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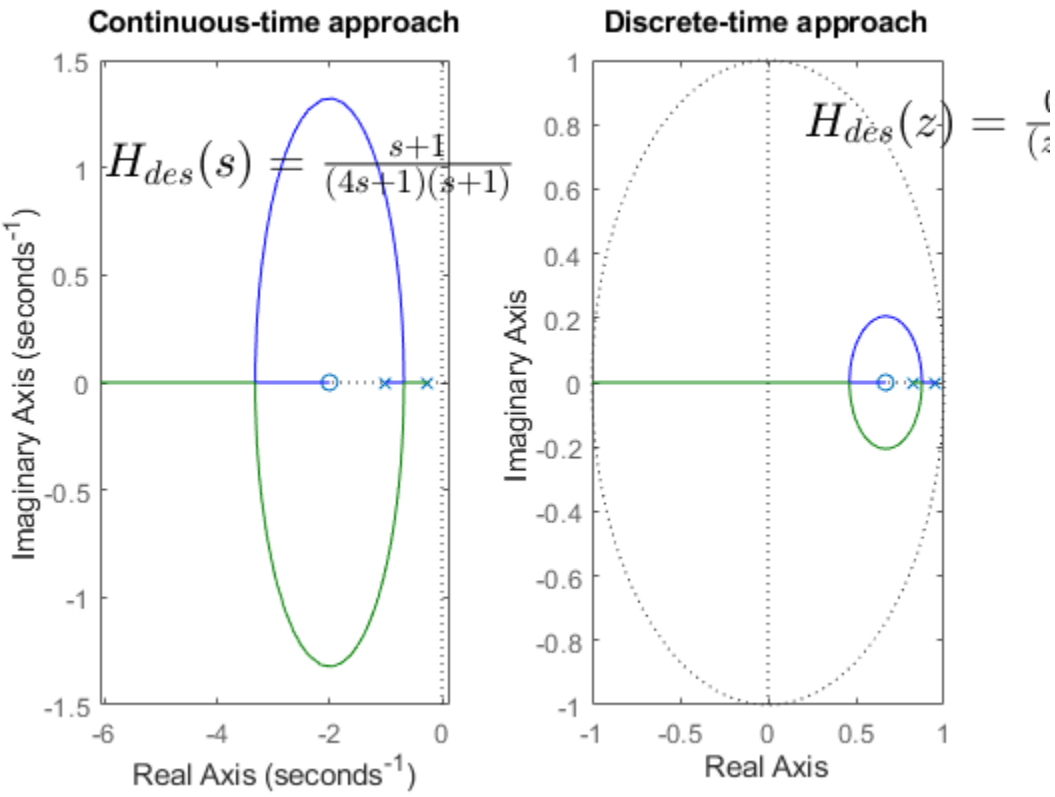
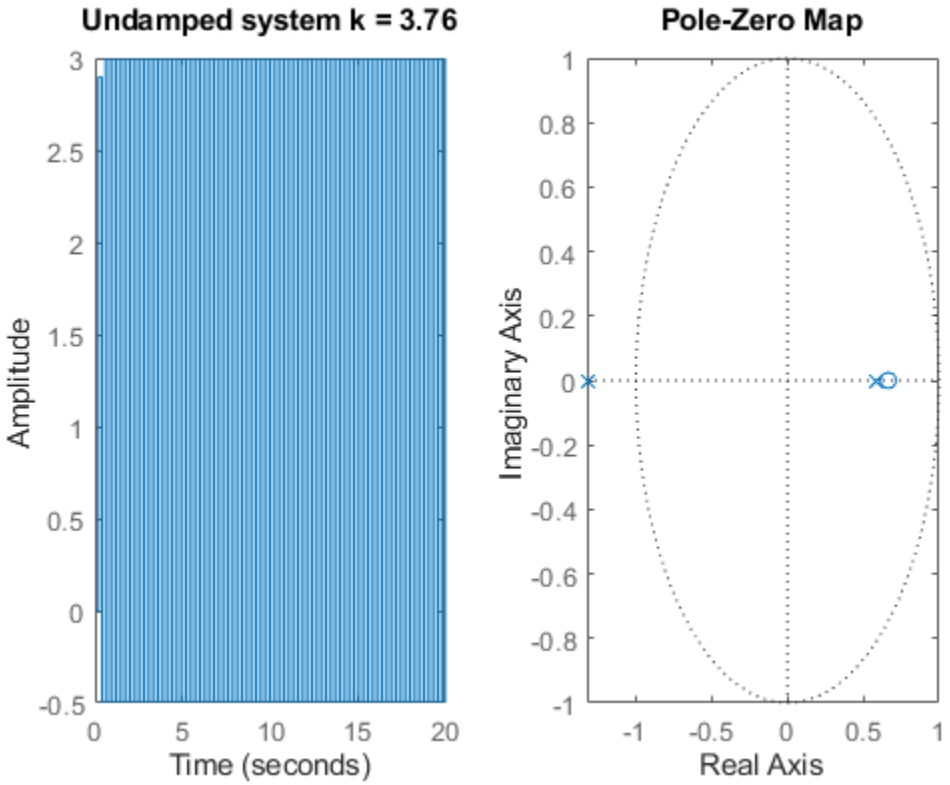
```
%%Laboratory 11
%%Stability analysis of discrete time control structures

clc
clear all

num = [1 2];
den = [4 5 1];
Hp = tf(num,den); %the process transfer function with new pole
T = 0.2;
Hdes = c2d(Hp,T,'zoh'); %the open loop discrete time transfer function


subplot(121);
rlocus(Hp);
title('Continuous-time approach');
text(-6,1,'$H_{des} (s)=\frac{s+1}{(4s+1)(s+1)}
$',"Interpreter","latex","FontSize",18);

subplot(122);
rlocus(Hdes);
title('Discrete-time approach');
text(0.2,0.8,'$H_{des} (z)=\frac{0.053375 (z - 0.6687)}{(z-0.9512)(z-0.8187)}
$',"Interpreter","latex","FontSize",18);


% (0, 0.39)
%(0.39, 15.8)
%(


%Observations from the rlocus
% For k = 3.76, zetta = 0, UNDAMPED, both poles on unity cirlce;
% For k in (3.76, 15.8) and zetta in (0,1), UNDERDAMPED, pair of
% complex conjugated poles
% For k in (25.7, 40.2) and zetta = 1, CRITICALLY DAMPED, real pole order 2
% For k = (0, 0.39) and zetta > 1, OVERDAMPED, two real poles, inside unity
% circle
```



