Syllabus

- Module 4:
  - Modern Electronics and its applications :
    - Communication System
      - General block diagram of a Communication system,
      - Block diagram of Fiber optic Communication system
      - Concept of AM and FM (No derivation required),
      - Block diagram of AM and FM super-heterodyne receiver
      - Basic concepts of Wired and Wireless communication,
      - Block diagram of GSM
      - Comparison of 3G, 4G, 5G and 6G communication technologies

Syllabus

14

- Module 4:
  - Modern Electronics and its applications :
    - Block diagrams of Electronic instrumentation system,
      - Digital Multimeter,
      - Function generator
      - Introduction to CRO and Lissajous patterns
    - Applications of modern electronics –
      - IoT based (Case study only)
        - smart homes,
        - healthcare and
        - agriculture

Module IV

Modern Electronics and its Applications

Basic Instruments

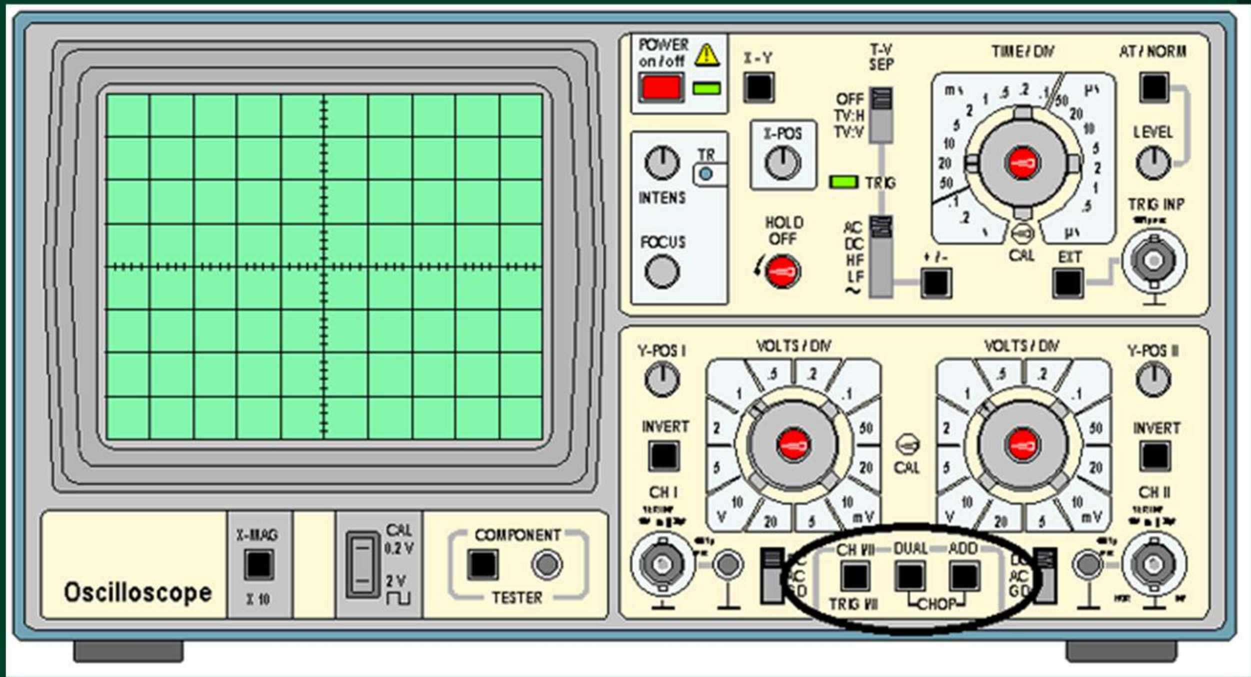
- Multimeter
- DVM, or electronic multimeter (analogue or digital)
- Cathode Ray Oscilloscope(CRO)
- Signal Generator
- Regulated Power Supply

Basic Instruments

- Multimeter
- DVM, or electronic multimeter (analogue or digital)
- Cathode Ray Oscilloscope(CRO)
- Signal Generator
- Regulated Power Supply

Basic Instruments

- Multimeter
- DVM, or electronic multimeter (analogue or digital)
- Cathode Ray Oscilloscope(CRO)
- Signal Generator
- Regulated Power Supply



Basic Instruments

- Multimeter
- DVM, or electronic multimeter (analogue or digital)
- Cathode Ray Oscilloscope(CRO)
- Signal Generator
- Regulated Power Supply

Basic Instruments

- Multimeter
- DVM, or electronic multimeter (analogue or digital)
- Cathode Ray Oscilloscope(CRO)
- Signal Generator
- Regulated Power Supply

Block diagrams of Electronic instrumentation system

- Digital Multimeter,
- Function generator
- Introduction to CRO and Lissajous patterns

Jesus Loves You

Electronic Measuring Instruments and Measuring Equipment

- Electronic measuring instruments are essential components of electronic applications.
- They are necessary for studying and analyzing the behaviour and operation of electronic circuits.
- Measurement is the process of determining the amount, degree, or capacity by comparison with the accepted standards of the system units being used.
- An electronic instrument is a device used for determining the value or magnitude of a quantity or variable such as voltage, current or resistance.

Electronic Measuring Instruments and Measuring Equipment

- The basic architecture of an electronic instrument is shown in Figure.

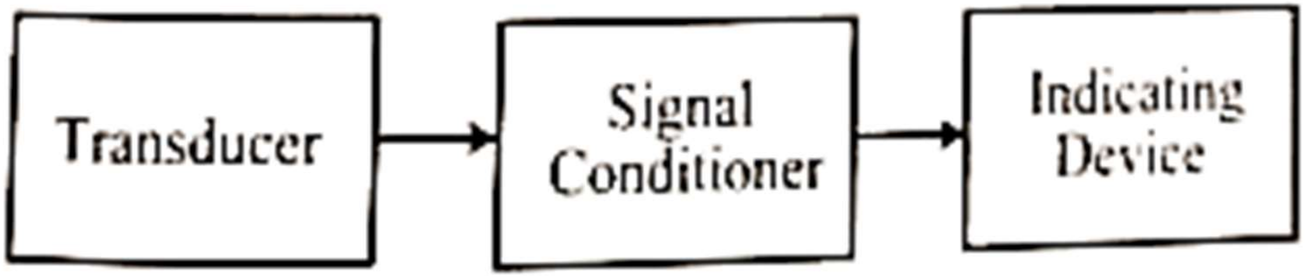


Figure 7.1: Basic architecture of an electronic instrument

Electronic Measuring Instruments and Measuring Equipment

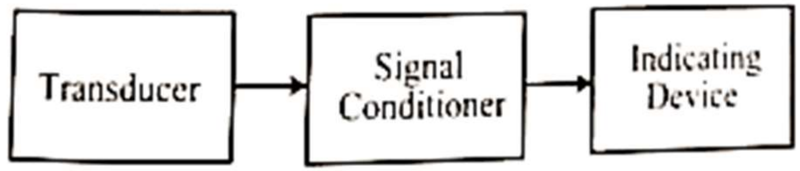


Figure 7.1: Basic architecture of an electronic instrument

- It consists of a transducer, a signal conditioner, and an indicating device.
  - The transducer converts an input signal into its equivalent electric form.
  - The signal conditioner converts this electrical signal into a suitable format, which is passed to an indicating device.
  - The indicating device is used to display the value of the quantity being measured.

Introduction to CRO and Lissajous Pattern

- It is primarily used for the display of waveforms.
- It works as an eye for the electronics engineer.
- A CRO is basically a very fast X-Y plotter.
- It displays an input signal versus another signal or versus time.
- The stylus of this plotter is a luminous spot which moves over the display area in response to input voltages.
- The heart of the oscilloscope is the cathode ray tube (CRT).
- The rest of the instrument consists of circuitry necessary to operate the CRT.

Cathode Ray Tube (CRT)

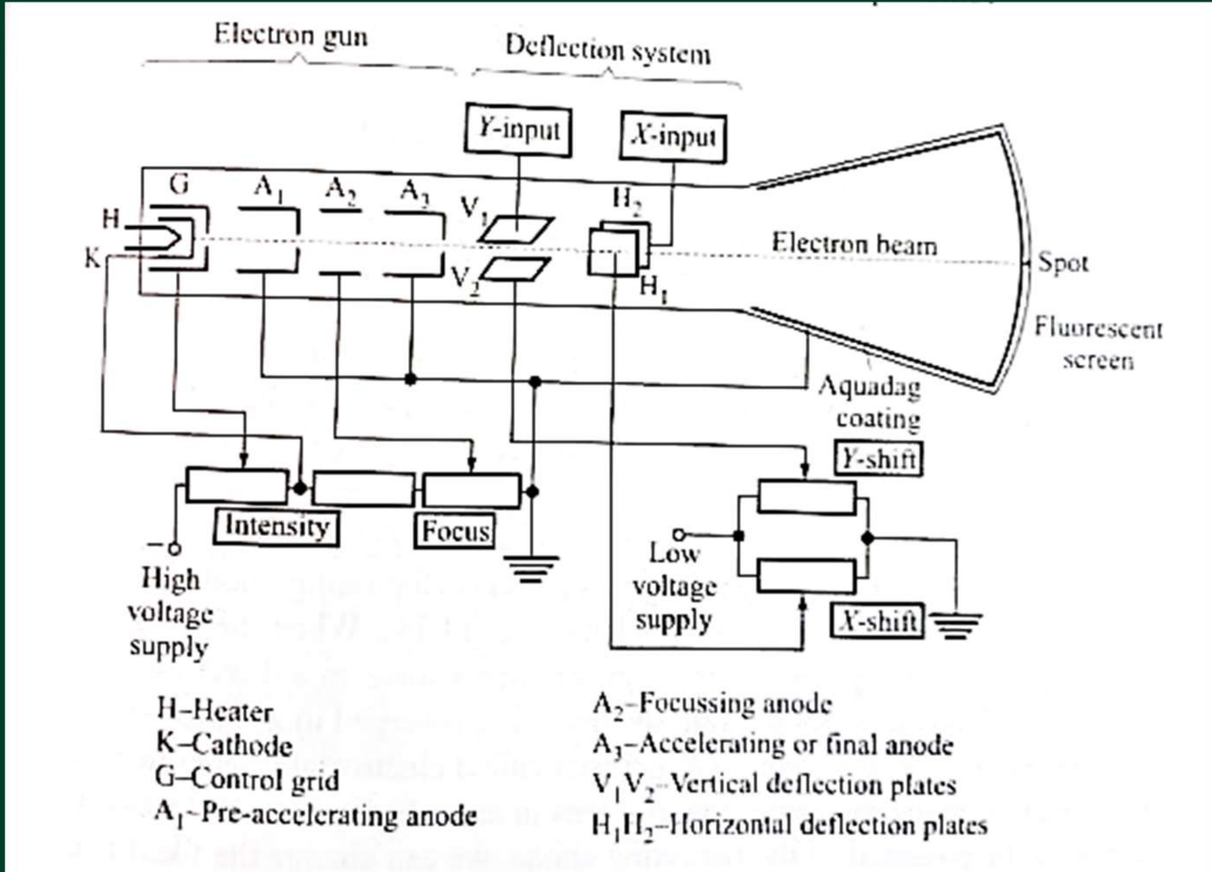


Fig. 14.17 *Schematic diagram of a CRT*

Cathode Ray Tube (CRT)

- A CRT essentially consists of three basic components:
  - The electron gun, which produces a beam of electrons sharply focused on screen, accelerated to a very high velocity.
  - The deflection system, which deflects the electron, both in the horizontal and vertical planes electrostatically (or magnetically in TV tubes) in accordance with the waveform to be displayed.
  - The fluorescent screen, upon which the beam of electrons impinges to produce a spot of visible light.

Cathode Ray Tube (CRT)

- These three essential components of a CRT are enclosed in a highly evacuated funnel-shaped glass envelope.
- The inside of the CRT tube is coated with a phosphor material.
- This material fluoresces when high-velocity electrons strike it, converting the energy of the electrons into visible light. Hence the name fluorescent screen.
- Depending upon the material (fluorescent), used in the fluorescent screen, it is possible to get different colors of light (green, orange or white).
- When the electron beam strikes the screen, besides giving out visible light, secondary emission electrons are also released.
- These electrons are collected by the conductive coating deposited on the inside surface of the glass bulb.
- The coating is usually an aqueous solution of graphite, known as aquadag.
- This is electrically connected to the final anode as shown in figure 14.17

Cathode Ray Tube (CRT)

- The electron gun gets its name because it fires electrons at a very high speed, like a gun which fires high-speed bullets.
- Electrons are emitted from the indirectly heated cathode.
- The control grid is a nickel cylinder surrounding the cathode.
- It has a small hole in the far end, opposite the cathode.
- The only way the emitted electrons can get past the grid is through this small hole.
- The control grid controls the number of electrons passing through it.
- Since the brightness of the spot on the face of the screen depends upon the beam intensity, it can be controlled by changing the negative bias on the control grid.
- This is done by the intensity control (on the front panel of the CRO).

