# GUJARAT TECHNOLOGICAL UNIVERSITY
**BE-1 SEMESTER– PAPER SOLUTION – SUMMER 2024**

## Subject Name & Code:
## Basic Electronics Engineering- 3110016

**Q.1** **(a)** Explain series positive clipper with diagram. **03**

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**Answer:**
**Series Positive Clipper**
A **clipper** is an electronic circuit used to "clip" or **remove a portion of the input waveform** without distorting the remaining part. A **series positive clipper** removes the **positive half** of the input signal.

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**Circuit Diagram:**

**Working:**
- **Positive Half Cycle:**
  - Diode becomes **forward-biased**.
  - It **conducts current**, acting like a short circuit.
  - No voltage appears across the load resistor **(Output = 0 V)** — **positive part is clipped**.
- **Negative Half Cycle:**
  - Diode is **reverse-biased**.
  - It **blocks current**, acting like an open circuit.
  - Entire negative voltage appears across the load resistor **(Output = Input)**.

**Waveforms:**
- **Input Waveform:** Full sine wave (positive + negative)
- **Output Waveform:** Only **negative half cycles** appear; **positive cycles are removed**.

**(b)** Draw and explain V-I characteristic of P-N junction diode. **04**

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**Answer:**
🔹 **V-I Characteristics of P-N Junction Diode:**
The **V-I characteristic** of a P-N junction diode shows the relationship between the **voltage (V)** applied across the diode and the resulting **current (I)** flowing through it.

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✅ **1. Forward Bias Region:**
- When the **P-side** is connected to the **positive terminal** and the **N-side** to the **negative terminal**, the diode is said to be in **forward bias**.
- A small forward voltage (~0.3 V for Ge and ~0.7 V for Si) is required to **overcome the barrier potential**.

- After this threshold, current increases **rapidly and exponentially**.

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✅ **2. Reverse Bias Region:**

- When the **P-side** is connected to the **negative terminal** and the **N-side** to the **positive terminal**, the diode is in **reverse bias**.
- Only a **very small leakage current** flows due to minority carriers.
- If reverse voltage exceeds a certain value (breakdown voltage), the diode enters **breakdown region** and large current flows, potentially damaging the diode.

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✅ **Diagram: V-I Characteristic of a P-N Junction Diode**

**Conclusion:**
The V-I characteristic curve of a P-N junction diode clearly shows that it **conducts current easily in forward bias** but **restricts current in reverse bias**, making it useful as a **rectifier** and **switching device**.

**(c)** Draw and Explain bridge rectifier. Explain advantage and disadvantage of bridge rectifier over full wave rectifier. **07**

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**Answer:**
**1. Introduction:**
A **bridge rectifier** is a type of **full-wave rectifier** that converts the **entire AC input** signal into **DC output** using **four diodes** arranged in a bridge configuration. It allows current to flow during both the **positive and negative half cycles** of the AC input.

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✅ **2. Circuit Diagram of Bridge Rectifier:**

**3. Working of Bridge Rectifier:**

🔷 **Positive Half Cycle:**

- Diodes **D1 and D3** become **forward biased** → they conduct.
- Diodes **D2 and D4** are **reverse biased** → they do not conduct.
- Current flows from the **positive terminal**, through **D1 → RL → D3**, and returns to the **AC source**.
- **Load receives positive voltage.**

🔷 **Negative Half Cycle:**

- Diodes **D2 and D4** become **forward biased** → they conduct.
- Diodes **D1 and D3** are **reverse biased** → they do not conduct.
- Current flows from the **now-positive lower terminal**, through **D2 → RL → D4**, and returns.
- Again, **load receives current in the same direction**.

Thus, both half cycles produce output in the **same direction**.

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✅ **4. Output Waveform:**

**5. Advantages of Bridge Rectifier over Center-Tap Full-Wave Rectifier:**

| Bridge Rectifier | Full-Wave Rectifier (Center Tap) |
|---|---|
| No center-tap transformer required | Requires center-tap transformer |
| Better transformer utilization | Only half of secondary winding is used |
| Higher output voltage for same input | Lower output due to center tap division |
| More efficient (both half-cycles used fully) | Less efficient |

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✅ **6. Disadvantages of Bridge Rectifier:**

- Uses **4 diodes**, so **more voltage drop** compared to full-wave rectifier (only 2 diodes).
- **Complex circuit** than center-tap design.

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✅ **7. Conclusion:**

The **bridge rectifier** is a widely used full-wave rectifier circuit that provides **better efficiency**, **higher output**, and **simpler transformer requirements**. It is preferred in **DC power supplies** and **electronic chargers**.

