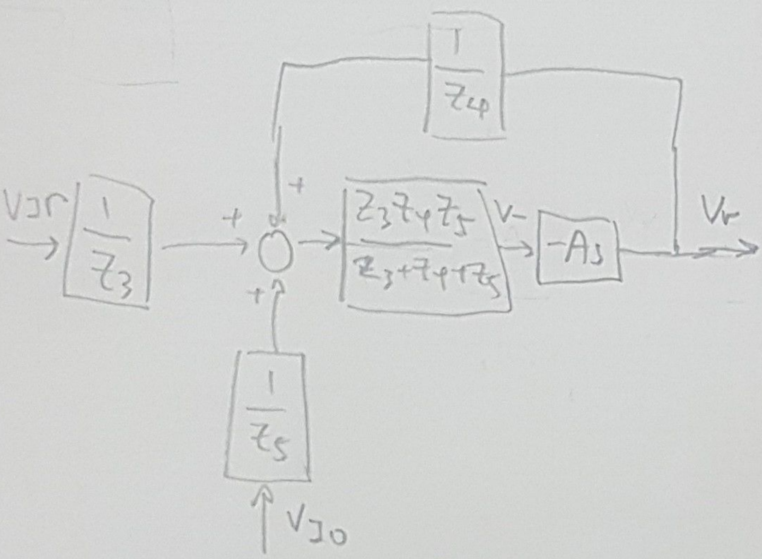
1a. Rattanamon Prahatpong #6320516J

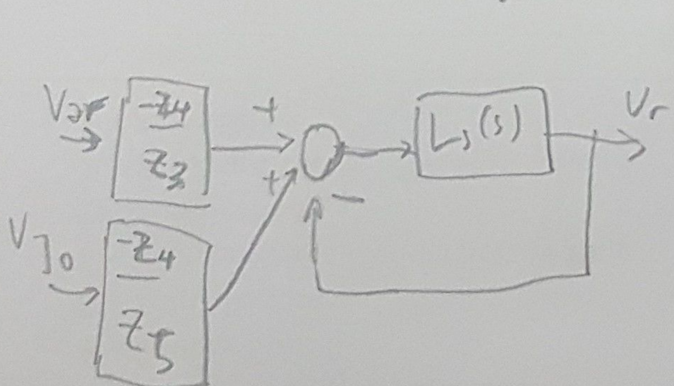
$$V_r = A_s(s)\,(0 - V_-)$$

$$0 = \frac{V_- - V_{Ir}}{Z_3} + \frac{V_- - V_r}{Z_4} + \frac{V_- - V_{I0}}{Z_5} \rightarrow V_- = \underbrace{\left(\frac{Z_3 Z_4 Z_5}{Z_3 + Z_4 + Z_5}\right)}_{B}\left(\frac{V_{Ir}}{Z_3} + \frac{V_r}{Z_4} + \frac{V_{I0}}{Z_5}\right)$$



b. $$L(s) = \left(\frac{Z_3 Z_5}{Z_3 + Z_4 + Z_5}\right)(A_s(s)) = \frac{B}{Z_4} A_s(s)$$ ← make it positive so part c make sense

c.

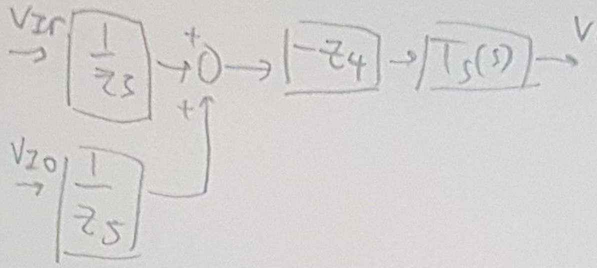


$$V_r = -A_s V_-$$

$$V_r = -A_s (B)\left(\frac{V_{Ir}}{Z_3} + \frac{V_r}{Z_4} + \frac{V_{I0}}{Z_5}\right)$$