Cathode Ray Tube (CRT)

- The electrons coming out fo the control grid are accelerated by the high potential applied to the accelerating anode.
- These electrons, being negatively charged, have a tendency to diverge from each other. (will not form a sharp image on the screen)
- The beam is focused to a very small dot on the screen by using the focusing anode.
- The focusing and accelerating anode are also cylindrical form, with small openings located in the centre of each cylinder, along the axis of the tube.

Cathode Ray Tube (CRT)

- These holes permit the electrons to pass through.
- The anode is only accelerating the electrons are not collected by it.
- *The focusing anode is given a slightly lower potential than the accelerating anodes.*
- Because of the difference in potentials, the equipotential surfaces between the two cylinders (focusing anode and accelerating anode) form a shape like a convex lens.
- When the electron beam passes through this region the electrons experience a force in a direction normal to the equipotential surfaces.
- As a result, the beam is converged to a sharp point on the screen.

Cathode Ray Tube (CRT)

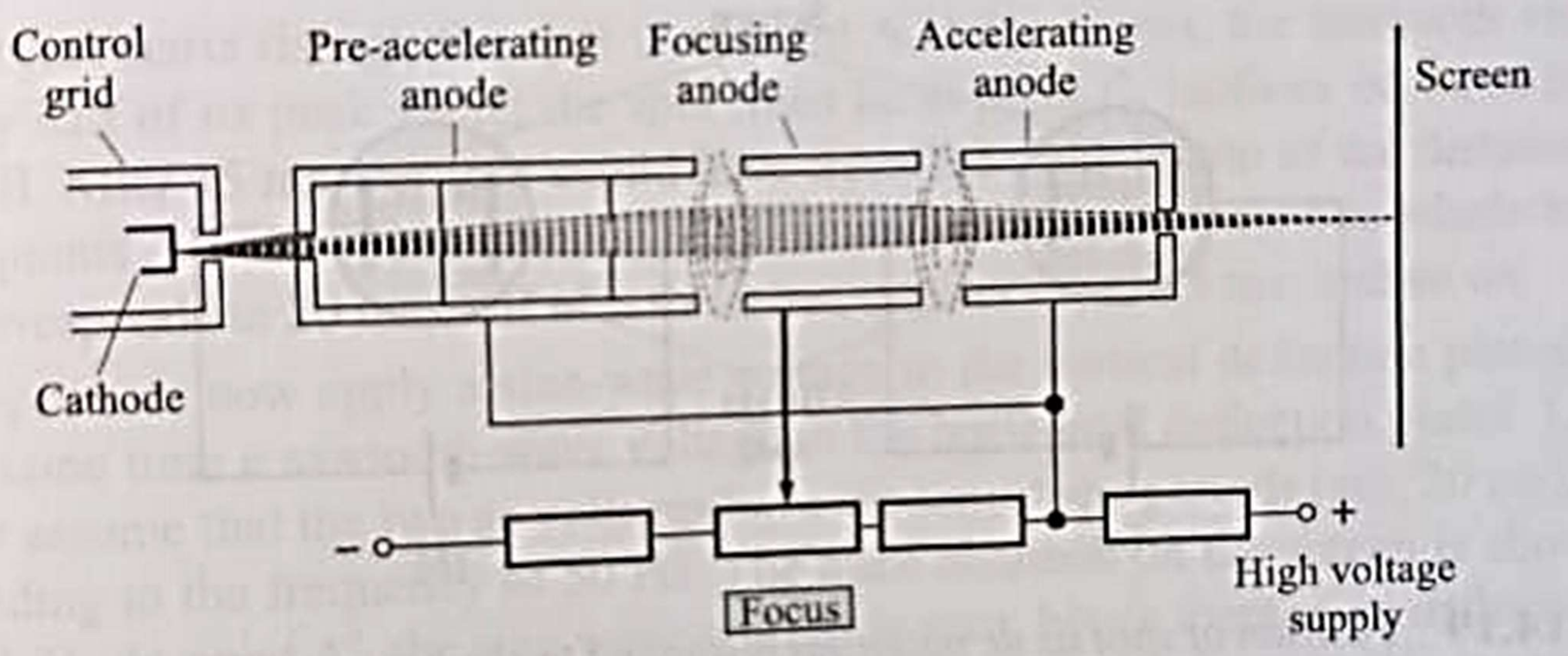


Fig. 14.18 *Electrostatic focussing arrangement in a CRT*

Cathode Ray Tube (CRT)

- The equipotential surface (sometimes called an electrostatic lens) focuses the electron beam in much the same way as a lens in an ordinary camera focuses light.
- *By changing the potential of the focusing anode, we can change the focal length of the electrostatic lens.*

Cathode Ray Tube (CRT)

- *The electron gun emits a very narrow (focussed), highly accelerated electron beam.*
- *This beam then passes through the deflection system consisting of two pairs of parallel plates.*
- *Y deflection plates are placed horizontally in the tube.*
  - *Any voltage applied to this set of plates, moves the electron beam up or down.*
- *X deflection plates are placed vertically in the tube.*
  - *Any voltage applied to this set of plates, moves the spot on the screen to the left or to the right.*
- *If no potential is applied externally to either of the plates, then the spot will be at the centre of the screen.*
- *The initial centring of the spot can be done by using the X shift and Y shift controls.*

How a CRO Displays Waveform

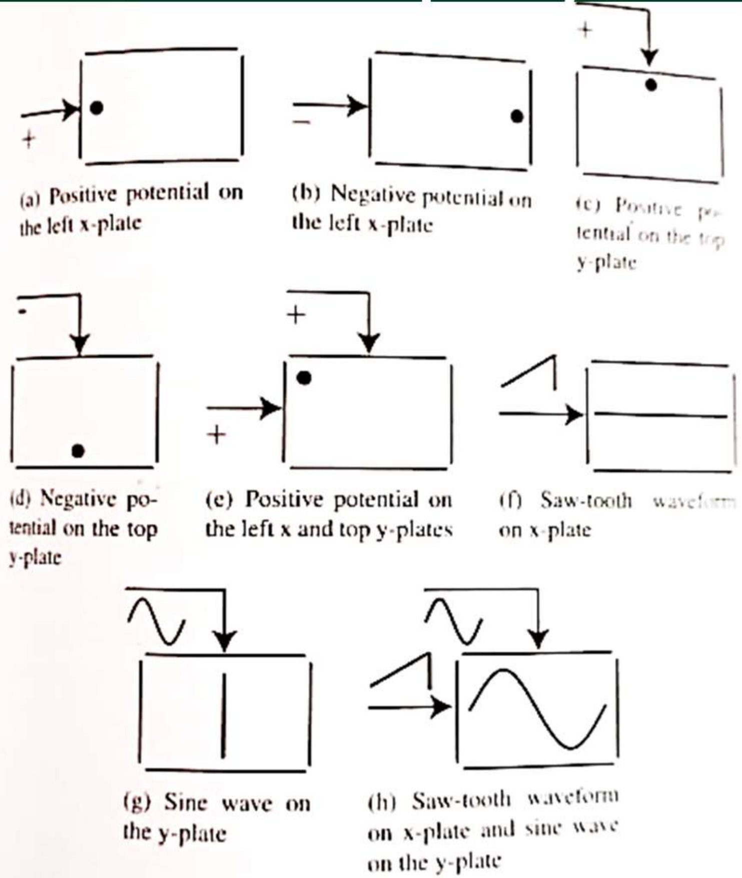
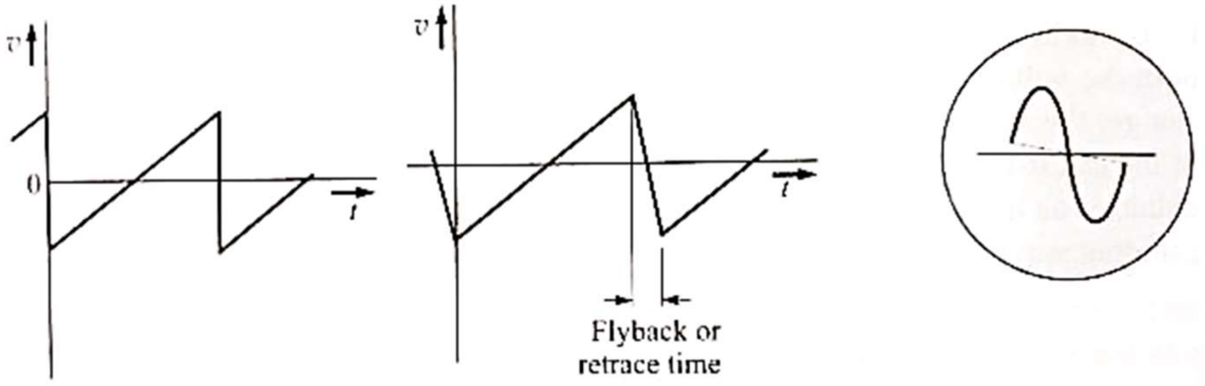


Figure 7.14: Deflection of electron beam on CRT screen due to several combination of voltages applied to deflection plates.

How a CRO Displays Waveform

- When a sawtooth is applied to the horizontal deflection plates, the x-axis on the screen may be taken to represent time.
- For this reason, the sawtooth wave voltage is called time base voltage.
- An ideal time base voltage is shown in the figure. 14.22 a
- But in practice, the time base generator in a CRO produces the waveform shown in figure 14.22 b

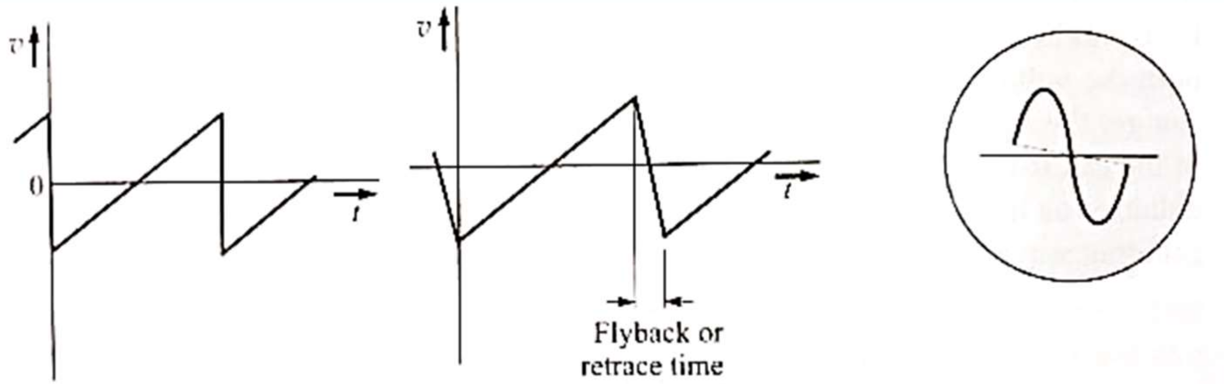


(a) Ideal sawtooth wave (b) Actual sawtooth wave generated by time-base generator (c) Retrace path is visible

Fig. 14.22 *Display of waveform gets distorted due to flyback period of time-base voltage*

How a CRO Displays Waveform

- It takes a little time for the voltage to fall from maximum positive to maximum negative.
- This time interval is called flyback or retrace time.
- Since, the time-base voltage has a finite flyback period, the display of the waveform is a little distorted as shown in Fig 14.22c
- The path traced by the spot during the flyback period is called retrace path.
- In most CROs, the electron beam is blanked off by applying a negative voltage to the control grid during the flyback period.



