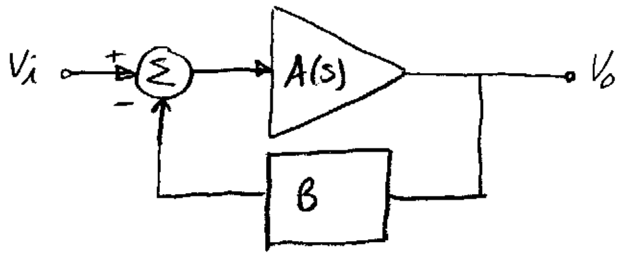
LECTURE 34 - FEEDBACK APPLICATIONS

Using Feedback to control frequency response

Let us determine the influence of negative feedback on the amplifiers frequency response—



Assume β is not a function of frequency

Let $A(s) = \dfrac{A_o \omega_H s}{(s+\omega_L)(s+\omega_H)}$ and $\omega_L \ll \omega_H$ (wideband)

1.) Low frequency ($\omega < \omega_H$)

$$A(s) \rightarrow \frac{sA_o}{s+\omega_L} \qquad A_F(s) = \frac{A}{1+A\beta} = \frac{\frac{sA_o}{s+\omega_L}}{1+\frac{sA_o\beta}{s+\omega_L}}$$

or $$A_F(s) = \frac{sA_o}{s+\omega_L+sA_o\beta} = \frac{sA_o}{s(1+A_o\beta)+\omega_L} = \left(\frac{A_o}{1+A_o\beta}\right)\left(\frac{s}{s+\frac{\omega_L}{1+A_o\beta}}\right)$$

$$\therefore \boxed{\omega_{LF} = \frac{\omega_L}{1+A_o\beta}}$$

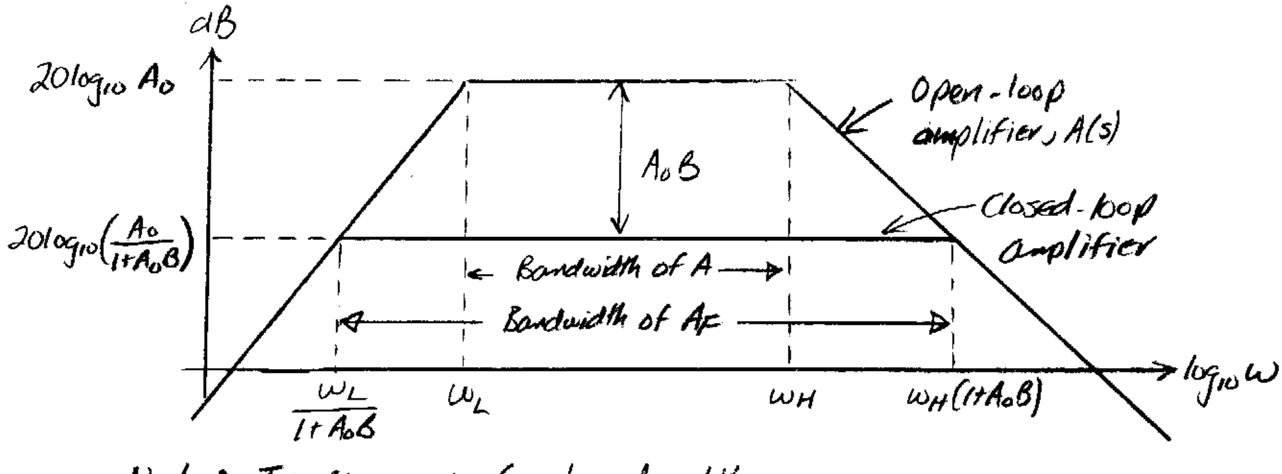
2.) High frequency ($\omega > \omega_L$)

$$A(s) \longrightarrow \frac{A_o\omega_H}{s+\omega_H} \qquad A_F(s) = \frac{A}{1+A\beta} = \frac{\frac{A_o\omega_H}{s+\omega_H}}{1+\frac{A_o\beta\omega_H}{s+\omega_H}}$$

or $$A_F(s) = \frac{A_o\omega_H}{s+\omega_H(1+A_o\beta)} = \left(\frac{A_o}{1+A_o\beta}\right)\left(\frac{\omega_H(1+A_o\beta)}{s+\omega_H(1+A_o\beta)}\right)$$

$$\therefore \boxed{\omega_{HF} = \omega_H(1+A_o\beta)}$$

Control of frequency response by feedback – cont'd



Note: Trade gain for bandwidth.

Calculating the Loop Gain of a Feedback Circuit

Why do we need the loop gain?

1.) Can estimate the influence of negative feedback on input and output resistance.

