EEE2002 – Supplementary material

Extra poles and zeros

A system has two poles at -1 and -2, and two complex poles at -10+/-40j (num=1)

1. Find the damping factors and natural frequencies of the system
2. Do you expect the system to have oscillations?
3. Find the step response of the system.
4. Approximate the system by using two dominant poles.
5. Find the new step response, natural frequency and damping factor.
6. Compare that response with the response of the original system.
7. Repeat the previous exercise by assuming that the second set of poles is at

   -0.5+/-1.5j.

8. At the system with the two poles at -0.5+/-1.5j add two zeros at -0.51+/-1.51j.

Solution:

1.

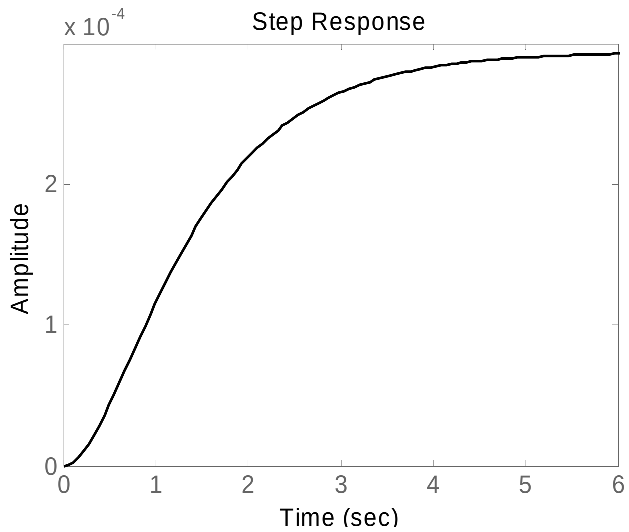
```
>> num=1; den=poly([-1 -2 -10+40j -10-40j]); g=tf(num,den);
[wn,z]=damp(g)

wn =

    1.0000
    2.0000
   41.2311
   41.2311


z =

    1.0000
    1.0000
    0.2425
    0.2425
```

2.

Yes the system is "expected" to have an oscillatory behaviour due to the two complex poles which give a damping factor of ~0.24.

3.

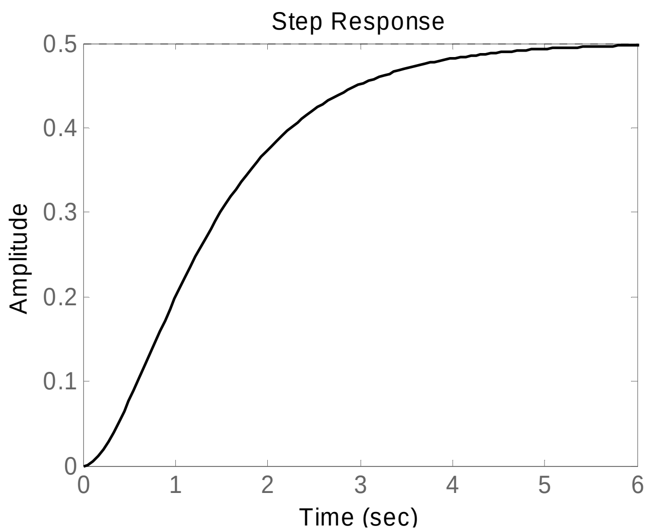
```
>> step(g)
```



The system has an overdamped response. This is due to the fact that the two real poles are far closer to the jw axis than the two complex poles. Therefore the dominant poles are the two real poles and the overall behaviour of the system is MOSTLY influenced by these two real poles.

