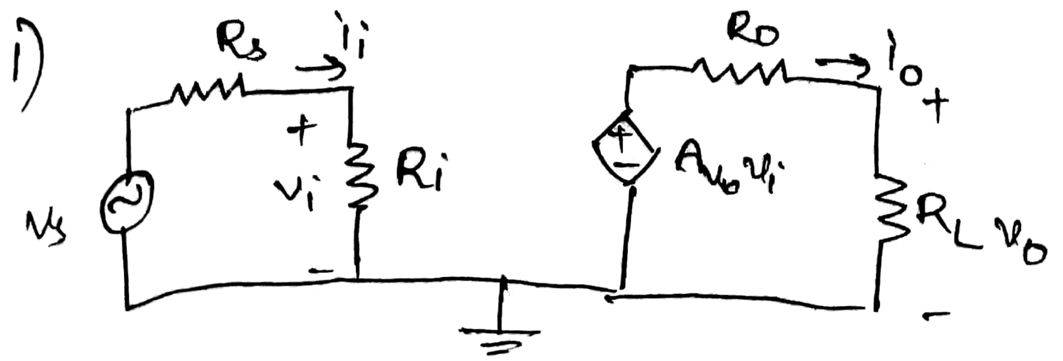
1)



$$v_i = v_s \times \frac{R_i}{R_i + R_s}$$

Overall gain

$$\frac{v_o}{v_s}$$

(a) $$v_i = v_s \times \frac{10R_s}{10R_s + R_s} = v_s \times \frac{10R_s}{11R_s} = \frac{10}{11} v_s$$

Overall gain

$$= \frac{v_o}{v_s} = \frac{v_o}{\frac{11 v_i}{10}} = \frac{10}{11}\left(\frac{v_o}{v_i}\right)$$

$$= \frac{10}{11} \times \frac{\frac{A_{vo} \cancel{v_i} \times R_L}{R_L + R_o}}{\cancel{v_i}}$$

$$= \frac{10}{11} \times A_{vo} \times \frac{R_L}{10R_o + R_o}$$

$$= \frac{10}{11} A_{vo} \times \frac{10\cancel{R_o}}{11\cancel{R_o}}$$

$$= \frac{100}{121} A_{vo}$$

$$= 0.82644\, A_{vo}$$

(b) $v_i = V_s \times \frac{R_i}{R_i + R_s}$

$= V_s \times \frac{R_i}{R_i + R_i} = \frac{V_s}{2}$

Overall gain

$= \frac{V_o}{V_s} = \frac{A_{vo} \times \cancel{V_i} \times \frac{R_L}{R_L + R_o}}{2\cancel{V_i}}$

$= \frac{A_{vo}}{2} \times \frac{R_o}{R_o + R_o}$

$= \frac{A_{vo}}{4}$

$= \underline{\underline{0.25 A_{vo}}} = 0.25(100)$

$= \underline{\underline{25}}$

(c) $v_i = V_s \times \frac{R_i}{R_i + R_s} = V_s \times \frac{R_i}{R_i + 10R_i}$

$v_i = \frac{V_s}{11}$

Overall gain

$\frac{V_o}{V_s} = \frac{A_{vo} \times \cancel{V_i} \times \frac{R_L}{R_L + R_o}}{11 \cancel{V_i}}$

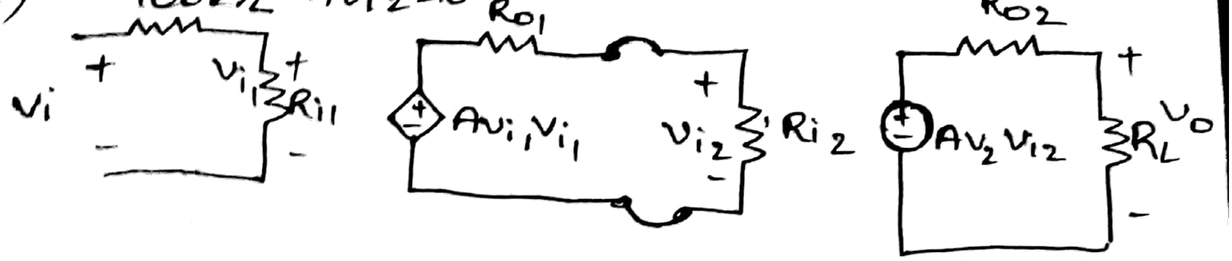
$= \frac{A_{vo}}{11} \times \frac{R_L}{R_L + 10R_L}$

