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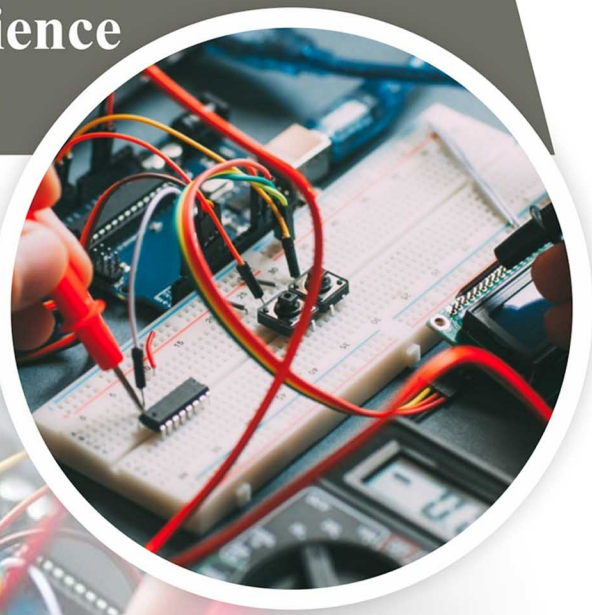

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Electronics (Paper - I)

Applied Electronics

(Code : C-2)

Std. XII (S.Y.J.C.) Science

BIFOCAL SCIENCE

Strictly As per HSC Board Syllabus of Higher Secondary Education

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Std. XII : Science (S.Y.J.C.)

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Preface

Dear Student,

We are extremely happy to present the book of "**Applied Electronics (Paper – I)**" for you. The topics within the chapters have been arranged in a proper sequence to ensure smooth flow of the subject.

Salient Features of the Book are as follows :

1. Selective Board Examination Questions till March 2023 have been fully solved in this edition.

2. Theory is accompanied with neat & clean figures.

3. MCQ's with explanation are also included at the end of each chapter. The latest trend in education is the teaching through multiple choice questions. The MCQ's are intended to enable students to prioritise and plan their learning through regular practice. The book contains large number of multiple choice questions on the subject.

4. Each chapter is divided into various sections and sub-sections. Entire syllabus is divided into Chapters, sections and headings. Each paragraph has been given a unique section/subsection number which is used to explain that particular section for the students as a cross reference to enable them to refer to the related paragraph.

5. Through this book, the author has made an effort to provide rationale for the solutions. The book, therefore, meets the expectations of the students as it answers the demand and the quest in their mind. It would give rise to real learning which would stand in good stead for the student's career and his life.

6. The book is user-friendly and provides information in a well structured manner. It provides comprehensive and critical study of the various concepts of the subject matter. It is felt that the contents should be crystal clear.

A word or suggestion from your side may help us add another feather to the cap of the subject matter of the book. The author looks forward to the comments, suggestions and criticism from the readers. Constructive suggestions and feedback from users would be highly appreciated, acknowledged and suitably incorporated.

We are thankful to team of Target Publications and Tech Neo Publications for the encouragement and support that they have extended to us.

- Authors

Syllabus

STD. XII - S.Y.J.C. (Science)

Electronics - Paper I : Applied Electronics

1. Electronic Instruments

Detailed study of CRT (Mathematical part not expected). How a CRO displays waveform, Block diagram of CRO, Front panel controls, Applications of CRO, Function Generator : Basic elements of function generator, Digital Multimeter : block diagram. **(Refer Chapter 1)**

2. Power Supply

Half wave rectifier, Full wave rectifier, Bridge Rectifier, Filter circuit, Load regulation, Line regulation, Zener as a voltage regulator, Basic principle of voltage regulation using transistor circuit, Three terminal regulator ICs, Basic principle of SMPS and its advantages. **(Refer Chapter 2)**

3. Transducers

Classification of transducers, Selection of transducers, Types of transducers, Working of following transuducer - Thermistor, LDR, Capacitive transducer, LVDT, Piezoelectric crystal, Loud Speaker, Gas sensor, Opto-coupler. **(Refer Chapter 3)**

4. Operational Amplifiers

Necessity of OP-AMP, Block diagram of OP-AMP, OP-AMP parameters, Linear applications of OP-AMP, Inverting and Non-Inverting Amplifiers, Buffer amplifier, Concept of virtual ground, Adder, Subtractor, Integrator and Differentiator circuits, Nonlinear applications : Comparator, Schmitt trigger.

(Refer Chapter 4)

5. Modern Electronic Communications

The elements of communication system, Types of electronic communication, Survey of communication applications, Electronic spectrum, Concept of bandwidth, AM principles, Modulation index and percentage of modulation, Sidebands and frequency domain, Frequency modulation (Principle), Phase modulation (Principle), Types of communication, Satellite, Satellite communication system, Application overview of Satellite communication, Concept of digital communication, Introduction to computer networks, Use of fiber optics in communication, Review of some modern communication applications : Cellular radio and Radar. **(Refer Chapter 5)**

6. Study of Integrated Circuits

Block diagram of timer, Pin functions and simple applications of following ICs 555, 741 and LM 317, Use of IC 555 as astable and monostable. **(Refer Chapter 6)**

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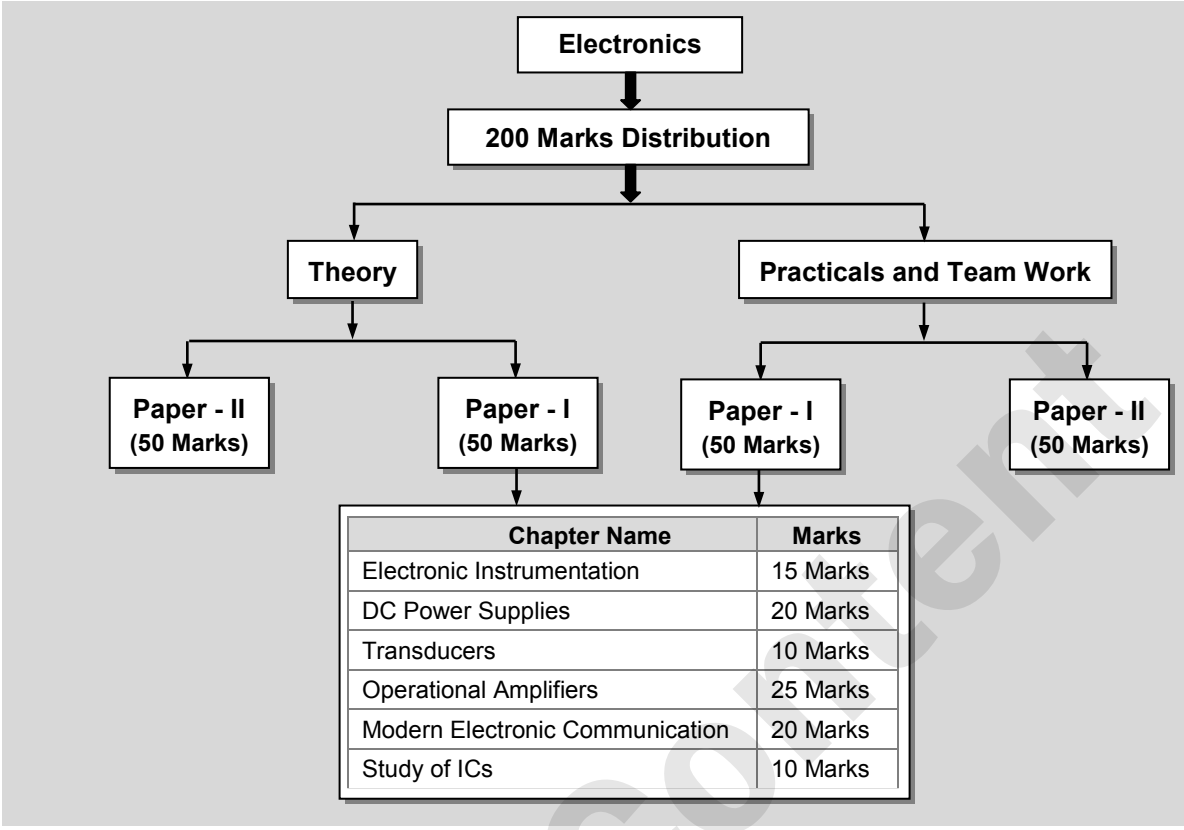

Chapter Name	Marks
Electronic Instrumentation	15 Marks
DC Power Supplies	20 Marks
Transducers	10 Marks
Operational Amplifiers	25 Marks
Modern Electronic Communication	20 Marks
Study of ICs	10 Marks

Question Paper Format

Each Question Paper will have Five Main Questions

Q. 1(A)	4 MCQs - 1 Mark each (Compulsory)	4 Marks
Q. 1(B)	**(a)** - 3 Marks **(b)** - 3 Marks **(c) -** 3 Marks *(Attempt any Two)*	6 Marks
Q. 2(A)	**(a)** - 3 Marks **(b)** - 3 Marks **(c)** - 3 Marks *(Attempt any Two)*	6 Marks
Q. 2(B)	**(a)** - 4 Marks **(b)** - 4 Marks *(Attempt any One)*	4 Marks
Q. 3(A)	**(a)** - 3 Marks **(b)** - 3 Marks **(c)** - 3 Marks *(Attempt any Two)*	6 Marks
Q. 3(B)	**(a)** - 4 Marks **(b)** - 4 Marks *(Attempt any One)*	4 Marks
Q. 4(A)	**(a)** - 3 Marks **(b)** - 3 Marks **(c)** - 3 Marks *(Attempt any Two)*	6 Marks
Q. 4(B)	**(a)** - 4 Marks **(b)** - 4 Marks *(Attempt any One)*	4 Marks
Q. 5	**(a)** - 5 Marks **(b)** - 5 Marks **(c)** - 5 Marks *(Attempt any Two)*	10 Marks
	OR	
Q. 5	**(a)** - 5 Marks **(b)** - 5 Marks **(c)** - 5 Marks *(Attempt any Two)*	10 Marks
	Total :	**50 Marks**

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CHAPTER

1

Electronic Instrumentation

1.1 INTRODUCTION TO CRO

i. The cathode ray oscilloscope (CRO) is probably the most versatile tools for the development of electronic circuit and system. The CRO allows the **amplitude of electrical signals**, whether they are voltage, current or power, to be displayed as a **function of time**.

ii. The CRO depends on the movement of an **electron beam**, which is bombarded on a screen coated with a fluorescent material, to produce a visible spot. The oscilloscope is basically an electron beam voltmeter. The heart of the oscilloscope is **CRT (Cathode Ray Tube)** which makes the applied signal visible by the deflection of a thin beam of electrons.

iii. The CRO basically operates on voltages, but it is possible to convert current, pressure, strain, acceleration and other physical quantities into the voltage using **transducer** and obtain their **visual representation** on the CRO.

iv. It is completely electronic in nature, the oscilloscope can reproduce **high frequency (HF) waves** which are too fast for electromechanical devices to follow. Thus the oscilloscope has simplified many tests and measurements. It can also be used in any field where a parameter can be converted into a proportional voltage for observation.

Example : Metrology, biology and medicine.

v. The oscilloscope is thus kind of voltmeter which uses beam instead of a pointer, and kind of recorder which uses an electron beam instead of a pen.