(a) Ideal sawtooth wave (b) Actual sawtooth wave generated by time-base generator (c) Retrace path is visible

Fig. 14.22 *Display of waveform gets distorted due to flyback period of time-base voltage*

Cathode Ray Tube (CRT)

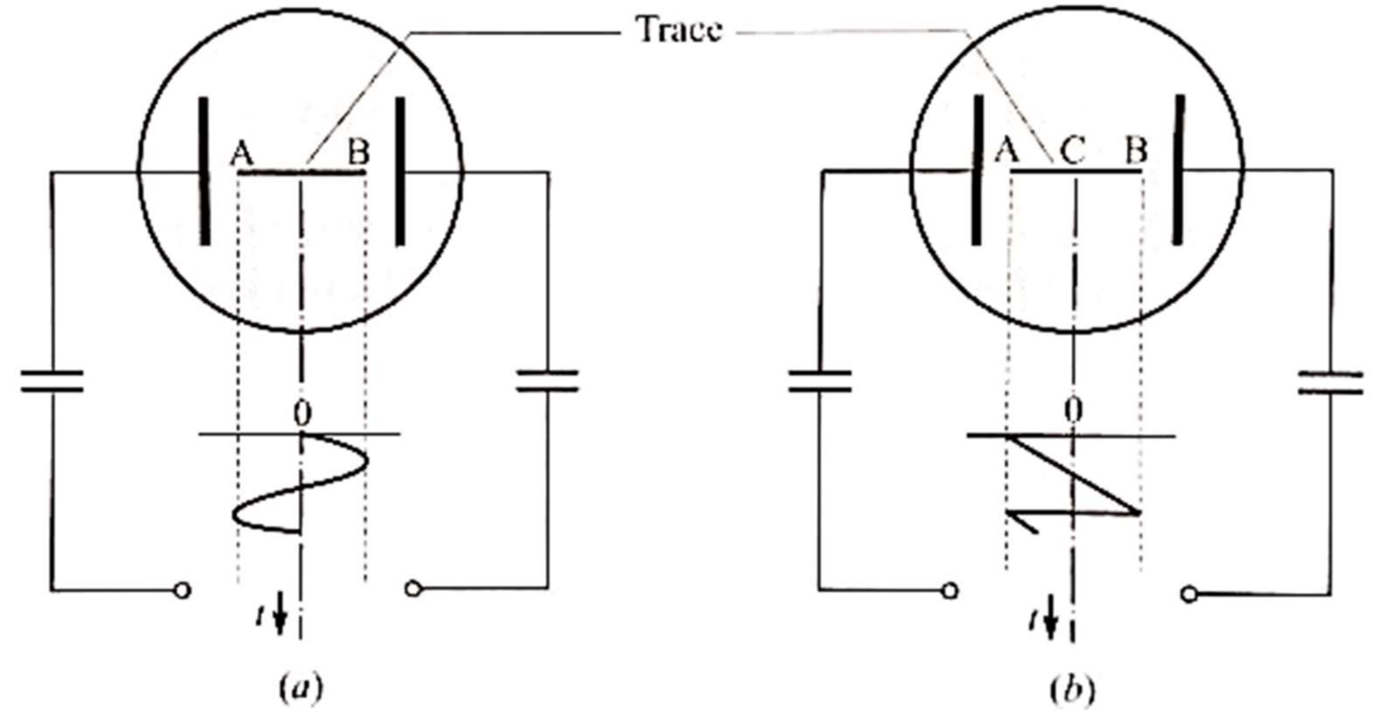


Fig. 14.20 *A solid line trace is obtained when we apply to the horizontal deflection plates (a) a sine voltage, (b) a sawtooth voltage*

Cathode Ray Tube (CRT)

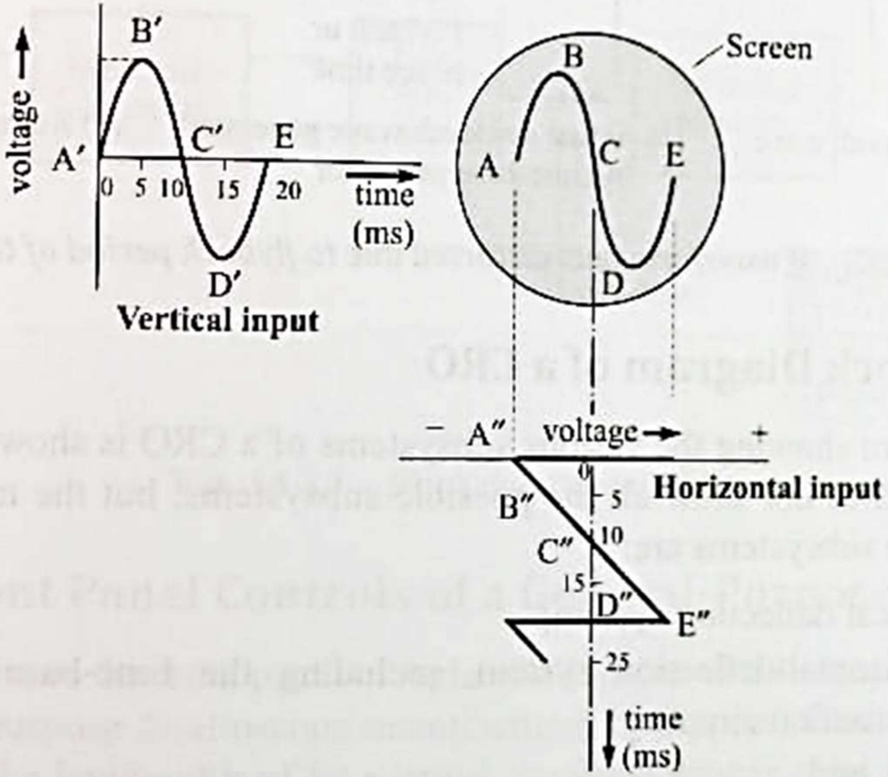


Fig. 14.21 *Display of sine wave on CRO when both horizontal and vertical input waves are 50 Hz*

Cathode Ray Tube (CRT)

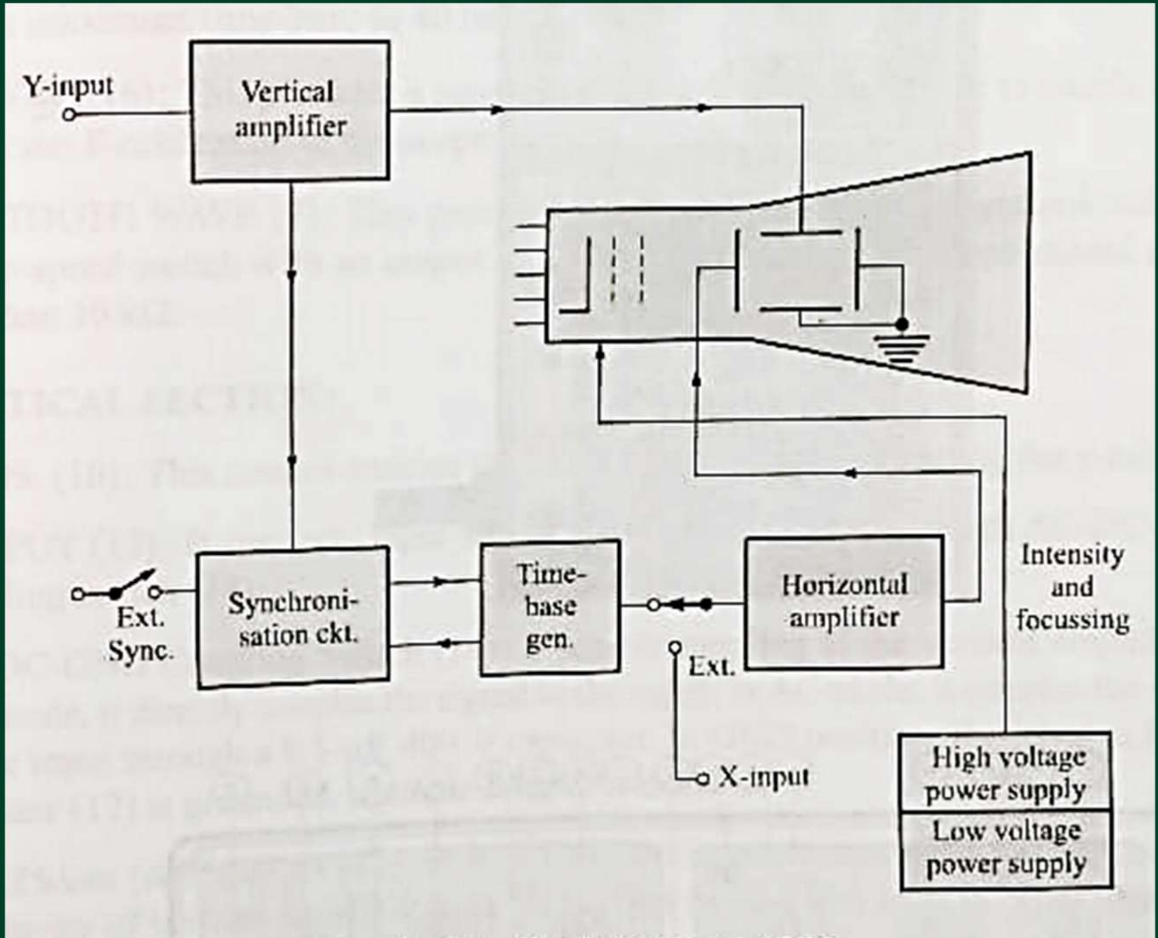


Fig. 14.23 *Block diagram of CRO*

Block diagram of CRO

1. **CRT (Cathode Ray Tube):**
   - **Electron Gun:** Produces a narrow beam of electrons.
   - **Deflection System:** Controls the movement of the electron beam (horizontal and vertical).
   - **Screen:** Displays the electron beam, which creates the visible trace.
2. **Vertical Amplifier:**
   - Amplifies the input signal for vertical deflection.
3. **Horizontal Amplifier:**
   - Controls the horizontal deflection of the electron beam.
4. **Time Base Generator:**
   - Produces the sawtooth waveform for the horizontal deflection system.

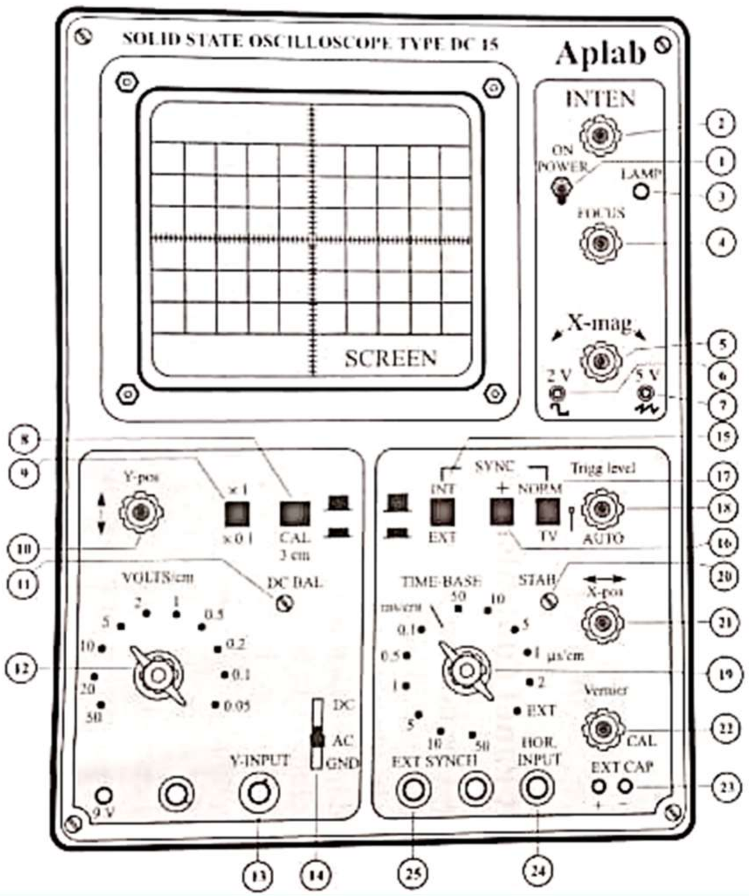
Block diagram of CRO

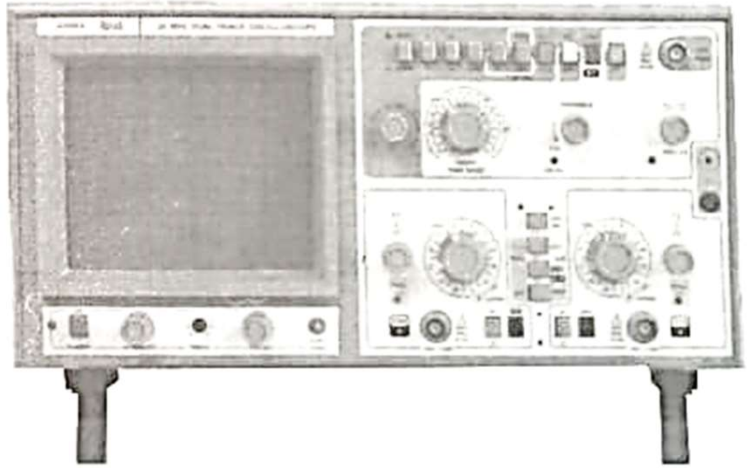
5. **Trigger Circuit:**
   - Synchronizes the input signal with the time base to ensure a stable display.
6. **Power Supply:**
   - Provides the necessary voltages (high and low voltages) for the CRT and other components.
7. **Synchronization Circuitry:**
   - Ensures the time base is synchronized with the input signal, allowing the waveform to be displayed steadily.

