Subject Name Solutions

4311102 – Summer 2024

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1 [14 marks]

Solution

0.0.1 Question 1(1) [2 marks]

Define resistor and give its unit.

Solution

A resistor is an electronic component that opposes the flow of electric current. Its unit is Ohm (Ω).

Table 1: Resistor Properties

Property	Description
Symbol	
Unit	Ohm (Ω)
Function	Limits current flow

Mnemonic

"Resistors Oppose Current" (ROC)

0.0.2 Question 1(2) [2 marks]

Give two examples of active and passive components each.

Solution

Table 2: Electronic Components Classification

Active Components	Passive Components
1. Transistors	1. Resistors
2. Diodes	2. Capacitors

Mnemonic

"TARD" - Transistors And Resistors Differ

0.0.3 Question 1(3) [2 marks]

Draw symbols of any two semiconductor devices.

Solution

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
```

```
    subgraph Diode
        A[Plus] {-{-}{} B["|{}|"] {-}{-}{} C[Minus]}
    end

    subgraph NPN\_Transistor
        D[C] {-{-}{} E}
        F[E] {-{-}{} E}
        G[B] {-{-}{} E}
    end
{Highlighting}
{Shaded}
```

Mnemonic

"Diodes Direct, Transistors Transfer"

0.0.4 Question 1(4) [2 marks]

Differentiate between intrinsic and extrinsic semiconductor.

Solution

Table 3: Intrinsic vs Extrinsic Semiconductors

Intrinsic	Extrinsic
Pure semiconductor without impurities	Semiconductor with added impurities
Equal number of holes and electrons	Unequal holes and electrons
Examples: Pure Silicon, Germanium	Examples: Silicon doped with Phosphorus

Mnemonic

"Pure In, Doped Ex"

0.0.5 Question 1(5) [2 marks]

LED stands for ____________________________.

Solution

LED stands for **Light Emitting Diode**.
Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Light] {-{-}{} B[Emitting] {-}{-}{} C[Diode]}
    style A fill:\#f96,stroke:\#333
    style B fill:\#9cf,stroke:\#333
    style C fill:\#f9f,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Light Emitters Dazzle"

0.0.6 Question 1(6) [2 marks]

State any two applications of Photo-diode.

Solution

Table 4: Photo-diode Applications

Application	How it works
Light sensors	Converts light to electrical current
Optical communication	Detects optical signals in fiber optics

Mnemonic

"Light Sensing Communication" (LSC)

0.0.7 Question 1(7) [2 marks]

List the types of transistor and draw their symbols.

Solution

Types of Transistors:

1. NPN Transistor
2. PNP Transistor

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph "NPN"
    A[C] {-{-}{-} B {-}{-}{-} C[E]}
    D[B] {-{-}{-} B}
    end
    subgraph "PNP"
    E[E] {-{-}{-} F {-}{-}{-} G[C]}
    H[B] {-{-}{-} F}
    end
{Highlighting}
{Shaded}
```

Mnemonic

"Not Pointing iN, Pointing outP"

0.0.8 Question 1(8) [2 marks]

Give the value of forward voltage drop of Germanium and Silicon diode.

Solution

Table 5: Forward Voltage Drop Values

Diode Type	Forward Voltage Drop
Germanium	0.3V
Silicon	0.7V

Mnemonic

"Germanium's Three, Silicon's Seven" (0.3V, 0.7V)

0.0.9 Question 1(9) [2 marks]

The ______________________________ diode can be used as a light detector.

Solution

The **Photodiode** can be used as a light detector.
Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Light] {-{-}{}|detected by| B[Photodiode]}
    B {-{-}{}|generates| C[Current]}
    style A fill:\#ff9,stroke:\#333
    style B fill:\#9cf,stroke:\#333
    style C fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Photo Detects Light" (PDL)

0.0.10 Question 1(10) [2 marks]

Define Q-factor of a coil.

Solution

Q-factor (Quality factor) of a coil is the ratio of its inductive reactance to its resistance, indicating how efficiently it stores energy.

Table 6: Q-Factor

Parameter	Description
Formula	Q = XL/R
Higher Q	Better quality, less energy loss
Lower Q	Poor quality, more energy loss

Mnemonic

"Quality equals Reactance over Resistance" (QRR)

Question 2(a) [3 marks]

Explain colour coding method of resistor.

Solution

Resistor color coding uses colored bands to indicate resistance value and tolerance.

