# Maharashtra Board Class 12 Electronics Question Paper 2026 with Solutions

| Time Allowed :3 Hours | Maximum Marks :50 | Total Questions :5 |
|---|---|---|

**General Instructions**

1. All questions are compulsory
2. Figures to the right indicate full marks.
3. Draw near labelled diagrams wherever necessary.
4. Use of logtable is allowed.

**1(A)(a). In astable multivibrator if charging time constant is equal to discharging time constant, duty cycle is _____.**

(i) 50%
(ii) 100%
(iii) 1%
(iv) 25%

**Correct Answer:** (i) 50%

**Solution:**

**Step 1: Understanding the Concept:**
In an astable multivibrator, the output continuously switches between HIGH and LOW states. The duty cycle represents the percentage of time the signal is in the HIGH (active) state during one full cycle.

**Step 2: Detailed Explanation:**
Given that the charging time constant is equal to the discharging time constant ($\tau_c = \tau_d$). This implies that the time the output stays HIGH is equal to the time it stays LOW:

$$T_{on} = T_{off}$$

Substituting this into the formula:

$$D = \frac{T_{on}}{T_{on} + T_{on}} = \frac{1}{2} = 0.5$$

In percentage: $0.5 \times 100\% = 50\%$.
This results in a symmetrical square wave output.

**Step 3: Final Answer:**
The duty cycle is 50%.

Quick Tip

For a standard IC 555 astable circuit, a 50% duty cycle cannot be achieved with the basic two-resistor configuration because $R_A$ is always involved in charging. Special diode bypass circuits are needed to make $T_{on} = T_{off}$.

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**1(A)(b). The area to be served by a cellular telephone system is divided into _____.**

(i) region
(ii) cells
(iii) MTSO
(iv) rings

**Correct Answer:** (ii) cells

**Solution:**

**Step 1: Understanding the Concept:**
The cellular concept was developed to solve the problem of limited radio frequency spectrum in mobile communication.

**Step 2: Detailed Explanation:**
The large geographic area to be covered is divided into many small coverage areas called "cells". Each cell is served by a low-power transmitter (base station).
This cellular architecture allows for "frequency reuse", where the same frequencies can be used in different cells located far enough apart to not interfere.
MTSO (Mobile Telephone Switching Office) is the central office that manages all the base stations, but it is not the name of the geographic division.

**Step 3: Final Answer:**
The area is divided into cells.

Quick Tip

The hexagonal shape is the standard theoretical model for a cell as it provides equidistant coverage to most areas and fits perfectly without gaps.

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**1(A)(c). _____ stage of operational amplifier rejects the noise.**

(i) Level Shifter
(ii) Differential Amplifier
(iii) Emitter Follower
(iv) Output

**Correct Answer:** (ii) Differential Amplifier

**Solution:**

**Step 1: Understanding the Concept:**
Operational Amplifiers (Op-Amps) are designed to amplify the voltage difference between two inputs while suppressing signals common to both.

**Step 2: Detailed Explanation:**
The input stage of an Op-Amp is a differential amplifier.
Noise signals usually appear as common-mode signals (affecting both input terminals equally with the same phase and magnitude).
A differential amplifier amplifies the difference: $V_{out} = A_d(V_1 - V_2)$.
Since the noise $V_n$ is common, it gets subtracted out: $(V_1 + V_n) - (V_2 + V_n) = V_1 - V_2$.
This ability is called Common Mode Rejection (CMRR).

**Step 3: Final Answer:**
The Differential Amplifier stage rejects the noise.

> Quick Tip
>
> A higher Common Mode Rejection Ratio (CMRR) indicates a better ability of the Op-Amp to reject noise.

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**1(A)(d). The semiconductor diode is used as _____.**

(i) Temperature Transducer
(ii) Pressure Transducer
(iii) Displacement Transducer
(iv) Piezoelectric Transducer

**Correct Answer:** (i) Temperature Transducer

**Solution:**

**Step 1: Understanding the Concept:**
Transducers convert physical quantities into electrical signals. Semiconductor devices often have properties that change linearly with temperature.

**Step 2: Detailed Explanation:**
The forward voltage drop ($V_f$) across a PN junction diode is highly temperature-dependent.
At a constant current, the forward voltage decreases linearly as the temperature increases.
The temperature coefficient is approximately $-2$ mV/$^\circ$C for Silicon.
By measuring the change in voltage across a forward-biased diode, we can accurately determine

the change in temperature.

**Step 3: Final Answer:**
The semiconductor diode is used as a Temperature Transducer.

> Quick Tip
>
> Many digital thermometers use a silicon diode or a transistor (configured as a diode) as the primary sensing element.

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**1(B)(a). A Zener voltage regulator is to be designed for output of 10 volts. If the input voltage to the regulator is 25 volts. Find the value of current limiting resistor. Given $P_z = 500$ mW.**

**Correct Answer:** 300 Ω

**Solution:**

**Step 1: Understanding the Concept:**
A Zener regulator circuit consists of an input voltage source, a series resistor ($R_s$), and a Zener diode in parallel with the load. The resistor drops the excess voltage and limits current.

