Introduction to Root locus

EML 4312

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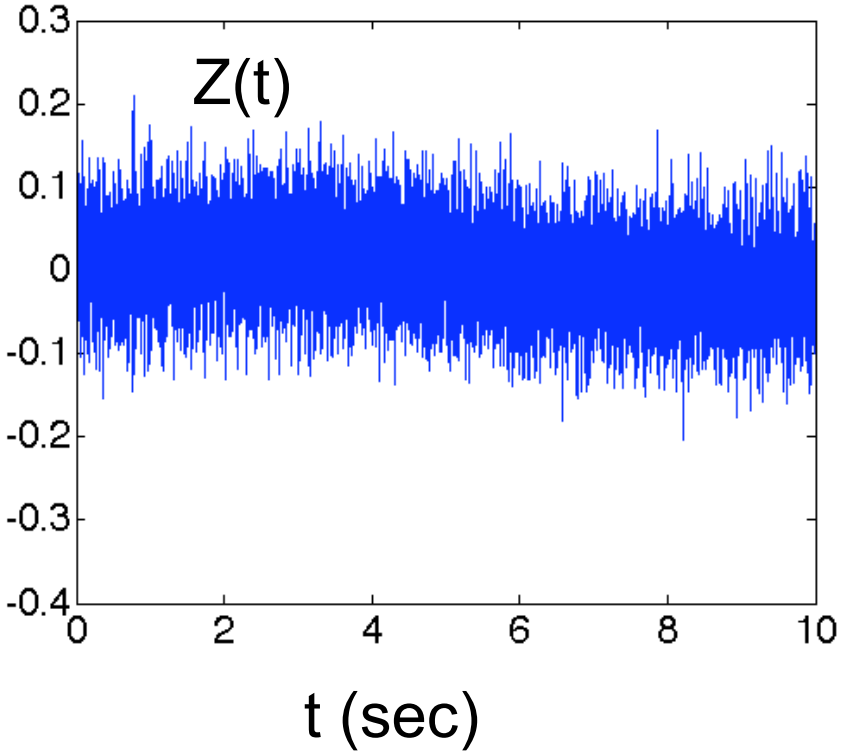
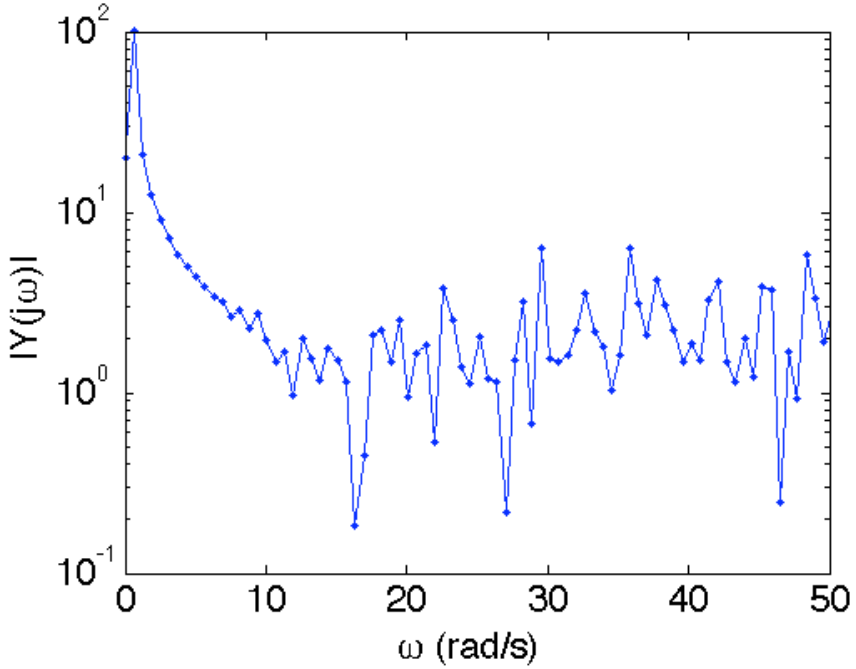
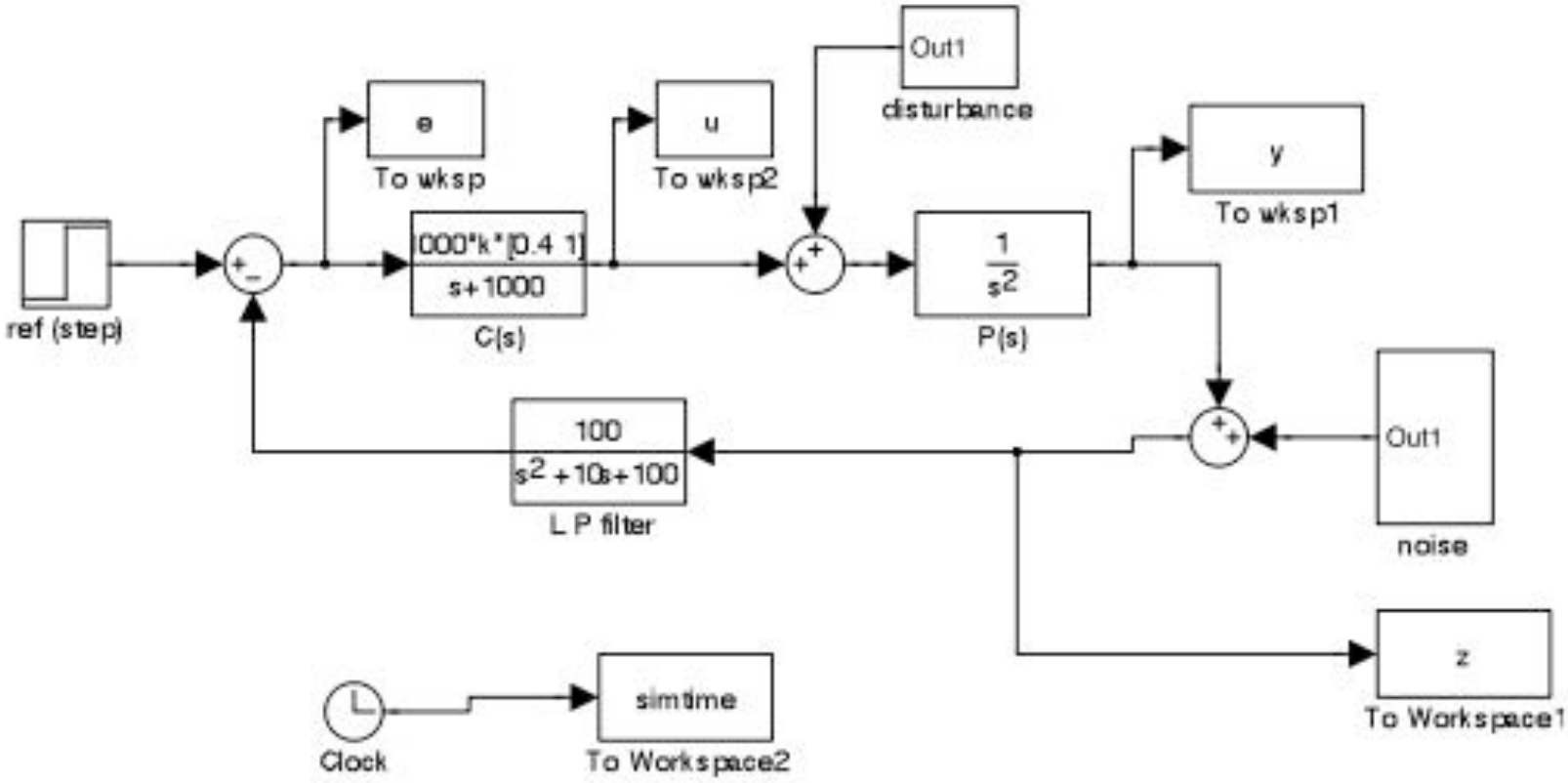
Satellite attitude control

Position sensor readings when satellite is executing a maneuver at 0.2 rad/s





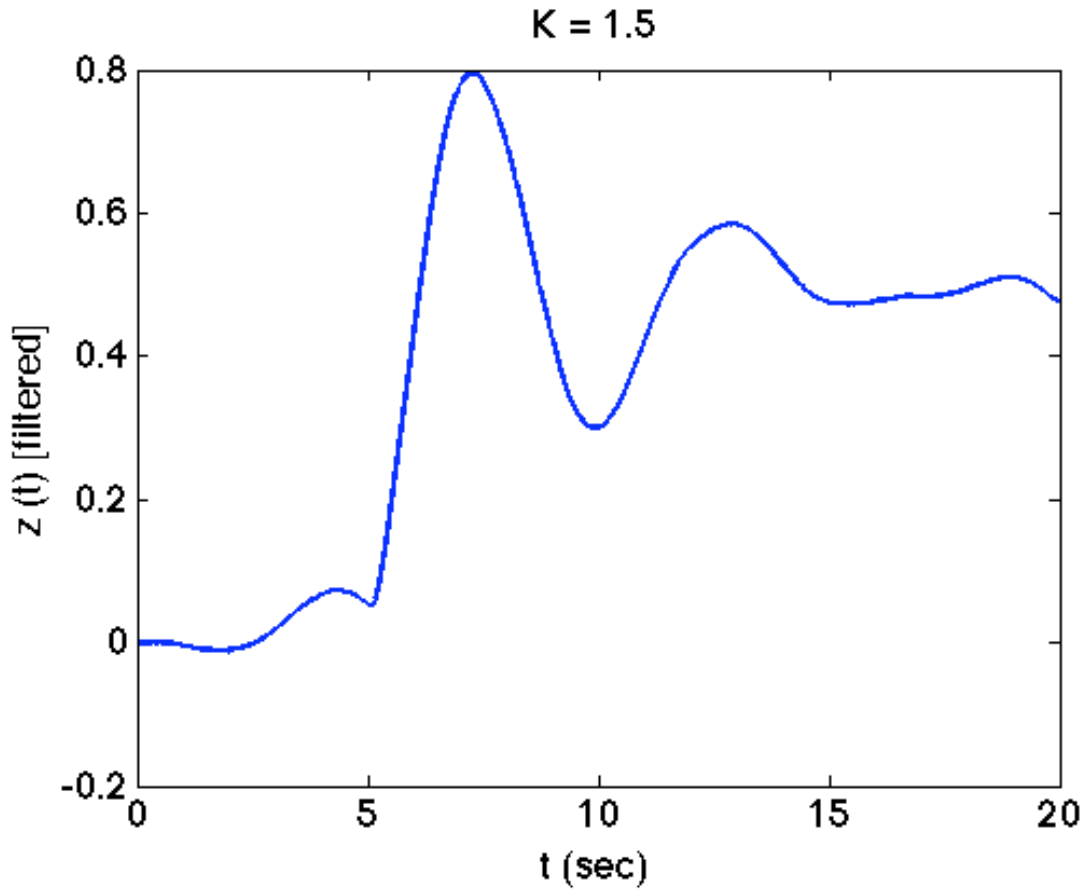
Satellite attitude control - design A



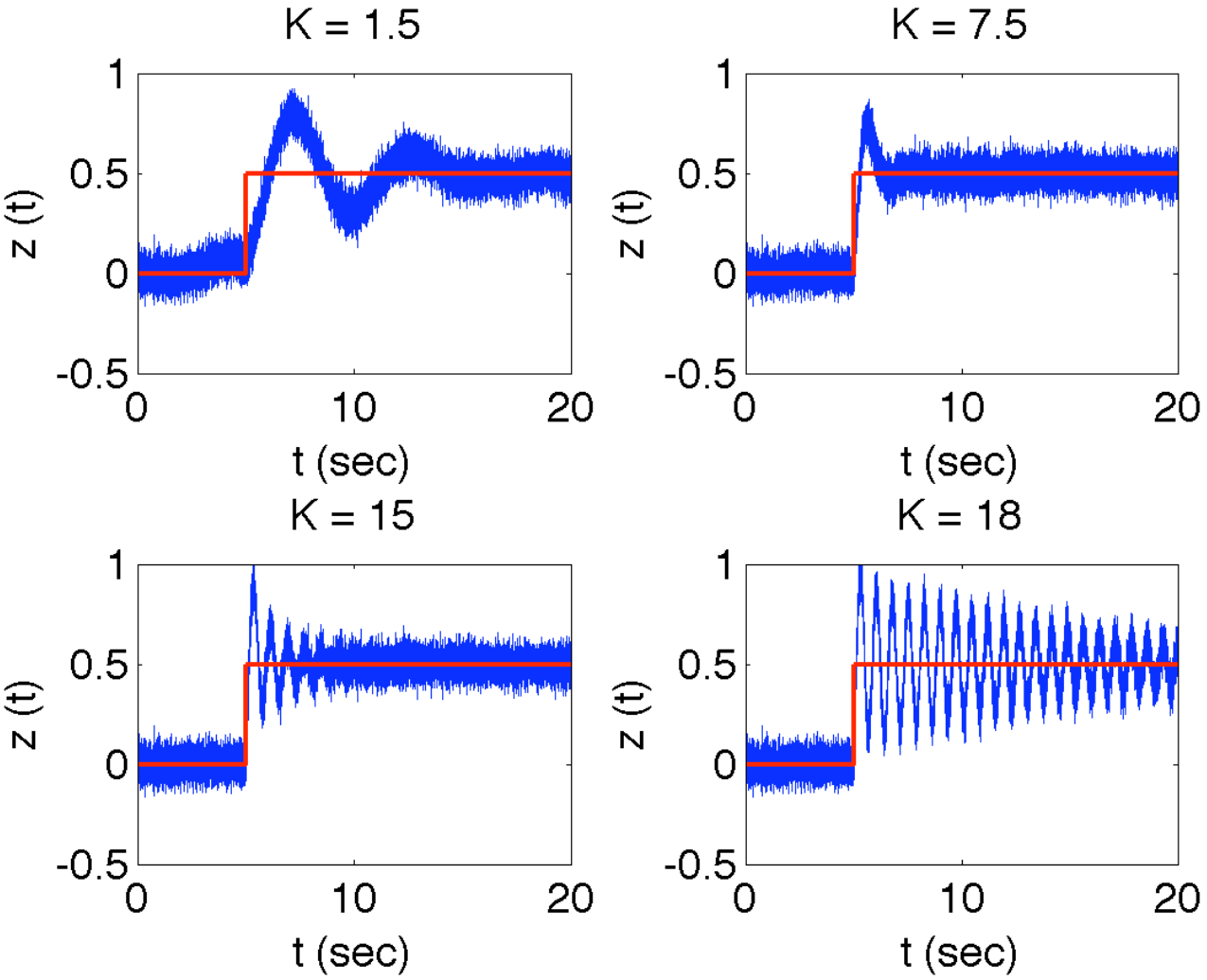
Simulink model (available in course website)

