

Clearing Workspace

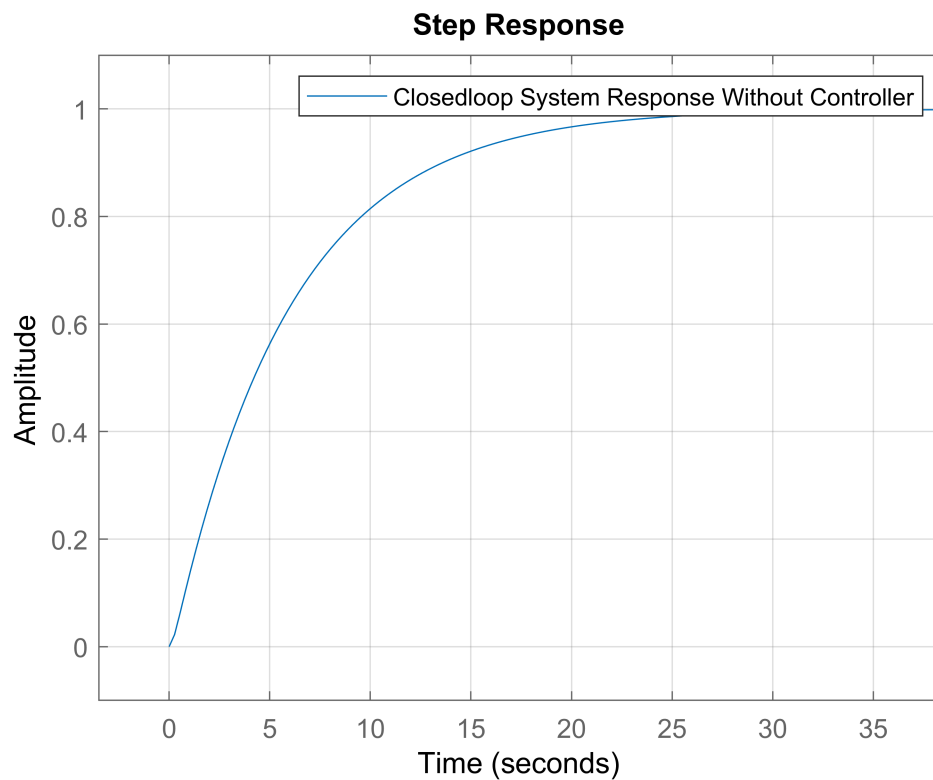
```
close all;  
clear;  
clc;
```

System without a controller

```
s=tf('s');  
G=1/(s*(s+6));
```

Gcl = Closedloop Transfer Function

```
Gcl = G/(1+G); % system without controller  
step(Gcl); % plotting step response  
grid on;  
setAxisLimits(axis);  
legend('Closedloop System Response Without Controller');
```



Poles for the system without controller

```
disp(pole(Gcl));
```

```
0  
-6.0000  
-5.8284  
-0.1716
```

Time domain parameters of system

```
stepinfo(Gcl)
```

```
ans = struct with fields:
    RiseTime: 12.8096
    SettlingTime: 22.9766
    SettlingMin: 0.9016
    SettlingMax: 0.9993
    Overshoot: 0
    Undershoot: 0
    Peak: 0.9993
    PeakTime: 42.6770
```

Designing a Phase Lead Controller

$\zeta = 0.4$

$\omega_n = 15$

```
zita = 0.4;
wn = 15;
desiredPoles = roots([1 2*zita*wn wn^2]);
```