$= \frac{A_{vo}}{121} = \frac{100}{121} = \underline{\underline{0.82644}}$

SABL $\quad Av_{i1} = 100 \quad R_{i1} = 100\,k\Omega \quad R_{o1} = 10\,k\Omega$

$Ri_2 = 10\,k\Omega \quad R_{o2} = 1\,k\Omega$

2) $\quad Av_{i2} = 10$



$$v_{i2} = Av_{i1} \times v_{i1} \times \frac{R_{i2}}{R_{o1}+R_{i2}}$$

$V_i = 10\,mV$

$R_L = 100\,\Omega$

$$= 100 \times 10 \times 10^{-3} \times \frac{100}{100+100} \times \frac{10}{10+10}$$

$$= \frac{100}{200} \times \frac{10}{20}$$

$$v_{i2} = \frac{1}{4}\,V$$

$$v_o = Av_{i2} \times v_{i2}\left(\frac{R_L}{R_{o2}+R_L}\right)$$

$$= 10 \times \frac{1}{4}\left(\frac{100}{1000+100}\right)$$

$$= 10 \times \frac{1}{4}\left(\frac{100}{1100}\right) = \frac{5}{22}\,V$$

$$\frac{V_o}{V_i} = \frac{\frac{5}{22}}{10 \times 10^{-3}} = \frac{250}{11}\ V/V$$

In $dB = 20 \log\left(\frac{250}{11}\right)$

SBAL

$Av_{i1} = 10 \quad Ri_1 = 10\,k\Omega \quad R_{o1} = 1\,k\Omega$

$Av_{i2} = 100 \quad Ri_2 = 100\,k\Omega \quad R_{o2} = 10\,k\Omega$

$$v_{i2} = A_{vi_1} \times v_{i1} \times \frac{R_{i2}}{R_{o1}+R_{i2}}$$

$$= \cancel{10} \times \cancel{10} \times 10^{-3} \times \frac{\cancel{10}}{10+100} \times \frac{100}{1+100}$$

$$= \frac{1}{11\cancel{0}} \times \frac{10\cancel{0}}{101} = \frac{10}{1111}$$

$$= 0.0090\ V$$

$$V_o = A_{vi2} \times v_{i2} \times \frac{R_L}{R_{o2}+R_L}$$

$$= 100 \times 0.0090 \times \frac{100}{10000+100}$$

$$= 0.9 \times \frac{10\cancel{0}}{1010\cancel{0}}$$

$$\frac{100}{101}$$

Gain

$$\frac{v_o}{V_i} = \frac{0.9 \times \frac{\cancel{10}}{101}}{\cancel{10} \times 10^{-3}} = \frac{0.9 \times 10^3}{101}$$

$$= \frac{900}{101}$$

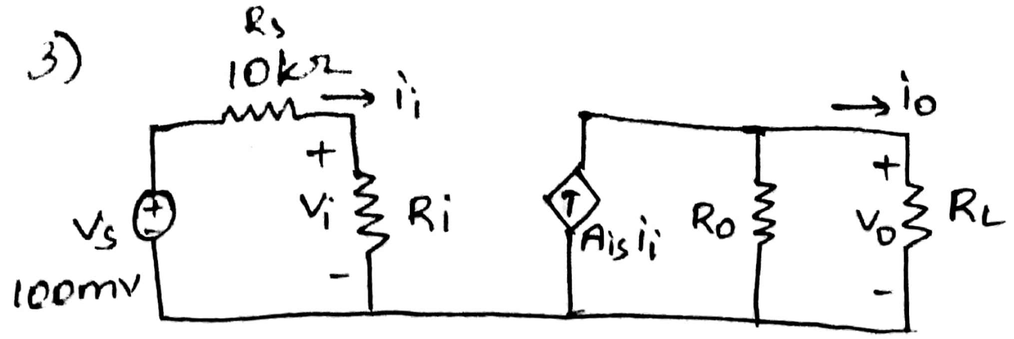
$$= 8.91089$$

In dB

$$20 \log(8.91089)$$

SBAL has more gain than that of SABL

3)



