

Electronics Devices & Circuits (1323202) - Summer 2024 Solution

Milav Dabgar

June 21, 2024

Question 1(a) [3 marks]

What is heat sink. lists its types

Solution

A heat sink is a passive device that absorbs and dissipates heat from electronic components to prevent overheating.

Table 1. Types of Heat Sinks

Type	Description
Passive	Uses natural convection without external power
Active	Incorporates fans or liquid cooling
Radial	Fins arranged in radial pattern from center
Pin-fin	Uses pins or rods for increased surface area
Extruded	Made by forcing aluminum through shaped die

Mnemonic

"PAPER" (Passive, Active, Pin-fin, Extruded, Radial)

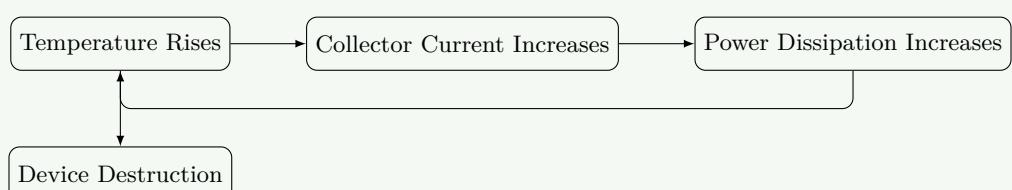
Question 1(b) [4 marks]

Define the Following: 1. Thermal Runaway 2. Thermal Stability

Solution

Thermal Runaway: The self-accelerating destructive process where increased temperature causes increased current flow, which further increases temperature, potentially destroying the transistor.

Thermal Stability: The ability of a transistor circuit to maintain stable operation despite temperature changes, preventing thermal runaway.



Mnemonic

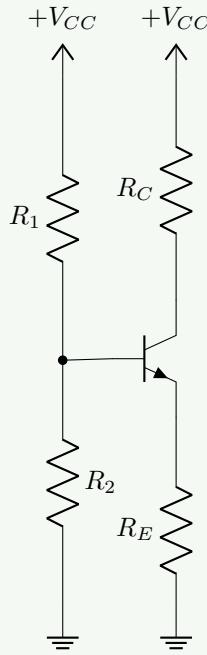
"RISE" (Runaway Is Self-Escalating)

Question 1(c) [7 marks]

Explain voltage divider bias in details.

Solution

Voltage divider bias is a common transistor biasing technique that provides stable operation.



- Voltage divider network:** R_1 and R_2 establish a fixed base voltage
- Stable Q-point:** Maintains operating point despite temperature variations
- Better stability:** Higher stability factor compared to fixed bias
- Self-adjusting:** Base current automatically adjusts to counter temperature changes

Mnemonic

"VSST" (Voltage divider, Stable, Self-adjusting, Temperature resistant)

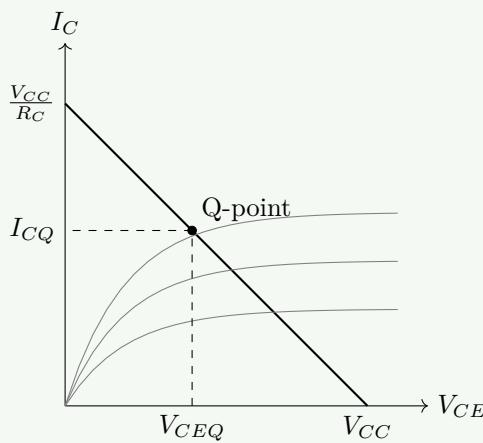
OR

Question 1(c) [7 marks]

Explain D.C. Load Line in details.

Solution

DC Load Line is a graphical method for analyzing transistor bias conditions.



- Definition:** Graphical line showing all possible operating points for a given circuit
- Endpoints:** $(0, V_{CC}/R_C)$ and $(V_{CC}, 0)$ on I_C - V_{CE} plane
- Q-point:** Intersection of load line with transistor characteristic curve
- Equation:** $I_C = (V_{CC} - V_{CE})/R_C$

Mnemonic

"QECC" (Q-point Exists where Collector Current meets characteristics)

Question 2(a) [3 marks]

Explain how transistor works as a switch.

Solution

A transistor switch operates in either saturation (ON) or cutoff (OFF) regions.

