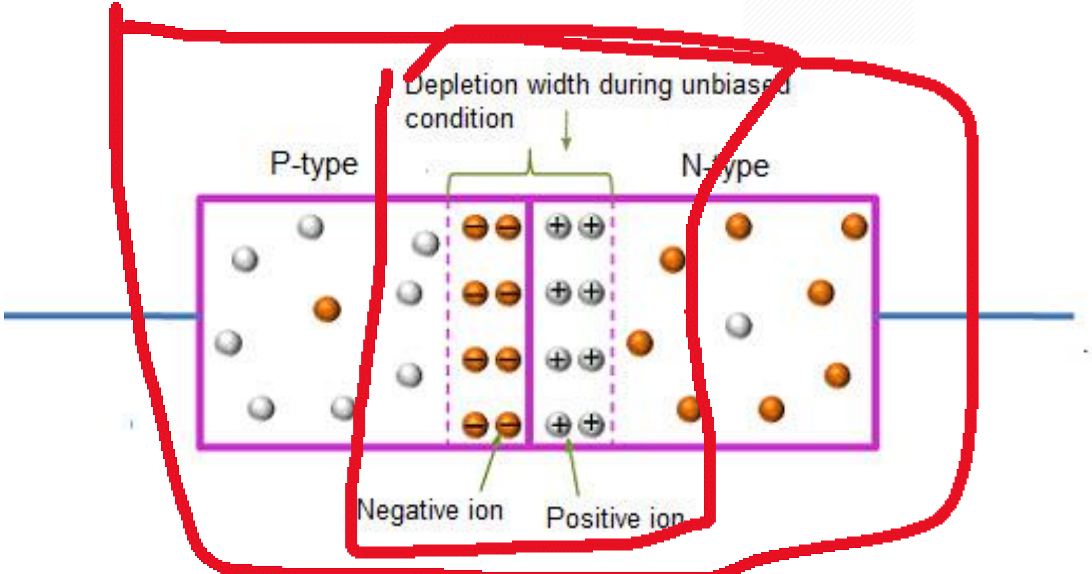
CONTINUUM

WORKSHOP-2

Introduction to OpAmps

WHAT IS DIODE?

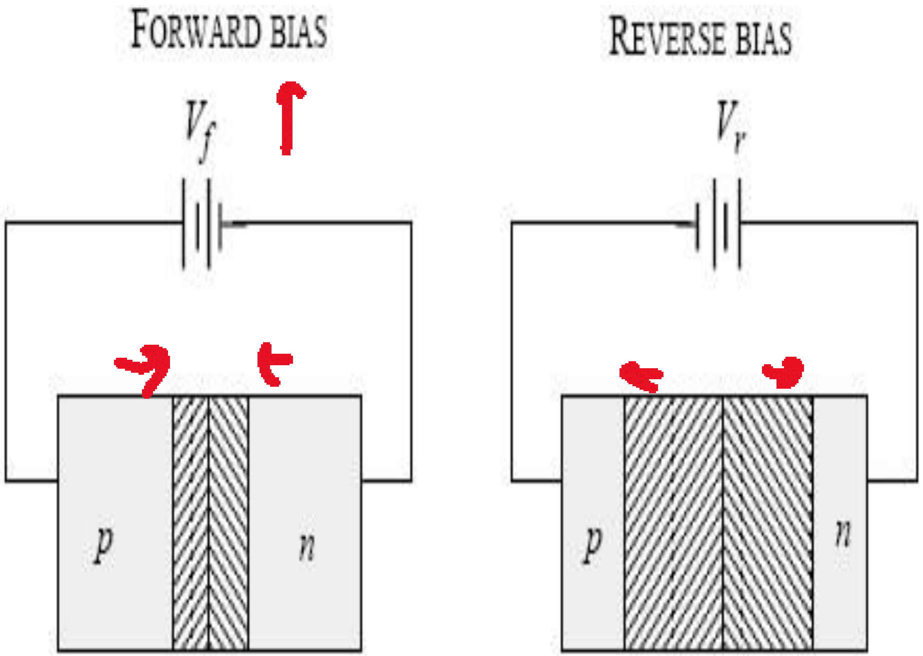
Electronic devices created by bringing together a *p*-type and *n*-type region within the same semiconductor lattice. Used for rectifiers, LED etc. It is represented by symbol



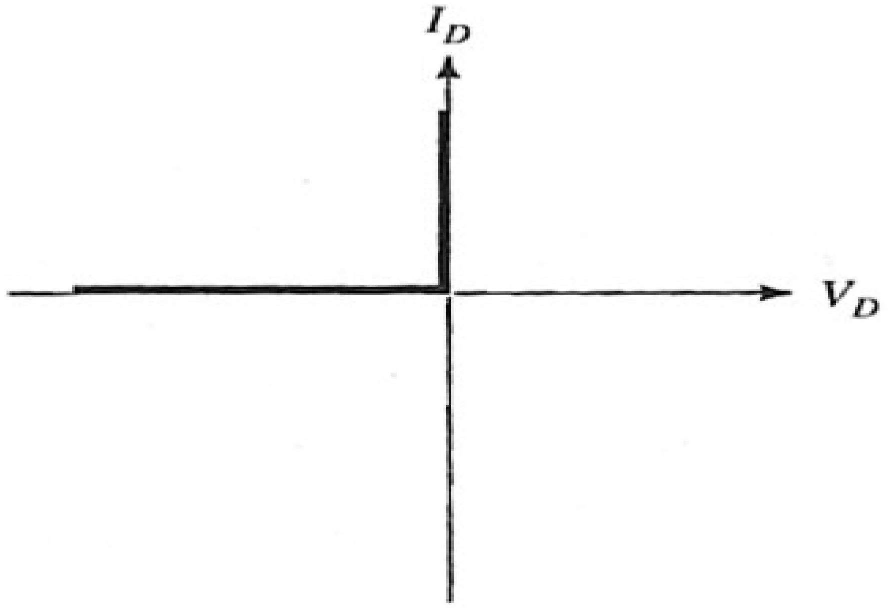
Biasing of Diode

Forward Bias : Connect positive of the Diode to positive of supply…negative of Diode to negative of supply

Reverse Bias: Connect positive of the Diode to negative of supply…negative of diode to positive of supply.



I-V characteristics of Ideal diode



Characteristics of Ideal Diode

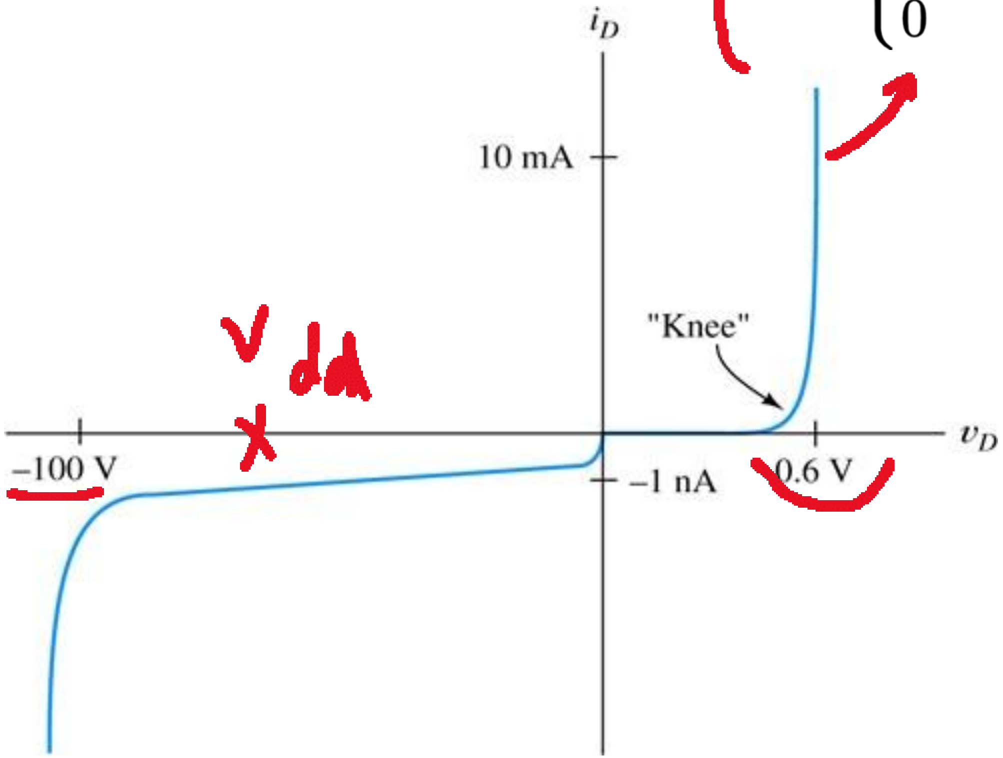
» Conducts in one direction. 

