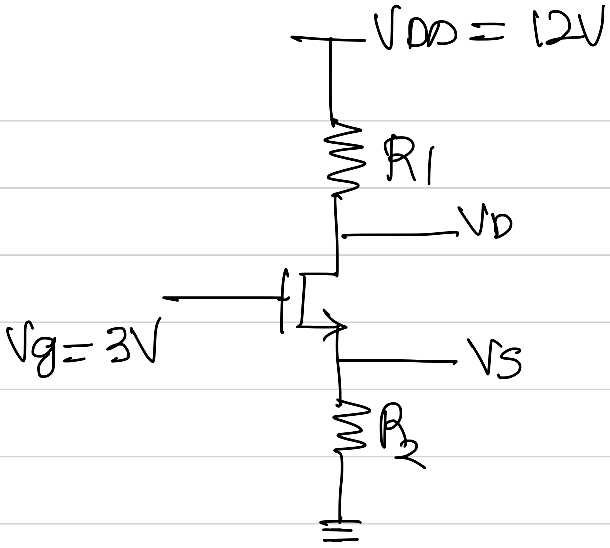


$$\frac{12-V_D}{R_1} = \frac{V_S}{R_2} = \frac{1}{2}K(3-V_S-V_{TH})^2$$

$\Rightarrow V_D$

$\Rightarrow V_S$

$\Rightarrow I_D$

$$V_D > V_G - V_{TH}$$

Project (40 marks)

30 viva | 5 simu | 5 report

Sine wave generator
and
cosine wave generator

mixer

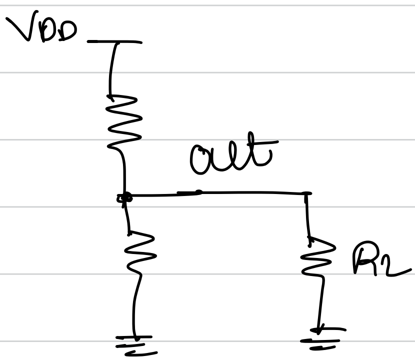
LPF

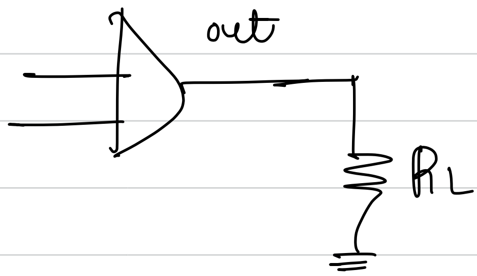
Op-amps:

High gain amplifiers

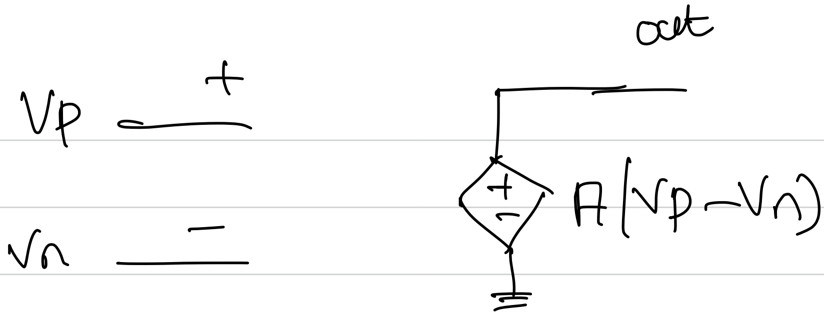
input impedance $\Rightarrow \infty$

output impedance $\rightarrow 0$

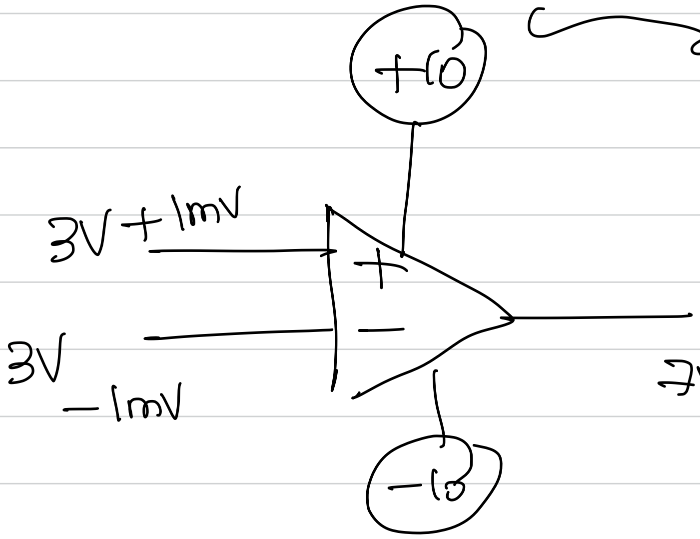




VCVS

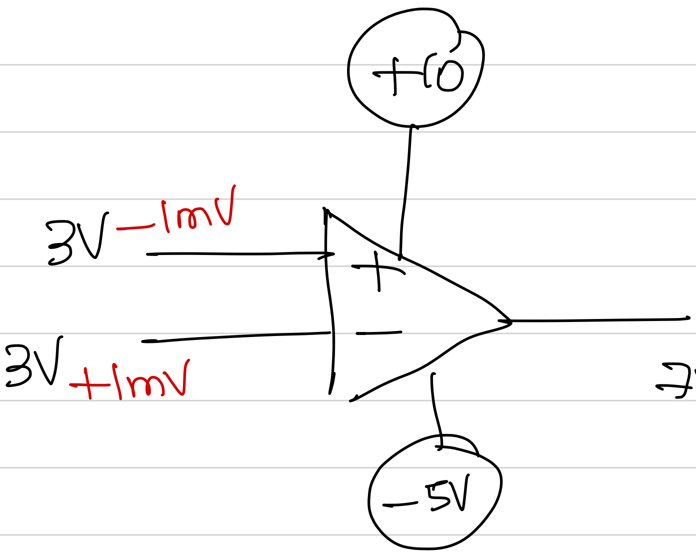


(small signal)



$7V + \underbrace{A(2mV)}_{20V}$

saturated to 10V



$7V + A(-2mV)$

$A = 10^4$

$7 + -20$

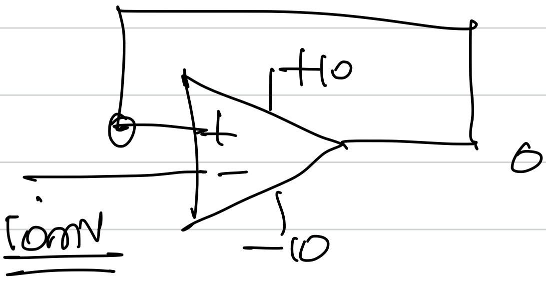
-13

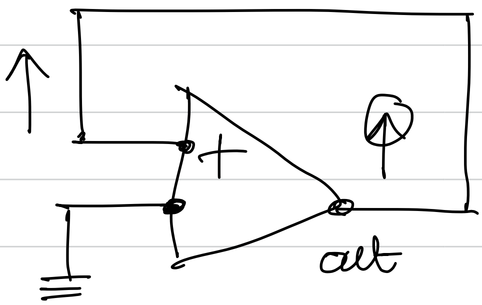
output saturated to

$-5V$

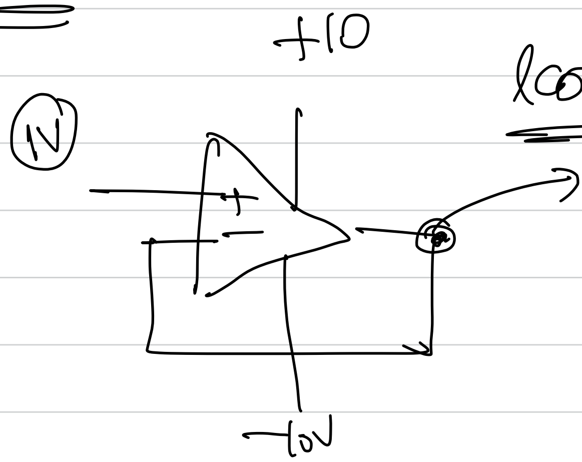
Feedback:

Positive feedback:





Negative feedback:

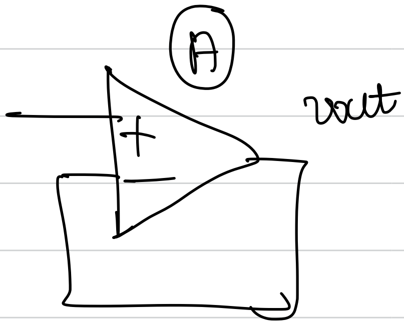


4V −10

large signal

$V_+ = V_-$

Small signal vin



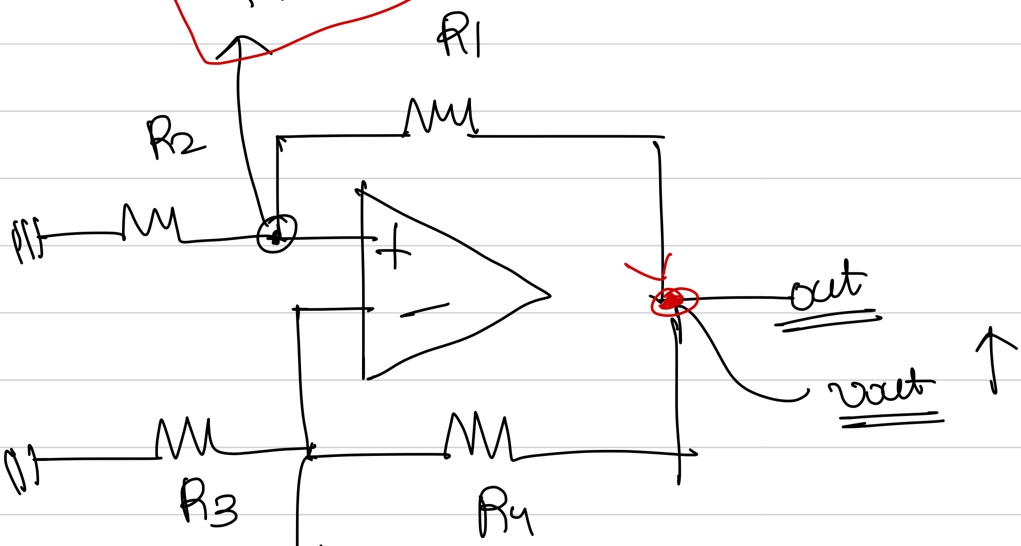
$A(v_{in} - v_{out}) = v_{out}$

$$\frac{v_{out}}{v_{in}} = \frac{A}{1+A} \sim 1$$

$$\underline{\underline{v_{out} = v_{in}}}$$

$$\boxed{\frac{v_{out} R_2}{R_1+R_2}} = V+$$

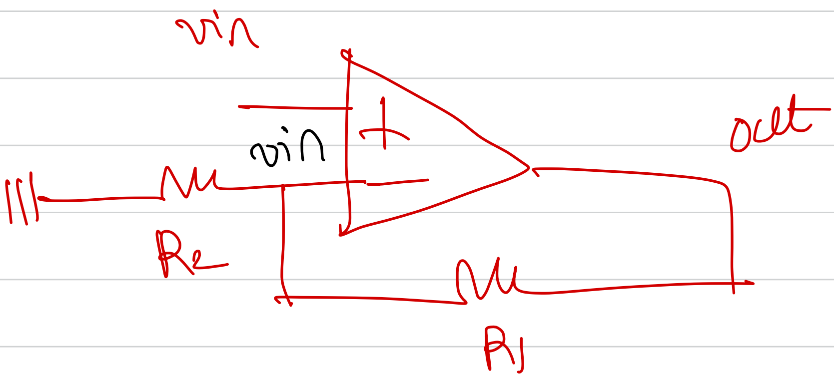
$$\boxed{V+ = V-}$$



$$\boxed{\frac{v_{out} R_3}{R_3+R_4}} = V-$$

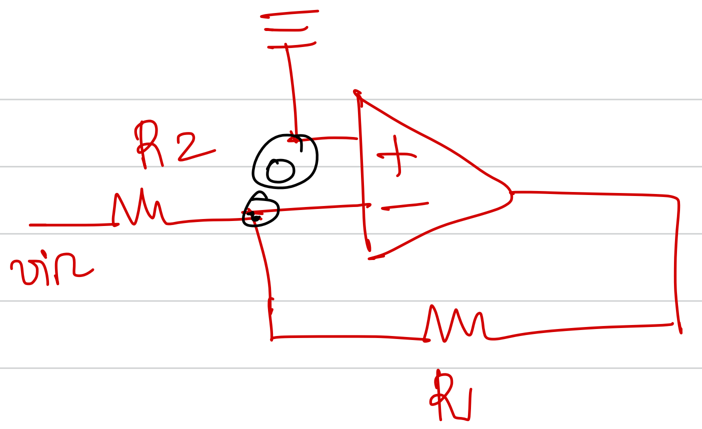
$$\boxed{V+ > V-}$$ +ve feedback

$$\boxed{V+ < V-}$$ −ve feedback



$$\frac{V_{out}}{v_{in}} = 1 + \frac{R_1}{R_2}$$

(NIA)