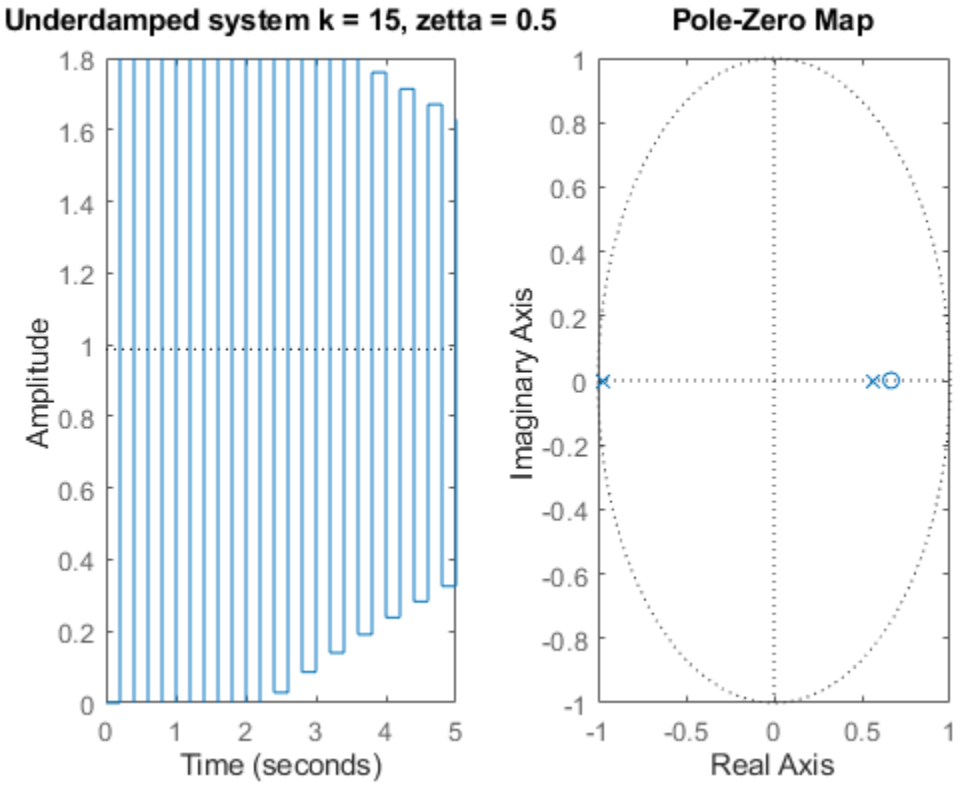
UNDAMPED CASE

```
k = 45;
num = [1 2];
den = [4 -3 1];
Hp = tf(num,den); %the process transfer function with new pole

Hdes = c2d(Hp,T,'zoh'); %the open loop discrete time transfer function
Hdes_2 = feedback(k*Hdes,1);

subplot(121);
step(Hdes_2);
axis([0 20 -0.5 3]);
title('Undamped system k = 3.76');

subplot(122);
pzmap(Hdes_2);
title('Pole-Zero Map');
```