Table 2. Transistor Switch Operation

State	Region	Base Current	Collector Current	VCE
OFF	Cutoff	$I_B \approx 0$	$I_C \approx 0$	$V_{CE} \approx V_{CC}$
ON	Saturation	$I_B > I_{B(sat)}$	$I_C \approx I_{C(sat)}$	$V_{CE} \approx 0.2V$

Mnemonic

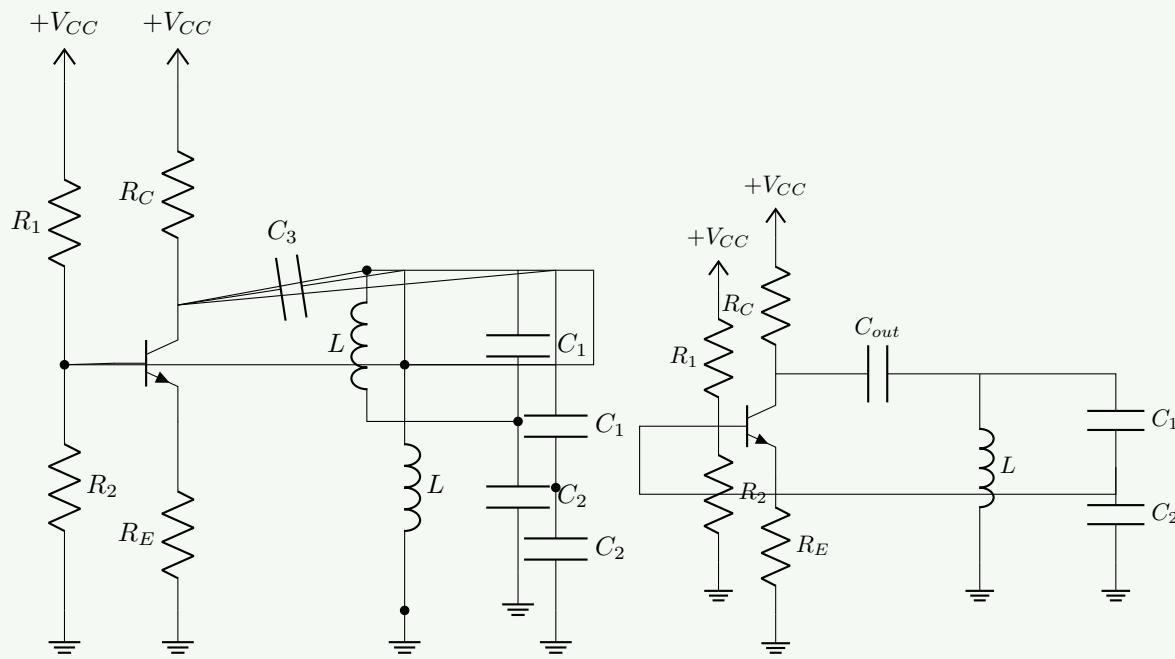
"COS" (Cutoff Off, Saturation on)

Question 2(b) [4 marks]

Draw and explain colpitt oscillator.

Solution

Colpitt oscillator is an LC oscillator using a capacitive voltage divider for feedback.



- **Feedback:** Provided by capacitive voltage divider (C_1, C_2)
- **Resonant frequency:** $f = 1/(2\pi\sqrt{L \times C})$, where $C = (C_1 \times C_2)/(C_1 + C_2)$
- **Oscillation:** Maintains through regenerative feedback
- **Phase shift:** 360° around the loop

Mnemonic

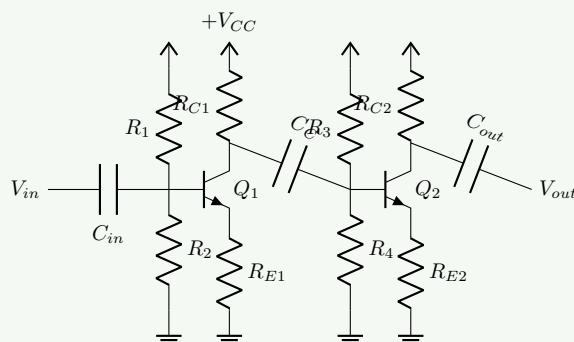
"CFPO" (Capacitive Feedback Produces Oscillations)

Question 2(c) [7 marks]

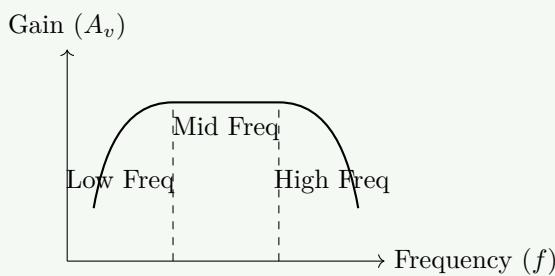
Explain Frequency Response Two Stage RC Coupled Amplifier with circuit diagram.