Table 7: Resistor Color Code

Color	Digit	Multiplier
Black	0	10^0
Brown	1	10^1
Red	2	10^2
Orange	3	10^3
Yellow	4	10^4

For a 4-band resistor:

- First band: First digit
- Second band: Second digit
- Third band: Multiplier
- Fourth band: Tolerance

Mnemonic

"Bad Boys Race Our Young Girls But Violet Generally Wins" (Colors in order: Black, Brown, Red, Orange, Yellow, Green, Blue, Violet, Grey, White)

Question 2(a) OR [3 marks]

Explain Light Dependent Resistor with its characteristics.

Solution

LDR is a resistor whose resistance decreases when light intensity increases.
Characteristics of LDR:

Table 8: LDR Properties

Parameter	Behavior
Dark condition	High resistance (MΩ)
Bright condition	Low resistance (kΩ)
Response time	Few milliseconds

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Increase Light] {-{-}{}|Causes| B[Decrease Resistance]}
    C[Decrease Light] {-{-}{}|Causes| D[Increase Resistance]}
    style A fill:\#ff9,stroke:\#333
    style B fill:\#9cf,stroke:\#333
    style C fill:\#999,stroke:\#333
    style D fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Light Up, Resistance Down" (LURD)

Question 2(b) [3 marks]

Explain classification of capacitors in detail.

Solution

Capacitors are classified based on dielectric material and construction.

Table 9: Capacitor Classifications

Type	Dielectric	Applications
Ceramic	Ceramic	High frequency
Electrolytic	Aluminum oxide	Power supplies
Polyester	Plastic film	General purpose
Tantalum	Tantalum oxide	Small, high capacity

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Capacitors] {-{-}{} B[Fixed]}
    A {-{-}{} C[Variable]}
    B {-{-}{} D[Ceramic]}
    B {-{-}{} E[Electrolytic]}
    B {-{-}{} F[Polyester/Film]}
    C {-{-}{} G[Air Gang]}
    C {-{-}{} H[Trimmer]}
    style A fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"CEPT" (Ceramic, Electrolytic, Polyester, Tantalum)

Question 2(b) OR [3 marks]

Explain classification of inductor in detail.

Solution

Inductors are classified based on core material and construction.

Table 10: Inductor Classifications

Type	Core	Characteristics
Air core	Air	Low inductance, low losses
Iron core	Iron	High inductance, high losses
Ferrite core	Ferrite	Medium inductance, low losses
Toroidal	Ring shaped	High efficiency, low EMI

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Inductors] {-{-}{} B[Air Core]}
    A {-{-}{} C[Iron Core]}
    A {-{-}{} D[Ferrite Core]}
    A {-{-}{} E[Toroidal]}
    style A fill:\#9cf,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Air Iron Ferrite Toroid" (AIFT)

Question 2(c) [4 marks]

State and explain Faraday's laws of Electromagnetic Induction.

Solution

Faraday's laws explain how electromagnetic induction works.
Faraday's First Law: When a magnetic field linked with a conductor changes, an EMF is induced in the conductor.
Faraday's Second Law: The magnitude of induced EMF is proportional to the rate of change of magnetic flux.

Table 11: Faraday's Laws Summary

Law	Statement	Formula
First Law	Change in magnetic field induces EMF	-
Second Law	EMF rate of change of flux	$E = -N(d\Phi/dt)$

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Moving Magnet] {-{-}{}|Creates| B[Changing Magnetic Field]}
    B {-{-}{}|Induces| C[EMF in Conductor]}
    style A fill:\#f96,stroke:\#333
    style B fill:\#9cf,stroke:\#333
    style C fill:\#ff9,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Change Magnetic Field, Create Electric Current" (CMFCEC)

Question 2(c) OR [4 marks]

Enlist specifications of capacitors and explain two in detail.

Solution

Specifications of Capacitors:

1. Capacitance value
2. Voltage rating
3. Tolerance
4. Leakage current
5. Temperature coefficient

Detailed Explanation:
Capacitance Value: The amount of charge a capacitor can store per volt, measured in Farads (F).
Voltage Rating: The maximum voltage that can be applied without damaging the capacitor.

Table 12: Capacitor Specifications

Specification	Description	Typical Values
Capacitance	Charge storage capacity	pF to mF
Voltage Rating	Maximum safe voltage	16V, 25V, 50V, etc.