UNDERDAMPED CASE

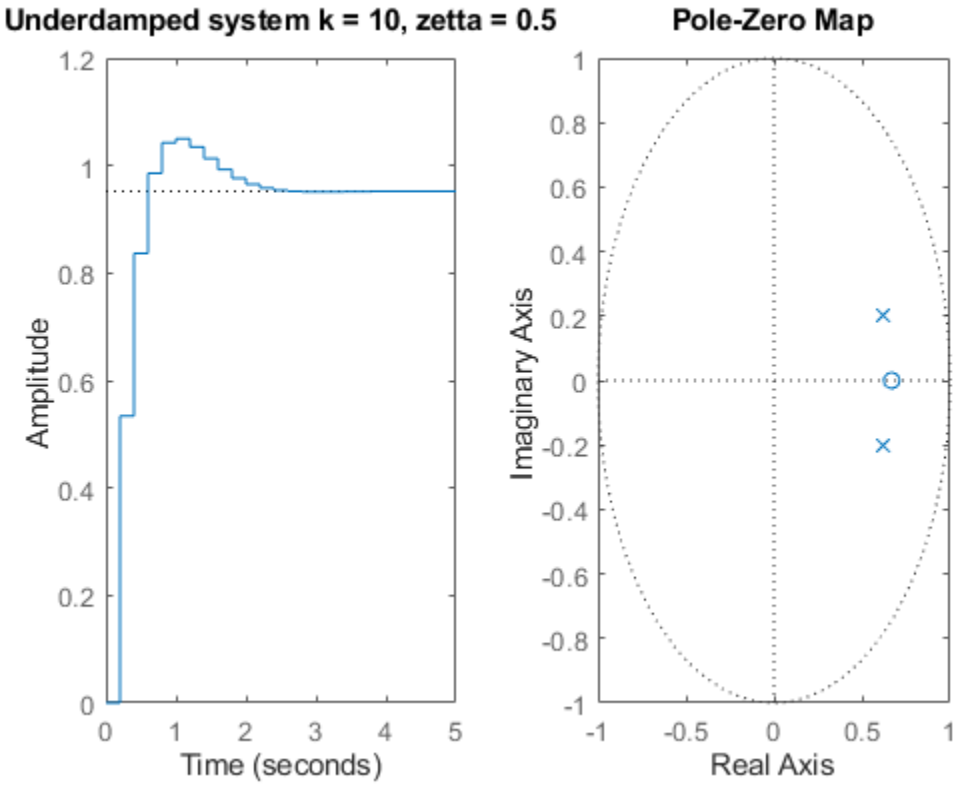
```
%In k 39.8 aproximately 40
k = 39.8;
num = [1 2];
den = [4 -3 1];
Hp = tf(num,den); %the process transfer function with new pole

Hdes = c2d(Hp,T,'zoh'); %the open loop discrete time transfer function
Hdes_2 = feedback(k*Hdes,1);

subplot(121);
step(Hdes_2);
axis([0 5 0 1.8]);
title('Underdamped system k = 15, zetta = 0.5');

subplot(122);
pzmap(Hdes_2);
title('Pole-Zero Map');
```



UNDERDAMPED CASE

k in (0.39, 15.8)

