International Islamic University Chittagong

Department of Computer Science and Engineering

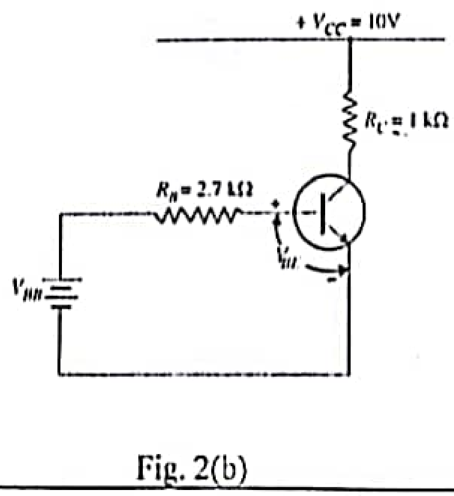
B.Sc. in CSE, Final Examination, Spring 2022

Course Code: EEE-1221 | **Course Title: Electronics**

Time: 2 hours 30 minutes | **Full Marks: 50**

(i) The figures in the right-hand margin indicate full marks

(ii) Course Outcomes and Bloom's Levels are mentioned in additional Columns

		Part A [Answer all the questions from the followings]			
1.	a)	Write down the difference between JFET and BJT. Describe its construction and working principle of (N-Channel JFET). i) When gate-source voltage (V_{GS}) is applied and drain-source voltage is zero i.e. V_{DS}= 0V. ii) When drain-source voltage (V_{DS}) is applied at constant gate-source voltage (V_{GS})	CO4	U	7
		Or,			
		What is MOSFET? What are the different types of MOSFET? With a neat diagram, explain the working principle of an n-channel enhancement type MOSFET.			
1.	b)	A JFET has the following parameters: I_{DSS}= 32 mA; $V_{GS(off)}$= -8V; V_{GS}= -4.5 V. Find out the value of drain current.	CO4	A	3
2.	a)	What is a multivibrator? Mention different types of multivibrators with proper waveshapes. With neat diagrams, explain the working of an astable multivibrator. Or, What is an oscillator? What are the essentials of an oscillator? With the help of a neat diagram, describe the circuit operation of a Hartley oscillator.	CO4	U	5
2.	b)	Fig. 2(b) shows the transistor switching circuit. Given that R_B = 2.7 kΩ, V_{BB} = 2V, V_{BE} = 0.7V and V_{knee} = 0.7V. i) Calculate the minimum value of β for saturation. ii) If V_{BB} is changed to 1V and transistor has minimum β = 50, will the transistor be saturated.  Fig. 2(b)	CO4	A	5

Part B

[Answer the questions from the followings]

3. a) Show that when the gain of summing amplifier is unity, the output voltage is the algebraic sum of the input voltages with proper circuit diagram. — CO5 | A | 6

Or,

Show that the output is the integral of the input with an inversion and scale multiplier of 1/RC.

3. b) Determine the output voltage from the circuit shown in Fig. 3(b) for each of the following input combinations: — CO5 | A | 4

V_1(V)	V_2(V)	V_3(V)
+ 10	0	+10
0	+10	+10
+10	+10	+10

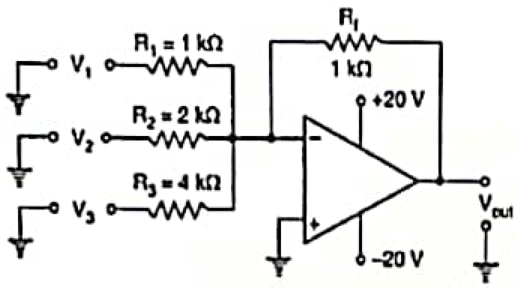
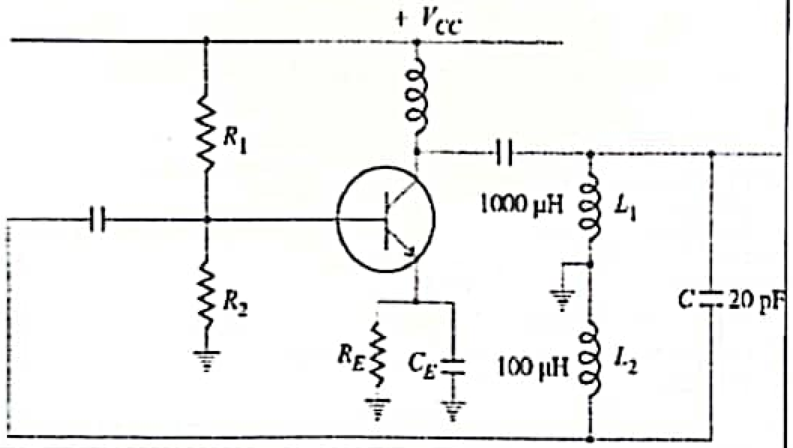


Fig. 3(b)

4. a) What is negative feedback? Show that the input impedance of an amplifier increases due to negative feed. — CO5 | U | 6

4. b) Calculate the operating frequency and feedback fraction of the following oscillator where the mutual inductance between two coils is 20μH. — CO5 | A | 4



5. a) What is negative feedback?. Show that the input impedance of an amplifier increases due to negative feed. — CO5 | U | 5

5. b) Write short on : — CO5 | U | 5

i) Precision Rectifiers

ii) Comparators

Or,

What is an operational amplifier? Draw the circuit diagram of non-inverting OP-AMP with indicating different terminals. Also show the voltage gain of a non-inverting amplifier is $1+\frac{R_f}{R_i}$.

5(a) Why negative is used in amps, derive the principal and gain of negative feedback.