1.2 FRONT PANEL CONTROL OF CRO

Board Exam Questions

Q. State any four different front panel controls of CRO. Explain any two.

(March 09, 10, 11, 16, 18, Oct. 15, 3 Marks)

Q. Explain function of following front Panel Controls used in CRO.

i. Intensity ii. Level iii. INT/EXT

iv. Time/div v. Volt/div

(March 11, Oct. 15, 3 Marks)

The Three Systems

i. The front panel of an oscilloscope is divided into three sections labeled **Vertical, Horizontal, and Trigger**.

ii. When using an oscilloscope, you adjust settings in these areas to accommodate an incoming signal :

a. **Vertical :** This is for the attenuation or amplification of the signal. Use the volts/div control to adjust the amplitude of the signal to the desired measurement range.

b. **Horizontal :** This is the time base. Use the sec/div control to set the amount of time per division represented horizontally across the screen.

c. **Trigger :** This is the triggering of the oscilloscope. Use the trigger level to stabilize a repeating signal, or to trigger on a single event.

The function of front panel control available on CRO are described as follows :

i. ON-OFF switch : It is a power switch also known as toggle switch, which is used to on/off the CRO. With the switch an indicator like an LED or a neon light is also provided.

ii. Intensity : It control the magnitude of emission of electron beam i.e. brightness of screen. Internally it changes the negative grid bias on control grid. So the number of electrons coming from cathode to screen is controlled and indirectly brightness is controlled.

iii. Focus : The sharpness of light spot or the line displayed on the screen is controlled with the help of this knob. Internally it changes the positive bias on focusing anode. So the focus is adjusted exactly on the screen.

iv. Scale illumination : Most of the CROs used graticules in front of the CRT. The scale illumination control is used to illuminates the scale and hence the line on the scale can be seen easily.

v. Vertical position : It is marked as Y-position on the front panel. With this control, we can shift the waveform up or down on the screen. Internally, a variable dc bias voltage is connected to vertical deflection plates. Therefore, the position of beam can be adjusted on Y axis.

vi. Y input : This is main input of CRO. The signal to be observed on screen is applied to this input.

vii. **Volt/division :** It selects the Y scale known as **vertical deflection sensitivity**. Just like the graph paper it is used to adjust the scale for Y - axis with volt/division scale. Internally, an attenuator is connected to this control, so that the height of waveform on the screen is controlled.

viii. **Horizontal position :** It is marked as ' **X - position**' on the front panel. With this control, we can shift the waveform horizontally on the screen. Internally, a variable dc bias voltage is connected to horizontal deflection plates. So the position of beam can be adjusted on X axis.

ix. **Time/division :** The time required to move the electron beam from left to right of screen is adjusted by using this knob. Here also just like graph paper, it is used to adjust the scale for X - axis with **time/div scale**. Internally, the frequency of time base generator is controlled with the help of this knob. So that the waveform can be compressed or elongated on the screen along X - axis.

x. **Time base generator :** It produces a **sawtooth wave**. The waveform is used to sweep (move) the electron beam horizontally on the screen. The rate of rise of positive going edge of sawtooth waveform is controlled by time/division control knob. Thus, the sawtooth wave controls the horizontal deflection of electron beam along X - axis.

INT/EXT : A switch known as **INT/EXT** is also connected after the output of time base generator . When the switch is in INT position, the output of time base generator is connected to horizontal plates through horizontal amplifier. When it is in **EXT position,** internal sawtooth is cut-off and some external signal can be connected to horizontal plates.

xi. **Trigger circuit :** It takes the sample of input voltage connected at Y - input of CRO and feeds it to the input of time base generator. Therefore, the time base generator starts only when input signal is present at Y- input.

xii. **X - input :** It is second input terminal of CRO. When the output terminal switch of time base generator is in EXT position, the internal sawtooth is cut-off and external signal can be applied to the horizontal deflection plates through X - input .

xiii. **Delay line :** The delay line delays the striking of electron beam on the screen. It synchronizes the arrival of the beam on screen when time base generator signal starts sweeping the beam horizontally. The **propagation delay** produced is about **0.25 µs**.

1.3 BLOCK DIAGRAM OF CATHODE RAY OSCILLOSCOPE (CRO)

Board Exam Questions

Q. Draw block diagram of CRO and explain function of each block. **(March 11, 13, 17, 4 Marks, Oct. 07,11, 10, 13, 17, 3 Marks)**

Q. Draw block diagram of Cathode Ray Oscilloscope (CRO) and explain function of each block. **(Oct. 10, 4 Marks)**

Q. Why delay line is used in CRO? **(March 08, 13, 3 Marks)**

Q. Explain the function of Delay Line in CRO. **(March 09, 3 Marks)**

i. A Cathode Ray Oscilloscopes (CRO) is basically a very fast X Y plotter.

ii. 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.

iii. Cathode ray oscilloscope is a very useful and versatile laboratory instrument used for **display, measurement analysis** of waveforms and other phenomena in electrical and electronic circuits.

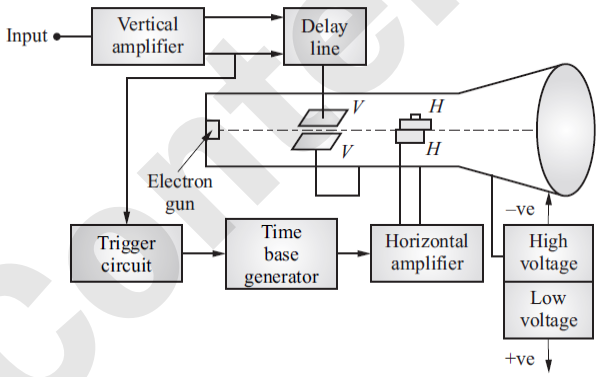


Fig. 1.3.1 : Block diagram of CRO

Parts of CRO	Functions
Cathode Ray Tube (CRT)	The CRT is used to emits the electron that strikes the phosphor screen internally to provide a visual display of signal.
Vertical amplifier	This is a wide band amplifier used to amplify signals in the vertical section.
Delay line	It is used to delay the signal for some time in the vertical sections.
Time base generator	It is used to generate the sawtooth voltage required to deflect the beam in the horizontal section.
Horizontal amplifier	This is used to amplify the sawtooth voltage before it is applied to horizontal deflection plates.
Trigger circuit	This is used to convert the incoming signal into trigger pulses so that the input signal and the sweep frequency can be synchronized.
Power supply	There are two power supplies, a **negative high voltage** supply and a **positive low voltage** supply. Two voltages are generated in the CRO. The positive voltages supply is from 300 volt to 400 volt. The negative high voltage supply is from **–1000 volt to –1500 volt.** This voltage is passed through a bleeder resistor at a few mA. The intermediate voltages are obtained from the bleeder resistor for intensity, focus and positioning control

Advantages of CRO

i. CRO is the only instrument that can give a visual display of the actual shape of the signal.

ii. It can be used to display and test signals of frequencies up to a few hundred MHz.

iii. It provides a graphical display of the amplitude of a signal as a function of time. Hence it is used to measured various electrical parameters.

iv. It can response very well to high frequency signals because it is completely an electronic device.

v. It can also be used to measure capacitance and inductance.

Applications of CRO

i. They are used to investigate waveforms, transient phenomena and other time varying quantities from a low frequency range to the radio frequencies.

ii. They can be used to measure ac as well as d.c. values of currents and voltage. It can calculate the peak-peak voltage, rms voltage, duty cycle of signal etc.

iii. It is used to observe B-H curves, P-V diagrams and other effects.

iv. In medical applications CRO is used to display cardiograms that are useful for diagrams of heart patient.

v. It can be used to study the response of various transducers that temperature, pressure, strain, humidity etc.

vi. CROs are useful to observe the radiation pattern generated by a transmitting antenna.

vii. CRO are useful in radio applications also. They are used to measure and trace the signal throughout RF, IF and AF channels of TV and radio receivers.

viii. It is used for giving visual representation of target e.g. ship, aeroplane etc in radars.

ix. It is used to measure inductance, capacitance.

x. It can be used to check diodes, transistors, FETs.

xi. It can be used to check faulty components in various circuits.

1.4 CATHODE RAY TUBE (CRT)

Board Exam Questions

Q. Draw a neat labeled diagram of Cathod Ray Tube and explain.

(March 07, 10, 12, 13,14, 15, Oct. 15, 17, 3 Marks)

Q. Draw labeled diagram of Cathode Ray Tube and explain function of each electrode.

(March 22, 3 Marks)

A cathode ray oscilloscope consists of a cathode ray tube (CRT), which is the heart of the tube, and some additional circuitry to operate the CRT. Constructional diagram of CRT :

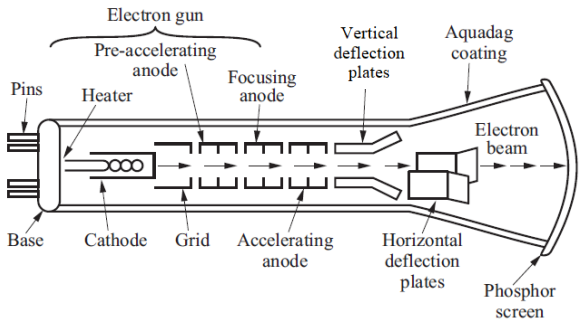


Fig. 1.4.1 : Internal structure of CRT

Cathode ray tube consists of following parts which are explained below :

i. Electron gun assembly:

a. In the electron gun of the CRT, electrons are emitted, converted into a sharp beam and focused upon the **fluorescent screen**. The electron beam consists of an indirectly **heated cathode, a control grid, an accelerating electrode and a focusing anode**.

b. The electrodes are connected to the base pins. The cathode emitting the electrons is surrounded by a **control grid** with a fine hole at its centre. The accelerated electron beam passes through the fine hole.

c. The negative voltage at the control grid controls the flow of electrons in the electron beam, and consequently, the brightness of the spot on the CRO screen is controlled.

ii. Deflection Plate Assembly:

a. There are four deflection plates made up of copper. Two plates are fitted vertical, known as horizontal deflection plates and other two plates are fitted horizontal, known as vertical deflection plates.

b. When the beam passes through four plates, it deflects towards positive plate and it is repelled from negative plate. The horizontal plates are connected to **sawtooth voltage** and the vertical plates are connected to the input signal.

iii. Fluorescent screen:

a. Phosphor is used as screen material on the inner surface of a CRT. Phosphor absorbs the energy of the incident electrons. The spot of light is produced on the screen where the electron beam hits.

b. The bombarding electrons striking the screen, release secondary emission electrons. These electrons are collected or trapped by an aqueous solution of graphite called "**Aquadag"** which is connected to the second anode.

c. Collection of the secondary electrons is necessary to keep the screen in a state of electrical equilibrium.

d. The type of phosphor used, determines the colour of the light spot. The brightest available **phosphor isotope, "P31"** produces yellow-green light with relative luminance of 99.99%.

iv. Glass envelope:

a. The whole assembly is protected in a conical highly evaluated glass housing through suitable supports. The inner walls of CRT between neck and screen are usually coated with a conducting material known as aquadag and this coating is electrically connected to the accelerating anode.

b. The coating is provided in order to accelerate the electron beam after passing between the deflecting plates and to collect the electrons produced by secondary emission when electron beam strikes the screen.

c. Thus, the coating prevents the formation of negative charge on the screen and state of equilibrium of screen is maintained.

d. Horizontal and vertical marks are marked on the screen of the CRT to provide user a correct measurement. These marks, usually in rectangular form, are called **graticules**.

v. Base:

The base is provided to CRT through which the connections are made to the various parts.