½ step input at t = 5 sec

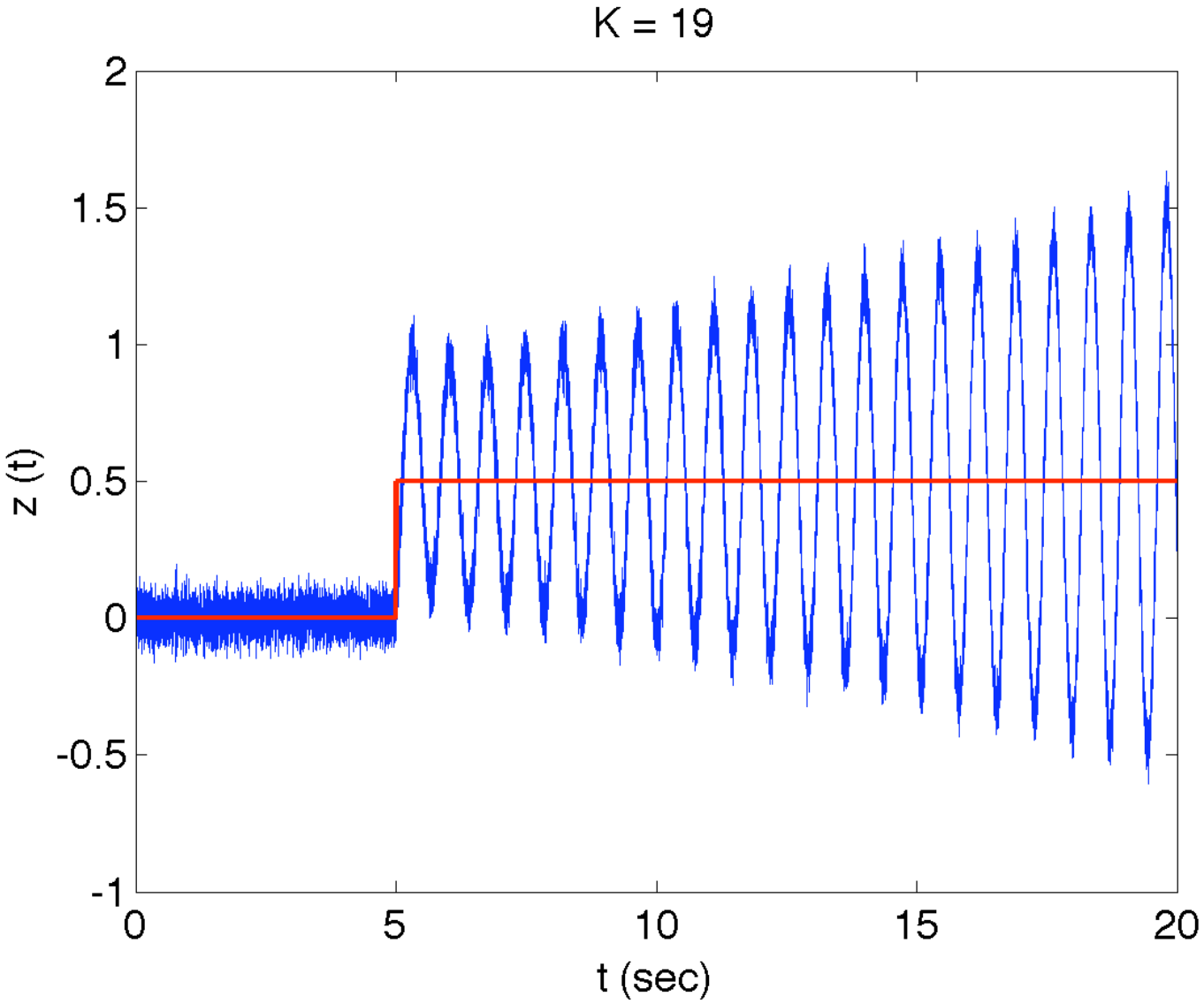
Filtered measurement of the response



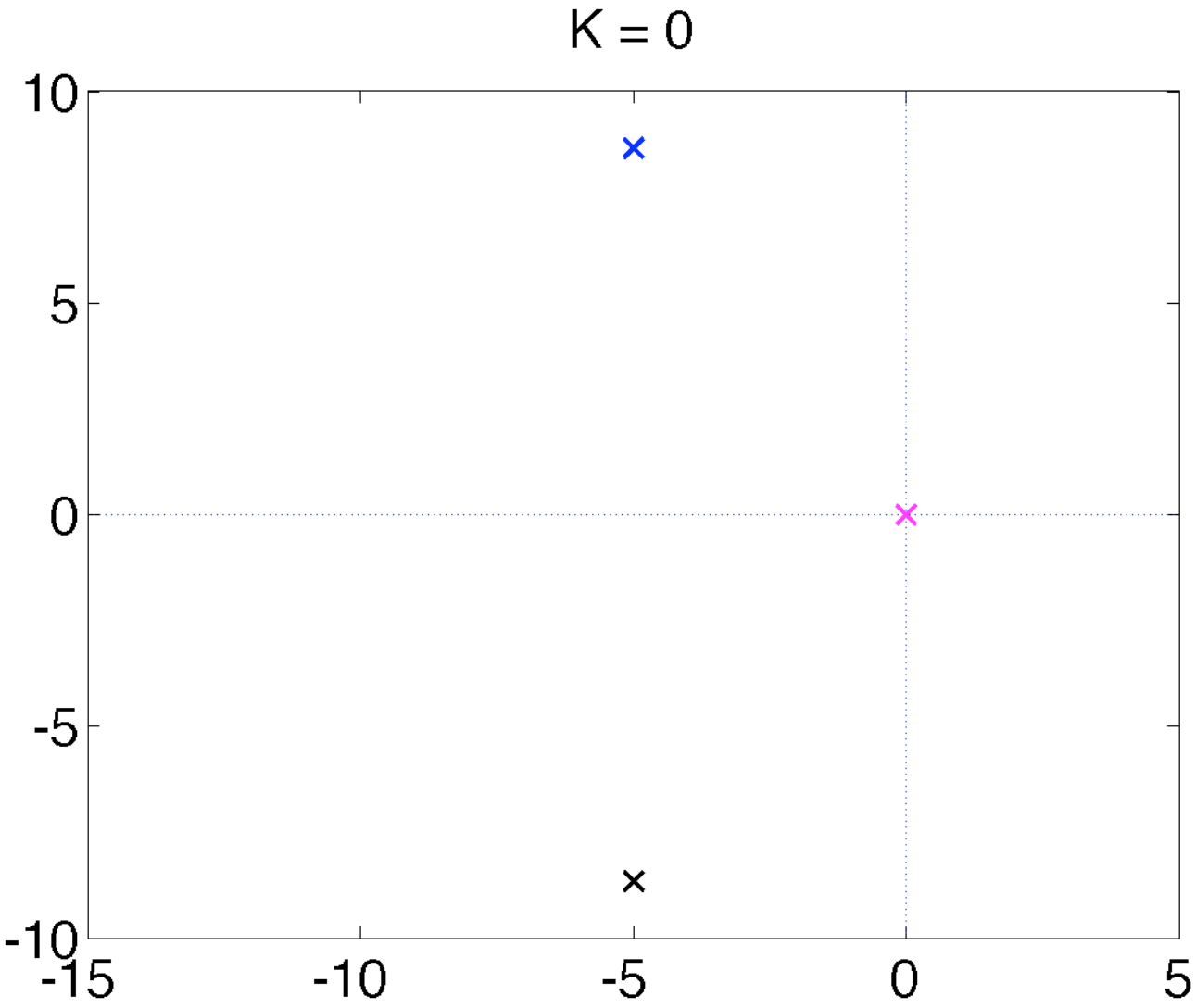
Response to 1/2 step input

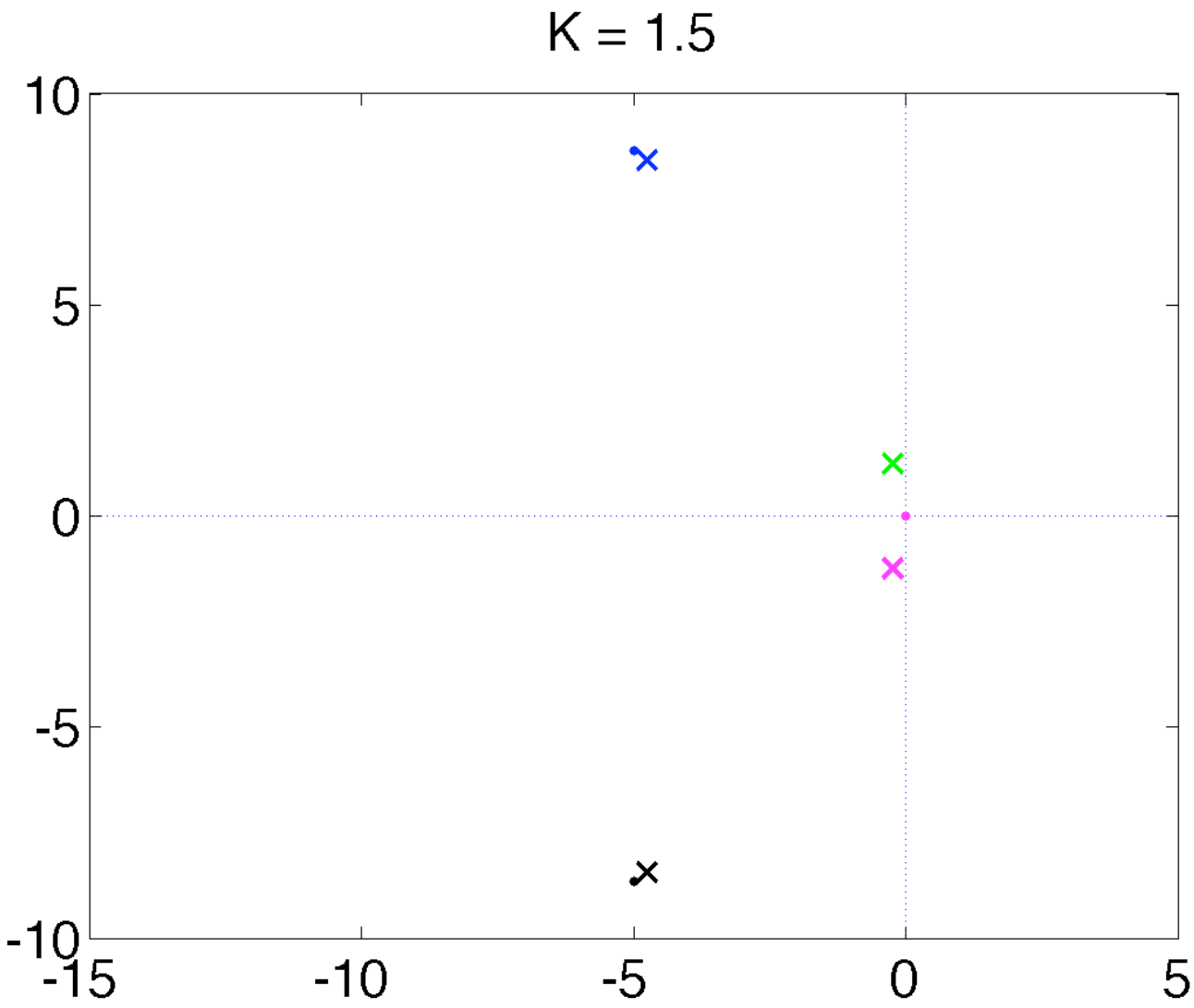


