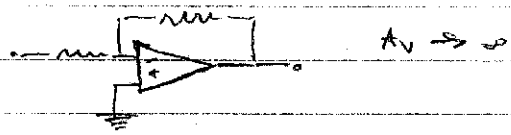
1/24/03 Friday

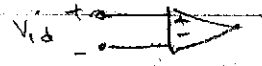
Frequency Response of Op-Amps

1) Ideal Op-Amp

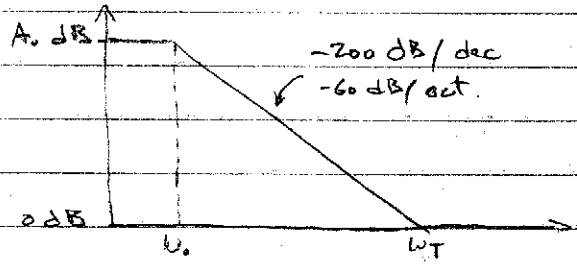
Sec. 12-6



2) Finite Gain GB

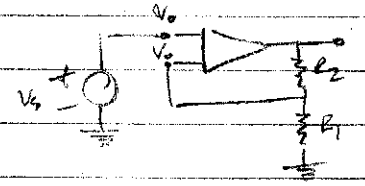


$$* \quad A(s) = \frac{A_o \omega_B}{s + \omega_B} = \frac{\omega_T}{s + \omega_B}$$

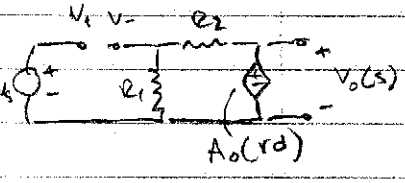


ω_T = unity gain

$GB = A_o \omega_B$



$$V_o = \frac{R_1 + R_2}{R_1} V_s \quad \text{(ideal)}$$



$$V_o = A(s) V_{id} = A(s)\left[V_+ - V_-\right] = A(s) V_s - A(s) \underbrace{\frac{R_1}{R_1 + R_2}}_{\beta} V_o$$

$$V_o = A(s) V_s - A(s) \beta V_o$$

$$V_o \left[1 + A(s)\beta\right] = A(s) V_s \longrightarrow \frac{V_o}{V_s} = A_V(s) = \frac{A(s)}{1 + \beta A(s)}$$

$$A_V(s) = \frac{1}{\frac{1}{A(s)} + \beta} = \frac{1}{\frac{s + \omega_B}{A_o \omega_B} + \beta} = \frac{A_o \omega_B}{s + \omega_B + \beta A_o \omega_B} = \frac{A_o \omega_B}{s + \omega_B(1 + A_o \beta)}$$

$$= \frac{A_o \omega_B}{\omega_B(1 + A_o \beta)} \left(\frac{1}{\frac{s}{\omega_B(1 + A_o \beta)} + 1} \right) = \boxed{\frac{A_V(0)}{\frac{s}{\omega_H} + 1}}$$

$$* \quad A_V(0) = \frac{A_o}{1 + A_o \beta}$$

$$* \quad \omega_H = \omega_B(1 + A_o \beta)$$

$$\approx \omega_B A_o \beta$$

$$\underbrace{\quad}_{\omega_T}$$

Example

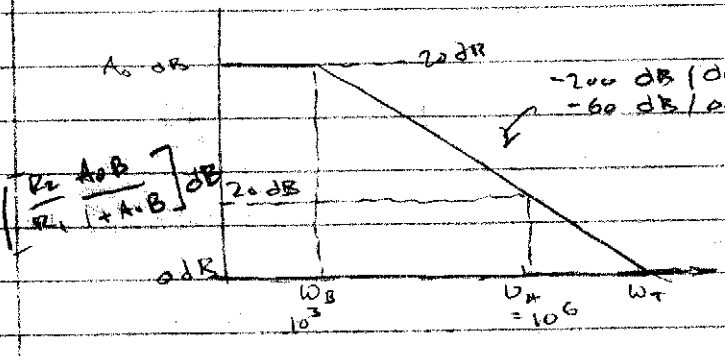
GNEN:

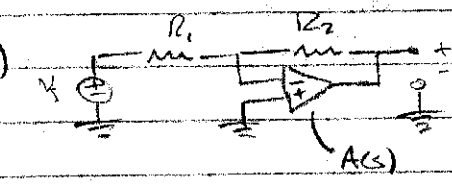
$A_0 = 10{,}000$ $\quad \beta = \frac{1}{10}$

$\omega_B = 10^3$ R/s

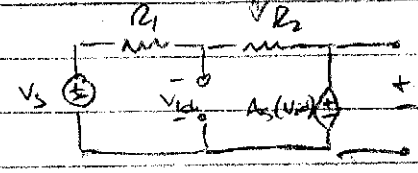
$R_2 = 9R_1$

$A_V(0) = \frac{A_0}{1+A_0\beta} \simeq 10 \quad \omega_H = \omega_B(1+A_0\beta) = 10^3(1+10^3) = 10^6$



3) 

$\Leftrightarrow$ Inverting



$A_0\beta \gg 1$

$A_V(0) = -\frac{R_2}{R_1}\frac{A_0\beta}{1+A_0\beta} \simeq -\frac{R_2}{R_1}$

$\omega_H = \omega_B(1+A_0\beta)$

$V_o(s) = A(s)V_{id} = A(s)\left[-V_s\frac{R_2}{R_1+R_2} - V_o\underbrace{\frac{R_1}{R_1+R_2}}_{\beta}\right]$

$V_o\left[1+\frac{A(s)R_1}{R_1+R_2}\right] = -A(s)\frac{R_2}{R_1+R_2}V_s = -A(s)\frac{R_2}{R_1}\frac{R_1}{R_1+R_2}V_s$

$A_V(s) = \frac{V_o(s)}{V_s(s)} = \frac{-\frac{R_2}{R_1}A(s)\beta}{1+A(s)\beta} = \frac{-\frac{R_2}{R_1}\beta}{\frac{1}{A(s)}+\beta} = \frac{-\frac{R_2}{R_1}\beta}{\frac{s+\omega_B}{\omega_B A_0}+\beta} = \frac{-\frac{R_2}{R_1}\beta\omega_B A_0}{s+\omega_B(1+A_0\beta)}$

ω_H

$= \frac{-\frac{R_2}{R_1}\omega_B\beta A_0}{\omega_B(1+A_0\beta)}\frac{1}{\frac{s}{\omega_B(1+A_0\beta)}+1} = \frac{A_V(0)}{\frac{s}{\omega_H}+1} \quad \therefore \omega_H$

$A_V(0) = -\left(\frac{R_2}{R_1}\right)\frac{A_0\beta}{1+A_0\beta} \simeq -\frac{R_2}{R_1}, \quad A_0\beta \gg 1$