CRT Screen

Board Exam Questions

Q. Define following properties of CRT screen.
i. Fluorescence ii. Phosphorescence
iii. Persistence time
(March 10, Oct. 15, 3 Marks)

Q. Give function of screen in CRT and explain phosphorescence. **(March 13, 3 Marks)**

i. The front end of CRT acts as a fluorescent screen. This screen is about **100 mm × 100 mm**. An inner side of the screen is coated with phosphor. This consists of pure crystals of phosphor.

The CRT is a **display screen** which produces images in the form of the **video signal.** The CRT **generates** the beams, **accelerates** it at high velocity and **deflect** it for creating the images on the **phosphorous screen** so that the beam becomes **visible.**

ii. **Fluorescence :** A phosphor converts the electrical energy to light energy. When an electron beam strikes the phosphor crystals, their energy level is increased. This causes the phosphor crystals are excited and they emit light. This phenomenon is called as **fluorescence.**

iii. **Phosphorescence :** The light produced by the phosphor crystals on the screen does not immediately disappear when the electron beam is switched off. When the electron beam is switched off, the phosphor crystals will return to their initial state and they will release a quantum of the light energy. The time period for which the trace is visible is called as **persistence** or **phosphorescence**. The persistence can be a few microseconds or tens or seconds or even minutes.

iv. **Persistence time :** The other metals such as silver, manganese, copper and chromium are added to the phosphor material. These metals are called as **activaters**. They are used to change the properties of phosphor such as luminous efficiency, spectral emission and persistence. Before the end of decay time, a phosphor must be refreshed in order to obtain a flicker free display.

a. Short persistence phosphors are used for high speed applications. They require frequent refreshes.

b. Medium persistence phosphors are used for general purpose applications.

c. Long persistence phosphors are used for medical applications, radars, storage oscilloscopes. They result in characters fading slowly. They are prone to permanent discolourations and loss of luminous efficiency at high beam current.

Advantages and disadvantages of CRT

Advantages of CRT:

i. The cathode ray tube can easily increase the monitor's brightness by reflecting the light.

ii. They produce more colours.

iii. The CRT monitors have lower price rate than the LCD display or plasma display.

iv. The quality of the image displayed on a CRT is superior to the LCD and Plasma monitors.

v. The contrast features of the cathode ray tube monitor are considered highly excellent.

Disadvantages of CRT:

i. Monitors cause a health hazard to the functioning of living cells.

ii. CRTs emit a small amount of X-ray radiation which can result in a health hazard.

iii. Constant refreshing of CRT monitors can result a headache.

iv. CRTs operate at very high voltage which can overheat system or result in an implosion.

1.5 ELECTROSTATIC FOCUSSING

Board Exam Question

Q. Explain Electrostatic focusing. **(March 13, 4 Marks)**

Q. With the help of diagram, explain electrostatic focusing in CRT. **(March 22, 3 Marks)**

i. **Electrostatic focusing :** An electron at rest placed in an electric field produced force between two parallel plates. Force on the electron is,

$$\mathbf{F = – eE \text{ newton}}$$

where, E = electric field intensity in V/m and **e = charge of electron = 1.602×10^{-19} C**

[The minus sign indicates that the force acts in the opposite direction to that of the field.]

ii. Fig. 1.5.1(a) shows equipotential surfaces, indicated by solid lines. Since the force is in a direction opposite the field and the equipotential surfaces are perpendicular to the field, the force on an electron is in a direction normal to the equipotential surfaces.

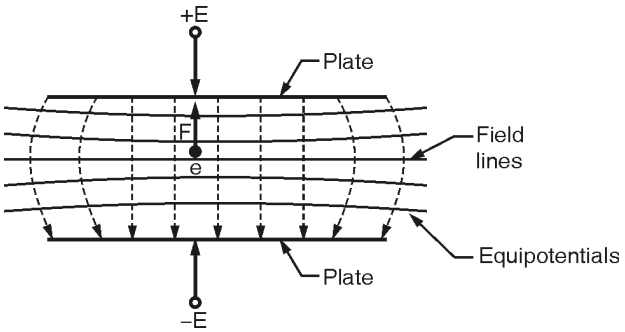


Fig. 1.5.1(a) : Electric field between parallel plates

iii. Fig.1.5.1(b) shows two concentric cylinders with a potential applied between them. Lateral repulsion again causes the spreading of the flux lines producing a field as shown. The equipotential surfaces are shown as solid lines. It is clear from the diagram that the equipotential surfaces formed here are curved.

iv. Let us consider the region on the two sides of an equipotential surface S as shown in Fig. 1.5.1(c). The potential on the left side of the surface is – V and on the right/side is + V.

Let an electron moving in a direction AB enter the area to the left of S. This electron experiences a force which is normal to the surface S and is thus accelerated.

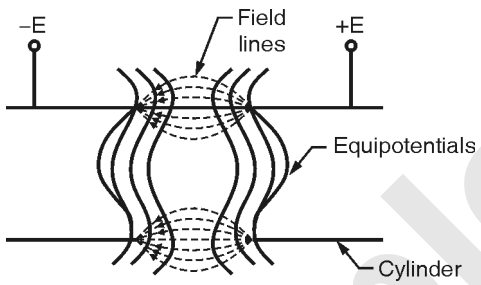


Fig. 1.5.1 (b)

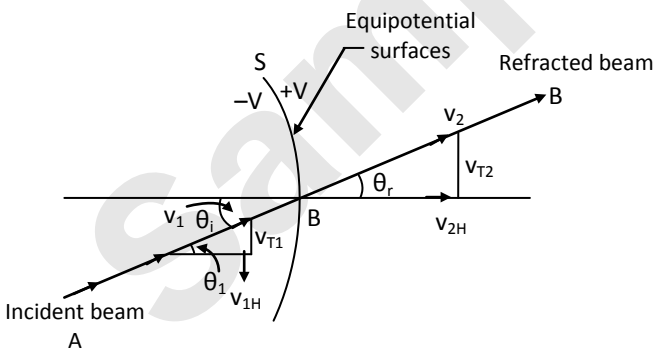


Fig. 1.5.1 (c)

v. Since the force acts in a direction normal to the surface, the normal components of velocity increases while the tangential component remains the same.

The tangential components are,

$v_{1T} = v_1 \sin\theta$, and $v_{2T} = v_2 \sin\theta$,

Now $v_{1T} = v_{2T} \Rightarrow v_1 \sin\theta_i = v_2 \sin\theta_r$

$$\therefore \quad \frac{\sin\theta_i}{\sin\theta_r} = \frac{v_2}{v_1}$$

Where, v_1 = Initial velocity of electrons

v_2 = Velocity of electrons after leaving surface S,

θ_I = Angle of incidence beam

θ_r = Angle of refraction beam

1.6 DEFLECTION SYSTEM OF CRT

Q. Explain deflection system of CRT.

i. Electrostatic deflection of an electron beam is used in a general purpose oscilloscope. The deflecting system consists of a pair of **horizontal and vertical deflecting plates**.

ii. Let us consider two parallel vertical deflecting plates P_1 and P_2. The beam is focused at point O on the screen in the absence of a deflecting plate voltage.

iii. If a positive voltage is applied to plate P_1 with respect to plate P_2, the negatively charged electrons are attracted towards the positive plate P_1, and these electrons will come to focus at point Y_1 on the fluorescent screen.

iv. The deflection is proportional to the deflecting voltage between the plates. If the polarity of the deflecting voltage is reversed, the spot appears at the point Y_2, as shown in Fig. 1.6.1(a).

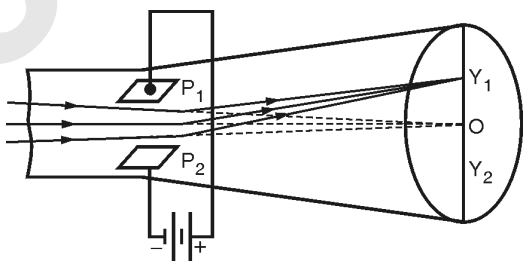


Fig. 1.6.1(a) : Deflecting system using parallel vertical plates

1.6.1 Display of Waveform in CRO

Board Exam Questions

Q. With diagram explain how Cathode Ray Oscilloscope (CRO) displays waveform.
(March 08, 14, Oct. 09, 14, 3 Marks)

Q. How CRO displays waveform ? Explain in brief.
(Oct. 12, 3 Marks)

Q. Explain how CRO displays sine wave form with the help of neat diagram.
(March-18, Oct. 16, 3 Marks)

i. Fig. 1.6.1(b) shows a sine wave applied to a vertical deflecting plates and a repetitive ramp or saw-tooth applied to the horizontal plates.

ii. The ramp waveform at the horizontal plates causes the electron beam to be deflected horizontally across the screen.

iii. If the waveforms are **perfectly synchronized** then the exact sine wave applied to the vertical display appears on the CRO display screen.

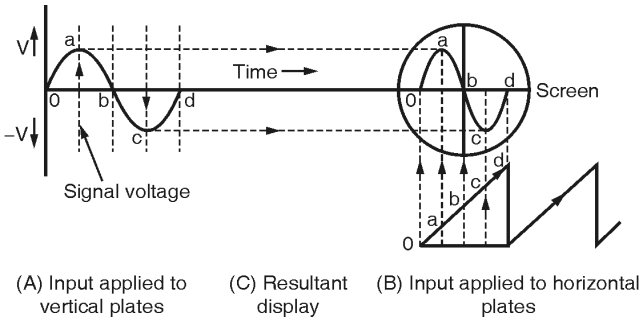


Fig. 1.6.1(b) : A typical display waveform on the screen

When the electron beam is accelerated it passes through the deflection system, with which beam can be positioned anywhere on the screen this deflection system can be explain as:

1.6.2 Electrostatic Deflection System

Board Exam Questions

Q. Explain the working principle of electrostatic system for CRT. **(Oct. 12, 13, 3 Marks)**

Q. Explain with suitable diagram Electrostatic Deflection system. Define deflection sensitivity of CRO. **(March 17, 4 Marks)**

i. It consists of four deflection plates or two pairs known as horizontal deflection plates and vertical deflection plates. The plates are made up of **aluminium or copper**.

ii. Two plates are fitted vertically, known as horizontal deflection plates and other two plates are fitted horizontally, known as vertical deflection plates. Each pair is maintained at different potential. So strong electrostatic field is produced between the plates.

iii. When the beam enters in this field, it is deflected towards the positive plate. So the path of beam become parabolic. Then the beam comes out of this field in straight line and strikes on the screen at particular point P on the screen shown in Fig.1.6.2(a).

