EE324 Problem Sheet 6

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Contents

1 Question 1

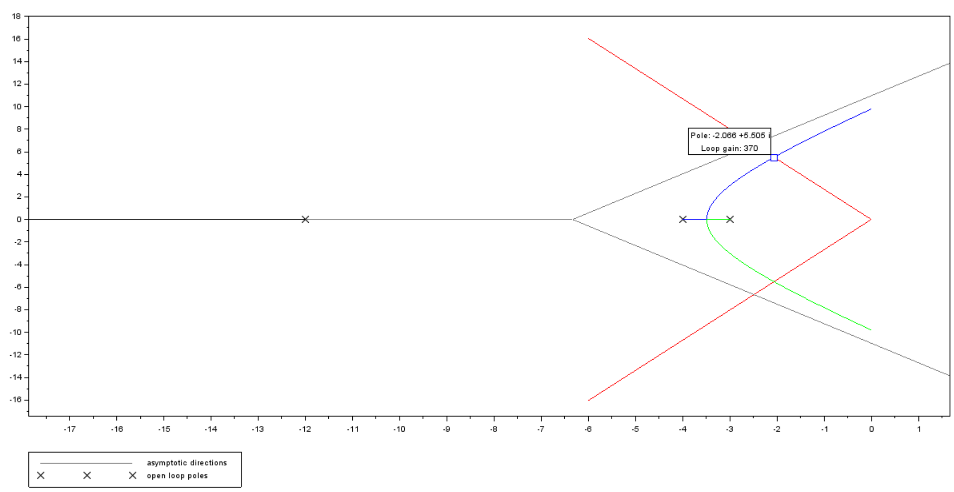
1.1 Part a

$$\frac{E}{R} = 1 - \frac{KG}{1+KG} = \frac{1}{1+KG} = \frac{(s+3)(s+4)(s+12)}{(s+3)(s+4)(s+12)+K}$$
$$e(\infty) = \lim_{s\to 0} s.\frac{1}{s}.E(s) = \frac{144}{144+K}$$

Using this, for steady state error to be 0.489, we get the value as: $\boxed{K = 150.478}$

1.2 Part b

The value of K is obtained by intersection of $\zeta = .35$ lines with root locus. This value found directly from graph comes roughly as 370