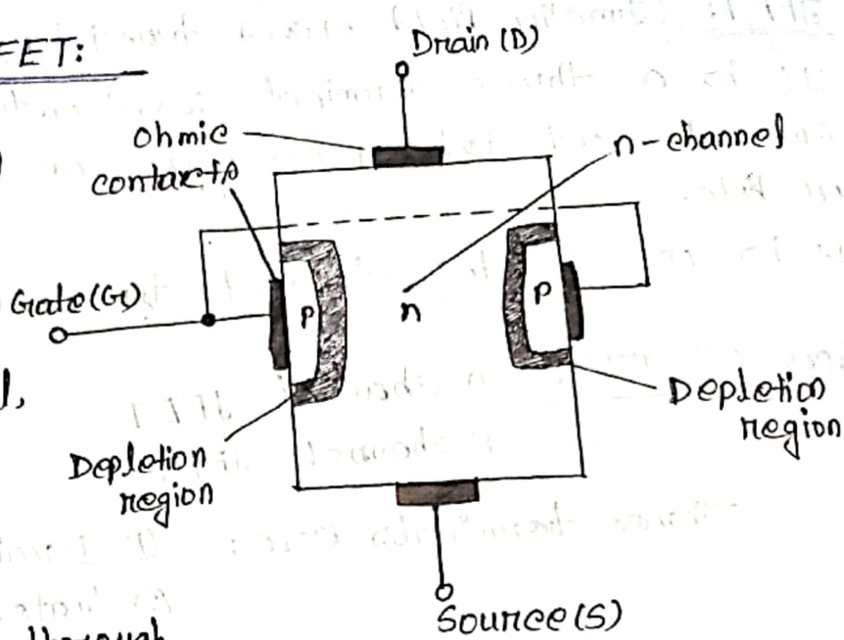
EEE (Previous)

Spring-22

1(a) Difference between JFET and BJT:

JFET	BJT
① Voltage control device.	① Current control device.
② Unipolar device	② Bipolar device
③ Input Impedence high.	③ Input Impedence low.
④ Less noisy	④ More noisy.
⑤ More temparature Stable	⑤ Less temparatur stable

Construction of JFET:



Source: The terminal through which the majority carriers enter into the channel, is called the source terminal (S).

Drain: The terminal, through which the majority carriers leave from the channel, is called the drain terminal D.

Gate: There are two internally connected heavily doped impurity regions to create two P-N junctions. These impurity regions are called the gate terminal G.

Channel: The region between the source and drain, sandwiched between the two ~~glasses~~ gates is called the channel.

(ii) when gate source voltage (V_{GS}) is applied and drain-source voltage (V_{DS}) is zero,

i.e, $V_{DS} = 0V$.

⇒ when $V_{GS} = 0V$, two depletion layer and channel are formed normally.

⇒ when V_{GS} increase negativity i.e, $0V > V_{GS} > V_{GS(off)}$ depletion layers are also increased and channel will be decrease.

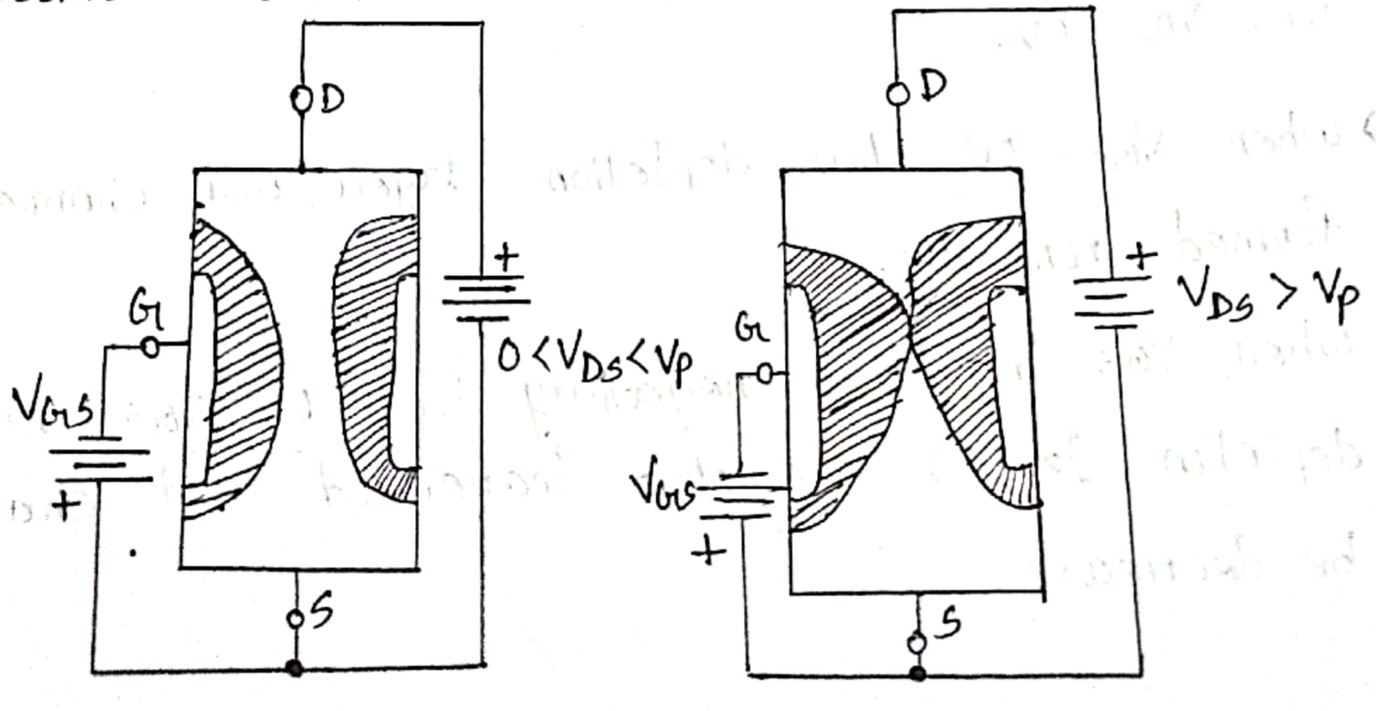
⇒ when $V_{GS} = V_{GS(off)}$ depletion layer will be touch each other and channel will totally removed. So, no current can flow through the channel.

(ii) when drain source voltage (V_{DS}) is applied at constant gate - source voltage (V_{GS}).

⇒ Now reverse bias at the drain end is larger than source ~~and~~ end and so the depletion layer is wider at the drain end than source end.

⇒ when V_{DS} increases i.e $0V < V_{DS} < V_P$ depletion layer at drain end is gradually increased and drain current also increased.

⇒ When $V_{DS} = V_P$ the channel is effectively closed at drain end and it does not allow further increas of drain current. so the drain current will become constant.