Solution

Two-stage RC coupled amplifier combines two amplifier stages with RC coupling.



Frequency Response:



- **Low frequency:** Gain drops due to coupling capacitor impedance
- **Mid frequency:** Maximum flat gain region (bandwidth)
- **High frequency:** Gain drops due to transistor capacitance effects
- **Overall gain:** Product of individual stage gains

Mnemonic

"LMH" (Low drops, Mid flat, High drops)

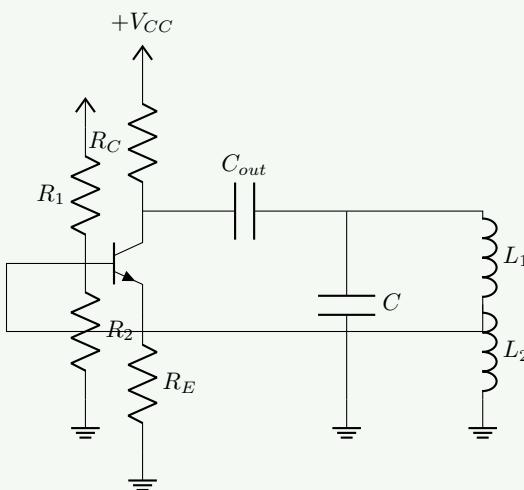
OR

Question 2(a) [3 marks]

Draw circuit diagram of Hartley oscillator.

Solution

Figure 1. Hartley Oscillator



Mnemonic

"ITLC" (Inductor Tapped for LC Circuit)

Question 2(b) [4 marks]

List different types of negative feedback.

Solution**Table 3.** Types of Negative Feedback

Type	Configuration	Effect on Parameters
Voltage Series	Output voltage fed to input in series	Increases input impedance, reduces distortion
Voltage Shunt	Output voltage fed to input in parallel	Decreases input impedance, increases bandwidth
Current Series	Output current fed to input in series	Increases output impedance, stabilizes current gain
Current Shunt	Output current fed to input in parallel	Decreases output impedance, stabilizes voltage gain

Mnemonic

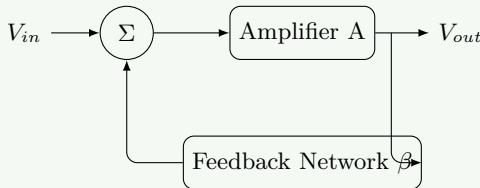
"VSCS" (Voltage Series, Current Shunt)

Question 2(c) [7 marks]

List advantages of Negative feedback amplifier and Explain voltage series negative feedback in details.

Solution**Advantages of Negative Feedback:**

- Stabilizes gain against component variations
- Reduces distortion and noise
- Increases bandwidth
- Modifies input/output impedance
- Improves linearity

Voltage Series Negative Feedback:

- **Configuration:** Output voltage sampled, fed back in series with input
- **Closed-loop gain:** $A_{CL} = A/(1 + A\beta)$, where A is open-loop gain and β is feedback fraction
- **Input impedance:** Increases by factor $(1 + A\beta)$
- **Output impedance:** Decreases by factor $(1 + A\beta)$

Mnemonic

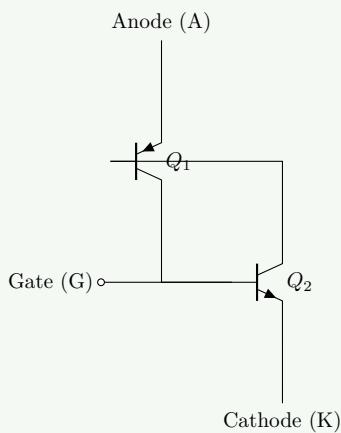
"SIGO" (Stable gain, Increased input impedance, Gain reduction, Output impedance reduction)

Question 3(a) [3 marks]

Draw circuit of SCR using two transistor analogy.

Solution

Two Transistor Analogy of SCR:



Mnemonic

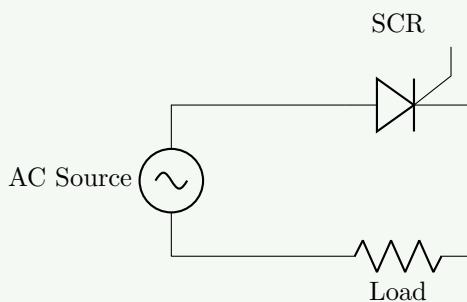
"PNPNPN" (PNP and NPN structure)

Question 3(b) [4 marks]

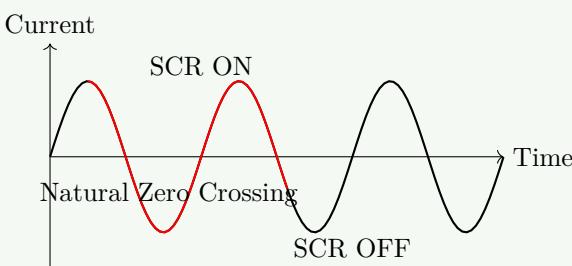
Draw and explain Natural Commutation of SCR.