**Q.2** **(a)** Drive the relation between current gain α and β for CE configuration. **03**

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**Answer:**

In a transistor, the two important current gain parameters are:

- **α (alpha)**: Current gain in **common base (CB)** configuration

  α=IC/IE
- **β (beta)**: Current gain in **common emitter (CE)** configuration

  β=IC/IB

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**Derivation:**

We know that:

$$I_E = I_C + I_B \quad \text{(Kirchhoff's Current Law)}$$

Now divide both sides by $I_B$:

$$\frac{I_E}{I_B} = \frac{I_C}{I_B} + 1$$

Substitute:

- $\beta = \frac{I_C}{I_B}$
- $\alpha = \frac{I_C}{I_E} \Rightarrow I_C = \alpha I_E$

Now, from $\beta = \frac{I_C}{I_B}$, express $I_B$ as:

$$I_B = I_E - I_C = I_E - \alpha I_E = I_E(1 - \alpha)$$

Now,

$$\beta = \frac{I_C}{I_B} = \frac{\alpha I_E}{I_E(1-\alpha)} = \frac{\alpha}{1-\alpha}$$

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**Final Relations:**

$$\boxed{\beta = \frac{\alpha}{1-\alpha}} \quad \text{and} \quad \boxed{\alpha = \frac{\beta}{1+\beta}}$$

**(b)** Draw the symbol of NPN & PNP transistor. Also state the advantage of transistor. **04**

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**Answer:**
**Symbols of NPN and PNP Transistor:**
**(i) NPN Transistor Symbol:**

(ii) **PNP Transistor Symbol:**

**Advantages of Transistor:**

1. ✅ **Small size and lightweight** – Useful for compact electronic devices.
2. ✅ **Low operating voltage and current** – Efficient for battery-powered circuits.
3. ✅ **Long life and high reliability** – Solid-state device with no moving parts.
4. ✅ **Can be used as amplifier or switch** – Very versatile in applications.

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✅ **Conclusion:**
The **symbols of NPN and PNP transistors** help identify the direction of current flow. Transistors are widely used due to their **compactness**, **efficiency**, and **reliability** in modern electronics.

**(c)** Draw and explain input and output characteristic of transistor in CE configuration. **07**

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**Answer:**
**Introduction:**
In the **Common Emitter (CE)** configuration of a transistor, the **emitter terminal is common** to both input and output circuits.

- **Input is applied** between **Base and Emitter**.
- **Output is taken** between **Collector and Emitter**.

This configuration is widely used in amplifiers because it offers **high voltage gain and moderate current gain**.

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**1. Input Characteristics (IB vs VBE at constant VCE):**
✅ **Definition:**
It is the curve plotted between **Base current (IB)** and **Base-Emitter voltage (VBE)** at **constant Collector-Emitter voltage (VCE)**.
✅ **Explanation:**

- The input characteristics of a CE transistor resemble a **forward-biased diode**.
- As **VBE increases**, the **base current IB increases rapidly** after a threshold (~0.6–0.7V for silicon).
- The input resistance is **low** (hundreds of ohms).

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📈 **Input Characteristics Diagram:**

**2. Output Characteristics (IC vs VCE at constant IB):**
✅ **Definition:**
It is the curve plotted between **Collector current (IC)** and **Collector-Emitter voltage (VCE)** at **constant Base current (IB)**.
✅ **Explanation:**

- Initially, when VCE increases from 0, IC rises rapidly.
- After a certain VCE (called **saturation voltage**), IC becomes **almost constant**, indicating transistor is in **active region**.
- As IB increases, IC increases linearly ($IC \approx \beta \times IB$).

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📈 **Output Characteristics Diagram:**

**Regions in Output Characteristics:**

| Region | Description |
|---|---|
| **Cut-off** | IB = 0, transistor is OFF |
| **Active** | IC increases with IB |
| **Saturation** | Both junctions are forward biased; transistor fully ON |

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✅ **Conclusion:**
In CE configuration:

- **Input characteristics** resemble a diode curve.
- **Output characteristics** show transistor behavior in **cut-off**, **active**, and **saturation** regions.

- It is the most commonly used configuration for **amplifiers** due to its **high gain and stability**.

**OR**

**(c)** Compare CE, CB, and CC configuration with respect to different transistor characteristics. **07**

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**Answer:**

**Introduction:**

A transistor can be connected in three basic configurations based on which terminal is common to both input and output:

1. **Common Emitter (CE)**
2. **Common Base (CB)**
3. **Common Collector (CC)**

Each configuration exhibits different electrical characteristics such as gain, impedance, and phase relation, and is used in different electronic applications.

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📊 **Comparison of CE, CB, and CC Configurations:**

| Parameter | Common Emitter (CE) | Common Base (CB) | Common Collector (CC) |
|---|---|---|---|
| **Input Impedance** | Medium (1 kΩ to 5 kΩ) | Low (50 Ω to 500 Ω) | High (>100 kΩ) |
| **Output Impedance** | Medium | High | Low |
| **Current Gain (β or α)** | High (20 to 500) | Less than 1 (α ≈ 0.95–0.99) | High (same as CE) |
| **Voltage Gain** | High | High | Less than 1 |
| **Power Gain** | High | Medium | Medium |
| **Phase Shift Between Input and Output** | 180° (inverted output) | 0° (no phase shift) | 0° (no phase shift) |
| **Application** | Most general-purpose amplifiers | High-frequency amplifiers | Buffer or impedance matching |
| **Input Between** | Base and Emitter | Emitter and Base | Base and Collector |
| **Output Between** | Collector and Emitter | Collector and Base | Emitter and Collector |
| **Feedback Type** | Negative | Positive | Negative |
| **Signal Inversion** | Yes (inverts signal) | No | No |

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✅ **Conclusion:**

- **CE configuration** is widely used for **amplification** due to high voltage and current gain.
- **CB configuration** is preferred for **high-frequency applications** because of its low input capacitance and high voltage gain.
- **CC configuration** is used for **impedance matching** (as a **buffer** stage) due to its high input and low output impedance.

