Calculating the "Loop Gain" of a feedback circuit

Why do we need Loop Gain ??

1) Can calculate "Rin" and "Rout" in presence of feedback

Shunt: $R_{inF} = \frac{R_{in}}{(1 + \text{Loop Gain})}$; $R_{outF} = \frac{R_{out}}{(1 + \text{Loop Gain})}$

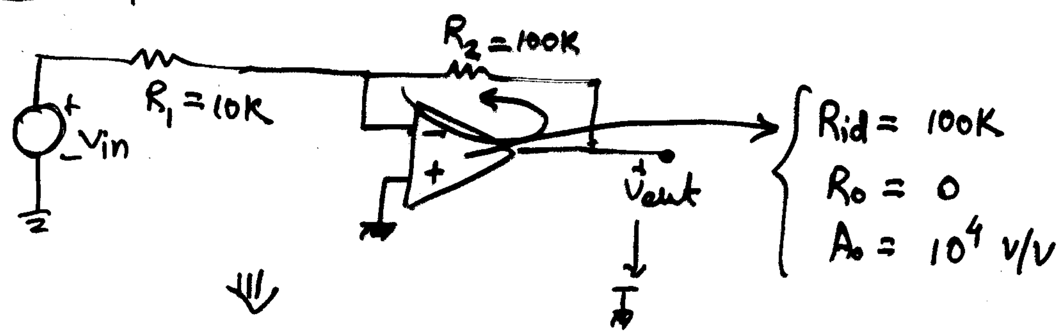
Series: $R_{inF} = R_{in}(1 + \text{Loop Gain})$; $R_{outF} = R_{out}(1 + \text{Loop Gain})$

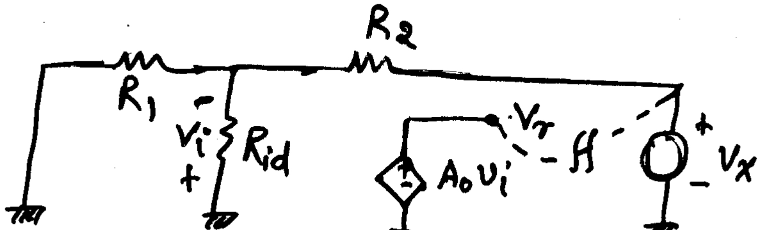
2) To find the stability of a negative feedback loop.

There are two methods for calculating the Loop gain :-

1) Direct
2) Successive voltage and current injection

<u>Example of Direct method</u>





$T = -\left(\frac{V_r}{V_x}\right) = ??$

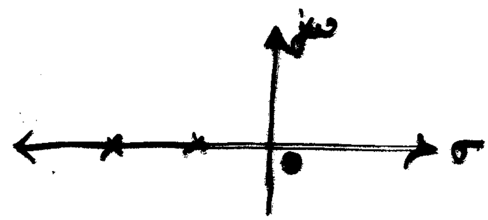
$$V_r = -10^4 v_i = 10^4 \underbrace{\left(\frac{-R_{id}\|R_1}{R_2 + R_{id}\|R_1}\right) v_x}_{v_i}$$

$$T = \frac{V_r}{V_x} = -10^4\left(\frac{9.09}{109.09}\right) = -83.33$$

Stability of Feedback Amplifiers

$$A_F(s) = \frac{A(s)}{1 + A(s)B(s)} = \frac{A(s)}{1 + T(s)}$$

$$T(s) = A(s)\,B(s)$$

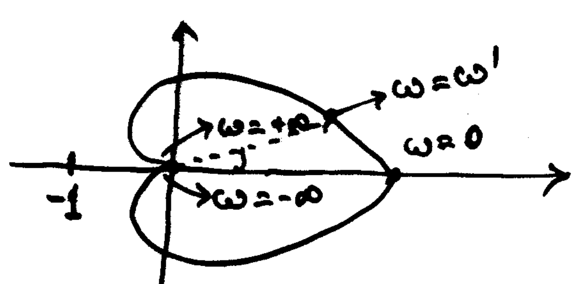


$(s = \sigma + j\omega)$

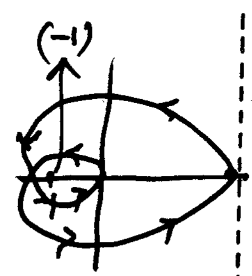
Two approaches :-

① Nyquist approach -

Plot $T(j\omega)$ on a complex plane, varying ω from $-\infty$ to $+\infty$.