$$V_r = \frac{-A_s B}{Z_3} V_{Ir} - \frac{A_s B}{Z_4} V_r - \frac{A_s B}{Z_5} V_{I0}$$

$$V_r = \underbrace{\frac{A_s B}{Z_4}}_{L_s}\left(\left(-\frac{Z_4}{Z_3} V_{Ir}\right) - (V_r) + \left(-\frac{Z_4}{Z_5} V_{I0}\right)\right)$$



$$T_s = \frac{BA_s/Z_4}{1 + BA_s/Z_4} = \frac{L_s}{1+L_s}$$

$$V_r(1 + L_s) = L_s(-Z_4)\left(\frac{V_{Ir}}{Z_3} + \frac{V_{Io}}{Z_5}\right)$$

$$V_r = \frac{L_s}{1+L_s}(-Z_4)\left(\frac{V_{Ir}}{Z_3} + \frac{V_{Io}}{Z_5}\right)$$

2a. $L(j\omega)\big|_{\omega \to 0} \to \infty \Rightarrow \frac{I_o}{V_{Ir}}\Big|_{\omega 0} = \frac{-1}{R_3}\left(\frac{R_5}{R_s}\right)$

from lecture notes

$$\frac{2A}{10V} = \frac{1}{R_3}\left(\frac{1k}{.2}\right)$$

$$R_3 = \frac{1000}{.2}\left(\frac{10}{2}\right)\Omega = 25\,k\Omega$$

2b. $L(s) = \left(\frac{1}{C_4 s} + R_4\right) T_g(s) \left(\frac{R_1+R_2}{R_1}\right) T_p(s) \left(\frac{1}{L_m s + R_m + R_s}\right)\left(\frac{R_s}{R_5}\right)$

$C_4 = \infty$ 1   ∝ 1 up to 300kHz

$$= R_4\left(\frac{10k}{1k}\right)\left(\frac{1}{1m\,s + 6}\right)\left(\frac{.2}{1k}\right)$$

$$= \frac{2R_4}{s+6000}$$

Using MATLAB → $\phi_m = 90.2$ deg $\geq 90°$

$\omega_c = 1.8\times10^6 \frac{rad}{s} = 286kHz \leq 300k\,Hz$

$R_4 = 900\,k\Omega$

```
1 -    r4 = 900000;
2 -    sys = tf([2*r4], [1 6000]);
3 -    margin(sys);
```