4,5.

```
>> num=1; den=poly([-1 -2]); g=tf(num,den); [wn,z]=damp(g)

wn =

     1
     2


z =

     1
     1
step(g)
```



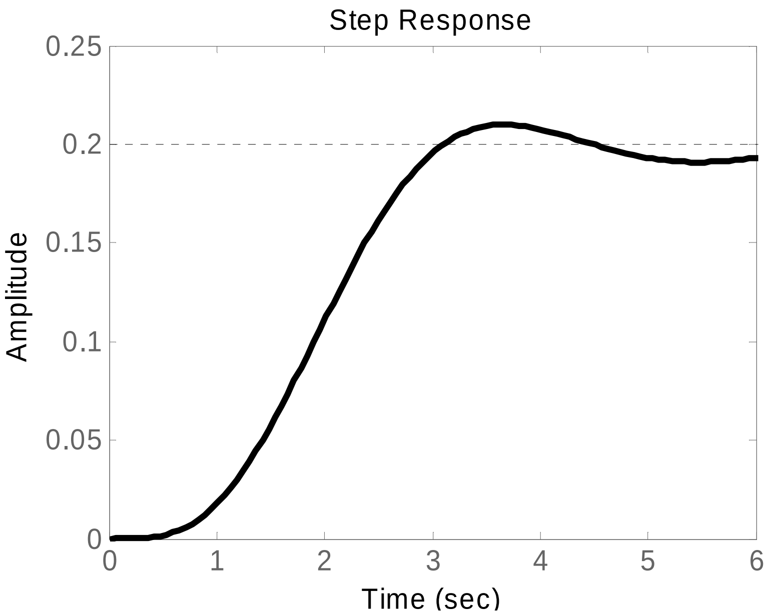
6.

It is clear that the dominant system has the same behaviour (not absolute value of steady state) as the original system. Hence our previous approximation was correct.

7.

```
>> num=1; den=poly([-1 -2 -0.5+1.5j -0.5-1.5j]); g=tf(num,den);
[wn,z]=damp(g)

wn =

    1.0000
    1.5811
    1.5811
    2.0000


z =

    1.0000
    0.3162
    0.3162
    1.0000
```

Notice that the new damping factor is similar to the old one; it is influenced only by the relative angle of the complex poles.

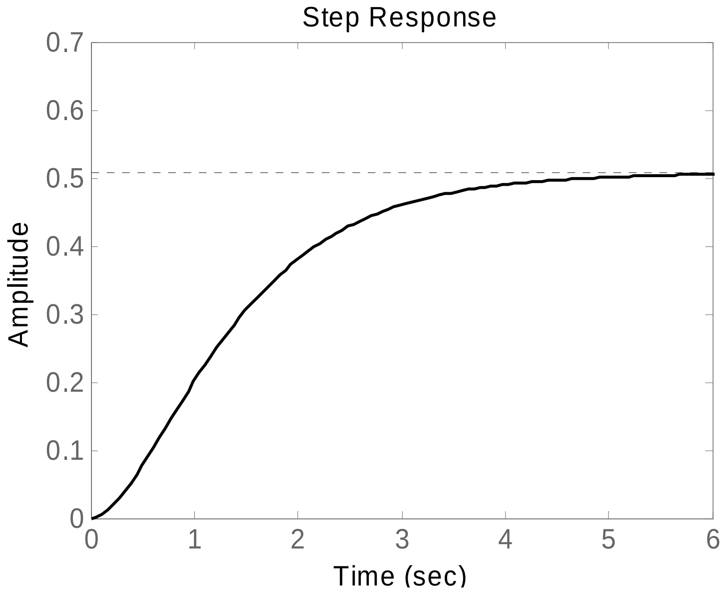


It is clear that since the complex poles are closer to the jw axis than before they have a greater impact on the overall performance.

8.

```
>> num=poly([-0.51+1.51j -0.51-1.51j]); den=poly([-1 -2 -0.5+1.5j
-0.5-1.5j]); g=tf(num,den); [wn,z]=damp(g)

wn =

    1.0000
    1.5811
    1.5811
    2.0000


z =

    1.0000
    0.3162
    0.3162
    1.0000
```

Notice that the damping factors remained unchanged.



It is clear that the addition of the two zeros near the two complex poles made the system overdamped and hence verified the statement that the response of the system depends on poles that are close to the jw axis and they are isolated (i.e. far away from zeros).