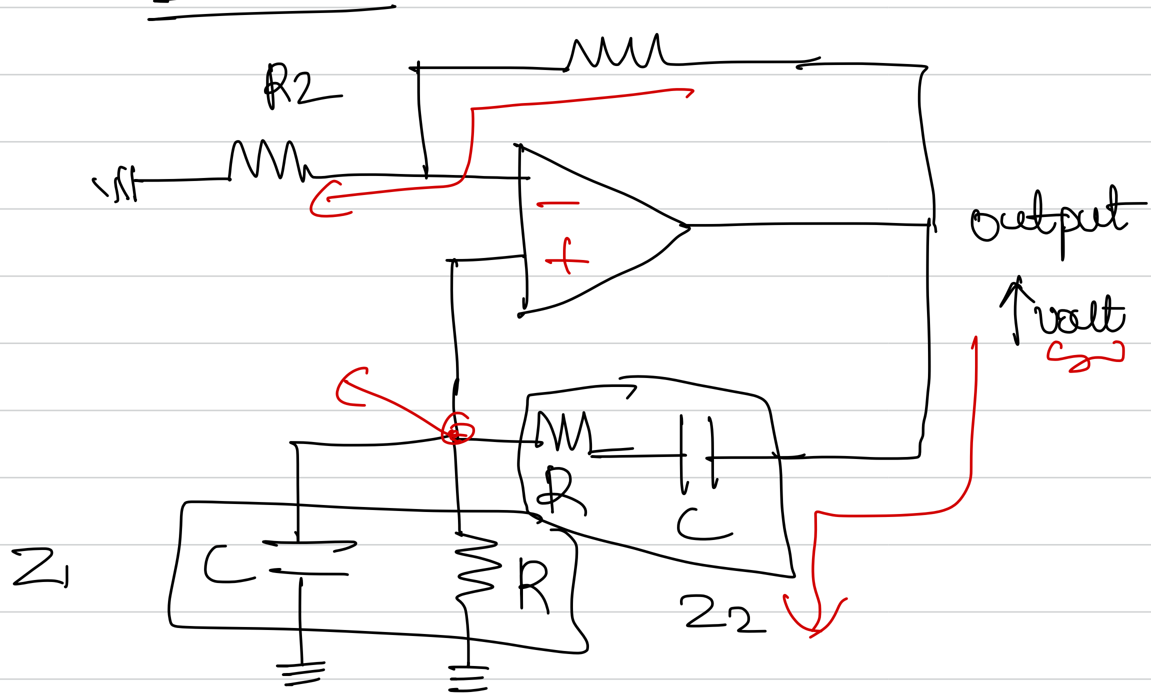


$$\frac{V_{out}}{v_{in}} = \frac{-R_1}{R_2}$$

(IA)

Positive feedback:

Oscillators:



$$V_- = \frac{V_{out} R_2}{R_1 + R_2}$$

$$Z_1 = R \parallel \frac{1}{sC}$$

$$V_+ = \frac{v_{out} Z_1}{Z_1 + Z_2}$$

$$Z_2 = R + \frac{1}{sC}$$

$$\frac{\cancel{V_{out}} Z_1}{Z_1 + Z_2} = \frac{\cancel{V_{out}} R_2}{R_1 + R_2}$$

$$\left| \frac{Z_1}{(Z_1 + Z_2)} \; \frac{R_1 + R_2}{R_1} \right| > 1$$

$$\frac{\frac{R}{1+SRC}}{\frac{R}{1+SRC}+\frac{SRC+1}{SC}} \times \left(1+\frac{R_2}{R_1}\right) \geq 1$$

$$\Rightarrow \boxed{\frac{SRC}{SRC+(SRC+1)^2} \times \left(1+\frac{R_2}{R_1}\right) \geq 1}$$

$$\frac{SRC}{S^2R^2C^2+3SRC+1}$$

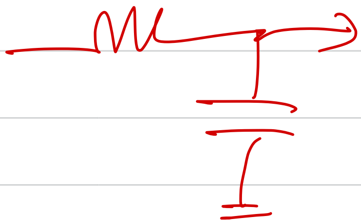
$$\left[\frac{1}{3+\left(SRC+\frac{1}{SRC}\right)}\right] \times \left(1+\frac{R_2}{R_1}\right)$$

$$\frac{1}{3+j\omega RC+\frac{1}{j\omega RC}}$$