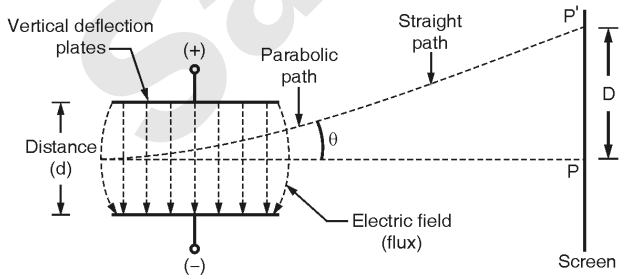


Fig. 1.6.2(a) Electrostatic deflection in CRT

The deflection sensitivity of a CRT is defined as the deflection of the screen (D) per unit deflection voltage (E_d).

$$\therefore \quad \textbf{Deflection sensitivity, } S = \frac{D}{E_d}$$

Applications:

i. It is used in CRO to deflect electron beam.

ii. It is used in Electro Cardio Graph machine (ECG) to plot the human heart beats.

iii. It is also used in earthquake monitors to display seismic activities.

1.6.3 Magnetic Deflection System

Board Exam Question

Q. Explain the working principle of electrostatic and magnetic deflection system for CRT. **(Oct. 12, 13, 3 Marks)**

i. It consists of two pairs of coils known as **yoke**. The yoke is fitted on the neck, outside the CRT. There are two pairs of coils horizontal deflection coils and vertical deflection coils.

ii. The vertical deflection coils are connected to input signal and the horizontal deflection coils are connected to sawtooth voltage. In this way the beam is deflected using magnetic force.

iii. The amount of deflection depends on ampere turns ratio of the coils. The magnetic deflection system is shown in fig.(1.6.3).

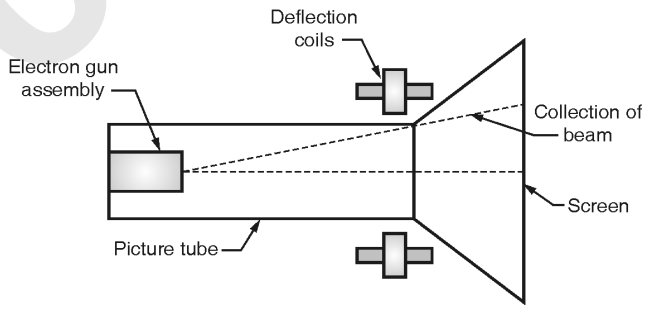


Fig. 1.6.3 : Magnetic deflection in CRT

iv. Magnetic deflection system is used, when the beam is deflected over very large distance like in the drawing mechanism of television.

Applications:

i. It is used in picture tube of a TV.

ii. It is used in visual display of RADAR systems.

iii. It is also used in visual display unit (VDU) monitors of computer.

1.6.4 Difference between Electrostatic Deflection and Magnetic Deflection

Board Exam Question

Q. Write comparison between Electrostatic and Electromagnetic deflection systems used in CRT. (Any three). **(March 15, 3 Marks)**

Sr. No.	Electrostatic deflection	Magnetic deflection
i.	The electrostatic deflection **needs little power** for deflection.	The magnetic deflection requires a **large power** to be consumed in the electromagnet.
ii.	It can be employed at **higher frequencies** than magnetic deflection.	It can be employed at **lower frequency** than electrostatic deflection.
iii.	The deflection sensitivity **falls rapidly** with increasing anode voltage.	The deflection sensitivity **falls slowly** with increasing anode voltage than electrostatic deflection.
iv.	The distortion and the enlargement of the spot on the screen with increasing angle of **deflection is larger.**	The distortion and the enlargement of the spot on the screen with increasing angle of **deflection is smaller** than electrostatic deflection.

1.7 HORIZONTAL AMPLIFIER USED IN CRO

Q. Explain the operation of horizontal amplifier used in CRO with suitable block diagram.

Horizontal amplifier

There are two purposes of application of horizontal amplifier that can be listed as follows :

i. Taking the case when the oscilloscope is being used in ordinary mode of operation for the purpose of displaying applied input signal then horizontal amplifier will perform amplification of sweep generator output.

ii. On the other hand when it is being used in X-Y mode the signal which is applied to horizontal input terminal will get amplified by horizontal amplifier. Out of both of the case when oscilloscope is taken under use in ordinary mode then gain and bandwidth that are required for horizontal amplifier are not as stringent as that for vertical amplifier. As low amplitude and high frequency output should be obtained from vertical amplifier. And that even having fast rising time, in that case requires from horizontal amplifier is to provide only reliable production of sweep signal that also come-up with relatively high amplitude and slow rising time.

iii. A push pull amplifier is applied in case of vertical amplifier, horizontal amplifier also contains a push pull amplifier. This arrangement can also be seen from the circuit diagram shown in Fig. 1.7.1.,

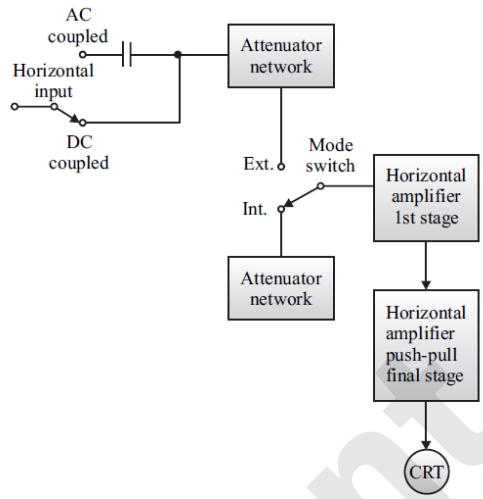


Fig. 1.7.1 : Block diagram of the horizontal amplifier of an oscilloscope

1.8 VERTICAL AMPLIFIER USED IN CRO

Q. Explain the operation of vertical amplifier used in CRO with the help of a block diagram.

Vertical amplifier:

i. The sensitivity (gain) and frequency bandwidth response characteristics of the oscilloscope are mainly determined by the vertical amplifier.

ii. Since the gain-bandwidth product is constant, to obtain a greater sensitivity the bandwidth is narrowed, or vice-versa.

iii. Some oscilloscopes give two alternatives, switching to a wide bandwidth position, and switching to a high sensitivity position.

Operational Block Diagram of Vertical Amplifier

The block diagram of a vertical amplifier is shown in Fig. 1.8.1.

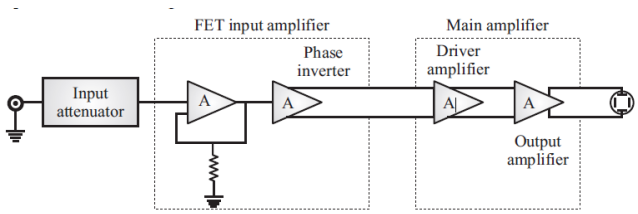


Fig. 1.8.1 : Vertical amplifier

The vertical amplifier consists of several stages with fixed overall sensitivity or gain expressed in V/division.

i. The advantage of fixed gain is that the amplifier can be more easily designed to meet the requirements of stability and bandwidth.

ii. The vertical amplifier is kept within its signal handling capability by proper selection of the input attenuator switch.

iii. The first element of the pre-amplifier is the input stage, often consisting of a FET source follower whose high input impedance isolates the amplifier from the attenuator. This FET input stage is followed by a BJT emitter follower, to match the medium impedance of FET output with the low impedance input of the phase inverter.

iv. This phase inverter provides two anti-phase output signals which are required to operate the push-pull output amplifier. The push-pull output stage delivers equal signal voltages of opposite polarity to the vertical plates of CRT.

v. The advantage of operation in CRO are similar to those obtained from push-pull operation in other applications, better hum voltage cancellation from the source or power supply (i.e. dc), even harmonic suppression, especially the large 2^{nd} harmonic is cancelled out, and greater power output per tube as a result of even harmonic cancellation. In addition, a number of defocusing and non-linear effects are reduced, because neither plate is at ground potential.

1.9 FUNCTION OF BLANKING CIRCUIT

i. The saw tooth sweep voltage applied to the X plates moves the beam across the CRT tube in a straight horizontal line from left to right during the sweep time.

ii. A comparatively slow movement of the spot will appear as a solid line provided the rate of movement exceeds the threshold of persistence of vision. Below the threshold limit a moving spot is a perceived.

iii. On the other hand, a fast movement of the spot will appear as a thin and dim line or may be invisible if the retrace time is very small.

iv. Ideally the retrace time is zero, hence the spot while moving from right to left remains invisible. Practically the retrace time is not zero. Hence, the retrace should be blanked out.

v. The retrace is blanked out by applying a high negative voltage to the grid during retrace period.

vi. The blanking voltage is developed by the sweep generator.

1.10 TIME BASE CIRCUIT

Board Exam Questions

Q. Why time base is required in CRO ? Explain with neat diagram working of time base circuit ? **(March 07, 3 Marks)**

Q. What is a time-base signal ? Explain its necessity in a CRO. **(Oct. 07, 3 Marks)**

Q. Explain the working of time base Generator using UJT. Draw the waveform and state the equation of its frequency. **(March 15, Oct. 08, 3 Marks)**

Q. Explain with neat circuit diagram the function of Time Base Generator used in CRO. **(March 10, Oct. 11, 3 Marks)**

Q. Explain working of Time Base Generator using Unijuction Transistor. **(Oct. 10, 13, 17, 3 Marks)**

Q. Explain Time Base Generator with circuit diagram.

Necessity of Time Base in CRO

i. Sweep or time base generator is used to generate sawtooth voltage, required to deflect the beam in horizontal section.

OR

A linear time base voltage is required on the deflection plates of cathode ray oscilloscope, to sweep the electron beam, from left to right across the screen.

ii. Principle of Operation : Oscilloscopes are generally used to display a waveform that varies as a function of time. If the waveform is to be accurately reproduced, the beam must have a constant horizontal velocity. Since the beam velocity is a function of the deflecting voltage, the deflecting voltage must increase linearly with time. A voltage with this characteristic is called a **ramp voltage**. If the voltage decreases rapidly to zero with the waveform repeatedly reproduced as shown in Fig. 1.10.1(a), the pattern is generally called a **sawtooth waveform.**

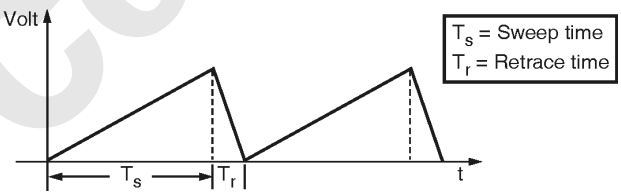


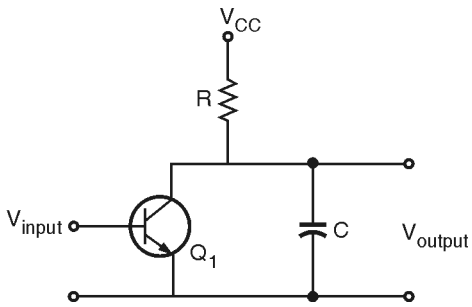
Fig. 1.10.1(a) : Sawtooth waveform applied to horizontal deflection plates

iii. During the sweep time, the beam moves from left to right across the CRT screen. The beam is deflected to the right by the increasing amplitude of the ramp voltage and the fact that the positive voltage attracts the negative electrons.