**Q.3** **(a)** Explain V-I characteristics of tunnel diode. **03**

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**Answer:**
**V-I Characteristics of Tunnel Diode**
A **tunnel diode** is a highly doped p-n junction diode that exhibits **negative resistance** due to the **quantum mechanical tunneling** effect.

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**V-I Characteristics Diagram:**

**Explanation of Regions:**

1. **Zero Bias:**
   - No current flows at zero voltage.
2. **Forward Bias (0 to Vp):**
   - As voltage increases, current increases rapidly due to **tunneling of electrons**.
   - At **peak point (Vp, Ip)**, maximum current flows.
3. **Negative Resistance Region (Vp to Vv):**
   - With further increase in voltage, the tunneling reduces.
   - Current **decreases** even though voltage increases.
   - This is called the **negative resistance region**.
   - The diode is **unstable** here.
4. **Valley Point (Vv, Iv):**
   - After this point, tunneling stops and normal diode conduction begins.
5. **Forward Bias Beyond Vv:**
   - The diode behaves like a normal forward-biased diode.
   - Current increases exponentially.
6. **Reverse Bias:**
   - In reverse bias, small tunneling current flows initially.
   - As reverse voltage increases, the diode eventually breaks down.

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**Important Points:**

- **Peak Point (Vp, Ip)**: Max current before negative resistance starts.
- **Valley Point (Vv, Iv)**: Min current before normal conduction resumes.
- Region between **Vp and Vv** is the **negative resistance region**.
- This unique property makes tunnel diodes useful in **oscillators** and **high-speed switching circuits**

**(b)** Explain Schottky diode in details. **04**

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**Answer:**
**Schottky Diode:**
A **Schottky diode** is a special type of semiconductor diode formed by the **junction of a metal (such as aluminum or platinum)** with a **n-type semiconductor** instead of a p-n junction. It is also known as a **hot-carrier diode**.

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✅ **Construction:**

- It consists of a **metal-semiconductor junction** (usually metal to n-type silicon).

- No depletion layer as in p-n junction diode.
- The junction has **low forward voltage drop** (typically 0.2 to 0.3 V).

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✅ **Working:**

- When **forward biased**, electrons move from the n-type semiconductor into the metal, resulting in **current conduction with very little voltage**.
- When **reverse biased**, it blocks current like a normal diode but **with a lower reverse breakdown voltage**.

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✅ **V-I Characteristic:**

- In forward bias, current increases rapidly at **lower voltage (~0.2–0.3 V)**.
- In reverse bias, a small leakage current flows until breakdown.

*(You may draw a curve similar to normal diode but starting at 0.2 V)*

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✅ **Advantages:**

1. 🔸 **Very fast switching speed**
2. 🔸 **Low forward voltage drop**
3. 🔸 **Low power loss and high efficiency**

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✅ **Applications:**

- Used in **high-frequency circuits**
- Power supplies
- RF and microwave applications
- Clamping and protection circuits

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✅ **Conclusion:**

A **Schottky diode** is a metal-semiconductor device known for its **low forward voltage drop** and **high switching speed**, making it suitable for **fast and efficient electronic circuits**.

**(c)** Comparison between P-N junction Diode and Zener Diode. **07**

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**Answer:**
**Introduction:**
Both **P-N junction diode** and **Zener diode** are semiconductor devices that allow current to flow in a specific direction. However, they differ significantly in construction, operation, and application — especially in **reverse bias condition**.

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### 📊 Comparison Table:

| Parameter | P-N Junction Diode | Zener Diode |
|---|---|---|
| **1. Definition** | A P-N diode allows current to flow in one direction only (forward bias). | A Zener diode is designed to operate in **reverse breakdown** region. |
| **2. Doping Level** | Normally doped | Heavily doped P-N junction |
| **3. Reverse Breakdown** | Not designed for reverse breakdown; may get damaged | Specially designed to **operate safely** in breakdown region |
| **4. Symbol** | | |

| | | |
|---|---|---|
| **5. Reverse Current** | Very small leakage current in reverse bias | Maintains constant voltage after breakdown |
| **6. Application** | Rectification in power supplies | Voltage regulation, over-voltage protection |
| **7. Operating Region** | Operates only in **forward bias** | Operates in **reverse breakdown region** |
| **8. Voltage Regulation** | Cannot regulate voltage | Used to **regulate voltage** at a fixed value |
| **9. VI Characteristic** | Sharp rise in forward, breakdown destroys in reverse | Sharp breakdown in reverse without damage |

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✅ **Diagram:**

**Conclusion:**

- The **P-N junction diode** is mainly used for **rectification**.
- The **Zener diode** is used for **voltage regulation** because it can operate reliably in the **reverse breakdown region**.

