODE
CH 1
CH 2
DUAL
ADD
INV
VOLTS/DIV.
VARIABLE
CAL
AC DC
GND
CH 1 - X
CH 2 - Y
CAT. II
400V MAX
X-POSITION
x10 MAG
XY
TIME/DIV.
CHOP
ALT
HOLDOFF
LEVEL
NORM
LOCK
AUTO
COUPLING
AC
HF
REJ
TV
DC
SOURCE
CH 1
X-Y
CH 2
LINE
EXT
SLOPE
TRIG.
ALT
EXT
CAT. II
100V MAX
POWER
ROTATION
INTENSITY
FOCUS
CAL
2V 1KHz
100
90
10
0%
A
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C
D
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Basic Structure and Operation

Screen: Usually displays a *V*/*t* graph, with voltage *V* on the vertical axis and time *t* on the horizontal axis. The scales of both axes can be changed to display a huge variety of signals.

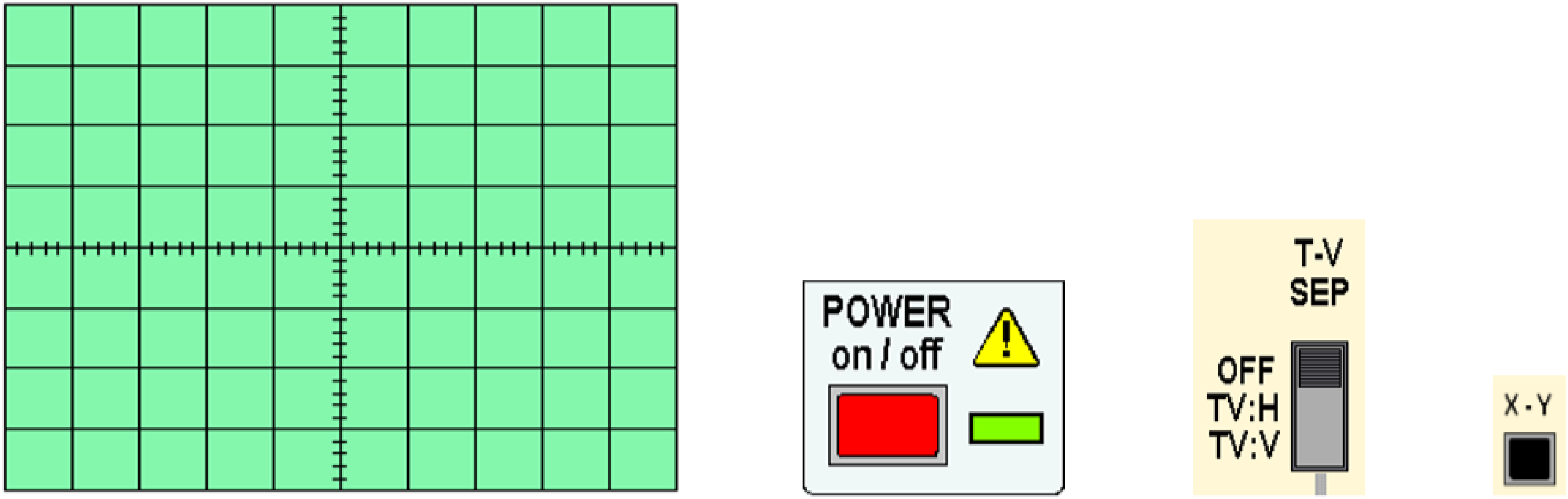


Fig. 3: Screen display of Oscilloscope

Basic Structure and Operation

On/Off Switch: Pushed in to switch the oscilloscope on. The green LED illuminates.

X-Y Control: Normally in the OUT position.

When the X-Y button is pressed IN, the oscilloscope does not display a *V*/*t* graph. Instead, the vertical axis is controlled by the input signal to CH II. This allows the oscilloscope to be used to display a *V*/*V* voltage/voltage graph.

The X-Y control is used when you want to display component characteristic curves, or Lissajous figures. (Links to these topics will be added later.)

Basic Structure and Operation

Time / Div: Allows the horizontal scale of the *V*/*t* graph to be changed.