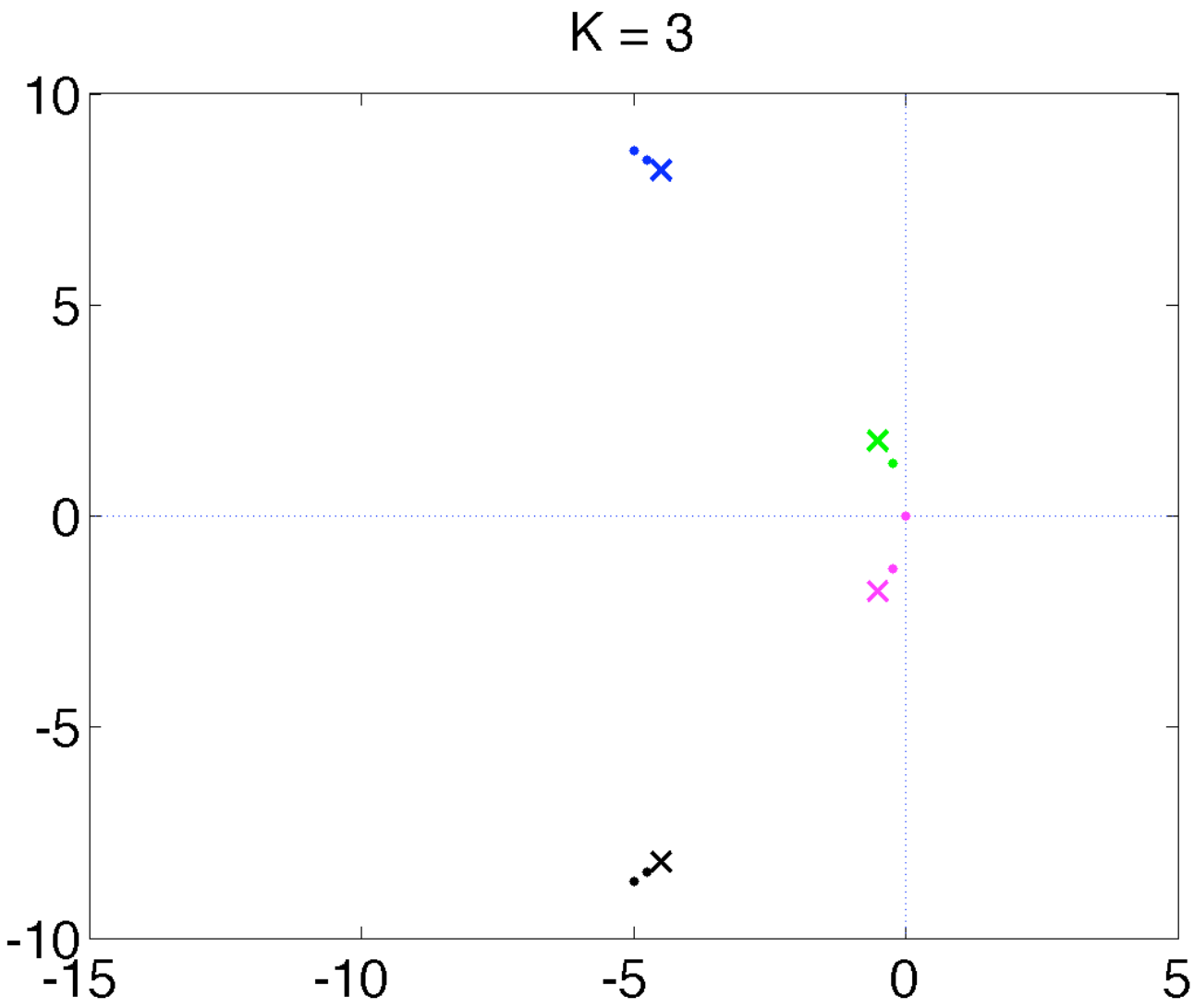
Closed loop performance (reference tracking) seems to ‘improve’ as k increases, until ….

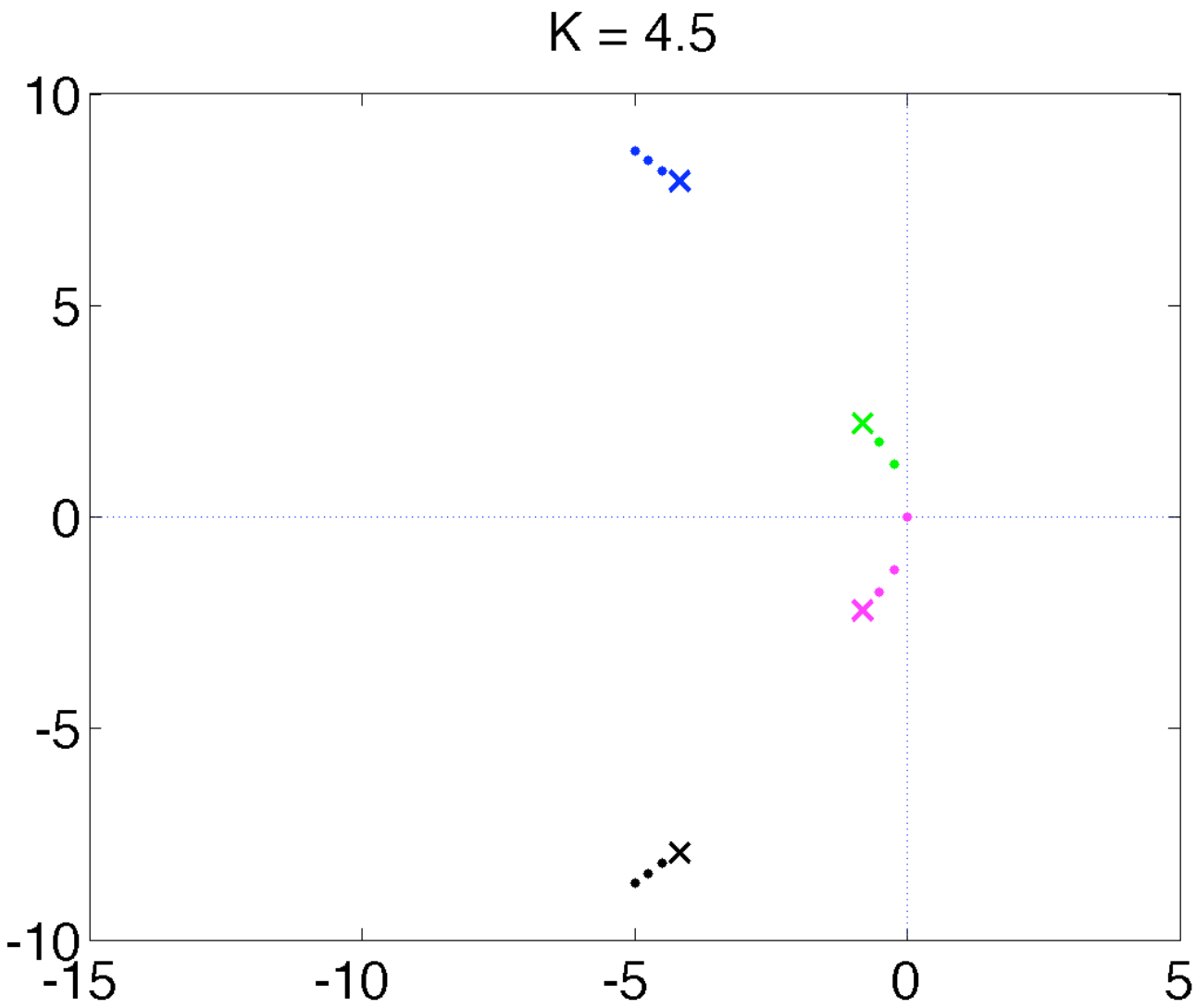

K = 19
2
1.5
1
0.5
0
-0.5
-1
z (t)
0
5
10
15
20
t (sec)