**OR**

**Q.3 (a)** Advantage, disadvantage and application of LED. **03**

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**Answer:**
**Advantages of LED:**

1. **Low Power Consumption** – LEDs require very little energy and are highly efficient.
2. **Long Life** – LEDs have a longer operational life (typically more than 50,000 hours).
3. **Fast Switching** – LEDs turn on and off instantly.
4. **Compact Size** – Small in size, making them suitable for compact circuits.
5. **Low Heat Output** – LEDs generate very little heat compared to incandescent bulbs.
6. **Environmentally Friendly** – No mercury or toxic materials used.

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❌ **Disadvantages of LED:**

1. **High Initial Cost** – More expensive than traditional light sources.
2. **Voltage Sensitivity** – LEDs require precise voltage and current regulation.
3. **Temperature Dependence** – Performance can be affected at very high temperatures.
4. **Limited Color Spectrum** – Though improving, pure white light is harder to achieve.

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💡 **Applications of LED:**

1. **Indicator Lamps** – Used in electronic devices as power indicators.
2. **Display Devices** – Used in digital watches, calculators, and display panels.
3. **Lighting** – Street lights, household lamps, and emergency lights.
4. **Optical Communication** – Used in remote controls and fiber optic communication.
5. **Signage** – Used in billboards, traffic signals, and decorative lighting.

**(b)** Compare PIN diode and Photo Diode. **04**

**Answer:**
The comparison between **PIN Diode** and **Photo Diode** is as follows:

| Parameter | PIN Diode | Photo Diode |
|---|---|---|
| 1. **Full Form** | P-type, Intrinsic, N-type Diode | Light-sensitive semiconductor diode |
| 2. **Construction** | Has an intrinsic (undoped) layer between P and N regions | Similar to P-N or PIN diode with transparent window |
| 3. **Function** | Works as a **high-speed switch** or **attenuator** | Converts **light into current** (used as sensor) |
| 4. **Biasing** | Usually operated under **forward bias** | Always operated under **reverse bias** |
| 5. **Light Sensitivity** | **Not light-sensitive** | **Light-sensitive** (generates current when exposed to light) |
| 6. **Applications** | Used in **RF, microwave circuits**, attenuators, and switches | Used in **optical communication**, light sensors, cameras |

✅ **Conclusion:**
While both are special types of diodes, the **PIN diode** is mainly used in **high-frequency applications**, and the **Photo diode** is used as a **light sensor** in optical systems.

**(c)** State the applications of Rectifier, and Comparison of Halfwave, Full-wave center- tap and Full-wave Bridge rectifier. **07**

**Answer:**
**1. Applications of Rectifier:**
A **rectifier** is an electronic device that **converts AC (alternating current) into DC (direct current)**. Rectifiers are widely used in various electronic systems where DC supply is required.

🔷 **Common Applications:**

1. **DC power supply circuits**
2. **Battery chargers**
3. **Radio and TV receivers**
4. **DC motor drives**
5. **Electronic measuring instruments**
6. **Welding equipment**
7. **Electroplating circuits**

✅ **2. Comparison of Rectifier Types:**

| Parameter | Half-wave Rectifier | Full-wave Center-tap Rectifier | Full-wave Bridge Rectifier |
|---|---|---|---|
| **Number of Diodes Used** | 1 | 2 | 4 |
| **Transformer Requirement** | No transformer required | Requires center-tap transformer | Does not require center-tap transformer |
| **Efficiency** | Low (~40.6%) | Higher (~81.2%) | Higher (~81.2%) |

| | | | |
|---|---|---|---|
| **PIV (Peak Inverse Voltage)** | High (equal to peak input voltage) | 2 × V<sub>m</sub> per diode | V<sub>m</sub> per diode |
| **Ripple Frequency** | Same as AC supply (f) | Twice the input frequency (2f) | Twice the input frequency (2f) |
| **Transformer Utilization** | Not used | Poor (only half secondary is used at a time) | Good (entire transformer secondary is used) |
| **Output Voltage** | Low | Higher than half-wave | Higher than half-wave |
| **Output Current** | Low | Higher | Higher |
| **Cost** | Cheapest | Moderate (requires center tap) | Moderate to high (4 diodes used) |
| **Complexity** | Very simple | Moderate | Slightly more complex |

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✅ **Conclusion:**

- **Half-wave rectifier** is simple and cheap but inefficient.
- **Full-wave center-tap rectifier** is better but needs a special transformer.
- **Bridge rectifier** gives the **best performance** using the **full AC waveform** and does not need a center-tap transformer.