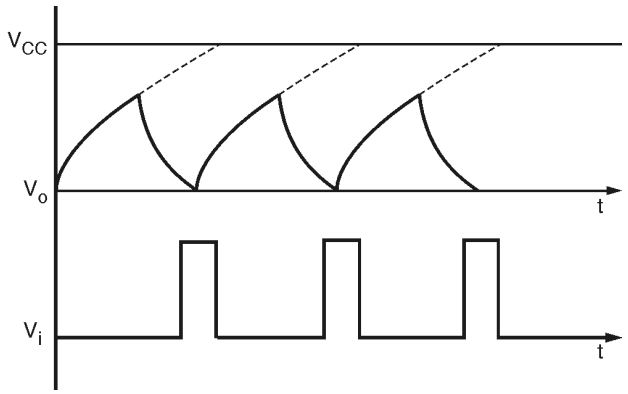
iv. During the retrace time or flyback time, the beam returns quickly to the left side of the screen.

v. Operation : The circuit shown in Fig. 1.10.1 (b) is a simple sweep circuit in which the capacitor C charges through the resistor R.

The capacitor discharges periodically through the transistor Q which causes the waveform shown in Fig. 1.10.1(c) to appear across the capacitor.



(b)



(c)

Fig. 1.10.1

vi. The signal, $_{input}V$, which must be applied to the base of the transistor to turn it "**ON**" for short time intervals shown in Fig. 1.10.1(c). When the transistor is turned completely "ON" it presents a low-resistance discharge path through which the capacitor discharges quickly.

vii. If the transistor is not turned "ON" the capacitor will charge exponentially to the supply voltage V_{CC} according to the equation.

1.11 MEASUREMENT USING CRO

Board Exam Questions

Q. Explain the following measurement using a CRO :
i. Voltage and current measurement
ii. Period and frequency measurement
iii. Measurement of phase difference
(Oct. 01, 3 Marks)

Q. Explain with suitable diagram, how CRO can be used to measure RMS value of unknown AC voltage.
(Oct. 14, 3 Marks)

Q. Explain the use of CRO to measure Amplitudes and frequency of sine wave A.C. signal.
(Oct. 16, 4 Marks)

Q. Explain use of CRO in measurement of AC voltage and frequency. **(Oct. 09, 12, 13, 4 Marks)**

Q. Explain use of CRO to measure frequency by using (i) Internal Time Base (ii) Lissajous figures
(March 15, 3 Marks)

Q. Explain the use of CRO to measure Amplitude and frequency of sine wave A.C. single.
(Oct. 16, 4 Marks)

Q. With the help of Lissajous figure explain the use of Cathod Ray Oscilloscope (CRO) to measure frequency.
(March 16, Oct. 11, 3 Marks, 4 Marks)

Q. Explain the use of CRO for frequency measurement and phase measurement using lissajous figures. **(March 23, 3 Marks)**

The following measurements are possible by using CRO:

(I) Measurement of Voltage and Currents

Board Exam Question

Q. Explain the use of CRO for the measurement of AC and DC voltages. **(March 22, 3 Marks)**

Measurement of Voltage:

i. CROs are voltage-dependent instruments and can be used for the measurement of voltages at any frequency within the range of the operation of the CRO.

ii. To measure voltages, the input voltage is applied on the vertical deflection plates and appropriate sweep to the horizontal deflection plates.

iii. The amplitude trace of the wave form is then observed on the screen. The amplitude attenuator is then adjusted such that the signal is displayed comfortably on the screen.

iv. The position of the attenuator knob gives the volts/cm position and thus the voltage of the input signal can be measured by multiplying this position value with the number of centimetres the signal is occupying in the vertical direction. Either ac or dc voltages can be measured.

v. The dc voltages are displayed as horizontal straight line whereas the exact waveform is displayed for that of ac signal. From the peak value of the ac signal, the RMS and other parameters can be determined. Not only can perfect sinusoidal waveforms be measured, but since the wave form is displayed, the amount of distortion and other parameters of interest can also be determined.

Measurement of Current:

i. Current cannot be directly measured with a CRO. To measure the current, a known resistance is taken and the potential drop across the resistance is determined with the help of measurement of potential at both ends of the resistor.

ii. This voltage difference divided by the considered resistance value gives the amount of current flowing in the device.

(II) Measurement of period and frequency

Frequency is measured by CRO using following method :

i. Direct method : A signal frequency is determined by measuring its time period T and calculating the frequency by $f = \frac{1}{T}$

The input waveform is fed into the vertical input, with vertical sensitivity sweep speed and triggering controls are adjusted for at least one complete stable cycle of waveform.

The number of horizontal divisions for a complete cycle is determined and time period is found by,

T = (Number of horizontal divisions in one cycle) (Sweep speed in s/division)

ii. Lissajous method:

Board Exam Questions

Q. Explain use of CRO for frequency measurement. **(March 07, 11, Oct. 09, 3 Marks)**

Q. With the help of Lissajous figure explain the use of Cathod Ray Oscilloscope (CRO) to measure phase. **(March 16, Oct. 11, 4 Marks)**

Frequency of a signal can be accurately measured by Lissajous patterns. The signal of unknown frequency is applied to Y plates. The signal of known frequency is applied to X plates. Depending on the frequency, ratio patterns are obtained.

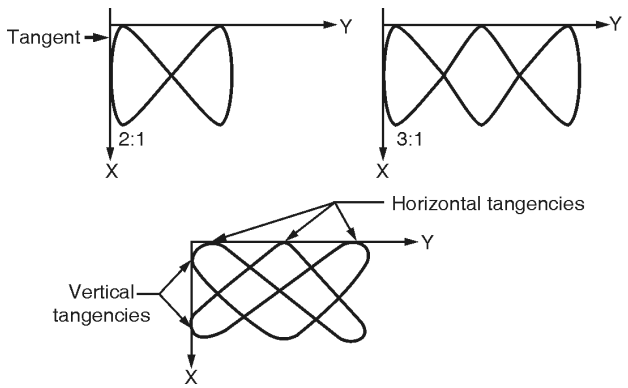


Fig. 1.11.1

For all the cases of patterns obtained the ratio of the two frequencies is,

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

where, f_y = Frequency of signal applied to Y - plates

f_x = Frequency of signal applied to X - plates

For open Lissajous patterns, free end is treated as 1/2 tangency.

iii. Measurement of phase difference by Lissajous Figures

Board Exam Questions

Q. Explain use of CRO for phase measurement. **(March 07, 11, Oct. 09, 3 Marks)**

Q. Explain use of CRO to measure phase difference between two signals. **(March 12, 3 Marks)**

i. The phase measurement can be done by a method called Lissajous figures. In this method two sine waves of the same frequency are applied to the CRO. (one to vertical and one to horizontal deflection plates)

ii. The CRO is set to operate in the X – Y mode. Then the display obtained on the screen of CRO is called **Lissajous pattern**.

Depending on the phase shift between the two signals, the shape of the Lissajous pattern will go on changing.

iii. The Lissajous pattern will be an ellipse if the sine waves of equal frequency but phase shift θ between 0° and 90° are applied to the two channels of CRO. The Lissajous pattern will then be as shown in Fig. 1.11.2.

The phase shift is given by,

$$\theta = \sin^{-1}\left(\frac{A}{B}\right)$$

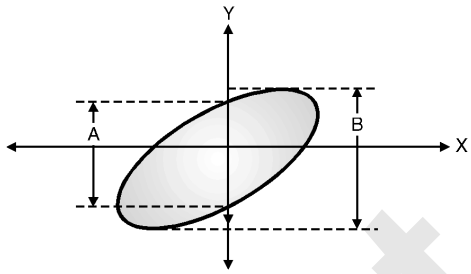


Fig. 1.11.2 : Lissajous pattern for ellipse for $0 < \theta < 90°$

iv. For the phase difference above 90° and less than 180°, the ellipse appears as shown in Fig. 1.11.3. The phase shift is,

$$\theta = 180° - \sin^{-1}\left(\frac{A}{B}\right)$$

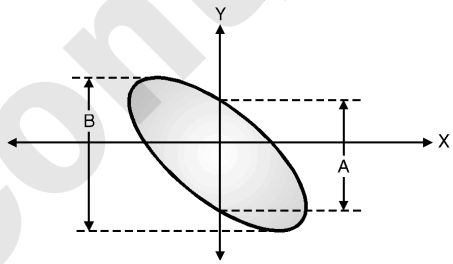


Fig. 1.11.3 : Lissajous pattern for ellipse for $90° < \theta < 180°$

v. If the two sine waves are of same frequency are in phase, then the Lissajous pattern will be a diagonal line making an angle of 45° with the X axis. Fig. 1.11.4 illustrates this.

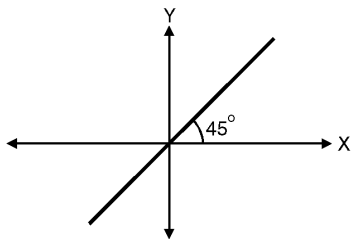


Fig. 1.11.4 : Lissajous pattern for $\theta = 0°$

vi. If the phase angle θ = 90°, frequency is identical and amplitudes are equal of the two input sinusoidal signals, the Lissajous pattern will be a circle.

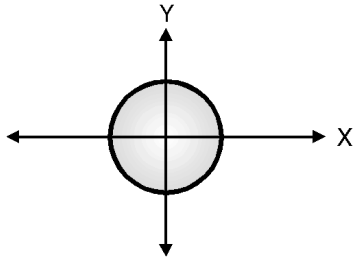


Fig. 1.11.5 : Lissajous pattern for $\theta = 90°$

vii. If the two input signals are of same frequency but are 180° out of phase then we get a straight line at an angle of 135° with the X-axis.

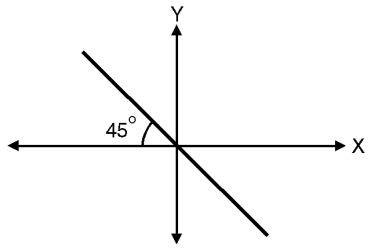


Fig. 1.11.6 : Lissajous pattern for θ = 180°

Examples from Board Question Papers

Important formulae for CRO:

1. Frequency: $f = \frac{1}{T}$

2. RMS voltage: $V_{rms} = \sqrt{2}\ V_p$,
where V_p is peak to peak voltage.

3. Deflection sensitivity: $S = \frac{D}{E_d}$

Example 1 (July 16, 3 Marks)

A CRO with calibrated time base is used to display a sine wave voltage. For convenient size of the display, the vertical amplifier attenuator is at 2 V/div and the time base control is set at 0.1 ms/div. The peak to peak height of sine wave is 7 divisions and horizontal displacement of one cycle is 4 div. Find the magnitude and frequency of the sine wave.

☑ Soln. :

Given: Vertical amplifier attenuator reading 2 V/div, time base reading 0.1 ms/div, Peak to peak height = 7 div

To find: i. Magnitude of sine wave
ii. Frequency

Calculation:

i. V_{pp} = VOLT/ DIV × No. of Div.
= 2 V/ Div. × 7 Div. = 14 V

$V_p = \frac{V_{pp}}{2} = \frac{14}{2} = 7$ V

$V_{rms} = 0.707 \times V_p = 0.707 \times 7 = 4.949$ V

Magnitude of sine wave = 4.949 V.

ii. Time period = TIME/DIV. × No. of horizontal div

T = 0.1 md/div × 4 div. = 0.4 ms

Frequency = $\frac{1}{T} = \frac{1}{0.4 \times 10^{-3}} = 0.25 \times 10^4$ Hz = 2.5 kHz.