» Conduct current when “Forward Biased” (Zero resistance/Short circuit) 

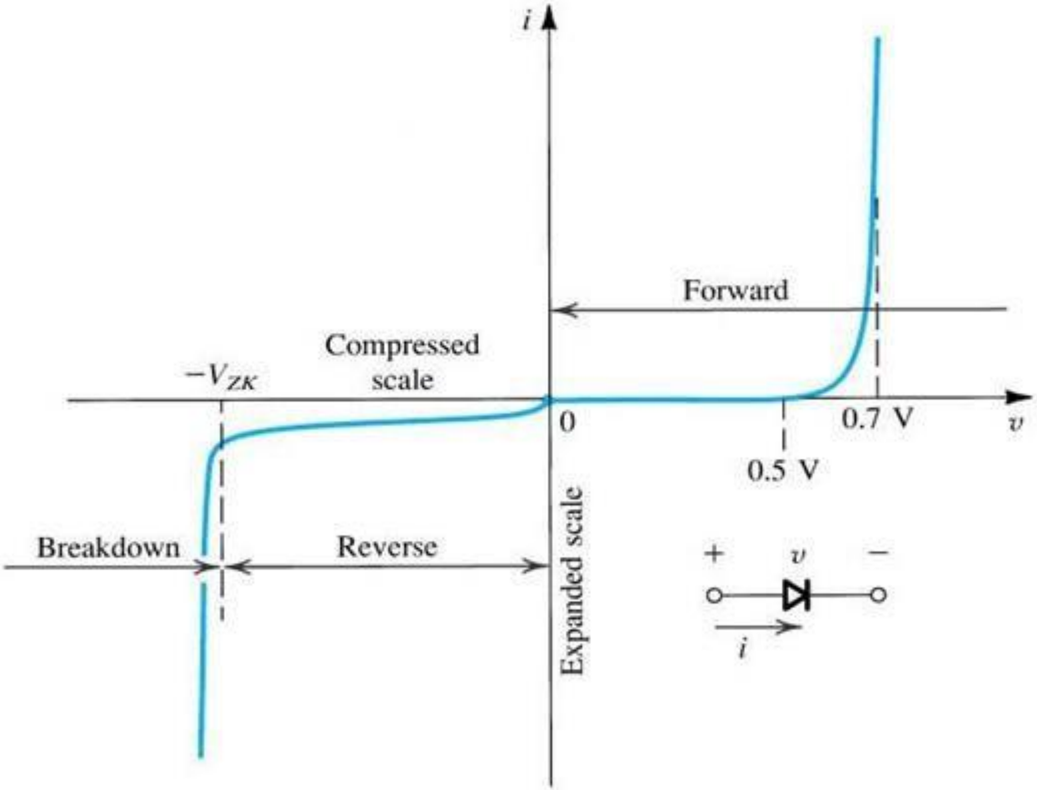
» Do not conduct when “Reverse Biased”
(Infinite resistance/Open circuit) 

I-V characteristics of a practical diode

$$i_D = \begin{cases} I_0\left(e^{\frac{v_D}{nV_T}} - 1\right) & v_D \geq 0 \\ 0 & v_D < 0 \end{cases}$$

