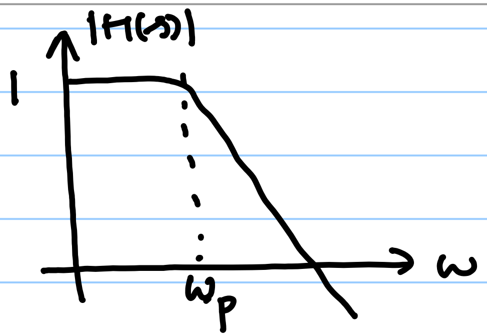
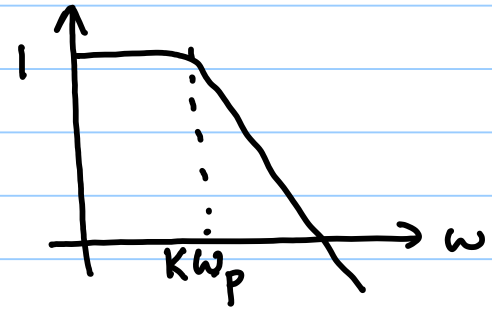
Note Title 17-03-2022

lecture # 30

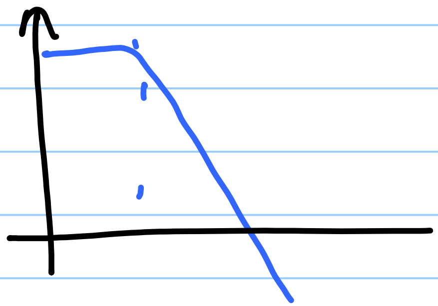


$$H(s) = \frac{1}{1+s/\omega_p} \xrightarrow{s \to \frac{s}{K}} H(s) = \frac{1}{1+\frac{s}{K\omega_p}}$$



$$H(s) = \frac{1}{1+s}$$

$$H(s) = \frac{1}{\left(\frac{s}{1}\right)^2 + \frac{1}{2}\left(\frac{s}{1}\right) + 1} \checkmark \xrightarrow{s \to \frac{s}{10^7}}$$

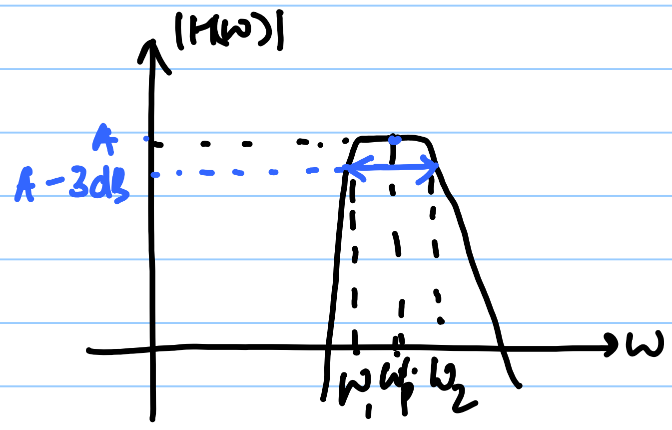


$$H(s) = \frac{1}{1+\frac{s}{\omega_p}} \xrightarrow{s \to Q\left(\frac{s}{\omega_0} + \frac{\omega_0}{s}\right)} H(s) = \frac{1}{1+\frac{Q}{\omega_p}\left(\frac{s}{\omega_0}+\frac{\omega_0}{s}\right)}$$

$$H(s) = \frac{s\,\omega_p\omega_0}{Q s^2 + \omega_p\omega_0 s + Q\omega_0^2}$$

$$H(s) = \frac{s\,\omega_p \omega_0 / Q}{s^2 + \frac{\omega_p \omega_0 s}{Q} + \omega_0^2} = \frac{s\,\boxed{\omega_p / Q\omega_0}}{\frac{s^2}{\omega_0^2} + \frac{s\,\boxed{\omega_p}}{\boxed{Q\omega_0}} + 1} \quad ✓$$

$$= \frac{s / \omega_p' Q_p'}{\left(\frac{s}{\omega_p'}\right)^2 + \frac{s}{\omega_p' Q_p'} + 1} \quad ✓$$



$$\omega_p = \sqrt{\omega_1 \omega_2}$$

$$\omega_p' = \omega_0$$

$$\omega_p' Q_p' = \frac{Q\omega_0}{\omega_p}$$

$$Q_p' = \frac{Q}{\omega_p}$$

$$|H(j\omega)| = \frac{|j\omega / \omega_p' Q_p'|}{\left|\left(1 - \frac{\omega^2}{\omega_p'^2}\right) + \frac{j\omega}{\omega_p' Q_p'}\right|} \quad ✓$$

