(1)

(a) A differential amplifier should have high differential voltage gain (A_{DM}) and very low Common mode voltage gain (A_{cm}). The ratio A_{DM}/A_{cm} is called common-mode rejection ratio (CMRR) i.e

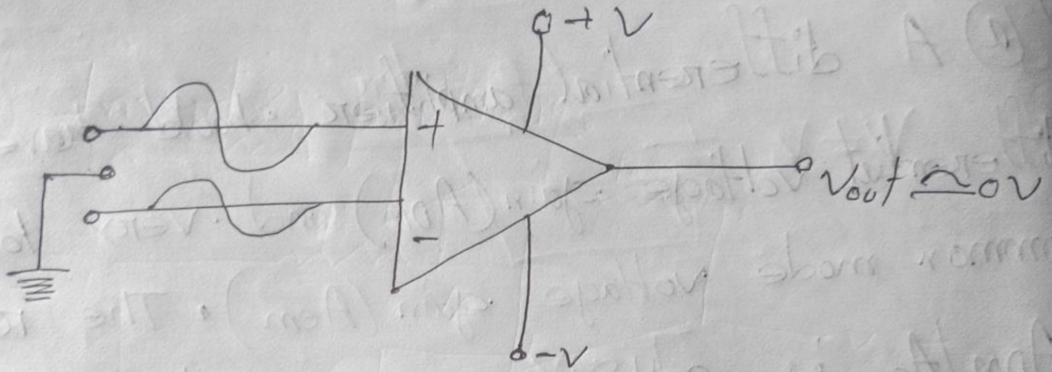
$$CMRR = \frac{A_{DM}}{A_{cm}}$$

Very often the CMRR is expressed in decibe

$$CMRR_{dB} = 20\log_{10}\frac{A_{Dm}}{A_{cm}}$$

$$= 20\log_{10} CMRR$$

<u>Importance of CMRR</u>: The CMRR is the ability of a DA to reject the common mode signals. The larger the CMRR, the bet the DA is at at eliminating common-mode signals. Let us illustrate this point.



This means that the output produced by a difference between the inputs would be 1500 times as great as an output produced by a common mode signal

(b) Differential gain A_{DM} = 100 Volt

Common-mode gain A_{cm} = 3.2 Volt

$A_{cm} = \frac{V_{out}}{V_{in}}$

$= \frac{26}{3.2}$

$= 8.125$

$CMRR = \frac{A_{DM}}{A_{cm}}$

$= \frac{100}{8.125}$

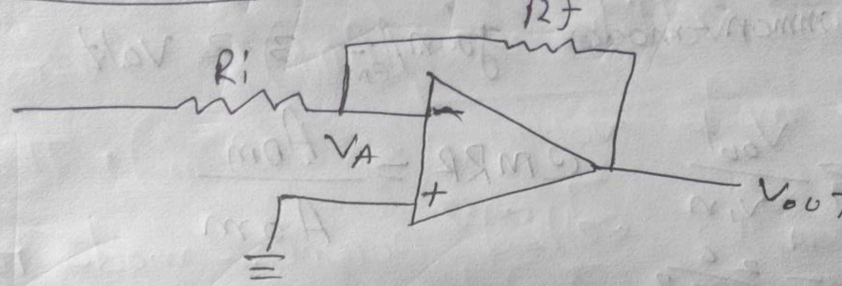
$\cancel{= 31.25}$

$= 12.30$

the CMRR in dB $= 20 \log_{10}(12.30)$

$\cancel{= 6.25}$ $= 12.3$

(c) Inverting amplifier:



$$I_{in} = \frac{V_{in} - V_A}{R_i}$$

$$= \frac{V_{in} - 0}{R_i} = \frac{V_{in}}{R_i}$$

$$I_f = \frac{V_A - V_{out}}{R_f}$$

$$= \frac{0 - V_{out}}{R_f}$$

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

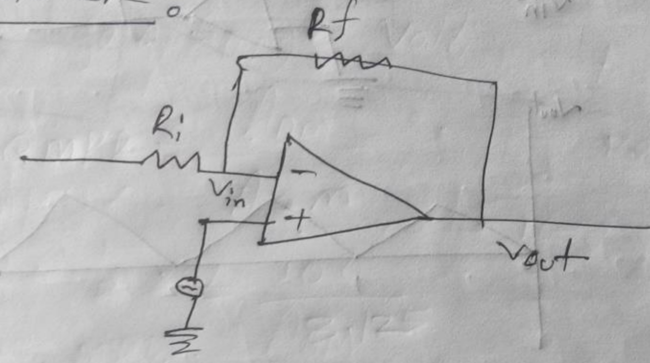
since $I_f = I_{in}$

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

$$A_{cl} = \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_i}$$

Question to the Answer 2(a)

Noninverting Amplifier:



Current through R_i = Current through R_f

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

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

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

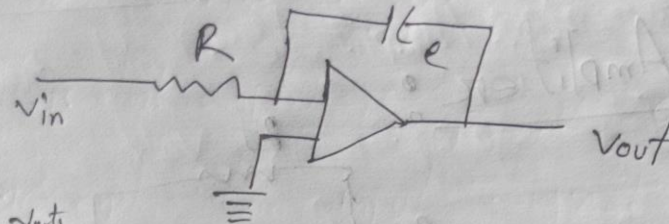
$$\frac{V_{out}}{V_{in}} = \frac{R_f+R_i}{R_i}$$

