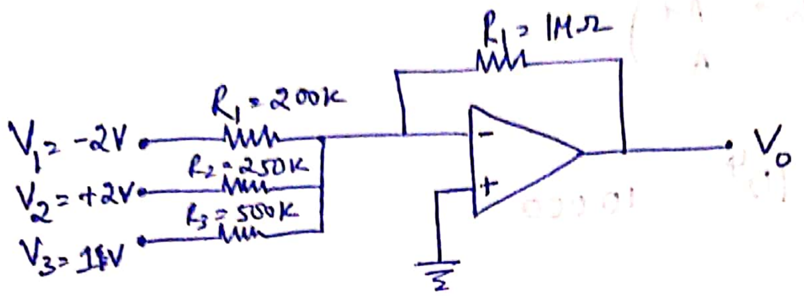
1) Calculate the output voltage of a three input Summing Amplifier given:

$R_1 = 200K\Omega$, $R_2 = 250K\Omega$, $R_3 = 500K\Omega$, $R_f = 1M\Omega$, $V_1 = -2V$

$V_2 = -2V$, $V_2 = +2V$, $V_3 = +1V$.



Soln

For Summing Amplifier,

$$V_0 = -\left[\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3\right]$$

$$= -\left[\frac{1\times10^6}{200\times10^3}(-2) + \frac{1\times10^6}{250\times10^3}(2) + \frac{1\times10^6}{500\times10^3}(1V)\right]$$

$$= -[-10 + 8 + 2]$$

$$= 0V$$

2) Op-amp has $A_d = 500$, CMRR of 80 dB, if common mode input is $2 \sin 10\omega t$, calculate common mode output voltage.

Soln

Scanned by CamScanner

$$CMRR = 20 \log \frac{A_d}{A_c}$$

$$80 = 20 \log \frac{A_d}{A_c}$$

$$4 = \log\left(\frac{A_d}{A_c}\right)$$

$$\frac{A_d}{A_c} = 10^4 = 10{,}000$$

$$\cancel{A_c = \frac{10{,}000}{500} = 20}$$

$$A_c = \frac{500}{10000} = 0.05$$

common mode output voltage, $V_o = A_c \cdot V_c$

$$= 0.05\,[2 \sin 10\pi t]$$

$$= 0.1 \sin 100\pi t$$

Q: open loop gain of op-amp is 10^4 and $A_c = 0.1$. Calculate CMRR.

Soln

$$CMRR = 20 \log\left(\frac{10^4}{0.1}\right)$$

$$= 100\,dB$$

Scanned by CamScanner

4) Calculate the output voltage of summing amplifier for the set of voltages. Use $R_f = 1M\Omega$ for all cases.

(a) $V_1 = +1V$, $V_2 = 2V$, $V_3 = 3V$, $R_1 = 500K$, $R_2 = 1M\Omega$, $R_3 = 1M\Omega$

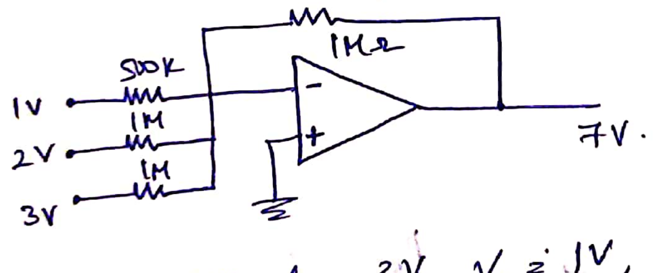
Soln

$$V_0 = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right]$$

$$= -\left[\frac{1\times10^6}{500\times10^3}(1) + \frac{1\times10^6}{1\times10^6}(2) + \frac{1\times10^6}{1\times10^6}(3)\right]$$

$$= -[2+2+3]$$

$$= -7V.$$



(b) $V_1 = -2V$, $V_2 = 3V$, $V_3 = 1V$, $R_1 = 200K$, $R_2 = 500K\Omega$, $R_3 = 1M\Omega$