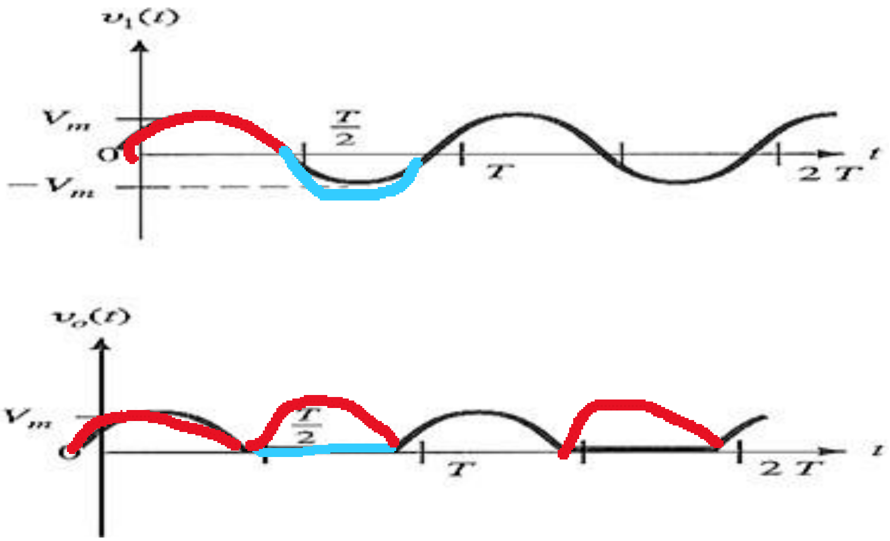


I-V Characteristics

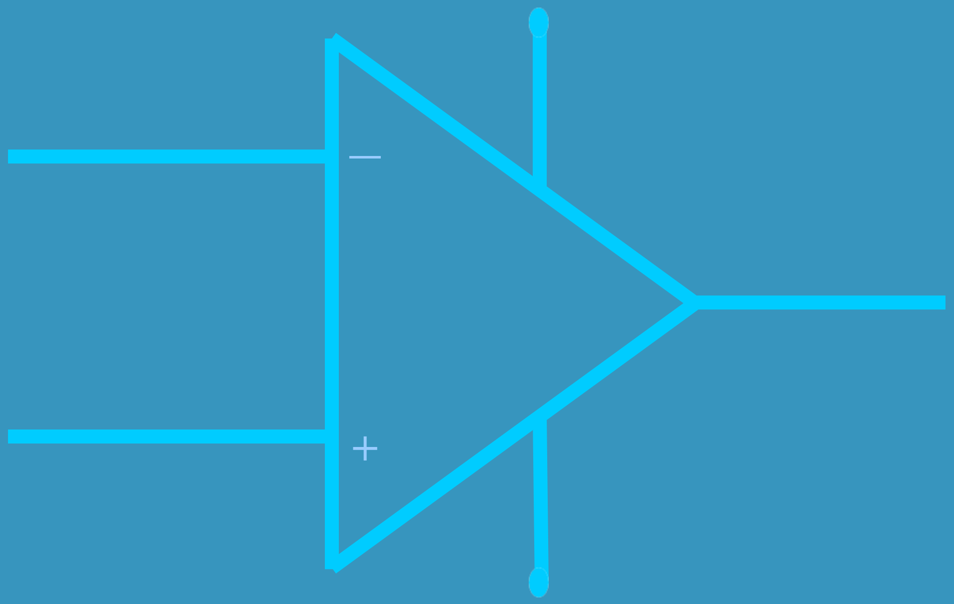


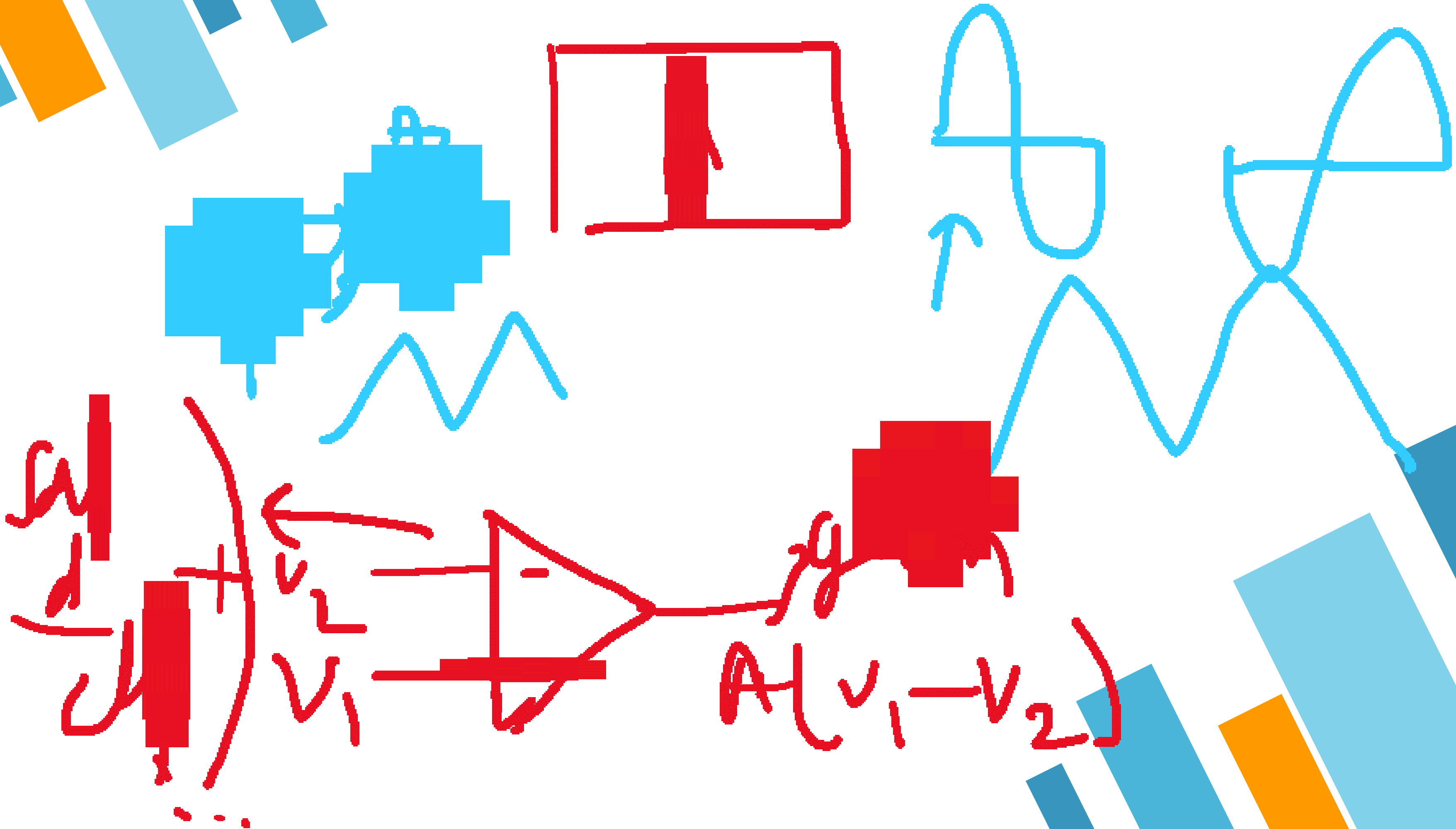
Half-wave Rectification

- Simplest process used to convert ac to dc.
- A diode is used to clip the input signal excursions of one polarity to zero.



Operational Amplifiers





v2
v1
−
A(v1 − v2)

Operational Amplifiers

- Usually Called Op Amps
- An amplifier is a device that accepts a varying input signal and produces a similar output signal with a larger amplitude.
- Usually connected so part of the output is fed back to the input. (Feedback Loop)
- Most Op Amps behave like voltage amplifiers. They take an input voltage and output a scaled version.
- The name “operational amplifier” comes from the fact that they were originally used to perform mathematical operations such as integration and differentiation..

Operational Amplifiers

Op amps can perform operations of:-

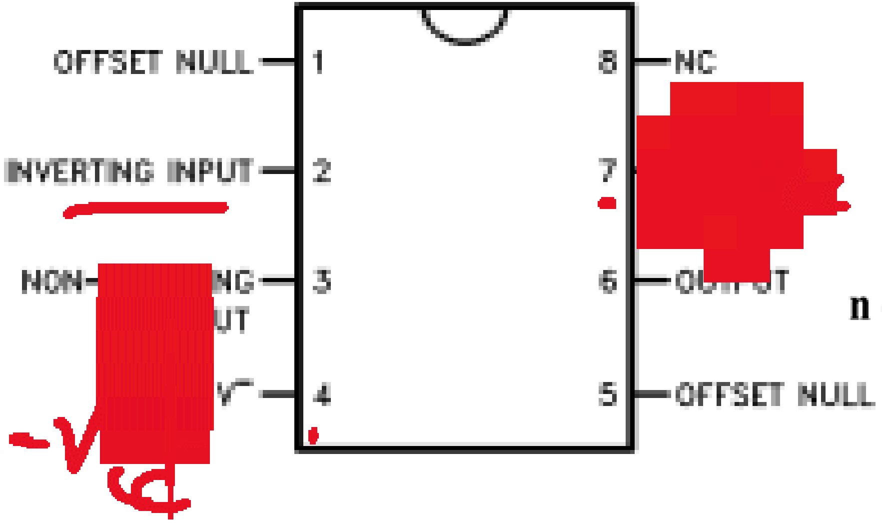
- ❑ Adding signals
- ❑ Subtracting signals
- ❑ Integrating signals
- ❑ Differentiating signals

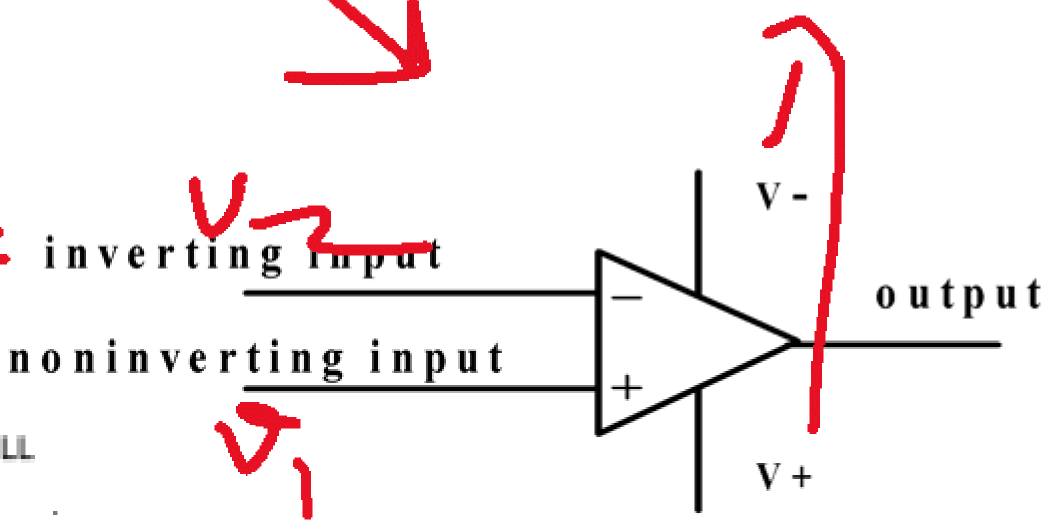
The applications of operational amplifiers (shortened to op amp) have grown beyond those listed above.