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Capacitor Specifications] {-{-}{} B[Capacitance Value]}
    A {-{-}{} C[Voltage Rating]}
    A {-{-}{} D[Tolerance]}
    A {-{-}{} E[Leakage Current]}
    A {-{-}{} F[Temperature Coefficient]}
    style A fill:\#9cf,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Capacitors Very Tolerant of Low Temperatures" (CVTLT)

Question 2(d) [4 marks]

Write colour band of 47Ω$\pm 5\% resistance.$

Solution

For 47Ω$\pm 5\% resistor, the color bands are:$

Table 13: Color Bands for 47Ω±5%

Band	Color	Represents
1st band	**Yellow**	**4**
2nd band	**Violet**	**7**
3rd band	**Black**	$\times 10^0$
4th band	**Gold**	$\pm 5\%$

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Yellow] {-{-}{}|4| B[Violet] {-}{-}{}|7| C[Black] {-}{-}{}|10^{0}| D[Gold] {-}{-}{}|5\%| E[47Ω5\%
    style A fill:\#ff9,stroke:\#333
    style B fill:\#f0f,stroke:\#333
    style C fill:\#000,stroke:\#fff
    style D fill:\#fd0,stroke:\#333
    style E fill:\#fff,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Yellow Violets Bring Gold" (The colors of the bands)

Question 2(d) OR [4 marks]

Calculate value of resistor and tolerance for a given colour code: Brown, Black, yellow.

Solution

Table 14: Interpretation of Brown, Black, Yellow

Band	Color	Value	Meaning
1st	Brown	1	First digit
2nd	Black	0	Second digit
3rd	Yellow	10^4	Multiplier

Calculation: 1st digit: 1 2nd digit: 0 Multiplier: 10^4
Value = 10 $\times 10^4 = 100,000 = 100k$
No 4th band means $\pm 20\% tolerance$
Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Brown] {-{-}{}|1| B[Black] {-}{-}{}|0| C[Yellow] {-}{-}{}|10^{4}| D[100kΩ 20\%]}
    style A fill:\#a52a2a,stroke:\#333
    style B fill:\#000,stroke:\#fff
    style C fill:\#ff0,stroke:\#333
    style D fill:\#fff,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Big Black Yield" (Brown-Black-Yellow)

Question 3(a) [3 marks]

Define doping. Give the name of semiconductor materials fabricated by doping with an example of each.

Solution

Doping is the process of adding impurities to a pure semiconductor to modify its electrical properties.

Table 15: Doped Semiconductors

Type	Dopant Added	Example	Majority Carriers
P-type	Trivalent (Boron, Gallium)	Silicon doped with Boron	Holes
N-type	Pentavalent (Phosphorus, Arsenic)	Silicon doped with Phosphorus	Electrons

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Pure Semiconductor] {-{-}{} B[Add Trivalent Impurity] {-}{-}{} C[P{-}type]}
    A {-{-}{} D[Add Pentavalent Impurity] {-}{-}{} E[N{-}type]}
    style A fill:\#9cf,stroke:\#333
    style C fill:\#f96,stroke:\#333
    style E fill:\#99f,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Positive has Plus Holes, Negative has Numerous Electrons" (PHNE)

Question 3(a) OR [3 marks]

Define Ripple factor, Peak Inverse Voltage (PIV), Rectification efficiency.

Solution

Table 16: Rectifier Terms

Term	Definition	Formula
Ripple Factor	**Measure of AC component in rectified output**	**r = Vrms(AC)/Vdc**
Peak Inverse Voltage	**Maximum reverse voltage a diode can withstand**	**-**
Rectification Efficiency	**Ratio of DC output power to AC input power**	**= (Pdc/Pac)** $\times 100\%$

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Rectifier Parameters] {-{-}{} B[Ripple Factor]}
    A {-{-}{} C[Peak Inverse Voltage]}
    A {-{-}{} D[Rectification Efficiency]}
    style A fill:\#9cf,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Ripples Peak Efficiently" (RPE)

Question 3(b) [3 marks]

Explain working of Crystal diode.

Solution

Crystal diode is a point-contact diode made with a semiconductor crystal.

Table 17: Crystal Diode Properties

Property	Description
Construction	Metal point contact on semiconductor crystal
Function	Rectification of high frequency signals
Application	Radio signal detection

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[RF Signal] {-{-}{} B[Crystal Diode] {-}{-}{} C[Rectified Signal]}
    style A fill:\#9cf,stroke:\#333
    style B fill:\#f96,stroke:\#333
    style C fill:\#9f9,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Crystal Detects Radio Frequencies" (CDRF)

Question 3(b) OR [3 marks]

Explain working of photodiode.