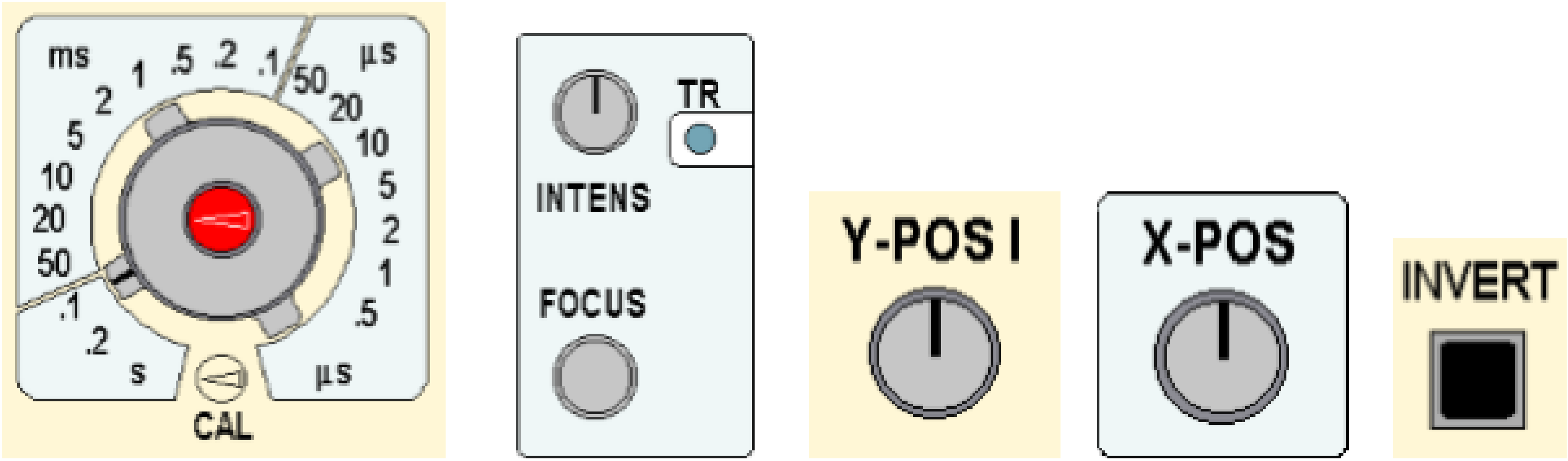


Fig. 4: Time division, Intensity, focus, X-Y mode knobs

With more experience of using the oscilloscope, you will develop a clear understanding of the functions of the important trigger controls and be able to use them effectively.

Basic Structure and Operation

Intensity and Focus: Adjusting the INTENSITY control changes the brightness of the oscilloscope display. The FOCUS should be set to produce a bright clear trace.

If required, TR can be adjusted using a small screwdriver so that the oscilloscope trace is exactly horizontal when no signal is connected.

Basic Structure and Operation

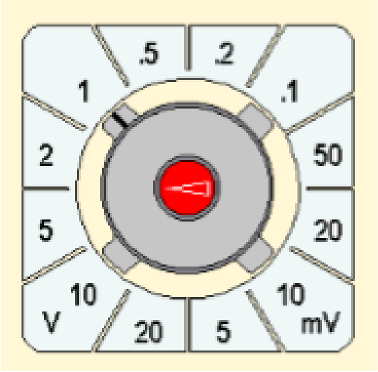
X-POS: Allows the whole *V/t* graph to be moved from side to side on the oscilloscope screen.

This is useful when you want to use the grid in front of the screen to make measurements, for example, to measure the period of a waveform.

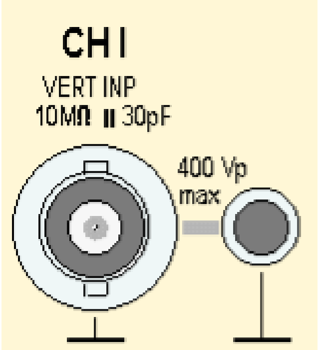
Y-POS I and Y-POS II: These controls allow the corresponding trace to be moved up or down, changing the position representing 0 V on the oscilloscope screen.

