Subject Name Solutions

4321103 – Summer 2024

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Explain amplifier parameters Ai, Ri and Ro for CE configuration.

Solution

In Common Emitter (CE) configuration, the key parameters are:

Diagram:

```
   +Vcc
     |
     R
     |
     |C
B{-{-}{-}{-}|{-}{-}{-}{-}+{-}{-}{-}{-}Output}
     |    |
     |   RC
  RB |    |
     |    |
  {-{-}{-}|    |{-}{-}{-}}
 |   |    |   |
 |   |    |   |
 +{-{-}{-}+{-}{-}{-}{-}+{-}{-}{-}+}
     |
     |
    GND
```

- **Current Gain (Ai)**: Ratio of output current to input current (Ic/Ib), typically 50-200 in CE
- **Input Resistance (Ri)**: Opposition to input current at base terminal, ranges from 1-2kΩ in CE
- **Output Resistance (Ro)**: Opposition at collector terminal, typically 50kΩ in CE

Mnemonic

"CIR parameters - Current gain, Input resistance, and output Resistance determine amplifier performance"

Question 1(b) [4 marks]

Write short-note on heat sink.

Solution

Diagram:

```
                    Fins
          |  |  |  |  |  |  |  |  |
          |   |   |   |   |   |   |   |   |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+   |   |   |   |   |   |   |   |}
| Transistor|\_\_\_|\_\_\_|\_\_\_|\_\_\_|\_\_\_|\_\_\_|\_\_\_|\_\_\_|
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
     Base
```

- **Purpose**: Dissipates excess heat from electronic components to prevent thermal damage
- **Types**: Passive heat sinks (aluminum/copper fins) and active heat sinks (with fans)
- **Thermal Resistance**: Lower thermal resistance ($^{/}W)indicatesbetterheatdissipation$
- **Materials**: Copper (best conductivity), aluminum (lightweight, cost-effective), composite

Mnemonic

"HARD sinks - Heat Away using Radiation and Dissipation through metal sinks"

Question 1(c) [7 marks]

Describe Thermal Runaway and Thermal Stability. How can overcome thermal run away in transistor?

Solution

Diagram:

```
flowchart LR
    A[Heat Generation] {-{-} B[Increased Temperature]}
    B {-{-} C[Increased Ic]}
    C {-{-} D[More Power Dissipation]}
    D {-{-} A}
    E[Thermal Stability Methods] {-{-} F[Break this cycle]}
```

Thermal Runaway:

- **Definition**: Self-accelerating process where transistor heats up, causing more current flow and further heating
- **Cause**: Increase in temperature increases Ico (leakage current) which increases Ic
- **Result**: Eventual destruction of transistor if unchecked

Thermal Stability:

- **Definition**: Ability to maintain stable operating point despite temperature changes
- **Measure**: Stability factor (S) - lower values indicate better stability

Overcoming Thermal Runaway:

- **Heat Sinks**: Attach to dissipate excess heat
- **Emitter Resistor**: Include unbypassed RE to provide negative feedback
- **Voltage Divider Bias**: Use instead of fixed bias for better stability
- **Thermal Compensation**: Add temperature-sensitive components in the bias circuit

Mnemonic

"SHEER protection - Sinks for Heat, Emitter resistors, External cooling, and Robust biasing prevent thermal runaway"

Question 1(c) OR [7 marks]

Write down types of biasing methods. Explain the voltage divider biasing method in details.

Solution

Types of Biasing Methods:

Table 1: Transistor Biasing Methods

Method	Stability	Complexity
Fixed Bias	Poor	Simple
Collector Feedback	Medium	Medium
Emitter Bias	Good	Medium
Voltage Divider	Excellent	Complex

Voltage Divider Biasing Circuit:

```
    +Vcc
      |
     R1
      |
     +{-{-}{-}{-}+}
      |    |
     R2   C1
      |    |
     +{-{-}{-}{-}+{-}{-}{-} Base}
      |
      |    +{-{-}{-}{-}+}
      |    |    |
     RE   RC   C2
      |    |    |
     +{-{-}{-}{-}+{-}{-}{-}{-}+{-}{-}{-} Output}
      |
    GND
```

Voltage Divider Biasing:

- **Circuit Structure**: Uses two resistors (R1, R2) in series to create stable voltage at base
- **Operating Principle**: Voltage at R2 sets base bias, remains stable despite variations
- **Advantage**: Most stable biasing technique with excellent temperature compensation
- **Formula**: Base voltage VB = Vcc $\times (R2/(R1+R2))$
- **Stability**: High stability factor as base voltage is nearly independent of collector current

Mnemonic

"DIVE for stability - Divider Is Very Effective for temperature and variations"

Question 2(a) [3 marks]

Explain Stability Factor with features.