(stable)

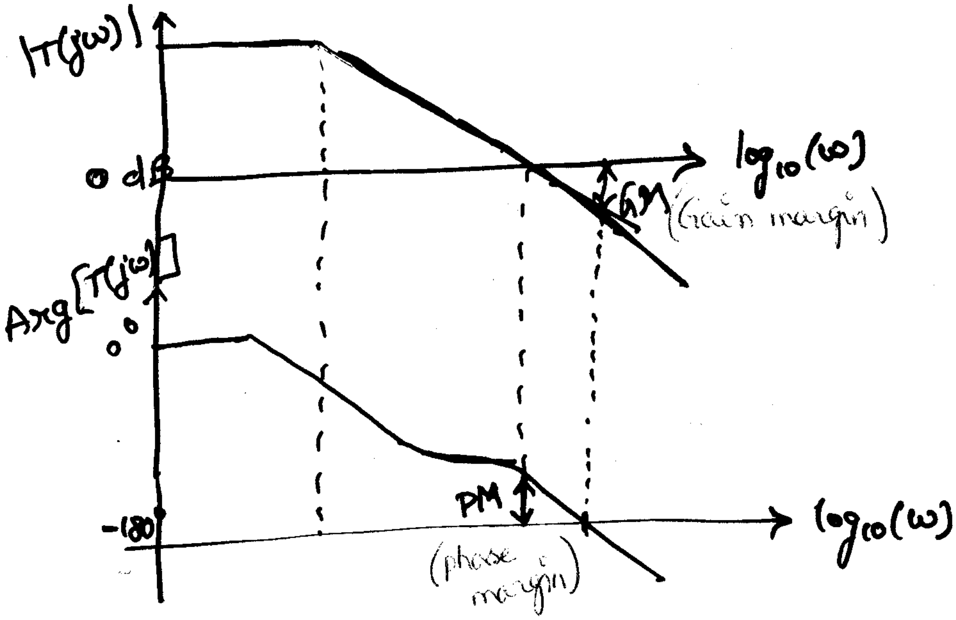


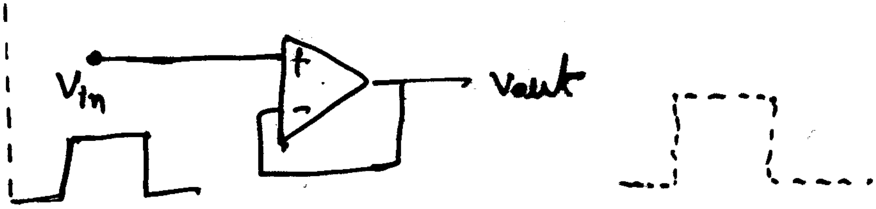
(unstable)