For example : Temperature sensor, Audio amplifiers, Active filters

Pin Diagram of LM 741

Dual-In-Line or S.O. Package

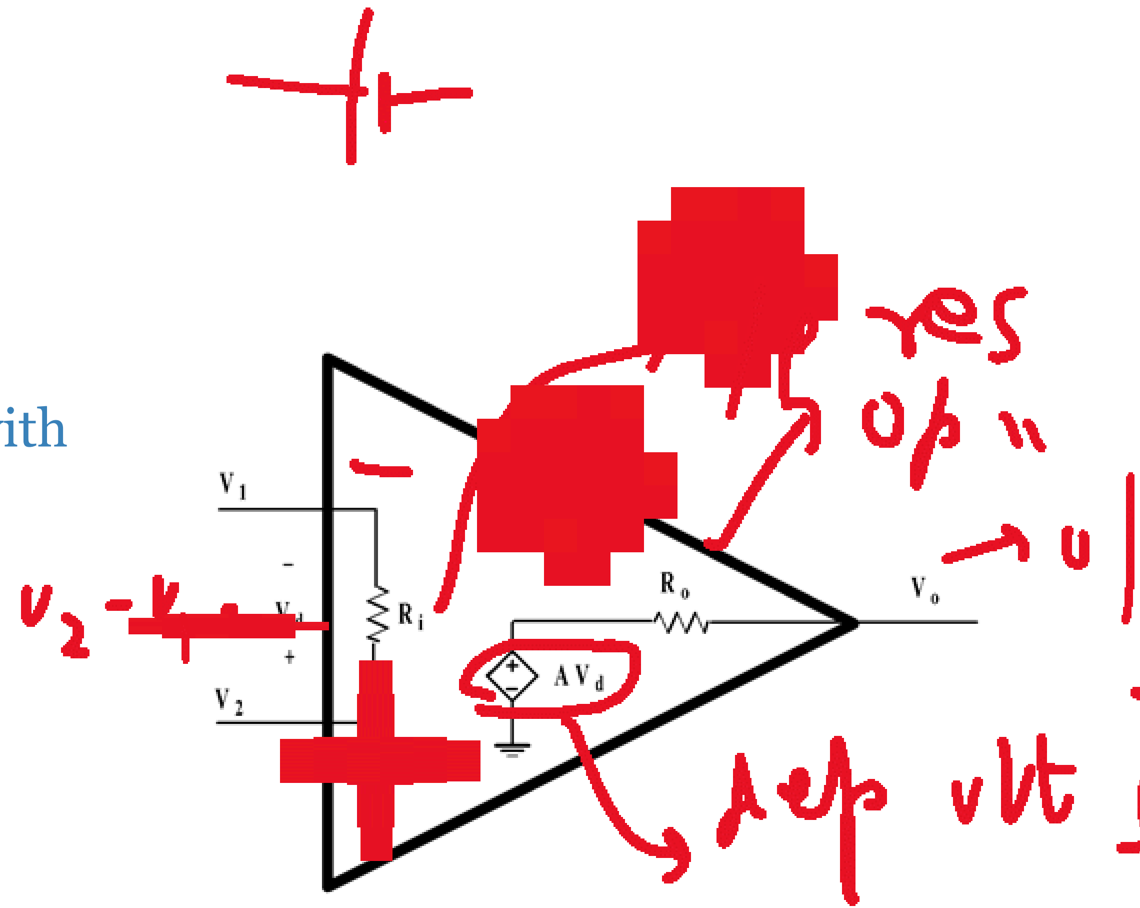




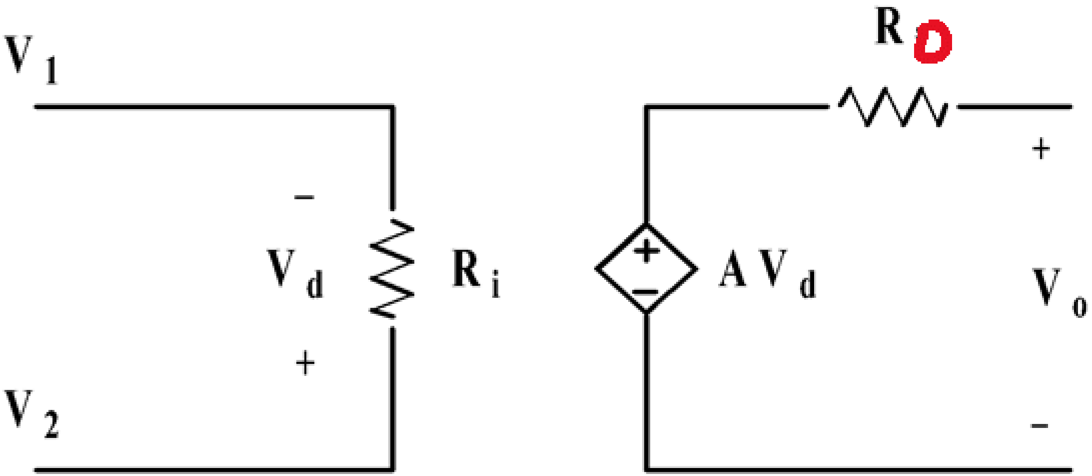
Operational Amplifiers

A model of the op amp, with respect to the symbol

$$\boxed{V_o = AV_d}$$



Working circuit diagram of op amp.



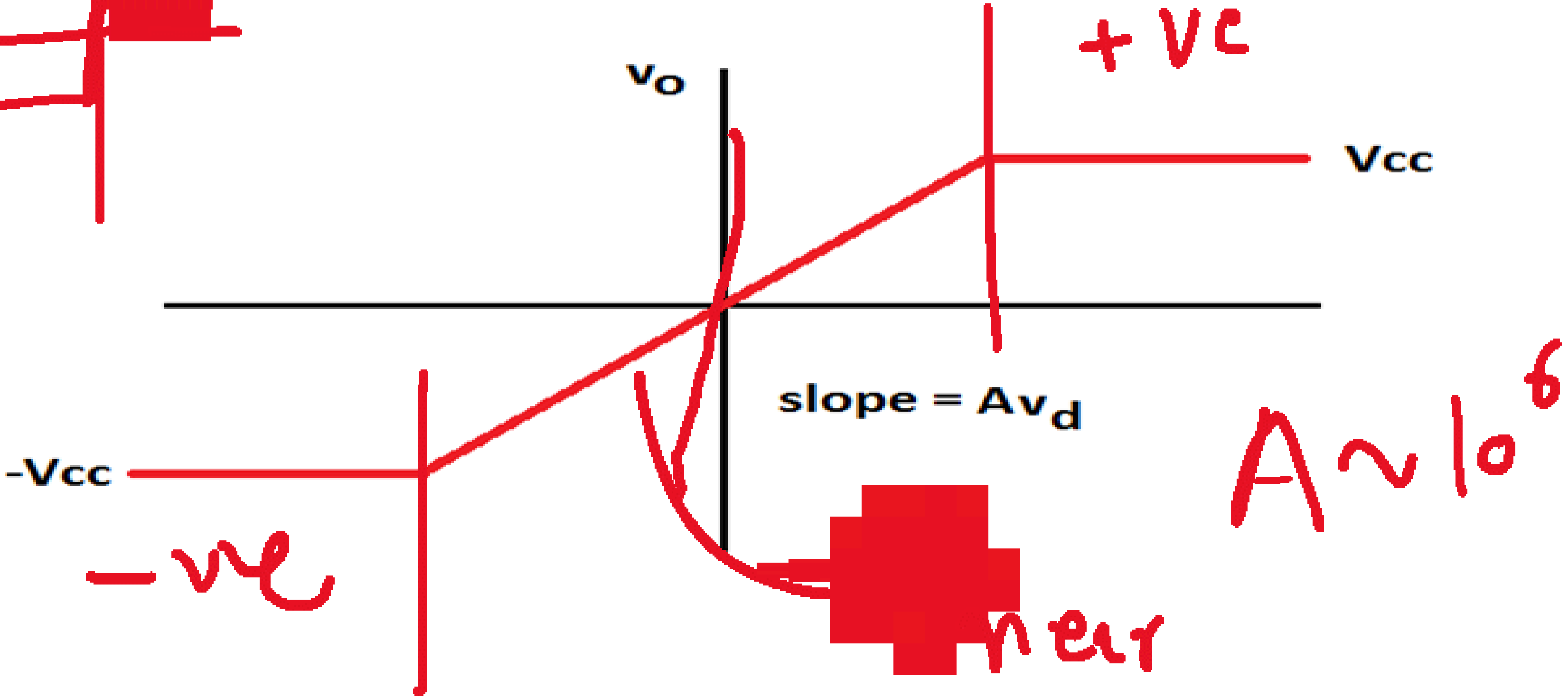
$v_o = Av_d$

Open Circuit Output Voltage

	Voltage Range	Output Voltage
Positive Saturation	$A\,v_d > V^+$	$v_o \sim V^+$
Linear Region	$V^- < A\,v_d < V^+$	$v_o = A\,v_d$
Negative Saturation	$A\,v_d < V^-$	$v_o \sim V^-$