$$i_i = \frac{V_i}{R_i} = \frac{V_s \times \frac{\cancel{R_i}}{R_i+R_s}}{\cancel{R_i}}$$

$$= 100\times10^{-3} \times \frac{1}{100+10000}$$

$$= \frac{100\times10^{-3}}{10100} = 0.0099\times10^{-3}$$

$$= \underline{\underline{9.9\ \mu A}}$$

$$i_o = A_{is}\times i_i \times \frac{R_o}{R_o+R_L}$$

$$= 100\times 9.9\times10^{-6} \times \frac{10}{10+1}$$

$$= \frac{9.9}{11}\times10^{-3}\ A = 0.9\ mA$$

$$\frac{i_o}{i_i} = \frac{\frac{\cancel{9.9}\times10^{-3}}{11}}{\cancel{9.9}\times10^{-6}} = \frac{10^3}{11} = \frac{1000}{11}$$

$$V_o = i_o R_L = \frac{9.9}{11}\times10^{-3}\times1\times10^{3}$$

$$= 0.9V$$

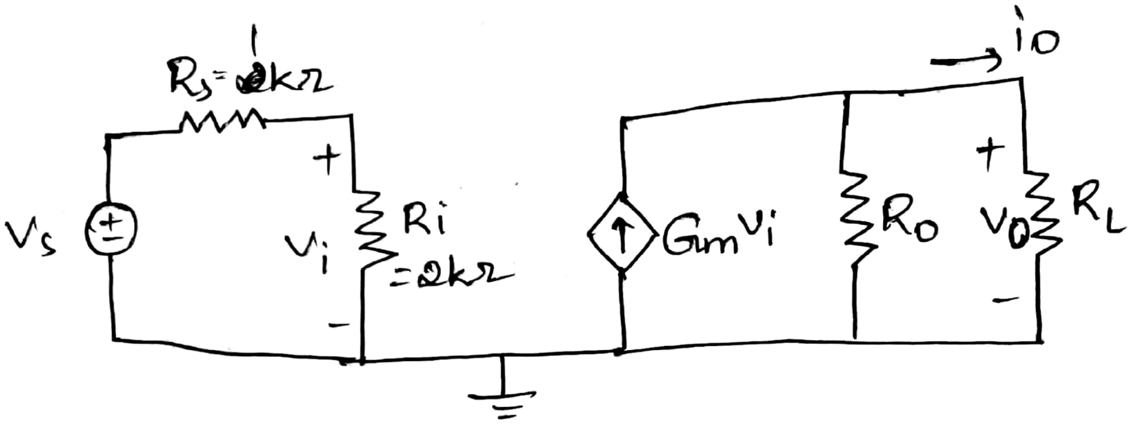
$$\frac{V_o}{V_i} = \frac{0.9}{100\times10^{-3}} = \frac{0.9}{10^{-1}} = \underline{\underline{9}}$$

$$\frac{P_o}{P_i} = \frac{V_o i_o}{V_i i_i} = \frac{9 \times 0.9 \times 10^{-3}}{V_s \times \frac{R_i}{R_i + R_s} \times 9.9 \times 10^{-6}}$$

in dB

$$20 \log_{10}\left(\frac{P_o}{P_i}\right)$$

4)



$$V_i = V_s \times \frac{R_i}{R_i + R_s}$$

$$= V_s \times \frac{2}{1+2}$$

$$V_i = \frac{2 V_s}{3}$$

$$i_o = G_m v_i \times \frac{R_o}{R_o + R_L}$$

$$V_o = i_o R_L$$

$$= G_m v_i \times \frac{R_o}{R_o + R_L} \times R_L$$

$$= 60\times10^{-3}\times\frac{2}{3}\times V_S\times\frac{20}{20+1}\times1\times10^{3}$$