**Q.4** **(a)** List out the salient feature of emitter follower. **03**

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**Answer:**
**Salient Features of Emitter Follower (Common Collector Amplifier):**
An **emitter follower** is a transistor circuit configuration where the **output is taken from the emitter terminal**, and the **input is applied at the base**. It is also called a **common collector (CC) amplifier**.

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🔹 **Salient Features:**

1. **Voltage Gain ≈ 1:**
   - The emitter follower provides **unity voltage gain** or slightly less than 1.
   - It **does not amplify voltage** but follows the input.
2. **High Input Impedance:**
   - It offers **very high input resistance**, which minimizes the loading effect on the previous stage.
3. **Low Output Impedance:**
   - The output impedance is very low, making it suitable for **impedance matching** between high and low impedance stages.
4. **No Phase Shift:**
   - The output signal is **in phase** with the input signal (i.e., 0° phase shift).
5. **Power Gain is High:**
   - While voltage gain is low, it provides **good current and power gain**.
6. **Excellent Buffer Stage:**
   - Commonly used as a **buffer amplifier** because of its impedance transformation properties.

**(b)** Classification of Logic families in details. **04**

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**Answer:**
A **logic family** is a group of electronic logic gates constructed using one particular type of electronic device. Logic families are primarily classified based on the **technology** used in their design.

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🔹 **Main Classification of Logic Families:**

**1. Bipolar Logic Families**
These use **bipolar junction transistors (BJT)** for logic operations.

- **(i) RTL (Resistor-Transistor Logic):**
  Uses resistors and transistors. Low speed and high power consumption. Obsolete.
- **(ii) DTL (Diode-Transistor Logic):**
  Uses diodes for input logic and transistor for amplification.
- **(iii) TTL (Transistor-Transistor Logic):**
  Most popular bipolar logic family. High speed and moderate power.
  **Variants:** Standard TTL, Low-Power TTL, High-Speed TTL, Schottky TTL
- **(iv) ECL (Emitter Coupled Logic):**
  Very high-speed logic family. Consumes more power. Used in high-speed applications.

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**2. Unipolar Logic Families**
These use **MOSFETs (Metal-Oxide-Semiconductor Field Effect Transistors)**.

- **(i) CMOS (Complementary MOS):**
  Uses both p-type and n-type MOSFETs.
  **Advantages:** Low power consumption, high noise immunity.
  Widely used in modern digital circuits.
- **(ii) NMOS (N-type MOS Logic):**
  Uses only N-channel MOSFETs. Faster than PMOS but consumes more power.
- **(iii) PMOS (P-type MOS Logic):**
  Uses only P-channel MOSFETs. Slower and obsolete now.

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✅ **Comparison Summary:**

| Logic Family | Technology | Power | Speed | Use Today |
|---|---|---|---|---|
| TTL | Bipolar BJT | Moderate | Fast | Yes (limited) |
| ECL | Bipolar BJT | High | Very fast | Rare |
| CMOS | MOSFET | Very low | Moderate | Widely used |
| NMOS/ PMOS | MOSFET | Low | Moderate | Mostly obsolete |

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✅ **Conclusion:**
Logic families are classified into **bipolar** and **MOS-based families**. Among them, **CMOS** is the most widely used today due to its **low power**

**consumption** and **high integration capability**.

**(c)** Explain application of Transistor as a switch. **07**

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**Answer:**
**1. Introduction:**
A **transistor** can be used not only as an amplifier but also as a **switch** in digital and power electronics. When operated in the **cut-off** and **saturation** regions, it behaves like an **electronic ON/OFF switch**.

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✅ **2. Transistor as a Switch – Basic Concept:**

- The transistor is used in **Common Emitter (CE)** configuration.
- Input signal is given to the **base** through a resistor.
- The **load (e.g., LED, relay, motor)** is connected to the **collector**.
- When base current is applied, the transistor turns ON, and current flows through the load.

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✅ **3. Working Principle:**

| Condition | Transistor Region | Output Condition |
|---|---|---|
| No base current (I<sub>B</sub> = 0) | **Cut-off** | Transistor is **OFF** → No current flows through collector. Output = HIGH. |
| Base current applied (I<sub>B</sub> > 0) | **Saturation** | Transistor is **ON** → Current flows through collector. Output = LOW. |

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✅ **4. Circuit Diagram:**

**5. Applications of Transistor as a Switch:**

1. **Switching LEDs** or **buzzers**
2. **Driving relays** in control systems
3. **Pulse generation circuits**
4. **Digital logic circuits**
5. **Motor drivers**
6. **Timer circuits** (e.g., in 555 timer applications)
7. **Power regulation circuits**

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✅ **6. Advantages:**

- Fast switching (microseconds to nanoseconds)
- Low power consumption
- Compact and reliable
- Can handle both analog and digital signals

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✅ **7. Conclusion:**
A transistor acts as an efficient **electronic switch** when operated between **cut-off and saturation**. It plays a vital role in **digital electronics**, **automation**, and **embedded systems** where ON/OFF control is required.