Block diagram of CRO

- **Vertical Deflection System:**
  - Consists of an input attenuator and multiple amplifier stages.
  - The gain of the vertical amplifier can be controlled by the attenuator.
  - Waveforms to be displayed are fed to the Y-input.
- **Horizontal Deflection System:**
  - Provides voltage for horizontal beam movement.
  - Includes several number of amplifier stages, the gain of which can be controlled.
  - It has a sawtooth oscillator or a time base generator
  - Contains a **synchronization circuit** to start the horizontal sweep at a specific instant, relative to the waveform.
  - Provides options for **external horizontal inputs (X-inputs):**
    - Select internal sweep voltage or an external voltage to control beam deflection horizontally.
  - The operation of the vertical section and horizontal section is independent.
  - Both sections together display the incoming signal on the CRO screen.

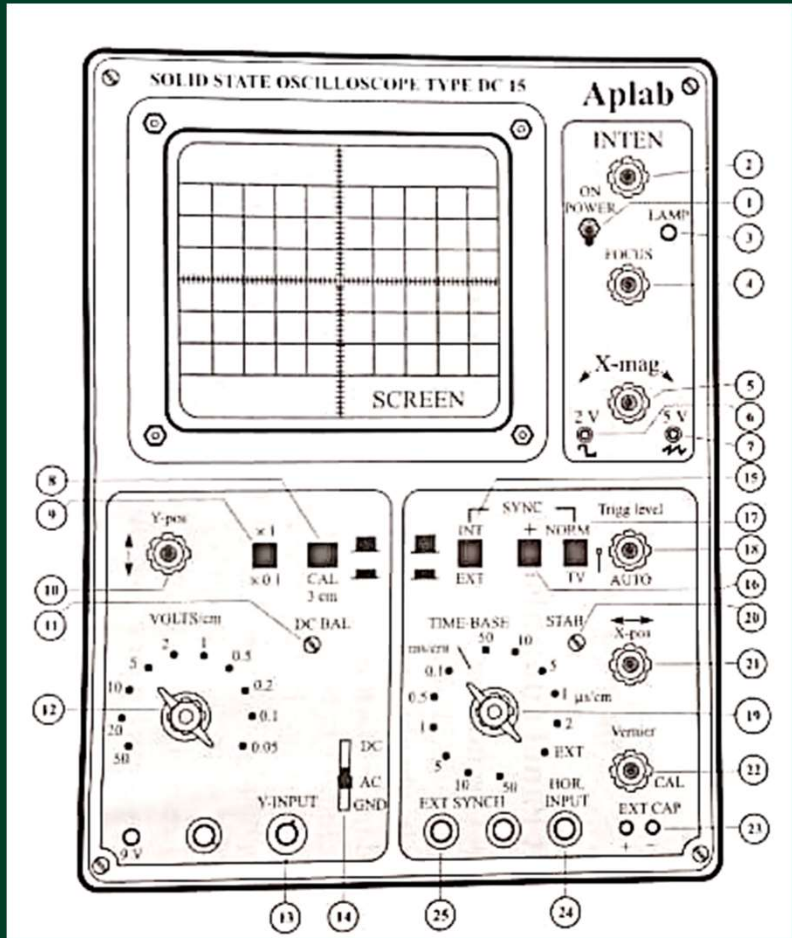
Front Panel controls of a General Purpose CRO





Front Panel controls of a General Purpose CRO

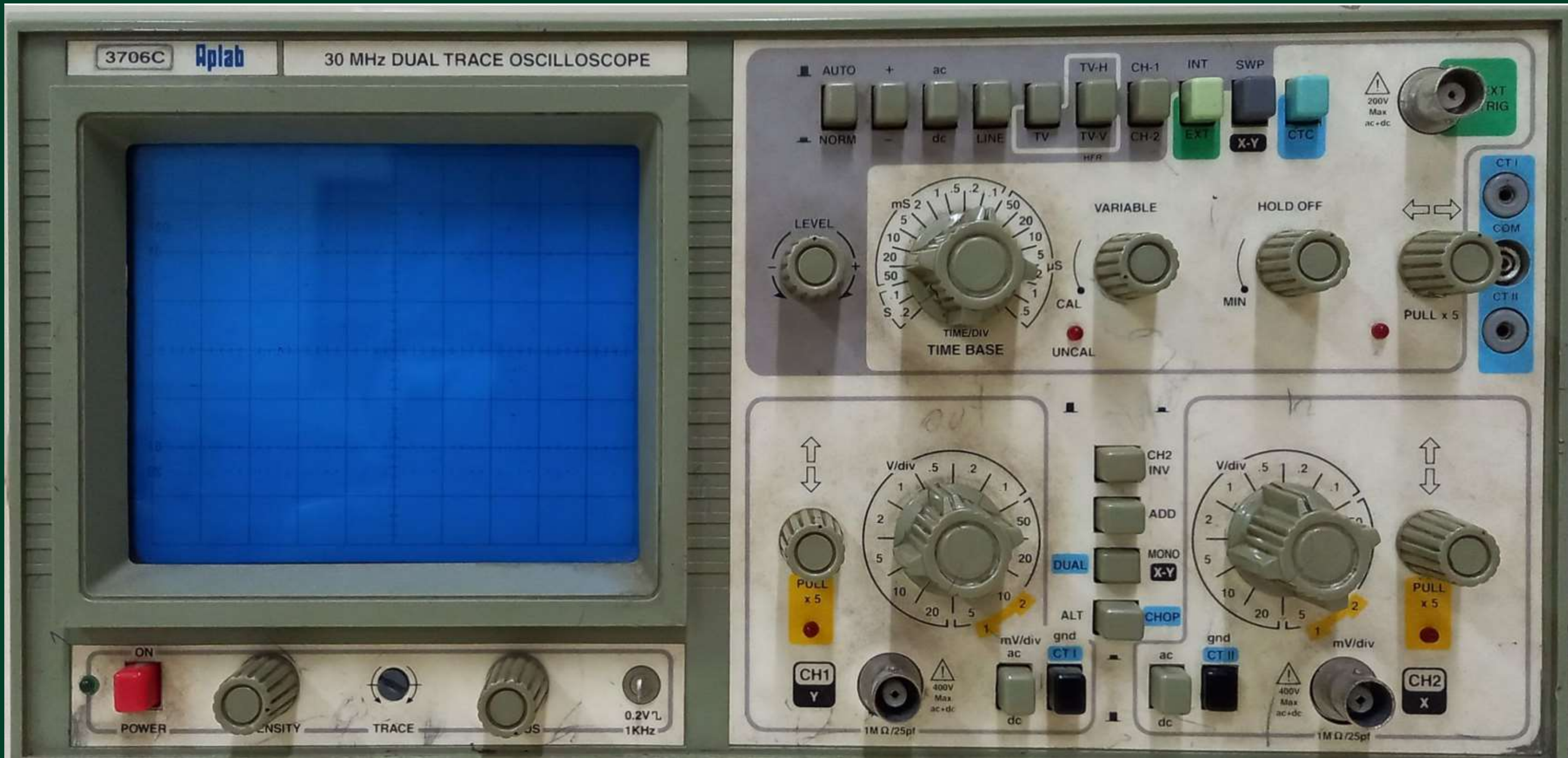
- Front Panel Controls of a CRO (Aplab Solid-State Oscilloscope, Type DC-15)“
  - Manufacturer:
    - Applied Electronics Limited, Thana, India.
  - Vertical Amplifier Bandwidth:
    - DC to 15 MHz.
  - Sweep Speed:
    - Ranges from 0.2 μs/cm to 50 ms/cm.
  - Waveform Triggering:
    - Supports frequencies from 1 Hz to 20 MHz with complete stability.
  - Y-Calibration Check:
    - Provision to produce a line-frequency (50 Hz) square wave of 2 V (peak-to-peak).
  - Power Consumption:
    - Operates on 55 W at 220 V, 50 Hz.



Front Panel controls of a General Purpose CRO

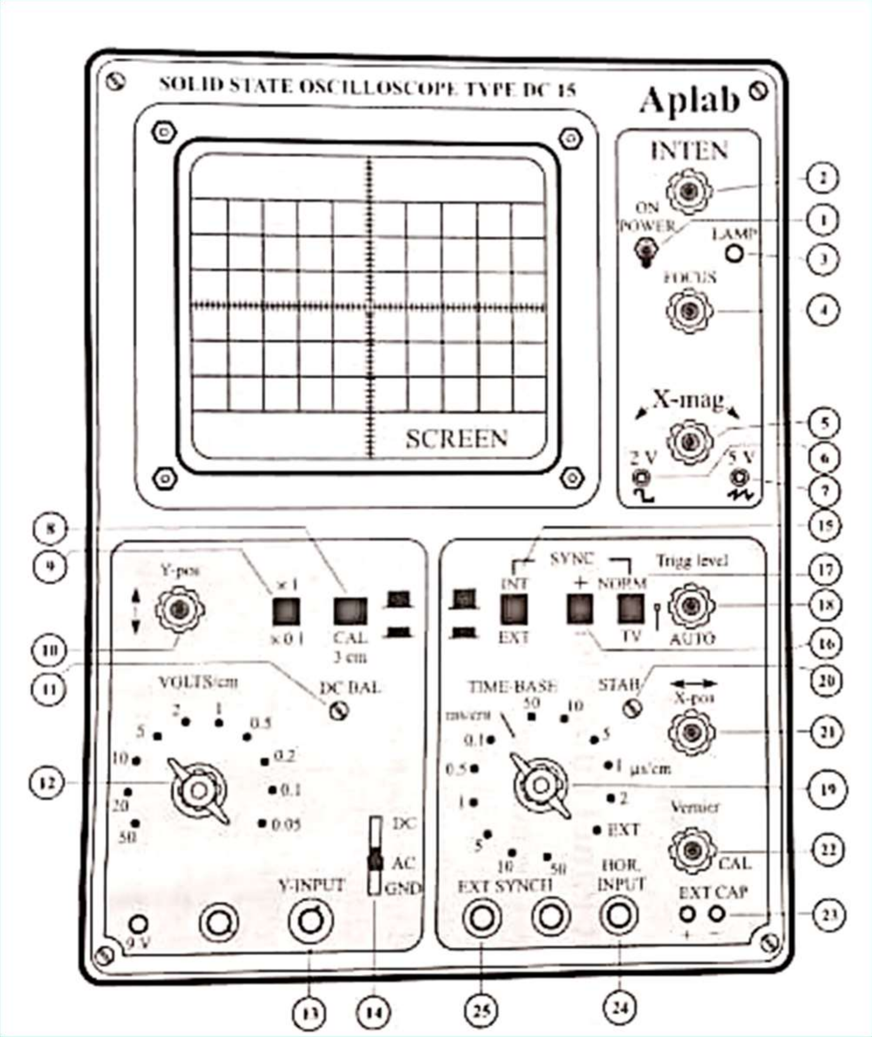
- The Aplab 3706C is a 30 MHz dual-trace oscilloscope designed for various electronic testing applications. Below are its key specifications and features:
  - Bandwidth: DC to 30 MHz.
  - Vertical Sensitivity:
    - 1 mV/div to 20 V/div with 5 mV/div to 20 V/div in calibrated steps.
    - A ×5 magnifier enhances sensitivity to 1 mV/div and 2 mV/div.
  - Time Base:
    - 0.5 μs/div to 0.2 s/div in 18 calibrated steps, extendable to 100 ns/div with ×5 magnification.
  - Triggering:
    - Operates up to 40 MHz, with modes like TV Frame and Line.
  - Display:
    - 140 mm rectangular CRT with an 8×10 cm viewing area and internal graticule.
  - Input:
    - Independent CH1 and CH2 with algebraic addition/subtraction and X-Y operation.
  - Component Tester:
    - Includes a built-in comparator for testing electronic components, providing a test voltage of 8.6 V and a test current of 28 mA.
  - Z-Modulation:
    - Compatible with TTL-level signals.
  - Calibration
    - Provides 0.2V ±2%, 1KHz square-wave output for probe compensation.