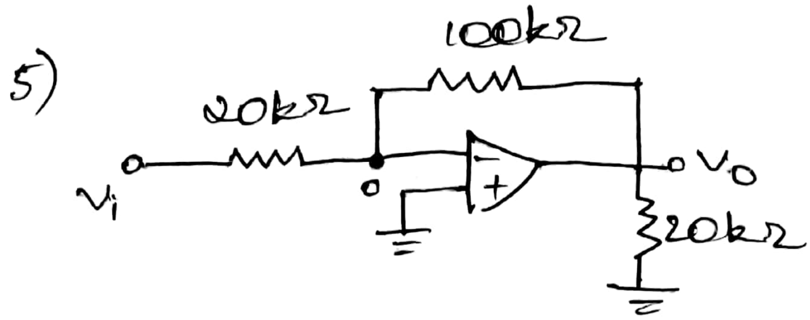
Voltage gain

$$\frac{V_o}{V_s} = \frac{60\times\cancel{10^{-3}}\times\frac{2}{3}\times\cancel{V_s}\times\frac{20}{21}\times\cancel{10^{3}}}{\cancel{V_s}}$$

$$= \overset{20}{\cancel{60}}\times\frac{2}{\cancel{3}}\times\frac{20}{21}$$

$$\frac{V_o}{V_s} = \frac{800}{21}$$

5)



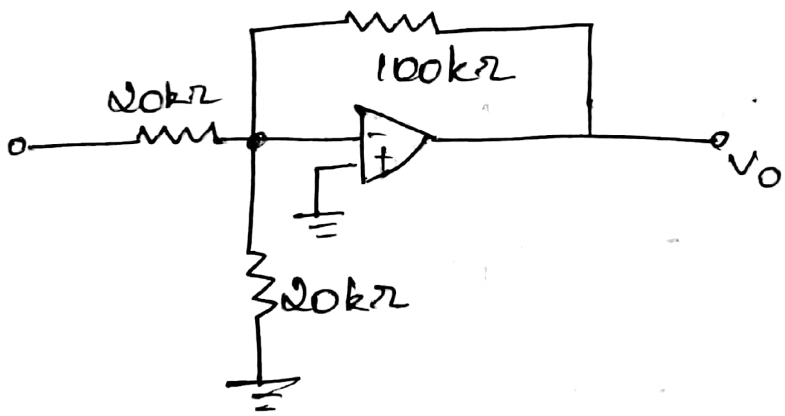
$\cancel{V_- = V_+}$

$V^- = V^+ = 0 \quad (\because V^+ = 0)$

$$\frac{V_i - 0}{20} = \frac{0 - V_o}{100}$$

$$\frac{V_o}{V_i} = \frac{-100}{20} = -5$$

$$V_o = -5V_i$$

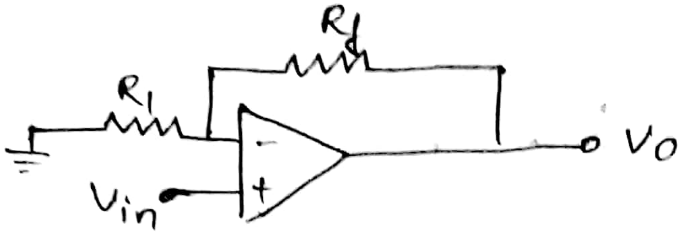


$$\frac{V_i - 0}{20} = \frac{0 - V_o}{100}$$

$$\frac{V_o}{V_i} = \frac{-100}{20} = -5$$

$$\underline{V_o = -5V_i}$$

6)