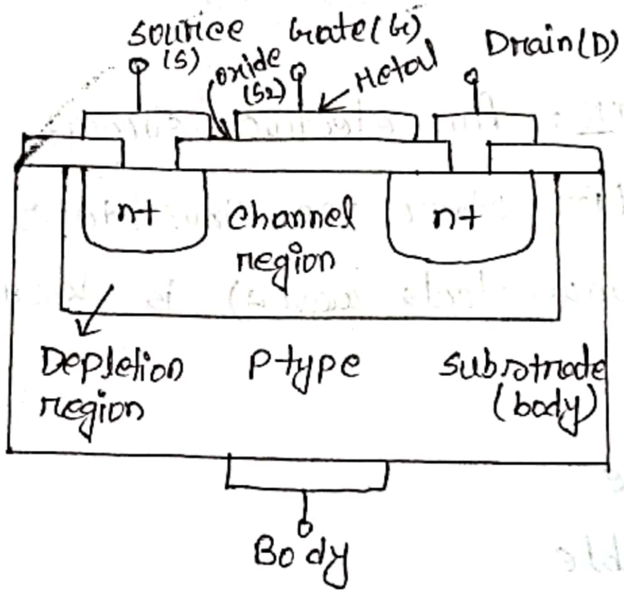
1(a) OR

MOSFET: It is a semiconductor device which is widely used for switching and amplifying electronic signals in the electronics devices.

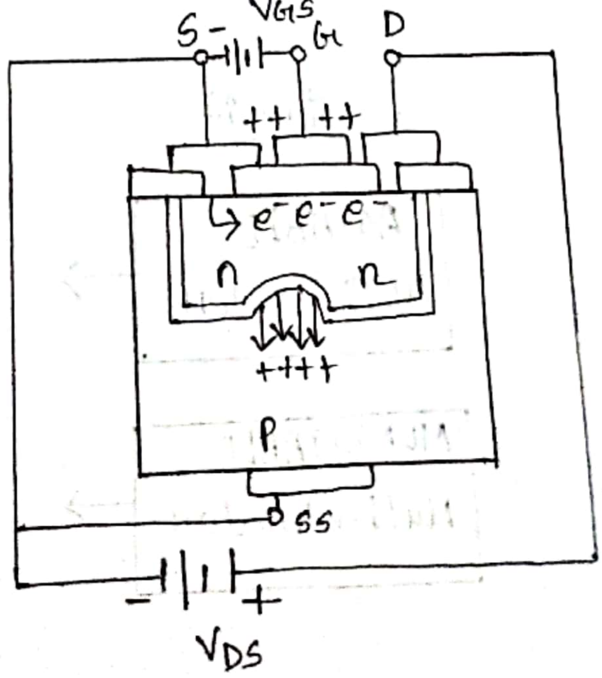
Types of MOSFET: There are two types of MOSFET.

1. Deplition MOSFET
   - ⇒ n- channel
   - ⇒ p- channel
2. Enhancement MOSFET
   - ⇒ n-channel
   - ⇒ p-channel

Diagram (n-channel MOSFET):



Working Principle of an n-channel enhancement type MOSFET



The device body that is formed due to p-type and the terminal source are connected to a common ground. A positive polarity of the voltage is applied to the terminal gate. Because of this positivism, it corresponds to an effect of the capacitor. Hence in the p substrate, the minority carriers that are free electrons get attracted and move towards the terminal gate.

Due to this a layer that is because of uncovered ions is formed bellow the layer of dielectric where the combinations of the holes with electrons occur. As the positive voltage applied gradually increases and crosses the minimum threshold the electrons which are minority carriers would be able to overcome the recombination with the holes and they form the channel between the two p type material .

Further application of the positive voltage value at the drain leads to the flow of current through the transistor. The concentrations of the electrons are dependent on the potential applied. These concentrations of the electrons are responsible for the formation of the channel and the application of the voltage at gate enhances the flow of the current. Hence it is termed as N- channel MOSFET of enhancement type.

1(b) $I_{DSS} = 32 mA$

$V_{GS(OFF)} = -8V$

$V_{GS} = -4.5V$

drain current, I_D

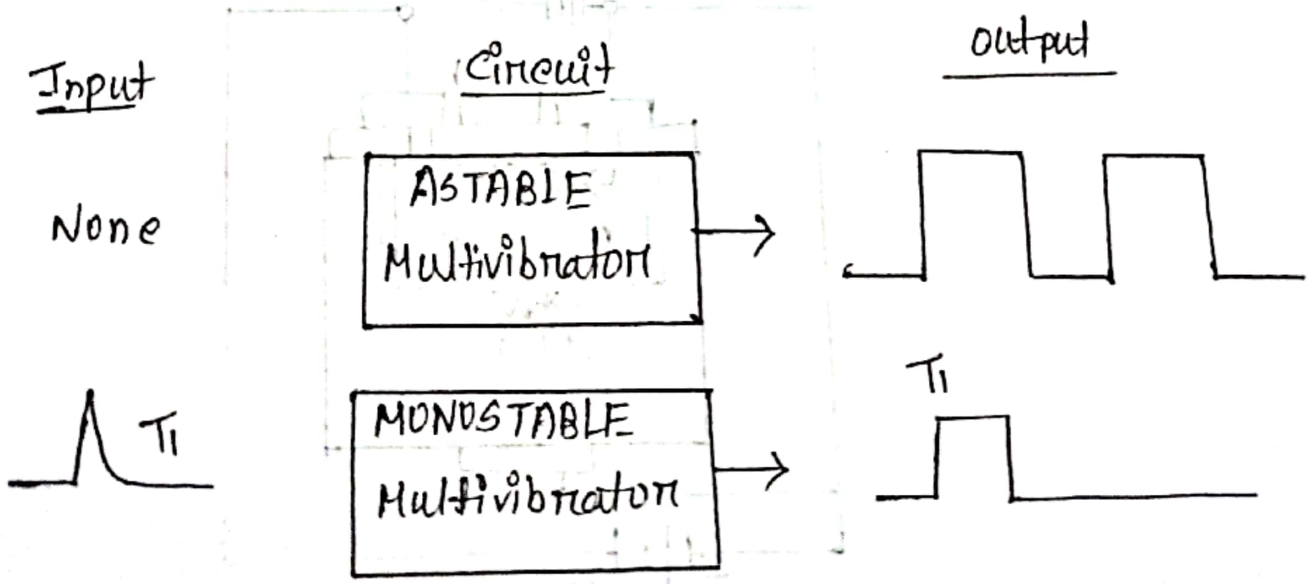
$$\therefore I_D = I_{DSS}\left[1 - \frac{V_{GS}}{V_{GS(OFF)}}\right]$$

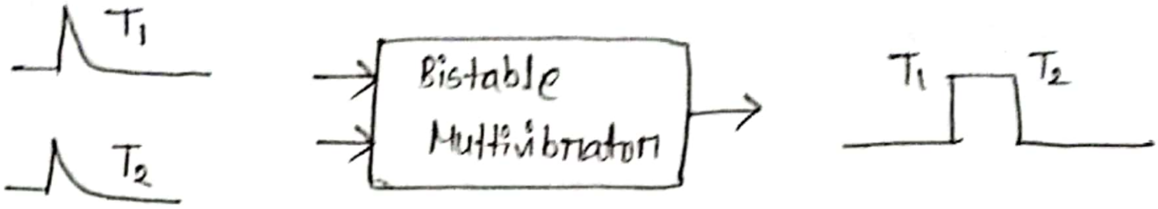
$$= 32\left[1 - \frac{-\cancel{8}4.5}{-8}\right]$$

$$= 14$$

2(a) Multivibrator: An electric circuit that generat square wave (for other non-sinusoidals such as rectangular, saw-tools waves) is known as Multivibrator.