Soln

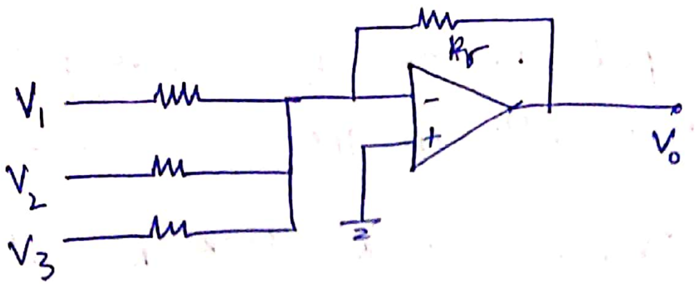
$$V_0 = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right]$$

$$= -\left[\frac{1\times10^6}{200\times10^3}(-2) + \frac{1\times10^6}{500\times10^3}(3) + \frac{1\times10^6}{1\times10^6}(1)\right]$$

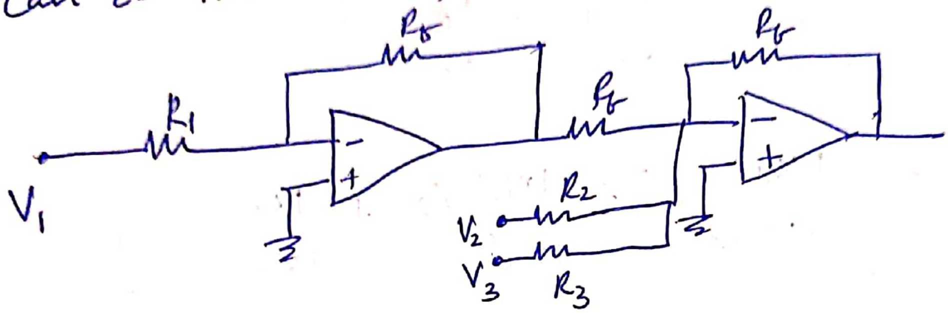
$$= -[-10+6+1]$$

$$= +3V.$$

Scanned by CamScanner



The above circuit using 2-ideal op-amps can be written as,



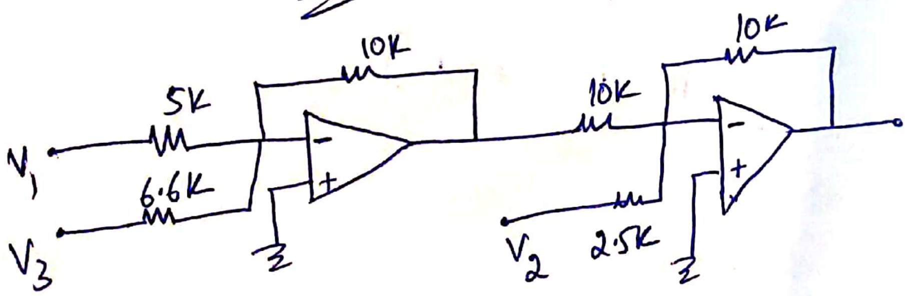
5) Design a summer circuit using 2 ideal op-amp

$$V_0 = 2V_1 - 4V_2 + 6V_3.$$

Soln: Assume, $R_f = 10K\Omega$.

$$\frac{R_f}{R_1} = 2, \quad \frac{R_f}{R_2} = 4, \quad \frac{R_f}{R_3} = 6.$$

$$R_1 = \frac{10\times10^3}{2} = 5K\Omega \quad \Bigg| \quad R_2 = \frac{10\times10^3}{4} = 2.5K\Omega \quad \Bigg| \quad R_3 = \frac{10\times10^3}{6} = 6.6K\Omega$$



Scanned by CamScanner

(b) $V_0 = V_1 + 3V_2 + 5V_3 - 7V_4 - 9V_5 - 11V_6$

Assume $R_f = 10K\Omega$.

