EE324 Problem Sheet 8

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Q1

0.1 Part a

The phase and gain margin are 0 when gain crossover and freq crossover freq coincide.

$$H(s) = 1 + \frac{K}{s^3 + 4s^2 + 8s} \implies H(j\omega) = \frac{K - j\omega^3 - 4\omega^2 + j8\omega}{-j\omega^3 - 4\omega^2 + j8\omega}$$

$$\Phi(\omega) = -180^\circ \text{ if } 8\omega - \omega^3 = 0 \text{ and } \frac{K - 4\omega^2}{-4\omega^2} < 0 \implies \omega^2 = 8$$

$$M(\omega) = \frac{|K - 4\omega^2|}{4\omega^2} = 1 \implies \frac{|K - 32|}{32} = 1 \implies \boxed{K = 64}$$

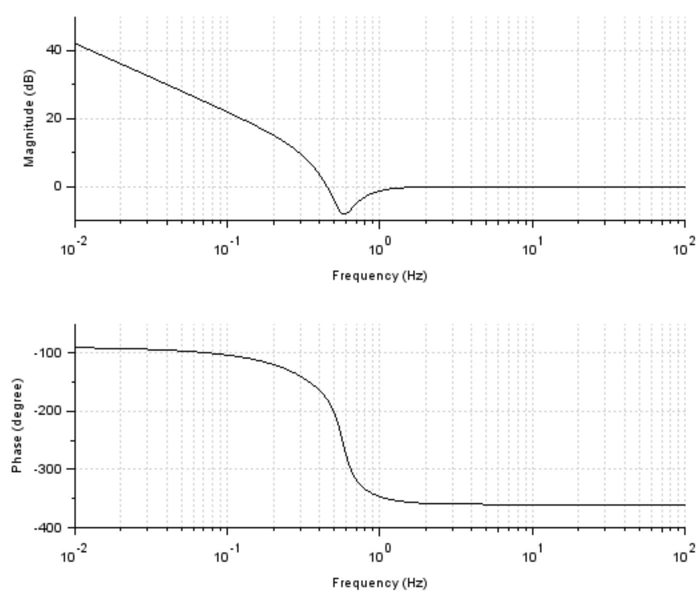

Figure 1: Bode Plot for Phase and Gain Margin=0

0.2 Part b

No. After the two margins intersect they are 0 thereafter.

0.3 Part c

Since the dominant poles of the closed loop system for the K when the closed 1oop characteristic equation has 0 phase and gain margins lie in the Right Half Plane, we observe that the system is unstable

Code

```
s = poly(0,'s');
G = 1/(s*(s^2+4*s+8));
G = syslin('c',64*G+1);

bode(G, 0.01, 100);
```

Q2

0.4 (a)