Figure 1

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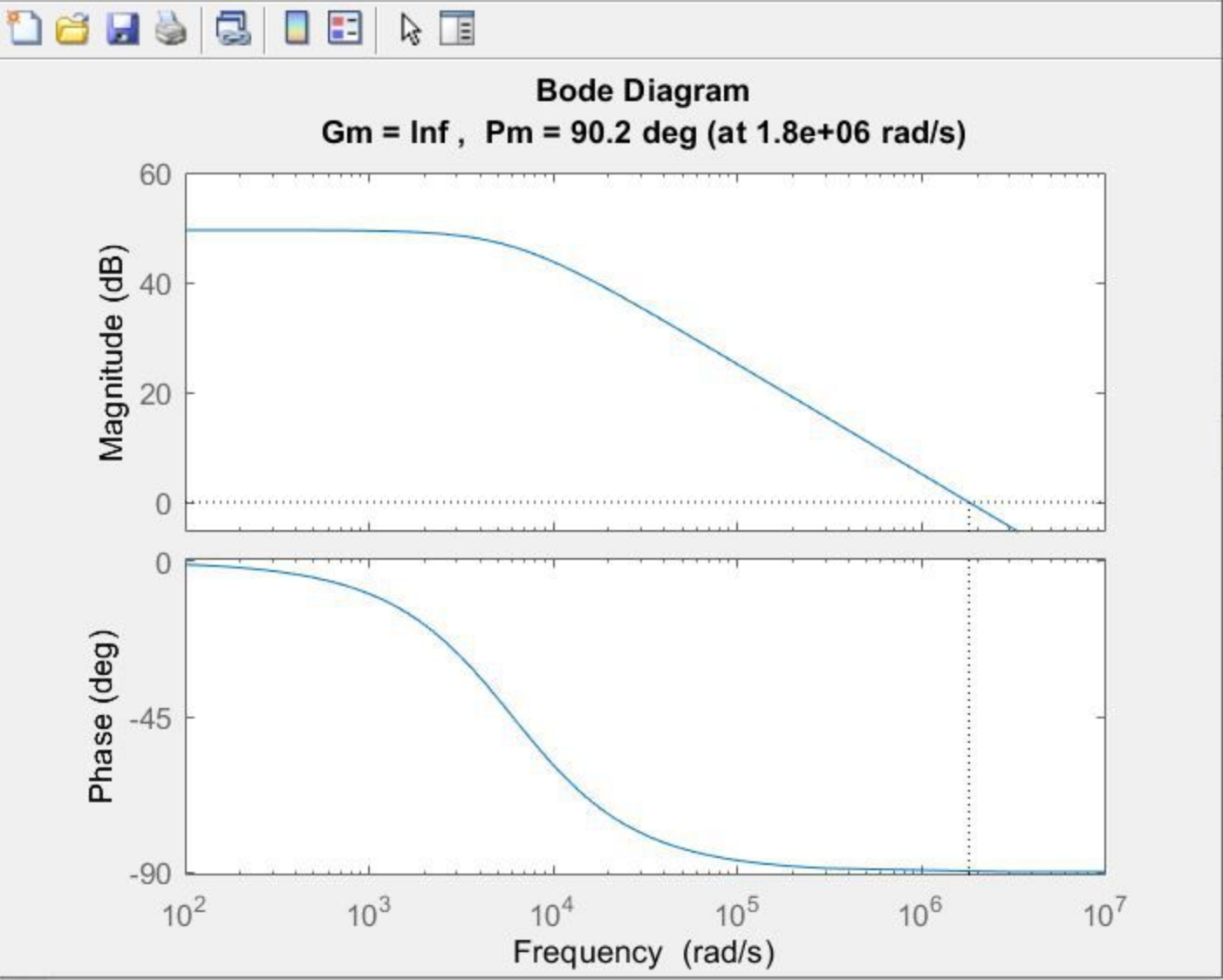

2C

$$L(s) = \left(\frac{1}{C_4 s} + 900k\right)\left(\frac{2}{s+6000}\right) = \frac{2(1+C_4 900k\, s)}{C_4 s(s+6000)}$$

$$G(s) = \frac{L(s)}{1+L(s)}$$

Using MATLAB → $W_c = 1.35 \times 10^5 \leq 300kHz$

$\phi_m = 176^\circ$

$C_4 = .1nF$

```
1 -    r4 = 900000;
2      %sys = tf([2*r4], [1 6000]);
3      %margin(sys);
4 -    c4 = .0000000001;
5 -    sys = tf([r4*c4*2 2], [c4 6000*c4 0]);
6 -    sys = sys/(1+sys);
7 -    margin(sys);
```