Solution

Natural commutation occurs when the SCR current naturally falls below the holding current.



Current Waveform:



- **Definition:** SCR turns off automatically when current falls below holding current
- **AC circuit:** Occurs naturally at end of each positive half-cycle
- **Zero crossing:** SCR turns off when AC voltage crosses zero
- **No external circuit:** No additional components needed for turn-off

Mnemonic

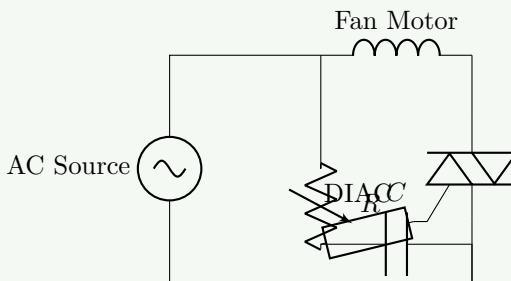
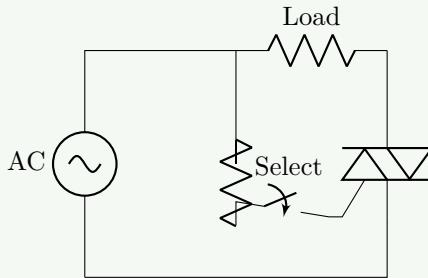
"NAZC" (Natural At Zero Crossing)

Question 3(c) [7 marks]

Explain how TRIAC can be used as fan regulator and on-off control for ac power.

Solution

TRIAC is a bidirectional device ideal for AC power control applications.

TRIAC Fan Regulator Circuit:**TRIAC On-Off Control:**

- **Fan Regulation:** Phase control technique varies power to fan
- **Potentiometer:** Adjusts firing angle of TRIAC
- **On-Off Control:** Simple switch triggers TRIAC gate
- **Bidirectional:** Controls current in both half-cycles

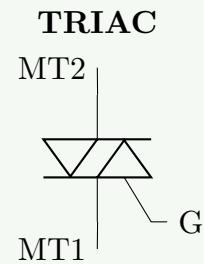
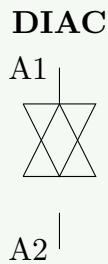
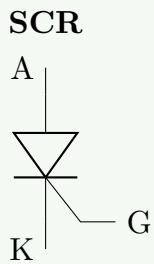
Mnemonic

"FPOB" (Fan Power is controlled by Phase angle in both directions)

OR

Question 3(a) [3 marks]

Draw symbol of SCR, DIAC and TRIAC.

Solution**Mnemonic**

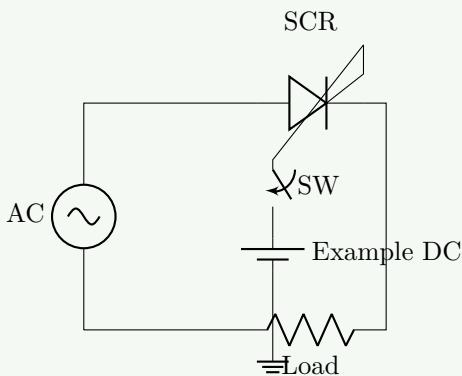
"SDT" (SCR has gate on one side, DIAC has none, TRIAC has gate in middle)

Question 3(b) [4 marks]

Draw and explain Gate triggering of SCR.

Solution

Gate triggering is the most common method to turn on an SCR.



- **Principle:** Applying positive voltage between gate and cathode
- **Current requirement:** Small gate current triggers much larger anode current
- **Latching:** Once triggered, SCR remains ON even if gate signal is removed
- **Turn-off:** Requires reducing anode current below holding current

Mnemonic

"GPLT" (Gate Pulse Latches Thyristor)

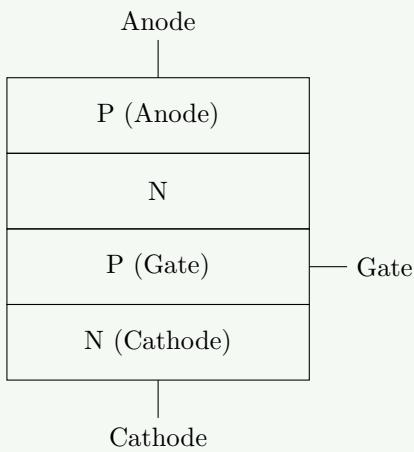
Question 3(c) [7 marks]

Draw Construction and Voltage Vs Current characteristic of SCR and explain V-I characteristic.