**Step 2: Detailed Explanation:**
Given:
Desired Output Voltage ($V_z$) = 10 V
Input Voltage ($V_{in}$) = 25 V
Power Rating of Zener ($P_z$) = 500 mW = 0.5 W

Calculate maximum allowable current:

$$I_{z(max)} = \frac{0.5}{10} = 0.05 \text{ A} = 50 \text{ mA}$$

Applying Ohm's law to the series resistor:
The voltage across $R_s$ is $V_{in} - V_z = 25 - 10 = 15$ V.
To prevent exceeding $P_z$, we calculate $R_s$ such that the current is 50 mA:

$$R_s = \frac{15}{0.05} = 300 \ \Omega$$

**Step 3: Final Answer:**
The value of the current limiting resistor is 300 Ω.

Quick Tip

In practical design, $R_s$ is usually chosen slightly higher than the calculated minimum value to provide a safety margin for the Zener diode.

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**1(B)(b). What are the drawbacks of RC coupled amplifier ?**

**Correct Answer:** Poor frequency response at extreme ends and lack of impedance matching.

**Solution:**

**Step 1: Understanding the Concept:**
RC coupling uses a resistor and a capacitor to transfer the signal from one stage to the next in a multi-stage amplifier.

**Step 2: Detailed Explanation:**
1. **Poor frequency response at low frequencies:** The reactance of the coupling capacitor ($X_c = 1/2\pi fC$) increases at low frequencies, causing a large signal drop across the capacitor and reducing overall gain.
2. **Poor frequency response at high frequencies:** Stray and junction capacitances act as low-impedance paths to ground at high frequencies, bypassing the signal and reducing gain.
3. **Impedance Matching:** It does not provide impedance matching. This results in lower power transfer efficiency compared to transformer coupling.
4. **No Isolation:** There is no complete DC isolation between stages if the capacitor fails.

**Step 3: Final Answer:**
Main drawbacks are poor low/high-frequency response and lack of impedance matching.

Quick Tip

RC coupling is widely used for audio voltage amplification because it is simple and inexpensive, despite these drawbacks.

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**1(B)(c). Explain the use of Cathode Ray Oscilloscope for measurement of AC and DC voltage.**

**Correct Answer:** Measuring vertical deflection using the VOLTS/DIV control.

**Solution:**

**Step 1: Understanding the Concept:**
A CRO visualizes waveforms on a screen. The vertical axis (Y-axis) represents voltage.

**Step 2: Detailed Explanation:**
**DC Voltage Measurement:**
1. Select "GND" on the input coupling switch to set a baseline reference line on the screen.
2. Select "DC" coupling and connect the unknown DC source.
3. The horizontal line will shift vertically. Measure the number of divisions it shifted from the reference.
4. $V_{DC}$ = (No. of divisions) × (VOLTS/DIV setting).

**AC Voltage Measurement:**
1. Apply the AC signal and adjust VOLTS/DIV to fit the wave on the screen.
2. Measure the total vertical height from the positive peak to the negative peak in divisions.
3. Peak-to-Peak Voltage: $V_{p-p}$ = (Vertical Divs) × (VOLTS/DIV).
4. Peak Voltage $V_p = V_{p-p}/2$.
5. RMS Voltage $V_{rms} = V_p/\sqrt{2}$ (for sine waves).

**Step 3: Final Answer:**
Voltages are measured by multiplying the vertical trace height in divisions by the VOLTS/DIV scale factor.

> Quick Tip
>
> Ensure the calibration knob (small red knob in the center of VOLTS/DIV) is in the "CAL" position for accurate readings.

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**2(A)(a). Draw the diagram showing pin connection of IC-555 and IC LM317.**

**Correct Answer:** Pinout diagrams for IC-555 and LM317.

**Solution:**

**Step 1: Understanding the Concept:**
Standard ICs have specific pin configurations that must be followed for correct operation.

**Step 2: Detailed Explanation:**
**IC 555 (8-pin Dual In-line Package):**
Pin 1: Ground (GND)
Pin 2: Trigger (TRIG)
Pin 3: Output (OUT)
Pin 4: Reset (RESET)
Pin 5: Control Voltage (CTRL)

Pin 6: Threshold (THRESH)
Pin 7: Discharge (DISCH)
Pin 8: Supply Voltage ($V_{cc}$)

**IC LM317 (Adjustable Voltage Regulator - TO-220 package):**
Pin 1: Adjust (ADJ)
Pin 2: Output (Vout) [This is also connected to the metal tab in some packages]
Pin 3: Input (Vin)

**Step 3: Final Answer:**
The pin configurations for IC 555 and LM317 are listed as standard industry pinouts.

> Quick Tip
>
> In a 555 timer, always connect Pin 4 (Reset) to $V_{cc}$ if you are not using the reset function to prevent unexpected shutdowns.