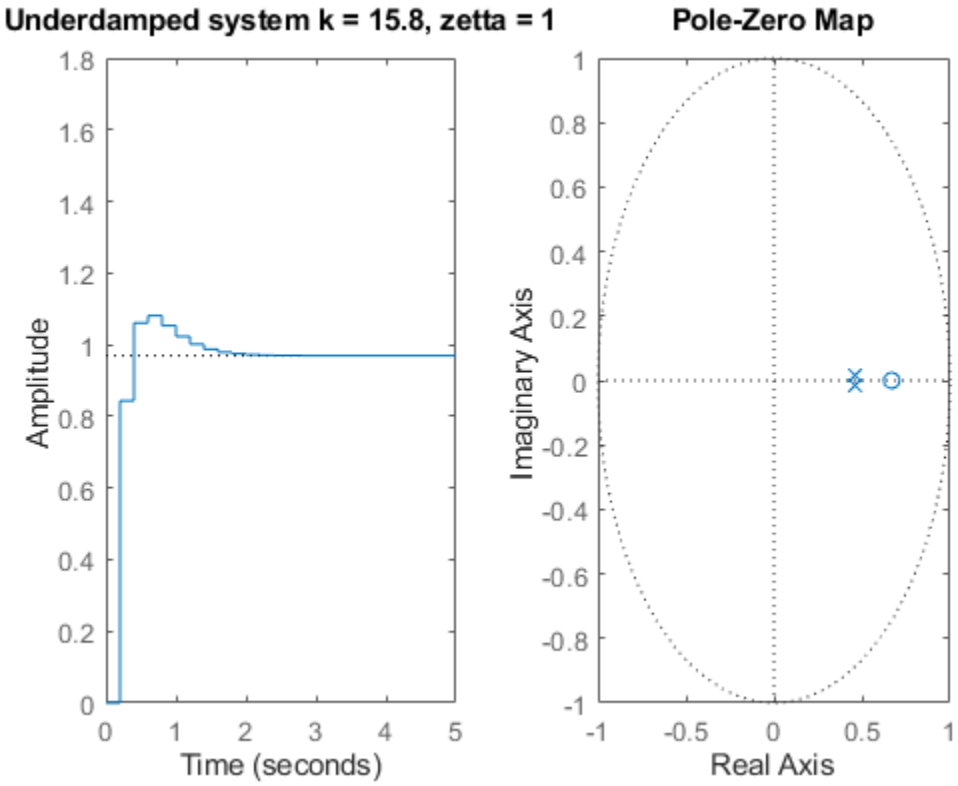
```
k = 10;
num = [1 2];
den = [4 5 1];
Hp = tf(num,den); %the process transfer function with new pole

Hdes = c2d(Hp,T,'zoh'); %the open loop discrete time transfer function
Hdes_2 = feedback(k*Hdes,1);

subplot(121);
step(Hdes_2);
%axis([0 5 0 1.8]);
title('Underdamped system k = 10, zetta = 0.5');

subplot(122);
pzmap(Hdes_2);
title('Pole-Zero Map');
```