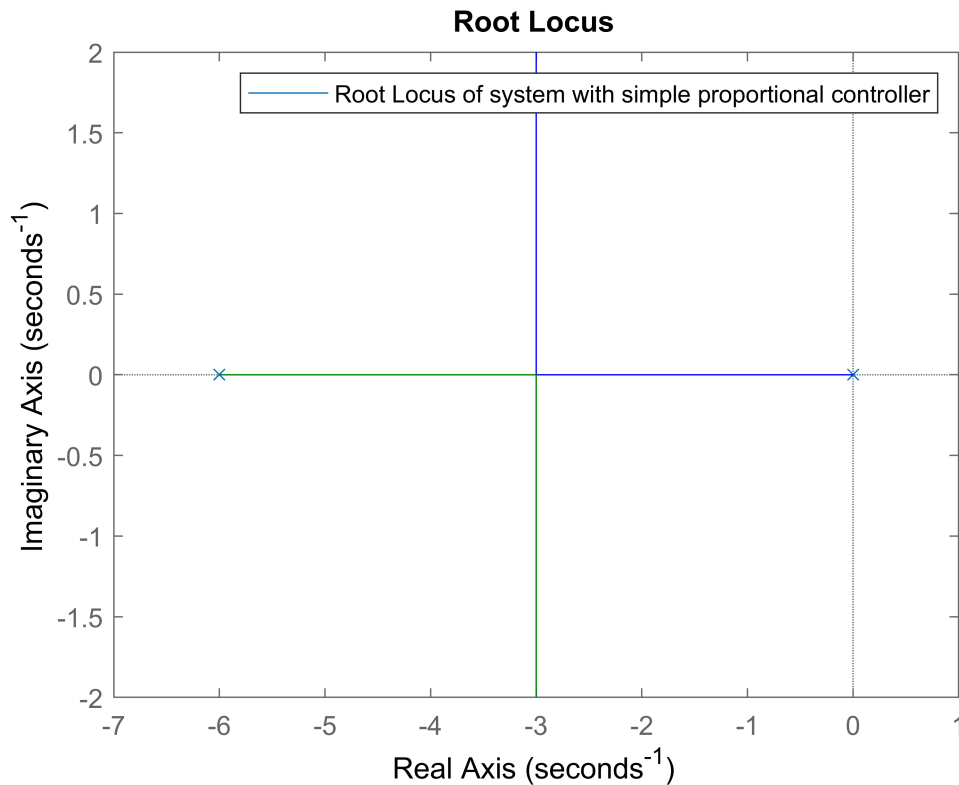
Root Locus must pass through desired poles.

```
disp(desiredPoles);
```

```
-6.0000 +13.7477i
-6.0000 -13.7477i
```

Root Locus of a system with a simple proportional controller

```
figure;
rlocus(G);
legend('Root Locus of system with simple proportional controller');
```



We can see that no matter what, the root locus doesn't pass through **desired poles**.

```
syms s1
G1=1/(s1*(s1+6));
phi=double(angle(subs(G1,s1,-6+13.74i)))*180/pi;
sphi=180-phi;
```

The zero of the controller is usually taken just below the desired poles, but as in this system, a pole already exists at $S = -6$.

∴ We take the zero of the controller slightly towards left of -6. i.e $S = -7$ or $Z = 7$.

```
z=-7;
p=z-13.7477/tand(90-sphi);
disp(p);
```

-13.0034

And thus we the pole of the controller as **-13** or **P = 13**.

Then we find out **k** using magnitude criteria.

```
Ds=(s1-z)/(s1-p);
k=1/(double(abs(subs(Ds*G1,-6+13.7477i))))
```

k = 230.8210

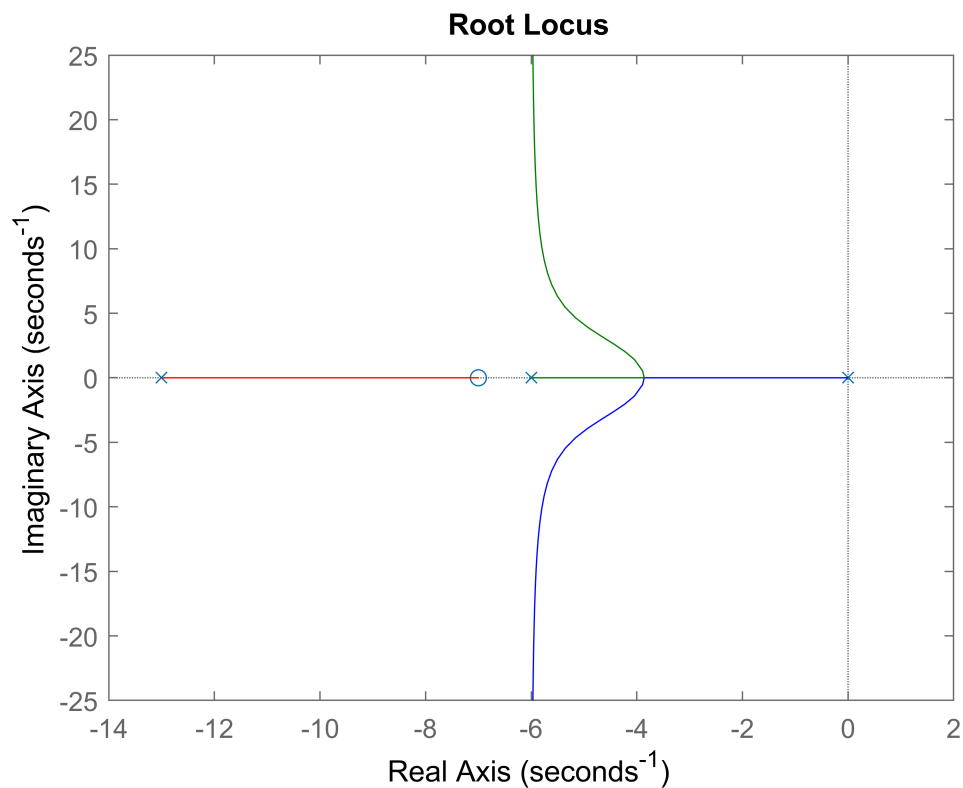
Thus at $k = 230.5863$, the RL passes through the desired pole location.