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**2(A)(b). What do you mean by Network Topology ? Enlist the types of network topologies and explain any one of them with diagram.**

**Correct Answer:** Physical layout of network nodes; Star, Bus, Ring, etc.

**Solution:**

**Step 1: Understanding the Concept:**
Network Topology refers to the physical or logical arrangement of computers, cables, and other components in a network.

**Step 2: Detailed Explanation:**
**Types of Topologies:**
1. Bus Topology
2. Star Topology
3. Ring Topology
4. Mesh Topology
5. Tree Topology
6. Hybrid Topology

**Explanation of Star Topology:**
In a Star Topology, all devices (nodes) are connected to a central hub or switch.
**Working:** Every node has a dedicated point-to-point connection to the hub. All data transfers between nodes pass through the central hub.
**Advantages:** Easy to install and expand; failure of one node does not affect others.
**Disadvantage:** If the central hub fails, the entire network goes down.

**Step 3: Final Answer:**
Topology defines network layout. In Star topology, all nodes connect to a central hub.

> Quick Tip
>
> Star topology is the most common topology used in modern local area networks (LANs) like Ethernet.

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**2(A)(c). Write a note on LDR.**

**Correct Answer:** Light Dependent Resistor.

**Solution:**

**Step 1: Understanding the Concept:**
An LDR (Light Dependent Resistor) is a variable resistor whose resistance changes based on the intensity of light falling on its surface. It is also known as a photoresistor.

**Step 2: Detailed Explanation:**
**Principle:** It works on the principle of photoconductivity. When light photons hit the semiconductor material (usually Cadmium Sulfide - CdS), they release electrons, increasing conductivity.
**Resistance Characteristic:** In darkness, the LDR has very high resistance (Mega-ohms). As light intensity increases, its resistance decreases significantly (hundreds of ohms).
**Applications:**
1. Automatic street light controllers.
2. Light meters in cameras.
3. Burglar alarm systems (optical).
4. Solar intensity trackers.

**Step 3: Final Answer:**
LDR is a light-sensitive resistor whose resistance decreases with increasing light intensity.

> Quick Tip
>
> Because LDRs have a slow response time, they are not suitable for high-speed light communication; photodiodes or phototransistors are used instead.

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**2(B)(a). In a circuit of Schmitt trigger $R_1 = 10$ k$\Omega, R_2 = 2$ k$\Omega, V_{in} = 3$ $V_{p-p}$ sinewave, with saturation voltage of $\pm 13$ volts. Calculate: (i) UTP, (ii) LTP, (iii) Hysteresis**

**voltage, (iv) Feedback factor $\beta$.**

**Correct Answer:** (i) 2.167 V, (ii) -2.167 V, (iii) 4.333 V, (iv) 0.1667

**Solution:**

**Step 1: Understanding the Concept:**
A Schmitt trigger uses positive feedback to create two threshold levels. The circuit stays in its current state until the input crosses one of these levels.

**Step 2: Detailed Explanation:**
Given: $R_1 = 10\ \text{k}\Omega, R_2 = 2\ \text{k}\Omega, V_{sat} = \pm 13\ \text{V}$.

(iv) Calculate $\beta$:

$$\beta = \frac{2000}{10000 + 2000} = \frac{2}{12} = \frac{1}{6} \approx 0.1667$$

(i) Calculate UTP:

$$UTP = 0.1667 \times (+13\ \text{V}) = 2.167\ \text{V}$$

(ii) Calculate LTP:

$$LTP = 0.1667 \times (-13\ \text{V}) = -2.167\ \text{V}$$

(iii) Calculate Hysteresis Voltage:

$$V_H = 2.167 - (-2.167) = 4.334\ \text{V}$$

**Step 3: Final Answer:**
UTP = 2.167 V, LTP = $-2.167$ V, $V_H = 4.334$ V, $\beta = 0.1667$.

**Quick Tip**

Hysteresis provides noise immunity. Any noise smaller than the hysteresis voltage will not cause the output to jitter or switch erroneously.

**2(B)(b). State eight advantages of fibre optic cable over conventional electrical cable for communication.**

**Correct Answer:** High bandwidth, EMI immunity, low loss, etc.

**Solution:**

**Step 1: Understanding the Concept:**
Fiber optic cables use light pulses through glass or plastic fibers, offering superior performance compared to traditional copper wires.

**Step 2: Detailed Explanation:**
1. **High Bandwidth:** Can carry significantly more data than copper cables.
2. **Low Signal Loss:** Allows for very long transmission distances without repeaters.
3. **EMI Immunity:** Since fibers are non-metallic, they are immune to electromagnetic interference and crosstalk.
4. **Security:** Light signals do not radiate outside the fiber, making them very difficult to tap into without detection.
5. **Lightweight and Compact:** Fibers are much thinner and lighter than bulky copper bundles.
6. **Safety:** Being insulators, there is no risk of sparks, making them safe for explosive environments.
7. **Future Proof:** The capacity can be increased simply by upgrading the terminal equipment.
8. **Cost Effective over Distance:** Fewer repeaters and less maintenance make them cheaper for long hauls.