Front Panel controls of a General Purpose CRO



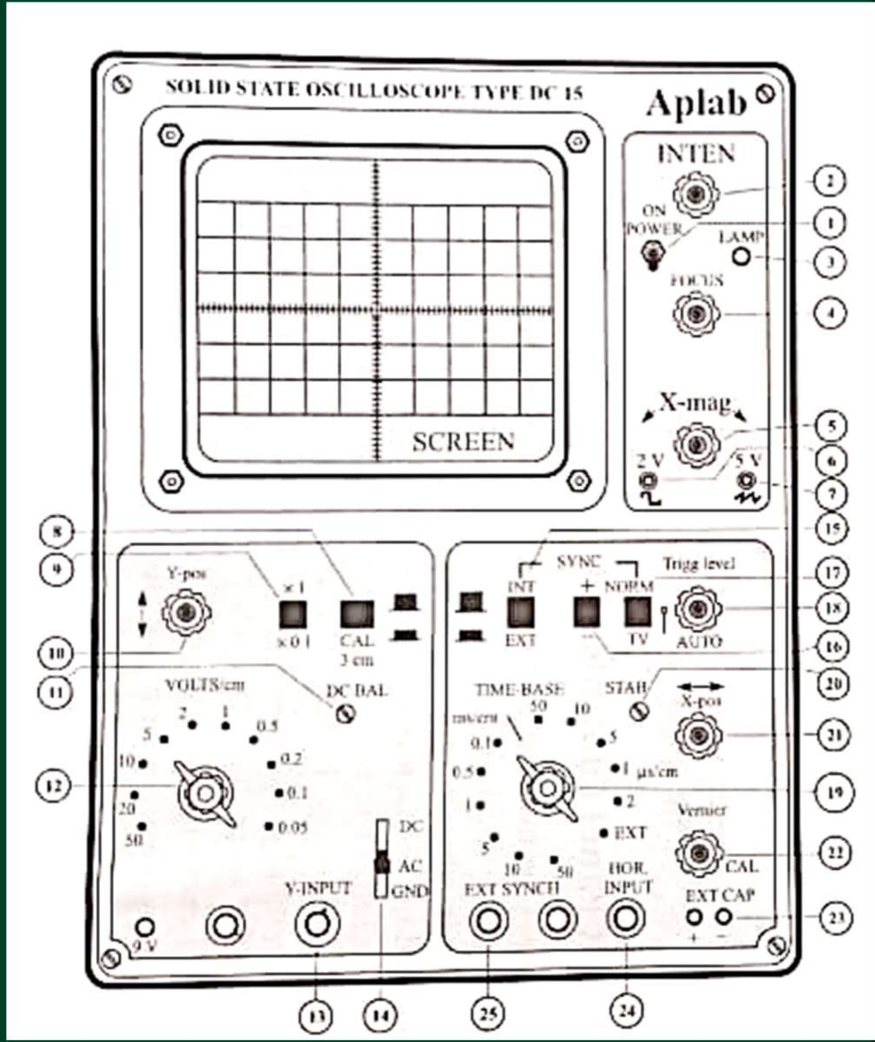
Front Panel controls of a General Purpose CRO

- **ON POWER (1):**
  - It is a toggle switch meant for switching on power. In the ON position, power is supplied to the instrument and the neon lamp (3) glows.
- **INTEN (2):**
  - It controls the trace intensity from zero to maximum.
- **FOCUS (4):**
  - It controls the sharpness of the trace. A slight readjustment of this control may be necessary after changing the intensity of the trace.



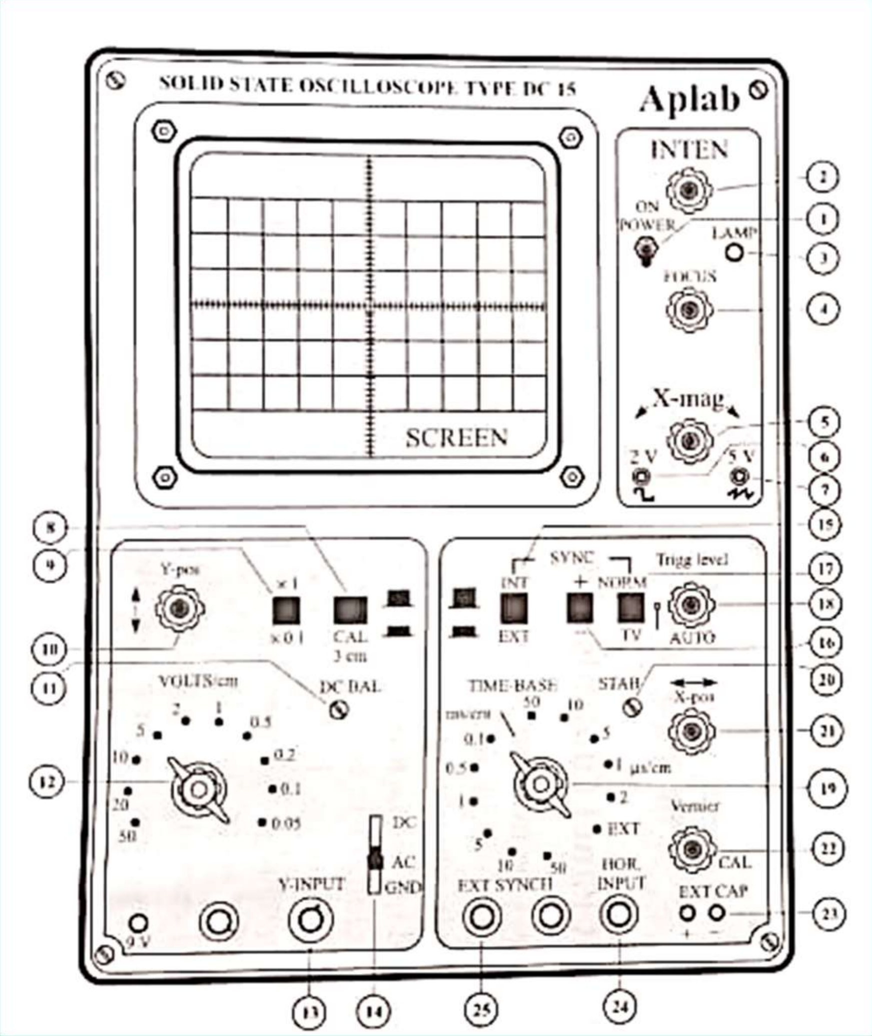
Front Panel controls of a General Purpose CRO

- **X MAG (5):**
  - It expands the length of the time-base from 1 to 5 times continuously, and makes the maximum time-base 40 ns/cm.
- **SQ. WAVE (6):**
  - This provides a square wave of 2 V (p-p) amplitude to enable one to check the Y-calibration of the scope.
- **SAWTOOTH WAVE (7):**
  - This provides a sawtooth-waveform output coincident to the sweep-speed switch with an output of 5 V (p-p). The load resistance should not be less than 10 kΩ.



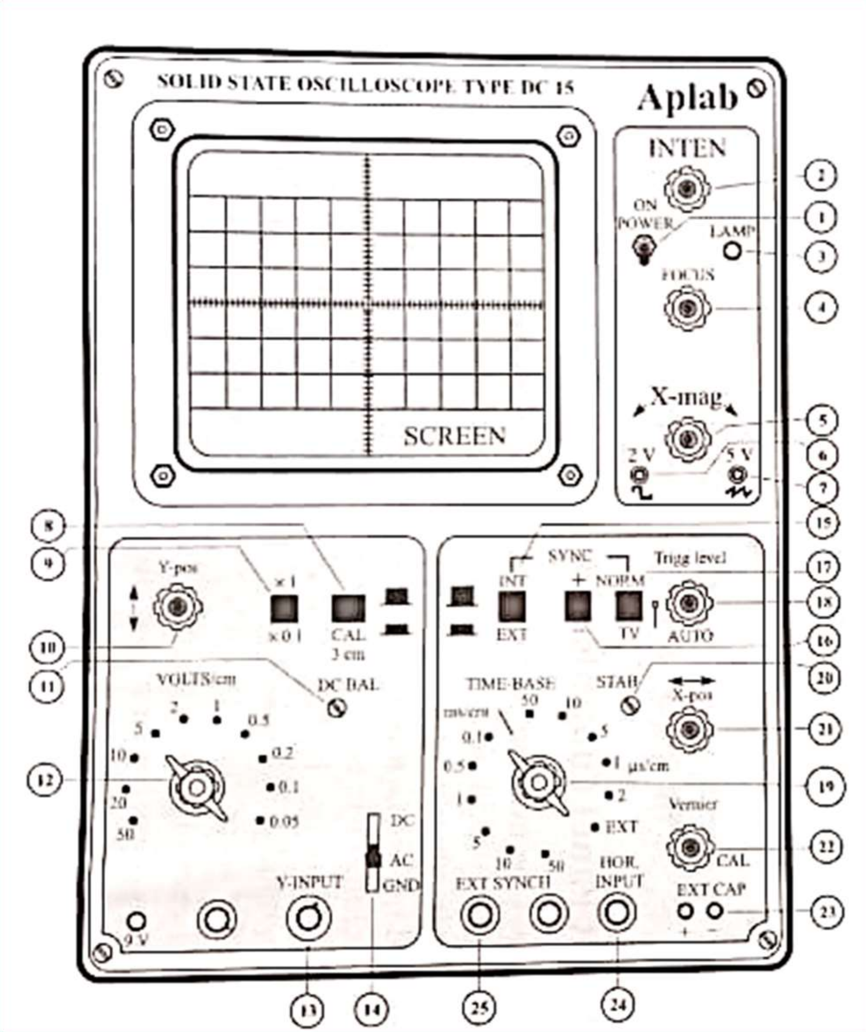
Front Panel controls of a General Purpose CRO

- **VERTICAL SECTION:**
- **Y-POS. (10):**
  - This control enables the movement of the display along the y-axis.
- **Y-INPUT (13):**
  - It connects the input signal to the vertical amplifier through the AC-DC-GND coupling switch (14).
- **AC-DC-GND Coupling Switch (14):**
  - It selects coupling to the vertical amplifier.
  - In DC mode,
    - it directly couples the signal to the input;
  - in AC mode,
    - it couples the signal to the input through a 0.1-μF, 400-V capacitor.
  - In the GND position,
    - the input to the attenuator (12) is grounded, whereas the Y-input is isolated.



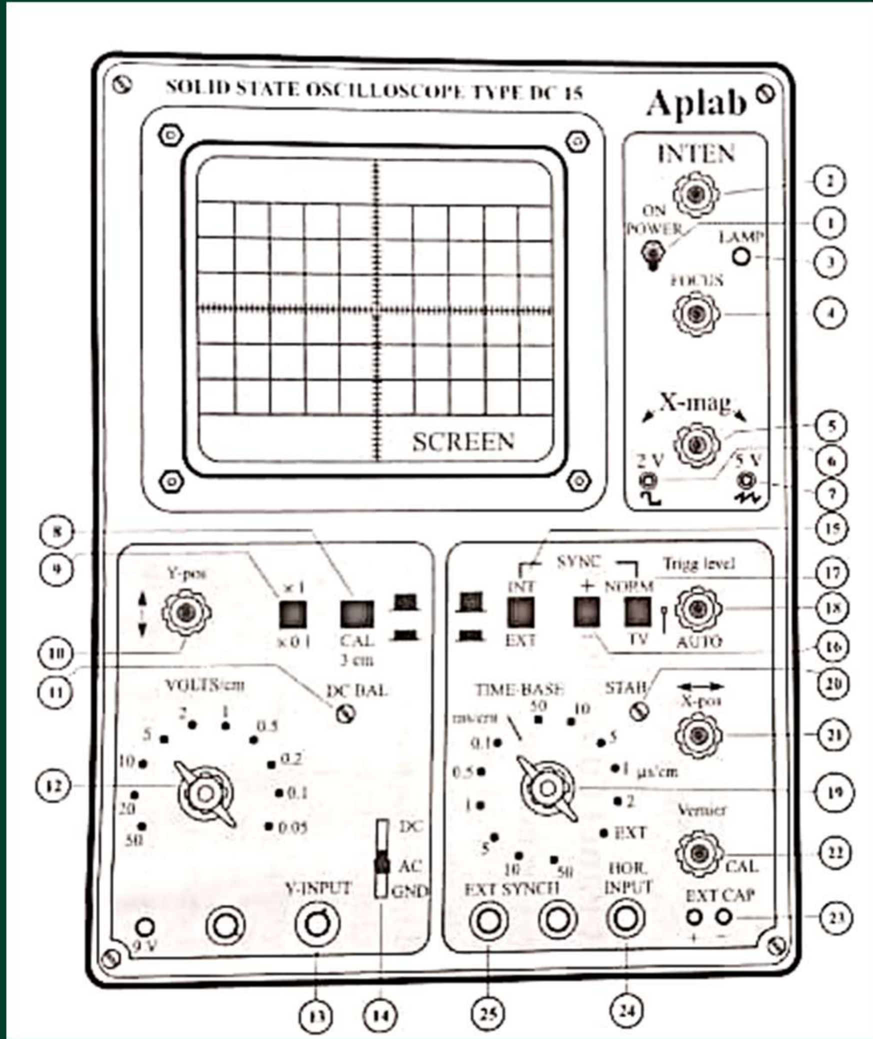
Front Panel controls of a General Purpose CRO

- **VOLTS/cm (Attenuator) (12):**
  - It is a 10-position attenuator switch that adjusts the sensitivity of the vertical amplifier from 50 mV/cm to 50 V/cm in a 1, 2, 5, 10 sequence.
  - Attenuator accuracy is ±3%.
- **x1-x0.1 Switch (9):**
  - When switched to the x0.1 position, it magnifies the basic sensitivity to 5 mV/cm from 50 mV/cm.
- **CAL. Switch (8):**
  - When pressed, a DC signal of 15 mV or 150 mV is applied to the vertical amplifier depending on the position of the x1-x0.1 switch (9).
- **DC BAL (11):**
  - It is a preset control on the panel.
  - It is adjusted for no movement of the trace when either the x1-x0.1 switch (9) is pressed, or the position of the AC-DC-GND coupling switch (14) is changed.