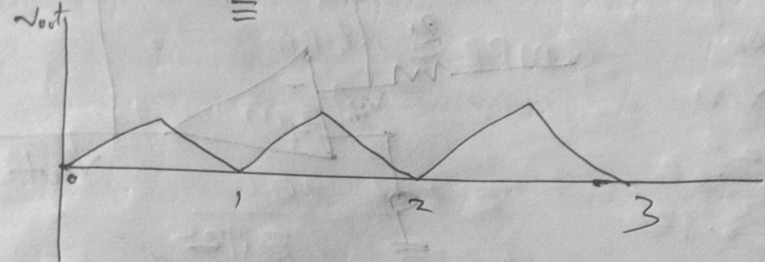
$$= 1+\frac{R_f}{R_i}$$

$\therefore$ Closed-loop voltage gain $A_{CL} = \frac{V_{out}}{V_{in}} = 1+\frac{R_f}{R_i}$

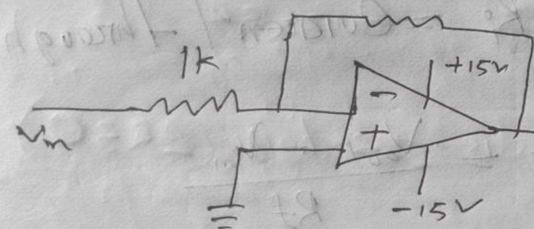
(b)

(i)





(ii)



$V_{out} = ?$

$A_{cl} = -\frac{R_f}{R_i} = \frac{40}{R_i} = 40$

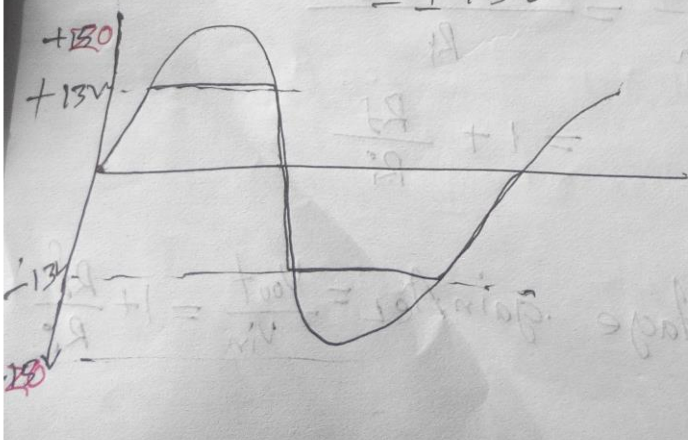
$V_{out} = 40 \times 0.5$

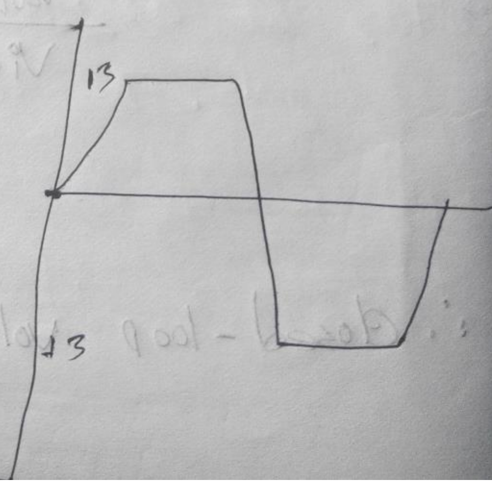
$= 20V$

$V_{sat} = \cancel{V}_{supply} \pm 2$

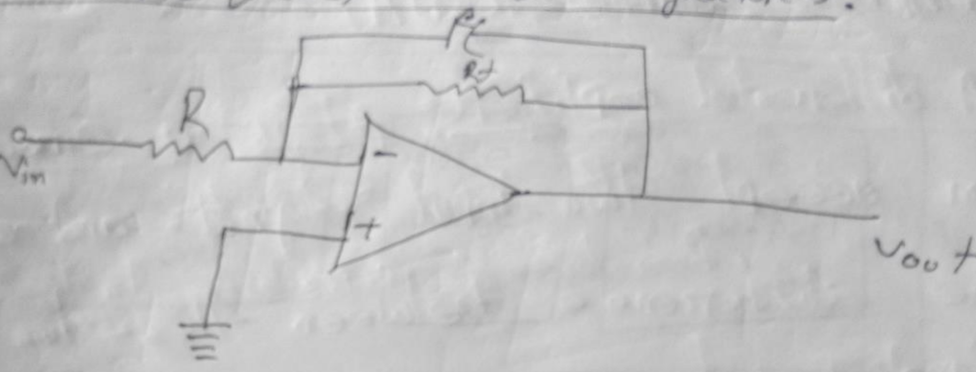
$= 15 - 2$

$= \pm 13V$



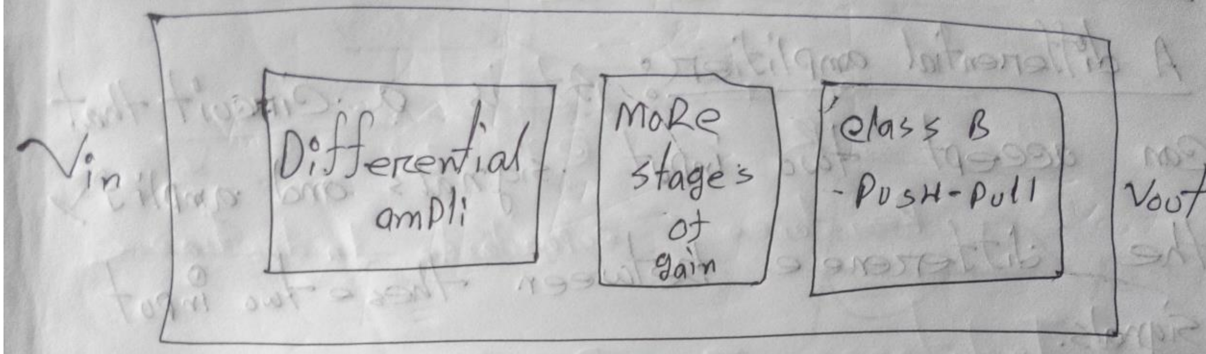


(c) Critical Frequency of Integrators:



$$f_c = \frac{1}{2\pi R_f C}$$

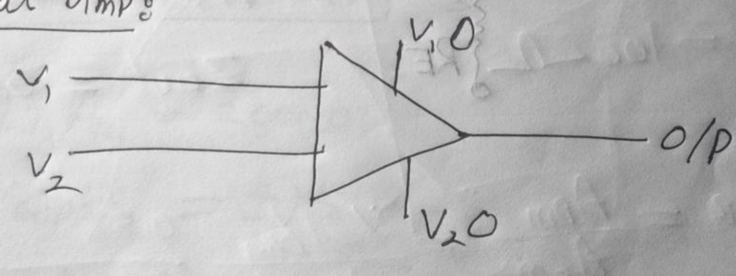
* operational Amplifier (OP-amp):



OP-AmP

An operational amplifier: op-amp is a circuit that can perform such mathematical operations as addition, subtraction, integration and differentiation.

Differential amp:

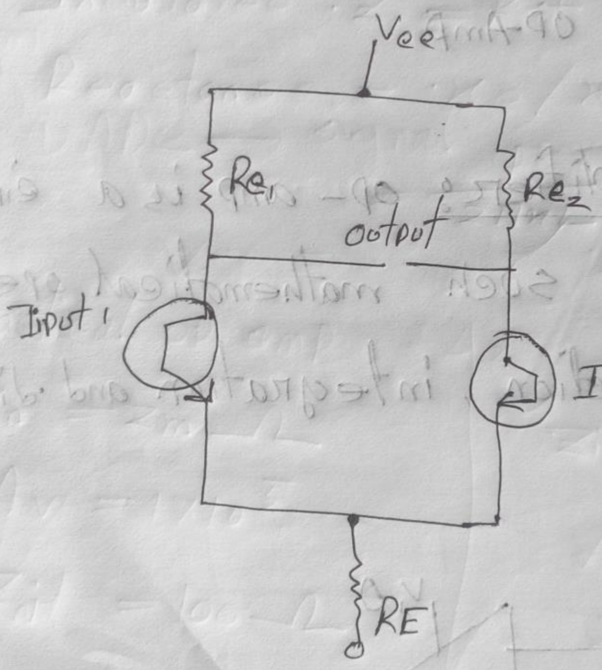


$$\text{Gain} = \frac{O/P}{i/P}$$

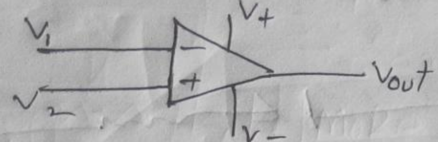
$$A(V_1 - V_2) = O/P$$

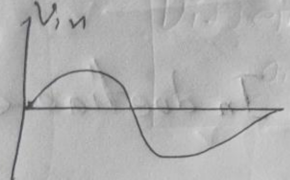
Differential amplifier (DA)

A differential amplifier: It is a circuit that can accept two input signals and amplify the difference between these two input signals.

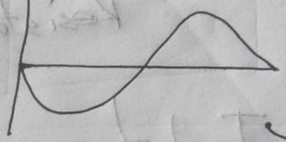


Schematic Diagram of OP-amp

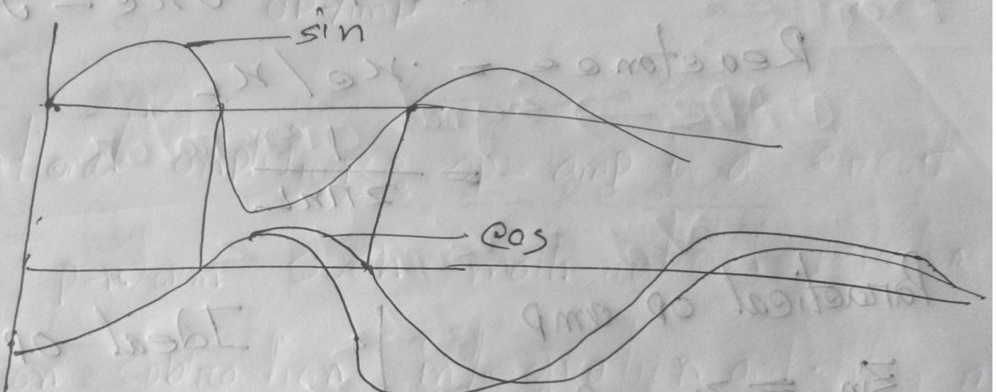




A.2V } same



>180 Dhesh



* $\boxed{V_{set} = V_{supply} \pm 2V}$ সূত্র

If $A_{OL} = 20000$

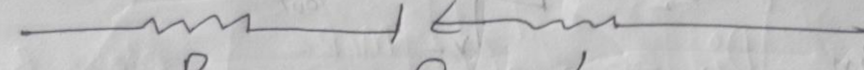
$V_{supply} = \pm 15 V$

$V_{set} = 15 - 2 = 13 V$

$$V_{ia} = \frac{V_{set}}{A_{OL}} = \frac{13}{20000}$$

$$= 6.5 \times 10^{-10} V$$

Passiv element:



Resistance capacitance Inductiace

Indutance $\cdot Z = R + Jx_C - Jx_L$

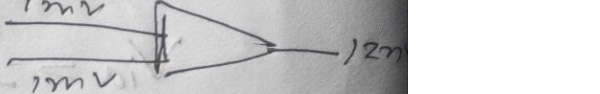
Reactance $= x_C / x_L$

$= \frac{1}{2\pi x L}$

Paractical op amp	Ideal op amp
$Z_{in} = 2m\Omega$	$Z_{in} = \alpha$ (oc)
$A_v = 1\times10^5$	$A_v = \alpha$
$Z_{nit} = 100\Omega$	$Z_{out} = 0$

* $CMRR = \frac{A_{Dm}}{A_{cm}} = \frac{V_{out}/V_{in}}{V_{out}/V_{in}}$

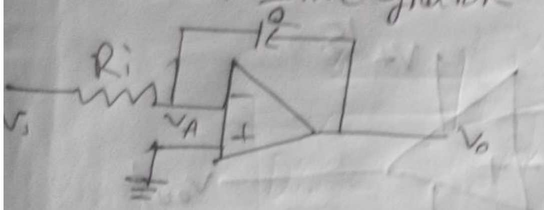
$= \frac{\frac{8}{1}}{\frac{12}{1}} = \frac{8}{12} = \frac{2}{3}$



Differential gain $A_{Dm} = \frac{0.5}{-0.5} = -1$

Common mode $A_{cm} = \frac{1}{1} = 1$

OP-amp Integrator



$i_R = i_C = i$

$\Rightarrow \frac{v_i - v_A}{R_i} = C\cdot\frac{dv_c}{dt}$

$\Rightarrow \frac{v_i}{R_i} = -C\frac{dv_o}{dt}$

$\Rightarrow \int\frac{v_i dt}{R_i C} = \int dv$

$\Rightarrow V_o = -\frac{1}{R_iC}\int v_i dt$

$\therefore V_o = -\frac{1}{R_iC}$

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

$= -1$

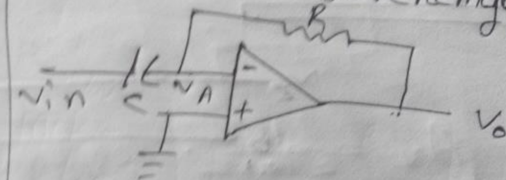
$= -1\times\int v_i dt$

$= -\int v_i dt$

$\Rightarrow -1\int_0^1$

$= -1$

OP-amp Differentiator

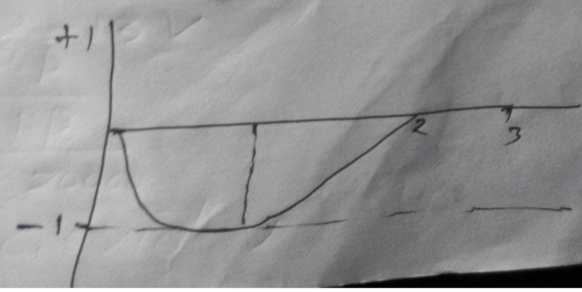


$i_R = i_C$

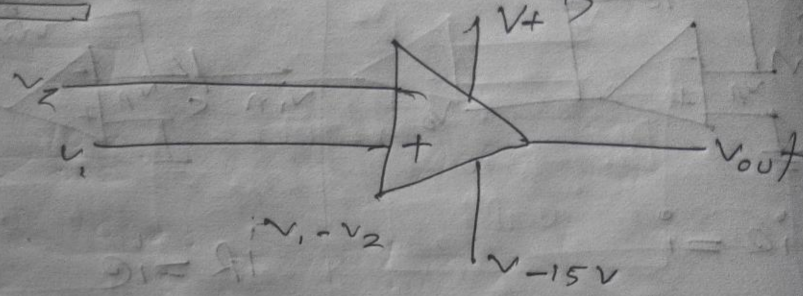
$\frac{v_A - v_o}{R} = C\cdot\frac{dv_c}{dt} = -C\left(\frac{dv_i}{dt}\right)$

$\Rightarrow \frac{v_o}{R} = -C\frac{dv_i}{dt}$

$\Rightarrow V_o = -RC\frac{dv_i}{dt}$



Comparator



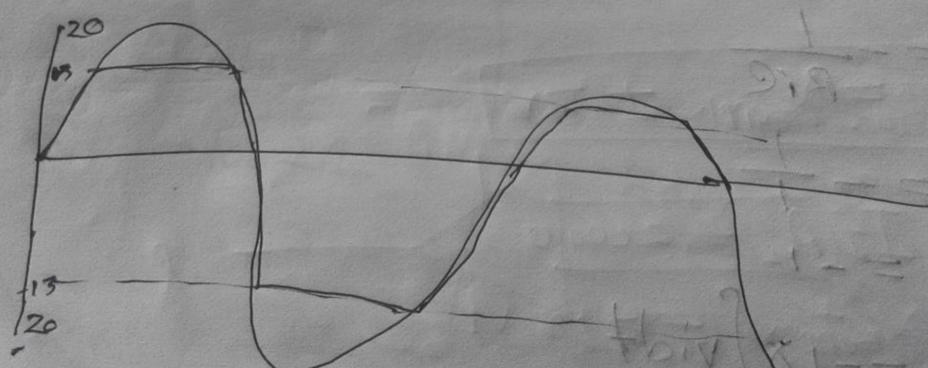
Example:

① ADC → signal Generator

$$V_{sat} = V_{suppy} \pm 2$$

$$= 15 - 2$$

$$= \pm 15V$$

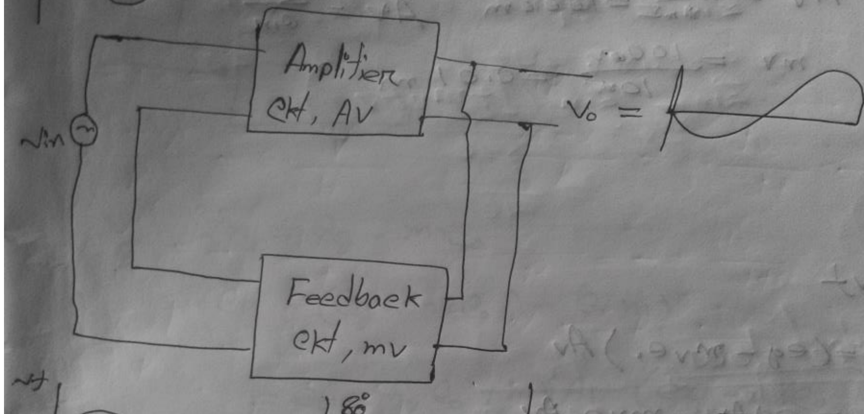


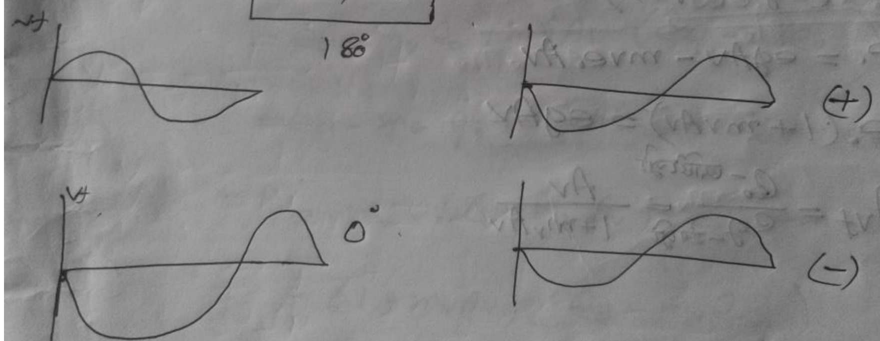
2. Zero crussing detector
3. Level Dectoctor.

ep-13:337

Chapter13 Feedback

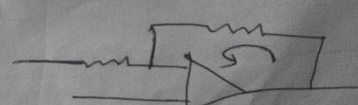
Positive Negative





Positive Exam : oscillator

Negetive Exam: OP. Amp



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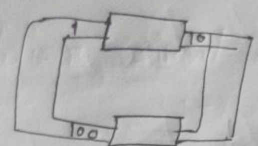


$$A_v = \frac{10v}{1mv} = 1000m \qquad A_v = \frac{e_o}{e_{in}}$$

$$m_v = \frac{1000v}{10mv} = 0.01\,m$$

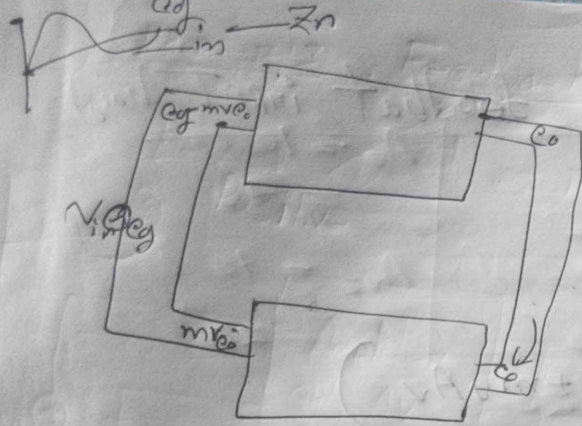
* A_{vf}

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

$$e_o = e_g A_v - m_v e_o A_v$$

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

$$\Rightarrow A_{vf} = \frac{e_o - \text{आउटपुट}}{e_g - \text{इनपुट}} = \frac{A_v}{1 + m_v A_v}$$



P 393
Math 339
H.W 13.1–13.8

$iZ_n = e_g - m_v e_o$

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

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

$= e_g - m_v e_o + m_v A_v e_g - m_v^2 A_v e_o$

$= -m_v e_o (1 + m_v A_v) + e_g (1 + m_v A_v)$

$= (1 + m_v A_v)(e_g - m_v e_o)$

$= (1 + m_v A_v) \cdot iZ_n$

$$Z_{in} = \frac{e_g}{(1 + m_v A_v)i}$$

Amplifier sircuit with feedbat input haigh

$$Z_{in} = e_g / i$$

$$Z_{in}' = Z_{in} (1 + m_v A_v)$$

output low:

13.1

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

$A_v = 3000$
$m_v = 0.01$

$$= \frac{3000}{1+3000 \times 0.01}$$

$$= \frac{3000}{31}$$

$$= 97$$

13.3

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

$A_v = 100$
$A_{vf} = .50$

$$50 = \frac{100}{1+100 m_v}$$

$$50 + 5000 m_v = 100$$

$$m_v = \frac{100-50}{5000}$$

$$= 0.01$$

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

$A_{vf} = 75$
$m_v = 0.01$
$A_v = ?$

$$75 = \frac{A_v}{1+0.01 A_v}$$

$$75 + 0.75 A_v = A_v$$

$$A_v = \frac{75}{1-0.75}$$

$$= 300$$

13.4

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

$$20 = \frac{40}{1+40m_v}$$

$$20 + 800 m_v = 40$$

$$m_v = \frac{40-20}{800}$$

$$= \frac{1}{40}$$

$A_v = 10/0.25$

$= 40$

$A_{vf} = 10/0.5$

$= 20$

13.5

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

$$25 = \frac{50}{1+50m_v}$$

$$m_v = \frac{1}{50}$$

%age reduction in stage gain

$$= \frac{50-40}{50} \times 100$$

$$= 20\%$$

(ii)

$$\text{Negative feedback} = \frac{A_v}{1 + A_v m_v}$$

$$= \frac{40}{1 + (40 \times 1/50)}$$

$$= 22.2$$

$$\text{stage gain} = \frac{25 - 22.2}{25} \times 100$$

$$= 11.2\%$$

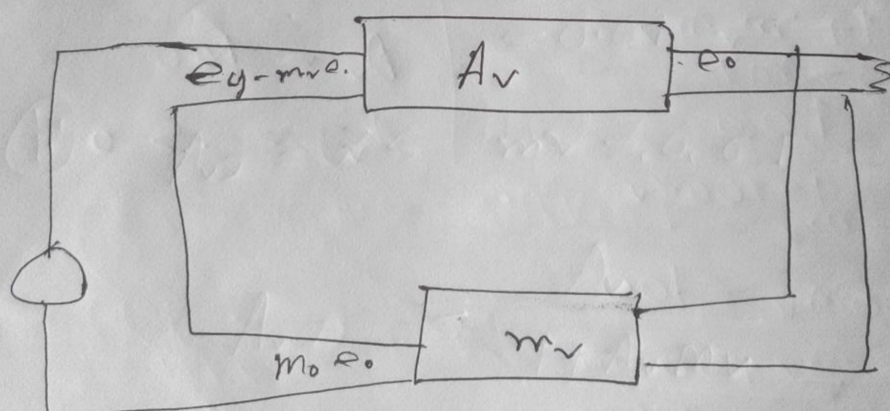
$$(e_g - m_v e_o) A_v = e_o$$

$$e_g A_v - A_v m_v e_o = e_o$$

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

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

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



13.1

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

$$= \frac{3000}{1+3000 \times 0.01}$$

$$= \frac{3000}{31} = 97$$

13.2

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

$A_v = 140$

$A_{vf} = 17.5$

$$17.5 = \frac{140}{1+140 m_v}$$

$$17.5 + 2450 m_v = 140$$

$$m_v = \frac{140-17.5}{2450}$$

$$= \frac{1}{20}$$

(i) $A_v = 100 \qquad A_{vf} = 50$

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

$$50 = \frac{100}{1 + 100 m_v}$$

$$50 + 5000 m_v = 100$$

$$m_v = \frac{100 - 50}{5000}$$

$$= 0.01$$

(ii) $A_{vf} = 75 \quad m_v = 0.01 \quad A_v = ?$

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

$$75 = \frac{A_v}{1 + 0.01 A_v}$$

$$75 + 0.75 A_v = A_v$$

$$A_v = \frac{75}{1 - 0.75}$$

$$= 300$$

(4)

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

$$A_v = \frac{10}{0.25} = 40$$

$$A_{vf} = \frac{10}{0.5} = 20$$

$$20 = \frac{40}{1+40m_v}$$

$$20+800m_v = 40$$

$$m_v = \frac{40-20}{800}$$

$$= \frac{1}{40}$$

(5)

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

$$25 = \frac{50}{1+50m_v}$$

$$m_v = \frac{1}{50}$$

(1) without feedback :

reduction in stage gain $= \frac{50-\cancel{40}}{\cancel{50}} \times 100$

$= 20\%$

(ii) New gain with negative feedback

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

$$= \frac{40}{1+(40 \times 1/50)}$$

$$= 22.2$$

Stage gain $= \frac{25 - 22.3}{25} \times 100$

$= 11.2\%$

(6)

$A_v = 100 \quad m_v = 0.1 \quad A_{vf} = ?$

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

$$= \frac{100}{1 + 100 \times 0.1}$$

$$= 9.09$$

$$20 \log_{10} \frac{A_v}{A_{v_1}} = 6$$

$$\log_{10} \frac{A_v}{A_{v_1}} = \frac{6}{20} = 0.3$$

$$\frac{A_v}{A_{v_1}} = \text{Antilog } 0.3 = 2$$

$$A_{v_1} = \frac{A_v}{2} = \frac{100}{2} = 50$$

$$\text{New } A_{vf} = \frac{A_{v_1}}{1 + A_{v_1} m_v}$$

$$= \frac{50}{1 + 50 \times 0.1}$$

$$= 8.33$$

$$\text{System gain} = \frac{9.09 - 8.33}{9.09} \times 100$$

$$= 8.36\%$$

(a) Input impedance :