Soln.

$$\frac{R_f}{R_1} = 1 \Rightarrow R_1 = 10K\Omega$$

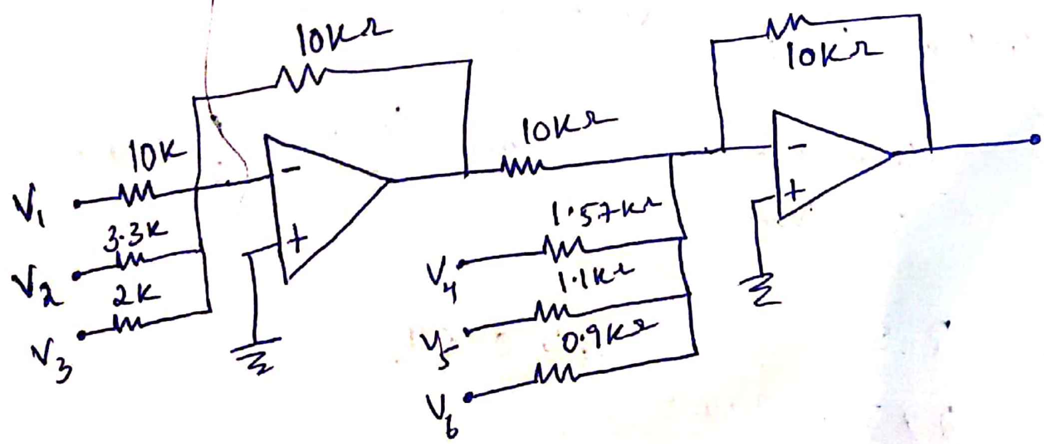
$$\frac{R_f}{R_2} = 3 \Rightarrow R_2 = \frac{10K}{3} = 3.3K\Omega$$

$$\frac{R_f}{R_3} = 5 \Rightarrow R_3 = 2K\Omega$$

$$\frac{R_f}{R_4} = 7 \Rightarrow R_4 = 1.57K\Omega$$

$$\frac{R_f}{R_5} = 9 \Rightarrow R_5 = 1.1K\Omega$$

$$\frac{R_f}{R_6} = 11 \Rightarrow R_6 = 0.9K\Omega$$



Scanned by CamScanner

6) An op-amp has a differential gain of 2×10^4 and a CMRR of 86dB. Determine the output, if differential input is $10\mu V$ and common mode i/p is 10 mV

soln

$$V_0 = A_d \cdot V_d + A_c \cdot V_c$$

$$CMRR = \frac{A_d}{A_c} \Rightarrow 20\log\left(\frac{A_d}{A_c}\right) = 86$$

$$A_c = 1.0002$$

$$V_o = 2\times10^4(10\times10^{-6}) + 1.002(10\times10^{-3})$$

$$= 0.21V.$$

7) The output signal of an op-amp with a slew rate of $2.5V/\mu s$ has a peak to peak value of 18V. Find the maximum frequency for undistorted output voltage.

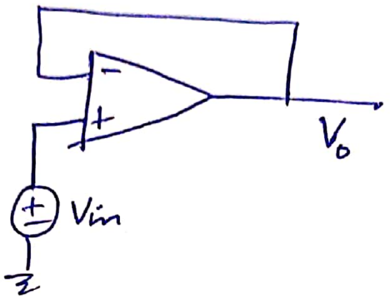
soln

$$f = \frac{\text{slew rate}}{2\pi V_m}, \quad V_m = \frac{V_{p-p}}{2} = \frac{18}{2} = 9V$$

$$f = \frac{2.5}{2\times3.14\times9\times10^{-6}} = 44.2\text{ KHz}$$

Scanned by CamScanner

8) In a voltage follower circuit, op-amp used is ideal in all respect, except it has a finite gain A, Determine $\frac{V_o}{V_i}$. If $A = 1000$, calculate the error of the gain from that of the voltage follower with an ideal op-amp.



Soln

$$\frac{V_o}{V_i} = 1, \quad \because \text{ it is a voltage follower.}$$

$$\% \text{ of error} = \left(1 - \frac{A}{A+1}\right) \times 100\%$$

$$= \left(1 - \frac{1000}{1001}\right)$$

$$= 1$$

9) If slew rate of op-amp is 3 V/μs and maximum output swing is ±12V, then calculate maximum frequency.

Soln

$$f_{max} = \frac{3}{2 \times \pi \times 12 \times 10^{-6}}$$

(μsec)

$$= 39.8 \text{ KHz}$$

Scanned by CamScanner