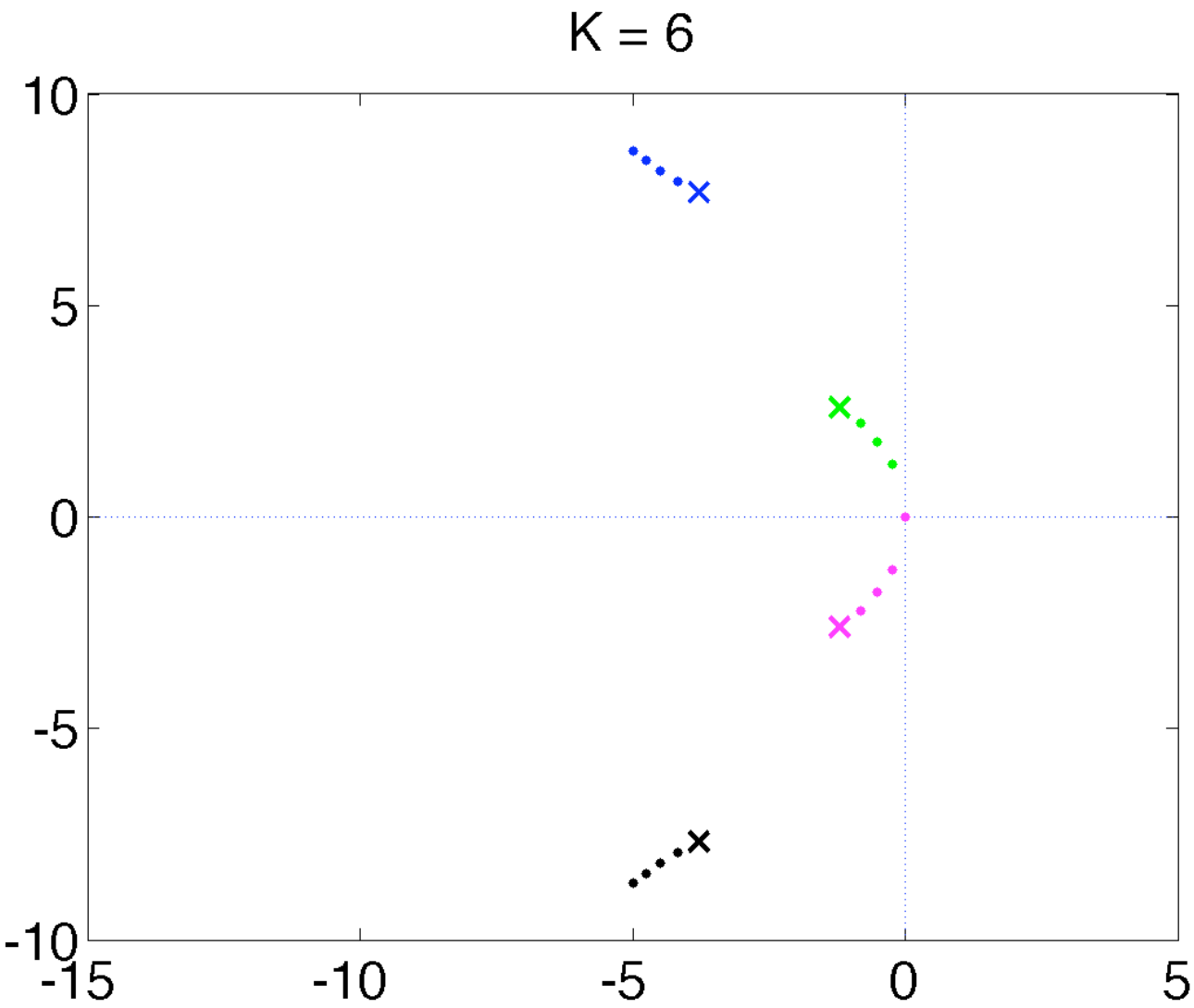
Closed loop poles as a function of K

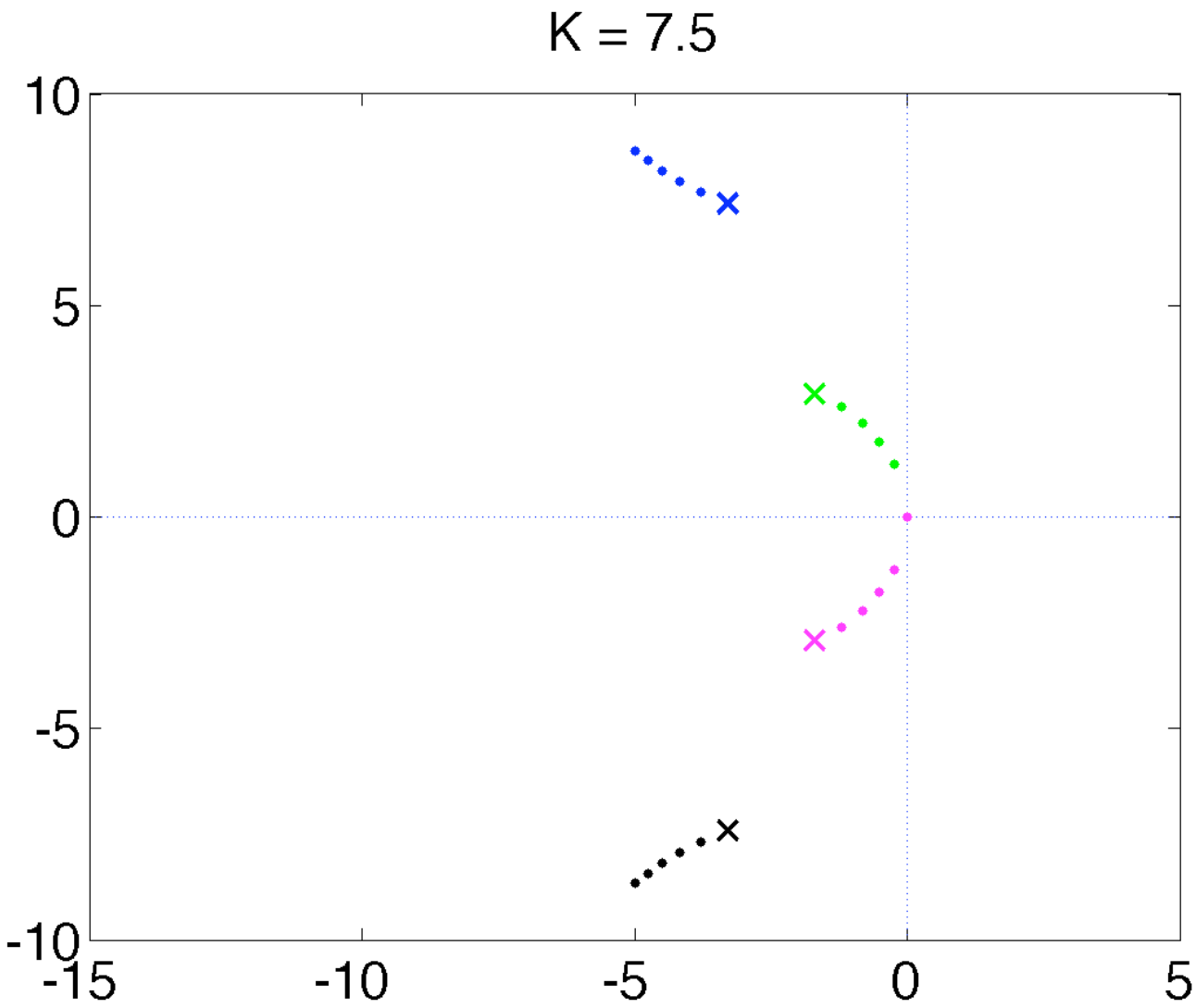

K = 0
10
5
0
-5
-10
-15
-10
-5
0
5

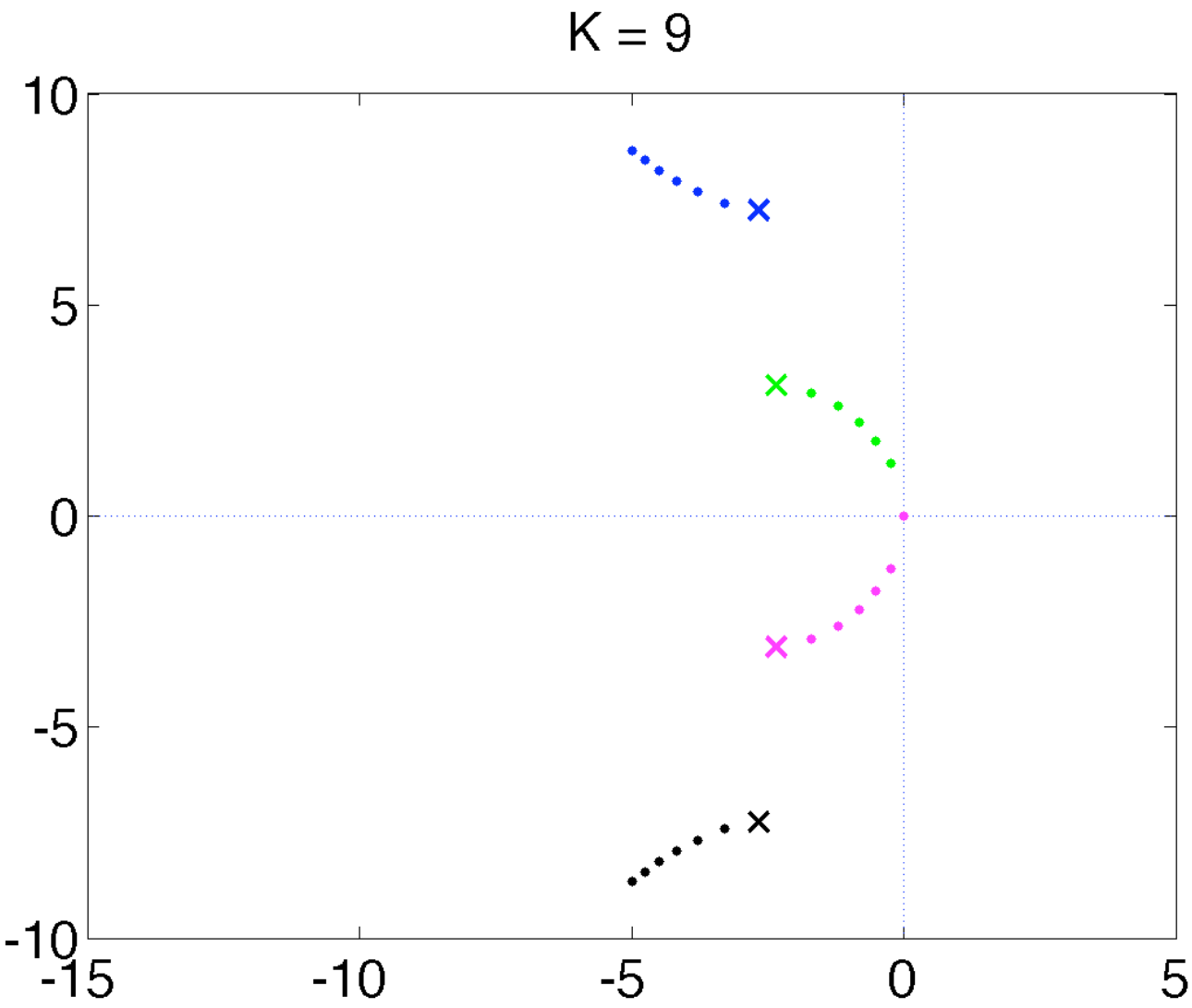

K = 1.5
10
5
0
-5
-10
-15
-10
-5
0
5

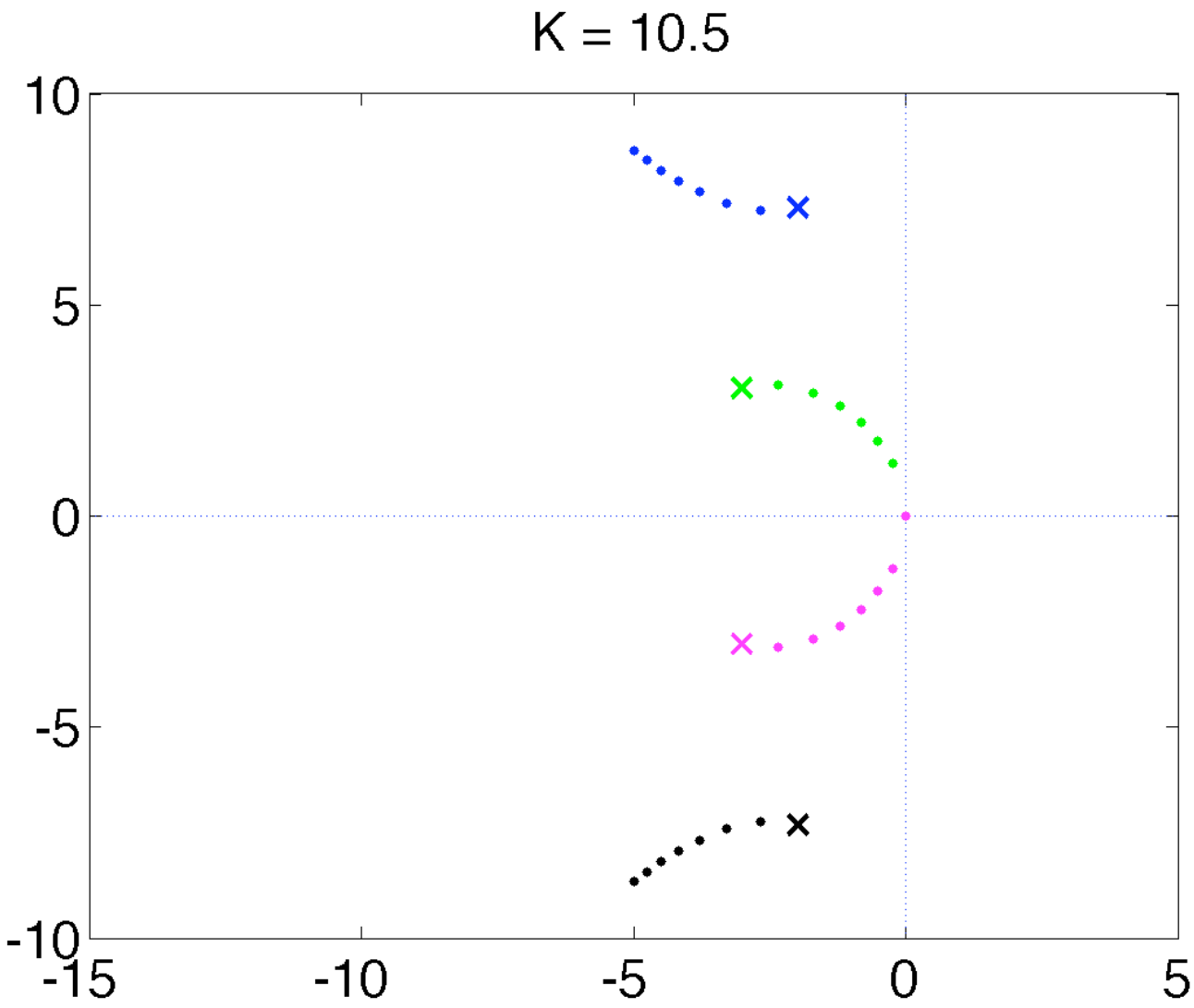

K = 3
10
5
0
-5
-10
-15
-10
-5
0
5

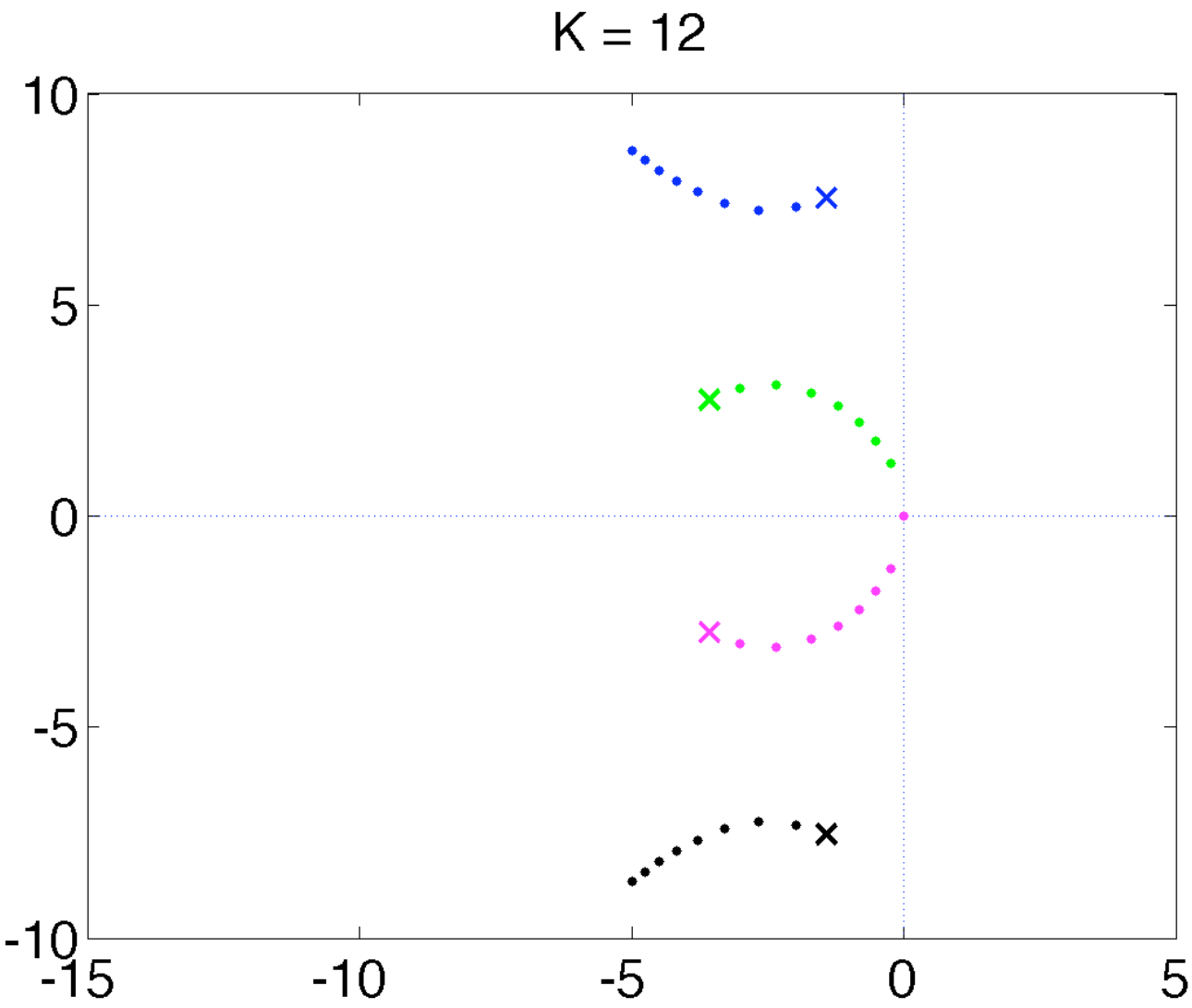

K = 4.5
10
5
0
-5
-10
-15
-10
-5
0
5

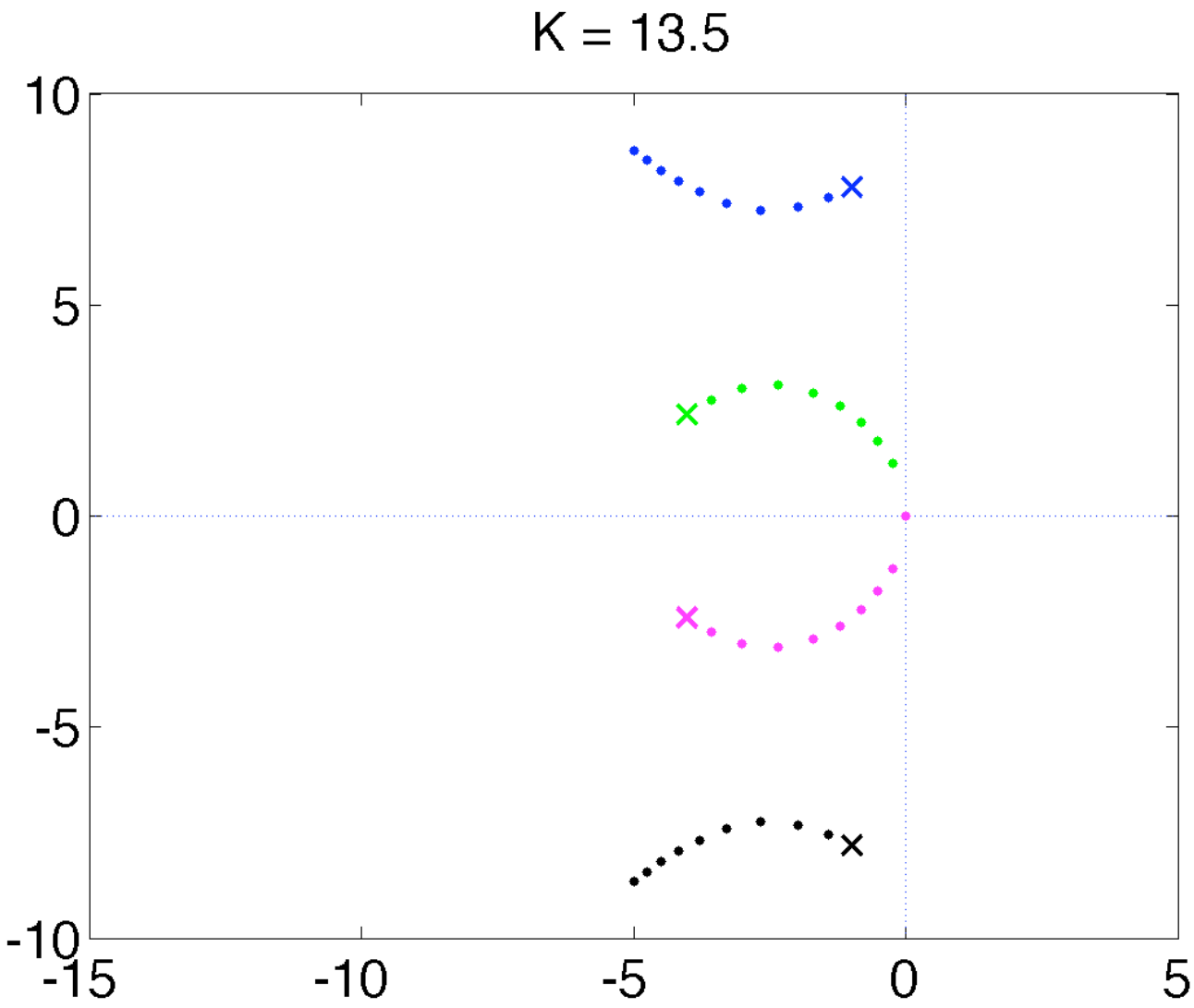

K = 6
10
5
0
-5
-10
-15
-10