Verification of design

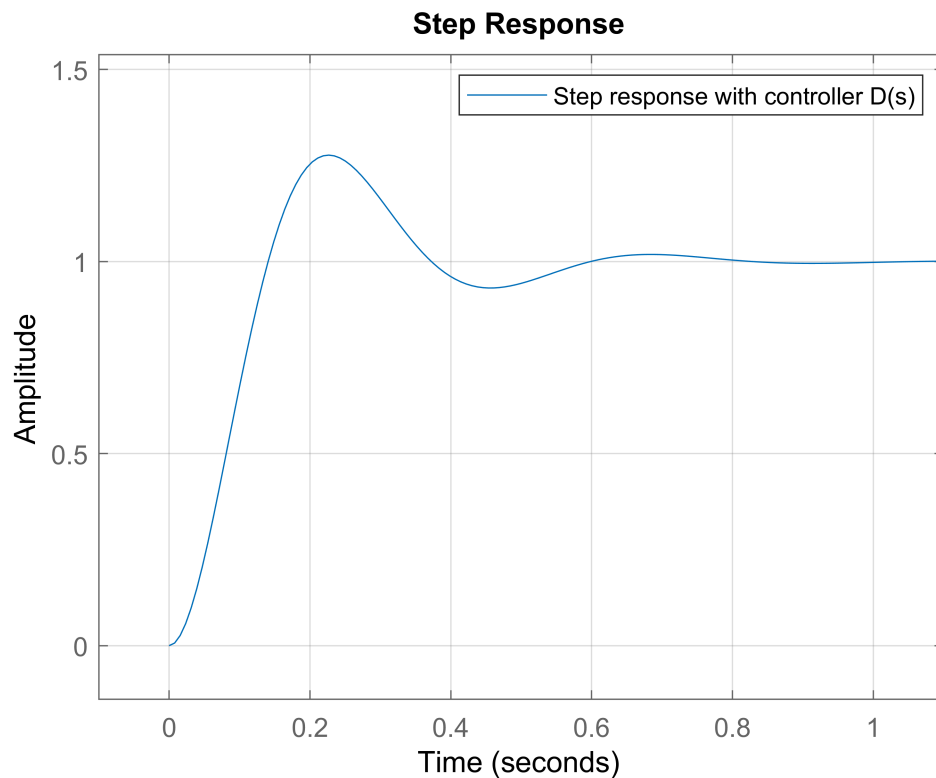
Ds = Controller Transfer Function

Ls = Closedloop Transfer Function with Controller

```
Ds = (s-z)/(s-p);  
Ls = k*Ds*G/(1+k*Ds*G);  
figure;  
rlocus(Ds*G);
```



```
figure;  
step(Ls);  
grid on;  
setAxisLimits(axis);  
legend('Step response with controller D(s)');
```



Time Domain parameters of system with controller.

```
stepinfo(Ls)
```

```
ans = struct with fields:
    RiseTime: 0.0952
    SettlingTime: 0.5612
    SettlingMin: 0.9312
    SettlingMax: 1.2771
    Overshoot: 27.7119
    Undershoot: 0
    Peak: 1.2771
    PeakTime: 0.2267
```

```
[gainMargin, phaseMargin, wcg, wcp] = margin(Ls)
```

```
Warning: The closed-loop system is unstable.
gainMargin = Inf
phaseMargin = 66.5761
wcp = Inf
wcp = 17.8151
```

Since the Gain Margin is infinity, and the Phase Margin is 66.5761, the system is unstable.

i.e. the magnitude of Nyquist Plot at crossover frequency is **0**.