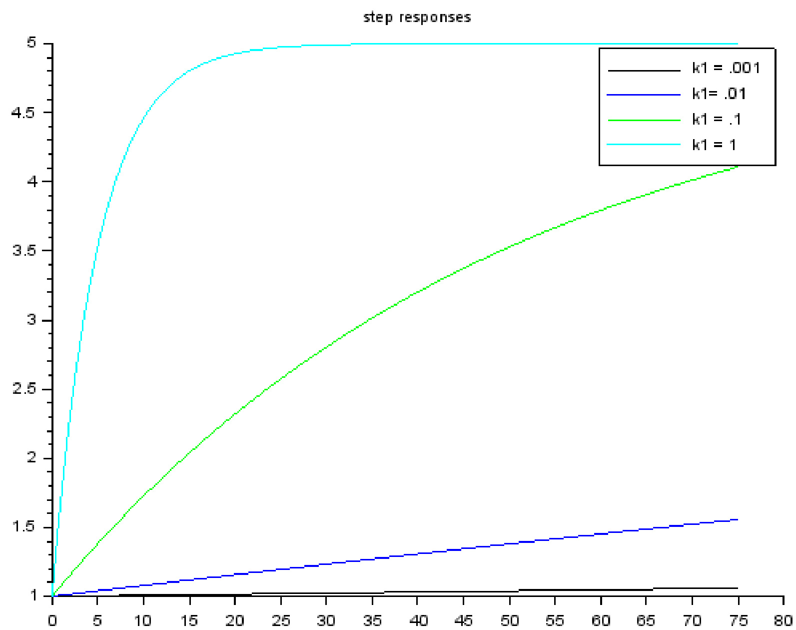

Figure 2: Step Response on Varying Pole Zero location of Lag Compensator

The further away K2 is from the origin, the faster will the transient decay to give 5 as the steady state output due to exp(-k2t) term.

0.5 (b)

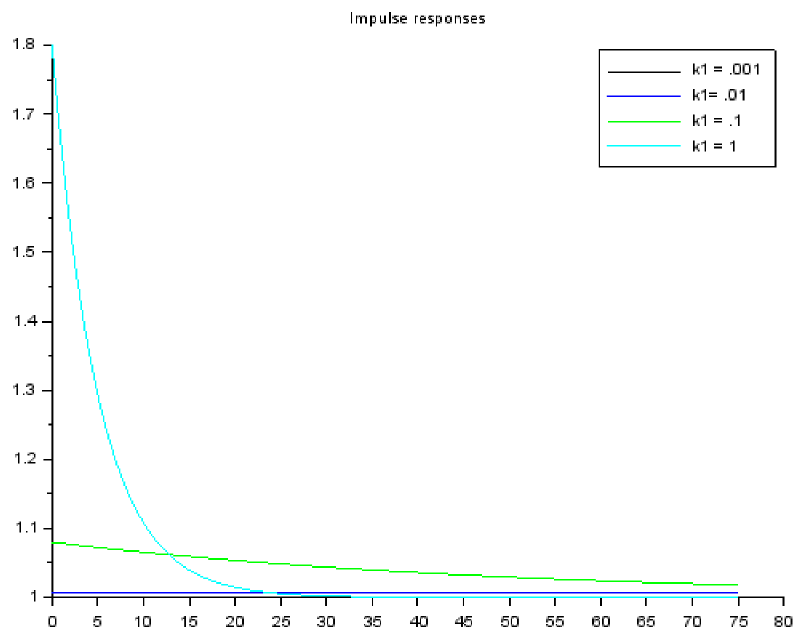

Figure 3: Impulse Response on Varying Pole Zero location of Lag Compensator

as the pole and zero move away from the origin, the graph becomes more and more steeper, this is due to the $e^{-K_2 t}$ term in the output.

Code

```
s = poly(0,'s');
k1_range = [.001, .01, .1, 1];
t = 0:.1:75;
steps = zeros(length(t), length(k1_range));
impulses = zeros(length(t), length(k1_range));

for i = 1:length(k1_range)
    k1 = k1_range(i)
    k2 = k1/5;
    G = (s+k1)/(s+k2);
    G = syslin('c',G);
    steps(:, i) = csim('step', t, G);
    impulses(:, i) = csim('impulse', t, G);
end

```

```
scf(0);
plot2d(t, steps)
title('step responses')
legend(['k1 = .001', 'k1= .01', 'k1 = .1', 'k1 = 1'])

scf(1);
plot2d(t, impulses)
title('Impulse responses')
legend(['k1 = .001', 'k1= .01', 'k1 = .1', 'k1 = 1'])
```