Types: (i) Astable
(ii) Monostable
(iii) Bi-stable





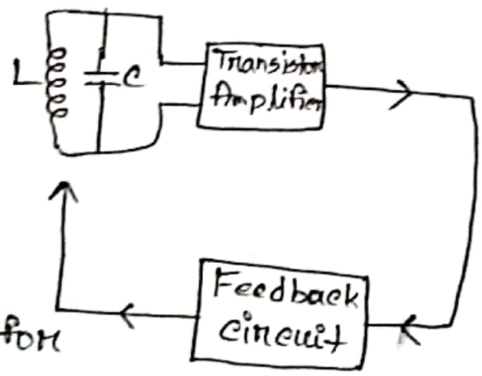
⇒ Explain Astable multivibrator ([illegible])

<u>2(a) OR</u>

<u>Oscillator:</u> A device for generating oscillatory electric currents or voltages by non-mechanical means.

<u>Essential of oscillator:</u> It essential components are

(i) <u>Tank circuit</u>: It consist of inductance coil (L) connected in parallel with capacitor (C). Frequency depends upon the values of inductance of the coil and capacitance of the capacitor.



(ii) <u>Transistor amplifier:</u> It receives d.c power from the battery and changes it into a.c power for supplying to the tank circuit. The oscillations occuring in the tank circuit are applied to the input of the transistor amplifier. Because of the amplifying properties of the transistor, we get increased output of these oscillations.

(iii) <u>Feedback circuit</u>: The feeback circuit supplies a part of collector energy to the tank circuit in correct phase to aid the oscillations i.e. it provides positive feedback

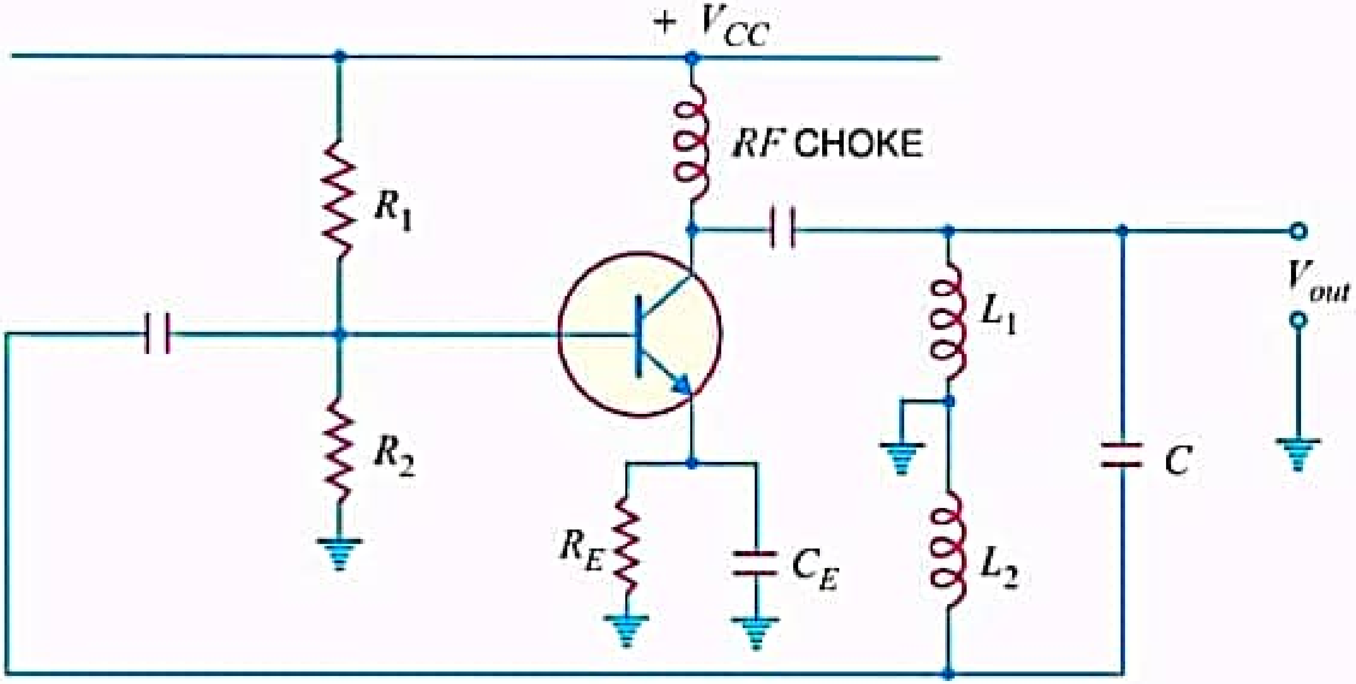


Fig. 14.13

Circuit operation. When the circuit is turned on, the capacitor is charged. When this capacitor is fully charged, it discharges through coils L_1 and L_2 setting up oscillations of frequency determined by *exp. (*i*). The output voltage of the amplifier appears across L_1 and feedback voltage across L_2. The voltage across L_2 is 180° out of phase with the voltage developed across L_1 (V_{out}) as shown in Fig. 14.14. It is easy to see that voltage fedback (*i.e.*, voltage across L_2) to the transistor provides positive feedback. A phase shift of 180° is produced by the transistor and a further phase shift of 180° is produced by $L_1 - L_2$ voltage divider. In this way, feedback is properly phased to produce continuous undamped oscillations.