**Step 3: Final Answer:**
Fiber optics offer higher speed, better security, and immunity to electrical noise.

Quick Tip

The core principle of fiber optics is Total Internal Reflection (TIR), which keeps light trapped inside the glass core.

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**3(A)(a). The turns ratio of transformer in a bridge rectifier is 12:1. Primary is connected to 230 volts, 50 Hz AC mains. Find the output of DC voltage under no load condition, assume the voltage drop across each diode to be zero.**

**Correct Answer:** 17.26 V (Average DC)

**Solution:**

**Step 1: Understanding the Concept:**
A transformer steps down the voltage, which is then rectified. Without a filter, "DC voltage" typically means the average value of the rectified sine wave.

**Step 2: Detailed Explanation:**
Given: $V_p = 230$ V, turns ratio $\frac{N_p}{N_s} = 12$.
1. $V_{s(rms)} = \frac{230}{12} \approx 19.167$ V.
2. $V_m = 19.167 \times 1.414 \approx 27.1$ V.
3. Since diode drops are zero:

$$V_{dc} = \frac{2 \times 27.1}{3.14159} \approx 17.26 \text{ V}$$

**Step 3: Final Answer:**
The average DC output voltage is 17.26 V.

> Quick Tip
>
> If a capacitor filter was used, the "no load DC voltage" would instead be approximately the peak value, 27.1 V.

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**3(A)(b). The deflection sensitivity of CRT is 0.04 mm/v. An unknown voltage applied to X-plates causes the deflection of spot 5mm horizontally. Find the value of unknown voltage.**

**Correct Answer:** 125 V

**Solution:**

**Step 1: Understanding the Concept:**
Deflection sensitivity ($S$) relates the displacement of the electron beam on the screen to the voltage applied to the deflection plates.

**Step 2: Detailed Explanation:**
Given:
Sensitivity $S = 0.04$ mm/V
Deflection $D = 5$ mm

$$V = \frac{5 \text{ mm}}{0.04 \text{ mm/V}} = \frac{5}{0.04} = 125 \text{ V}$$

**Step 3: Final Answer:**
The value of the unknown voltage is 125 V.

Quick Tip

Deflection sensitivity is the reciprocal of the deflection factor. Always check the units to ensure compatibility.

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**3(A)(c). Explain the working of Piezoelectric Transducer.**

**Correct Answer:** Generating voltage from mechanical stress (Piezoelectric Effect).

**Solution:**

**Step 1: Understanding the Concept:**
A piezoelectric transducer is an active transducer that works on the principle of the "Piezoelectric Effect".

**Step 2: Detailed Explanation:**
**Principle:** Certain materials like quartz, Rochelle salt, and Barium Titanate generate an electrical potential (voltage) when subjected to mechanical pressure or stress.
**Working:** When force is applied to the crystal, it deforms, causing internal charge displacement. This results in an output voltage proportional to the applied force. The effect is reversible (Inverse Piezoelectric effect).
**Applications:** Accelerometers, microphones, ultrasonic cleaners, and pressure sensors.

**Step 3: Final Answer:**
It converts mechanical energy (pressure/force) directly into electrical energy (voltage).

Quick Tip

Piezoelectric transducers are excellent for high-frequency dynamic measurements but cannot measure static pressure because the charge leaks away over time.

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**3(B)(a). List any four advantages of SMPS.**

**Correct Answer:** High efficiency, small size, lightweight, wide input range.

**Solution:**

**Step 1: Understanding the Concept:**
SMPS (Switched-Mode Power Supply) uses a switching regulator to convert electrical power efficiently.

**Step 2: Detailed Explanation:**
1. **High Efficiency:** Unlike linear regulators, SMPS operates the switching transistor in saturated or cut-off regions, minimizing power loss (typically 70–90% efficiency).
2. **Small Size and Lightweight:** Higher switching frequencies allow for much smaller and lighter transformers and capacitors.
3. **Wide Input Voltage Range:** It can maintain stable output across a broad range of input voltages.
4. **Lower Heat Generation:** High efficiency results in significantly less wasted energy as heat.

**Step 3: Final Answer:**
The key advantages are efficiency, compactness, and reduced heat.

Quick Tip

The main disadvantage of SMPS is electrical noise (RFI/EMI) generated by the high-frequency switching, requiring filtering.

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**3(B)(b). Draw the circuit diagram of Inverting Operational Amplifier and obtain an expression for its gain. Explain how it can be used as sign changer.**

**Correct Answer:** $A_v = -R_f/R_1$.

**Solution:**

**Step 1: Understanding the Concept:**
An inverting amplifier is an Op-Amp configuration where the input signal is applied to the inverting (-) terminal, and the output is phase-shifted by 180°.

**Step 2: Detailed Explanation:**
**Gain Derivation:**
1. The non-inverting terminal is grounded (0 V). Due to virtual ground, the inverting terminal is also at 0 V.
2. $I_{in} = (V_{in} - 0)/R_1 = V_{in}/R_1$.
3. $I_f = (0 - V_{out})/R_f = -V_{out}/R_f$.
4. Equating $I_{in} = I_f \implies V_{in}/R_1 = -V_{out}/R_f$.
5. Gain $A_v = V_{out}/V_{in} = -R_f/R_1$.