**OR**

**Q.4** **(a)** Explain Negative Clamping circuit with diagram. **03**

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**Answer:**
**Negative Clamping Circuit**
A **clamping circuit** shifts the **entire waveform** either above or below the zero voltage level **without changing the shape** of the waveform.
A **negative clamping circuit** moves the waveform **downward**, so the entire signal lies **below the zero reference level**.

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🔧 **Circuit Diagram:**

**Components:**
- Diode (D)
- Capacitor (C)
- Resistor (R)

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⚙️ **Working:**
- During the **positive half cycle** of the input:
  - The diode **conducts** (forward-biased).
  - Capacitor **charges** to the peak voltage ($V_m$) of the input.
- During the **negative half cycle**:
  - The diode becomes **reverse-biased** (open circuit).
  - The charged capacitor now acts as a **voltage source**, shifting the entire waveform **downward**.
- As a result, the **output waveform is clamped negatively**, i.e., its **peak goes below 0V**.

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📈 **Output Waveform:**
- The output waveform has **same shape as input**, but is **shifted downward**, such that the **maximum value touches zero** and the **rest goes negative**.

**(b)** Explain why NAND and NOR gate are called universal gate. **04**

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**Answer:**
**Universal Gates:**
A **universal gate** is a logic gate that can be used to construct **any other basic logic gate** such as **AND**, **OR**, and **NOT**.
The **NAND** and **NOR** gates are called **universal gates** because **any Boolean logic function** can be implemented using **only NAND or only NOR gates**.

---

🔹 **Why NAND is Universal:**
- NAND gate can be used to create:
  - **NOT gate** → by connecting both inputs of NAND together
  - **AND gate** → by using NAND followed by a NAND as inverter
  - **OR gate** → using a combination of NAND and inverters

📌 Hence, NAND alone is sufficient to realize all logic functions.

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🔹 **Why NOR is Universal:**
- NOR gate can be used to create:

- **NOT gate** → by connecting both inputs of NOR together
- **OR gate** → by using NOR followed by a NOR as inverter
- **AND gate** → using a combination of NOR and inverters

📌 Therefore, NOR alone can also implement all logic operations.

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✅ **Conclusion:**
Since **NAND** and **NOR** gates can be used to construct **all other logic gates**, they are called **universal gates** and are widely used in **digital circuit design**.

**(c)** Discuss MOSFET in details. **07**

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**Answer:**
**1. Introduction:**
**MOSFET** stands for **Metal Oxide Semiconductor Field Effect Transistor**. It is a type of **FET (Field Effect Transistor)** used widely in analog and digital electronics. It is a **voltage-controlled device** with **high input impedance**, widely used in **amplifiers, switches, and digital ICs**.

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✅ **2. Types of MOSFET:**
MOSFETs are mainly classified into two types:
1. **Enhancement Type MOSFET**
2. **Depletion Type MOSFET**

Each of these comes in **n-channel** and **p-channel** versions.

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✅ **3. Construction of MOSFET:**
- It has **three terminals**: **Gate (G), Drain (D), Source (S)**.
- The **gate** is insulated from the channel by a thin layer of **silicon dioxide ($SiO_2$)**.
- This insulation provides **very high input resistance**.
- The **substrate** is usually connected to the source terminal.

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✅ **4. Symbol of MOSFET:**

**5. Working Principle:**
MOSFET operates by controlling the **flow of charge carriers** in a semiconductor channel between **source and drain** terminals.

🔹 **Enhancement Type:**
- No channel exists by default.
- A **positive voltage at gate (VGS)** creates an **n-channel** by attracting electrons.
- Current starts flowing from drain to source when **VGS > threshold voltage (Vth)**.

🔹 **Depletion Type:**
- Channel exists naturally.
- Applying **negative VGS** depletes the channel and reduces current.

---

✅ **6. V-I Characteristics:**
**Output Characteristics (ID vs VDS):**
- For **VGS below threshold**, no current flows.

- As **VDS increases**, current rises and then saturates.
- Device enters **cut-off, linear, and saturation** regions.

(*You should draw labeled graph of ID vs VDS for various VGS*)

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✅ **7. Applications of MOSFET:**

1. **Switching devices** in digital electronics
2. **Power amplifiers**
3. **Motor control circuits**
4. **Analog signal processing**
5. **CMOS technology** in integrated circuits
6. **Voltage-controlled resistors and capacitors**

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✅ **8. Advantages:**

- **Very high input impedance**
- **Low power consumption**
- **Compact and easy for IC fabrication**
- **Fast switching speed**

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✅ **9. Disadvantages:**

- Sensitive to **electrostatic discharge (ESD)**
- More **complex to handle** compared to BJT in power circuits

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✅ **Conclusion:**

The **MOSFET** is a highly efficient, **voltage-controlled device** that dominates modern **digital and analog electronic applications**. Due to its high input impedance and low power consumption, it is widely used in **microprocessors, memory chips, and switching circuits**.