Solution

Photodiode converts light energy into electrical current when operated in reverse bias.

Table 18: Photodiode Characteristics

Parameter	Behavior
Light condition	Generates electron-hole pairs
Reverse current	Increases with light intensity
Speed	Fast response time

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Light] {-{-}{}|Strikes| B[PN Junction]}
    B {-{-}{}|Creates| C[Electron{-}Hole Pairs]}
    C {-{-}{}|Produces| D[Current Flow]}
    style A fill:\#ff9,stroke:\#333
    style D fill:\#9cf,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Light In, Current Out" (LICO)

Question 3(c) [4 marks]

Explain half-wave rectifier with circuit diagram and waveforms.

Solution

Half-wave rectifier converts AC to pulsating DC by allowing current flow only during positive half cycles.
Circuit Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[AC Input] {-{-}{-} B[Transformer] {-}{-}{-} C[Diode] {-}{-}{-} D[Load Resistor] {-}{-}{-} E[Groun
    E {-{-}{-} A}
    style A fill:\#9cf,stroke:\#333
    style D fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Waveforms:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph "Input AC"
    A[+Vp] {-{-}{-} B[(0)] {-}{-}{-} C[{-}Vp]}
    end
    subgraph "Output DC"
    D[+Vp] {-{-}{-} E[(0)] {-}{-}{-} F[(0)]}
    end
    style A fill:\#9cf,stroke:\#333
    style C fill:\#9cf,stroke:\#333
    style D fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Table 19: Half-Wave Rectifier Properties

Parameter	Value
Ripple Factor	**1.21**
Efficiency	**40.6%**
Output Frequency	**Same as input**

Mnemonic

"Half Wave Passes Half" (HWPH)

Question 3(c) OR [4 marks]

Explain full-wave rectifier with circuit diagram and waveforms.

Solution

Full-wave rectifier converts both halves of AC input to pulsating DC output.
Circuit Diagram (Bridge type):

Mermaid Diagram (Code)

```
{Shaded}
```

```
{Highlighting}[]
graph LR
    A[AC Input] {-{-}{-} B[D1]}
    A {-{-}{-} C[D3]}
    B {-{-}{-} D[D2] {-}{-}{-} E[+Output]}
    C {-{-}{-} F[D4] {-}{-}{-} G[{-}Output]}
    E {-{-}{-} H[Load] {-}{-}{-} G}
    style A fill:\#9cf,stroke:\#333
    style H fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Waveforms:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph "Input AC"
    A[+Vp] {-{-}{-} B[(0)] {-}{-}{-} C[{-}Vp] {-}{-}{-} B}
    end
    subgraph "Output DC"
    D[+Vp] {-{-}{-} E[(0)] {-}{-}{-} D}
    end
    style A fill:\#9cf,stroke:\#333
    style C fill:\#9cf,stroke:\#333
    style D fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Table 20: Full-Wave Rectifier Properties

Parameter	Value
Ripple Factor	**0.48**
Efficiency	**81.2%**
Output Frequency	**Twice the input**

Mnemonic

"Full Wave Makes Full Use" (FWMFU)

Question 3(d) [4 marks]

Draw and explain VI characteristics of PN junction diode.

Solution

VI Characteristics:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph "Forward Bias"
    A[Vf] {-{-}{} B[If]}
    end
    subgraph "Reverse Bias"
    C[Vr] {-{-}{} D[Ir]}
    E[Breakdown] {-{-}{} F[Reverse Current Increases]}
    end
    style A fill:\#9cf,stroke:\#333
```

```
    style C fill:\#f96,stroke:\#333
    style E fill:\#f00,stroke:\#333
{Highlighting}
{Shaded}
```

Table 21: PN Junction Diode Characteristics

Region	Behavior
Forward Bias	Current increases exponentially after 0.7V (Si)
Reverse Bias	Very small leakage current flows
Breakdown	Occurs at high reverse voltage, current increases rapidly

Forward Bias: Positive voltage to P-side, current flows easily after threshold. Reverse Bias: Positive voltage to N-side, only small leakage current flows.

Mnemonic

"Forward Flows, Reverse Restricts" (FFRR)

Question 3(d) OR [4 marks]

Write difference between P-type and N-type semiconductor.