**Sign Changer:**
If we choose $R_f = R_1$, then $A_v = -1$.

The output will be $V_{out} = -V_{in}$. It changes the sign (polarity) of the input without changing its magnitude.

**Step 3: Final Answer:**
Gain is $-R_f/R_1$. It acts as a sign changer when resistors are equal.

> Quick Tip
>
> The negative sign in the gain expression indicates a 180° phase reversal between input and output.

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**4(A)(a). Explain the working of IC 555 as a Monostable Multivibrator.**

**Correct Answer:** Generation of a single pulse of duration $T = 1.1RC$.

**Solution:**

**Step 1: Understanding the Concept:**
A monostable multivibrator has one stable state (LOW). It produces a high-output pulse for a predetermined time interval when triggered by an external signal.

**Step 2: Detailed Explanation:**
1. **Initial State:** The output is LOW, and the internal discharge transistor is ON, keeping the external capacitor discharged.
2. **Triggering:** A negative-going trigger pulse ($< 1/3V_{cc}$) is applied to pin 2. This sets the internal flip-flop.
3. **Charging State:** The output goes HIGH, and the discharge transistor turns OFF. The external capacitor $C$ starts charging through resistor $R$ towards $V_{cc}$.
4. **Resetting:** When the capacitor voltage reaches $2/3V_{cc}$, the threshold comparator resets the flip-flop.
5. **Discharge:** The output returns to LOW, and the discharge transistor turns ON, rapidly discharging the capacitor. The circuit stays in this stable state until another trigger is applied.

**Step 3: Final Answer:**
The duration of the output pulse is given by the formula $T = 1.1 \times R \times C$.

> Quick Tip
>
> To increase the duration of the timer, you can increase either the resistance $R$ or the capacitance $C$.

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**4(A)(b). List three applications of simplex and three applications of duplex communication system.**

**Correct Answer:** Simplex: TV, Radio, Pagers. Duplex: Phone, Internet, Video chat.

**Solution:**

**Step 1: Understanding the Concept:**
Simplex is one-way communication where data flows in only one direction. Duplex (Full-Duplex) allows simultaneous two-way communication.

**Step 2: Detailed Explanation:**
**Applications of Simplex:**
1. **Television Broadcasting:** Signals are sent from the station to your TV; you cannot talk back to the station via the same signal.
2. **Radio Broadcasting:** FM/AM radio stations broadcast content to listeners.
3. **Wireless Paging Systems:** A pager receives text alerts but generally does not transmit back.

**Applications of Duplex:**
1. **Mobile Telephony:** Both parties can speak and hear each other at the same time.
2. **Broadband Internet:** Simultaneous uploading and downloading of data occurs.
3. **Video Conferencing:** Tools like Zoom or Skype allow real-time two-way audio-visual interaction.

**Step 3: Final Answer:**
Simplex is for broadcasting, whereas Duplex is for interactive, two-way services.

Quick Tip

Don't confuse Full-Duplex with Half-Duplex (like walkie-talkies), where communication is two-way but not simultaneous.

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**4(A)(c). Explain how CRO displays a waveform.**

**Correct Answer:** Visualization of voltage vs. time on a phosphor screen.

**Solution:**

**Step 1: Understanding the Concept:**
A Cathode Ray Oscilloscope (CRO) uses an electron beam to trace a pattern on a screen, representing the variation of an electrical signal over time.

**Step 2: Detailed Explanation:**
The display of a waveform involves two synchronized deflections:
1. **Vertical Deflection (Y-axis):** The input signal to be observed is amplified and applied to the vertical deflection plates. This moves the electron beam up and down proportional to the instantaneous voltage of the input signal.
2. **Horizontal Deflection (X-axis):** An internal "sweep" or "time-base" generator produces a sawtooth voltage. This is applied to the horizontal deflection plates, moving the beam linearly from left to right at a constant speed.
3. **Resultant Trace:** The combined movement traces the voltage variation over time. Because the sweep is periodic and synchronized (triggered) with the input, the waveform appears as a stable image on the phosphor-coated screen.

**Step 3: Final Answer:**
By combining a vertical movement (voltage) with a horizontal sweep (time), the CRO creates a graphical plot of the input signal.

Quick Tip

The "Trigger" control is essential to ensure the horizontal sweep starts at the same point on the waveform every time, preventing a flickering or moving image.

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**4(B)(a). State any eight characteristics of ideal Op-Amplifier.**

**Correct Answer:** Infinite gain, zero output impedance, infinite bandwidth, etc.

**Solution:**

**Step 1: Understanding the Concept:**
An ideal Op-Amp is a theoretical model used in circuit design to simplify calculations by assuming perfect component parameters.