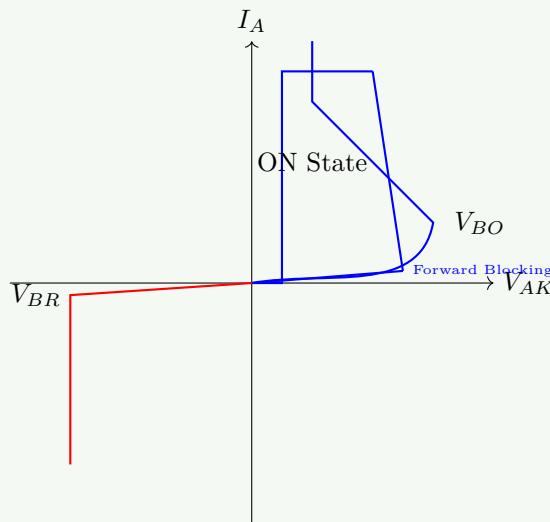
Solution

SCR (Silicon Controlled Rectifier) is a four-layer PNPN semiconductor device.

SCR Construction:



V-I Characteristic:



- **Forward blocking region:** SCR conducts minimal current until breakover voltage
- **Forward conduction region:** Low resistance state after triggering
- **Reverse blocking region:** Blocks current in reverse direction
- **Gate triggering:** Reduces breakover voltage, facilitating turn-on

Mnemonic

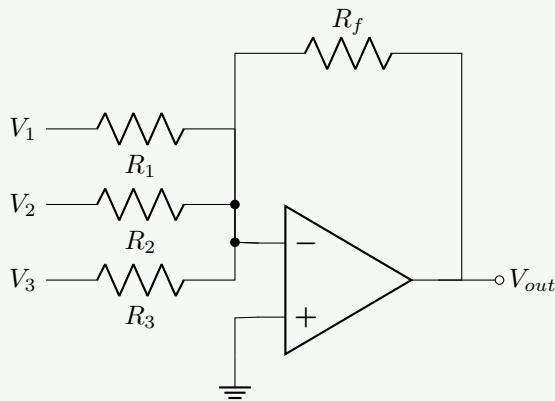
"FBRH" (Forward Blocking, Reverse blocking, Holding current)

Question 4(a) [3 marks]

Explain OP-AMP as a summing amplifier.

Solution

Summing amplifier adds multiple input signals with weighted gains.



- Function:** Outputs weighted sum of input voltages
- Output equation:** $V_{out} = -(V_1 \cdot \frac{R_f}{R_1} + V_2 \cdot \frac{R_f}{R_2} + V_3 \cdot \frac{R_f}{R_3})$
- Equal weights:** When $R_1 = R_2 = R_3$, output is simple sum multiplied by $-R_f/R$
- Virtual ground:** Inverting input maintains 0V potential

Mnemonic

"SWAP" (Sum Weighted And Proportional)

Question 4(b) [4 marks]

Define the following OP-AMP parameters: 1. input bias current 2. CMRR

Solution

Input Bias Current: The average of the currents flowing into the two input terminals of an op-amp when the output is at zero.

CMRR (Common Mode Rejection Ratio): The ratio of differential gain to common-mode gain, indicating how well an op-amp rejects signals common to both inputs.

Table 4. Op-Amp Parameters

Parameter	Typical Value	Importance
Input Bias Current	20-200 nA	Lower is better for high impedance circuits
CMRR	80-120 dB	Higher is better for noise rejection

Mnemonic

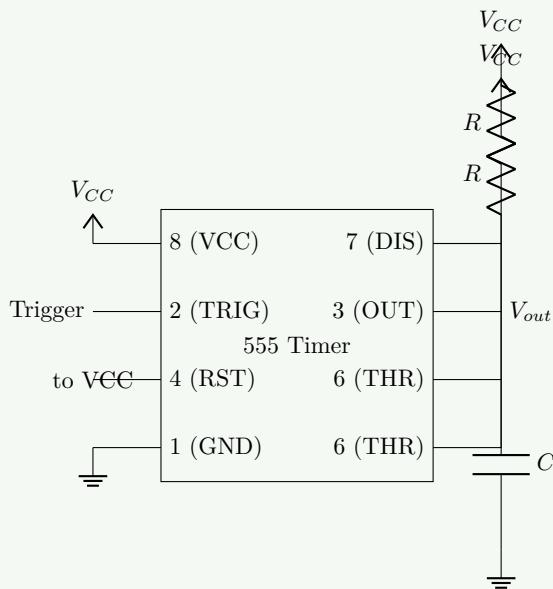
"BIC-CMR" (Bias Is Current, Common Mode Rejection)

