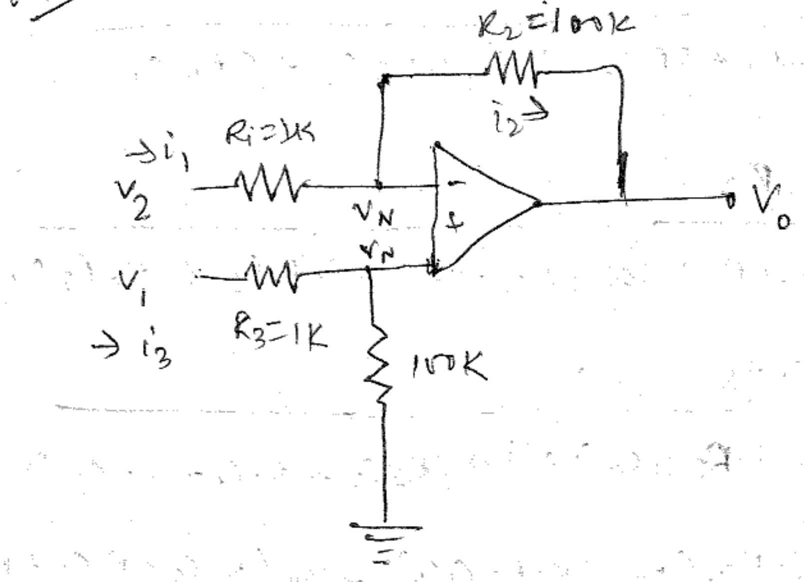
04/07/11. Basic differential amplifier



$$\frac{V_2 - V_N}{R_1} = \frac{V_N - V_0}{R_2}$$

$$\frac{V_2}{R_1} - \frac{V_N}{R_1} = \frac{V_N}{R_2} - \frac{V_0}{R_2}$$

$$\frac{V_2}{R_1} - \frac{V_N}{R_1} - \frac{V_N}{R_2} = -\frac{V_0}{R_2}$$

$$\frac{V_2}{R_1} - V_N\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = -\frac{V_0}{R_2} \quad \text{--- } (1)$$

$$\frac{V_1 - V_N}{R_3} = \frac{V_N - 0}{R_4}$$

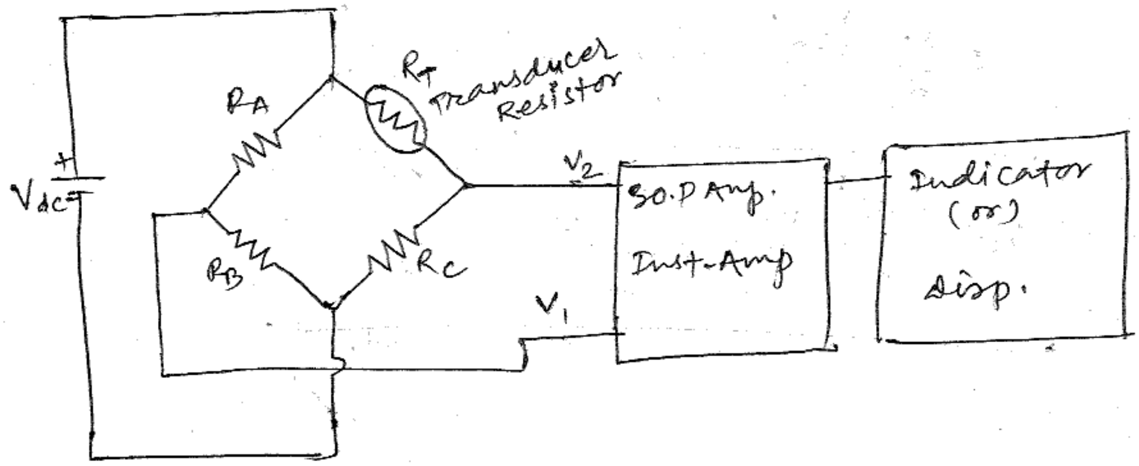
$$\frac{V_1}{R_3} - V_N\left(\frac{1}{R_3} + 1/R_4\right) = 0 \quad \text{--- } (2)$$

$$\frac{V_2}{R_1} - V_1\left(1/R_1 + 1/R_2\right) - V/R_3 + V_N\left(\frac{1}{R_3} + \frac{1}{R_4}\right) = -\frac{V_0}{R_2}$$