**Step 2: Detailed Explanation:**
The eight primary characteristics of an ideal Op-Amp are:
1. **Infinite Open-Loop Gain ($A_{OL} = \infty$):** It can amplify even an infinitesimal difference between inputs.
2. **Infinite Input Impedance ($R_{in} = \infty$):** It draws zero current from the source, causing no loading effect.
3. **Zero Output Impedance ($R_{out} = 0$):** It can supply any amount of current to the load without voltage drop.
4. **Infinite Bandwidth ($BW = \infty$):** It can amplify signals of any frequency from DC to infinity.
5. **Infinite Common Mode Rejection Ratio (CMRR $= \infty$):** It perfectly rejects any noise common to both inputs.

6. **Infinite Slew Rate ($SR = \infty$):** The output can change states instantaneously.
7. **Zero Offset Voltage ($V_{os} = 0$):** If both inputs are at 0 V, the output is exactly 0 V.
8. **Zero Thermal Drift:** Its characteristics do not change with temperature variations.

**Step 3: Final Answer:**
The characteristics include infinite gain, input impedance, bandwidth, and CMRR, with zero output impedance, offset, and drift.

> Quick Tip
>
> When analyzing Op-Amp circuits, always start by assuming $I_{in} = 0$ and $V_+ = V_-$, which are derived from these ideal characteristics.

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### 4(B)(b). Draw internal block diagram of IC555 and explain its working.

**Correct Answer:** Block diagram featuring comparators, flip-flop, and discharge transistor.

**Solution:**

**Step 1: Understanding the Concept:**
The IC 555 timer is a highly versatile integrated circuit that can be used in astable, monostable, or bistable modes.

**Step 2: Detailed Explanation:**
**Internal Components:**
1. **Voltage Divider:** Three 5 kΩ resistors connected in series between $V_{cc}$ and GND create reference voltages of $1/3V_{cc}$ and $2/3V_{cc}$.
2. **Comparators:** Two operational amplifiers used as comparators. One compares the trigger pin to $1/3V_{cc}$, and the other compares the threshold pin to $2/3V_{cc}$.
3. **RS Flip-Flop:** Receives the outputs from the comparators to store the state (HIGH or LOW).
4. **Output Stage:** A power buffer that can sink or source up to 200 mA of current.
5. **Discharge Transistor:** Connected to pin 7, used to discharge external capacitors when the flip-flop is in the reset state.

**Working:**
When the trigger voltage falls below $1/3V_{cc}$, the lower comparator sets the flip-flop, making the output HIGH. When the threshold voltage rises above $2/3V_{cc}$, the upper comparator resets the flip-flop, making the output LOW and turning on the discharge transistor.

**Step 3: Final Answer:**
IC 555 works by comparing input voltages against internal references to control an RS flip-flop and an output stage.

Quick Tip

The "555" name comes from the three 5 kΩ internal resistors used in its reference divider network.

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**5(A)(a). Define deflection sensitivity of CRO. What is the function of delay line in CRO ?**

**Correct Answer:** Deflection per unit voltage; synchronizing trigger and signal.

**Solution:**

**Step 1: Understanding the Concept:**
Deflection sensitivity is a performance metric for the CRT, while the delay line is a critical circuit component for high-speed signal viewing.

**Step 2: Detailed Explanation:**
1. **Deflection Sensitivity ($S$):** It is defined as the vertical displacement of the electron beam on the screen produced by a unit deflection voltage. It is typically measured in mm/V.

$$S = \frac{D}{V}$$

where $D$ is deflection in mm and $V$ is the applied voltage.
2. **Function of Delay Line:** In a CRO, the signal is split into a vertical path and a trigger path. Triggering circuits take a small amount of time to process and start the horizontal sweep. To prevent losing the beginning of the waveform, a delay line is inserted in the vertical amplifier path. It stalls the vertical signal just enough so that the sweep has already started by the time the signal reaches the deflection plates.

**Step 3: Final Answer:**
Sensitivity is deflection per volt. The delay line ensures the leading edge of fast signals is displayed.

Quick Tip

The higher the sensitivity, the smaller the voltage required to produce a visible deflection on the CRO screen.

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**5(A)(b). A single phase half wave rectifier supplies power to 1 kΩ load. The input supply voltage is 220 $V_{RMS}$. Neglect the forward resistance of diode. Calculate average voltage and current in the circuit.**

**Correct Answer:** $V_{avg} = 99.04$ V, $I_{avg} = 99.04$ mA

**Solution:**

**Step 2: Detailed Explanation:**
Given: $V_{rms} = 220$ V, $R_L = 1000\ \Omega$.
First, find the peak amplitude:

$$V_m = 220 \times 1.414 = 311.127 \text{ V}$$

Now, calculate the average (DC) voltage:

$$V_{dc} = \frac{311.127}{3.14159} \approx 99.04 \text{ V}$$

Finally, calculate the average current using Ohm's law:

$$I_{dc} = \frac{99.04}{1000} = 0.09904 \text{ A} = 99.04 \text{ mA}$$

**Step 3: Final Answer:**
The average voltage is 99.04 V and the average current is 99.04 mA.

Quick Tip

For half-wave rectification, remember the simple constant: $V_{avg} \approx 0.318 \times V_m$ or $0.45 \times V_{rms}$.