$$|H(j\omega_p')| = \frac{1/Q_p'}{1/Q_p'} = 1$$

$$|D(j\omega)|^2 = \left(1-\frac{\omega^2}{\omega_p'^2}\right)^2 + \frac{\omega^2}{\omega_p'^2 Q_p'^2}$$

$$\frac{d}{d\omega}\left(|\quad|^2\right) = 2\left(1-\frac{\omega^2}{\omega_p'^2}\right) \times -\frac{\cancel{2}\cancel{\omega}}{\cancel{\omega_p'^2}} + \frac{\cancel{2}\cancel{\omega}}{\cancel{\omega_p'^2} Q_p'^2} = 0$$

$$-\cancel{2}\left(1-\frac{\omega^2}{\omega_p'^2}\right) + \frac{1}{2Q_p'^2} = 0$$

$$\frac{\omega^2}{\omega_p'^2} = 1-\frac{1}{2Q_p'^2}$$

$$\omega = \omega_p'\sqrt{1-\frac{1}{2Q_p'^2}}$$

$$|H(j\omega)|^2 = \frac{\omega^2/\cancel{\omega_p'^2 Q_p'^2}}{(\qquad\qquad)}$$

$$\cancel{2\omega}\left[\left(1-\frac{\omega^2}{\omega_p'^2}\right)^2+\frac{\omega^2}{\omega_p'^2 Q_p'^2}\right]-\omega^{\cancel{2}}\left\{\cancel{2}\left(1-\frac{\omega^2}{\omega_p'^2}\right)\times-\frac{2\omega}{\omega_p'^2}+\frac{\cancel{2}\omega}{\omega_p'^2 Q_p'^2}\right\}=0$$

$$\left(1-\frac{\omega^2}{\omega_p'^2}\right)^2+\cancel{\frac{\omega^2}{\omega_p'^2 Q_p'^2}}-\omega\left\{-\frac{2\omega}{\omega_p'^2}\left(1-\frac{\omega^2}{\omega_p'^2}\right)+\cancel{\frac{\omega}{\omega_p'^2 Q_p'^2}}\right\}=0$$

$$\left(1-\frac{\omega^2}{\omega_p'^2}\right)^2+\frac{2\omega^2}{\omega_p'^2}\left(1-\frac{\omega^2}{\omega_p'^2}\right)=0$$

$$\left(1-\frac{\omega^2}{\omega_p'^2}\right)\left(1-\frac{\omega^2}{\omega_p'^2}+\frac{2\omega^2}{\omega_p'^2}\right)=0$$

$$\underline{\omega=\omega_p'}$$

$$|H(j\omega)| = \frac{|\,j\omega / \omega_p' Q_p'\,|}{\left|\left(1-\frac{\omega^2}{\omega_p'^2}\right) + \frac{j\omega}{\omega_p' Q_p'}\right|} = \frac{1}{\sqrt{2}}$$

$$\left(\frac{\omega}{\omega_p'}\right) = x$$

$$\left|\frac{jx/Q_p'}{(1-x^2)^2 + j\frac{x}{Q_p'}}\right| = \frac{1}{\sqrt{2}}$$

$$\frac{x^2/Q_p'^2}{1+x^4-2x^2+\frac{x^2}{Q_p'^2}} = \frac{1}{2}$$

$$\frac{2x^2}{Q_p'^2} = 1+x^4-2x^2+\frac{x^2}{Q_p'^2}$$

$$x^4 + x^2\left(-2 - \frac{1}{Q_p'^2}\right) + 1 = 0$$

$$x^4 - x^2\left(2+\frac{1}{Q_p'^2}\right) + 1 = 0$$

$$x^2 = \frac{\left(2+\frac{1}{Q_p'^2}\right) \pm \sqrt{\cancel{4}+\frac{1}{Q_p'^4}+\frac{4}{Q_p'^2}-\cancel{4}}}{2}$$

$$\left(\frac{\omega}{\omega_p'}\right)^2 = 1+\frac{1}{2Q_p'^2} \pm \sqrt{\frac{1}{4Q_p'^4}+\frac{1}{Q_p'^2}}$$

$$= 1+\frac{1}{2Q_p'^2} \pm \frac{1}{Q_p}\sqrt{1+\frac{1}{4Q_p'^2}}$$

$$= \left(1+\frac{1}{4Q_p'^2}\right) \pm \frac{1}{Q_p}\sqrt{1+\frac{1}{4Q_p'^2}} + \frac{1}{4Q_p'^2}$$

$$\omega = \pm\omega_p'\sqrt{1+\frac{1}{2Q_p'^2} \pm \sqrt{\frac{1}{4Q_p'^4}+\frac{1}{Q_p'^2}}}$$

$$\omega_1 = \omega_p'\sqrt{1+\frac{1}{2Q_p'^2} + \sqrt{\frac{1}{4Q_p'^4}+\frac{1}{Q_p'^2}}}$$

$$\omega_2 = \omega_p'\sqrt{1+\frac{1}{2Q_p'^2} - \sqrt{\frac{1}{4Q_p'^4}+\frac{1}{Q_p'^2}}}$$