-5
0
5

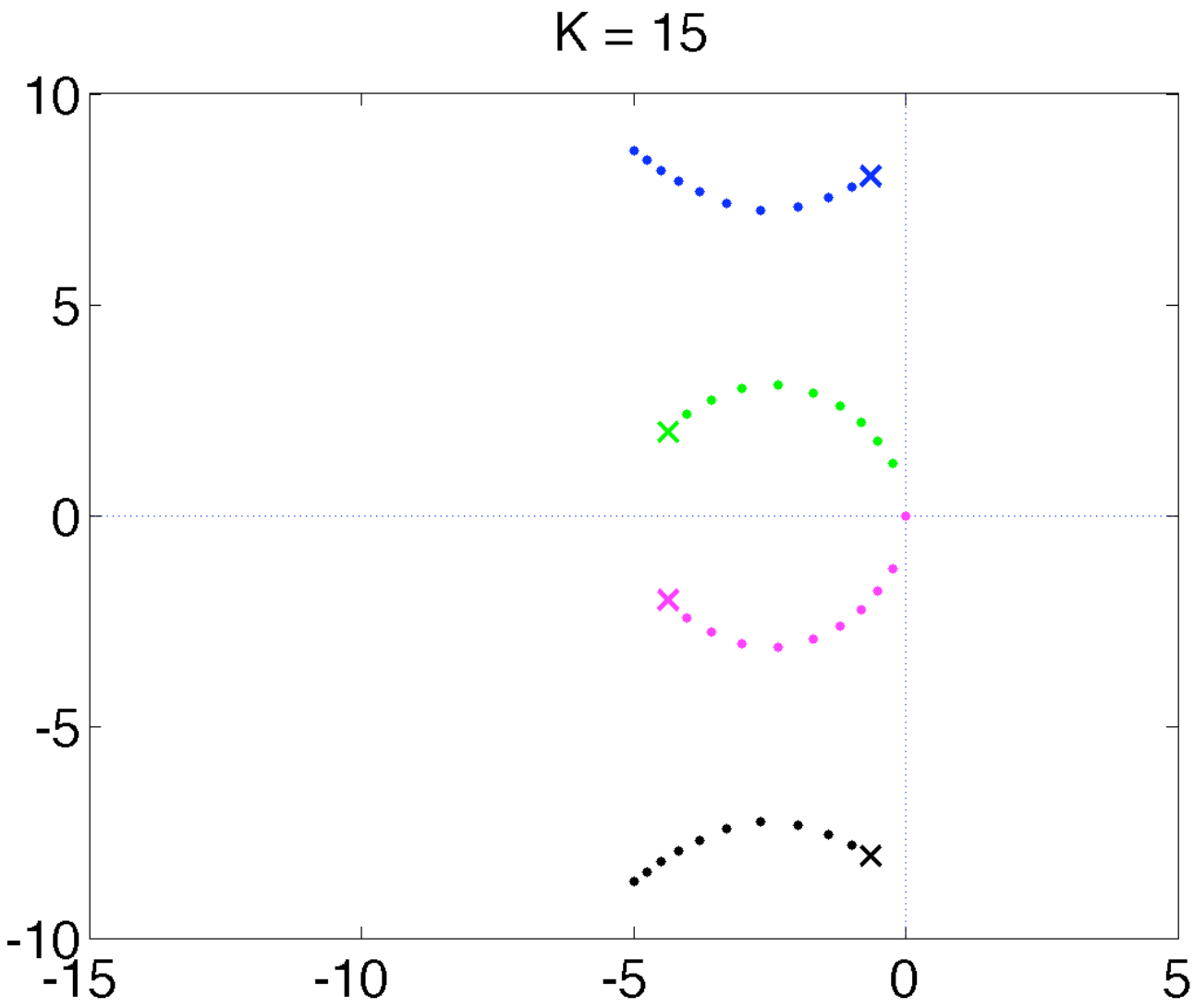

K = 7.5
10
5
0
-5
-10
-15
-10
-5
0
5

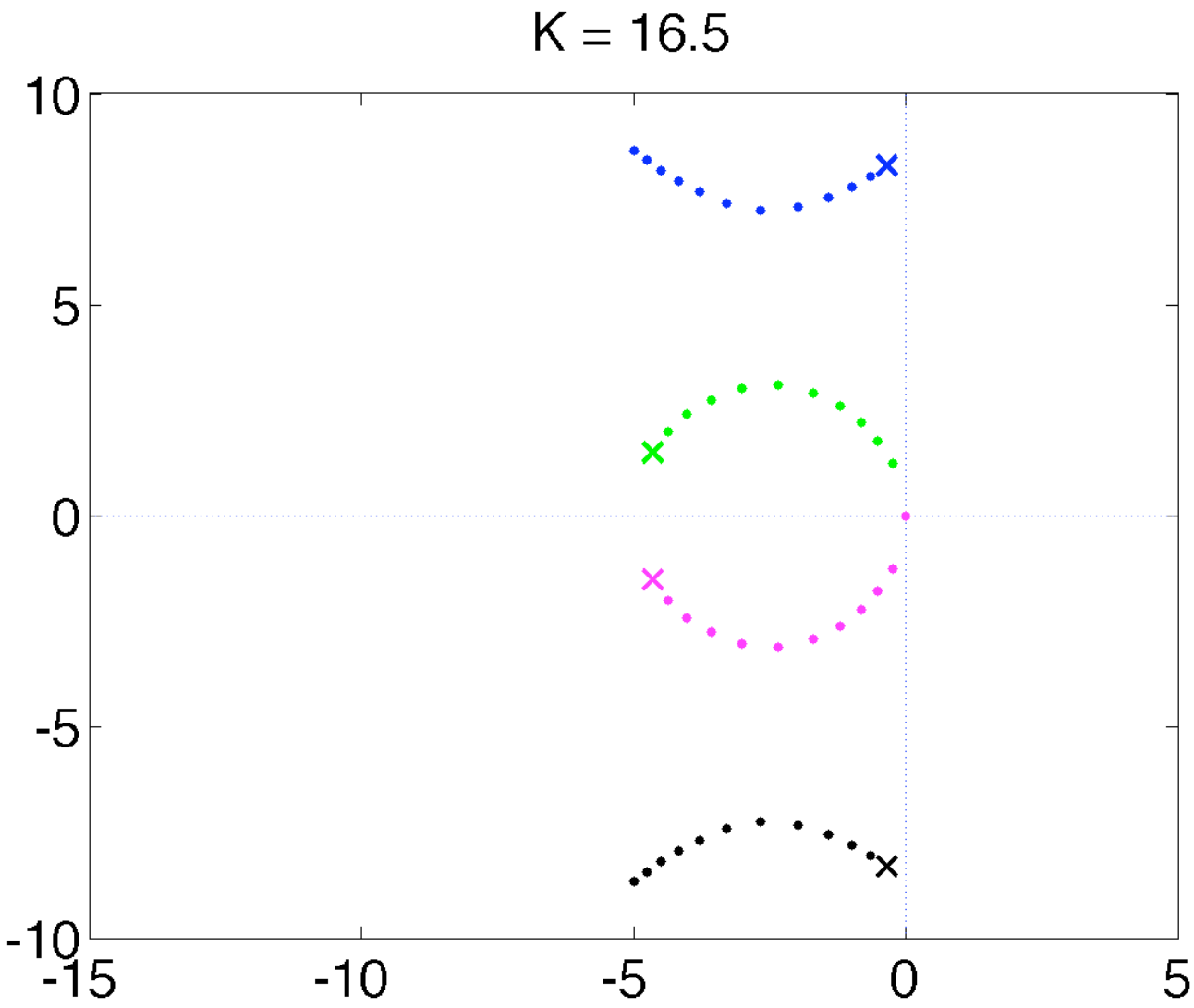

K = 9
10
5
0
-5
-10
-15
-10
-5
0
5

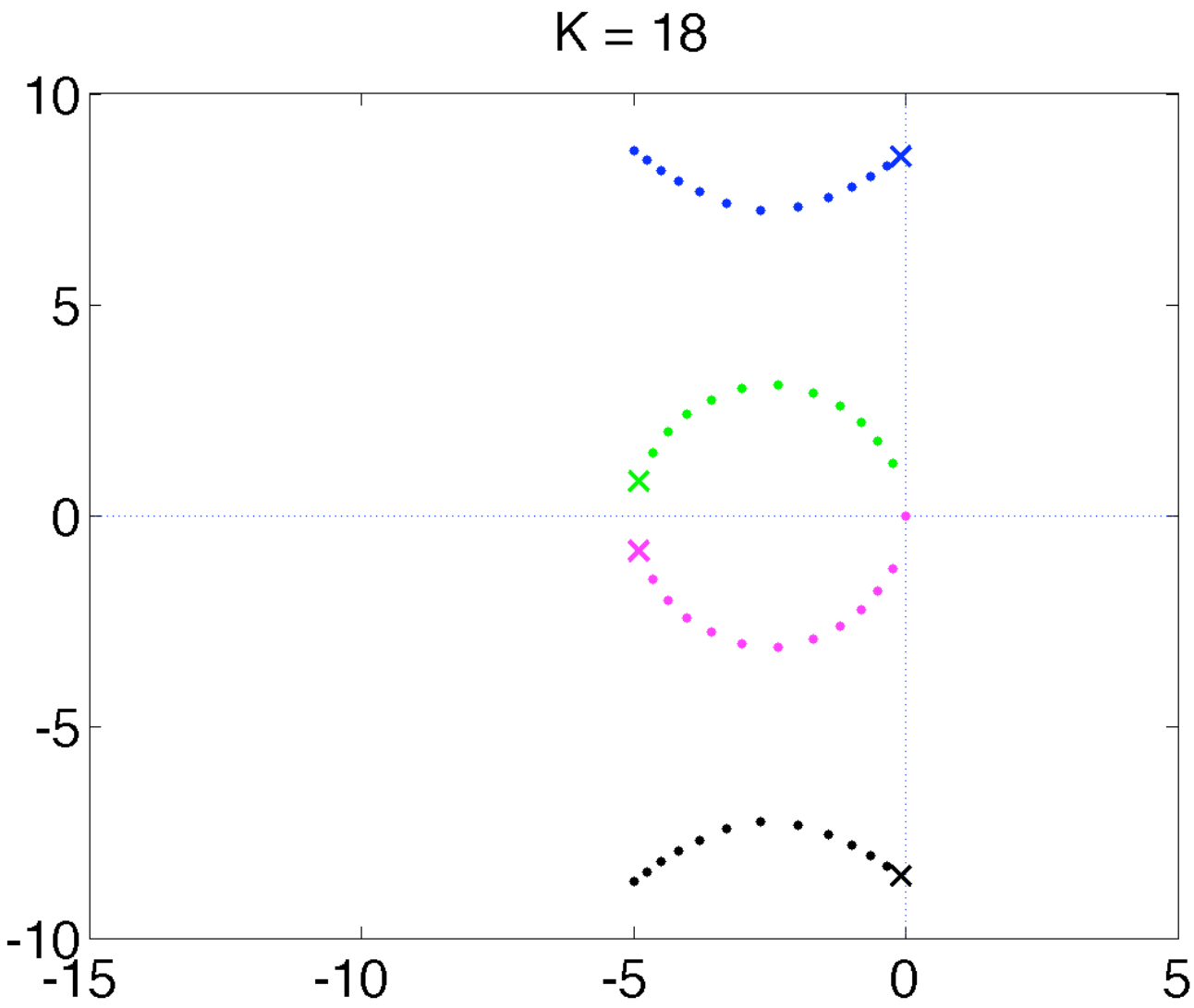

K = 10.5
10
5
0
-5
-10
-15
-10
-5
0
5

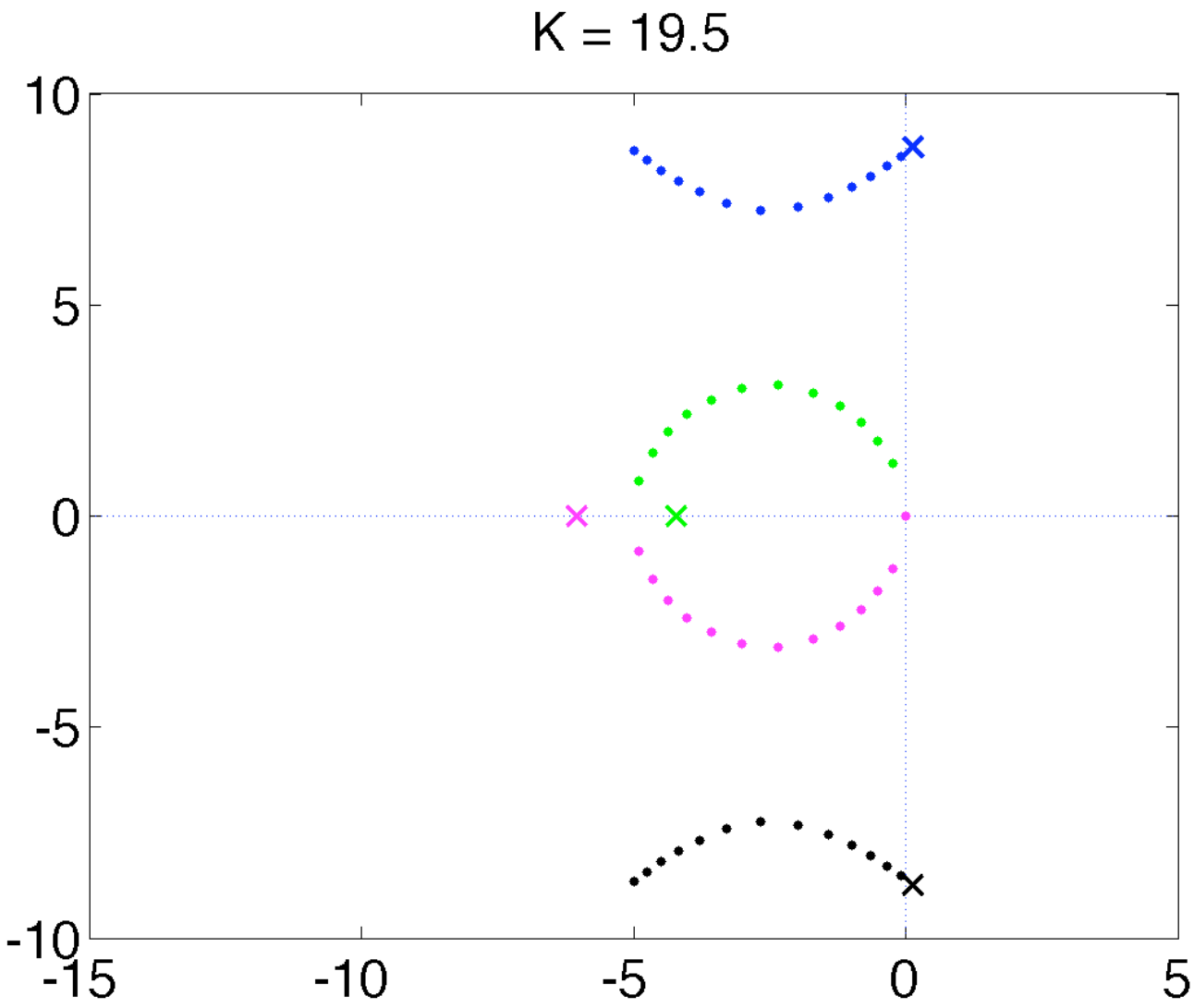

K = 12
10
5
0
-5
-10
-15
-10
-5
0
5

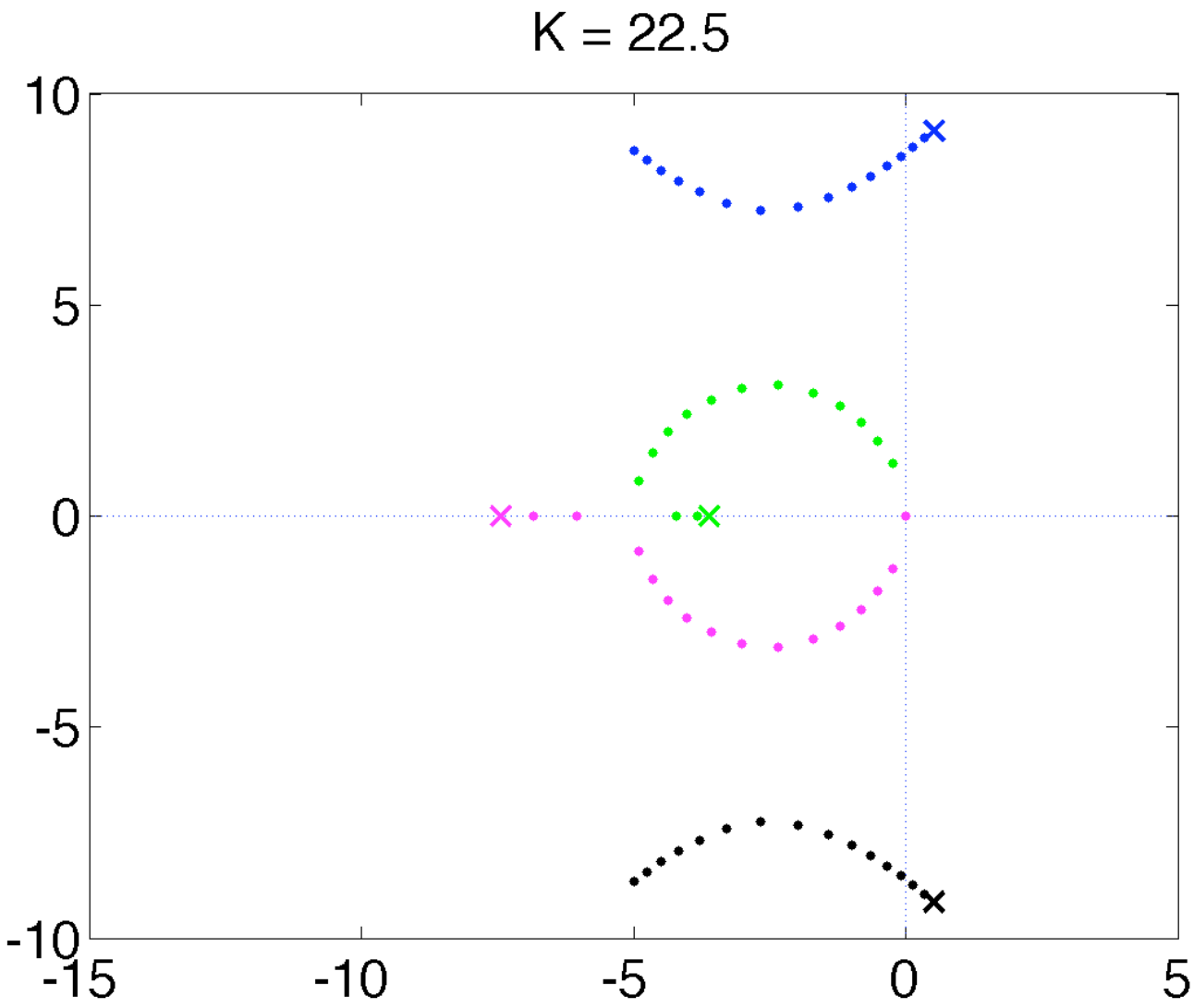

K = 13.5
10
5
0
-5
-10
-15
-10
-5
0
5

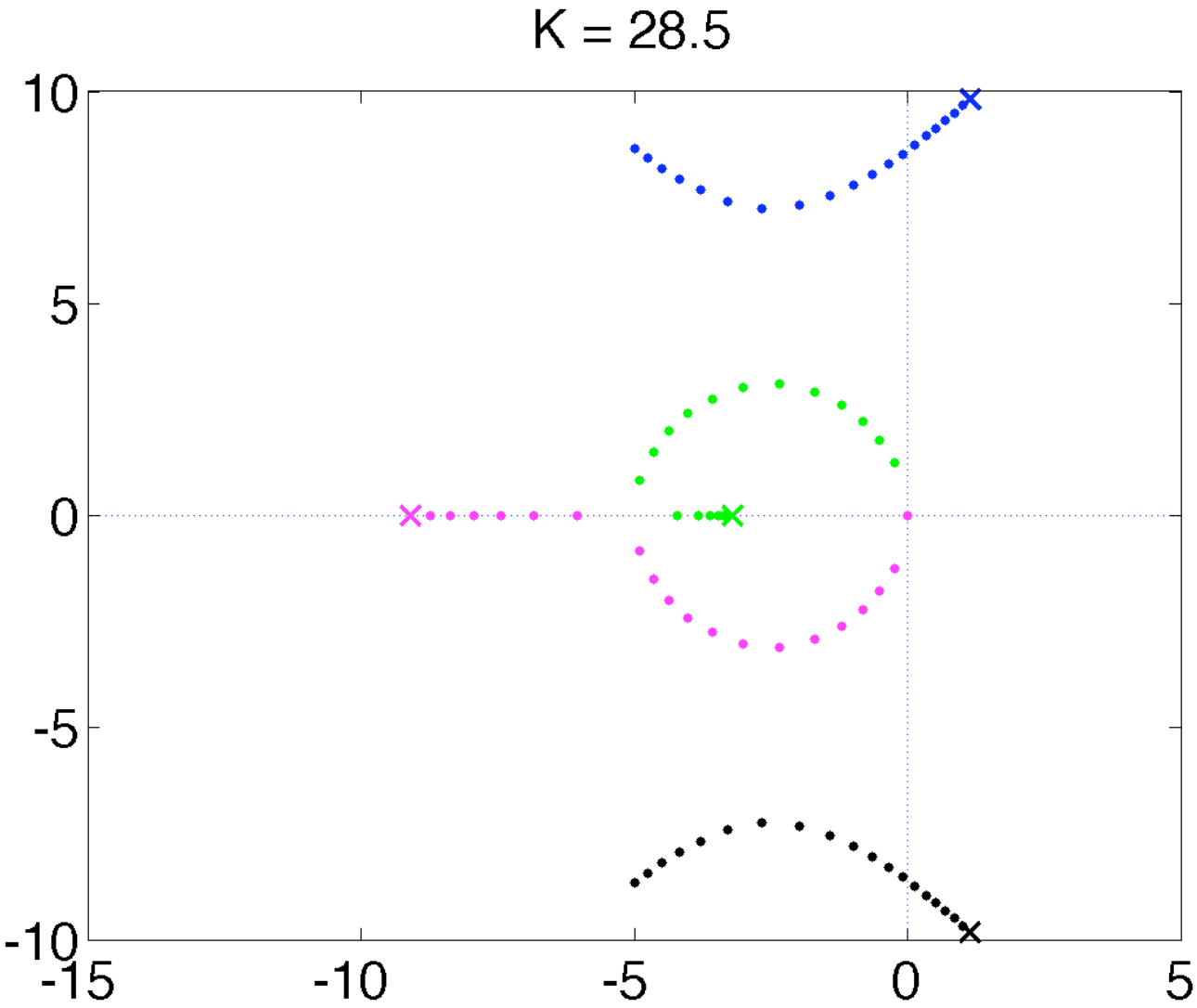

K = 15
10
5
0