Question 4(c) [7 marks]

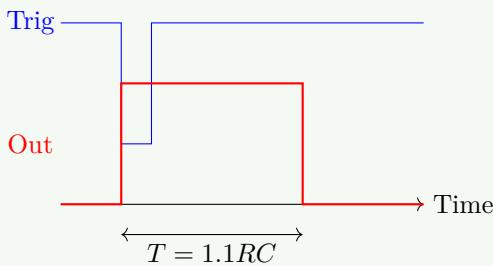
Draw and explain monostable multivibrator using 555 Timer.

Solution

Monostable multivibrator generates a single pulse of predetermined duration when triggered.



Output Waveform:



- **Operation:** Single stable state (output LOW), temporarily HIGH when triggered
- **Pulse width:** $T = 1.1 \times R \times C$ (seconds)
- **Triggering:** Falling edge on TRIG pin (pin 2)
- **Timing components:** R and C determine pulse duration

Mnemonic

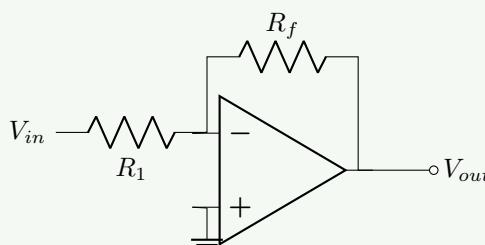
"POST" (Pulse Output, Single Trigger)

OR

Question 4(a) [3 marks]

Draw the circuit diagram of OP-AMP as a inverting amplifier.

Solution



Mnemonic

"IRON" (Inverting Requires One Negative input)

Question 4(b) [4 marks]

Define the following OP-AMP parameters: 1. input offset current 2. slew rate

Solution

Input Offset Current: The difference between the currents flowing into the two input terminals of an op-amp.

Slew Rate: The maximum rate of change of output voltage per unit of time, typically measured in $V/\mu s$.

Table 5. Op-Amp Parameters

Parameter	Typical Value	Importance
Input Offset Current	2-50 nA	Lower is better for precision applications
Slew Rate	0.5-20 V/ μs	Higher is better for high-frequency operation

Mnemonic

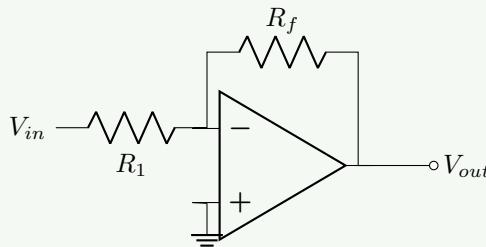
"IOSR" (Input Offset and Slew Rate)

Question 4(c) [7 marks]

Explain op-amp as Inverting amplifier and obtain equation of its Voltage gain.

Solution

Inverting amplifier produces an output signal that is inverted and amplified.

**Voltage Gain Derivation:**

At node N (inverting input):

$$I_1 + I_f = 0 \quad (\text{By Kirchhoff's Current Law})$$

$$\frac{V_{in} - V_N}{R_1} + \frac{V_{out} - V_N}{R_f} = 0$$

Since $V_N \approx 0$ (virtual ground):