1.2.1 Part c

Gain value at breakaway point is roughly 2.127

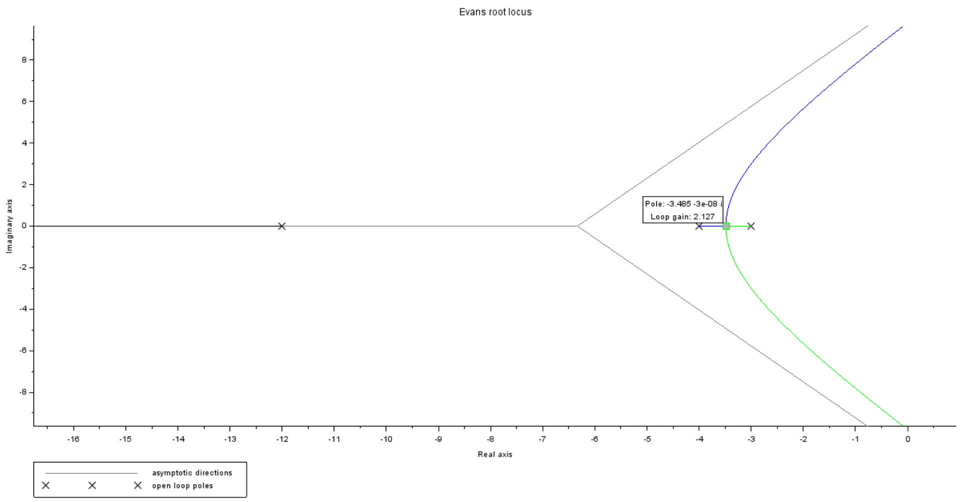


Figure 1: Root locus

1.3 Part d

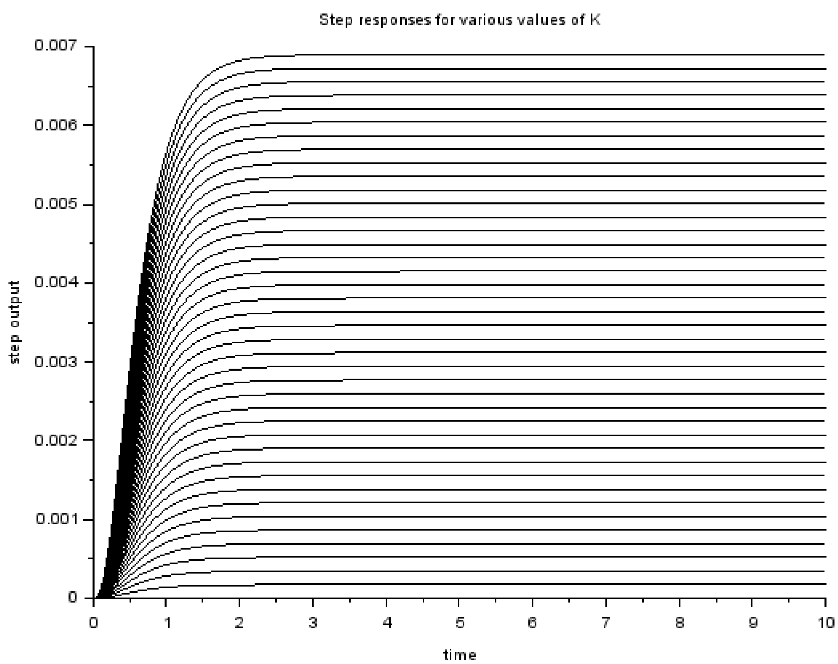


Figure 2: Step responses for various k < 1

In this range, the steady state errors decrease as k increases. Also in this range all roots in root locus are still real.

1.3.1 Part e

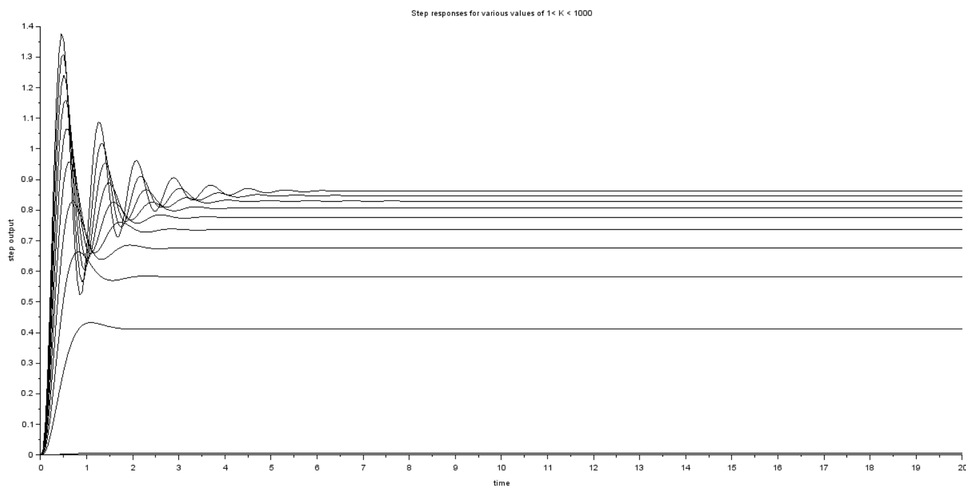


Figure 3: Step responses for various k < 1000

As we can see, for this range of k, settling time increases as k increases. The closed loop systems still remain stable as none of closed loop poles lie in ORHP. There are oscillations since two dominant poles are complex. The steady state errors decrease as k increases.

2 Code

```
s = poly(0,'s')

G = 1/((s+4)*(s+3)*(s+12));

// part a
err = .489
K = ((1-err)*3*4*12)/err;

// part b
scf(0);
G = syslin('c',G);
zeta = .35
m = sqrt(1-zeta^2)/zeta;
x = -6:.01:0;
os_line_1 = m.*x;
```

```
os_line_2 = -1*m.*x;
plot(x,os_line_1,'r');
plot(x,os_line_2,'r');
evans(G,kpure(G));

// part c
scf(1);
evans(G,kpure(G));

// part d
scf(2);
k_range = 0:.025:1;
t = 0:.05:10;
G = 1/((s+4)*(s+3)*(s+12));
for k = k_range
    G_eq = k*G/(1+k*G);
    G_eq = syslin('c',G_eq);
    plot2d(t, csim('step',t,G_eq));
end
xlabel('time');
ylabel('step output');
title('Step responses for various values of K');

// part e
scf(3);
k_range = 1:100:1000;
t = 0:.05:20;
G = 1/((s+4)*(s+3)*(s+12));
for k = k_range
    G_eq = k*G/(1+k*G);
    G_eq = syslin('c',G_eq);
    plot2d(t, csim('step',t,G_eq));
end
xlabel('time');
ylabel('step output');
title('Step responses for various values of 1< K < 1000');
```