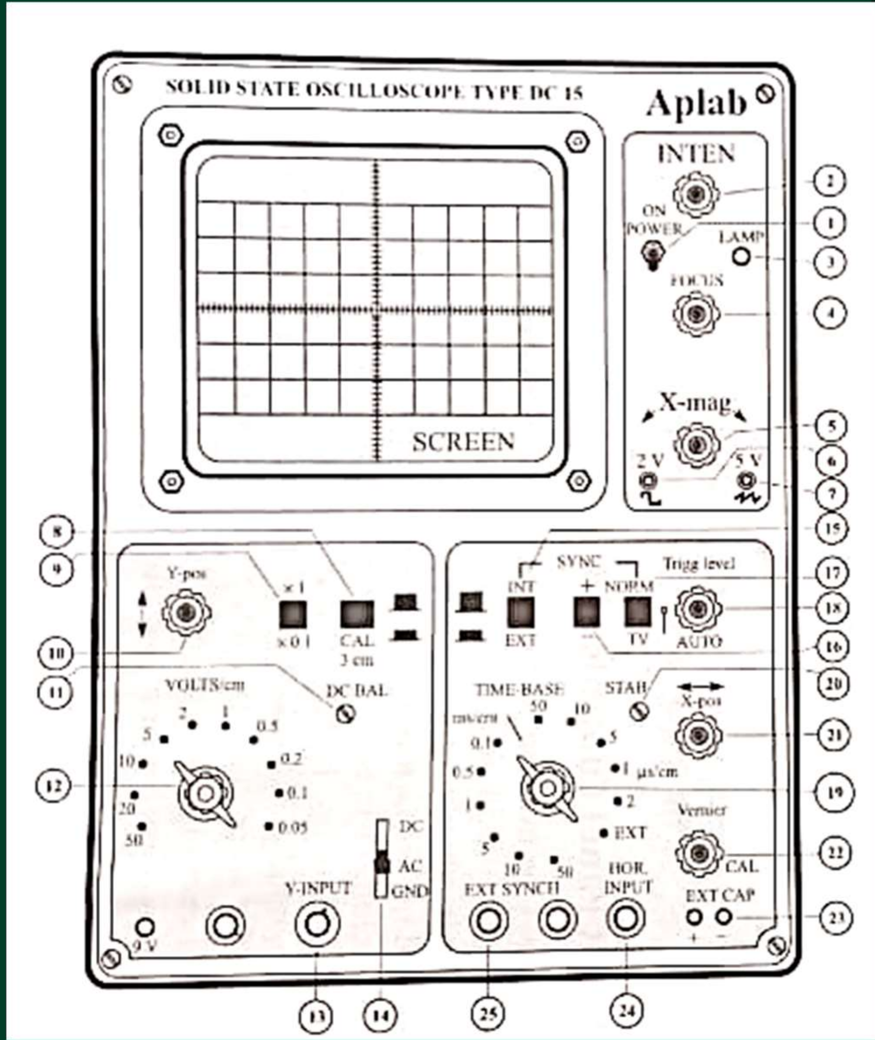
52 Front Panel controls of a General Purpose CRO

- **HORIZONTAL SECTION:**
  - **X-POS (21):**
    - This control enables the movement of the display along the x-axis.
  - **TRIGG LEVEL (18):**
    - It selects the mode of triggering.
    - In the AUTO position, the time-base line is displayed in the absence of an input signal.
    - When the input signal is present, the display is automatically triggered.
    - The span of the control enables the trigger point to be manually selected.



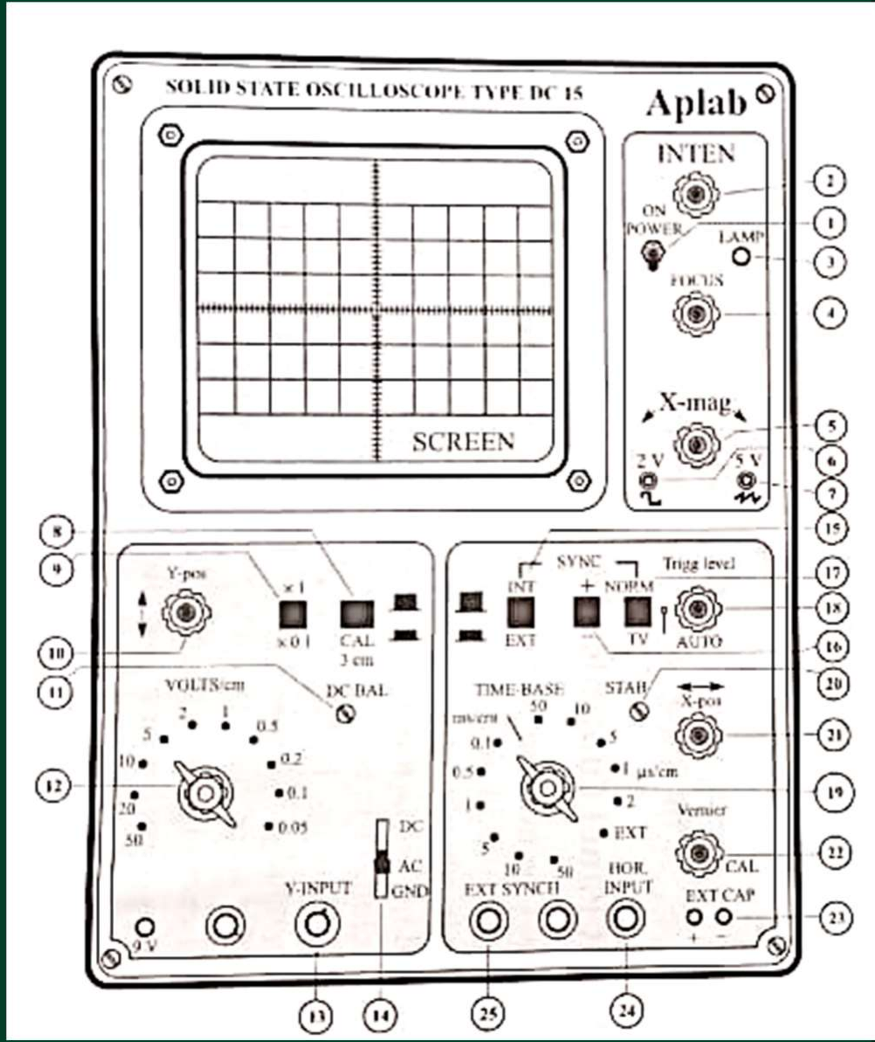
53 Front Panel controls of a General Purpose CRO

- **TIME-BASE (19):**
  - This selector switch selects sweep speeds from 50 ms/cm to 0.2 μs/cm in 11 steps.
  - The position marked EXT is used when an external signal is to be applied to the Horizontal Input (24).
- **VERNIER (22):**
  - This control is a fine adjustment associated with the Time-base Sweep Selector Switch (19).
  - It extends the range of sweep by a factor of 5.
  - It should be turned fully clockwise to the CAL position for calibrated sweep speeds.



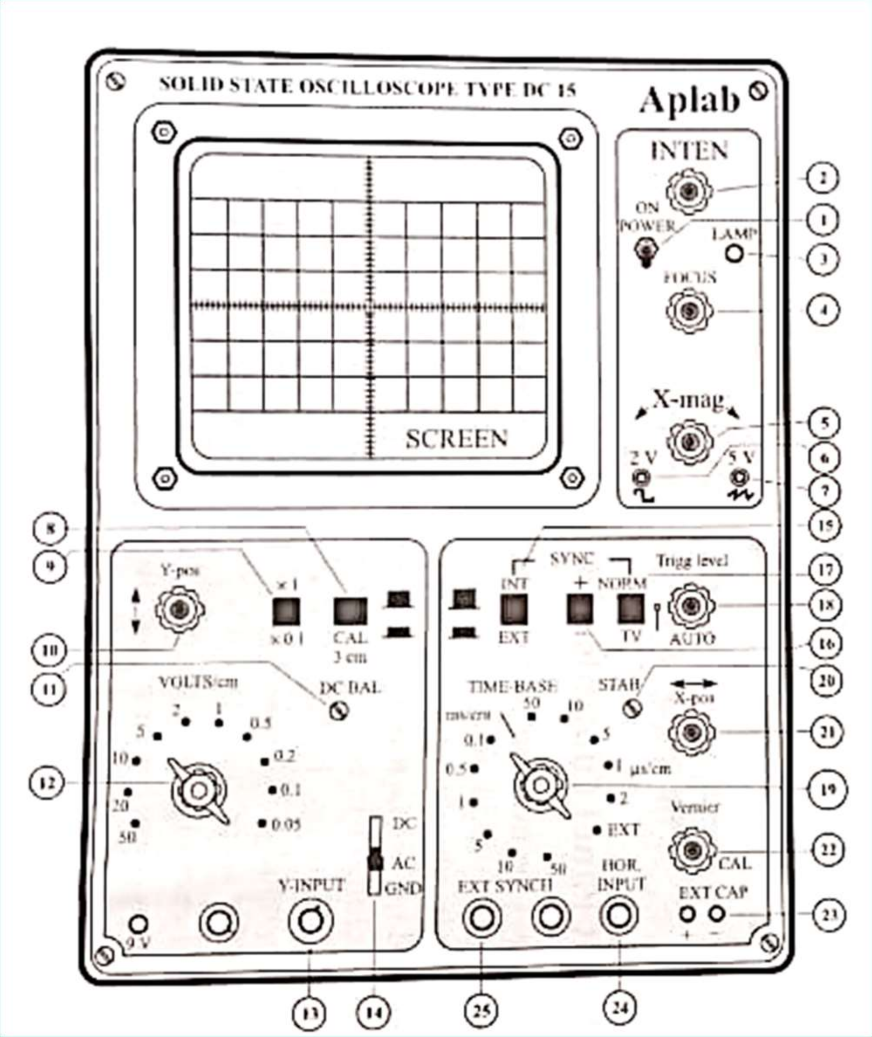
54 Front Panel controls of a General Purpose CRO

- **SYNC Selector (15, 16, 17):**
  - The INT/EXT switch (15) selects internal or external trigger signal.
  - The +ve or -ve switch (16) selects whether the waveform is to be triggered on +ve or -ve step.
  - NORM/TV switch (17) permits normal or TV (line frequency) frame.
- **STAB (20):**
  - It is a preset control on the panel.
  - It should be adjusted so that you just get the base line in AUTO position of Trigger Level Control (18).
  - In any other position of the Trigger Level Control, you should not get the base line.