$$\frac{V_{in}}{R_1} + \frac{V_{out}}{R_f} = 0$$

$$\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_1}$$

- **Gain equation:** $V_{out}/V_{in} = -R_f/R_1$

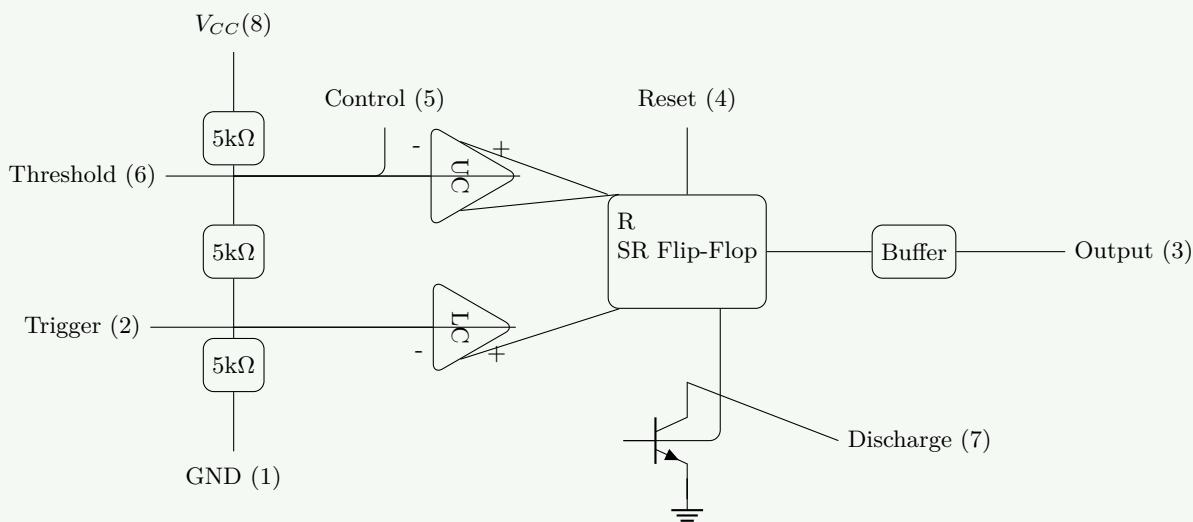
- **Virtual ground:** Inverting terminal maintained at 0V
- **Input impedance:** Equal to R_1
- **Negative feedback:** Provides stability and linearity

Mnemonic

"GIVN" (Gain Is Negative, Virtual ground)

Question 5(a) [3 marks]

Draw the block diagram of IC 555.

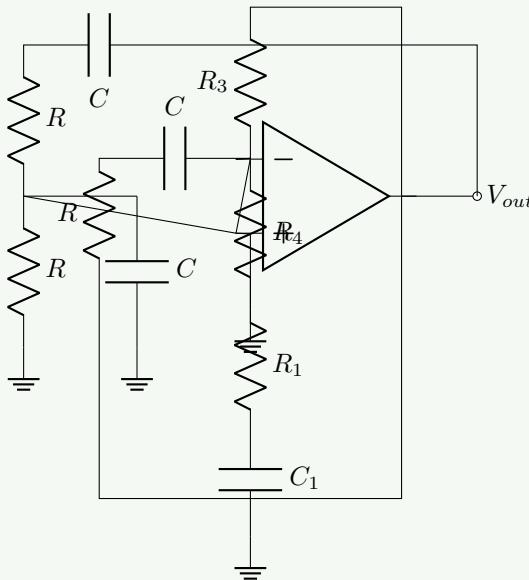
Solution**Block Diagram of IC 555:****Mnemonic**

"CVOT" (Comparators, Voltage divider, Output stage, Timer)

Question 5(b) [4 marks]

Draw the circuit diagram of OP-AMP as a wein bridge oscillator.

Solution**Wein Bridge Oscillator Circuit:**

**Mnemonic**

"WPRC" (Wein Produces Resonant Circuit)

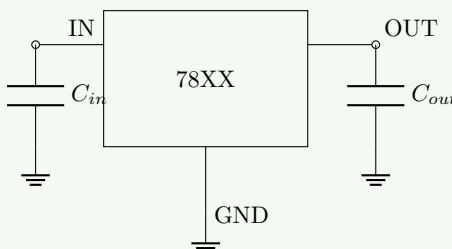
Question 5(c) [7 marks]

Explain working of different types of Fixed and variable voltage regulator IC.

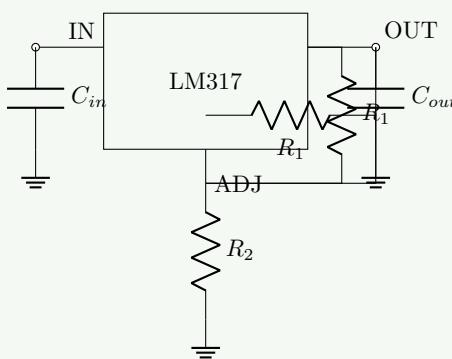
Solution

Voltage regulator ICs maintain stable output voltage despite input or load variations.