Solution

Diagram:

```
flowchart LR
    A[Temperature Changes] {-{-} B\{Stability Factor S\}}
    B {-{-}|High S| C[Unstable Circuit]}
    B {-{-}|Low S| D[Stable Circuit]}
```

- **Definition**: Stability factor (S) measures how collector current changes with leakage current
- **Formula**: S = ΔIC/ΔICBO
- **Ideal Value**: Lower value (S ≈ 1)$indicates better stability$
- **Factors Affecting**: Biasing circuit design, temperature, and transistor parameters

Mnemonic

"LESS is better - Lower values Ensure Stable System for temperature changes"

Question 2(b) [4 marks]

Describe direct coupling technique of cascading.

Solution

Diagram:

```
    +Vcc
```

```
       |
       |
       RC1     RC2
       |       |
       +{-{-}{-}{-}{-}+ |}
       |     | |
    +{-{-}+     +{-}+{-}{-}+}
    |  |     |    |
Q1  |C |    C|    | Q2
    |  |     |    |
    +{-{-}+     +{-}+{-}{-}+}
    |  |     | |
    E  |     E |
    |  |     | |
    +{-{-}+     +{-}+}
       |       |
       RE1     RE2
       |       |
      GND     GND
```

- **Definition**: Direct connection between collector of first stage to base of second stage
- **Advantages**: No coupling components needed, excellent low-frequency response
- **Disadvantages**: DC levels must be matched, thermal drift compounds across stages
- **Applications**: DC amplifiers, integrated circuits, operational amplifiers

Mnemonic

"DIAL for DC - Direct Interconnection Amplifies Low frequencies without capacitors"

Question 2(c) [7 marks]

Explain frequency response of two stages RC coupled amplifier.

Solution

Frequency Response Curve:

```
    Gain (dB)
    \^{}
    |                 \_\_\_\_\_\_\_\_\_\_\_\_
    |               /           {}
    |              /             {}
    |             /               {}
    |            /                 {}
    |{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}/                   {-}{-}{-}{-}Frequency}
              f1                    f2
        Low frequency    Mid frequency    High frequency
          region           region          region
```

Two-Stage RC Coupled Amplifier:

- **Circuit Structure**: Two transistor amplifiers connected via coupling capacitors
- **Low-Frequency Response (f < f1)**: Gain drops due to coupling and bypass capacitor effects
- **Mid-Frequency Response (f1 < f < f2)**: Maximum gain region, flat response
- **High-Frequency Response (f > f2)**: Gain drops due to internal capacitances and Miller effect
- **Bandwidth**: Range between lower cutoff (f1) and upper cutoff (f2) frequencies
- **Overall Gain**: Product of individual stage gains minus coupling losses

Mnemonic

"LMH frequency regions - Low has rising gain, Middle has flat gain, High has falling gain"

Question 2(a) OR [3 marks]

Briefly explain bandwidth and gain-bandwidth product of an amplifier.

Solution

Diagram:

```
Gain (dB)
\^{}
|     \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
|    /|              {}
|   / |               {}
|  /  |                {}
| /   |                 {}
|/    |                  {}
+{-{-}{-}{-}{-}|{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}|{-}{-}{-}{-}{-} Frequency}
      f1                  f2
      |{{-}{-}{-}Bandwidth{-}{-}{-}{-}|}
```

- **Bandwidth**: Frequency range between lower (f1) and upper (f2) cutoff frequencies where gain is at least 70.7% of maximum
- **Formula**: Bandwidth = f2 - f1 (measured in Hz)
- **Gain-Bandwidth Product**: Constant value of gain multiplied by bandwidth for a given amplifier
- **Significance**: Represents fundamental limitation of amplifier performance

Mnemonic

"BIG value - Bandwidth and gain Inverse relationship is a Given constant"

Question 2(b) OR [4 marks]

Explain effects of emitter bypass capacitor and coupling capacitor on frequency response of an amplifier.

