Quiz 12 -

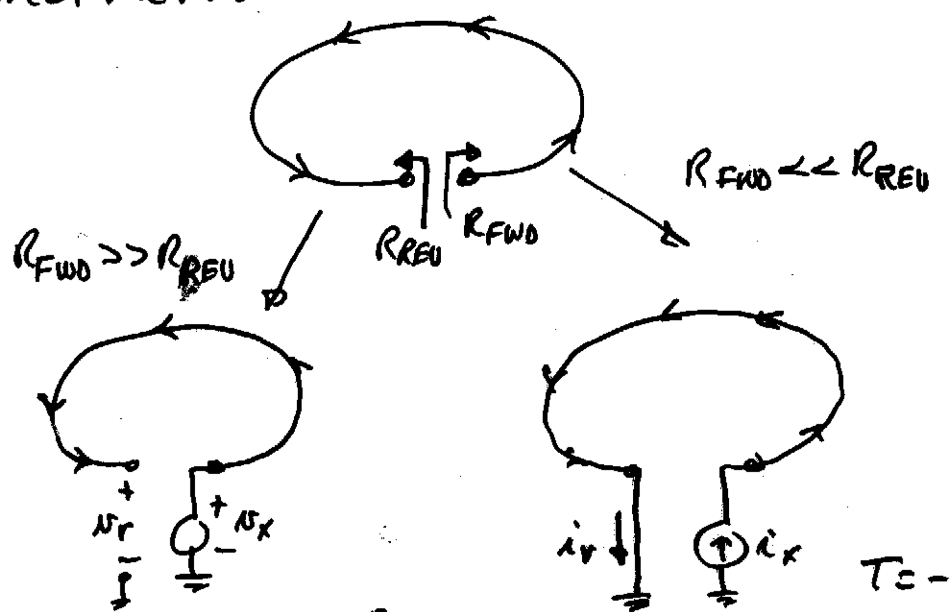
Series at the output and shunt or series at the input

Calculating the loop gain (AB) -

1.) Direct method

2.) Successive voltage and current injection

Direct method -

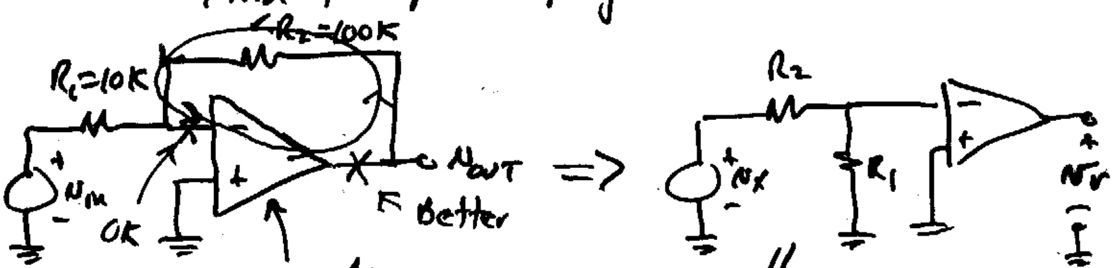


$$T = AB = -\frac{v_r}{v_x}$$

$$T = -\frac{i_r}{i_x}$$

1.) Op Amp Example.

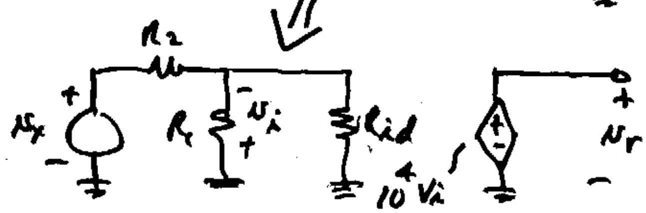
Find the open-loop gain -



$A_v = 10^4$ V/V

$R_{id} = 100K\Omega$

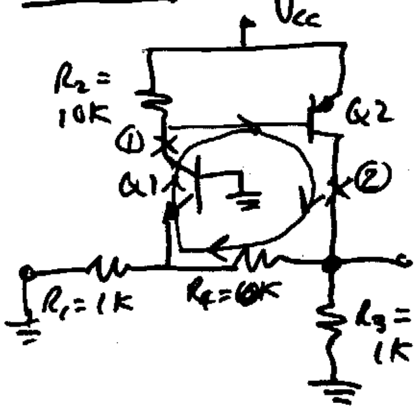
$R_o = 0$



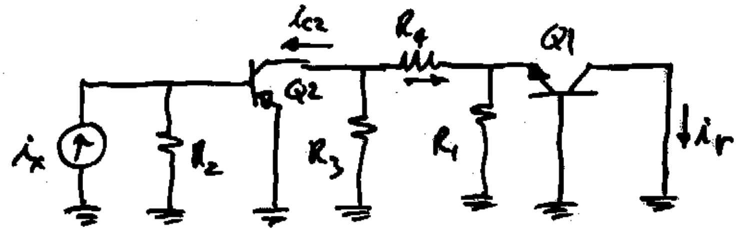
$$v_r = 10^4 v_i = -10^4\left(\frac{R_1 \| R_{id}}{R_2 + R_1\|R_{id}}\right) v_x = -10^4\left(\frac{9.09}{109.09}\right) = -83.33$$