To investigate an alternating signal, you adjust Y-POS so that the 0 V level is close to the centre of the screen. For a pulse waveform, it is more useful to have 0 V close to the bottom of the screen. Y-POS I and Y-POS II allow the 0 V levels of the two traces to be adjusted independently

Basic Structure and Operation



Invert: When the INVERT button is pressed IN, the corresponding signal is turned upside down, or inverted, on the oscilloscope screen. This feature is sometimes useful when comparing signals.



CH I And CH II Inputs: Signals are connected to the BNC input sockets using BNC plugs.

The smaller socket next to the BNC input socket provides an additional 0 V, GROUND or EARTH connection.

Basic Structure and Operation

Volts / Div: Adjust the vertical scale of the *V/t* graph. The vertical scales for CH I and CH II can be adjusted independently.

DC/AC/GND Slide Switches: In the DC position, the signal input is connected directly to the Y-amplifier of the corresponding channel, CH I or CH II. In the AC position, a capacitor is connected into the signal pathway so that DC voltages are blocked and only changing AC signals are displayed.

In the GND position, the input of the Y-amplifier is connected to 0 V. This allows you to check the position of 0 V on the oscilloscope screen. The DC position of these switches is correct for most signals.

Basic Structure and Operation

Trace Selection Switches: The settings of these switches control which traces appear on the oscilloscope screen.

Measurement of Amplitude

Measurement of Amplitude & Frequency:

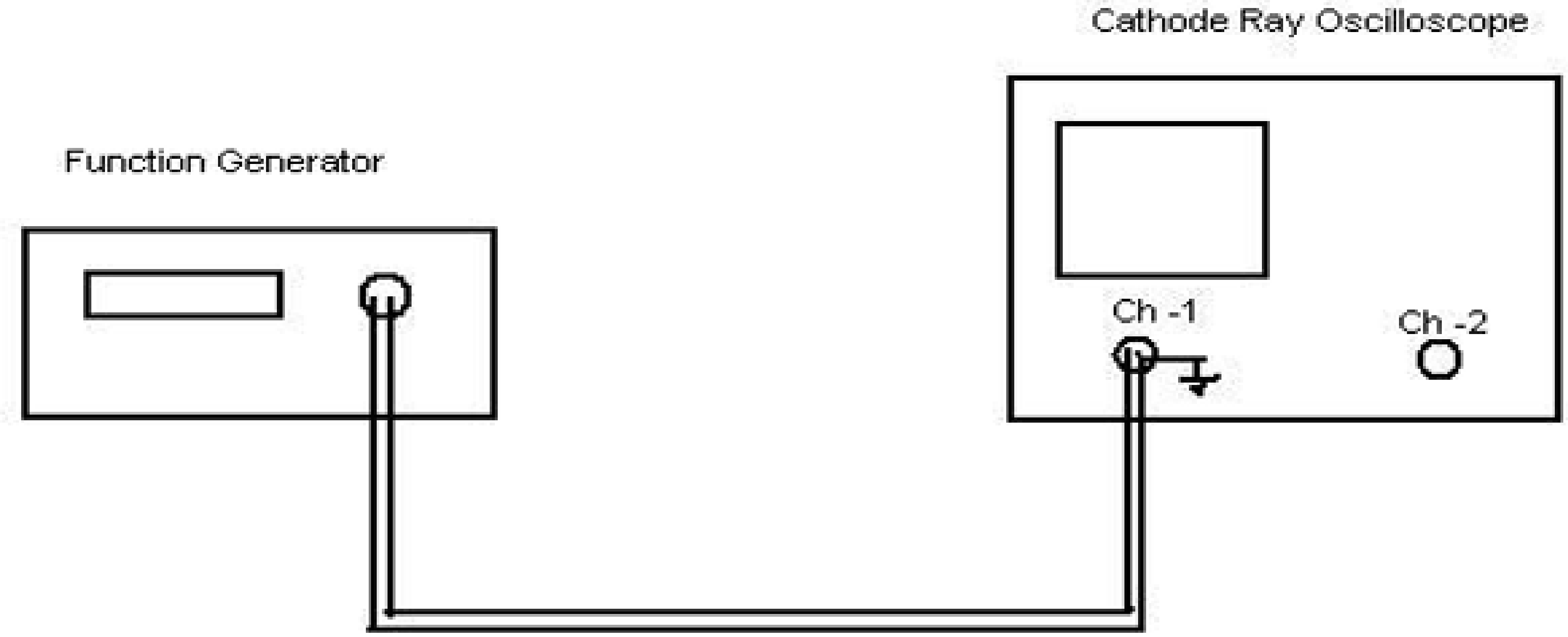
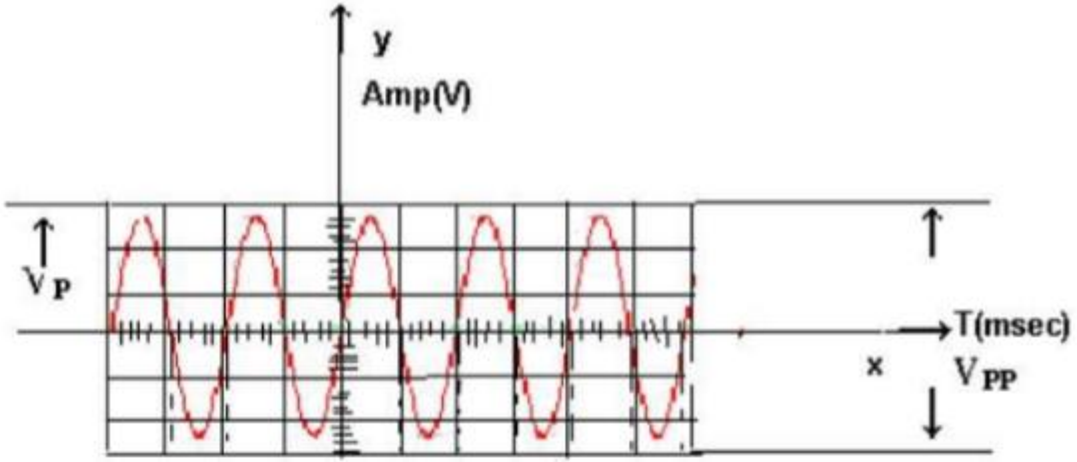