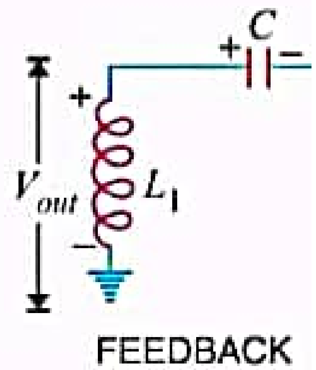
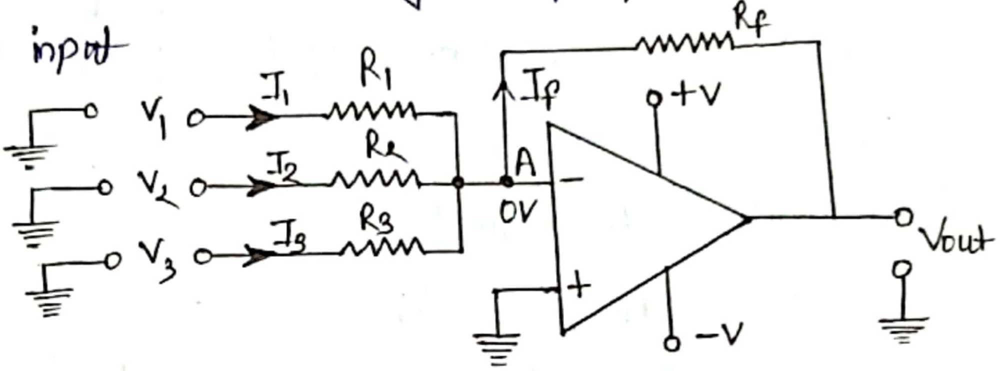


Fig. 14.14

3(a)

Summing Amplifier: A summing amplifier is an inverted op-amp that can accept two or more inputs. The output voltage of a summing amplifier is proportional to the negative of the algebraic sum of its input voltages.

{(Question:) ⇒ Show that the output voltage is proportional to the algebraic sum of the input voltages.}



$$I_f = I_1 + I_2 + I_3$$

when all the three inputs are applied, output voltage is,

$$V_{out} = -I_1 R_f$$
$$= -R_f (I_1 + I_2 + I_3)$$
$$= -R_f \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$$
$$V_{out} = -R_f \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$$

If, $R_1 = R_2 = R_3 = R$ then we have,

$$V_{out} = -\frac{R_f}{R}(V_1 + V_2 + V_3)$$

If, $R_f = R_1 = R_2 = R_3 = R$ then output voltage is.

$$V_{out} = -(V_1 + V_2 + V_3)$$

Thus, when the gain of summing amplifier is unity the output voltage is the algebraic sum of the input voltages.

$$\therefore V_{out} = -\frac{R_f}{R}(V_1 + V_2 + V_3 + \ldots)$$

3(a) OR

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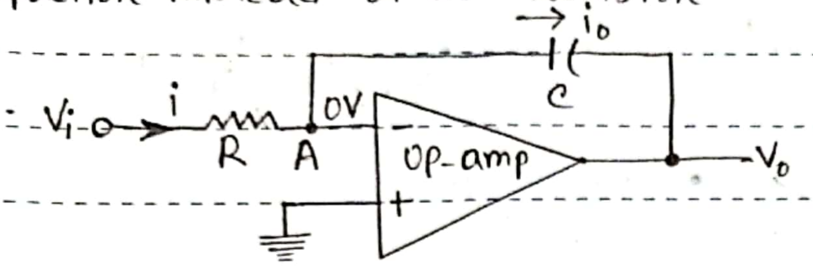
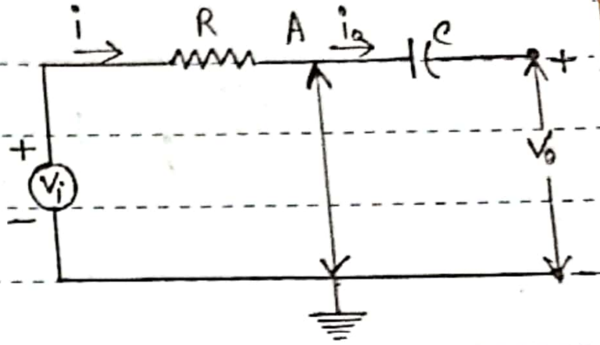
Op-Amp Integrator: An integrator is a circuit that performs integration of the input signal. Here, feedback component is a capacitor instead of a resistor.





$$i = i_C$$

$$i = \frac{V_i - 0}{R} = \frac{V_i}{R} \quad \text{---} (1)$$

Voltage across capacitor is $V_C = 0 - V_0 = -V_0$

$$i_C = \frac{C dV_C}{dt} = -C\frac{dV_0}{dt} \quad \text{---} (2)$$

From (1) and (2) $\frac{V_i}{R} = -C\frac{dV_0}{dt}$

$$\frac{dV_0}{dt} = -\frac{1}{RC}V_i \quad \text{---} (3)$$

Integrating both sides, of eqn (3) we get,

$$V_0 = -\frac{1}{RC}\int_0^t V_i \, dt$$

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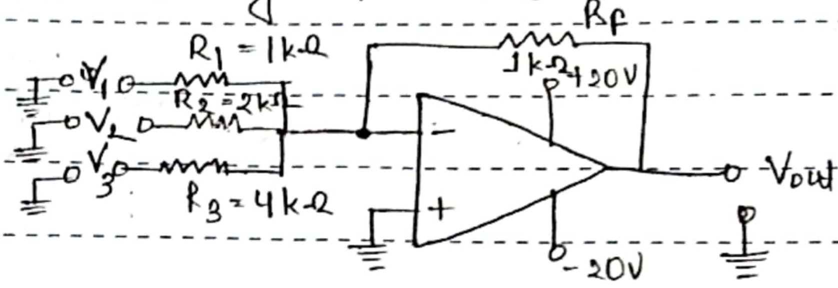
3(b)

Determine the output voltage from the circuit shown in figure for each of the following input combinations.