Solution

Table 2: Capacitor Effects on Frequency Response

Capacitor Type	Low Frequency	Mid Frequency	High Frequency
Emitter Bypass	Affects gain	Full bypass	No effect
Coupling	Blocks signal	Full coupling	No effect

Effects of Capacitors:

Emitter Bypass Capacitor:

- **Purpose**: Bypasses emitter resistor to increase gain
- **Low Frequency**: Acts as high impedance, reduces gain
- **Formula**: Xc = 1/(2 fC) increases at low frequencies
- **Cutoff Effect**: Sets lower cutoff frequency with RE

Coupling Capacitor:

- **Purpose**: Blocks DC, allows AC signal between stages
- **Low Frequency**: High reactance blocks signal transfer
- **Response Impact**: Larger capacitance improves low-frequency response
- **Phase Shift**: Creates phase shift at low frequencies

Mnemonic

"CABLE effect - Capacitors Act as Barriers at Low frequencies, improving at higher frequencies"

Question 2(c) OR [7 marks]

Compare transformer coupled amplifier and RC coupled amplifier.

Solution

Table: Comparison of Transformer Coupled vs RC Coupled Amplifiers

Parameter	Transformer Coupled	RC Coupled
Coupling Element	Transformer	Capacitor & Resistor
Efficiency	Higher (90%)	Lower (30-50%)
Frequency Response	Limited, poor at extremes	Wide, better at low freq
Size & Weight	Bulky, heavy	Compact, lightweight
Cost	Higher	Lower
Impedance Matching	Excellent	Poor
Distortion	Lower	Higher
DC Isolation	Complete	Good

Diagram Comparison:

```
Transformer Coupled              RC Coupled
    +Vcc                            +Vcc
      |                               |
     RC                              RC
      |                               |
     +-----|OOOO|-----+              +-------||------+
      |     |OOOO|     |              |      CC      |
     C     |OOOO|     C              C              C
      |                |              |              |
     +                +              +              +
      |                |              |              |
    GND              GND            GND            GND
```

Mnemonic

"TREE factors - Transformers provide Robust Efficiency and Excellent impedance matching, RC provides Cost savings"

Question 3(a) [3 marks]

Describe the transistorized tuned amplifier.

Solution

Circuit Diagram:

```
    +Vcc
      |
      |
     +{-{-}{-}{-}+}
      |    |
     L    C
      |    |
     +{-{-}{-}{-}+}
      |
     C1
      |
     +{-{-}{-}{-}+{-}{-}{-}Output}
      |    |
     Q    RC
      |    |
     +{-{-}{-}{-}+}
      |
    GND
```

- **Definition**: Amplifier with LC tank circuit in collector to amplify specific frequency band

- **Principle**: LC circuit resonates at fr = 1/(2), providing maximum gain at resonance
- **Bandwidth**: Narrower than RC amplifiers, determined by Q factor of the tuned circuit
- **Applications**: RF amplifiers, radio receivers, wireless communication circuits

Mnemonic

"TRIP to resonance - Tuned Resonant circuits Improve Performance at specific frequencies"

Question 3(b) [4 marks]

Explain in brief Direct coupled amplifier.

Solution

Circuit Diagram:

```
    +Vcc
      |
     RC2
      |
     +{-{-}{-}{-}{-}{-}+{-}{-}{-}Output}
      |      |
      C      RC1
      |      |
     +{-{-}{-}{-}{-}+}
      |
      E
      |
    GND
```

- **Definition**: Multi-stage amplifier where stages connect directly without coupling components
- **Working**: Collector of first stage directly connects to base of next stage
- **Advantages**: Excellent low-frequency response, fewer components, compact design
- **Disadvantages**: DC bias problems, thermal stability issues, limited gain per stage

Mnemonic

"COLD advantages - Compact design, Outstanding low-frequency response, Less components, Direct connection"

Question 3(c) [7 marks]

Describe the importance of h parameters in two port network. Draw h-parameters circuit for CE amplifier.