Q3

0.6 Part a

Roots chosen are -1, +-i, +-2i

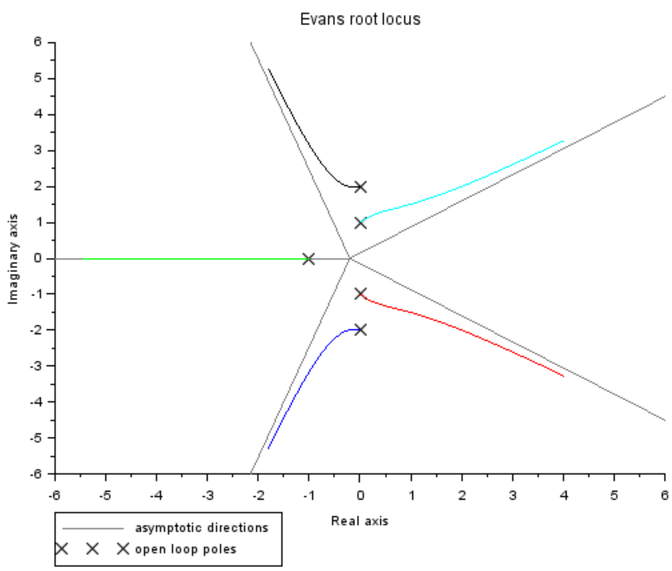

Figure 4: Root Locus Plot

0.7 Part b

Translating by 2

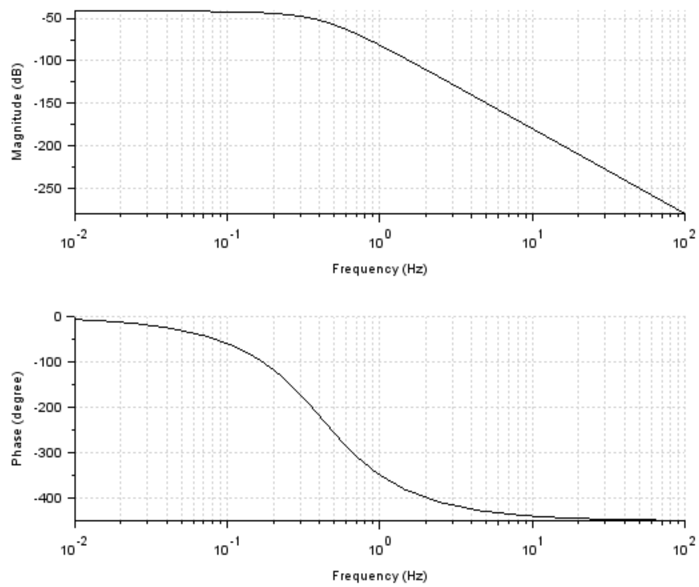

Figure 5: Translated bode Plot

0.8 Part c

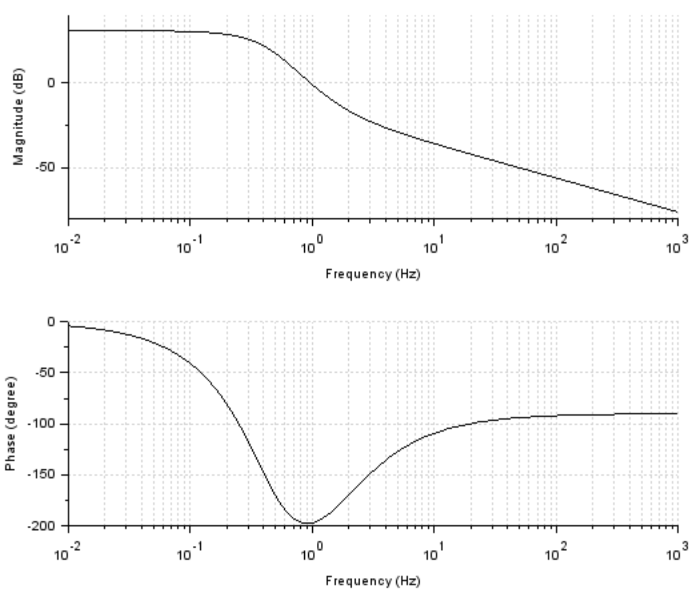

Figure 6: Designed Bode Plot

0.9 Part d

(d)