**Q.5** **(a)** Define the use of Coupling capacitor. **03**

---

**Answer:**

**Use of Coupling Capacitor**

A **coupling capacitor** is used in amplifier circuits to **connect (or couple)** two stages of a circuit **without allowing DC components to pass** from one stage to the next. It **blocks DC** and **passes AC signals**.

---

🔹 **Definition:**

A **coupling capacitor** is a capacitor that is placed between two stages of an amplifier circuit to **transfer the AC signal** while **blocking DC voltage** from affecting the next stage.

---

🔧 **Use / Purpose:**

1. **Blocks DC component:**
   - Prevents **DC bias** of one stage from disturbing the biasing of the next stage.
2. **Passes AC signal:**
   - Allows **AC signal** (useful information) to pass from one stage to another.
3. **Maintains biasing stability:**

- Keeps the **biasing of each stage independent**, improving performance and preventing distortion.

4. **Used in amplifier stages:**
    - Commonly used between **transistor amplifier stages** (like CE → CE or CE → CC).

---

📝 **Example in Amplifier Circuit:**
In a **common emitter amplifier**, a coupling capacitor is connected between the **collector of the first stage** and the **base of the second stage** to transfer the signal.

**(b)** Give Comparison of BJT and FET. **04**

---

**Answer:**
The comparison between **BJT (Bipolar Junction Transistor)** and **FET (Field Effect Transistor)** is given below:

| Parameter | BJT (Bipolar Junction Transistor) | FET (Field Effect Transistor) |
|---|---|---|
| 1. **Type of Device** | Current-controlled device | Voltage-controlled device |
| 2. **Current Flow** | Involves both electrons and holes (bipolar) | Involves either electrons or holes (unipolar) |
| 3. **Input Impedance** | Low | High |
| 4. **Noise** | More noise | Less noise |
| 5. **Thermal Stability** | Less | Better |
| 6. **Gain** | High current gain | High voltage gain |
| 7. **Power Consumption** | More | Less |
| 8. **Applications** | Amplifiers, switches, analog circuits | High-speed and low-noise applications, integrated circuits |

---

✅ **Conclusion:**

- **BJT** is preferred for **high gain and linear amplification**.
- **FET** is ideal where **low power, high input impedance**, and **low noise** are required.

**(c)** Draw symbol and explain all logic gates in details. **07**

---

**Answer:**
**1. Introduction:**
**Logic gates** are the basic building blocks of digital circuits. They perform **logical operations** on one or more binary inputs to produce a single binary output. The basic logic gates are:

1. AND Gate
2. OR Gate
3. NOT Gate
4. NAND Gate
5. NOR Gate
6. XOR Gate
7. XNOR Gate

Each gate follows a **truth table** based on **Boolean algebra**.

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## ✅ 2. Basic Logic Gates and Their Explanation:

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### 🔷 (1) AND Gate

- **Symbol:**
- **Boolean Expression:**
  Y = A · B (A AND B)
- **Truth Table:**

| A | B | Y (A · B) |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

- **Explanation:**
  Output is **1 only when both inputs are 1**.

---

### 🔷 (2) OR Gate

- **Symbol:**
- **Boolean Expression:**
  Y = A + B (A OR B)
- **Truth Table:**

| A | B | Y (A + B) |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

- **Explanation:**
  Output is **1 if any one input is 1**.

---

### 🔷 (3) NOT Gate

- **Symbol:**
- **Boolean Expression:**
  Y = $\bar{A}$ (NOT A)
- **Truth Table:**

| A | Y ($\bar{A}$) |
|---|---|
| 0 | 1 |
| 1 | 0 |

- **Explanation:**
  Output is the **inverse of input**.

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## ✅ 3. Universal Logic Gates

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### 🔷 (4) NAND Gate

- **Symbol:**

- **Boolean Expression:**
  $Y = \overline{(A \cdot B)}$
- **Truth Table:**

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

- **Explanation:**
  Output is **0 only when both inputs are 1**.

---

### 🔷 (5) NOR Gate

- **Symbol:**

- **Boolean Expression:**
  $Y = \overline{(A + B)}$
- **Truth Table:**

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

- **Explanation:**
  Output is **1 only when both inputs are 0**.

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## ✅ 4. Exclusive Logic Gates

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### 🔷 (6) XOR Gate (Exclusive OR)

- **Symbol:**

- **Boolean Expression:**
  $Y = A \oplus B = \overline{A}B + A\overline{B}$
- **Truth Table:**

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |

| | | |
|---|---|---|
| 1 | 1 | 0 |

- **Explanation:**
  Output is **1 when inputs are different**.

---

### 🔷 (7) XNOR Gate (Exclusive NOR)

- **Symbol:**

- **Boolean Expression:**
  $Y = A \odot B = AB + \overline{A}\,\overline{B}$
- **Truth Table:**

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

- **Explanation:**
  Output is **1 when inputs are equal**.

---

### ✅ Conclusion:

Logic gates are the foundation of digital electronics. Understanding their **symbols, functions, and truth tables** is essential for designing **combinational and sequential logic circuits**.