$$T = |AB| = -\frac{v_r}{v_x} = \underline{\underline{83.33\ V/V}}$$

Quiz 11



$r_o = \infty$ Breaking the loop at ①



$$i_r = i_{c2}\left[\frac{-R_3}{R_3 + R_4 + R_1 \| \frac{1}{g_{m1}}}\right]\left[\frac{R_1}{R_1 + \frac{1}{g_{m1}}}\right]\left(\frac{\beta}{1+\beta}\right)$$

$$i_x = \frac{R_2}{R_2 + r_{\pi 2}}$$

$$-\frac{i_r}{i_x} = \left[\frac{R_3}{R_3 + R_4 + R_1\|\frac{1}{g_{m1}}}\right]\left(\frac{R_1}{R_1 + \frac{1}{g_{m1}}}\right)\left(\frac{\beta}{1+\beta}\right)\left(\frac{R_2}{R_2 + r_{\pi 2}}\right)$$

$$= \left(\frac{1K}{11K + 0.2K}\right)\left(\frac{1K}{1.25K}\right)\left(\frac{100}{101}\right)\left(\frac{10K}{35K}\right)$$

$$= 2.526\left(\frac{1}{1.25}\right) = ??$$

STABILITY OF FEEDBACK AMPLIFIERS

$$A_F(s) = \frac{A(s)}{1 + \underbrace{A(s)B(s)}_{\text{Loop gain}}} = \frac{A(s)}{1 + T(s)}$$

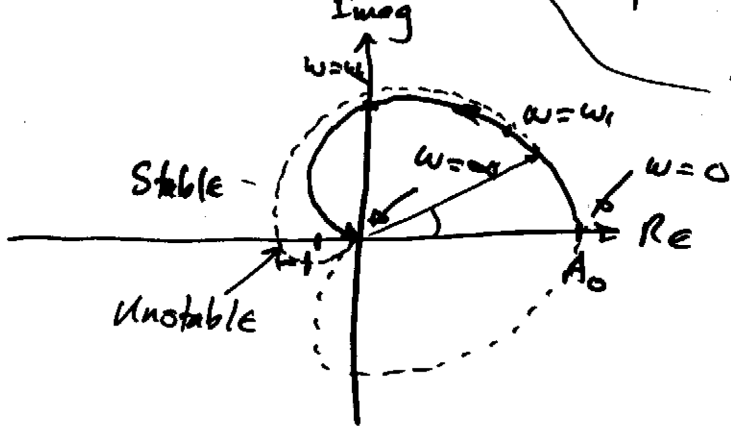
Approaches to Determining Stability

1.) Nyquist Plot

Plot $T(j\omega)$ or $A(j\omega)B(j\omega)$ on a complex frequency plane from $\omega = -\infty$ to $\omega = +\infty$. If this plot encloses the -1 point, the amplifier is unstable.

$$T(s) = \frac{A_0}{\left(\frac{s}{\omega_1}+1\right)\left(\frac{s}{\omega_2}+1\right)}$$

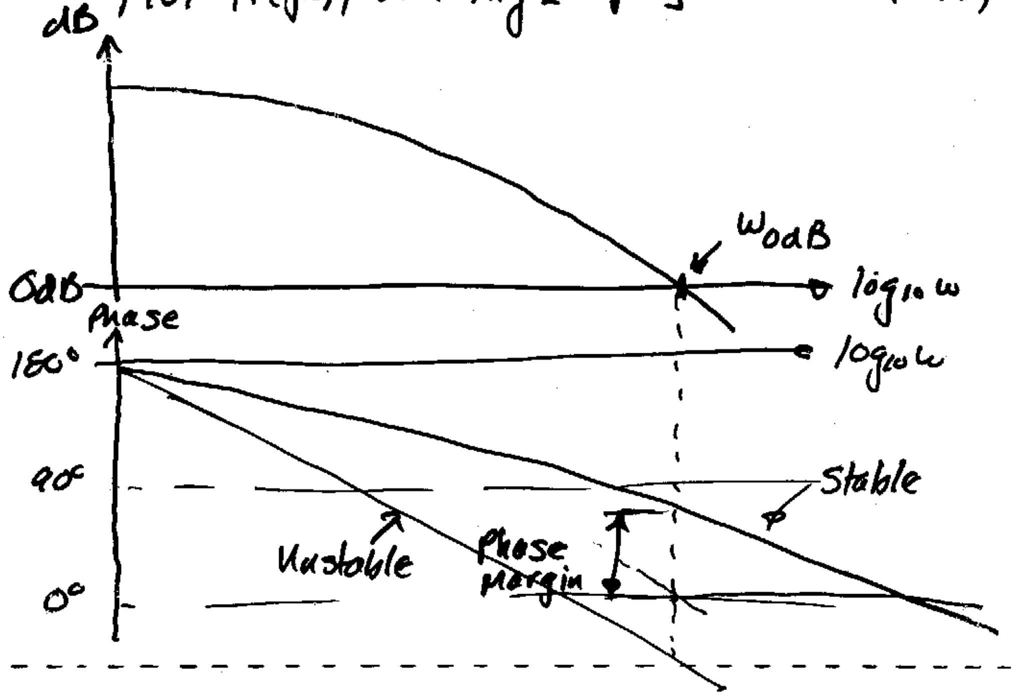
$$T(j\omega) = \frac{A_0}{\left(1+j\frac{\omega}{\omega_1}\right)\left(1+j\frac{\omega}{\omega_2}\right)}$$