Solution

h-parameter Equivalent Circuit for CE:

```
                RC
      +{-{-}{-}{-}{-}+    |}
      |     |     |
Input |    +++    | Output
 o{-{-}{-}{-}+{-}{-}{-}||{-}{-}{-}{-}o}
      |    +++    |
      |     |     |
      +{-{-}+{-}{-}+    |}
         |        |
        +++       |
        GND       |
```

Importance of h-parameters:

- **Universal Application**: Works for all transistor configurations (CE, CB, CC)
- **Easy Measurement**: Parameters can be directly measured using simple circuits
- **Complete Characterization**: Fully describes transistor behavior with four parameters
- **Circuit Analysis**: Simplifies complex transistor circuit analysis
- **Temperature Independence**: Relatively stable over normal operating temperatures

h-parameters for CE:

- **h11 (hie)**: Input impedance with output short-circuited
- **h12 (hre)**: Reverse voltage transfer ratio
- **h21 (hfe)**: Forward current gain ( )
- **h22 (hoe)**: Output admittance with input open-circuited

Mnemonic

"FINE parameters - Four Interconnected Network Elements define transistor completely"

Question 3(a) OR [3 marks]

Compare transformer coupled amplifier and direct coupled amplifier.

Solution

Table 3: Transformer vs Direct Coupled Amplifiers

Parameter	Transformer Coupled	Direct Coupled
DC Isolation	Complete	None
Low Freq Response	Poor	Excellent
Size	Bulky	Compact
Impedance Matching	Excellent	Poor
Distortion	Low	Can be high
Cost	High	Low
Complexity	Medium	Simple

Mnemonic

"TIP for selection - Transformer for Impedance matching and Power transfer, Direct for low frequencies"

Question 3(b) OR [4 marks]

Draw and Explain circuit diagram of common emitter amplifier.

Solution

CE Amplifier Circuit:

```
     +Vcc
       |
       RC
       |
       +{-{-}{-}{-}||{-}{-}{-}o Output}
       |    CC
       |
    +{-{-}+}
    |  |
    |  C
    |  |
 {-{-}{-}+{-}{-}+{-}{-}{-}}
 |  |  |  |
 |  |  |  |
 +{-{-}+{-}{-}+{-}{-}+}
    |
```

```
   RE
   |
  GND
```

- **Configuration**: Input at base, output from collector, emitter is common to both
- **Characteristics**: Voltage gain ~50-500, current gain ~50-200, phase shift 180°
- **Advantages**: High voltage gain, medium input impedance, good voltage amplification
- **Applications**: Audio amplifiers, radio frequency amplifiers, switching circuits

Mnemonic

"GAIN characteristics - Good Amplification with Inverted output and Notable efficiency"

Question 3(c) OR [7 marks]

Draw Transistor Two Port Network and describe h-parameters for it. Write down advantages of hybrid parameters.

Solution

Two-Port Network Diagram:

```
      +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
      |             |
 I1 {-{-}+             +{-}{-}{-} I2}
      |   Two{-Port  |}
 V1 {-{-}+   Network   +{-}{-}{-} V2}
      |             |
      +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

h-parameters Equations:

- V1 = h11I1 + h12V2
- I2 = h21I1 + h22V2

h-parameters Description:

- **h11**: Input impedance (Ω) with output short-circuited
- **h12**: Reverse voltage transfer ratio (dimensionless)
- **h21**: Forward current gain (dimensionless)
- **h22**: Output admittance (Siemens) with input open-circuited

Advantages of Hybrid Parameters:

- **Easy Measurement**: Each parameter can be measured individually
- **Standard Notation**: Universal acceptance in industry and academics
- **Accurate Model**: Provides precise modeling of transistor behavior
- **Configuration Flexibility**: Applicable to all transistor configurations
- **Temperature Stability**: Relatively stable over operating temperature range

Mnemonic

"SMART parameters - Simple Measurement, Accurate modeling, Reliable, Temperature-stable"

Question 4(a) [3 marks]

Explain Darlington pair and its applications.

Solution

Darlington Pair Circuit:

```
   +{-{-}+}
   |  |
   |  C1    +{-{-}+}
 {-{-}{-}+{-}{-}+{-}{-}{-}{-}{-}| |}
```

```
  |   |   |      |  C2   Output
  |   |  +{-{-}{-}{-}{-}|  |{-}{-}{-}{-}{-}o}
  |  B1 |      |   |
 o{-{-}{-}{-}{-}+{-}{-}{-}{-}{-}|  |}
    |     B2 |   |
   E1{-{-}{-}{-}{-}{-}{-}|  |}
            E2 |
             {-{-}|{-}{-}}
              GND
```

- **Definition**: Configuration of two transistors where emitter of first drives base of second
- **Characteristics**: Very high current gain (1×2), *highinputimpedance*
- **Drawbacks**: Higher saturation voltage, reduced switching speed
- **Applications**: Power amplifiers, motor drivers, touch-sensitive switches, Darlington ICs

Mnemonic

"HIGH gain - Hugely Increased Gain from Harnessing two transistors"

Question 4(b) [4 marks]

Describe the diode clamper circuit with necessary diagram.

Solution

Positive Clamper Circuit:

```
              D
    Input o{-{-}{-}||{-}{-}{-}+{-}{-}{-}o Output}
             |      |
             C      R
             |      |
             +{-{-}{-}{-}{-}+}
             |
            GND
```

- **Definition**: Circuit that shifts waveform up/down by adding DC component
- **Types**: Positive clamper (shifts up), negative clamper (shifts down)
- **Working Principle**: Capacitor charges during first half-cycle, then maintains DC level
- **Applications**: TV sync pulse restoration, pulse modulation circuits, waveform processing

Mnemonic

"CAPS effect - Capacitor And diode Pair Shifts signal by exact DC level"

Question 4(c) [7 marks]

Explain the construction, working and applications of OLED.

Solution

OLED Structure:

```
       +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
       | Cathode (Metal)|
       +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
       | Emissive Layer |
       +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
       |Conductive Layer|
       +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
       |   Anode (ITO)  |
```

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
|   Substrate    |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

OLED Construction:

- **Layers**: Substrate, anode (ITO), conductive layer, emissive layer, cathode
- **Materials**: Organic semiconductor materials between electrodes
- **Types**: PMOLED (passive matrix) and AMOLED (active matrix)

Working Principle:

- **Mechanism**: Electric current causes organic material to emit light via electroluminescence
- **Process**: Electrons and holes recombine in emissive layer to produce photons
- **Efficiency**: Direct light emission without backlight, high efficiency

Applications:

- **Displays**: Smartphones, TVs, wearables, digital cameras
- **Lighting**: Flexible and transparent lighting panels
- **Signage**: High-contrast digital signs and billboards

Mnemonic

"OLED benefits - Organic materials, Lightweight design, Efficient operation, Direct emission, Stunning contrast"

Question 4(a) OR [3 marks]

Explain Short note on LDR.

Solution

LDR Symbol and Structure:

```
Symbol              Structure
                   +{-{-}{-}{-}{-}{-}{-}{-}+}
 /     {            |///////|}
+       +           |///////|
|       |           +{-{-}{-}{-}{-}{-}{-}{-}+}
+       +
 {     /}
```

- **Definition**: Light Dependent Resistor, a photoresistor whose resistance decreases with light
- **Material**: Cadmium sulfide (CdS) or cadmium selenide (CdSe)
- **Principle**: Photoconductivity - light energy releases electrons, increasing conductivity
- **Applications**: Light sensors, automatic lighting controls, camera exposure systems

Mnemonic

"DARK increases resistance - Decreasing light And Rising darkness Keep resistance high"

Question 4(b) OR [4 marks]

Describe the diode clipper circuit with necessary diagram.

Solution

Positive Clipper Circuit:

```
          R
Input o{-{-}{-}www{-}{-}{-}+{-}{-}{-}o Output}
                 |
                 |
               \_\_|\_\_
               {   /}
```