V_1(V)	V_2(V)	V_3(V)
+10	0	+10
0	+10	+10
+10	+10	+10



Solution: $V_{out} = -\frac{R_f}{R_f}(V_1+V_2+V_3)$

$$= -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$$

$$= -\left(\frac{1}{1}V_1 + \frac{1}{2}V_2 + \frac{1}{4}V_3\right)$$

$$V_{out} = -(V_1 + 0.5V_2 + 0.25V_3)$$

The output voltage for the first set of input is

$$V_{out} = -(10 + 0.5\times 0 + 0.25\times 10) = -1.25\ V$$

For the 2nd set of input is

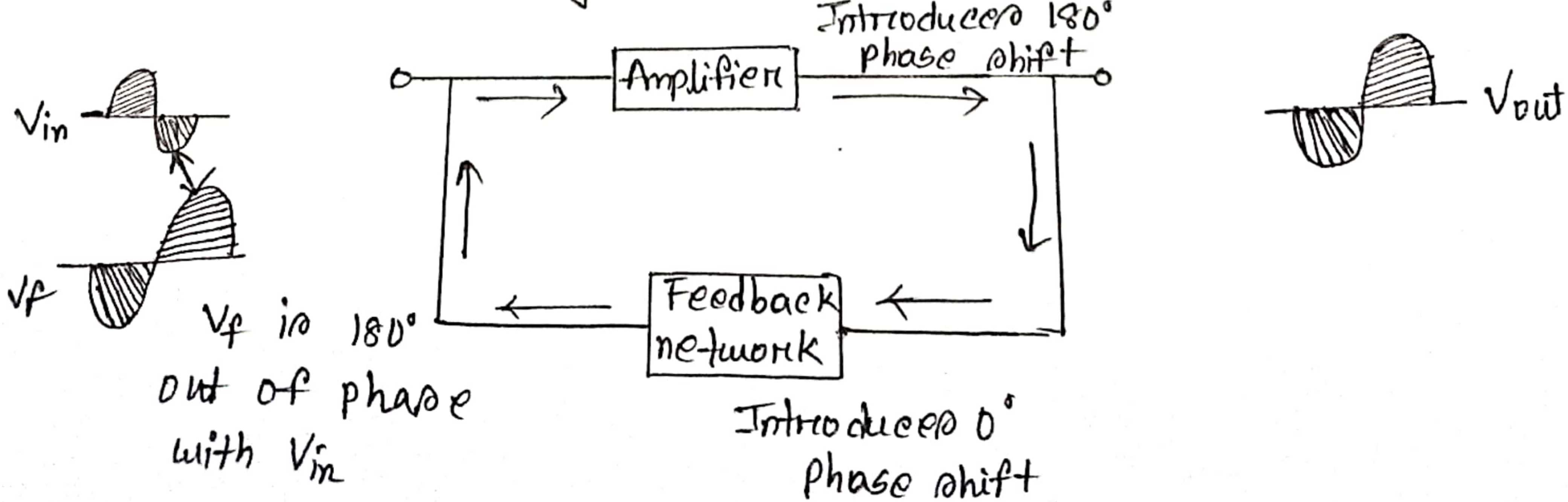
$$V_{out} = -(0 + 0.5\times 10 + 0.25\times 10) = -7.5V$$

For the 3rd set of input is

$$V_{out} = -(10 + 0.5\times 10 + 0.25\times 10) = -17.5V.$$

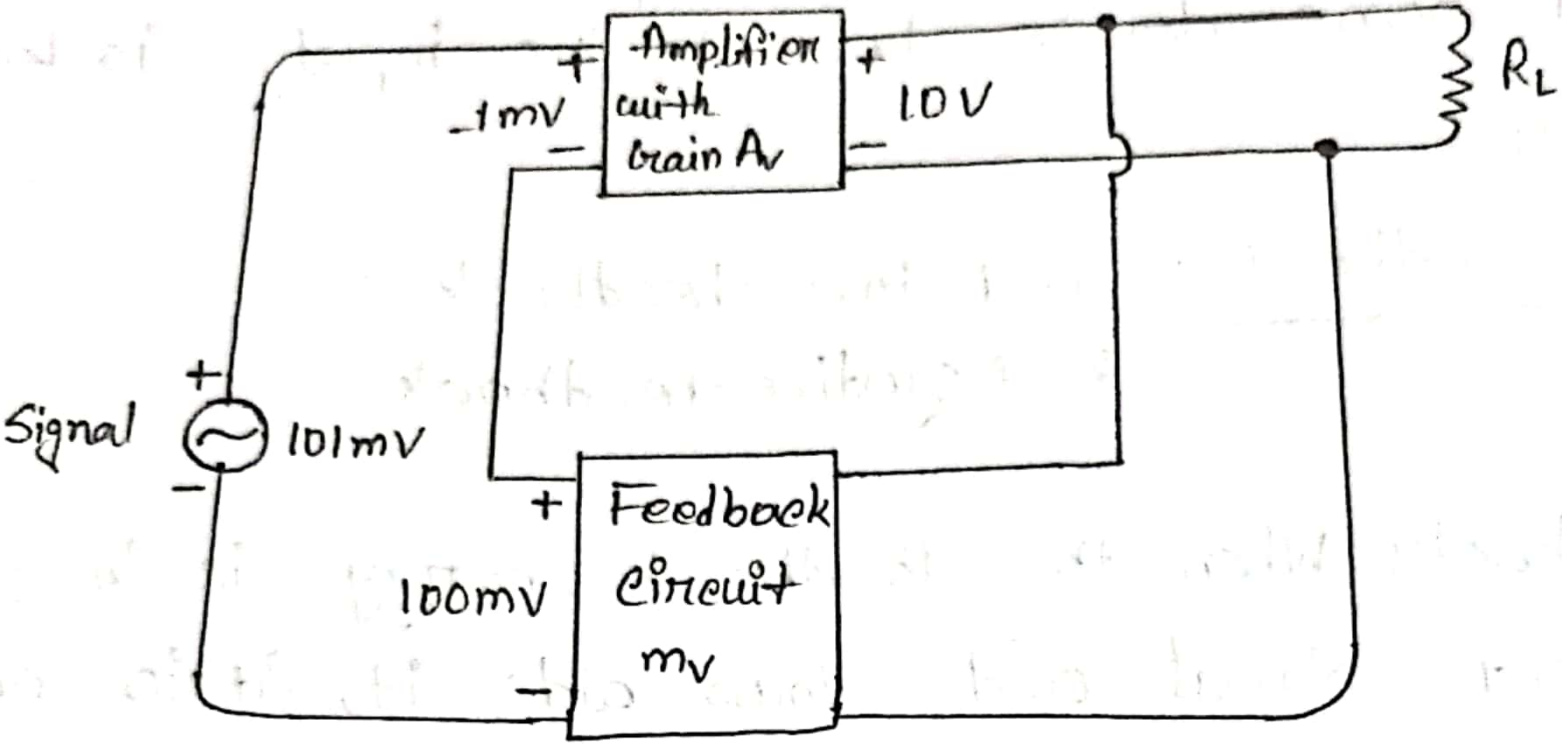
4(a)

Negative feedback: When the feedback energy (voltage or current) is out of phase with the input signal and thus opposes it, it is called Negative feedback.



Principles of negative voltage feedback in Amplifiers:

input impedance: $Z'_{in} = Z_{in}(1 + A_v m_v)$



5(a)

Gain of negative feedback amplifier.