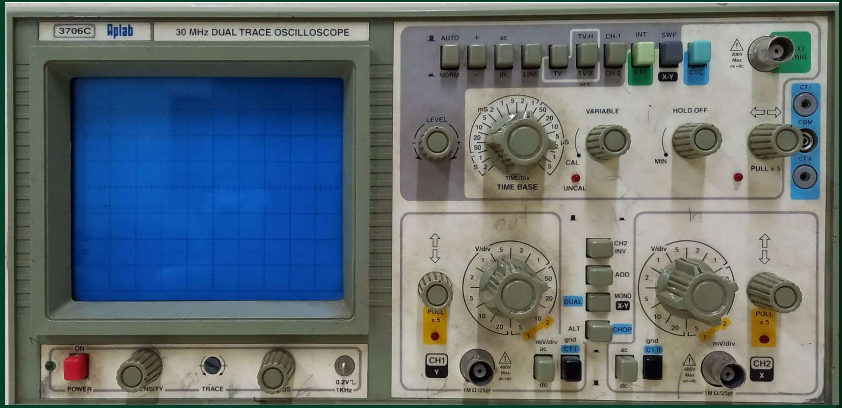
55 Front Panel controls of a General Purpose CRO

- **EXT CAP (23):**
  - This pair of connectors enables the time-base range to be extended beyond 50 ms/cm by connecting a suitable capacitor.
- **HOR INPUT (24):**
  - It connects the external signal to Horizontal Amplifier, when the Time-Base switch is put at EXT position.
- **EXT SYNC (25):**
  - It connects external signal to trigger circuit for synchronisation.



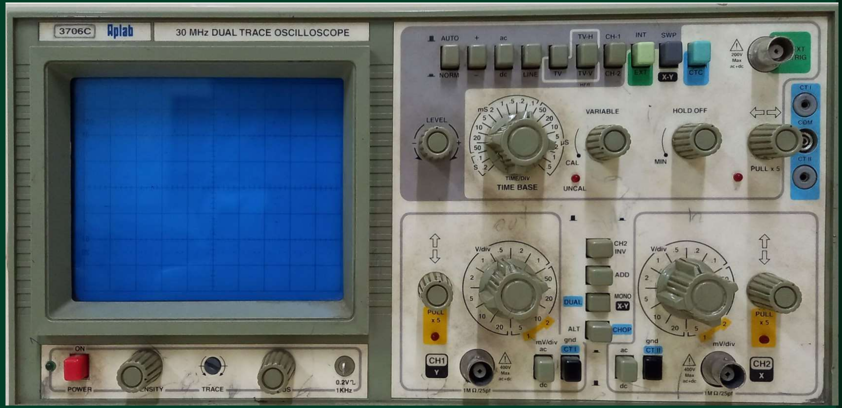
Front Panel controls of a General Purpose CRO

- **HOLD OFF:**
  - Allows triggering on certain complex signals by changing the holdoff (dead) time of the main (A) sweep.
  - This avoids triggering on intermediate trigger points within the repetition cycle of the desired display.
  - The holdoff time increases with clockwise rotation.
  - NORM is a position at full counter clockwise
  - Rotation that is used for ordinary signals.



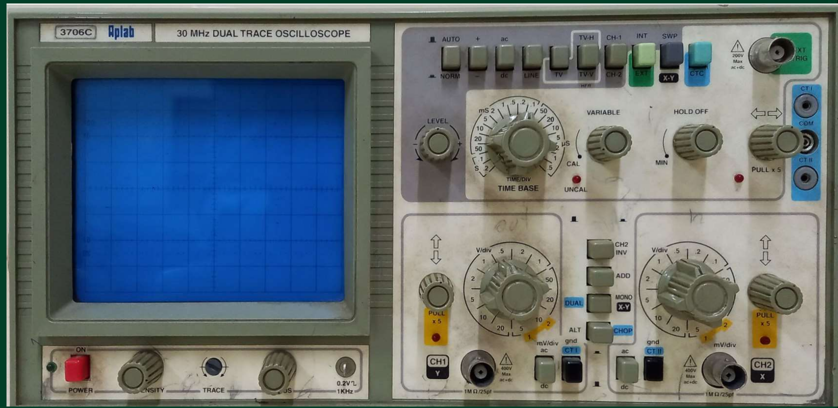
Front Panel controls of a General Purpose CRO

- **Trigger LEVEL control:-**
  - To select the trigger-signal amplitude at which triggering occurs.
  - When rotated clockwise, the trigger point moves toward the positive peak of the trigger signal.
  - When this control is rotated counterclockwise, the trigger point moves toward the negative peak of the trigger signal.

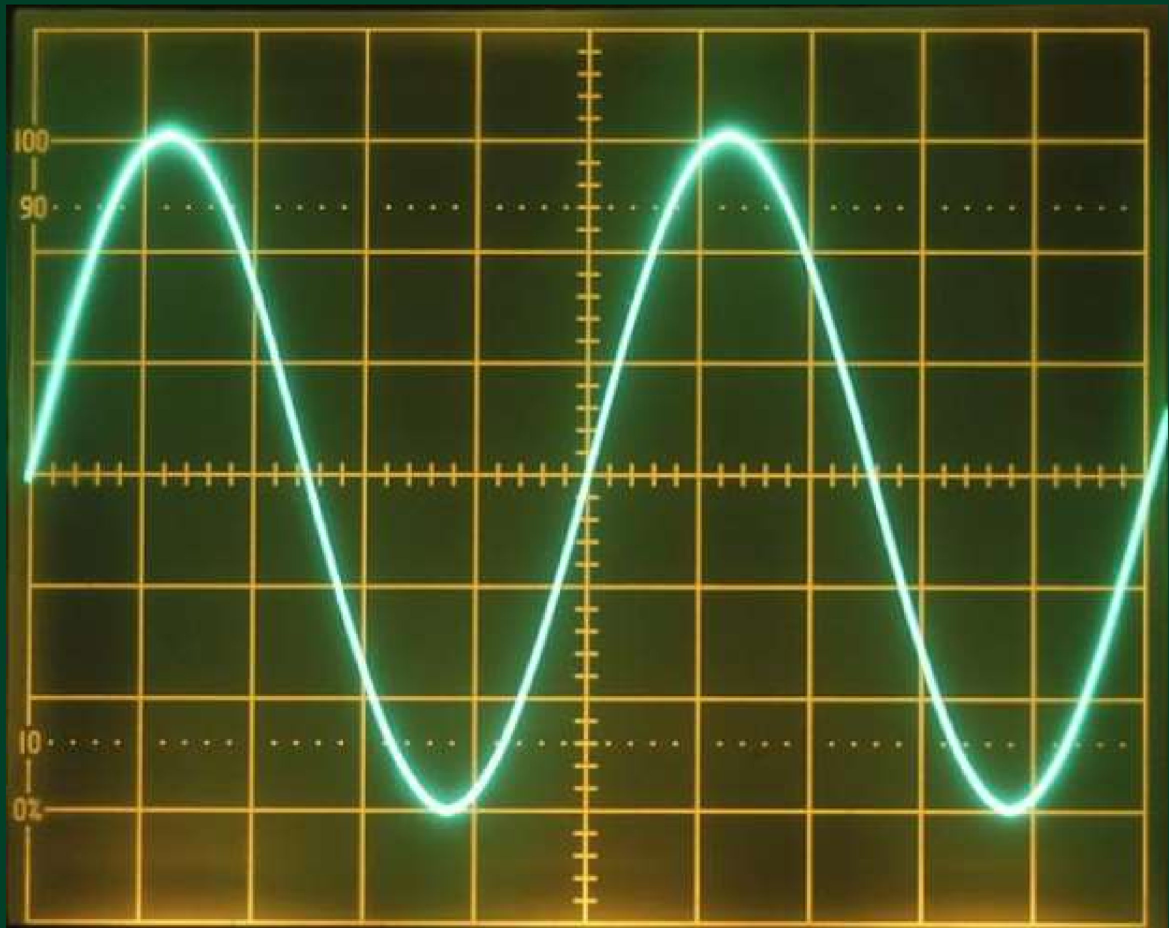


Front Panel controls of a General Purpose CRO

- **Trigger SLOPE switch:-**
  - To select the positive or negative slope of the (on LEVEL control) trigger signal for initiating sweep.
  - Pushed in, the switch selects the positive (+) slope.
  - When pulled, this switch selects the negative (-) slope.

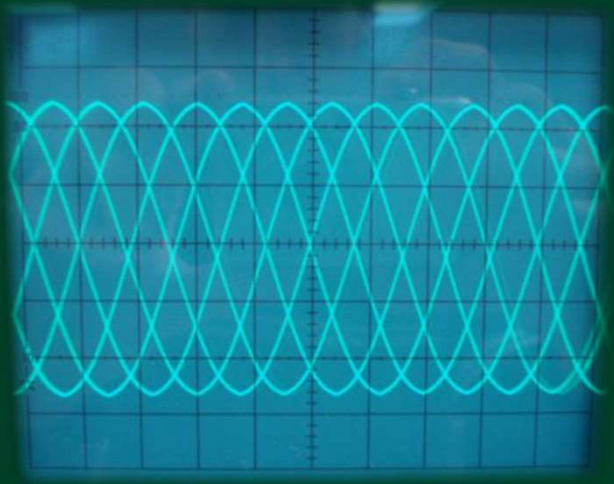


Front Panel controls of a General Purpose CRO

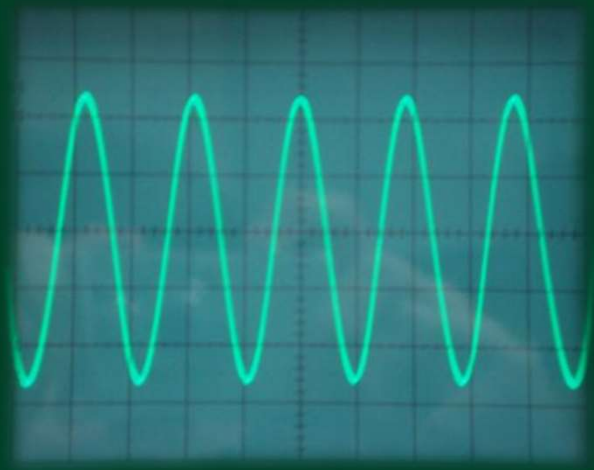


Triggering

- Electric signals change much faster than we can observe.
- To view a meaningful version of the signal, we must tell the Oscilloscope when to refresh the display.
- We accomplish this by setting a Triggering Level.



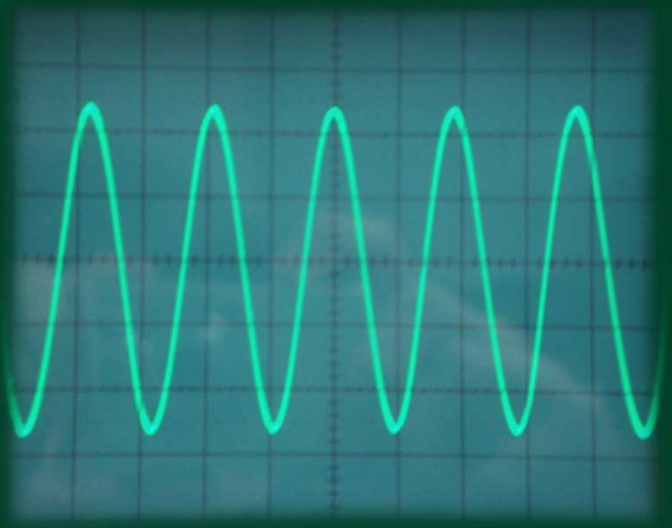
Without Triggering

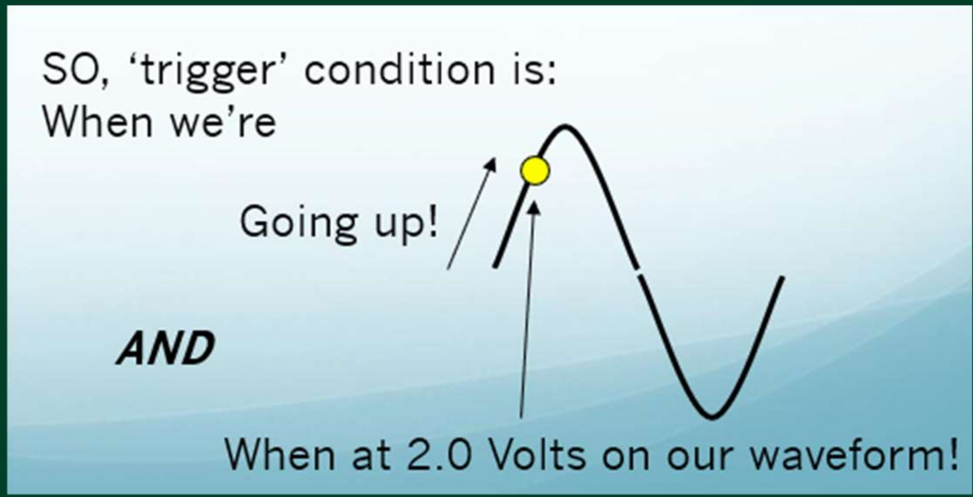


With Triggering

Triggering

- We want to tell the oscilloscope when it is the best time for it to "refresh" the display
- In our wave below, we tell the scope to "trigger" or 'capture' the signal when it is going upward AND hits 2.0Volts