Shunt: $R_{INF} = \frac{R_{in}}{1+\text{Loop Gain}}$ and $R_{OUTF} = \frac{R_{OUT}}{1+\text{Loop Gain}}$

Series: $R_{INF} = R_{in}(1+\text{Loop Gain})$ and $R_{OUTF} = R_{OUT}(1+\text{Loop Gain})$

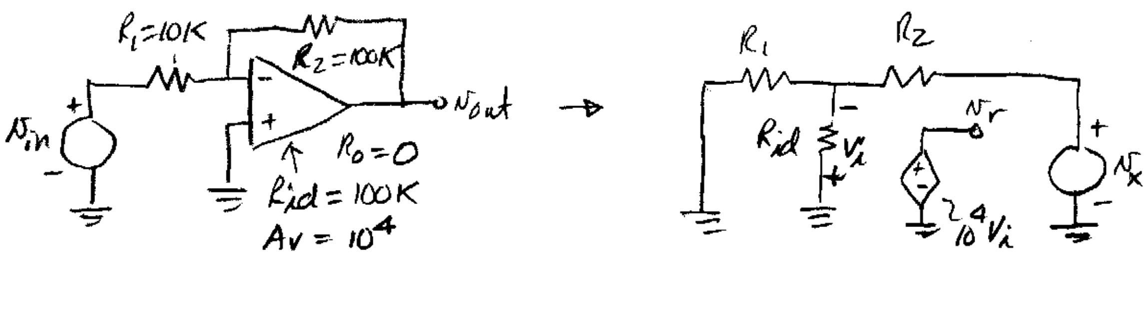
2.) To find the stability of a negative feedback loop.

There are two methods for calculating the loop gain.

1.) Direct

2.) Successive voltage and current injection

Example of Direct Method of Finding the Loop Gain



Example - Cont'd

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

STABILITY OF FEEDBACK AMPLIFIERS

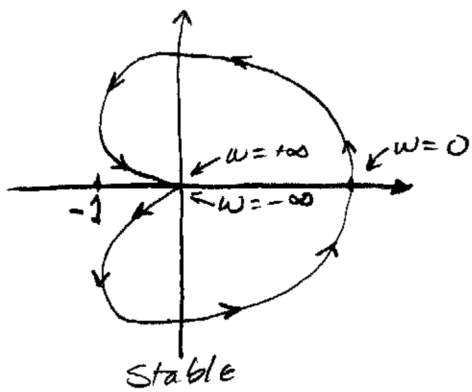
$$A_F(s) = \frac{A(s)}{1 + A(s)B(s)} = \frac{A(s)}{1 + T(s)}$$

Poles (roots of the denominator) must be in the LHP of the complex frequency plane.

Two Approaches for Analyzing Stability

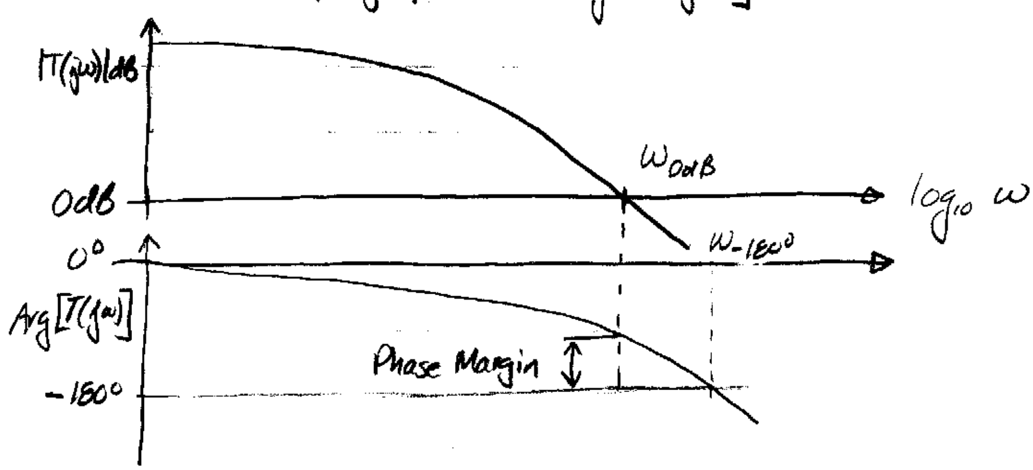
1.) Nyquist plot -

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



2.) Bode Plot -

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



A feedback amplifier is stable if –

a.) $Arg[T(j\omega_{0dB})] > -180°$ The loop phase shift is greater than $-180°$ when the loop magnitude = 1

b.) $|T(j\omega_{-180°})| < 1$ The magnitude of the loop gain is less than 1 at the frequency where the loop phase is $-180°$.