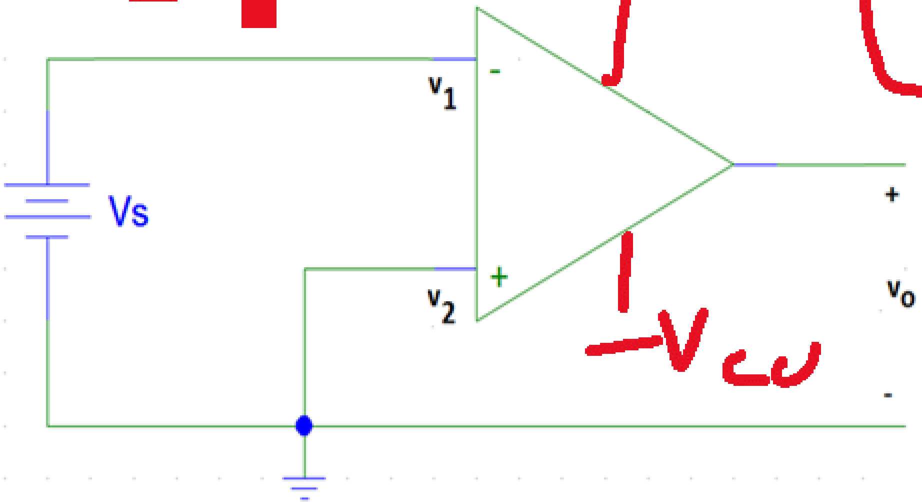
The voltage produced by the dependent voltage source inside the op amp is limited by the voltage applied to the positive and negative rails.

Voltage Transfer Characteristic



Example: Voltage Comparator

V_{cc} 12V



$V_1 < V_2$

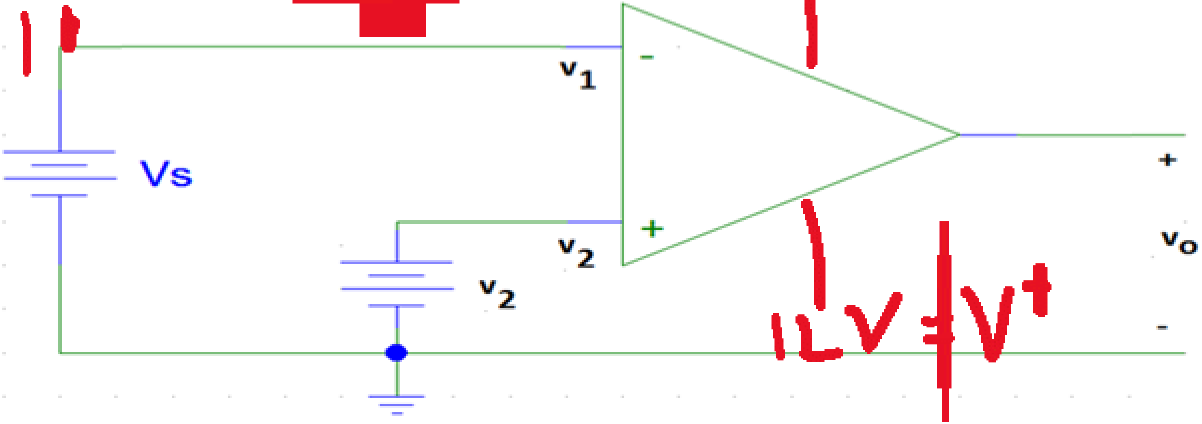
$V_d < 0 \rightarrow Av_d < -$

When V1 is equal to V2, Vo = 0V When V1 is smaller than V2, Vo = V^+. When V1 is larger than V2, Vo = V^-.

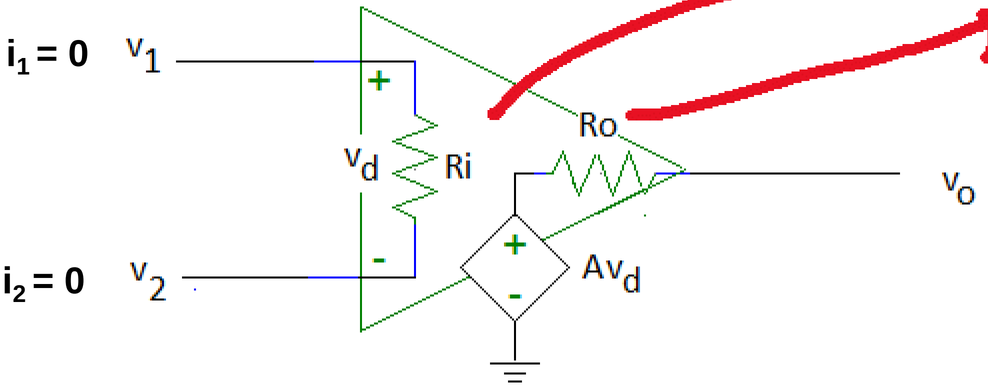
Electronic Response

Given how an op amp functions, what do you expect V_o to be if v_2 = 5V, A=10 when:

- V_s = 0V?
- V_s = 5V?
- V_s = 6V?



Ideal Op Amp

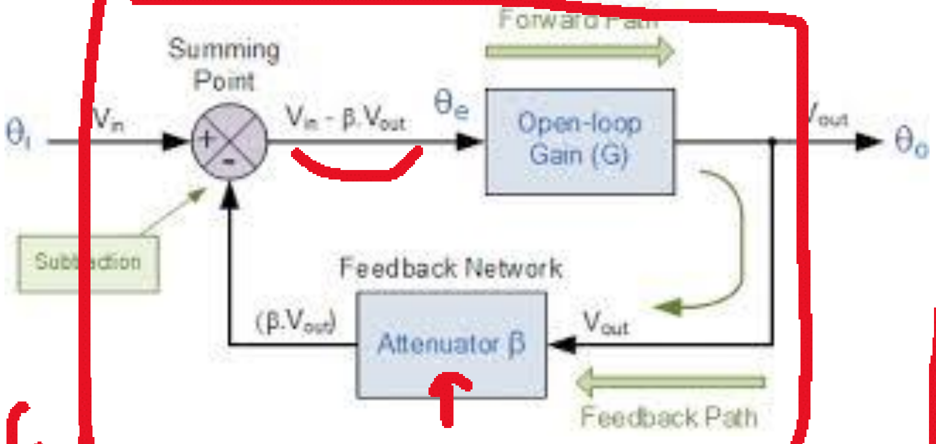


$R_i = \infty\Omega$
Hence $i_1 = i_2 = 0A$
$R_o = 0\Omega$

$A \to \infty$

FEEDBACK IN CIRCUITS

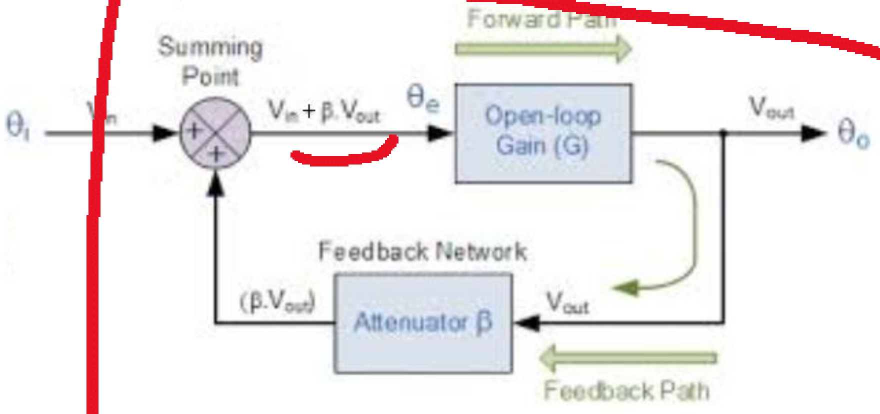
$V_o \uparrow \propto$



$G \downarrow$

Negative feedback

$\downarrow V_o \propto V_{in} \downarrow$



Positive feedback

Why Negative Feedback?

- Gain of op amp (open loop gain) is of the order of 10^6 which is enough to drive the op amp into saturation.
- We want the operation of op amp to be in the linear region for proper amplification purpose.
- So to reduce gain we apply negative feedback.

Why positive feedback?