Example 2 (March 18, 3 Marks)

The spot of a CRO is shifted by 4 cm when 10 volt dc is applied to its vertical input. Find maximum displacement of spot when 8 V ac is applied.

☑ Soln. :

Given: For 10 V dc (peak value), the displacement is 4 cm.

To find: Maximum displacement

Calculation: The peak value of 8 V_{ac} = 8 × 1.141 = 11.312 V

Hence displacement = $\frac{11.312 \times 4}{10} = 4.5248$ cm

Peak to peak (maximum) displacement
= 2 × 4.5248
= 9.0496 cm

Example 3 (July 18, 3 Marks)

A CRO has a deflection sensitivity 1 mm/V. Find the maximum vertical displacement of bright spot on the screen, when AC 10 V is applied between vertical plates.

☑ Soln. :

Given: Sensitivity = 1 mm/V, Input ac voltage = 10 V_{rms}

To find: Maximum displacement

Calculation: $V_p = \frac{V_{rms}}{0.707} = \frac{10}{0.707} = 14.14$ V

$V_{pp} = 2\ V_p = 2 \times 14.14 = 28.28$ V

Displacement = Deflection sensitivity
× Applied voltage
= 1 × 28.28 = 28.28 mm
= 2.828 cm

1.12 FUNCTION GENERATOR

Q. Explain the working of function generator with operational block diagram.

OR

Describe the circuit of function generator which generates square, triangular and sine wave shape.

Board Exam Questions

Q. Explain with neat block diagram the working of function generator. **(March 23, 4 Marks)**

A function generator is more versatile instrument than the sine-and square-wave generator. Most laboratories use function generators rather than a simple **sine-and square-wave generator**. A function generator in general is used to generate sine waves, square wave's triangular waves, and sweep waves. These wave forms are useful for variety of applications in a lab.

Functional Block Diagram of function Generator

The functional block diagram of a function generator is shown in below. In this circuit the Wien bridge oscillator is replaced by two constant current source driving an integrator. The top constant-current source is used to charge the integrator capacitor at a uniform rate, and this produces a positive going ramp.

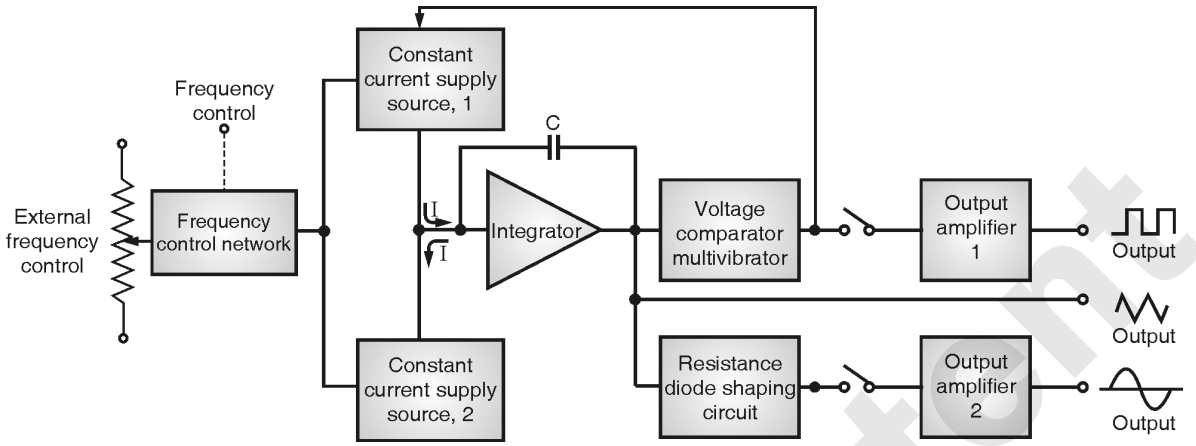


Fig. 1.12.1(a) : Block diagram of a typical function generator

The capacitor after reacting a finite value, will discharge through the second constant current source, and a negative going ramp results in the two actions will produce a triangular wave, as shown in Fig. 1.12.1(b).

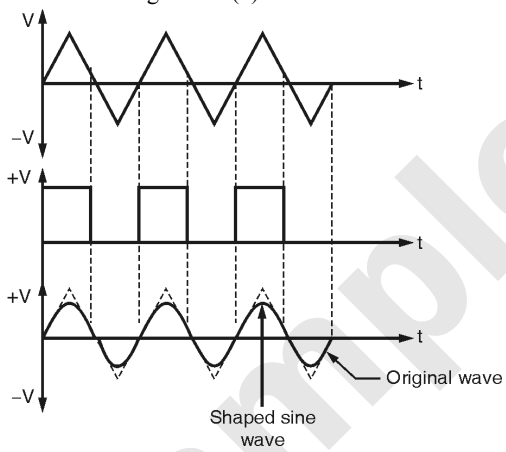


Fig. 1.12.1(b) : Triangular, square, and shaped waves

Operation:

i. The frequency controlled voltage is used to regulate two current sources namely upper current source and lower current source. The upper current source supplies constant current to an integrator.

ii. The output voltage of integrator then increases linearly with time. If the current, charging the capacitor increases or decreases, the slope of output voltage increases or decreases respectively. Hence this controls **frequency**.

iii. The voltage comparator multivibrator circuit changes the state of the network when the output voltage of integrator equals the maximum predetermined upper level. Because of this change in state, the upper current source is removed and the lower current source is switched ON. This lower current source supplies opposite current to the integrator circuit.

iv. The output of integrator decreases linearly with time. When this output voltage equals maximum predetermined upper level on negative side, the voltage comparator multivibrator again changes the condition of the network by switching OFF the lower current source and switching ON the upper current source.

v. The output voltage of the integrator has triangular waveform. The frequency of this triangular waveform is determined by the magnitudes of the currents supplied by upper current source and lower current source.

vi. To get square wave, the output of the integrator is passed through comparator. The voltage comparator delivers square wave output voltage of same frequency as that of input triangular waveform.

vii. The sine wave is derived from triangular wave. The triangular wave is synthesized into sine wave using diode resistance network. In this shaper circuit, the **slope of triangular wave is changed as its amplitude changes**.

viii. This results in a sine wave with less than 1% distortion. The two output amplifiers provide two simultaneous, individually selected outputs of any of the waveform functions.

ix. The function of a signal generators is to supply signals of known amplitude and known frequency. The signal generators are used to supply signal levels at very low levels for the testing of receivers. But it is very difficult to measure and calibrate a signal at a very low level. Thus attenuators are used in function generators. It is a device which reduces power level of a signal by fixed amount.

Additional Information

Function generators are available in the open market with 1 MHz, 3 MHz or 10 MHz maximum output frequency and 20 V peak to peak continuous variability.

Advantages and disadvantages of Function Generator

The advantages of Function Generator:

i. Different waveforms of higher frequency can be generated.
ii. It can be generate different waves like, sine wave, triangular wave, square wave, sawtooth wave etc.
iii. External calibration is not required.

The Disadvantage of Function Generator:

Function generator is not suitable for applications that need low distortion signals.

1.13 DIGITAL MULTIMETER

The digital multimeter is an instrument capable of measuring dc voltage, ac voltage, dc current, ac current, resistance, conductance and decibels. Thus DMM offers increased versatility.

Advantages of DMM

Board Exam Questions

Q. What are the advantages of Digital Multimeter over Analog Multimeter ? **(Oct. 10, 3 Marks)**

Q. State advantages of DMM Over Analog Multimeter. (Any three) **(March 17, 3 Marks)**

i. They have **high input impedance**. So there is no loading effect.
ii. They are having **higher accuracy**.
iii. An **unambiguous** reading is obtained.
iv. The output can be interfaced with external equipment.
v. They are available in smaller sizes.

Comparison of Analog Multimeters and Digital Multimeters

Board Exam Question

Q. What are the advantages of DMM over analog multimeter? **(March 22, March 23, 3 Marks)**

Sr. No.	Analog multimeters	Digital multimeters
1.	Power supply is not required.	Power supply is required.
2.	Better visual indication of changes in the reading is obtained.	Visual indication of changes in the reading is not that much better.
3.	Less suffered from electric noise.	More suffered from electric noise.
4.	Less isolation problems.	More isolation problems.
5.	Accuracy is less.	High accuracy is obtained.
6.	The output cannot be interfaced with external equipment.	The output can be interfaced with external equipment.
7.	Construction is simple.	Construction is complicate.
8.	Bigger in size.	Smaller in size.
9.	Many times output is ambiguous.	An unambiguous reading is obtained.
10.	Less expensive.	More expensive.

Basic Digital Multimeters

Board Exam Questions

Q. Draw the block diagram of DMM and explain the function of each block. **(March 07, 09, 15, 18, Oct. 12, 3 Marks)**

Q. Draw the functional block diagram of DMM and explain its working. **(March 12, Oct. 07, 08, 09, 14, 16, 4 Marks)**

Q. Draw and explain block diagram of DMM. **(March 16, 18, 4 Marks)**

Q. Explain working of current voltage converter circuit used in DMM. **(March 08, 3 Marks)**

Q. Draw block diagram of Digital Multimeter and describe each block in brief. **(March 23, 4 Marks)**

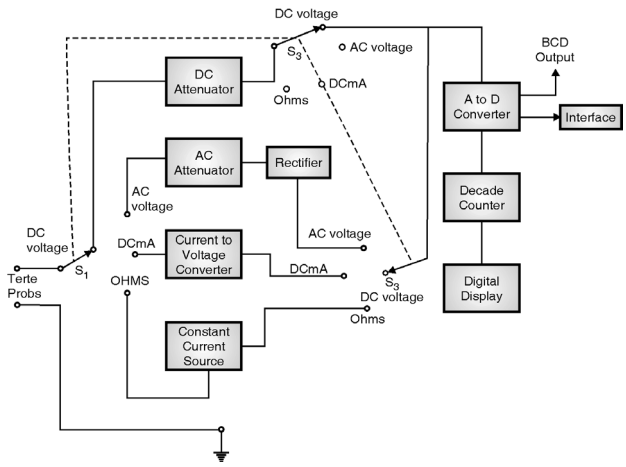


Fig. 1.13.1 : Block diagram of basic DMM

i. All digital multimeters make use of some type of **analog to digital converter (ADC)**. Generally dual slope integration type AD is used for this purpose. The block diagram of basic digital multimeter is as shown in Fig. 1.13.1.
ii. A commercial digital multimeter consists of several A to D converters, decade counters and display. It is basically dc voltmeter. In order to measure unknown current; current to voltage converter is used. This circuit is as shown in Fig. 1.13.2.

iii. An unknown current to be measured is applied to one of the input terminals of op-amp. Let this input is I_{in}.

Since an input impedance of op-amp is very high; very small current can pass through it. This current passing into the op-amp can be neglected.

Thus $\mathbf{I_{in} = I_{fb}}$

Here $\mathbf{I_{fb}}$ **= Feedback current.**

iv. This feedback current is allowed to pass through one of the known resistances. This current will cause a voltage drop across the resistance. This voltage is applied to analog to digital converter and finally digital display is obtained. Thus, output displayed on the digital display is directly proportional to unknown current.