Actual input amplifier $= e_g - m_v e_o$

The output e_o must be equal to the input voltage $e_g - m_v e_o$ multiplied by gain A_v of the amplifier,

$$(e_g - m_v e_o) A_v = e_o$$

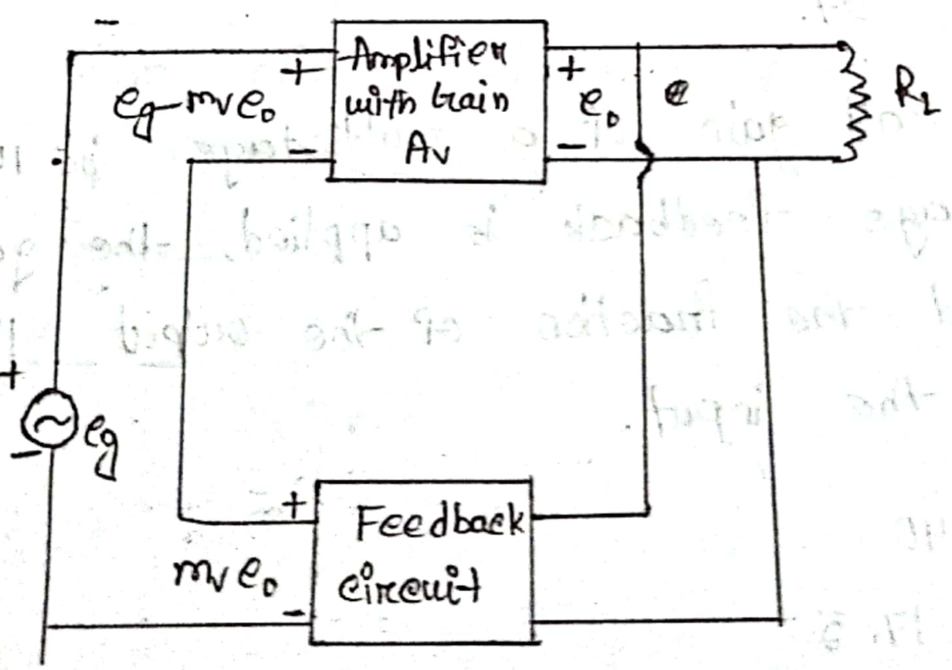
$$\Rightarrow A_v e_g - A_v m_v e_o = e_o$$

$$\Rightarrow e_o (1 + A_v m_v) = A_v e_g$$

$$\Rightarrow \frac{e_o}{e_g} = \frac{A_v}{1 + A_v m_v}$$

∴ Voltage gain ~~of~~ with negative feedback is,

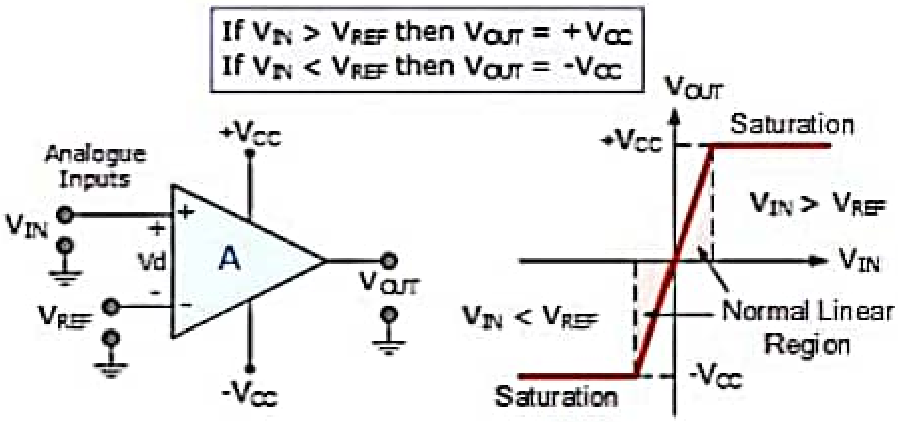
$$A_{vf} = \frac{A_v}{1 + A_v m_v}$$



Nonlinear Circuit Applications

Comparator

Op-amp Comparator Circuit:



Operation:

With reference to the op-amp comparator circuit above, lets first assume that V_{IN} is less than the DC voltage level at V_{REF}. ($V_{IN} < V_{REF}$). As the non-inverting (positive) input of the comparator is less than the inverting (negative) input, the output will be LOW and at the negative supply voltage, -Vcc resulting in a negative saturation of the output.

If we now increase the input voltage, V_{IN} so that its value is greater than the reference voltage V_{REF} on the inverting input, the output voltage rapidly switches HIGH towards the positive supply voltage, +Vcc resulting in a positive saturation of the output. If we reduce again the input voltage V_{IN}, so that it is slightly less than the reference voltage, the op-amp's output switches back to its negative saturation voltage acting as a threshold detector.

Then we can see that the op-amp voltage comparator is a device whose output is dependent on the value of the input voltage, V_{IN} with respect to some DC voltage level as the output is HIGH when the voltage on the non-inverting input is greater than the voltage on the inverting input, and LOW when the non-inverting input is less than the inverting input voltage. This condition is true regardless of whether the input signal is connected to the inverting or the non-inverting input of the comparator.

We can also see that the value of the output voltage is completely dependent on the op-amps power supply voltage. In theory due to the op-amps high open-loop gain the magnitude of its output voltage could be infinite in both directions, ($\pm\infty$). However practically, and for obvious reasons it is limited by the op-amps supply rails giving $V_{OUT} = +Vcc$ or $V_{OUT} = -Vcc$.

Precision Rectifier

Why we need Precision Rectifier:

A rectifier is a circuit that converts alternating current (AC) to Direct current (DC). An alternating current always changes its direction over time, but the direct current flows continuously in one direction. In a typical rectifier circuit, we use diodes to rectify AC to DC. But this rectification method can only be used if the input voltage to the circuit is greater than the forward voltage of the diode which is typically 0.7V. We previously explained diode-based half-wave rectifier and full-wave rectifier circuit.

To overcome this issue, the **Precision Rectifier Circuit** was introduced. The precision rectifier is another rectifier that converts AC to DC, but in a precision rectifier we use an op-amp to compensate for the voltage drop across the diode, that is why we are not losing the 0.6V or 0.7V voltage drop across the diode, also the circuit can be constructed to have some gain at the output of the amplifier as well.