Fixed Voltage Regulators:



Variable Voltage Regulator:



- **Fixed regulators:** 78XX (positive) and 79XX (negative) series provide specific voltages
- **Variable regulators:** LM317 (positive) and LM337 (negative) allow adjustable output

- **Three-terminal design:** Input, output, and ground/adjust terminals
- **Output equation for LM317:** $V_{out} = 1.25V \times (1 + R_2/R_1)$
- **Protection features:** Short circuit, thermal overload, and safe area protection

Mnemonic

"FAVOR" (Fixed And Variable Output Regulators)

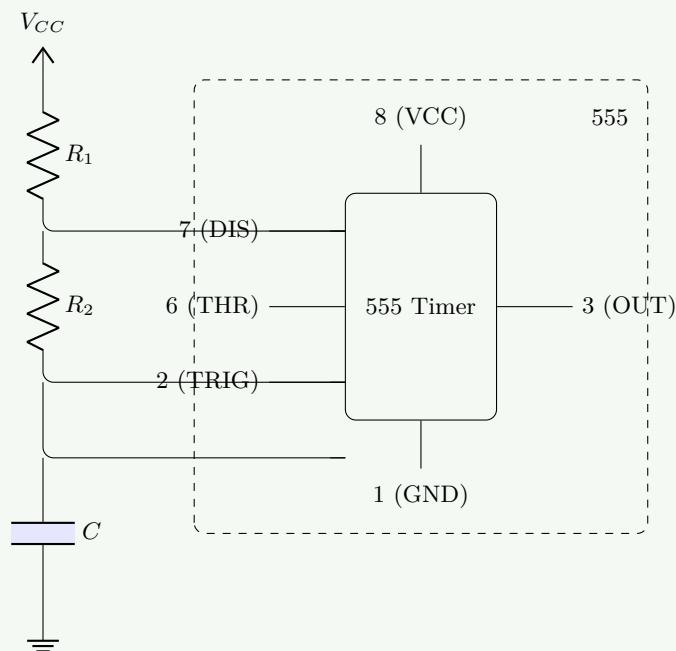
OR

Question 5(a) [3 marks]

Draw the block diagram of astable multivibrator using 555 timer.

Solution

Astable Multivibrator Block Diagram:



Mnemonic

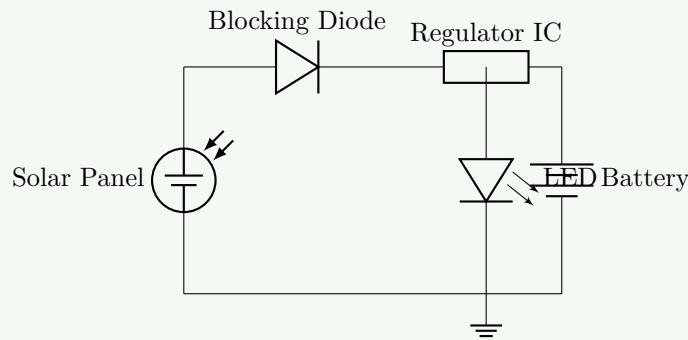
"FOFT" (Free-running Oscillator From Timer)

Question 5(b) [4 marks]

Draw and explain solar based battery charger circuits.

Solution

Solar battery charger converts solar energy to charge batteries.



- **Solar panel:** Converts sunlight to DC electricity
- **Blocking diode:** Prevents battery discharge through panel at night
- **Regulator IC:** Controls charging voltage and current
- **Charge indicator:** Shows charging status
- **Protection:** Overcharge and reverse polarity protection

Mnemonic

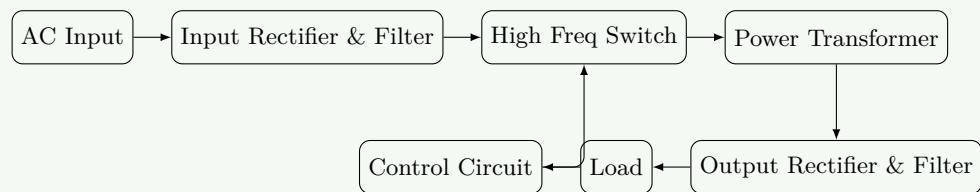
"SBRCP" (Solar, Blocking diode, Regulator, Charging, Protection)

Question 5(c) [7 marks]

Draw and explain the block diagram of SMPS.

Solution

SMPS (Switch Mode Power Supply) converts electrical power efficiently using switching regulators.



- **Input Stage:** Rectifies and filters AC mains to high voltage DC
- **Switching:** Chops DC into high-frequency AC pulse train
- **Transformer:** Steps down/up voltage and provides isolation
- **Output Stage:** Rectifies and filters high-frequency AC to flat DC
- **Feedback:** Compares output to reference for PWM control

Mnemonic

"IRS-TOF" (Input, Rectifier, Switching, Transformer, Output, Feedback)