CRITICALLY DAMPED CASE

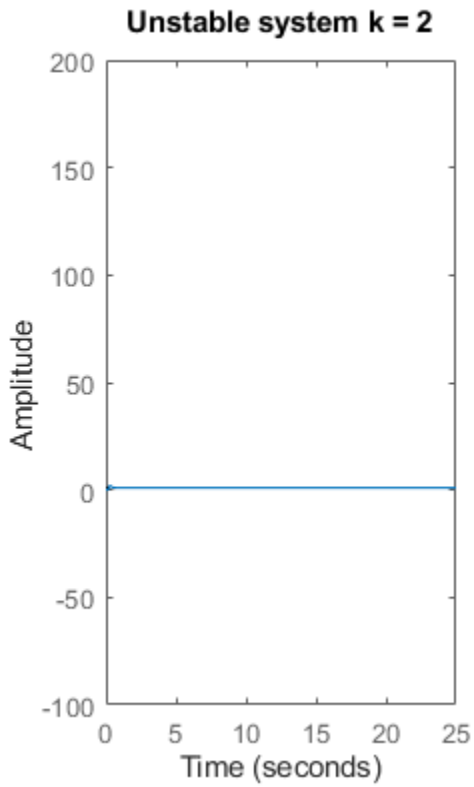
for k exactly at 15.8

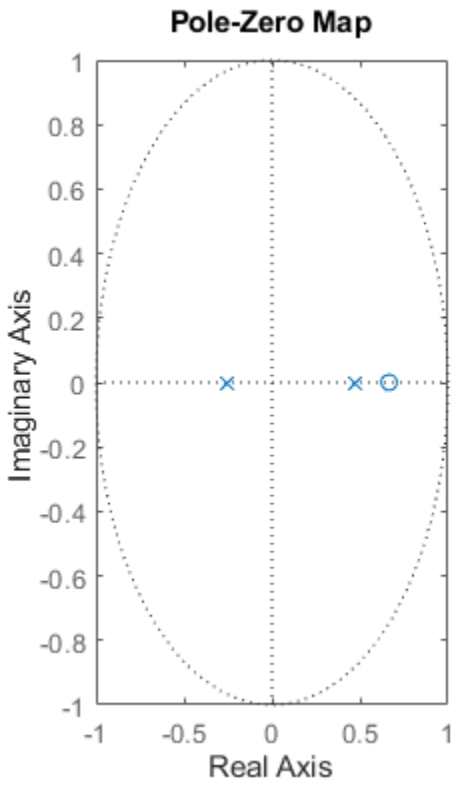
```
k = 15.8;
num = [1 2];
den = [4 5 1];
Hp = tf(num,den); %the process transfer function with new pole

Hdes = c2d(Hp,T,'zoh'); %the open loop discrete time transfer function
Hdes_2 = feedback(k*Hdes,1);

subplot(121);
step(Hdes_2);
axis([0 5 0 1.8]);
title('Underdamped system k = 15.8, zetta = 1');

subplot(122);
pzmap(Hdes_2);
title('Pole-Zero Map');
```



OVERDAMPED

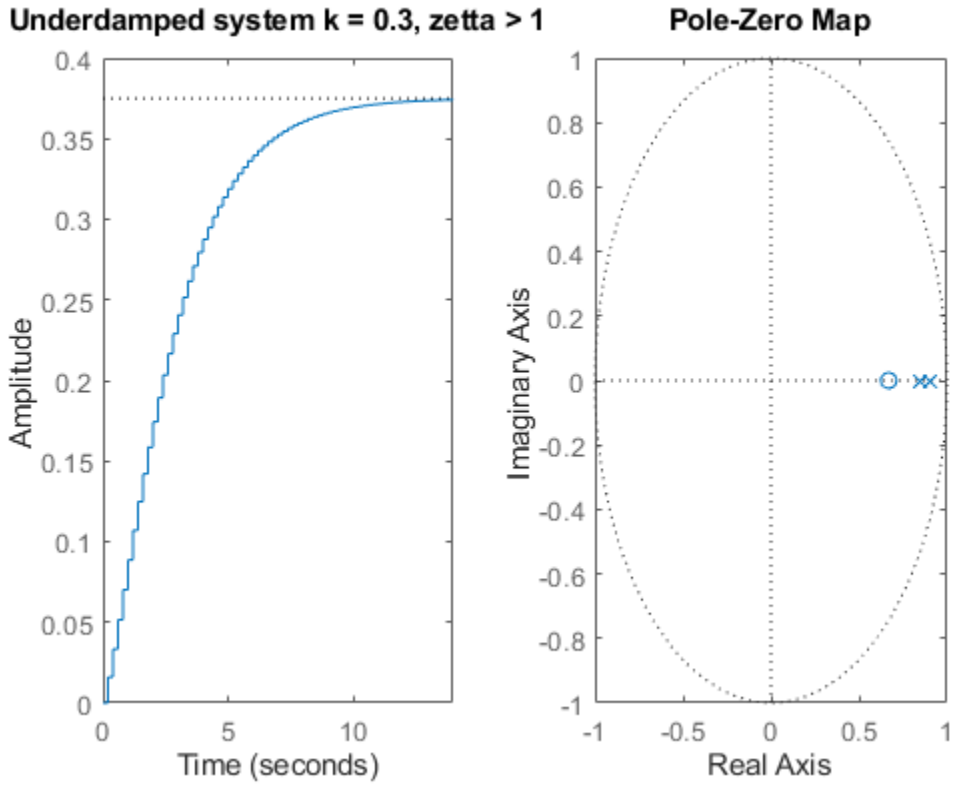
```
%for k in (15.8,40)
k = 30;
num = [1 2];
den = [4 -3 1];
Hp = tf(num,den); %the process transfer function with new pole

Hdes = c2d(Hp,T,'zoh'); %the open loop discrete time transfer function
Hdes_2 = feedback(k*Hdes,1);

subplot(121);
step(Hdes_2);
axis([0 25 -100 200]);
title('Unstable system k = 2');

subplot(122);
pzmap(Hdes_2);
title('Pole-Zero Map');
```





OVERDAMPED CASE

```
%For k from (0, 0.39)
k = 0.3;
num = [1 2];
den = [4 5 1];
Hp = tf(num,den); %the process transfer function with new pole

Hdes = c2d(Hp,T,'zoh'); %the open loop discrete time transfer function
Hdes_2 = feedback(k*Hdes,1);

subplot(121);
step(Hdes_2);
%axis([0 5 0 1.8]);
title('Underdamped system k = 0.3, zetta > 1');

subplot(122);
pzmap(Hdes_2);
title('Pole-Zero Map');
```



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