Circuit and Operation:

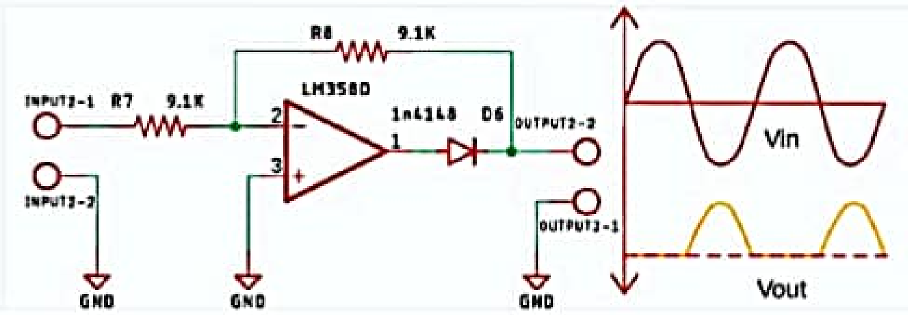


Fig. 1

The above circuit in Fig. 1 shows a basic, **half-wave precision rectifier circuit** with an LM358 Op-Amp and a 1n4148 diode. The above circuit also shows you the input and output waveform of the precision rectifier circuit, which is exactly equal to the input. That's because we are taking the feedback from the output of the diode and the op-amp compensates for any voltage drop across the diode. So, the diode behaves like an ideal diode.

Now in the circuit in Fig. 2, you can clearly see what happens when a positive and a negative half cycle of the input signal is applied in the input terminal of the Op-Amp. The circuit also shows the transfer characteristics of the circuit.

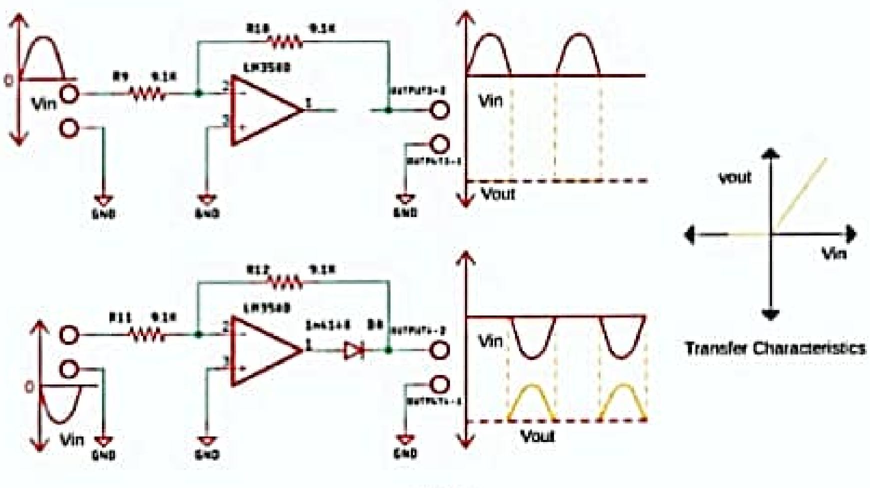


Fig. 2

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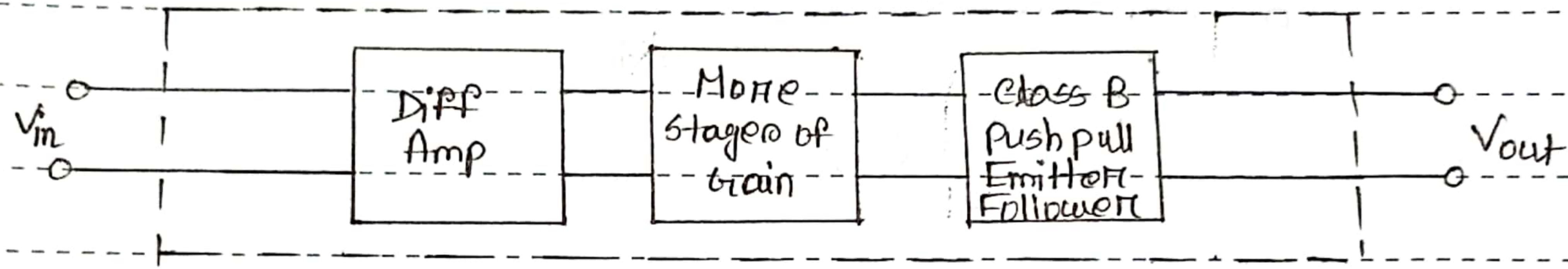
5(b) OR

Operation amplifier: An operation amplifier is a circuit that can perform such mathematical operations as addition, subtraction, integration and differentiation.



Block diagram of op-amp

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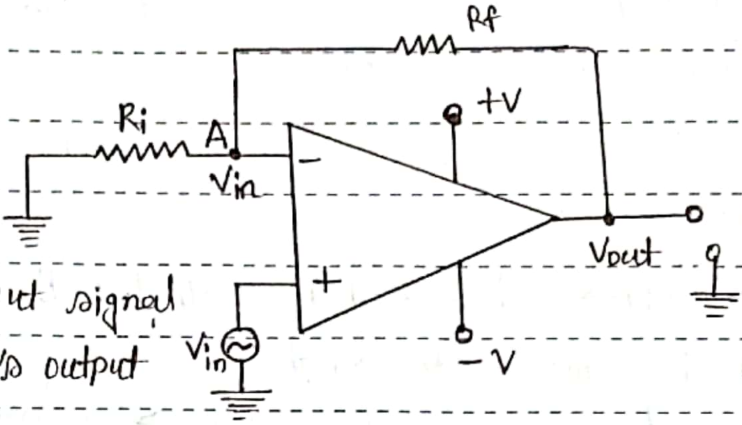
Non inverting amplifier:



A non inverting amplifier Produces an output signal that is in phase with the input signal whereas an inverting amplifier's output is out of phase.

Voltage Across, $R_i = V_{in} - 0$

Voltage Across, $R_f = V_{out} - V_{in}$

Now, Current through R_i = Current through R_f

$$\Rightarrow \frac{V_{in} - 0}{R_i} = \frac{V_{out} - V_{in}}{R_f}$$

$$\Rightarrow V_{in} R_f = V_{out} R_i - V_{in} R_i$$

$$\Rightarrow V_{in} R_f + V_{in} R_i = V_{out} R_i$$

$$\Rightarrow V_{in} (R_f + R_i) = V_{out} R_i$$

$$\Rightarrow \frac{V_{out}}{V_{in}} = \frac{R_f + R_i}{R_i}$$

$$\Rightarrow \frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_i}$$

$\therefore$ closed loop Voltage Gain, $A_{CL} = \frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_i}$

$$\therefore A_{CL} = 1 + \frac{R_f}{R_i}$$