```
                    { /}
                     V
                     |
                    GND
```

- **Definition**: Circuit that limits (clips) portions of input waveform above/below threshold
- **Types**: Positive clipper (clips positive), negative clipper (clips negative), biased clipper
- **Working Principle**: Diode conducts when signal exceeds threshold, limiting output
- **Applications**: Waveform shaping, protection circuits, signal conditioning

Mnemonic

"CLIP waves - Circuit Limits Input Peaks by using diode conduction"

Question 4(c) OR [7 marks]

Explain Half Wave and Full wave Voltage Doubler.

Solution

Half-Wave Voltage Doubler:

```
         D1
AC o{-{-}{-}{-}{-}{-}||{-}{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}o Output}
Input                |    (+2Vp)
           |         |
           C1        C2
           |         |
          GND       GND
```

Full-Wave Voltage Doubler:

```
         D1
AC o{-{-}{-}{-}{-}{-}||{-}{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}o Output}
Input     |          |    (+2Vp)
          |          |
          C1         C2
          |          |
          |    D2    |
          +{-{-}{-}||{-}{-}{-}+}
          |
         GND
```

Half-Wave Voltage Doubler:

- **Operation**: During negative half cycle, C1 charges to peak voltage; during positive cycle, output becomes 2Vp
- **Output**: Pulsating DC with peak value twice input peak
- **Ripple**: Higher ripple content
- **Efficiency**: Lower than full-wave

Full-Wave Voltage Doubler:

- **Operation**: Both half cycles contribute to output, with each capacitor charging during alternate cycles
- **Output**: Smoother DC with peak value twice input peak
- **Ripple**: Lower ripple content
- **Efficiency**: Higher than half-wave

Applications:

- **High voltage generation**: CRT displays, photomultipliers
- **Power supplies**: Low current, high voltage applications
- **Cascade connection**: For voltage multiplication beyond doubling

Mnemonic

"CHASE 2V - Capacitors Hold Alternating Supply Energy to produce 2×$Voltage''$

Question 5(a) [3 marks]

Draw circuit diagram for +5v Power Supply using its IC and explain in brief.

Solution

5V Power Supply using 7805:

```
        D1    D2
    o{-{-}{-}||{-}{-}{-}||{-}{-}{-}+{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}o}
AC       |         |     |        +5V
Input    +{-{-}||{-}{-}+ |    7805      Output}
         |  D3   | |     |
         +{-{-}||{-}{-}+ |     |}
         |  D4     C1    C2
         |         |     |
    o{-{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}o}
                GND
```

- **Components**: Bridge rectifier (D1-D4), filter capacitor (C1), 7805 regulator, output capacitor (C2)
- **Working**: AC converted to DC by rectifier, filtered by C1, regulated to exact 5V by 7805
- **Features**: Short-circuit protection, thermal shutdown, up to 1A current capability
- **Applications**: Digital circuits, microcontrollers, electronics projects

Mnemonic

"FIRM voltage - Filtered Input, Regulated by 7805 Makes stable voltage"

Question 5(b) [4 marks]

Discuss load regulation and line regulation in reference to power supply.

Solution

Regulation Performance Curves:

```
    Vout           Vout
     \^{              \^{}}
     |              |
     |{-{-}            |{-}{-}}
     |  {           |  }
     |   { Load     |    Line}
     |    {         |    }
     +{-{-}{-}{-}{-}{-}{-}      +{-}{-}{-}{-}{-}{-}{-}}
           Iload           Vin
```

Load Regulation:

- **Definition**: Ability to maintain constant output voltage despite load current changes
- **Formula**: % Load Regulation = ((VNL - VFL)/VFL) $\times$100
- **Importance**: Ensures stable voltage for varying load demands
- **Ideal Value**: 0% (no change in output voltage with load changes)

Line Regulation:

- **Definition**: Ability to maintain constant output despite input voltage variations
- **Formula**: % Line Regulation = (ΔVout/ΔVin) $\times$100
- **Importance**: Protects circuits from mains voltage fluctuations
- **Ideal Value**: 0% (no change in output voltage with input changes)

Mnemonic

"LIVER health - Line regulation for Input Variations, load regulation for External Resistance changes"

Question 5(c) [7 marks]

Explain adjustable voltage regulator using LM317 with circuit diagram.

Solution

LM317 Adjustable Regulator Circuit:

```
                 R1
     +Vin o{-{-}{-}+{-}{-}{-}{-}www{-}{-}{-}{-}+}
              |           |
              |    ADJ    |
              |  +{-{-}{-}{-}{-}+  |}
              +{-{-}| 317 |{-}{-}+{-}{-}o +Vout}
                 |     |     |
                 +{-{-}{-}{-}{-}+     |}
                           R2
                           |
                          GND
```

Working Principle:

- **Basic Operation**: LM317 maintains 1.25V between output and adjustment pin
- **Output Voltage**: Vout = 1.25V(1 + R2/R1) + IADJ(R2)
- **Simplified Formula**: Vout $\approx 1.25V(1 + R2/R1)(sinceIADJisverysmall)$
- **Adjustment Range**: 1.25V to 37V depending on input voltage

Features:

- **Current Capability**: Up to 1.5A output current
- **Protection**: Internal thermal overload and short circuit protection
- **Advantages**: Simple design, minimal external components, stable output
- **Applications**: Variable power supplies, battery chargers, custom voltage regulators

Mnemonic

"VAIR control - Variable Adjustable Integrated Regulator controls voltage precisely"

Question 5(a) OR [3 marks]

Explain working of solar battery charger circuits.

Solution

Solar Battery Charger Block Diagram:

```
flowchart LR
    A[Solar Panel] {-{-} B[Charge Controller]}
    B {-{-} C[Battery]}
    C {-{-} D[Load/Output]}
```

- **Components**: Solar panel, charge controller, battery, protection circuits
- **Working Principle**: Solar panel generates DC, controller regulates charging current
- **Charge Phases**: Bulk charging (constant current), absorption (constant voltage), float (maintenance)
- **Protection Features**: Overcharge protection, deep discharge prevention, reverse polarity

Mnemonic

"SCBL system - Solar panel Converts sunlight, Battery stores, Load consumes"

Question 5(b) OR [4 marks]

Explain working of UPS.

Solution

UPS Block Diagram:

```
    +{-{-}{-}{-}{-}{-}+    +{-}{-}{-}{-}{-}{-}+    +{-}{-}{-}{-}{-}{-}{-}+}
    |      |    |       |    |        |
AC{-{-}+ Rect +{-}{-}{-}{-}+ Batt. +{-}{-}{-}{-}+ Invert +{-}{-}{-}AC}
    |      |    |       |    |        |
    +{-{-}{-}{-}{-}{-}+    +{-}{-}{-}{-}{-}{-}+    +{-}{-}{-}{-}{-}{-}{-}+}
       |                         |
       +{-{-}{-}{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
                 |
              Control
              Circuit
```

- **Definition**: Uninterruptible Power Supply provides backup power during main supply failure
- **Types**: Offline (standby), Line-interactive, Online (double conversion)
- **Components**: Rectifier, battery, inverter, control circuitry, transfer switch
- **Operation**: Normally passes filtered mains power, switches to battery during outage

Mnemonic

"PRIME power - Power Remains Intact during Mains Electricity problems"

Question 5(c) OR [7 marks]

Draw and explain SMPS block diagram with its advantages and disadvantages.

Solution

SMPS Block Diagram:

```
flowchart LR
    A[AC Input] {-{-} B[EMI Filter]}
    B {-{-} C[Rectifier]}
    C {-{-} D[High{-}Freq Switch]}
    D {-{-} E[Transformer]}
    E {-{-} F[Output Rectifier]}
    F {-{-} G[Filter]}
    G {-{-} H[DC Output]}
    I[Feedback] {-{-} J[Control Circuit]}
    J {-{-} D}
```

Working Principle:

- **Input Stage**: AC converted to unregulated DC by rectifier
- **Switching Stage**: High-frequency transistors chop DC into pulses
- **Transformer**: Isolates and transforms voltage at high frequency
- **Output Stage**: Rectifies and filters to produce clean DC
- **Feedback Loop**: Monitors output and adjusts switching for regulation

Advantages:

- **Efficiency**: 70-90% compared to 30-60% for linear supplies
- **Size/Weight**: Smaller transformers due to high-frequency operation
- **Heat Generation**: Less power dissipation, reduced cooling requirements
- **Wide Input Range**: Can operate over wide input voltage variations

Disadvantages:

- **Complexity**: More complex design than linear supplies
- **EMI/RFI**: Generates electromagnetic interference
- **Noise**: Higher output noise due to switching operation
- **Cost**: More expensive for low-power applications

Mnemonic

"FISH factors - Frequency switching, Isolation, Small size, High efficiency are SMPS benefits"

Summary of Key Concepts

0.0.1 Transistor Biasing and Stability

- **Biasing Methods**: Fixed bias, Collector feedback, Emitter bias, Voltage divider (most stable)
- **Thermal Stability**: Use emitter resistors, voltage divider bias, heat sinks to prevent thermal runaway
- **Stability Factor (S)**: Lower value indicates better stability against temperature changes

0.0.2 Amplifier Parameters

- **CE Amplifier**: High voltage gain (50-500), medium input impedance, $180° phaseshift$
- **h-parameters**: h11 (input impedance), h21 (current gain), h12 (reverse voltage ratio), h22 (output admittance)
- **Frequency Response**: Affected by coupling capacitors at low frequencies, internal capacitances at high frequencies

0.0.3 Coupling Methods

- **RC Coupling**: Simple, low cost, good frequency response (except very low frequencies)
- **Transformer Coupling**: Good impedance matching, excellent efficiency, bulky and expensive
- **Direct Coupling**: Excellent low-frequency response, DC bias issues, used in integrated circuits

0.0.4 Practical Applications

- **Clippers & Clampers**: Waveform shaping, limiting, level shifting circuits
- **Voltage Multipliers**: Generate higher DC voltages from lower AC inputs (doubler, tripler, etc.)
- **Darlington Pair**: Super-high current gain configuration for power applications
- **OLED Displays**: Organic light-emitting diodes with high contrast, energy efficiency

0.0.5 Power Supply Circuits

- **Voltage Regulators**: 78xx series (positive), 79xx series (negative), LM317 (adjustable)
- **SMPS**: High-efficiency switch-mode power supplies with smaller size but greater complexity
- **UPS**: Provides backup power during outages using battery-inverter systems
- **Solar Chargers**: Convert solar energy to charge batteries with overcharge protection

Important Formulas to Remember

Parameter	Formula	Description
Voltage Gain (Av)	Vout/Vin	Ratio of output to input voltage
Current Gain (Ai)	Ic/Ib	Ratio of collector to base current
Bandwidth	f2 - f1	Frequency range between cutoff points
Load Regulation	((VNL-VFL)/VFL)×100%	Voltage stability with load change
Line Regulation	(ΔVout/ΔVin)×100%	Voltage stability with input change
Stability Factor (S)	ΔIC/ΔICBO	Change in collector current vs leakage
LM317 Output	1.25V(1+R2/R1)	Adjustable regulator output voltage
Resonant Frequency	1/(2)	Tuned amplifier resonance point

Exam Tips for Electronic Circuits

1. **Draw the Basics First**: Always begin with the basic circuit diagram before adding details
2. **Remember Polarities**: Pay attention to voltage polarities and current directions
3. **Compare in Tables**: Use tables for comparison questions to organize information
4. **Focus on Practical Uses**: Connect theoretical concepts to real-world applications
5. **Know the Numbers**: Memorize typical values (gains, impedances, voltages)
6. **Use Mnemonics**: Create memory aids for complex concepts and formulas

Common Mistakes to Avoid

1. **Mixing Up Biasing**: Don't confuse the different biasing methods and their stability factors
2. **Parameter Confusion**: Keep h-parameters definitions clear and distinct
3. **Sign Errors**: Remember phase inversions (180$^\circ shift)incommonemitterconfigurations$
3. **Regulation Formulas**: Don't mix up load regulation and line regulation formulas
4. **Overcomplicating Diagrams**: Keep circuit diagrams simple and focused on key components

Quick Reference: Component Symbols

```
Transistor (NPN)    Transistor (PNP)    Diode        LED
    C                   C                 A            A
    |                   |                 |            |
    |                   |                 +-|>|-+      +-|>|-+
    B---|               B---|             K            K  \/
    |                   |
    E                   E

Resistor     Capacitor     Inductor    Transformer
  --www--      --||--      --OOOO--    --OOOO--
                                        --OOOO--
```