Applications of CRO

- Study of Waveforms
- Measurement of Voltages
- Measurement of currents
- Measurement of frequency
- Measurement of phase difference

Measurement of frequency

- A Lissajours pattern is produced on the screen when two sine-wave voltages are applied simultaneously to both pairs of deflection plates.
- A stable pattern is obtained when the ratio of two frequencies is an integer, or a ratio of integers.
- The type of pattern depends upon this ratio.
- Lissajous patten for ratio of their frequencies 2:1 is shown in figure 14.25

Measurement of frequency

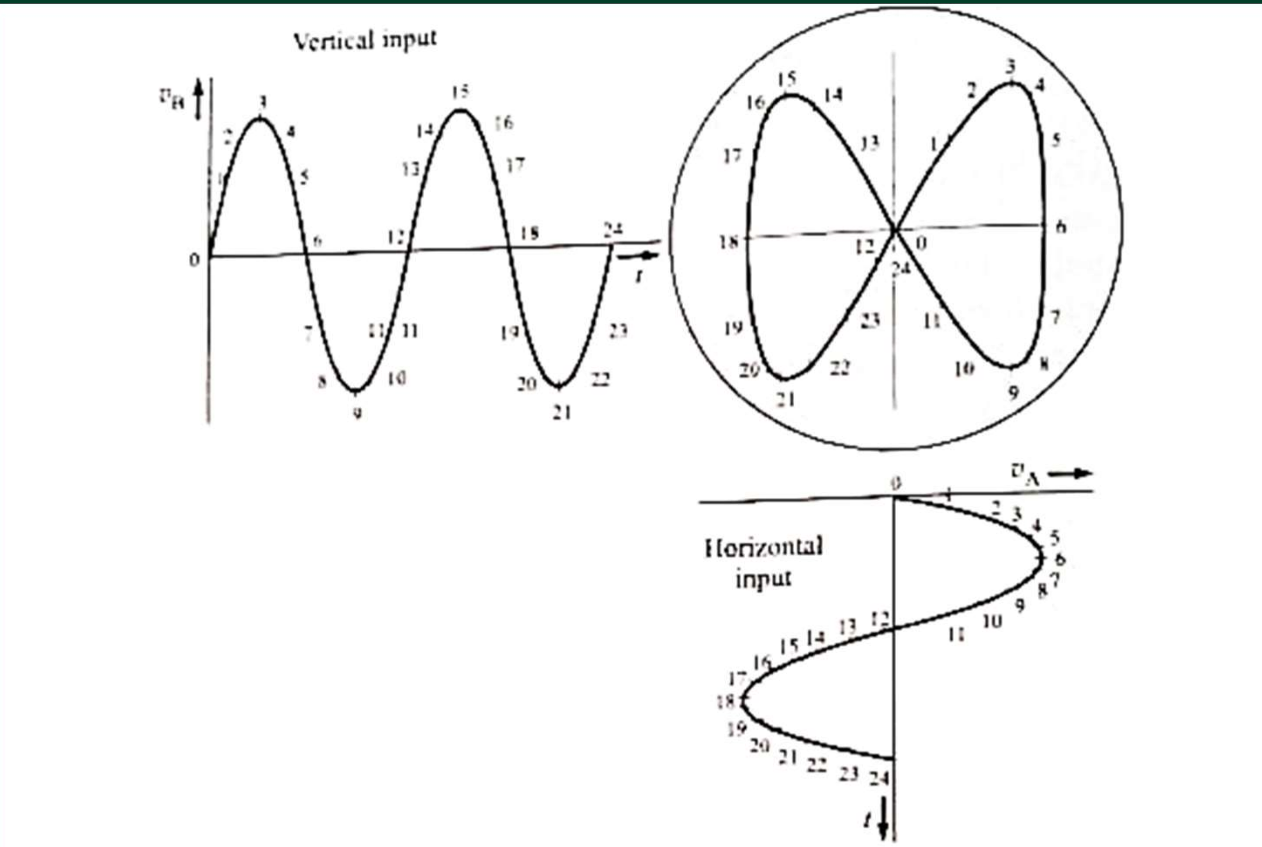


Fig. 14.25 *Graphical construction of Lissajous pattern, when the ratio of frequencies is 2 : 1*

Lissajous Pattern

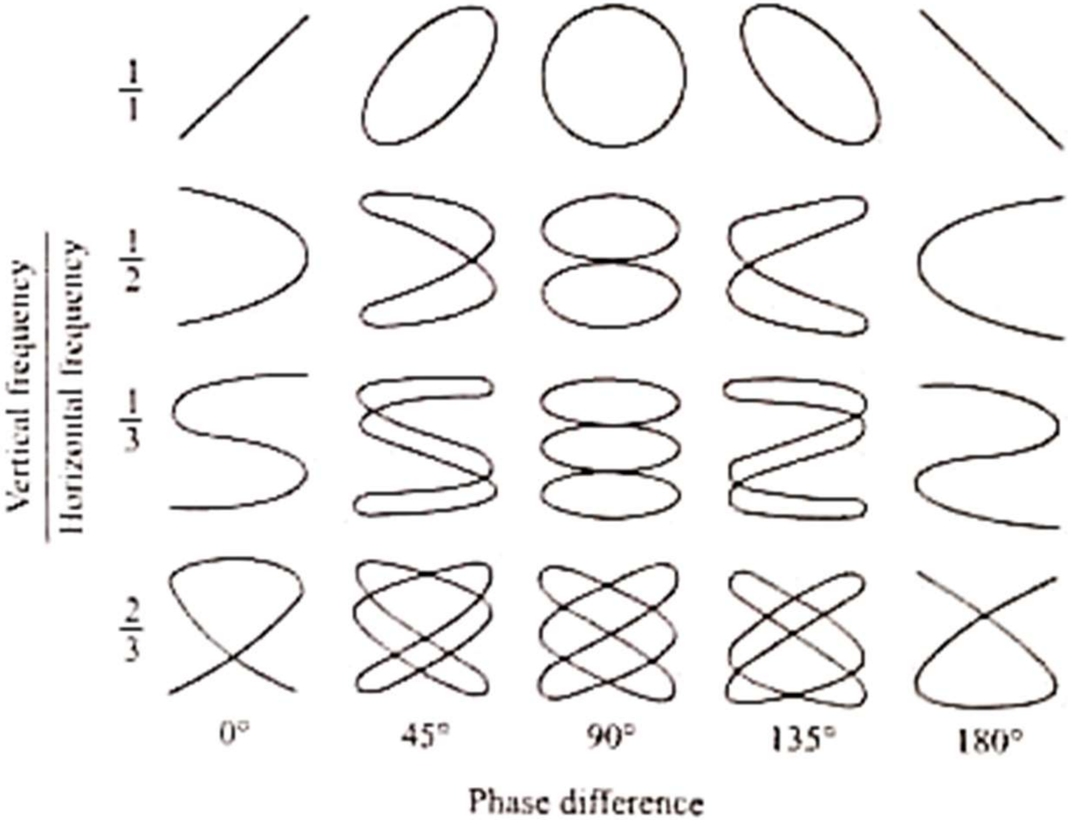


Fig. 14.26 *Lissajous pattern for different frequency ratios and phase differences*

Measurement of frequency

- To measure the frequency of a sinewave voltage, it is applied to one set of deflection plates.
- To the other set we apply a sine-wave voltage obtained from a standard variable-frequency oscillator.
- The frequency of this oscillator is varied till a suitable stationary pattern is obtained on the screen.
- Knowing this frequency, it is easy to determine the unknown frequency.

Cathode Ray Tube (CRT)

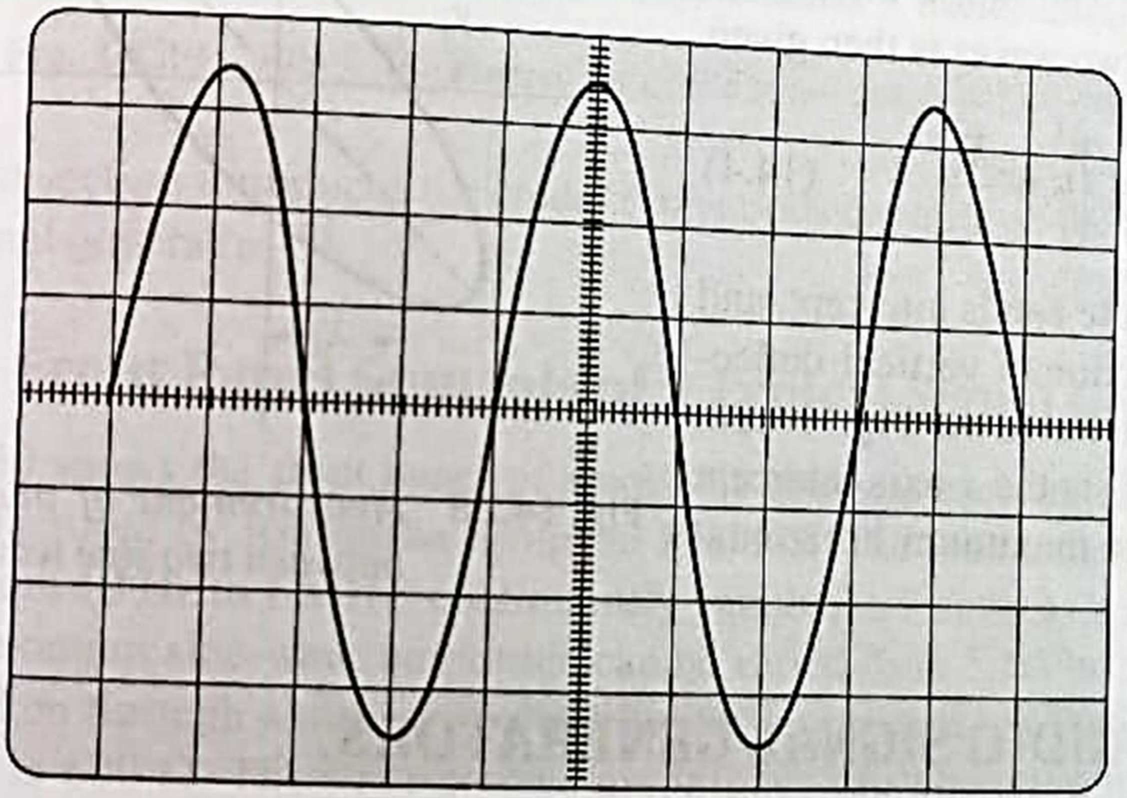


Fig. 14.27 *Display of a sine-wave voltage on a CRO*

Measurement of Phase Difference

Measurement of phase difference A CRO can be used to determine the phase difference between two sine-wave voltages (of the same frequency). The two voltages are applied to the two sets of deflection plates simultaneously. The resultant pattern on the screen is an ellipse. The phase difference between the two waves is then given by

$$\sin\theta = \frac{Y_1}{Y_2} = \frac{X_1}{X_2} \qquad (14.4)$$

where, Y_1 is the y-axis intercept, and Y_2 is the maximum vertical deflection, as illustrated in Fig. 14.28. (Similarly, X_1 is the x-axis intercept and X_2 is the maximum horizontal deflection.)

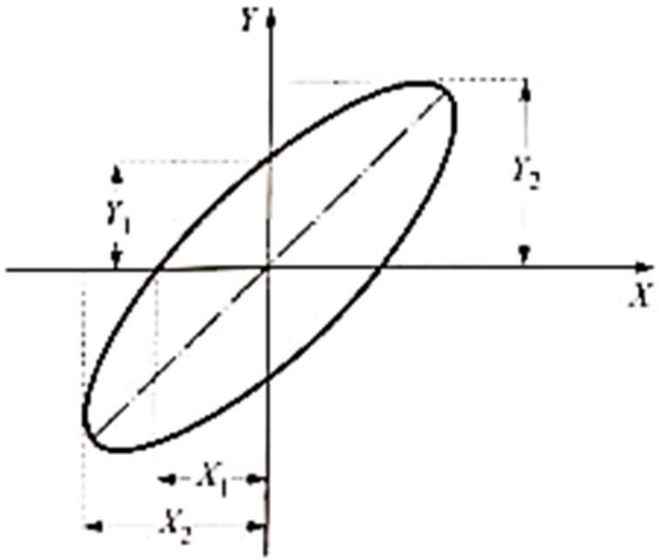


Fig. 14.28 *Measurement of phase difference between two sine waves*