Fig. 6: Measurement of Amplitude & Frequency

Measurement of Amplitude



A) Measurement of Amplitude:

Procedure:

1. Make the connections as per the diagram shown above.
2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
3. Now apply the sinusoidal wave of different amplitudes by using the LEVEL and COARSE buttons of the function generator.
4. Note on the vertical scale the peak to peak amplitude (Vpp).

Measurement of Amplitude

Observations:

S. No.	No. of Vertical Divisions(X)	Voltage/ Division (Y)	Vp-p=X*Y	Vm=Vp-p/2

B) Measurement of Frequency:

Procedure:

1. Make the connections as per the diagram shown above.
2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
3. Now apply the sinusoidal wave of different frequencies by using the LEVEL and COARSE buttons of the function generator.
4. Note down the horizontal scale period (T) in second by observing difference between the two successive peaks of the waveform.

S. No.	No. of Horizontal Divisions(X)	Time/Division (Y)	T=X*Y	f=1/T

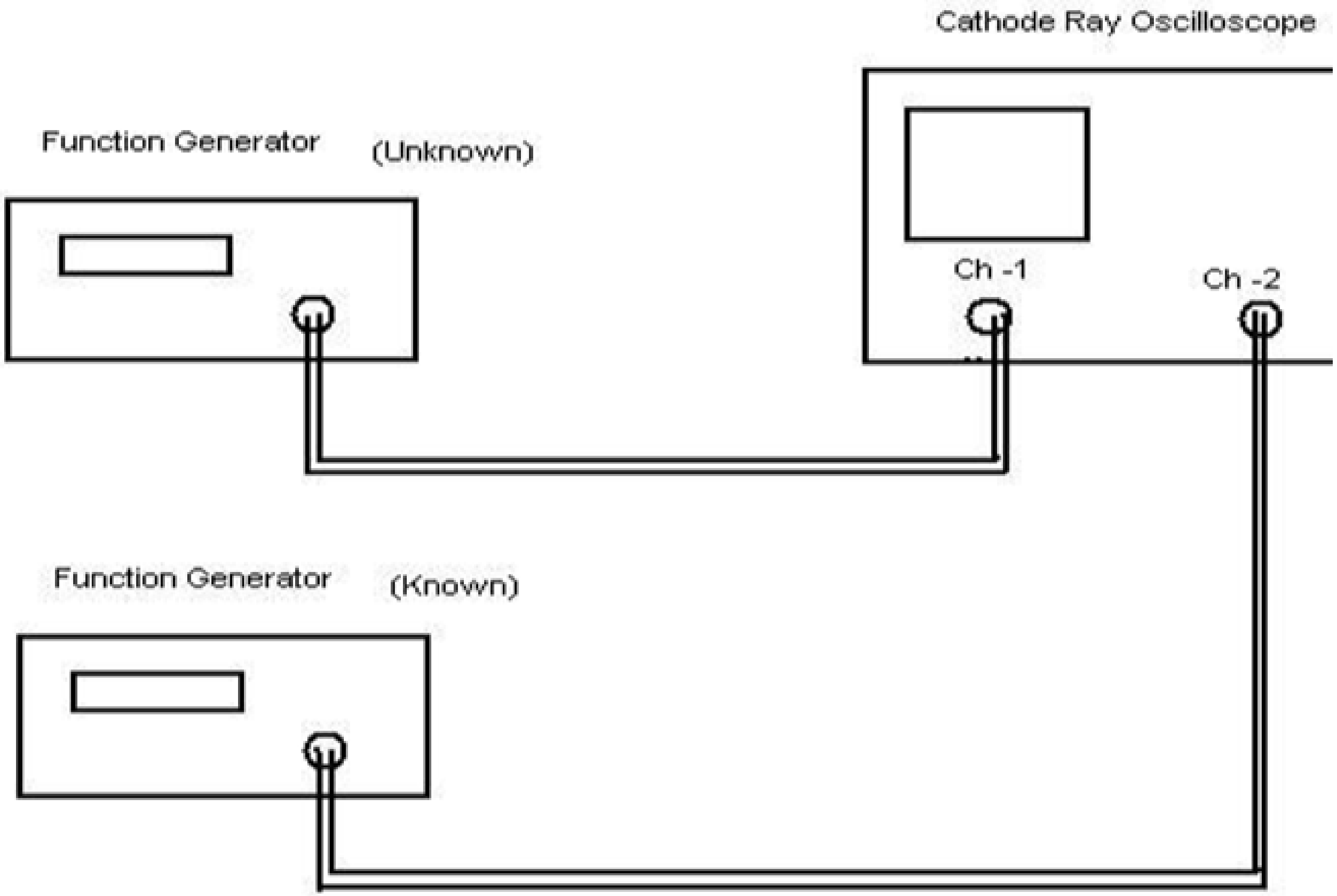


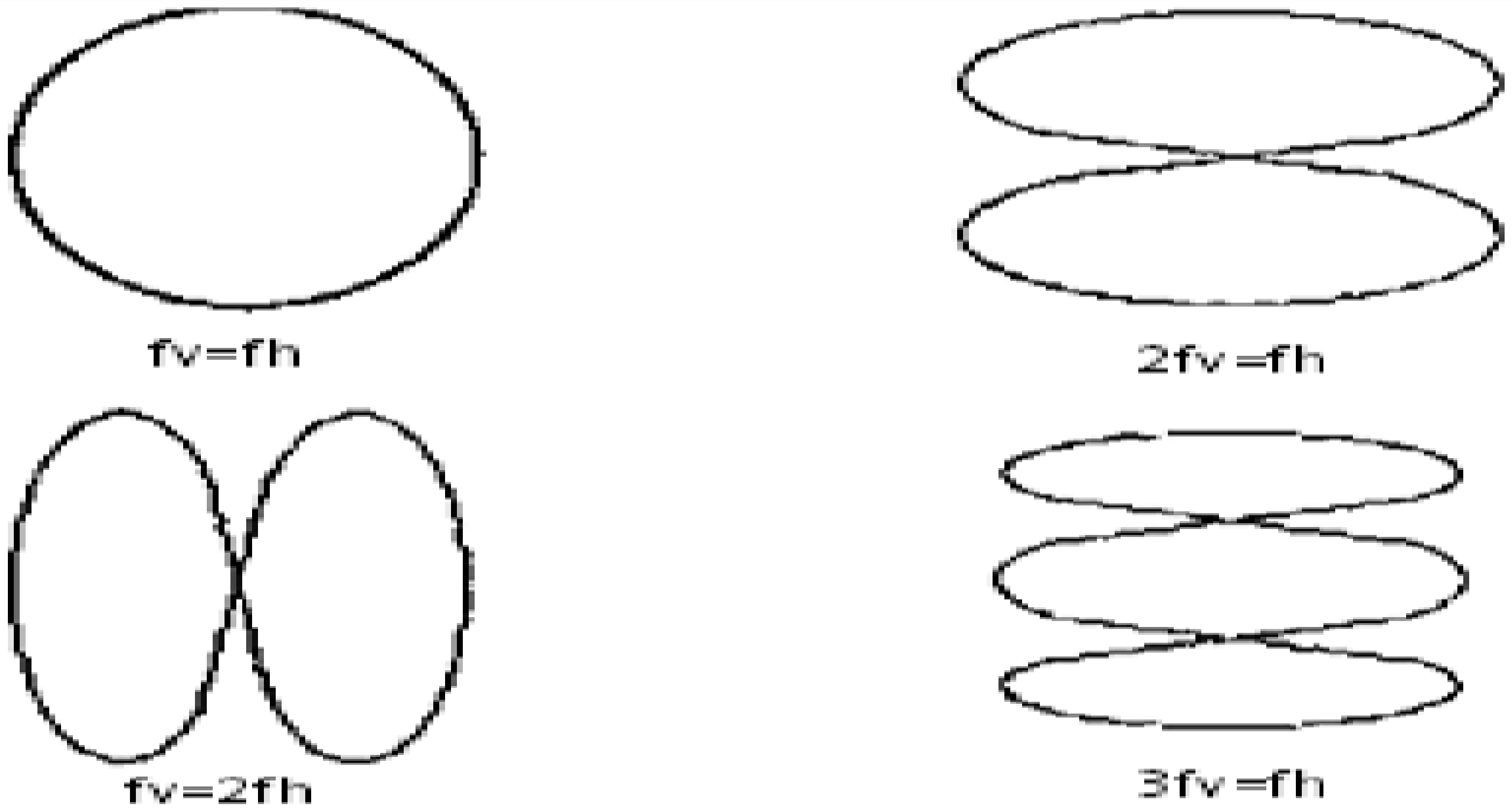
Fig. 8: Measurement of Unknown Frequency

Procedure:

1. Connect the unknown frequency to the vertical (Y) deflection plates (CH -1) and the known frequency to the horizontal (X) deflection plates (Ch-2) from two function generators as shown in the figure.
2. Press X- Y mode button on the CRO and obtain the LISSAJOUS PATTERN. The lissajous pattern is obtained when two sinusoidal signals of different frequencies are applied to the X and Y deflection plates of the CRO. If the two frequencies are equal, we get a circle or ellipse.
3. Note down Nx (Number of touching points on X- axis), Ny (Number of touching points on Y – axis), Fx (Frequency of known signal).
4. If the LISSAJOUS pattern obtained is not clear to note the readings, Vary the known frequency such that a clear lissajous pattern is obtained.
5. The unknown frequency Fy is given by Fy = (Nx * Fx) / (Ny)

Observations:

S. No.	Known frequency (f_x)	N_x	N_y	Unknown frequency $f_y = (N_x . f_x) / N_y$



$$\frac{fv}{fh} = \frac{\text{No.of loops cut by horizontal line}}{\text{No.of loops cut by vertical line}}$$