$$\frac{0-V_{in}}{R_1} = \frac{V_{in}-V_o}{R_f}$$

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

$$\Rightarrow \boxed{\frac{V_o}{V_{in}} = 1+\frac{R_f}{R_1}}$$

(i) $R_1 = 10k\Omega \quad R_f = 100k\Omega$

$$V_o = V_{in}\left(1+\frac{100}{10}\right)$$

$$= V_{in}(1+10)$$

$$V_o = 11V_{in}$$

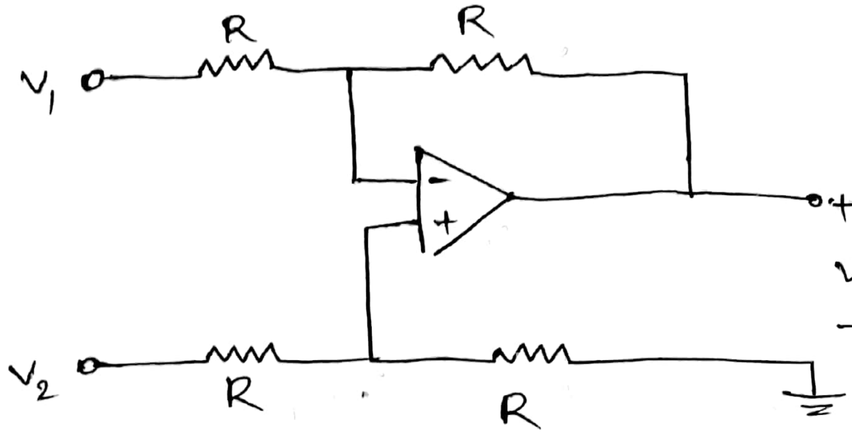
(ii) $R_1 = 1k\Omega \quad R_f = 1M\Omega \quad R_L = 5k\Omega$

$$V_o = V_{in}\left(1+\frac{10^6}{10^3}\right)$$

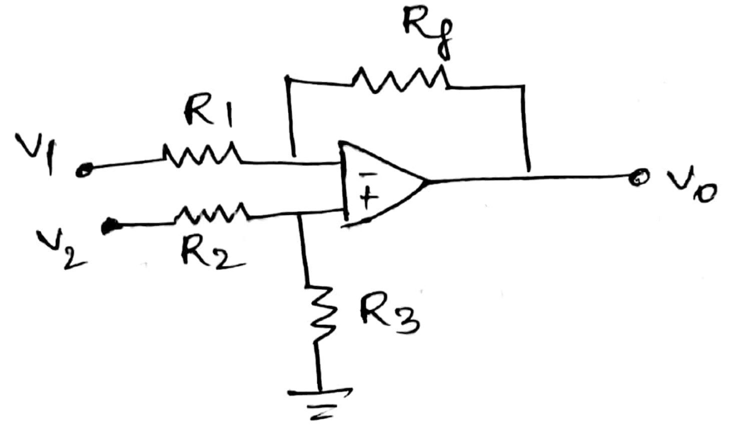
$$= V_{in}(1+1000)$$

$$= 1001\,V_{in}$$

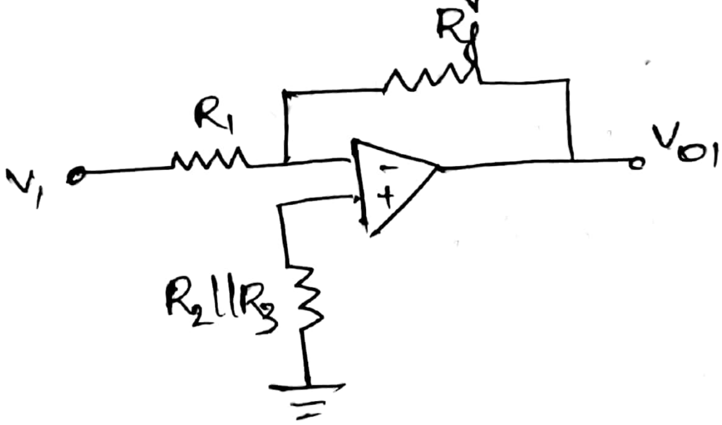
7)