Solution

Table 22: P-type vs N-type Semiconductor

Property	P-type	N-type
Dopant	Trivalent (Boron, Gallium)	Pentavalent (Phosphorus, Arsenic)
Majority Carriers	Holes	Electrons
Minority Carriers	Electrons	Holes
Electrical Charge	Relatively Positive	Relatively Negative
Conductivity	Lower than N-type	Higher than P-type

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    subgraph "P{-type"}
    A[Silicon] {-{-}{-} B[Boron]}
    C[Holes] {-{-}{-} D[+]}
    end
    subgraph "N{-type"}
    E[Silicon] {-{-}{-} F[Phosphorus]}
    G[Electrons] {-{-}{-} H[{-}]}
    end
    style C fill:\#f96,stroke:\#333
    style G fill:\#9cf,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Positive has Plus Holes, Negative has Numerous Electrons" (PHNE)

Question 4(a) [3 marks]

Explain the principle of operation of LED.

Solution

LED (Light Emitting Diode) emits light when forward biased due to electron-hole recombination.
Principle of Operation: When forward biased, electrons from N-side move to P-side and recombine with holes, releasing energy as photons (light).

Table 23: LED Operation

Process	Result
Forward bias	Current flows
Electron-hole recombination	Energy release
Energy band gap	Determines color

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Forward Bias] {-{-}{}|Causes| B[Current Flow]}
    B {-{-}{}|Creates| C[Electron{-}Hole Recombination]}
    C {-{-}{}|Releases| D[Photons or Light]}
{Highlighting}
{Shaded}
```

Mnemonic

"Forward Current Emits Light" (FCEL)

Question 4(a) OR [3 marks]

State applications of LED.

Solution

Table 24: LED Applications

Application	Advantage
Display indicators	Low power consumption
Digital displays	Varied colors available
Lighting	Energy efficient
Remote controls	Infrared communication
Traffic signals	Long life, high visibility

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[LED Applications] {-{-}{} B[Indicators]}
    A {-{-}{} C[Displays]}
    A {-{-}{} D[Lighting]}
    A {-{-}{} E[Communication]}
    A {-{-}{} F[Signals]}
    style A fill:\#9cf,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Display Lights In Clever Signals" (DLICS)

Question 4(b) [4 marks]

Explain Zener diode as voltage regulator.

Solution

Zener diode maintains constant output voltage despite input voltage fluctuations when operated in reverse breakdown region.
Circuit:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Unregulated DC] {-{-}{-} B[Series Resistor] {-}{-}{-} C[Output]}
    C {-{-}{-} D[Zener Diode] {-}{-}{-} E[Ground]}
    C {-{-}{-} F[Load] {-}{-}{-} E}
    style A fill:\#9cf,stroke:\#333
    style C fill:\#9f9,stroke:\#333
    style D fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Working:

- **Series resistor limits current**
- **Zener operates in breakdown region**
- **Maintains constant voltage across load**

Table 25: Zener Regulator Characteristics

Parameter	Description
Voltage regulation	Maintains constant output despite input changes
Power rating	Must handle power dissipation
Temperature stability	Output varies slightly with temperature

Mnemonic

"Zeners Break to Regulate" (ZBR)

Question 4(b) OR [4 marks]

Give limitations of zener voltage regulator.

Solution

Table 26: Limitations of Zener Voltage Regulator

Limitation	Effect
Power Dissipation	Limited by zener power rating
Current Capacity	Can handle only small loads
Temperature Sensitivity	Output varies with temperature
Efficiency	Poor efficiency due to power loss in series resistor
Noise	Generates electrical noise

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Zener Limitations] {-{-}{} B[Power Limits]}
    A {-{-}{} C[Current Limits]}
    A {-{-}{} D[Temperature Effects]}
    A {-{-}{} E[Efficiency Issues]}
    A {-{-}{} F[Noise Generation]}
    style A fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Power Current Temperature Efficiency Noise" (PCTEN)

Question 4(c) [7 marks]

Discuss the necessity of filter circuit in rectifier. List various types of filter circuits used in rectifier and explain any one with neat diagram.

Solution

Necessity of Filter Circuit: Rectifier output contains AC ripple that must be removed for smoother DC. Filters reduce these ripples to provide steady DC output.

Types of Filter Circuits:

1. Capacitor filter (Shunt capacitor)
2. LC filter
3. -filter (Pi-filter)
4. RC filter

Explanation of Capacitor Filter:

Circuit Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Rectifier Output] {-{-}{-} B[+]}
    B {-{-}{-} C[Load]}
    B {-{-}{-} D[Capacitor]}
    C {-{-}{-} E[Ground]}
    D {-{-}{-} E}
    style A fill:\#9cf,stroke:\#333
```

```
    style C fill:\#f96,stroke:\#333
    style D fill:\#9f9,stroke:\#333
{Highlighting}
{Shaded}
```