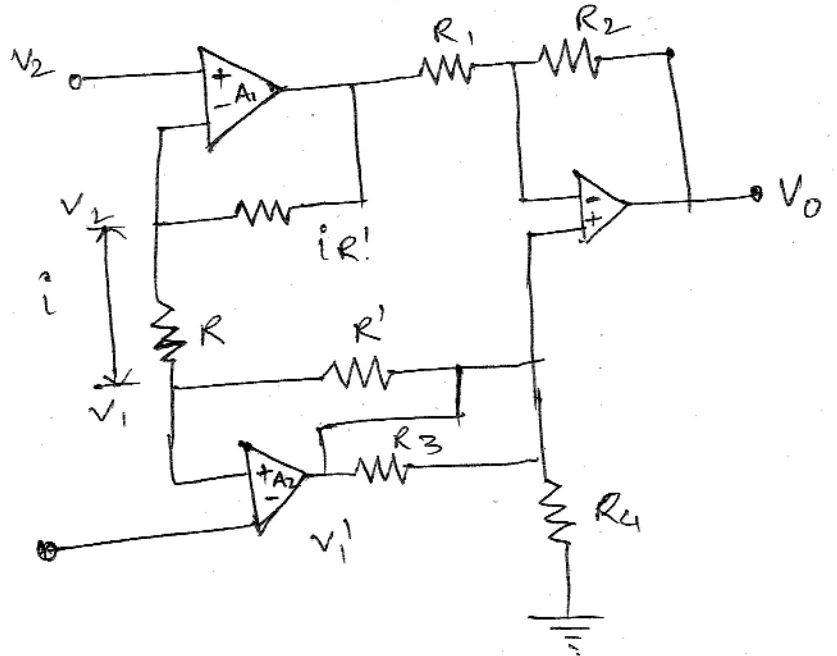
$$\frac{V_1}{R_3} - \frac{V_2}{R_1} = \frac{V_0}{R_2}$$

$$\Rightarrow \boxed{V_0 = R_2/R_1\,(V_1 - V_2)}$$

Instrumentation Amplifier



Circuit Design:



$$V_o = R_2/R_1 (V_1 - V_2)$$

$$V_o = R_2/R_1 (V_1' - V_2')$$

$$V_1' = iR' + V_1$$

$$V_2' = iR' + V_2$$

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

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

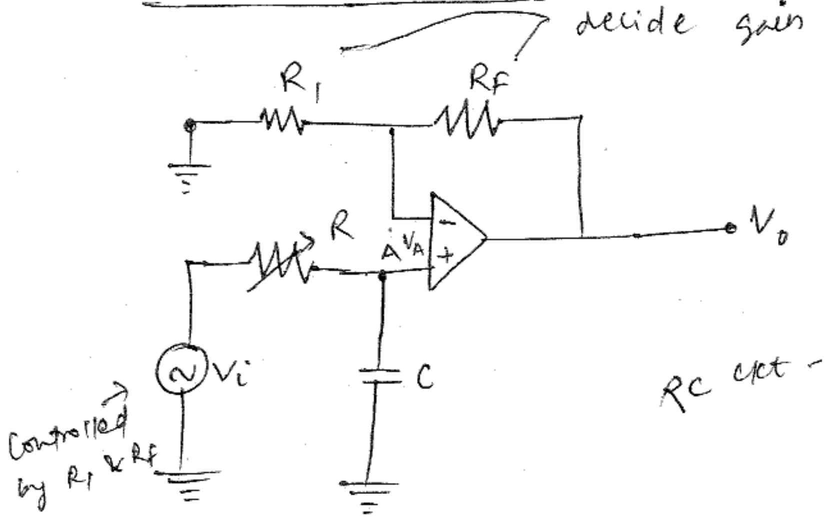
$$V_0 = \frac{R_2}{R_1}\left[\frac{V_1 - V_2}{R}\right] R' + (V_1 - V_2) + \left(\frac{V_1 - V_2}{R}\right) R'$$

$$= \frac{R_2}{R_1}\left[\frac{2R'}{R}(V_1 - V_2) + (V_1 - V_2)\right]$$

$$\boxed{V_0 = \frac{R_2}{R_1}\left[\left(\frac{2R'}{R} + 1\right)(V_1 - V_2)\right]}$$