- When we want the amplifier to work in saturation **only** then we use positive feedback.

- It decreases the bandwidth and increases the overall amplification.

- $G_{pf} = A/(1-A\beta)$

Negative Feedback Equation

We see that the effect of the negative feedback is to reduce the gain by the factor of: 1 + βG. This factor is called the “feedback factor” or “amount of feedback” and is often specified in decibels (dB) by the relationship of 20 log (1+ βG).

$$\text{System Gain, } G = \frac{V_{out}}{V_{in}}$$

G = open loop voltage gain

$$G \times V_{in} = V_{out}$$

$$G\left(V_{in} - \beta V_{out}\right) = V_{out}$$

β is the feedback fraction

$$G.V_{in} - \beta.G.V_{out} = V_{out}$$

βG = the loop gain

$$G.V_{in} = V_{out}\,(1 + \beta G)$$

1 + βG = the feedback factor

$$\therefore \quad \frac{V_{out}}{V_{in}} = Gv = \frac{G}{1 + \beta G}$$

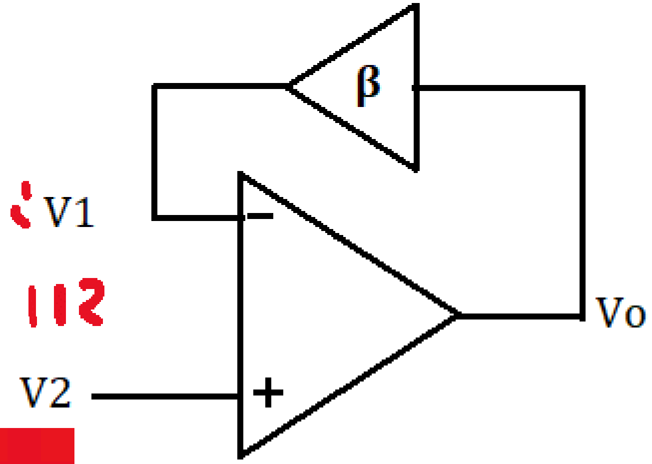
Gv = closed loop voltage gain

Applications of Negative Feedback:-

- Inverting Amplifier
- Non-Inverting Amplifier
- Adder , Subtractor
- Log , Antilog
- Integrator, Differentiator
- Temperature sensor
- Instrumentation amplifier
- Active Filters

Virtual Short Circuit in Ideal OpAmp

$A \to \infty$



$$V_0 = A(V_2 - V_1)$$

$$\implies V_0 = A(V_2 - \beta V_0)$$

$$\implies V_0(1 + A\beta) = AV_2$$

$$\implies V_0 = \frac{AV_2}{1 + A\beta}$$

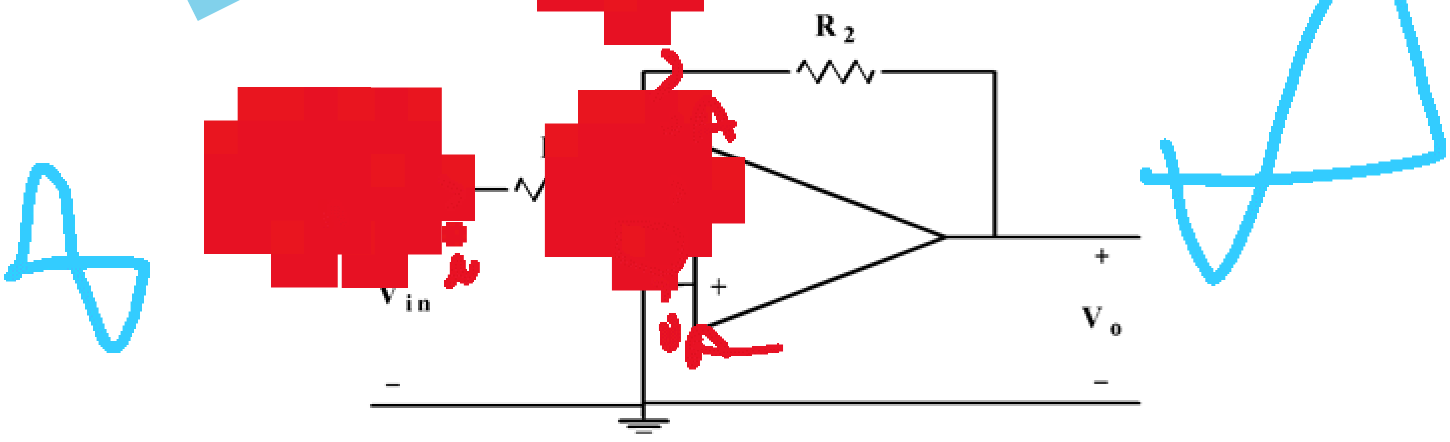
$$= \frac{AV_2}{\beta +}$$

$$as\ A \to \infty, V_0 = \frac{V_2}{\beta}$$

$$\implies V_1 = \beta V_0 = V_2$$

$V_1 \uparrow$

nverting amplifier:



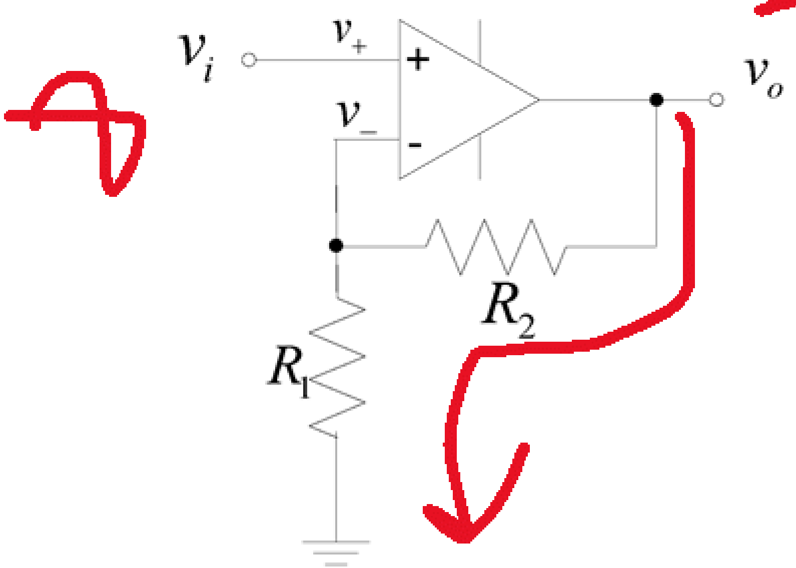
Writing a nodal equation at (a) gives;

$$i = \frac{V_{\text{in}} - V_i}{R_1} = \frac{V_i - V_0}{R_2}$$

With $V_i = 0$ we have;

$$\boxed{V_0 = \frac{-R_2}{R_1} V_{in}}$$

Non-inverting Amplifier

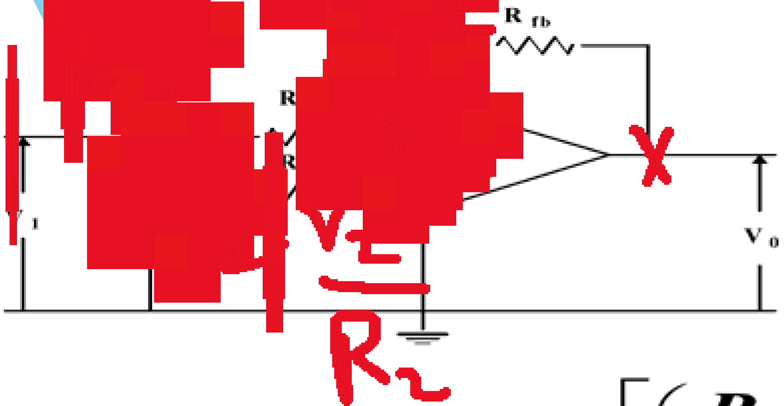


Closed-loop voltage gain $A_F = \dfrac{v_o}{v_i}$

$$v_i = v_+ = v_- = \frac{R_1}{R_1 + R_2} v_o$$

$$A_F = \frac{v_o}{v_i} = 1 + \frac{R_2}{R_1}$$

[illegible]ing Amplifier



$$\boxed{\frac{V_1}{R_1}+\frac{V_2}{R_2}=\frac{-V_0}{R_{fb}}}$$

$$\rightarrow V_0=-\left[\left(\frac{R_{fb}}{R_1}\right)V_1+\left(\frac{R_{fb}}{R_2}\right)V_2\right]$$