$$3+j\omega RC-\frac{j}{\omega RC}$$

$$\left[3+j\left(\omega RC-\frac{1}{\omega RC}\right)\right] \times \left(1+\frac{R_2}{R_1}\right)$$

$$\frac{1}{3+j\left(\omega RC-\frac{1}{\omega RC}\right)} \times \left(1+\frac{R_2}{R_1}\right)$$



$\rightarrow \tan^{-1}(\omega RC)$

$$V_+ = \frac{V_{out} Z_1}{Z_1 + Z_2}$$

$$\frac{V_{out}}{3 + j\left(\omega RC - \frac{1}{\omega RC}\right)}$$

$$\frac{Z_1}{Z_1 + Z_2}$$

$$j\left(\omega RC - \frac{1}{\omega RC}\right) = 0$$

$$\omega RC = \frac{1}{\omega RC}$$

$$\frac{1}{1 + j\omega RC}$$

$$\boxed{\omega = \frac{1}{RC}}$$

Out $\rightarrow$ Single frequency signal

$$\left(\omega = \frac{1}{RC}\right)$$

Req ⇒ ②

$$\left(\frac{z_1}{z_1+z_2}\right)\left(1+\frac{R_2}{R_1}\right) > 1$$

$$\left(\frac{1}{3}\right)\left(1+\frac{R_2}{R_1}\right) > 1$$

$$\boxed{\frac{R_2}{R_1} > 2}$$

sin(