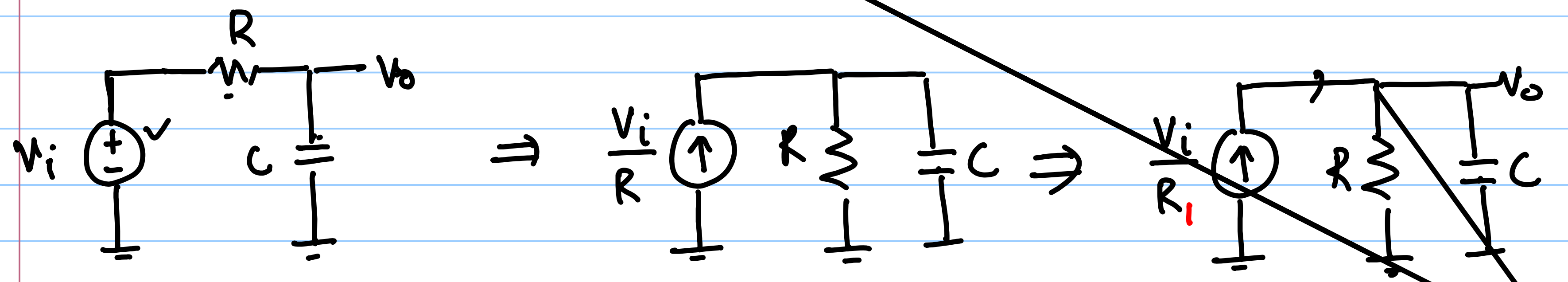
$$\omega_1\omega_2/\omega_p'^2$$

$$= \sqrt{\left(1+\frac{1}{2Q_p'^2}\right)^2 - \frac{1}{4Q_p'^4} - \frac{1}{Q_p'^2}}$$

$$= \sqrt{1+\frac{\cancel{2}}{2Q_p'^2} - \frac{1}{Q_p'^2}} = 1$$

$$\omega_1\omega_2 = \omega_p'^2$$

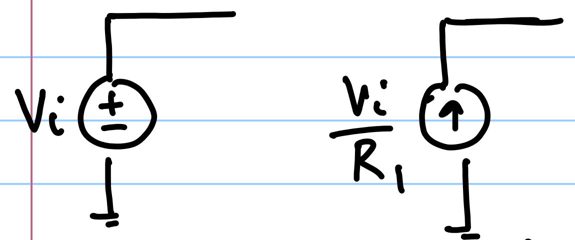
LPF, HPF, BPF have max. gain as 1.