If $R_1 = R_2 = R_{fb}$ then,

$$\boxed{V_0=-\left[V_1+V_2\right]}$$

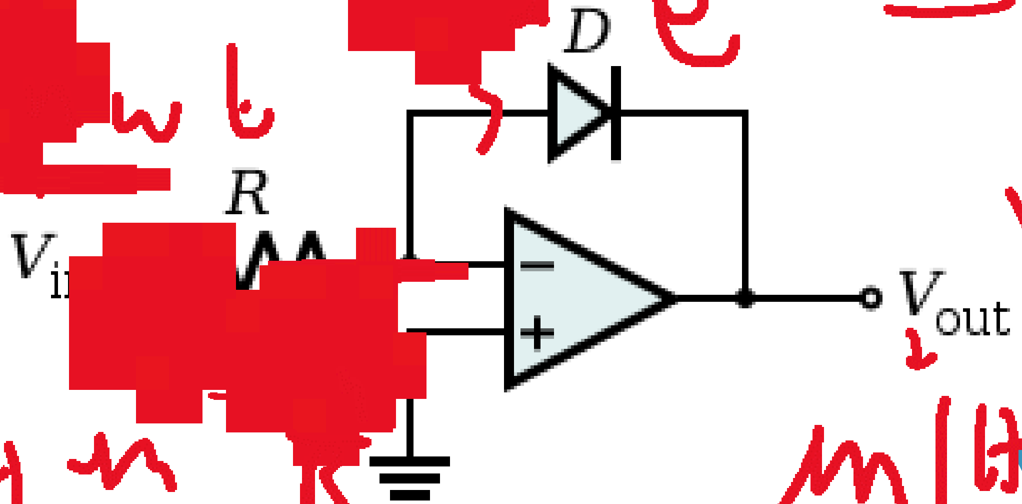
Therefore, we can add signals with an o[illegible]mp.

R_1 [illegible] R_2

V_0 [illegible] $V_1 + V_2$

Logarithmic Amplifier

- Logarithmic amplifier gives the output proportional to the logarithm of input signal.
- If V_i is the input signal then the output is
- $$V_o = K^*\ln(V_i)$$
- where K is gai[illegible]hmic amplifier.