2.) Bode Plot

Plot $|T(j\omega)|$ and $\mathrm{Arg}[T(j\omega)]$

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



Bode Criteria-

A feedback amplifier is stable if

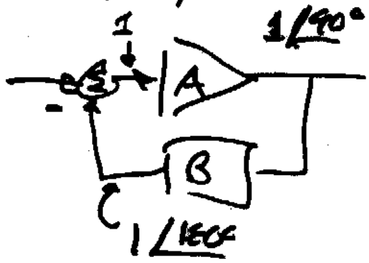
a.) $\mathrm{Arg}[T(j\omega_{0dB})] > 0^\circ$

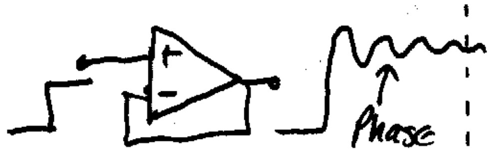
The loop phase shift must less than 180° when the loop magnitude is 1 (0dB).

or

b.) $|T(j\omega_{0^\circ})| < 1$

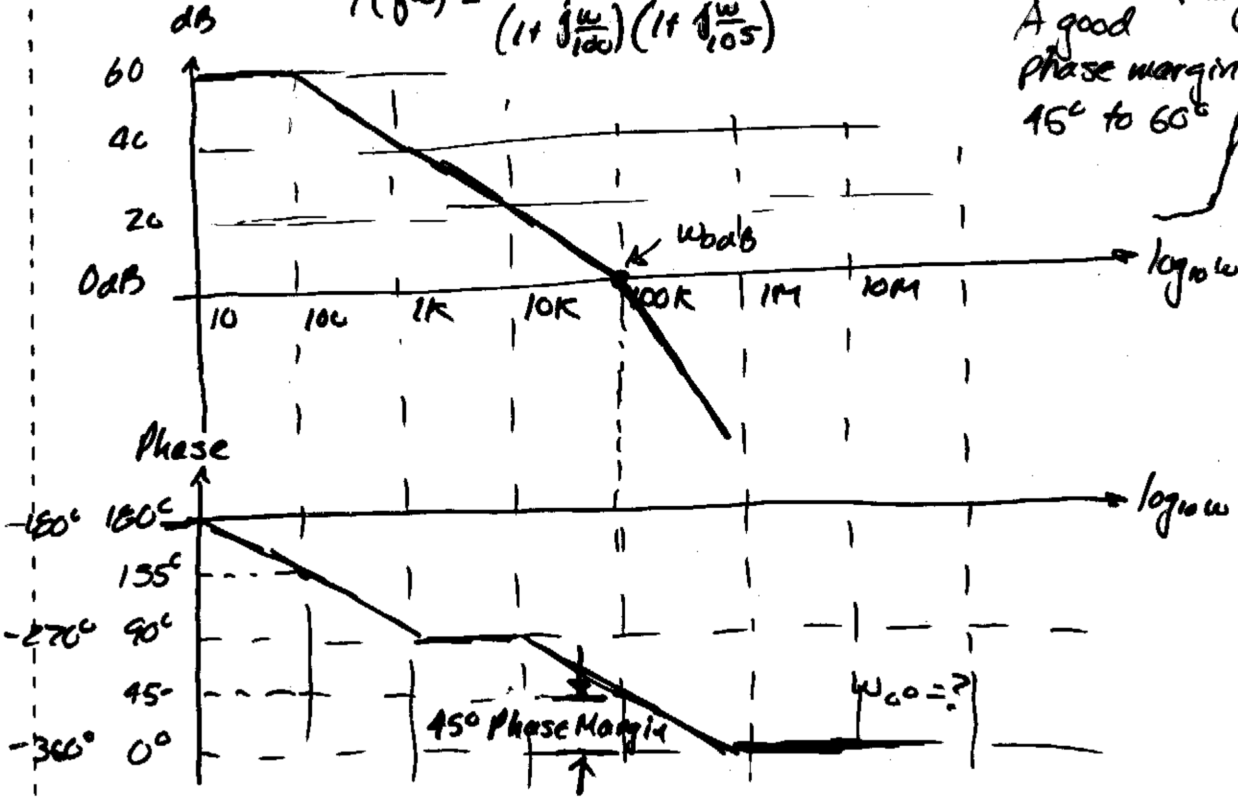
The loop magnitude must be less than 1 when the phase shift of the loop is 180°.





Example -

$$T(j\omega) = \frac{10^3}{(1+j\frac{\omega}{100})(1+j\frac{\omega}{10^5})}$$



A good phase margin 45° to 60°