$$e_g - m_v e_o = i_1 Z_{in}$$

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

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

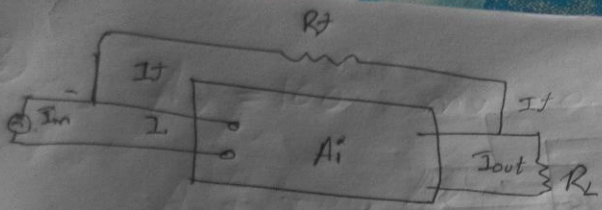
$$= (e_g - m_v e_o)(1 + A_v m_v)$$

$$= i_1 Z_{in} (1 + A_v m_v)$$

$$\frac{e_g}{i_1} = Z_{in} (1 + A_v m_v)$$

$$Z_{in}' = Z_{in} (1 + A_v m_v)$$

*



Feedback current $I_f = m_i I_{out}$

" fraction $m_i = \frac{I_f}{I_{out}} = \frac{\text{Feedback e}}{\text{output e}}$

*

$$I_{in} = I_1 + I_f$$

$$I_{in} = I + m_i I_{out}$$

$$I_{in} = I_1 + m_i A_i I_1$$

$$\therefore A_{if} = \frac{I_{out}}{I_{in}}$$

$$= \frac{A_i I_1}{I_1 + m_i A_i I_1}$$

$$A_{if} = \frac{A_i}{1 + m_i A_i}$$

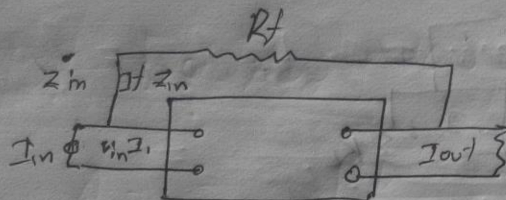
$A_i = 200$
$m_i = 0.012$

*

$$= \frac{200}{1 + (0.012)(200)}$$

$$= 58.82$$

①



$* \quad Z_{in} = \dfrac{V_{in}}{I_1}$

$* \quad Z'_{in} = \dfrac{V_{in}}{I_{in}}$

$$Z_{in} = \frac{V_{in}}{I_1}$$

$$V_{in} = I_1 Z_{in}$$

$$I_{in} = I_1 + I_f$$

$$= I_1 + m_i I_{out}$$

$$= I_1 + m_i A_i I_1$$

$$Z'_{in} = \frac{I_1 \cdot Z_{in}}{I_1 + m_i A_i I_1}$$

$$= \frac{Z_{in}}{1 + m_i A_i}$$

$$Z'_{in} = \frac{Z_{in}}{1 + m_i A_i}$$

(6)

$A_v = 100 \quad m_v = 0.1 \quad A_{vf} = ?$

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

$$= \frac{100}{1 + 100 \times 0.1} = 9.09$$

Then

$$20 \log_{10} \frac{A_v}{A_{v_1}} = 6$$

$$10 \log \frac{A_v}{A_{v_1}} = \frac{6}{20} = 0.3$$

$$\frac{A_v}{A_{v_1}} = \text{Anti} \log 0.3 = 2$$

$$A_{v_1} = \frac{A_v}{2} = \frac{100}{2} = 50$$

$$\text{New } A_{vf} = \frac{A_{v_1}}{1 + A_{v_1} m_v}$$

$$= \frac{50}{1 + 50 \times 0.1}$$

$$= 8.33$$

$$\text{Change} = \frac{9.09 - 8.33}{9.09} \times 100$$

$$= 8.36\%$$

(2) $A_v = 500 \quad A_{vf} = 100 \quad m_v = ?$

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

$$100 = \frac{500}{1 + 500 m_v}$$

$$100 + 500 m_v = 500$$

$$500 m_v = 500 - 100$$

$$m_v = \frac{500 - 100}{500}$$

$$= \frac{400}{500}$$

$$= 0.8$$

$$A_v = \frac{80}{100} \times 500$$

$$= 400 \quad m_v = 0.8 \quad A_{vf} = ?$$

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

$$= \frac{400}{1 + 400 \times 0.8}$$

$$= \frac{400}{4.2} = 95.3$$

$$A_{vf} = \frac{100 - 95.3}{100} \times 100$$

$$= 4.7\%$$

(8) (i)

$= 20 \log_{10} 100000$

$= 20 \log_{10} 10^5$

$= 100db$

$= 100 - 10 = 90$

Now,

$20 \log_{10} (A_{vf}) = 90$

$\log_{(10)} A_{vf} = \frac{90}{20} = 4.5$

$A_{vf} = \text{Antilog } 4.5 = 31622$

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

$$31622 = \frac{100000}{1 + 100000 \times m_v}$$

$= 2.17 \times 10^{-5}$

(8) (i)

$$= 20 \log_{10} 100000$$

$$= 20 \log_{10} 10^5$$

$$= 100db$$

$$= 100 - 10 = 90$$

Now,

$$20 \log_{10}(A_{vf}) = 90$$

$$\log_{(10)} A_{vf} = \frac{90}{20} = 4.5$$

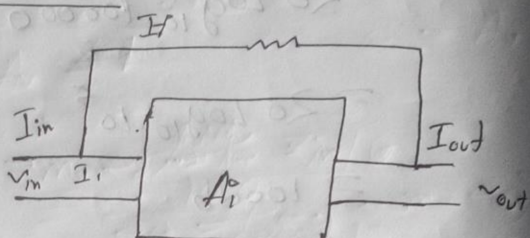
$$A_{vf} = \text{Antilog } 4.5 = 31622$$