**OR**

**Q.5** **(a)** Explain the properties and application of common base amplifier. **03**

---

**Answer:**
**Common Base Amplifier: Properties and Applications**
A **common base (CB) amplifier** is a type of single-stage transistor amplifier where the **base terminal is common** to both the **input and output** circuits.

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### 🔷 Properties of Common Base Amplifier:

1. **Input is applied between** emitter and base.
2. **Output is taken from** collector and base.
3. **Base is grounded** for both AC and DC signals.
4. **Input impedance is very low** (approx. 50–100 Ω).
5. **Output impedance is high** (approx. 1–10 kΩ).
6. **Current gain (α)** is less than 1 (typically around 0.98).
7. **Voltage gain is high.**
8. **Power gain is moderate.**
9. **Phase difference:** Input and output signals are **in-phase** (0° phase shift).

---

### 🔶 Applications of Common Base Amplifier:

1. **High-frequency amplifiers:**
   - Used in **VHF and UHF circuits** due to **low input capacitance** and **high-frequency response**.

2. **Impedance matching:**
   - Suitable for applications where **low input impedance** and **high output impedance** are required.
3. **RF amplifiers:**
   - Used in **radio transmitters and receivers** for signal amplification.
4. **Buffer stages:**
   - Used between stages to prevent loading due to **low input impedance**

**(b)** State advantage, disadvantage and application of FET. **04**

---

**Answer:**

**Advantages of FET (Field Effect Transistor):**

1. **High input impedance** – reduces the loading effect on the preceding stage.
2. **Low power consumption** – due to small input current.
3. **Low noise operation** – suitable for sensitive signal amplification.
4. **Thermal stability** – better than BJT under temperature variation.
5. **Voltage controlled device** – makes circuit design simpler.

---

🔹 **Disadvantages of FET:**

1. **Lower gain** – compared to BJT in certain applications.
2. **More sensitive to static electricity** – especially MOSFETs.
3. **Limited frequency response** – especially in high power operations.
4. **Complex manufacturing** – especially for integrated circuits.

---

🔹 **Applications of FET:**

1. Used in **amplifiers** (low-noise, high-impedance amplifiers).
2. Used in **oscillators and mixers** in RF circuits.
3. Commonly used in **analog switches and buffer stages**.
4. Widely used in **CMOS logic circuits and VLSI design**.
5. Preferred in **automotive and industrial control** due to reliability.

---

✅ **Conclusion:**

FETs are widely used in modern electronics due to their **low power, high input impedance**, and **low noise** characteristics, making them essential in **amplification and switching** applications.

**(c)** Give comparison between different types of digital logic families. **07**

---

**Answer:**

**1. Introduction:**

Digital logic families are groups of **electronic logic gates** that are built using similar internal circuitry. Each family has its own electrical characteristics such as **speed, power consumption, voltage levels**, and **fan-out**. The two main categories of logic families are:

- **Bipolar families** (e.g., TTL)
- **Unipolar families** (e.g., CMOS)

Each logic family is suitable for specific applications depending on the required speed, power, and cost.

---

## ✅ 2. Types of Digital Logic Families:

The commonly used digital logic families include:

1. **TTL (Transistor-Transistor Logic)**
2. **CMOS (Complementary Metal-Oxide Semiconductor)**
3. **ECL (Emitter Coupled Logic)**
4. **RTL (Resistor-Transistor Logic)**
5. **DTL (Diode-Transistor Logic)**

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## 📊 3. Comparison Table of Digital Logic Families:

| Parameter | TTL | CMOS | ECL | RTL | DTL |
|---|---|---|---|---|---|
| **Technology** | Bipolar | MOSFET | Bipolar | Bipolar | Bipolar |
| **Speed** | Moderate | Moderate to High | Very High | Low | Low |
| **Power Consumption** | High | Very Low | Very High | High | High |
| **Noise Margin** | Medium | High | Low | Low | Low |
| **Fan-out** | 10 | >50 | 25 | 5 | 5 |
| **Power Supply Voltage** | +5V | 3V to 15V | –5.2V | +5V | +5V |
| **Switching Speed (ns)** | 10–30 ns | 50–200 ns (older), 1–10 ns (modern) | <1 ns | 100+ ns | 50–100 ns |
| **Cost** | Low | Low | High | Very Low | Low |
| **Integration Level** | SSI, MSI, LSI | SSI to VLSI | SSI | SSI | SSI |
| **Application** | General purpse, microprocessors | Battery-operated systems, ICs | High-speed computing, supercomputers | Historical use only | Replaced by TTL |

---

## ✅ 4. Conclusion:

- **TTL** is widely used in general-purpose logic circuits.
- **CMOS** is preferred for **low power and high-density** IC applications.
- **ECL** is used in **very high-speed systems** despite high power use.
- **RTL** and **DTL** were used in early logic circuits and are now largely obsolete.

Understanding the **characteristics and comparison** of logic families helps engineers choose the **right family for specific digital applications**.

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