5. In order to measure an unknown resistance; a constant current source is used. The current from this constant current source is allowed to pass through unknown resistance. Thus the proportional voltage is obtained. The output display is directly proportional to unknown resistance.

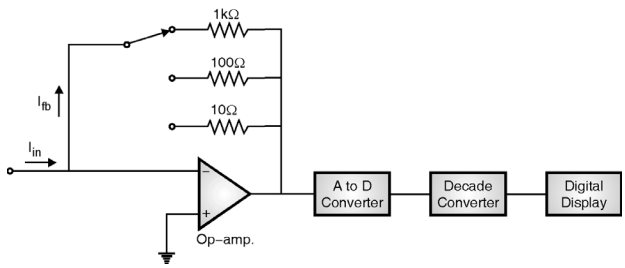


Fig. 1.13.2 : I to V converter

vi. To measure the ac voltage; a rectifier and filter is used. This rectifier converts ac signal into dc signal. Now this dc signal is applied to A to D converter and to the digital display. The BCD output can be obtained from A to D converter. Similarly the output from digital multimeter can be used to interface with other equipments.

MULTIPLE CHOICE QUESTIONS

CRO and CRT

1. A recorder is a device _____
   (a) Which records electrical and non-electrical quantities or relates two signals to each other as a function of time
   (b) which displays a time-varying signal
   (c) whose function is to record the value of the quantity as it is being measured
   (d) Which records the value of the quantity measured as well as the electrical and non-electrical quantities as a function of time

   ✓ **Ans. : (d)**

   Explanation : A recorder is a device which record the value of quantity as it is being measured. It records electrical and non-electrical quantities or relates two signals to each other as a function of time.

2. A CRO can display _____
   (a) Time-invariant signals
   (b) AC signals
   (c) Both AC and DC signals
   (d) DC signals ✓**Ans. : (c)**

   Explanation : A Cathode Ray Oscilloscope cannot measure or display Time invariant signals. However, it can measure both AC and DC signals.

3. X and Y plates of a CRO are connected to unequal voltages of equal frequency with phase shift of 90°. The Lissajous figure on the screen will be_____.
   (a) straight line (b) figure of eight
   (c) ellipse (d) circle ✓**Ans. : (c)**

   Explanation : The pattern observed on the CRT, when two sinusoidal signals are applied to the X-X and Y-Y plates of the CRT are known as Lissajous pattern.

   $$\sin\theta = \frac{y_1}{y_2} = \frac{x_1}{x_2}$$

   Here, the voltages are unequal and frequencies are equal with a phase shift of 90°. Therefore the Lissajous figure on the screen will be an ellipse.

4. To the Y input of a CRO, we feed a signal defined by 10sin100t, to the X-input, we feed signal 10cos100t. The gain for both X channel and Y channel is the same, the screen will show?
   (a) An ellipse (b) Sinusoidal signal
   (c) A straight line (d) A circle

   ✓**Ans. : (d)**

   Explanation : The pattern observed on the CRT, when two sinusoidal signals are applied to the X-X and Y-Y plates of the CRT are known as Lissajous pattern.

   $$\sin\theta = \frac{y_1}{y_2} = \frac{x_1}{x_2}$$

   ∴ Screen will show a circle.

5. A CRO uses _____
   (a) No focusing technique
   (b) Electrostatic focusing
   (c) Electromagnetic focusing
   (d) Both Electrostatic and Electromagnetic focusing

   ✓**Ans. : (b)**

   Explanation : A Cathode Ray Oscilloscope always using the focusing technique for its operation. Electromagnetic focusing is used by the Cathode Ray Tube. However, the Cathode Ray Oscilloscope employs Electrostatic focusing.

6. An oscilloscope indicates _____.
   (a) The peak to peak value of the voltage
   (b) Average value
   (c) DC value of the voltage
   (d) RMS value ✓**Ans. : (a)**

Explanation : The oscilloscope can measure not only the DC value but also the AC value. The RMS value cannot be measured by the oscilloscope. Similarly, the average value is also not measured. Therefore the peak to peak value of the voltage is measured.

7. CRO is used in a radar for _____
   (a) measuring voltage
   (b) visualizing a target
   (c) determining the distance between source and destination
   (d) studying the pattern of flights ✓**Ans. : (b)**

   Explanation : A Cathode Ray Oscilloscope is used in a radar for visualizing a target such as an aeroplane, ship, etc.

8. In radio applications, CRO is used for measuring _____
   (a) a narrow range of frequencies
   (b) audio frequency range
   (c) a wide range of frequencies
   (d) radio frequency range ✓**Ans. : (c)**

   Explanation : By making use of a Cathode Ray Oscilloscope, a wide range of frequencies can be measured. The radio frequency, audio frequency and intermediate frequency signals can be measured by making use of a CRO.

9. In medical applications CRO can be used for _____
   (a) improving the nervous system functioning
   (b) measuring the heart beats
   (c) monitoring the brain
   (d) displaying cardiograms ✓**Ans. : (d)**

   Explanation : A Cathode Ray Oscilloscope, can be used in medical applications for displaying cardiograms. Cardiograms are used for diagnosing the condition of heart of a patient. Electromyograms are used for studying the condition of a patient's muscle.

10. Curve tracers use CRO in _____
    (a) op amps (b) diodes
    (c) active devices (d) passive devices
    ✓**Ans. : (c)**

    Explanation : Curve tracers in a Cathode Ray Oscilloscope are used for testing active devices such as vacuum tubes, transistors and integrated circuits.

11. A CRO is used to check _____
    (a) voltage
    (b) op amps
    (c) resistors
    (d) capacitance, inductance and diodes
    ✓**Ans. : (d)**

    Explanation : A Cathode Ray Oscilloscope is used for checking diodes. It is also used in the measurement of inductances and capacitances. A CRO can also be used for detecting the faults in a circuit.

Function generator

12. A function generator can produce
    (a) none of the mentioned
    (b) many identical waves
    (c) different types of waves simultaneously
    (d) square and sine waves only ✓**Ans. : (c)**

    Explanation : Oscillator circuits generate only one type of waveform like square, triangular or sine wave separately, whereas a function generator can produce all three types of waves simultaneously.

13. Which of the following has distorted sinewave?
    (a) Function generator
    (b) Wein bridge oscillator
    (c) Biphasic oscillator
    (d) RC phase shit oscillator ✓**Ans. : (a)**

    Explanation : The sine shaper in function generator produces a sine wave by rounding off the tips of the triangular wave. The distortion of the sine wave thus produced is very high compared to the sine waves generated by other oscillator.

14. How a triangular wave generator is derived from square wave generator?
    (a) Connect differential at the output
    (b) Connect oscillator at the output
    (c) Connect Voltage follower at the output
    (d) Connect integrator at the output ✓**Ans. : (d)**

    Explanation : The output waveform of the integrator is triangular, if its input is square wave. Therefore, a triangular wave generator can be obtained by connecting an integrator at the output of the square wave generator.

15. The increase in the frequency of triangular wave generator_____.
    (a) ramps amplitude of triangular wave
    (b) decreases the amplitude of triangular wave
    (c) none of the mentioned
    (d) increases the amplitude of triangular wave
    ✓**Ans. : (a)**

    Explanation : As the resistor value increase or decrease, the frequency of triangular wave will decrease or increase, respectively. Therefore, the amplitude of the triangular wave decreases with an increase in it frequency and vice verse.

DMM

16. Digital multimeter is used for _____.
    (a) measuring a.c. and d.c. current, voltage and resistance.
    (b) measuring a.c. voltage and resistance.
    (c) measuring a.c. current and voltage.
    (d) measuring d.c. current and resistance.
    ✓**Ans. : (a)**

    Explanation : Digital multimeter is usually used for the measurement of a.c. current, voltage and resistance. It is also used for the measurement of d.c. current, voltage and resistance as well over several range.

17. Current is converted to voltage _____.
(a) through a galvanometer
(b) through a resistance
(c) through a voltmeter
(d) through an ammeter ✓**Ans. : (b)**

Explanation : Current is passed through a low shunt resistance and is converted to voltage. A.C. quantities are converted to D.C. through various rectifier and filter circuits. Voltmeter and ammeter are used for voltage and current measurement respectively.

18. For resistance measurement, meter contains _____.
(a) medium current source
(b) high current source
(c) low current source
(d) low voltage source ✓**Ans. :** (c)

Explanation : Usually in the measurement of resistance, meter consists of a precision low current source applied across an unknown resistance which gives a d.c. voltage.

19. Quantities are digitized using _____
(a) Oscillator (b) Amplifier
(c) D/A converter (d) A/D converter
✓**Ans. : (d)**

Explanation : Quantities such as current, voltage and resistance are digitized by making use of an A/D converter. They are then displayed on the screen by making use of a digital display.

20. Output of a digital multimeter is _____
(a) optical (b) analog
(c) electrical (d) mechanical
✓**Ans. : (c)**

Explanation : Digital multimeter gives an electrical signal as the output. A/D converter is employed for the conversion from analog to digital signal. This can be used for interfacing with external equipment.

21. Resistance is measured using _____
(a) constant current source
(b) variable voltage source
(c) constant voltage source
(d) variable current source ✓**Ans. : (a)**

Explanation : Constant current source is used to measure resistance in a digital multimeter. Standard known value of current is passed through an unknown resistance and the drop in voltage across the resistance is measured.

22. A.C. voltages are measured using _____
(a) resistor and capacitor
(b) rectifiers and filters
(c) inductor and resistor
(d) oscillators and op amps ✓**Ans. : (b)**

Explanation : Rectifiers and filter circuits with various configurations are employed for measuring A.C. voltages. A.C. is converted to D.C. and is applied to the A/D converter.

23. Basic circuit of multimeter consists _____
(a) power amplifier
(b) of d.c. amplifier
(c) of a.c. amplifier
(d) operational amplifier ✓**Ans. : (b)**

Explanation : A.C. as well as D.C. voltage, current and resistance can be measured by making use of an electronic multimeter. The basic circuit of a multimeter is made up of d.c. amplifier circuit in the form of a balanced bridge.

24. Input signal magnitude is limited by _____
(a) voltage (b) button
(c) attenuator (d) resistance
✓**Ans. : (c)**

Explanation : A range switch is provided in an electronic multimeter in order to limit the input signal in terms of magnitude. We can adjust the input attenuator and limit the input signal in terms of magnitude.

25. Multimeter can be used as an ammeter by _____.
(a) making use of a transformer
(b) connecting series resistances
(c) making use of a transducer
(d) connecting shunts ✓**Ans. : (d)**

Explanation : An electronic multimeter can be used as an ammeter by making use of shunt resistances across the meter. This is achieved by range selecting switch.

26. What is the initial setting made in a multimeter before it is used for measuring resistance?
(a) voltage is applied
(b) Fine adjustment
(c) instrument is open circuited
(d) zero adjustment ✓**Ans. : (d)**

Explanation : Initially the multimeter is short circuited and zero adjustment control is made. This is done till the meter reads zero resistance or in other words displays full scale current.

27. What is the role of a rectifier in a multimeter?
(a) Inversion (b) Bias purpose
(c) Rectification (d) Thermal stability
✓**Ans. : (c)**

Explanation : When the multimeter is used for the measurement of A.C. voltages, rectifier section is used. It mainly performs the conversion of the input A.C. voltage into D.C. for the measurement of A.C. voltage.