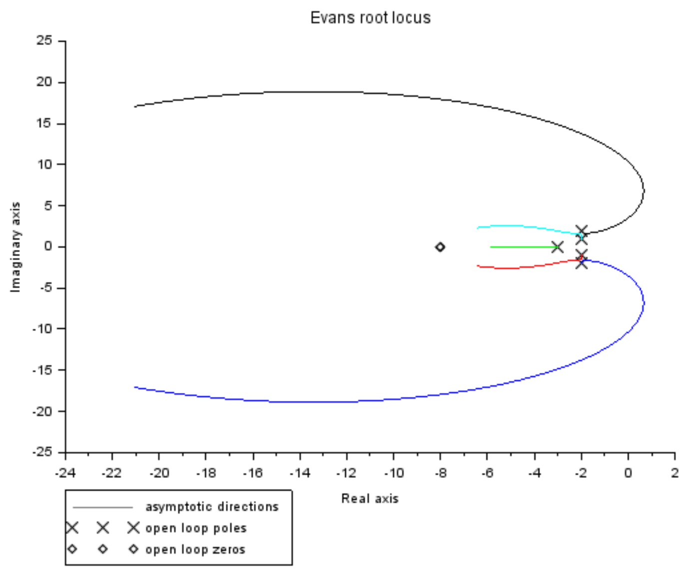

Figure 7: Obtained Root Locus Plot

Code

```


s = poly(0,’s’);

// part a
G = 1/((s+1)*(s^2+1)*(s^2+4));
scf(0);
evans(G, kpure(G));


//part b
// shifting origin by 2
G1 = 1/((s+3)*((s+2)^2+1)*((s+2)^2+4));
G1= syslin(’c’,G1);
scf(1);
bode(G1, 0.01, 100);

// part c
G2= ((s+8)^4)/((s+3)*((s+2)^2+1)*((s+2)^2+4));
scf(2);
```

```
bode(syslin('c',G2), .01, 1000)

// part d
G3 =  ((s+8)^4)/((s+3)*((s+2)^2+1)*((s+2)^2+4));
scf(3);
evans(G3, 50);
```

Q4

The asymptotic points are at 1, 5, 10, and 100. There is a positive slope after 1 and negative/constant slopes after it. Therefore, 5, 10 and 100 form the pole points and hence the transfer function is

$$G(s) = \frac{(s+1)}{(s+5)(s+10)(s+100)}$$

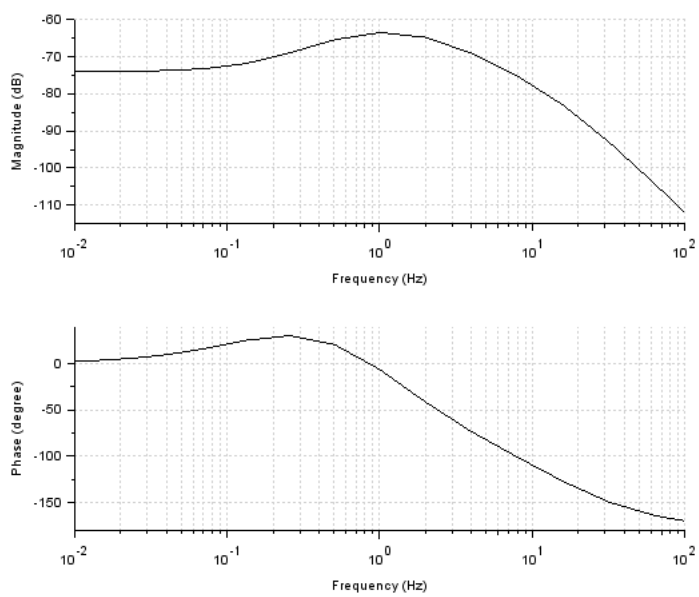

Figure 8: Bode Plot of the Transfer Function

Code

```
s = poly(0,'s');
G = (s+1)/((s+5)*(s+10)*(s+100));
G = syslin('c',G);

bode(G, 0.01, 100);
```