08/07/2011. Filters

1. First order low pass filter



RC ckt - freq. generating ckt.

Total impedence of C,

~~$X_c = -jX_C = \frac{1}{j2\pi fC}$~~

$X_C = -jX_C = \frac{1}{2\pi f_C}$

$[-j = -j \times j/j = 1/j]$

$V_A = \frac{-jX_C}{R-jX_C} \cdot V_{in}$ $\quad [X_C = 1/2\pi f_C]$

$V_A = \left[\frac{-j/2\pi f_C}{R - j/2\pi f_C}\right] V_{in}$

$V_A = \left[\frac{-j}{R2\pi f_C - j}\right] V_{in}$

$= \frac{V_{in}/j}{jR2\pi f_C + 1}$

$\boxed{V_A = \frac{V_{in}}{1+j2\pi R f_C}}$

$$V_A = \frac{V_{in}}{1+j(f/f_c)}$$

$\cancel{f_c = \frac{1}{2\pi RC}}$ $\quad f_c = \frac{1}{2\pi RC} \rightarrow$ cut-off frequency.

$f \rightarrow$ operating frequency.

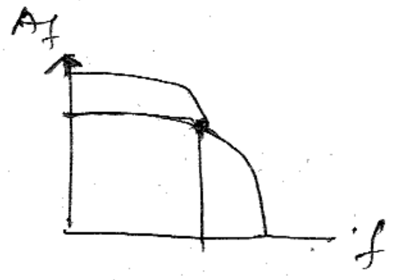
$$V_o = \left[1+\frac{R_f}{R_1}\right] V_{in} = \left(1+\frac{R_f}{R_1}\right) \cdot \frac{V_{in}}{1+j(f/f_c)}$$

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

$$\frac{V_o}{V_{in}} = \frac{A}{1+j(f/f_c)}$$

$$\boxed{\left|\frac{V_o}{V_{in}}\right| = \frac{A}{\sqrt{1+(f/f_c)^2}}}$$

i) $f < f_c$



$$\left|\frac{V_o}{V_{in}}\right| = \frac{A_f}{\sqrt{1+(0)}}$$

$$\boxed{\left|\frac{V_o}{V_{in}}\right| = A_f}$$

ii) $f = f_c$

$$\boxed{\left|\frac{V_o}{V_{in}}\right| = \frac{A_f}{\sqrt{2}} = 0.707 A_f}$$

iii) $f > f_c$

$$\left|\frac{V_o}{V_{in}}\right| = \frac{A_f}{1 + f/0} = \frac{A_f}{\infty} = 0$$

$$\therefore \boxed{\frac{V_o}{V_{in}} = 0}$$

Q.1] Design a low pass filter at a cut-off frequency 15.9 KHz with a pass band gain 1.5 dB.

$C = 0.001 \mu F$

$f_c = 15.9 KHz$

$A_f = 1.5 dB$

$f_c = \frac{1}{2\pi RC}$

$15.9 = \frac{1}{2\pi R \times 0.001}$

$R = \frac{1}{2\pi \times 0.001} = \frac{1}{0.099} = 10 k\Omega$

$\boxed{R = 10 k\Omega}$

$A_f = 1 + \frac{R_f}{R_1}$

$1.5 = 1 + \frac{R_f}{10} = \frac{10 + R_f}{10}$

$15 - 10 = R_f$

$\therefore \boxed{R_f = 5 k\Omega}$

Hence $\boxed{f_c = f}$ ($\because$ for low pass filter).