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**5(A)(c). What is cell in cellular phone system ? Explain in brief.**

**Correct Answer:** A small geographic unit served by a base station.

**Solution:**

**Step 1: Understanding the Concept:**
The concept of a "cell" allows for the efficient use of limited radio frequency channels to serve a massive number of mobile users.

**Step 2: Detailed Explanation:**
1. **Definition:** A cell is a small, specific geographic area that forms the basic unit of a cellular network.
2. **Base Station:** Each cell is equipped with its own base station (antennas and transceivers) that communicates with mobile devices within its boundaries.

3. **Frequency Reuse:** The total available frequency spectrum is divided into sets. Adjacent cells use different sets to avoid interference, while non-adjacent cells far enough apart can reuse the same set. This vastly increases system capacity.
4. **Shape:** Theoretically, cells are represented as hexagons because they tile perfectly without overlapping or leaving gaps.

**Step 3: Final Answer:**
A cell is a sub-area of a network that enables frequency reuse and supports high-capacity communication.

Quick Tip

As a user moves from one cell to another, a process called "Handoff" occurs to maintain the connection without dropping the call.

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**5(B)(a). Explain the working of centre tapped full wave rectifier and compare any two parameters in case of centre tapped full wave rectifier and bridge rectifier.**

**Correct Answer:** Rectification using two diodes and a tapped transformer.

**Solution:**

**Step 1: Understanding the Concept:**
A full-wave rectifier utilizes both halves of the AC input cycle to produce a DC output in the same direction.

**Step 2: Detailed Explanation:**
**Working:**
It uses a transformer with a center-tapped secondary and two diodes.
1. **Positive Half Cycle:** Upper end of secondary is positive. Diode $D_1$ is forward biased, $D_2$ is reverse biased. Current flows through $D_1$, then through the load to the center tap.
2. **Negative Half Cycle:** Lower end of secondary becomes positive. Diode $D_2$ is forward biased, $D_1$ is reverse biased. Current flows through $D_2$ and through the load in the same direction as before.

**Comparison:**
1. **Peak Inverse Voltage (PIV):** In Centre-tapped, PIV is $2V_m$. In Bridge, PIV is only $V_m$. Bridge is better for high-voltage applications.
2. **Transformer Utilization Factor (TUF):** Bridge rectifier has a higher TUF ($\approx 0.812$) compared to centre-tapped ($\approx 0.692$), making bridge rectifiers more efficient for a given transformer size.

**Step 3: Final Answer:**
Centre-tapped uses two diodes and a specialized transformer. Bridge rectifiers are generally

preferred due to lower PIV and better transformer efficiency.

Quick Tip

Modern electronics almost exclusively use Bridge rectifiers because center-tapped transformers are bulkier and more expensive.

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**5(B)(b). State any two Linear and Non-linear applications of Op-Amp.**

**Correct Answer:** Linear: Summing Amp, Subtractor. Non-linear: Comparator, Schmitt Trigger.

**Solution:**

**Step 1: Understanding the Concept:**
Op-Amp applications are classified based on whether the output relates linearly to the input or involves switching/saturation.

**Step 2: Detailed Explanation:**
**Linear Applications:** (Output is proportional to input)
1. **Summing Amplifier:** Produces an output voltage that is the weighted algebraic sum of several input voltages.
2. **Differential Amplifier (Subtractor):** Amplifies only the difference between two input signals.
3. **Voltage-to-Current (V-I) Converter.**

**Non-Linear Applications:** (Op-Amp operates in saturation region)
1. **Comparator:** Compares two input voltages and switches the output to either $+V_{sat}$ or $-V_{sat}$.
2. **Schmitt Trigger:** A comparator with hysteresis that provides two distinct threshold levels for better noise immunity.
3. **Precision Rectifier.**

**Step 3: Final Answer:**
Linear apps include Summing Amps and Subtractors. Non-linear apps include Comparators and Schmitt Triggers.

Quick Tip

Linear applications usually use negative feedback, while non-linear applications use positive feedback or no feedback at all.

**OR.**

**5(A)(a). State any three applications of function generator.**

**Correct Answer:** Circuit testing, signal sourcing, and equipment calibration.

**Solution:**

**Step 1: Understanding the Concept:**
A function generator is a piece of laboratory equipment capable of producing different periodic waveforms like sine, square, and triangular waves.

**Step 2: Detailed Explanation:**
Three key applications are:
1. **Testing and Troubleshooting:** Used to inject standard signals into electronic circuits to observe their response on an oscilloscope.
2. **Signal Source for Amplifiers:** Used to measure the gain, frequency response, and distortion characteristics of audio and RF amplifiers.
3. **Calibration of Test Equipment:** Provides precise, stable waveforms used to calibrate oscilloscopes and digital multimeters.

**Step 3: Final Answer:**
Function generators are primarily used for circuit testing, frequency response analysis, and calibration.

Quick Tip

Function generators often include a "DC offset" control, which allows you to shift the entire AC waveform above or below zero volts.