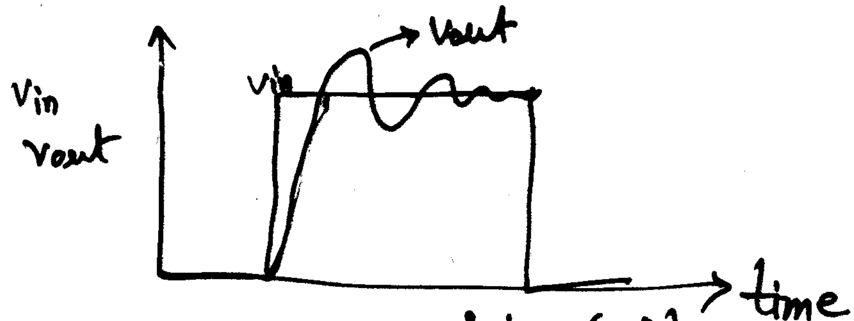
Bode plot

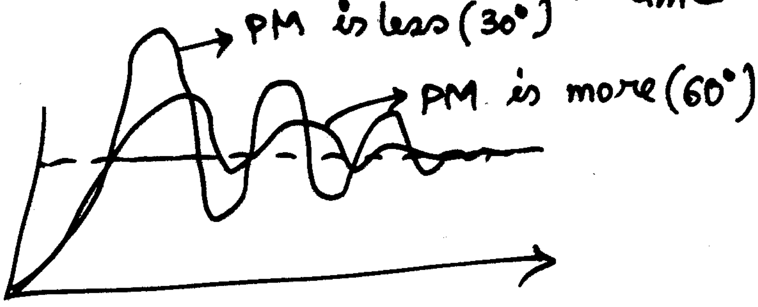
① Phase margin (PM)

② Gain margin (GM)