-5
-10
-15
-10
-5
0
5


K = 16.5
10
5
0
-5
-10
-15
-10
-5
0
5

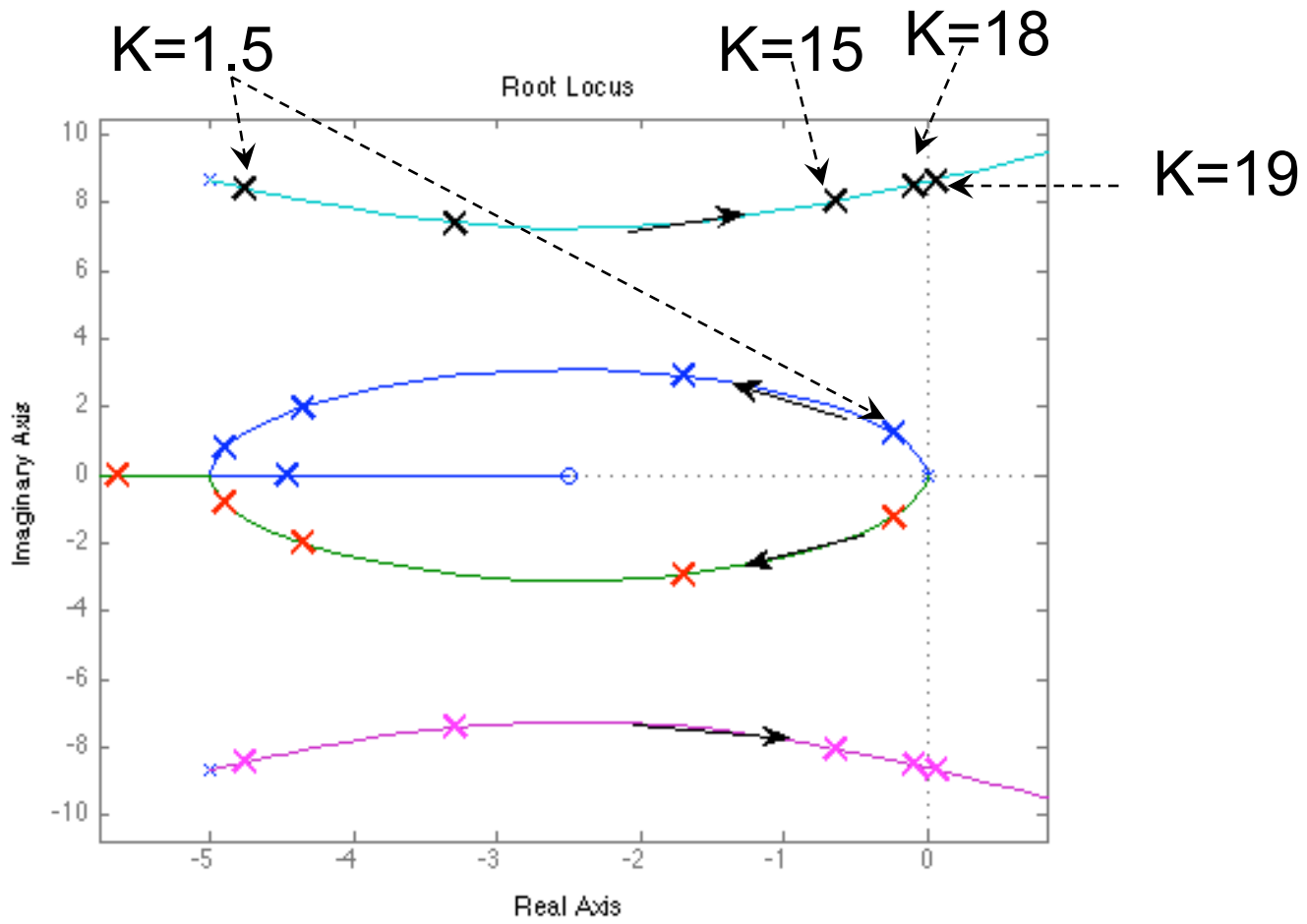

K = 18
10
5
0
-5
-10
-15
-10
-5
0
5


K = 19.5
10
5
0
-5
-10
-15
-10
-5
0
5

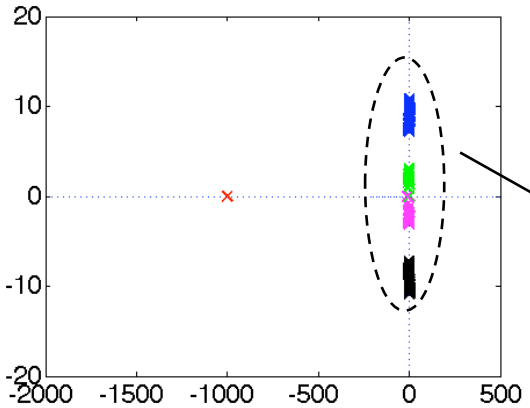

K = 22.5
10
5
0
-5
-10
-15
-10
-5
0
5

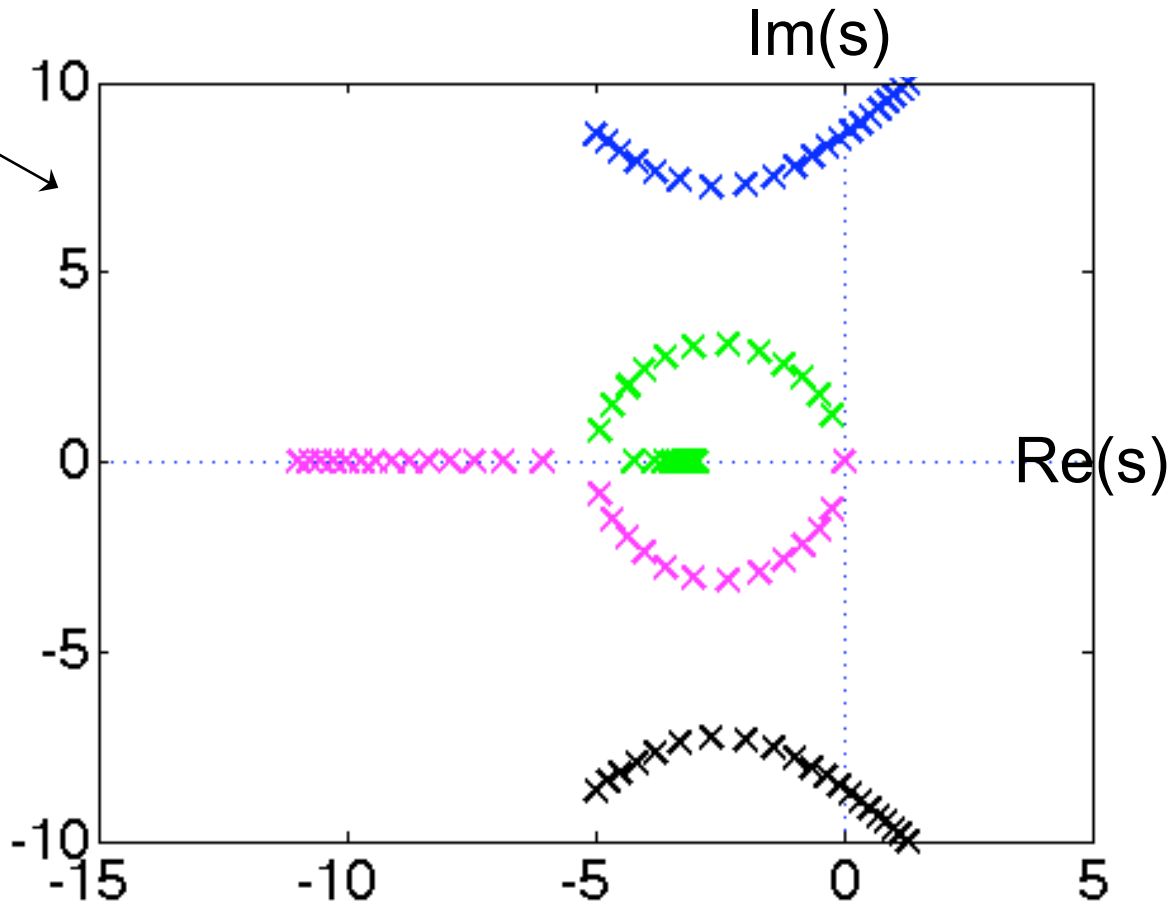

K = 28.5
10
5
0
-5
-10
-15
-10
-5
0
5

Closed loop pole locations as a function of K



Closed loop pole locations as K changes …

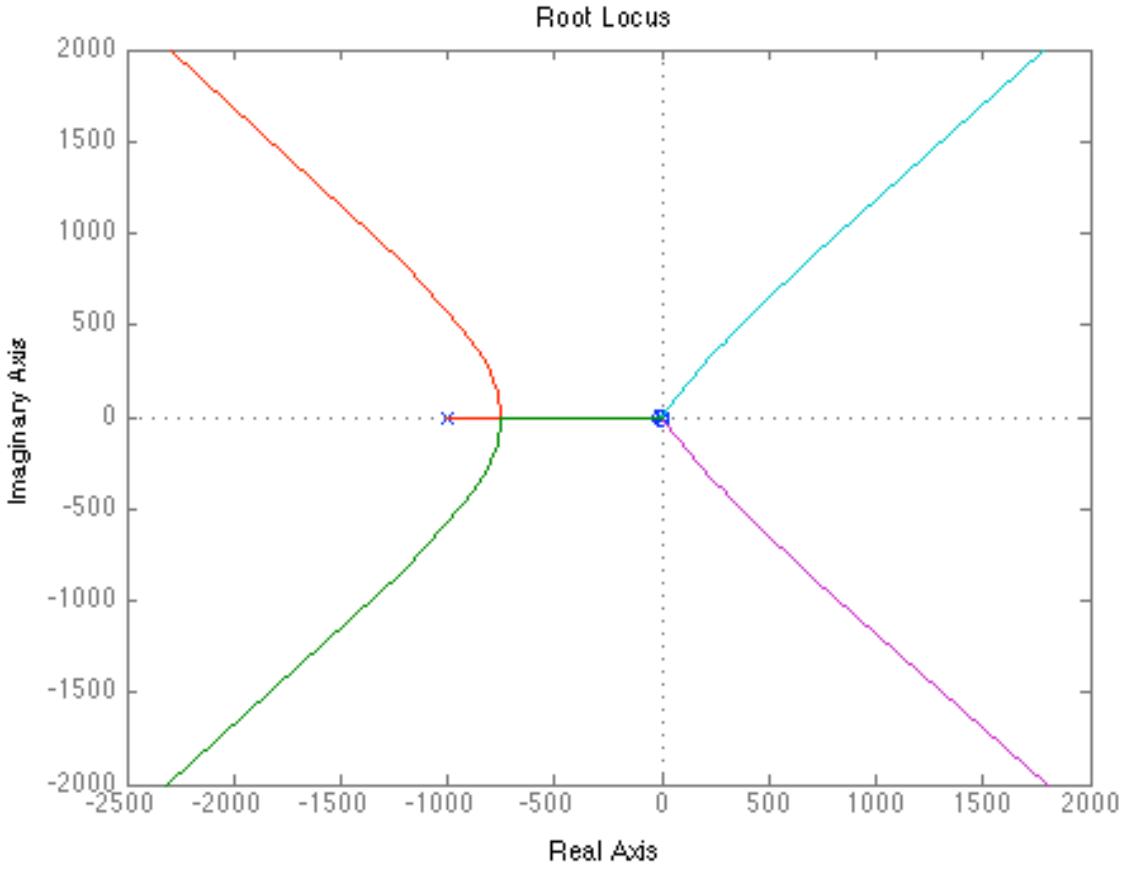