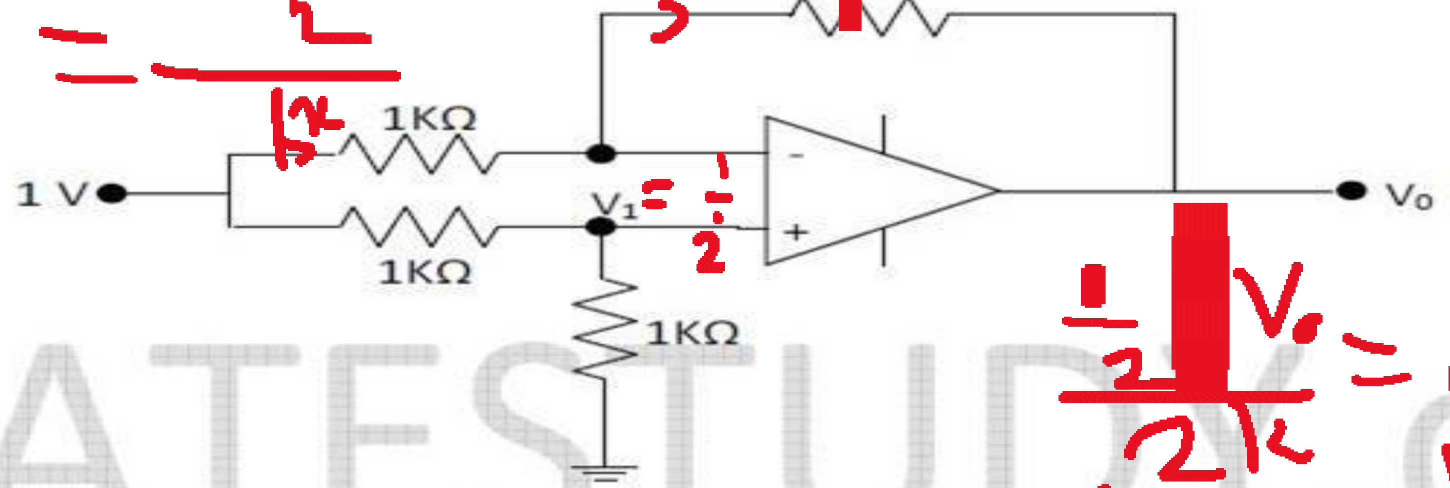
$e^{V_o} \Rightarrow V_o \propto \ln$

$\ln(1+\sin\omega t)$

Questions

.. For the Op-Amp circuit shown in the figure. V_o is

$$= \frac{1-\frac{1}{2}}{1k}$$



$V_1 = \frac{1}{2}$

$$\frac{\frac{1}{2} - V_o}{2k} = 0.5m$$

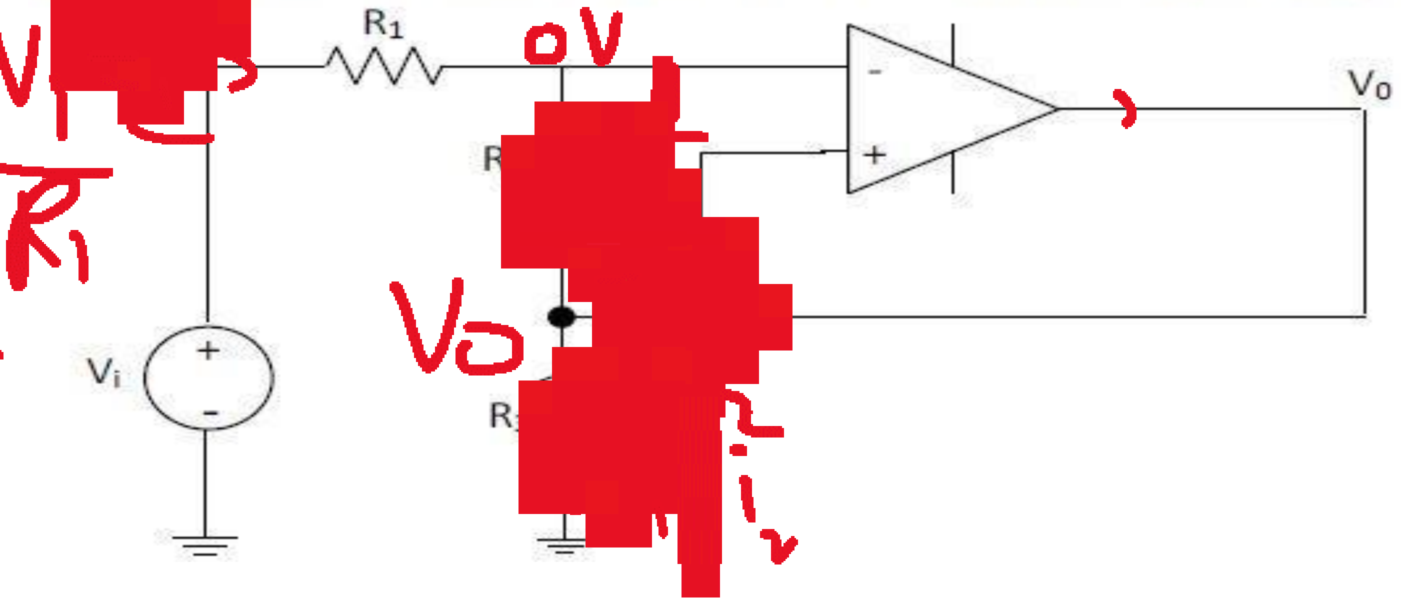
$V_o = \frac{1}{2}$

a.	-2 V	c.	-0.5 V
b.	-1 V	d.	0.5 V

Questions

$-\frac{R_2}{R_1}\cancel{V_i}$

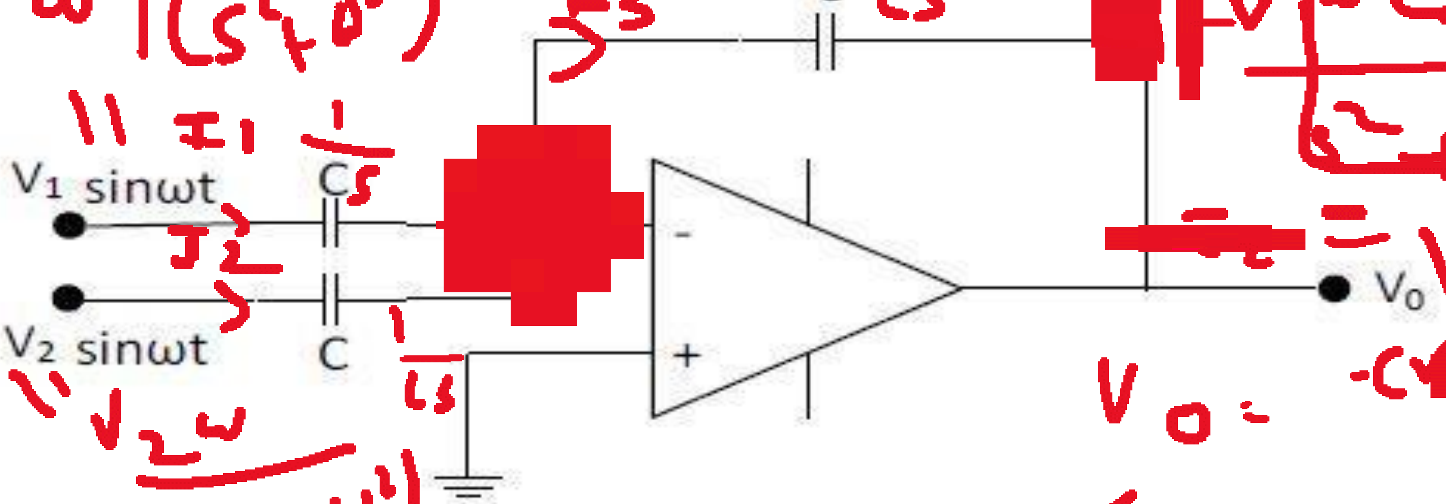
A ng the op-amp to be ideal, the voltage gain of the amplifier shown below is



$\frac{V_o}{} =$

Questions

.. If the op-amp in the figure, is ideal then V_0 is



a. Zero

b. $(V_1 - V_2)\sin\omega t$

c. $-(V_1 + V_2)\sin\omega t$

d. $(V_1 + V_2)\sin\omega t$

$-\frac{V_0}{1/C_s}$ [redacted] $I_3 = I_1 + I_2 = (V_1 + V_2)\,k$

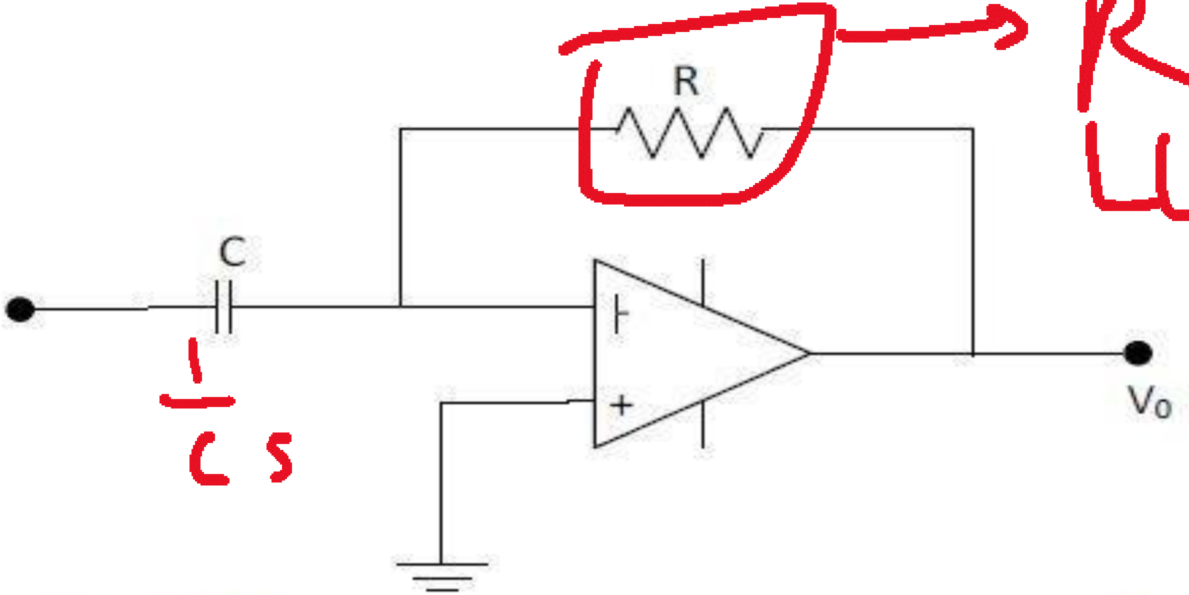
$$V_0(s) = -(V_1 + V_2)\,\frac{\omega}{s\,\text{[redacted]}}$$

$$= -(V_1 + V_2)\,\frac{\omega}{s^2 + \omega^2}$$

Questions

$A \sin \omega t$

. Assume that the op-amp of the figure is ideal. If V_i is a triangular wave, then V_0 will be

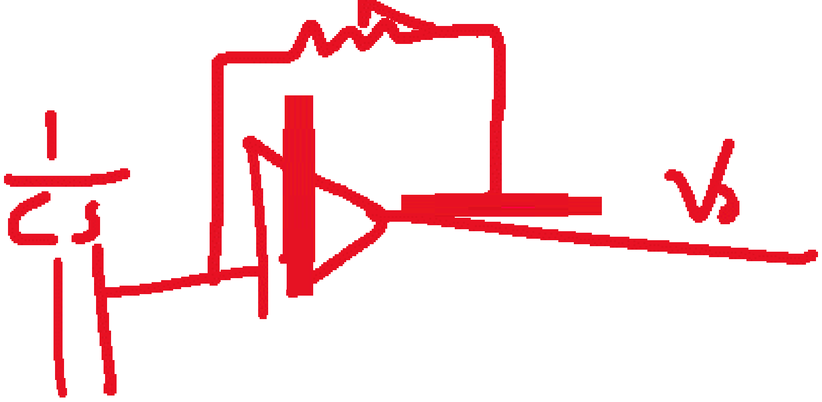


R

$L(\omega)$ $\frac{s}{s^2+\omega^2}$

a.	square wave	c.	parabolic wave
b.	triangular wave	d.	sine wave

[redacted] ωt

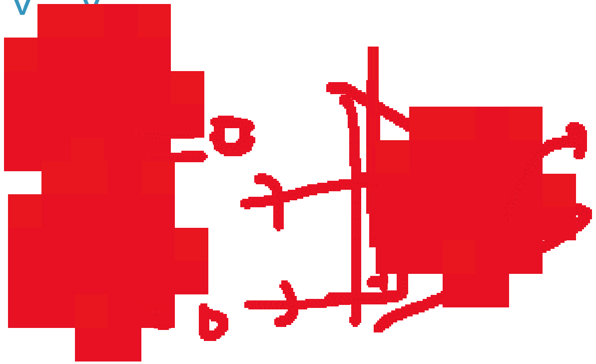


$$I = \frac{Cs\omega}{s^2+\omega^2} \rightarrow V_o = -\frac{\omega R}{1}\left[\frac{s}{s^2+\omega^2}\right.$$

$$V_o = -RC\omega \cos \omega t$$

Alternate proof for virtual short circuit in Ideal OpAmp

In ideal OpAmp, R_i=∞Ω (approx), and currents in input terminals are zero, then potential difference between the terminals V_d=0V, hence $V_1=V_2$



$\sim \infty$

$V_d = I R_i = 0 \Rightarrow V_1 = V_2$

Thank You!

☺

Contact us:

Mohit Shringi: 6377566533
Rishabh Borad: 9450336209
P. Shyam Prasad: 9494146711