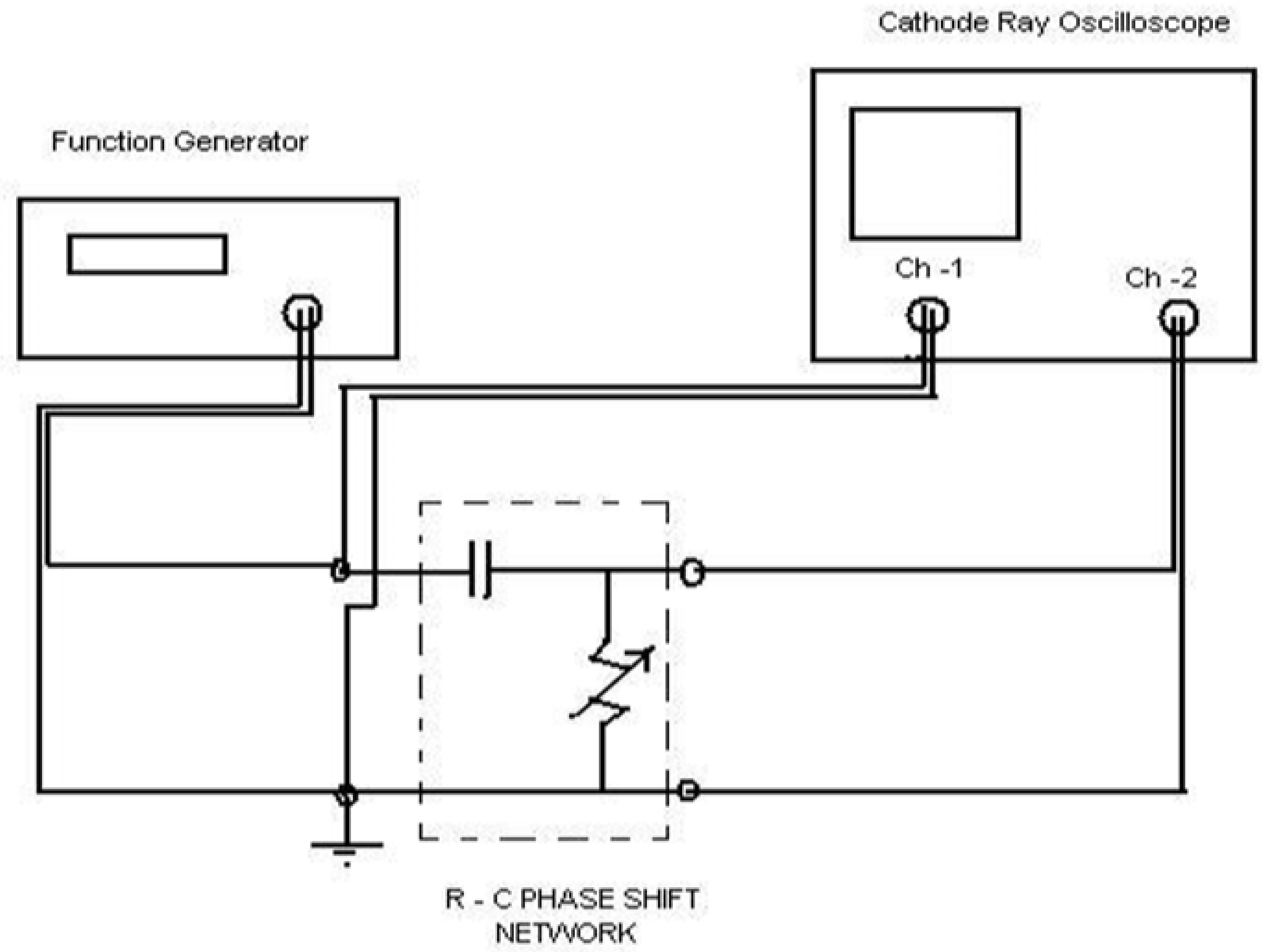


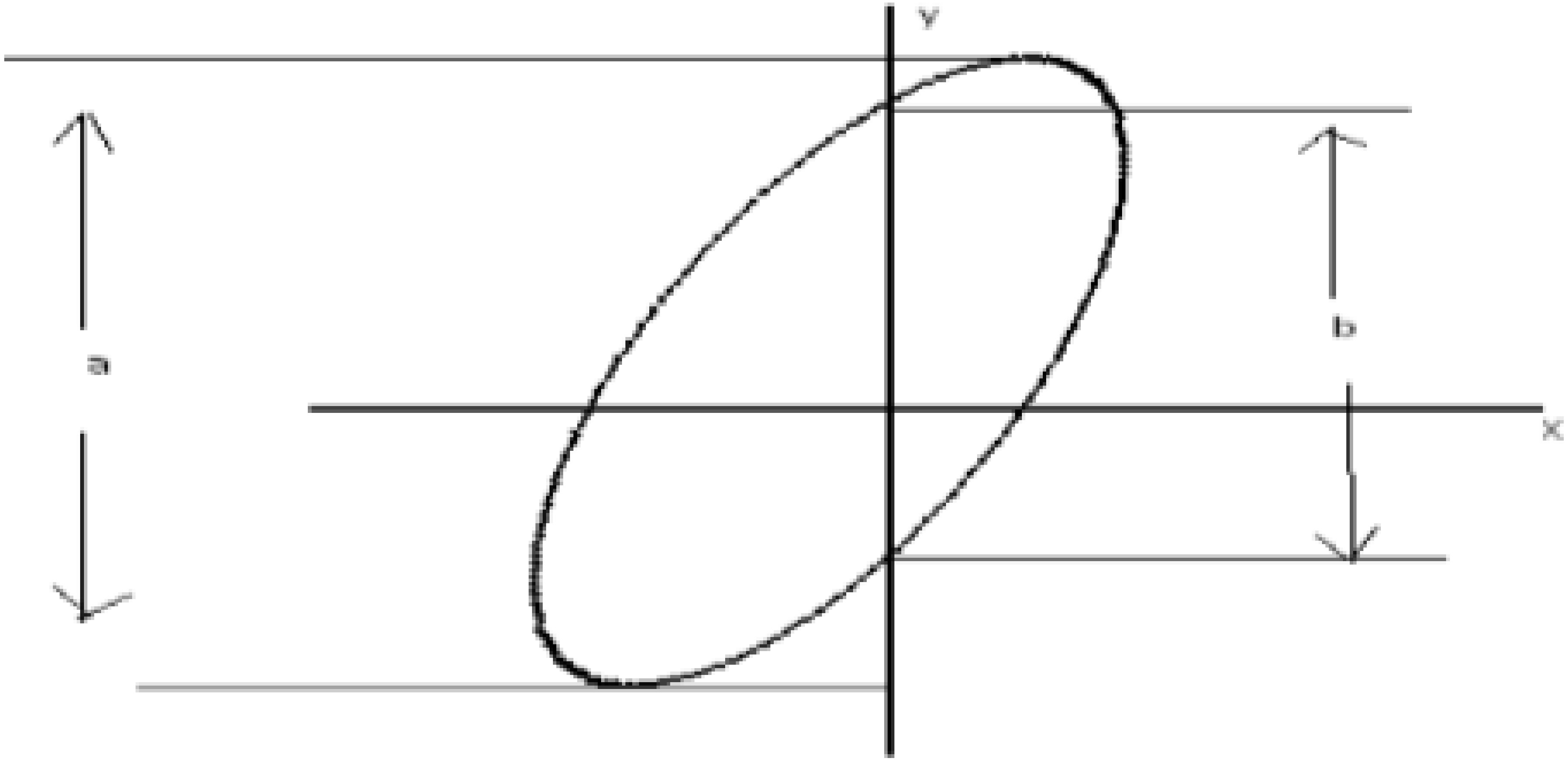
Fig. 9: Measurement of Phase Difference

Procedure:

1. Connect the RC phase shift network as shown above in the circuit diagram.
2. Obtain a sinusoidal signal of 5V (Pk- Pk) at 1 KHz from the function generator.
3. Connect the signal from the function generator to the input of the RC phase shift network and the same signal to the CH-1 of the CRO.
4. Connect the output of the Phase shift network to the CH-2 of the CRO.
5. Press X- Y mode button.
6. The pattern obtained on the screen will be an ellipse.
7. The phase difference between the two signals (θ) is given by $\theta = \sin^{-1}(B/A)$.
8. By varying the different values of the resistances from DRB, frequencies, note the values of B and A and hence find θ.

Observations:

S. No.	f	R	C	$\theta = \tan^{-1}(1/wRC)$	B	A	$\theta = \sin^{-1}(B/A)$



$$\theta = \sin^{-1}(b/a)$$

Where "θ" is the phase difference between the two signals