Substraction Op-amp

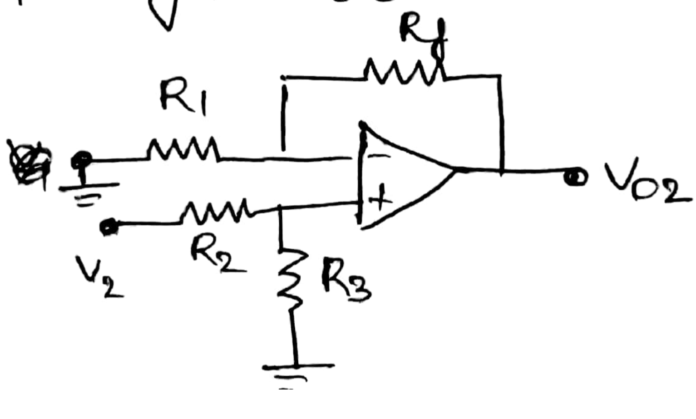


When V_2 is grounded



$$V_{01} = -\frac{R_f}{R_1} V_1$$

When V_1 is grounded



$$V_{O2} = \left(1 + \frac{R_f}{R_1}\right) V_2'$$

$$V_2' = \left(\frac{R_3}{R_2 + R_3}\right) V_2$$

$$V_{O2} = \left(\frac{R_3}{R_2 + R_3}\right)\left(1 + \frac{R_f}{R_1}\right) V_2$$

$$V_O = V_{O1} + V_{O2}$$

$$= -\frac{R_f}{R_1} V_1 + \frac{R_3}{R_2 + R_3}\left(1 + \frac{R_f}{R_1}\right) V_2$$

Here

$$R_f = R_1 = R_2 = R_3$$

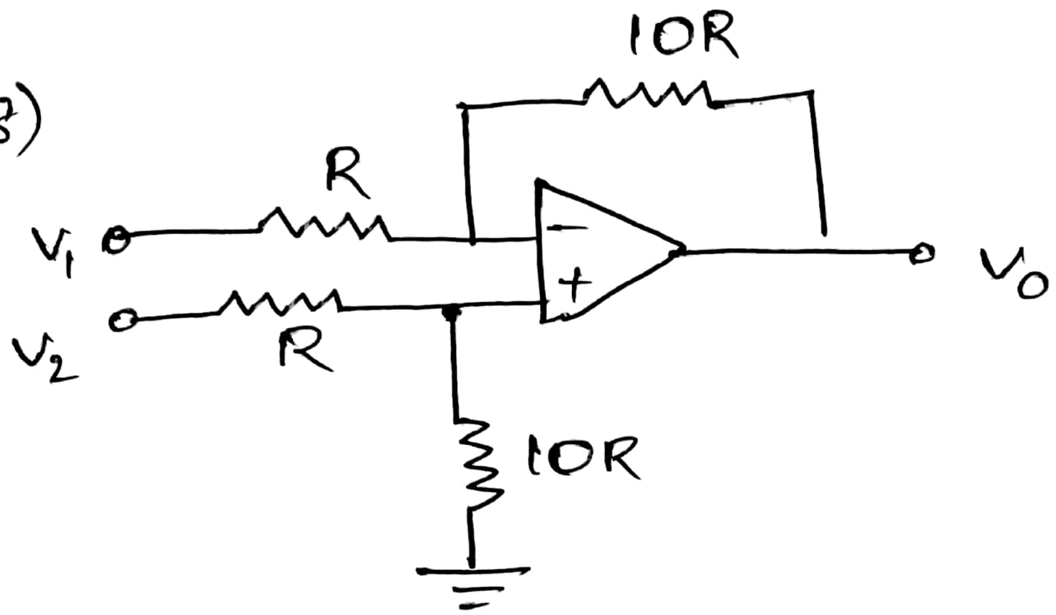
$$= -\frac{R}{R} V_1 + \frac{R}{R+R}\left(1 + \frac{R}{R}\right) V_2$$

$$= -V_1 + \frac{1}{2}(1+1) V_2$$

$$= -V_1 + V_2$$

$$= \underline{\underline{V_2 - V_1}}$$

8)



Here $R_f = 10R$

$R_1 = R$

$R_2 = R$

$R_3 = 10R$

$$V_o = -\frac{R_f}{R_1} V_1 + \frac{R_3}{R_2+R_3}\left(1+\frac{R_f}{R_1}\right) V_2$$

$$V_0 = -\frac{10R}{R}V_1 + \frac{10R}{R+10R}\left(1+\frac{10R}{R}\right)V_2$$

$$= -10V_1 + \frac{10\cancel{R}}{11\cancel{R}}(1+10)V_2$$

$$= -10V_1 + \frac{10}{\cancel{11}}(\cancel{11})V_2$$

$$= -10V_1 + 10V_2$$

$$V_0 = 10(V_2 - V_1)$$