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

$$31622 = \frac{100000}{1 + 100000 \times m_v}$$

$$= 2.17 \times 10^{-5}$$

Current Feedback



Feedback current $I_f = m_i I_{out}$

Feedback fraction $m_i = \frac{\text{Feed back}}{\text{i/p current}} = \frac{I_f}{I_{out}}$

Current gain $I_{in} = I_1 + I_f$

$= I_1 + m_i I_{out}$

$= I_1 + m_i A_i I_1$

With negative current feedback

$$A_{if} = \frac{I_{out}}{I_{in}}$$

$$= \frac{A_i I_1}{I_1 + m_i A_i I_1}$$

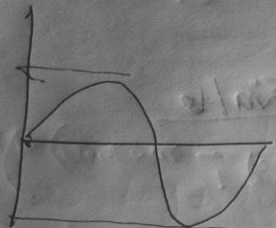
$$A_{if} = \frac{A_i}{1 + m_i A_i}$$

20-03-17

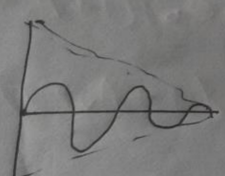
oscillator

↓

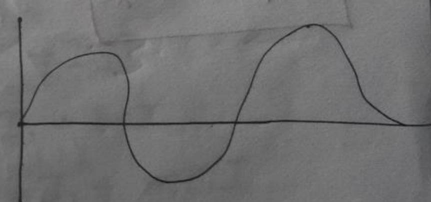
Positive Feedback Amplifier



* Damped

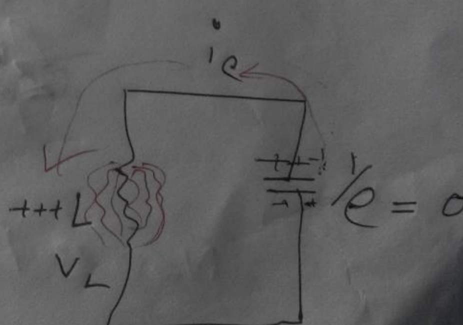


Undamped



* Tank - ckt

↓ L-C ckt



$x_L = x_C$

$\Rightarrow 2\pi f_r L = \dfrac{1}{2\pi f_r C}$

$\Rightarrow f_r^2 = \dfrac{1}{4\pi^2 LC}$ $\quad f_r = \dfrac{1}{2\pi\sqrt{LC}}$ — (maximum frequency)

27 Mar

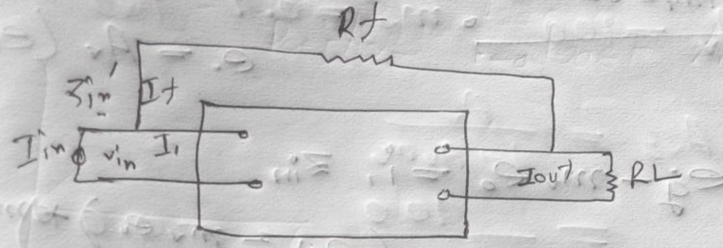
* Barch hansen

$$m_v A_v \leq 1$$

$$= \frac{\text{finite value}}{0}$$

$\boxed{14.1 - 14.7}$

Effects of negative current Feedback



$$Z_{in} = \frac{V_{in}}{I_1}$$

$$Z_{in}' = \frac{V_{in}}{I_{in}}$$

But

$$V_{in} = I_1 Z_{in} \qquad I_{in} = I_1 + I_f$$

$$= I_1 + m_i I_{out}$$

$$= I_1 + m_i A_i I_1$$

$$\therefore Z_{in}' = \frac{I_1 Z_{in}}{I_1 + m_i A_i I_1}$$

$$\simeq \frac{Z_{in}}{1 + m_i A_i I_1}$$

Increas bandwidth :

$$BW' = BW(1 + m_i A_i)$$

Input impedance :

$$e_0 = A_v (e_g - m_v$$

$$e_g - m_v e_0 = i_1 Z_{in}$$

$$e_g = (e_g - m_v e_0) + m_v e_0$$

$$= (e_g - m_v e_0) + A_v m_v$$

$$(e_g - m_v e_0$$

$$= (e_g - m_v e_0)(1 + A_v m_v$$

$$= i_1 Z_{in} (1 + A_v m_v)$$

$$\frac{e_g}{i_1} = Z_{in} (1 + A_v m_v)$$

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

Gain of Negative Voltage Feedback

∴ Actual input to amplifier

$$= e_g - m_v e_o$$

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

$$A_v e_g - A_v m_v e_o = e_o$$

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

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

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

(6)

$A_v = 100 \quad m_v = 0.1, \quad A_{vf} = ?$

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

$$= \frac{100}{1 + 100 \times 0.1} = 9.09$$

Fall in gain = 6 dB

$$20 \log_{10} \frac{A_v}{A_{v_1}} = 6$$

$$\log_{10} \frac{A_v}{A_{v_1}} = \frac{6}{20} = 0.3$$

$$\frac{A_v}{A_{v_1}} = \text{Antilog } 0.3 = 2$$

$$A_{v_1} = \frac{A_v}{2} = \frac{100}{2} = 50$$

$$\text{New } A_{vf} = \frac{A_{v_1}}{1 + A_{v_1} m_v}$$

$$= \frac{50}{1 + 50 \times 0.1}$$

$$= \frac{9.09 - 8.33}{9.09} \times 100 \quad = 8.33$$

$= 8.36\%$