**5(A)(b). Explain the working of Loudspeaker with neat diagram.**

**Correct Answer:** Conversion of electrical current into mechanical sound waves.

**Solution:**

**Step 1: Understanding the Concept:**
A dynamic loudspeaker is a transducer that converts electrical energy into sound energy using electromagnetic principles.

**Step 2: Detailed Explanation:**
**Working:**
1. **Structure:** It consists of a permanent magnet, a movable voice coil, and a paper or plastic cone (diaphragm).
2. **Electromagnetism:** When an AC audio signal flows through the voice coil, it creates a fluctuating magnetic field around it.
3. **Interaction:** This varying magnetic field interacts with the steady magnetic field of the permanent magnet. According to Lorentz force law, the coil is alternately attracted to and repelled by the magnet.
4. **Vibration:** This force causes the coil to move back and forth, vibrating the attached diaphragm at the same frequency as the audio signal.
5. **Sound Waves:** The vibrating diaphragm pushes and pulls the surrounding air, creating pressure waves that we hear as sound.

**Step 3: Final Answer:**
Loudspeakers use the interaction between a fixed magnet and an AC-driven voice coil to produce mechanical vibrations that create sound.

> Quick Tip
>
> The impedance of most standard loudspeakers is 4 Ω or 8 Ω.

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**5(A)(c). State any three advantages of Op-Amp over normal amplifier.**

**Correct Answer:** Higher gain, better stability, and multi-purpose versatility.

**Solution:**

**Step 1: Understanding the Concept:**
Operational Amplifiers are integrated circuits that offer vastly superior performance and flexibility compared to traditional single-transistor amplifiers.

**Step 2: Detailed Explanation:**
1. **High Gain Stability:** The extremely high open-loop gain of Op-Amps allows for precise gain control via negative feedback, which is independent of transistor variations.
2. **Versatility:** A single Op-Amp IC can perform many different functions (adding, subtracting, integrating, filtering) just by changing a few external passive components.
3. **Miniaturization:** Op-Amps are available in tiny IC packages, saving significant circuit board space compared to discrete multi-stage amplifiers.
4. **Excellent Input/Output Impedance:** They typically have high input impedance and very low output impedance, making them ideal buffers.

**Step 3: Final Answer:**
Advantages include stable gain, smaller size, and the ability to perform various mathematical

operations.

Quick Tip

Because Op-Amps are direct-coupled internally, they can amplify DC signals, which single-stage RC-coupled amplifiers cannot do easily.

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**5(B)(a). State any four points of comparison between Amplitude Modulation and Frequency Modulation.**

**Correct Answer:** Comparison based on parameter, noise, bandwidth, and complexity.

**Solution:**

**Step 1: Understanding the Concept:**
Modulation is the process of varying a property of a high-frequency carrier signal in accordance with an information-bearing message signal.

**Step 2: Detailed Explanation:**

- **Modulated Parameter:** In AM, the amplitude of the carrier changes. In FM, the frequency of the carrier changes while amplitude remains constant.
- **Noise Immunity:** FM is much more immune to noise and atmospheric interference because most noise affects signal amplitude, which FM receivers largely ignore.
- **Bandwidth:** AM requires less bandwidth (2× signal frequency). FM requires a much larger bandwidth (governed by Carson's Rule).
- **Transmitter/Receiver Complexity:** FM equipment is generally more complex and expensive to design than AM equipment.

**Step 3: Final Answer:**
FM provides higher quality and noise rejection at the cost of higher bandwidth and complexity compared to AM.

Quick Tip

This is why AM is used for long-distance, low-quality talk radio, while FM is used for high-fidelity music broadcasting.

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**5(B)(b). Give one advantage and one disadvantages of following types of filter circuits: (i) Capacitor input filter (ii) Inductor filter (iii) R.C. filter (iv) L.C. filter**

**Correct Answer:** Summary of performance trade-offs for power supply filters.

**Solution:**

**Step 1: Understanding the Concept:**
Filters are used after rectifiers to smooth out the pulsating DC and remove AC ripples.

**Step 2: Detailed Explanation:**
**(i) Capacitor input filter:**
Advantage: Provides a high DC output voltage (near peak).
Disadvantage: High peak charging current can stress the rectifier diodes.

**(ii) Inductor filter:**
Advantage: Provides good ripple smoothing for heavy (low resistance) loads.
Disadvantage: Lower DC output voltage compared to capacitor filters; inductors are bulky.

**(iii) R.C. filter:**
Advantage: Very inexpensive, small size, and lightweight.
Disadvantage: Poor voltage regulation and significant power loss in the series resistor.

**(iv) L.C. filter ($\pi$ or L-type):**
Advantage: Excellent ripple reduction and high efficiency.
Disadvantage: Uses two large components (L and C), making it the most expensive and bulkiest option.

**Step 3: Final Answer:**
Capacitor filters are best for light loads, Inductor/LC for heavy loads, and RC for very cheap low-current circuits.

Quick Tip

Always use a capacitor filter if high DC voltage is your priority, and an L-C filter if high purity (low ripple) is your priority.

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