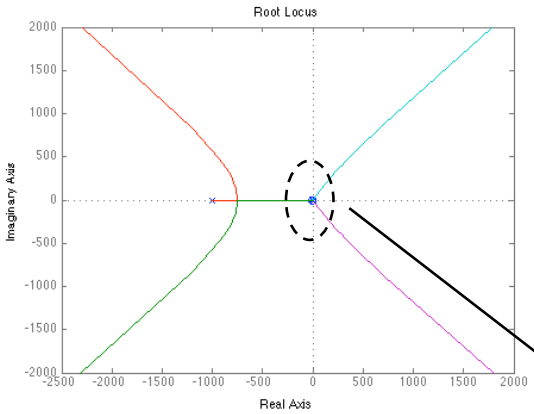
Plotting Root Locus in MATLAB

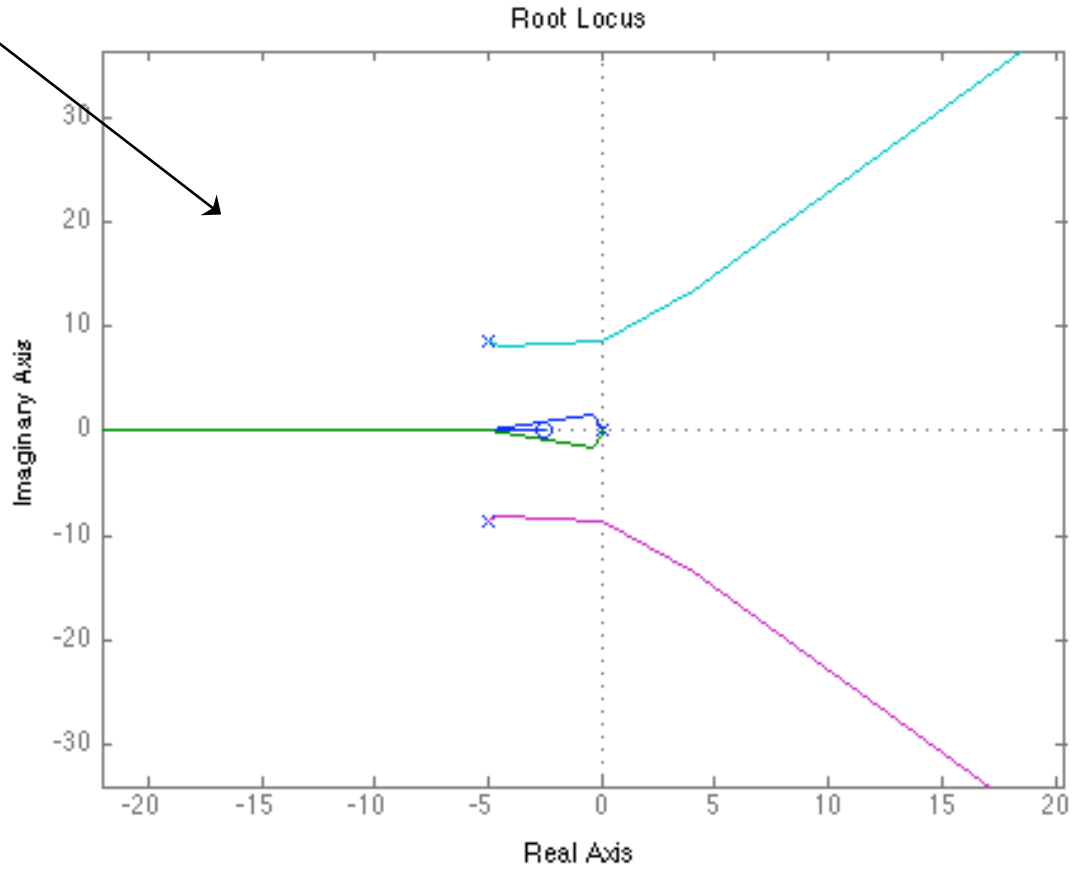
```
Co = tf(1000*[0.4 1],[1 1000]); %the part of C(s) without k in front
P = tf([1],[1 0 0]); %plant
F = tf([100],[1 10 100]); %low pass filter
L = Co*P*F; %closed loop denominator is 1 + k L(s)

figure;
rlocus(L); %MATLAB command to plot the locus of
% roots of 1 + k L(s) = 0 as k varies from 0 to infinity
```