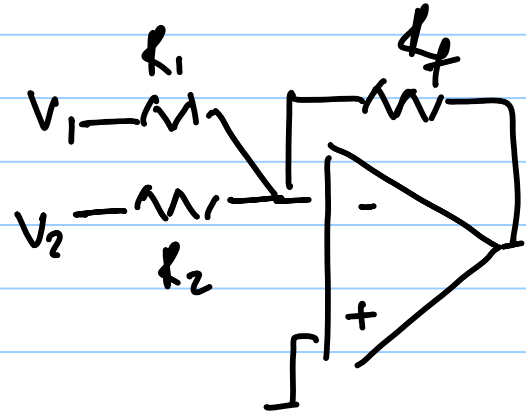


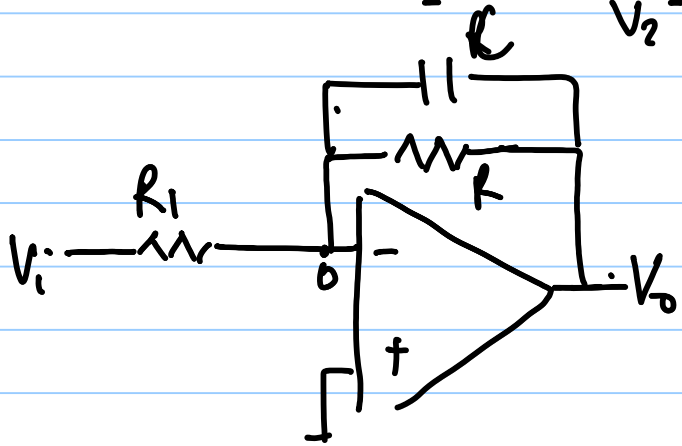
$$\frac{V_o}{V_i} = \frac{1}{1+sRC}$$

$$\frac{V_o}{V_i} = \frac{1}{R_1}\frac{R}{1+sRC}$$

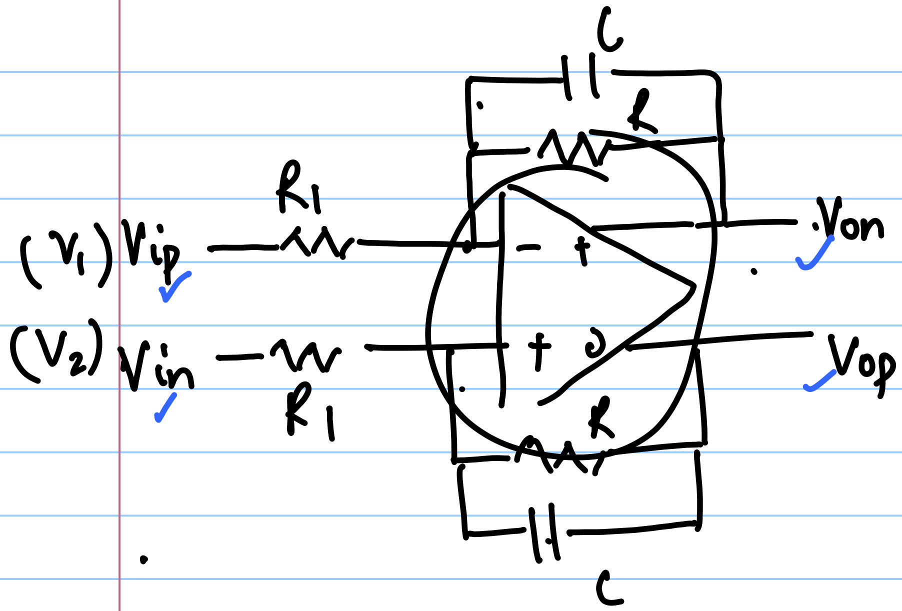
$$= \frac{(R/R_1)}{1+sRC} \checkmark$$







$$\frac{V_o}{V_i} = \frac{-(R/R_1)}{1+sRC}$$

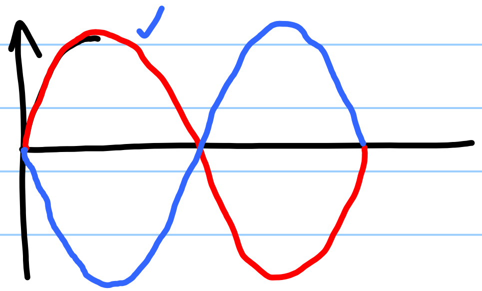


$$V_{on} = -\frac{R/R_i}{1+sRC} \cdot V_i \quad \checkmark$$

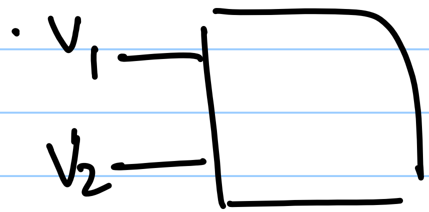
$$V_{op} = -\frac{R/R_1}{1+sRC} \cdot (-V_i) \quad \checkmark$$

$$V_{op} - V_{on} = \frac{R/R_1}{1+sRC} \cdot 2V_i$$

$V_{ip} = -V_{in} = V_i$



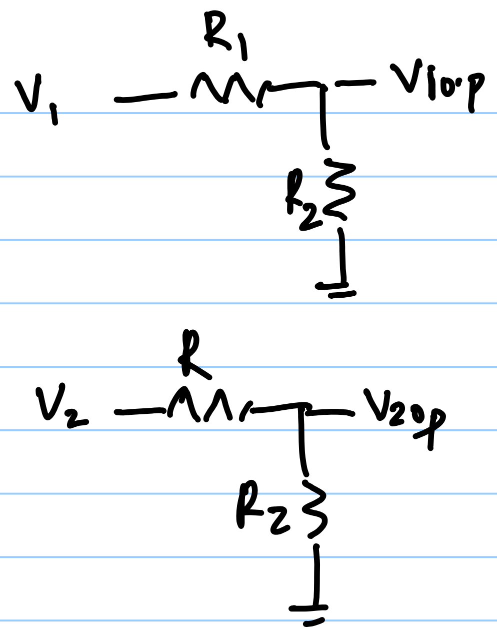
$$\frac{V_{op}-V_{on}}{2V_i} = \frac{R/R_1}{1+sRC}$$



Common Mode Sig

$$V_1 = \frac{V_1+V_2}{2} + \frac{V_1-V_2}{2} = \frac{V_1+V_2}{2} + \frac{V_{diff}}{2} = V_{cm} + \frac{V_{diff}}{2}$$

$$V_2 = \frac{V_1+V_2}{2} - \frac{V_1-V_2}{2} = \frac{V_1+V_2}{2} - \frac{V_{diff}}{2} = V_{cm} - \frac{V_{diff}}{2}$$



$V_{1op} - V_{2op} =$