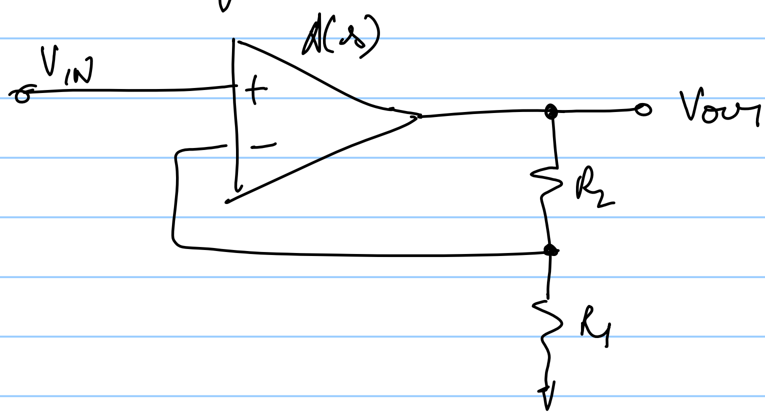
SINGLE POLE OPAMP IN FEEDBACK

Note Title 12/21/2010

→ To see the bode plot of Amp, loop gain & Transfer function in 1 plot for comparison.

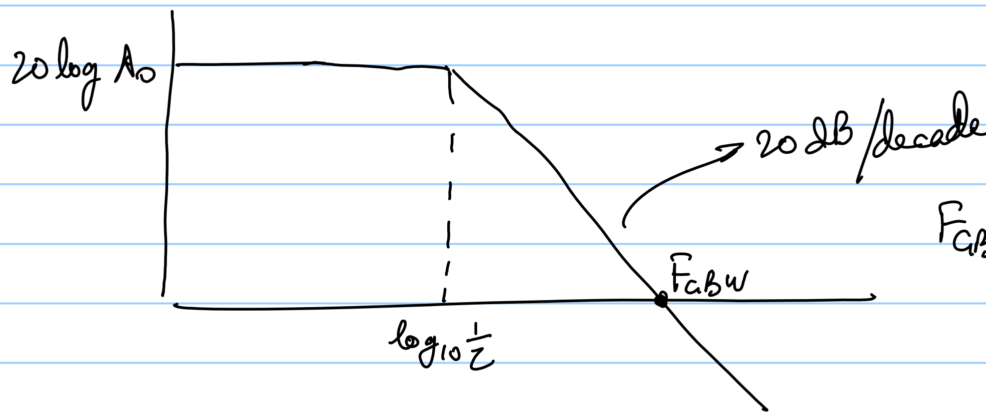
If we have a single pole block & we put it in feedback:



$$A(s) = \frac{A_0}{1+\tau s}$$

$$\text{pole} = -\frac{1}{\tau}$$

The bode plot of A(s) is:



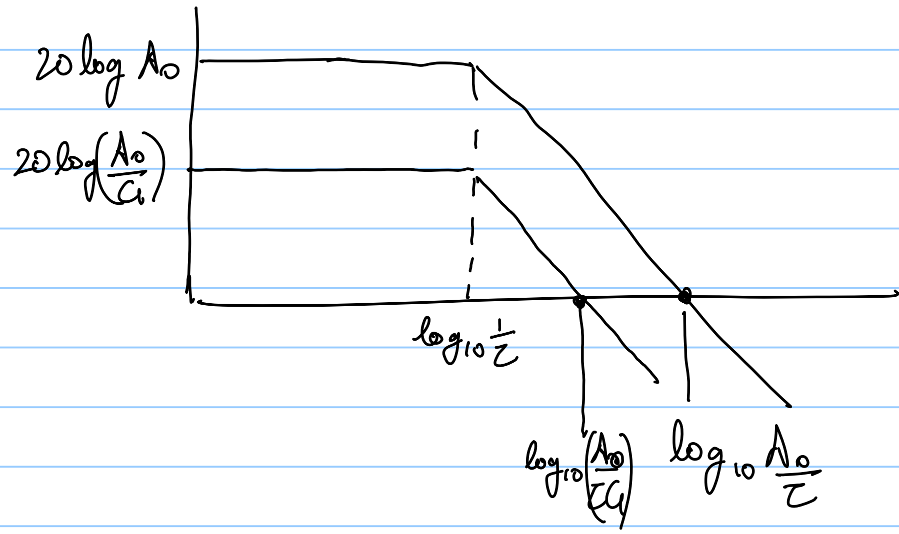
$$F_{GBW} = \left(\frac{1}{\tau}\right) \times 10^{\frac{20\log A_0}{20}} = \frac{A_0}{\tau}$$

The loop gain of the above system which has to be considered to make the system stable is given as:

$$L.G. = A(s) \cdot \frac{R_1}{R_1+R_2} = \frac{A(s)}{1+R_2/R_1} = \frac{A_0/G}{(1+\tau s)}$$

$$1+\frac{R_2}{R_1} = G \text{ (Gain of ckt)}$$

∴ the bode plot showing the amplifier response & the loop gain is



→ Thus the loop gain has less DC gain & hence less Gain bandwidth.