28. Digital voltmeters converts _____.
(a) analog to digital signal
(b) current to voltage
(c) resistance to voltage
(d) digital to analog signal ✓**Ans. : (a)**

Explanation : In general digital voltmeters are known as DVM. They convert analog signals into digital voltage. They also display the voltage to be measured in the form of discrete numerals in place of pointer deflection.

29. Digital voltmeters can be used to measure _____.
(a) voltage only
(b) voltage, temperature, pressure, etc
(c) voltage and resistance
(d) voltage and current ✓**Ans. : (b)**

Explanation : Digital voltmeters are used for the measurement of A.C. as well as D.C. voltages and also to measure physical quantities such as temperature, pressure, stress etc. through the use of appropriate transducer and signal conditioning circuits.

30. In a DVM, a transducer converts _____.
(a) input to a proportional resistance
(b) input to a proportional current
(c) input to a proportional voltage
(d) input to a proportional power ✓**Ans. : (c)**

Explanation : In a digital voltmeter, a transducer is used. In general a transducer converts a physical quantity into an electrical signal. In a DVM the transducer converts the input signal into a proportional voltage.

31. In a DVM, a signal conditioning circuit is used _____.
(a) to bring resistance to a suitable limit
(b) to bring current to a suitable limit
(c) to bring resistance to a suitable limit
(d) to bring voltage to a suitable limit ✓**Ans. : (d)**

Explanation : In a DVM, signal conditioning circuit is used. It converts the input signal into an voltage of suitable limit. This is done so that the voltmeter can read the magnitude of the signal correctly.

32. Input range of DVM is _____
(a) 1 V to 1000 V (b) 0.001 V to 0.1 V
(c) 0.1 V to 10 V (d) 0.01 V to 1 V
✓**Ans. : (a)**

Explanation : In a DVM, the input voltage range is given as 1 V to 1000 V. It includes automatic range selection and overload indication.

33. Basic range of DVM is _____.
(a) 1 or 10 V (b) 100 or 1000 V
(c) 0.1 or 1 V (d) 10 or 100 V
✓**Ans. : (a)**

Explanation : In a DVM, the basic range is 1 V or 10 V. Range of a DVM can be extended from a few μV to kV. This is achieved by making use of an attenuator.

34. Accuracy of a DVM is _____.
(a) zero (b) high
(c) low (d) medium ✓**Ans. : (b)**

Explanation : Accuracy of a DVM is based on the resolution. Resolution depends on the number of digits. The more the number of digits, the higher is the accuracy. For a DVM, the accuracy is of the order of ±0.005 % of the reading.

35. Input impedance of a DVM is _____.
(a) medium (b) low
(c) high (d) zero ✓**Ans. : (c)**

Explanation : Typical input impedance of a DVM is usually very high. Typical value is of the order of 10 MΩ. This is usually done in order to reduce the loading effect. In DVM the comm.

36. On mode rejection noise is eliminated by _____.
(a) using a transformer
(b) increasing the signal amplitude
(c) making use of a resistance
(d) guarding ✓**Ans. : (d)**

Explanation : In a DVM, common mode noise can be eliminated through guarding. A guard is basically a sheet metal box around the circuit. This is made available to the circuit being measured by making use of a terminal at the front panel.

37. Output of DVM needs _____.
(a) 4 lines (b) 16 lines
(c) 2 lines (d) 8 lines ✓**Ans. : (a)**

Explanation : Type of DVM used depends on the digital output lines. Four lines of BCD or a single line serial output may be provided so as to read the output from a DVM.

38. DVM has _____
(a) 7-10 digits (b) 2-5 digits
(c) 3-6 digits (d) 1-3 digits
✓**Ans. : (c)**

Explanation : The DVM consists of 3 to 6 digits. As the number of digits are increased the resolution also increases. Thus, the resolution of a DVM is very high.

BOARD MULTIPLE CHOICE QUESTIONS

1. If the Lissajous pattern seen on the CRT screen is a circle, then the phase difference between the two signals is _____
(a) 0° (b) 90° (c) 180° (d) 45°
(March 01, 1 Mark)
✓**Ans. : (b)**

Explanation : X and Y plates of a CRO are connected to unequal voltages of equal frequency with phase shift of 90°.

2. Deflection sensitivity of a CRT is measured in _____.
(a) Ω / volt (b) Volts / Ω
(c) mm / volt (d) none of these
(March 03, 1 Mark)
✓**Ans. : (c)**

Explanation : The deflection sensitivity of CRT is defined as the deflection on screen in meters per volt of the deflection voltage. $S = D / E_d$ Where, D = deflection on screen in meters E_d = deflection voltage (Volts)

3. In function generator for the generation of triangular wave _____ circuit is used.

(a) Integrator

(b) Schmitt Trigger

(c) Resistance diode wave shaping

(d) Differentiator

(March 04, 1 Mark)

✓Ans. : (a)

Explanation : The output waveform of the integrator is triangular, if its input is square wave. Therefore, a triangular wave generator can be obtained by connecting an integrator at the output of the square wave generator.

4. DMM measures _____ value of A.C. voltage.

(a) RMS (b) Peak

(c) Average (d) none of these

(Oct. 05, 1 Mark)

✓Ans. : (a)

Explanation : In DMM Current is passed through a low shunt resistance and is converted to voltage. A.C. quantities are converted to D.C. through various rectifier and filter circuits.

5. If a Lissajous pattern like 8 is obtained, then frequency to vertical input f_v and frequency to horizontal input f_x are related by the equation _____.

(a) fy = 2 fx (b) fx = 2 fy

(c) fx = fy (d) none of these

(March 99, 06, 1 Mark)

✓Ans. : (b)

Explanation : The ratio of frequencies of signals applied to deflection plates,

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

6. Electrostatically deflected CRT (Cathode Ray Tube) is used in _____.

(a) Computer monitor

(b) Television picture tube

(c) Cathode ray oscilloscope

(d) Radar indicator

(Oct. 09, 1 Mark)

✓Ans. : (c)

Explanation : A Cathode Ray Oscilloscope always uses the focusing technique for its operation. Electromagnetic focusing is used by the Cathode Ray Tube. However, the Cathode Ray Oscilloscope employs Electrostatic focusing.

7. Saw tooth voltages are applied at _____ in CRO.

(a) X-deflecting plates (b) Y-deflecting plates

(c) Focusing anode (d) Control grid

(Oct. 10, 1 Mark)

✓Ans. : (a)

Explanation : The time-based generator generates saw tooth waveforms and applies them between the horizontal deflection plates as the Saw tooth wave varies linearly with time and takes place at a constant velocity hence X-axis of the CRO can be calibrated in terms of time and input can be displayed with respect to time.

8. A circle is obtained on the screen if phase difference between the two sine wave voltages is _____.

(a) 180° (b) 90° (c) 45° (d) 0°

(Oct. 11, 1 Mark)

✓Ans. : (b)

Explanation : $\sin\theta = \frac{y_1}{y_2} = \frac{x_1}{x_2}$

Here, the voltages are unequal and frequencies are equal with a phase shift of 90°. Therefore the Lissajous figure on the screen will be a circle.

9. CRO measures _____ value of AC voltage

(a) rms (b) peak

(c) average (d) all of the above

(March 12, 1 Mark)

✓Ans. : (b)

Explanation : In a Cathode Ray Oscilloscope, the error in measurement is reduced by making use of the peak-to-peak value.

10. The aquadag coating of CRT is made from _____.

(a) Lead (b) Graphite

(c) Phosphor (d) Iron

(Oct. 13, 1 Mark)

✓Ans. : (c)

Explanation : The aquadag covers the inside faces of the CRT located between the neck and the display. This substance conducts electricity and functions as a high-voltage electrode. In order to assist the electron in serving the centre, the coating's surface is electrically attached to the accelerating anode.

11. The unit of deflection sensitivity of CRT is _____.

(a) mm/volt (b) cm

(c) volt/mm (d) volt/mm

(March 03, May 14, 1 Mark)

✓Ans. : (a)

Explanation : The deflection sensitivity of CRT is defined as the deflection on screen in meters per volt of the deflection voltage. S = D / E d Where, D = deflection on screen in meters Ed = deflection voltage (Volts)

12. The colour of bright spot on the screen of CRO is the characteristics of _____.
    (a) A signal being viewed
    (b) The primary electrons emitted from the cathode
    (c) The final speed with which the electrons strike the screen.
    (d) The coating material of the screen.

    (Oct. 15, 1 Mark)

    ✓Ans. : (d)

    Explanation : Phosphor crystals are used to cover the inside face of the faceplate and convert electrical energy into light. This phenomenon is known as fluorescence it occurs when an electronic ray strikes the phosphor crystal.

13. In CRO the Lissajous Figure method can be used for measurement of _____.
    (a) Frequency (b) Current
    (c) Resistance (d) None of these

    (March 17, 1 Mark)

    ✓Ans. : (a)

14. Select correct alternatives and rewrite sentences.
    In CRT _____ Anode has variable positive voltage
    (a) Pre-accelerating (b) Focussing
    (c) Accelerating (d) Control grid

    (Oct. 17, 1 Mark)

    ✓Ans. : (b)

    Explanation : The source of focused and the accelerated electron beam is the electron gun. The electron gun which emits electrons forms them into a beam consisting of a heater, a cathode, a grid, a pre-accelerating anode, a focusing anode and an accelerating anode.

15. In CRT, _____ anode has variable positive voltage.
    (a) pre-accelerating (b) focusing
    (c) accelerating (d) control grid

    (Oct. 08, Mar 23 1 Mark)

    ✓Ans. : (b)

    Explanation : While passing through the control grid, the electron is accelerated by a high positive potential, which is applied to the pre-accelerating or accelerating anodes. The focusing anode being positive tries to converge the beam and pass it to the next anode to accelerate further.

TRUE OR FALSE

CRO and CRT

1. A CRO can't be used in transmission lines.
   (a) True (b) False **✓Ans. : (b)**

   Explanation : A Cathode Ray Oscilloscope, is used in transmission lines for the measurement of modulation characteristics. It is also used for detecting the standing waves in a transmission line.

DMM

2. Analog mulimeters require power supply.
   (a) True (b) False **✓Ans. : (b)**

   Explanation : Analog multimeters are less affected by electric noise and isolation problems. As a result analog multimeters don't require a power supply.

3. Electronic multimeter consists of a rectifier.
   (a) True (b) False **✓Ans. : (a)**

   Explanation : An electronic multimeter is used for the measurement of A.C. as well as D.C. voltage, current and resistance. It consists of a rectifier section that is used to convert the a.c. input signal to d.c. voltage.

4. A digital voltmeter reduces parallax error.
   (a) True (b) False **✓Ans. : (a)**

   Explanation : A digital voltmeter minimizes the errors due to human interference, interpolation mismatch and errors due to parallax. A digital display is used to show the output voltage on a front panel.

5. Output in digital form can't be used directly.
   (a) True (b) False **✓Ans. : (b)**

   Explanation : The output obtained from a DVM can be used directly. It can be recorded and is also suitable for further processing.

…Chapter Ends

❑❑❑

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