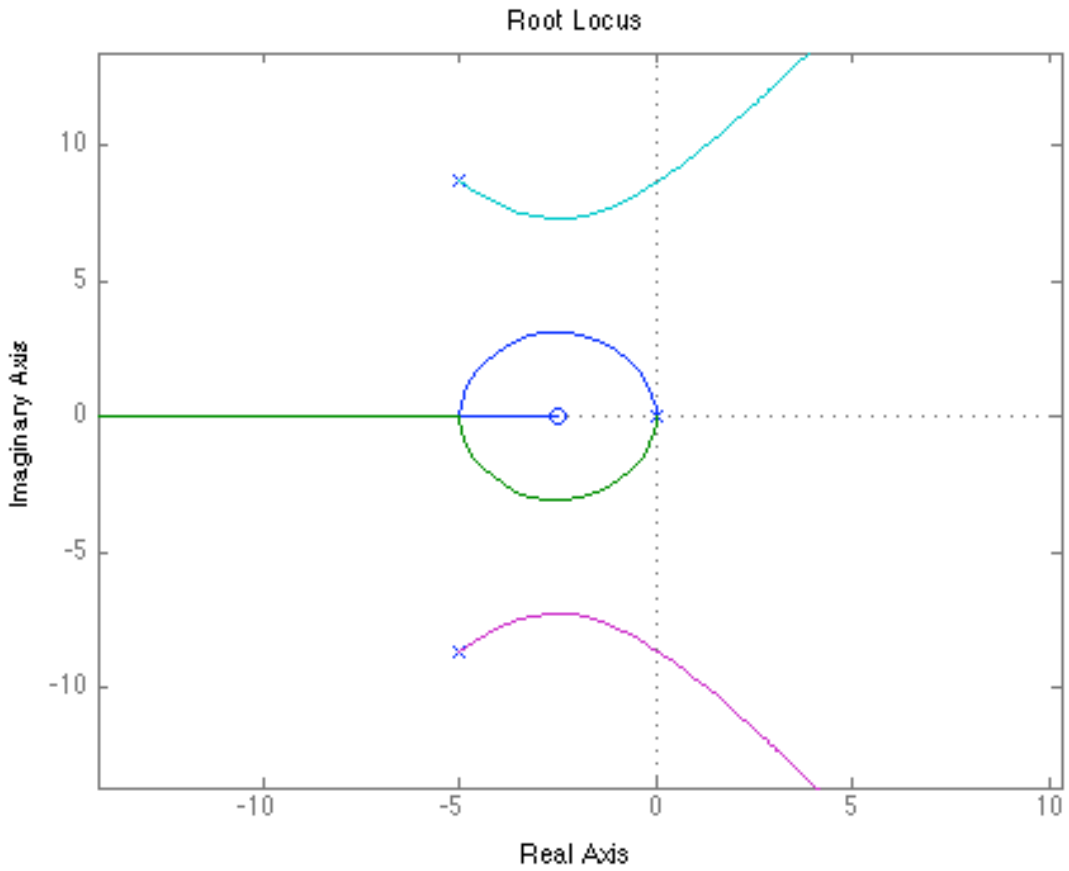


Zoom in

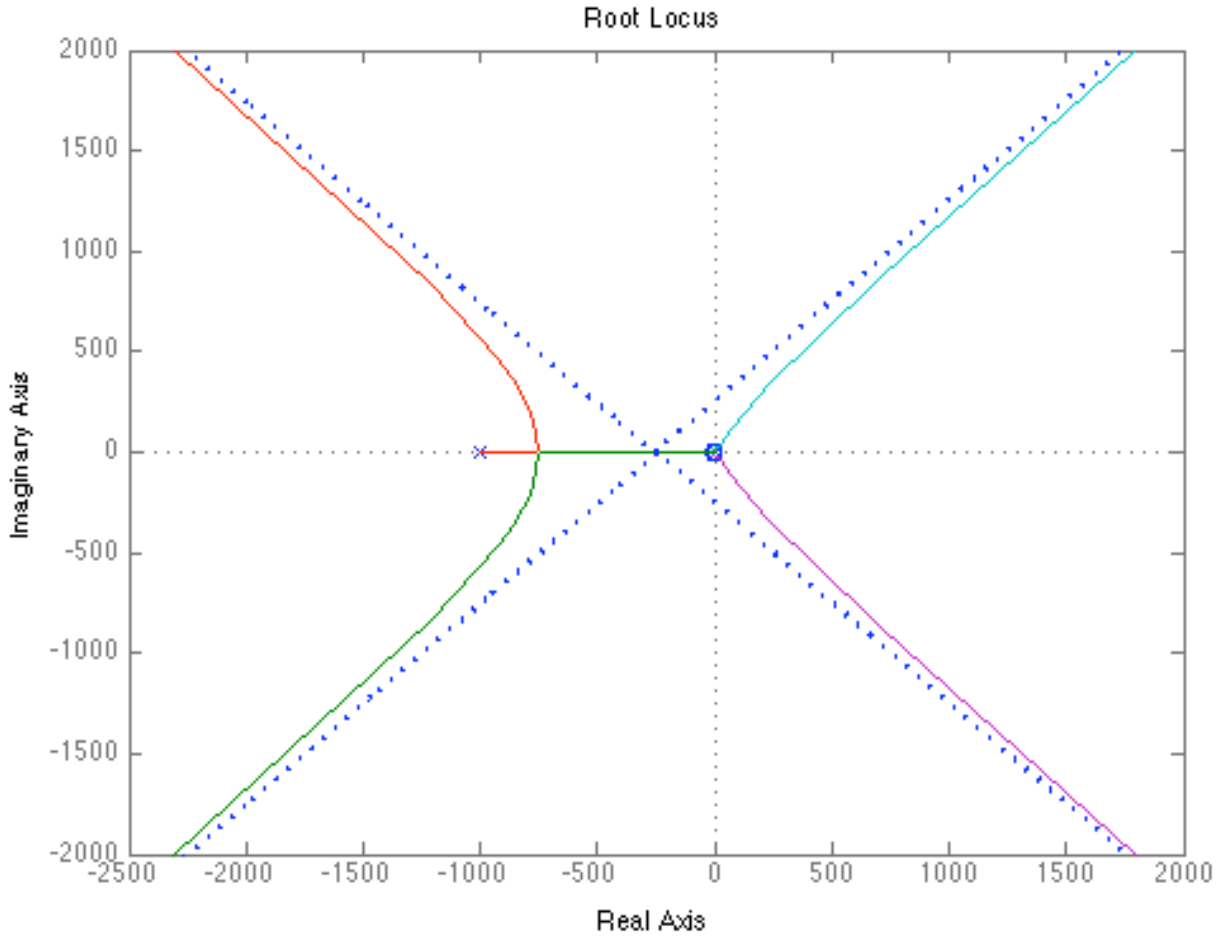

Root Locus
Imaginary Axis
Real Axis
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
-2000
-1500
-1000
-500
0
500
1000
1500
2000


Root Locus
Imaginary Axis
Real Axis
30
20
10
0
-10
-20
-30
-20
-15
-10
-5
0
5
10
15
20

Higher resolution



Asymptotes


Root Locus
Imaginary Axis
Real Axis
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
-2000
-1500
-1000
-500
0
500
1000
1500
2000