→ Thus stabilizing it just got simpler compared to it in unity gain feedback.

The transfer function is given as:

$$\left(V_{IN} - V_{OUT}\frac{R_1}{R_1+R_2}\right) A(s) = V_{OUT}$$

$$V_{IN}\,A(s) = V_{OUT}\left(\frac{A(s)\,R_1}{R_1+R_2} + 1\right)$$

$$\frac{V_{OUT}}{V_{IN}} = \frac{A(s)}{1+\frac{A(s)}{G_1}} = \frac{A_0}{(1+\tau s)\left(1+\frac{A_0}{(1+\tau s)G_1}\right)}$$

$$TF = \frac{A_0}{1+\tau s+\frac{A_0}{G_1}}$$

$$\text{Pole} = -\frac{1}{\tau}\left(1+\frac{A_0}{G_1}\right)$$

$$\text{DC gain} = \frac{A_0}{1 + A_0/a}$$

Now to check if this point lies on any of the above 2 bode plots

The amplifier bode plot falling line equation is:

$$\frac{0 - 20 \log A_0}{\log \frac{A_0}{\tau} - \log \frac{1}{\tau}} = \frac{y - 20 \log A_0}{\log x - \log \frac{1}{\tau}}$$

for $x = \frac{1}{\tau}\left(1 + \frac{A_0}{a}\right)$ $y = y_0$

$$\Rightarrow \quad - \frac{20 \cancel{\log A_0}}{\cancel{\log A_0}} = \frac{y_0 - 20 \log A_0}{\log\left(1 + \frac{A_0}{a}\right)}$$

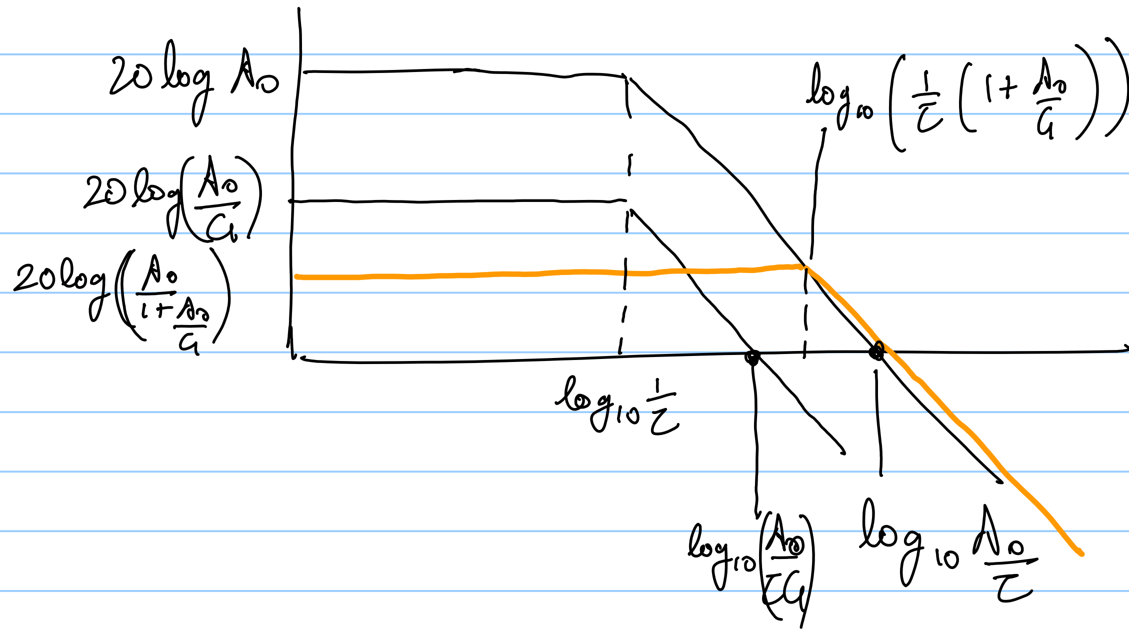
$$-20 \log\left(1 + \frac{A_0}{a}\right) + 20 \log A_0 = y_0$$

$$y_0 = 20 \log \frac{A_0}{1 + A_0/a}$$

i.e. Gain at that point is $\frac{A_0}{1 + A_0/a}$

which is same as gain of transfer function at that frequency.

Thus the bode plot with all 3 functions is:



Although we have to work to stabilize with pole at $\frac{1}{\tau}$ we get performance & bandwidth upto $\frac{1}{\tau}\left(1+\frac{A_0}{G_1}\right)$!!

This is also obvious if you think that for a single pole system feedback does not change the F_{GBW}