Working:

- Capacitor charges during voltage peaks
- Discharges slowly during voltage drops
- Maintains output voltage between peaks
- Reduces ripple voltage

Table 27: Capacitor Filter Characteristics

Parameter	Effect
Capacitance value	Higher value gives less ripple
Ripple reduction	Typically reduces by 70-80%
Load current	Higher load current causes more ripple
Frequency	Higher frequency is easier to filter

Waveforms:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph "Rectifier Output"
    A[Pulsating DC]
    end
    subgraph "Filter Output"
    B[Smoother DC]
    end
    style A fill:\#f96,stroke:\#333
    style B fill:\#9f9,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Capacitors Hold Voltage During Drops" (CHVDD)

Question 5(a) [3 marks]

Define e-waste. List common e-waste items.

Solution

E-waste refers to discarded electronic devices and components that have reached the end of their useful life.

Table 28: Common E-waste Items

Category	Examples
Computing devices	Computers, laptops, tablets
Communication devices	Mobile phones, telephones
Home appliances	TVs, refrigerators, washing machines
Electronic components	Circuit boards, batteries, cables
Office equipment	Printers, scanners, copiers

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[E{-waste] {-}{-}{} B[Computing]}
    A {-{-}{} C[Communication]}
    A {-{-}{} D[Home Appliances]}
    A {-{-}{} E[Components]}
    A {-{-}{} F[Office Equipment]}
    style A fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Computers, Communication, Components, Home Appliances" (CCCHA)

Question 5(b) [3 marks]

State and explain various strategies of e-waste management.

Solution

Table 29: E-waste Management Strategies

Strategy	Description
Reduce	Minimize purchase of new electronics
Reuse	Extend life through repair and repurposing
Recycle	Process e-waste to recover valuable materials
Responsible disposal	Use authorized e-waste collection centers
Extended producer responsibility	Manufacturers take back end-of-life products

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[E{-waste Management] {-}{-}{} B[Reduce]}
    A {-{-}{} C[Reuse]}
    A {-{-}{} D[Recycle]}
    A {-{-}{} E[Responsible Disposal]}
    A {-{-}{} F[Extended Producer Responsibility]}
    style A fill:\#9cf,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"3R's

Question 5(c) [4 marks]

Explain transistor as switch.

Solution

Transistor can function as an electronic switch by operating in either cutoff (OFF) or saturation (ON) region.

Table 30: Transistor Switch Operation

State	Condition	Behavior
OFF (Cutoff)	Base current = 0	No collector current flows
ON (Saturation)	Base current sufficient	Maximum collector current flows

Circuit Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[+Vcc] {-{-}{-} B[Rc] {-}{-}{-} C[Collector]}
    C {-{-}{-} D[Emitter] {-}{-}{-} E[Ground]}
    F[Vin] {-{-}{-} G[Rb] {-}{-}{-} H[Base]}
    H {-{-}{-} D}
    style F fill:\#9cf,stroke:\#333
    style A fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Working:

- **When input is HIGH: Transistor saturates, acts like closed switch**
- **When input is LOW: Transistor cuts off, acts like open switch**

Mnemonic

"No Base No Current, Apply Base Connect Circuit" (NBNC-ABC)

Question 5(d) [4 marks]

Derive relation between and for CE configuration of transistor.

Solution

In transistors, (alpha) and (beta) are current gain parameters.
Definitions:

- ** = IC/IE (Common Base current gain)**
- ** = IC/IB (Common Emitter current gain)**

Derivation: Since IE = IC + IB, we can write: = IC/IE = IC/(IC + IB)
Dividing numerator and denominator by IB: = (IC/IB)/[(IC/IB) + 1] = /(+ 1)
Therefore: = /(1-)

Table 31: Relationship between and

Parameter	Formula	Typical Range
from	= /(+1)	0.9 to 0.99
from	= /(1-)	50 to 300

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[alpha = IC divided by IE] {-{-}{-} B[beta = IC divided by IB]}
    C[beta = alpha divided by 1 minus alpha] {-{-}{-} D[alpha = beta divided by beta plus 1]}

    style A fill:\#9cf,stroke:\#333
    style B fill:\#f96,stroke:\#333
{Highlighting}
{Shaded}
```

Mnemonic

"Beta equals Alpha divided by One minus Alpha" (BAOA)