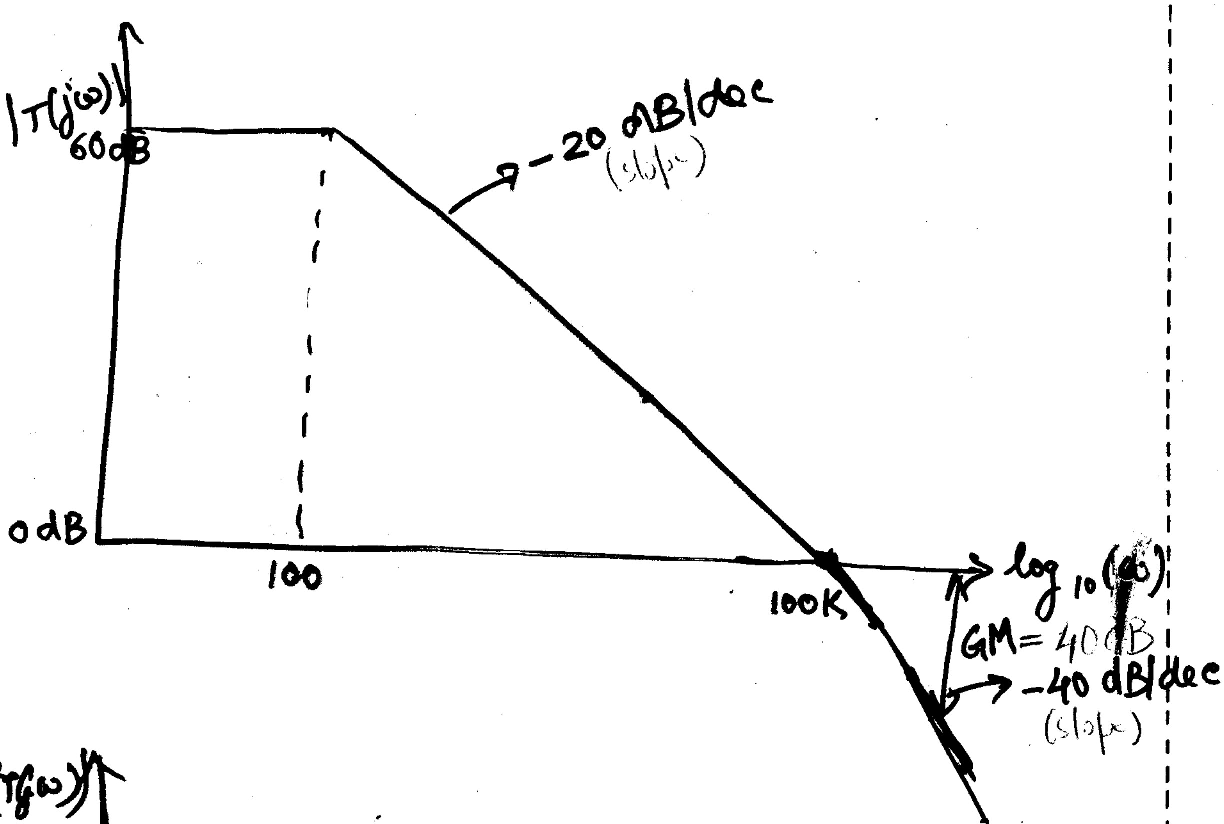


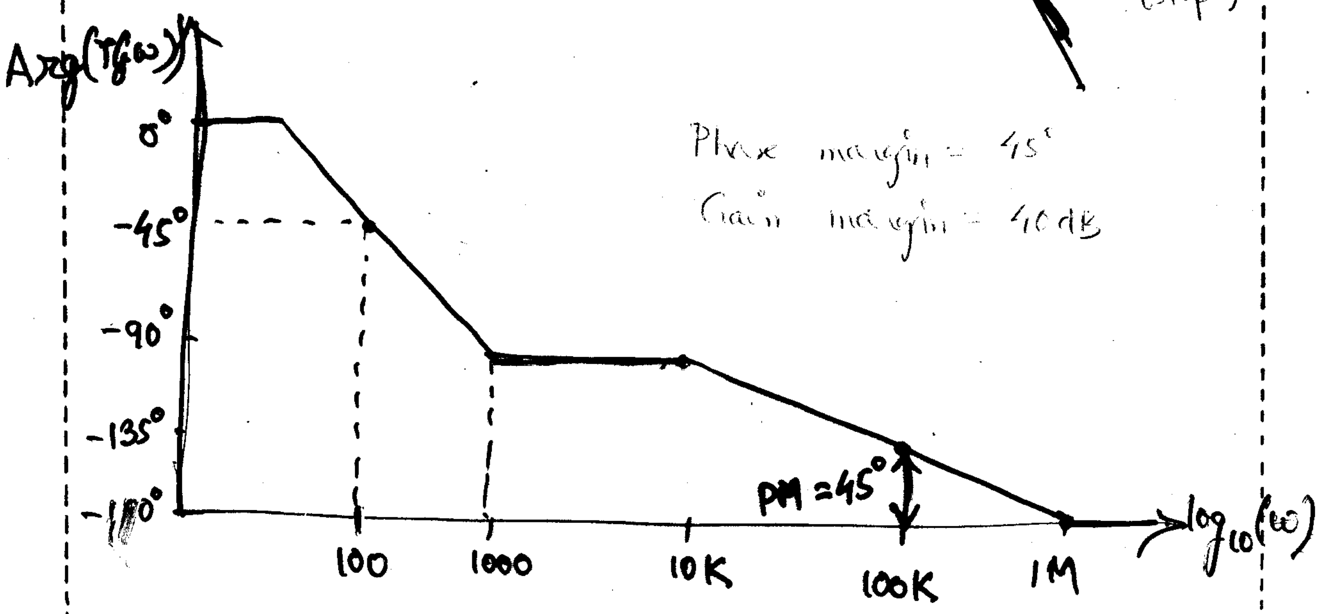




$$A(s) = \frac{10^3}{\left(1+\frac{s}{100}\right)\left(1+\frac{s}{10^5}\right)} \quad ; \quad B(s) = 1$$

$$T(s) = A(s) \cdot B(s)$$





Phase margin = 45°

Gain margin = 40 dB

Rin / Rout with feedback

1. Draw the circuit without feedback.
2. Find Rin/Rout without feedback.
3. Find Loop-gain (T)
4. If input signal is

 a) Voltage $\longrightarrow R_{in}(1+T)$
 b) Current $\longrightarrow \dfrac{R_{in}}{(1+T)}$

 } R_{inF}

 If output signal is

 a) Voltage $\longrightarrow \dfrac{R_o}{(1+T)}$
 b) Current $\longrightarrow R_o(1+T)$

 } R_{outF}