Figure 1

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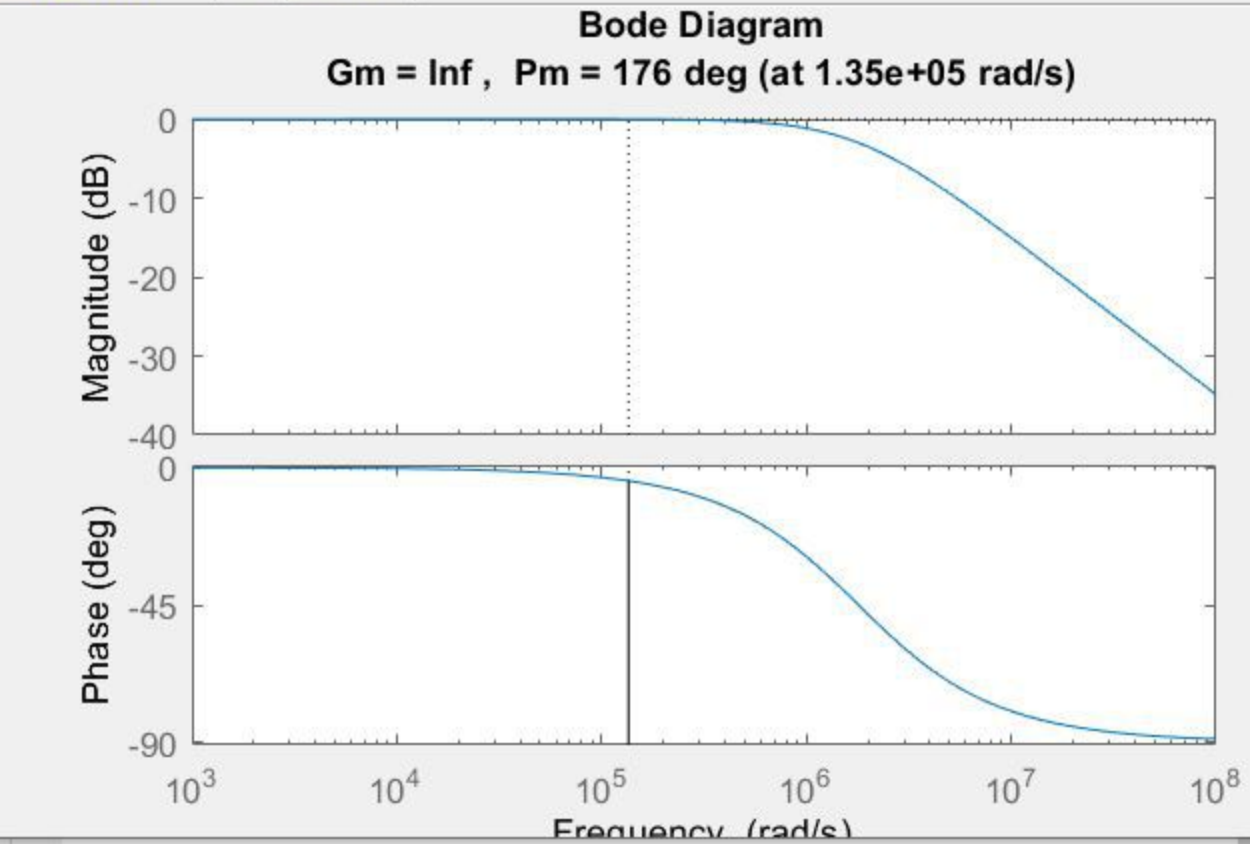

2d. $L(s) = T_s(s)\left(\frac{1}{.1ns} + 900k\right)\frac{2}{s+6000}$

from Q1 $\rightarrow T_s = \frac{B\,Z_5/Z_4}{1 + B\,Z_5/Z_4}$

$= \frac{Z_3 Z_5}{Z_3 + Z_4 + Z_5 + Z_3 Z_5}$

$= \frac{(25k)\,1k}{25k + \frac{1}{.1ns} + 900k + 1k + 25k(1k)}$

$G(s) = \frac{L(s)}{1 + L(s)}$

```
r4 = 900000;
%sys = tf([2*r4], [1 6000]);
%margin(sys);
c4 = .1*10^(-9);
sys = tf([r4*c4*2 2], [c4 6000*c4 0]);
z4 = tf([r4*c4 1], [c4 0]);
Ts = 25000*1000/(25000+z4+1000+25000*1000);
sys = Ts*sys;
sys = sys/(1+sys);
margin(sys);
```

and Window

o MATLAB? See resources for Getting Started.

```
hw4
hw4
hw4
hw4
hw4
hw4
hw4
hw4
hw4
```

Figure 1

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