firstPI

May 8, 2021

1 First order PI

[1]:
```
import numpy as np
import sympy as sym
import matplotlib.pyplot as plt

sym.init_printing()
```

[2]:
```
z, Wn, Kg, Kp, tau, Ti = sym.symbols('zeta omega_n K_G K_p tau T_i')
```

[3]:
```
eq1 = sym.Eq(2*z*Wn, (1+Kg*Kp)/tau);
eq2 = sym.Eq(Wn**2 , (Kg*Kp)/(tau*Ti));
sym.solve((eq1, eq2),(Kp,Ti))
```

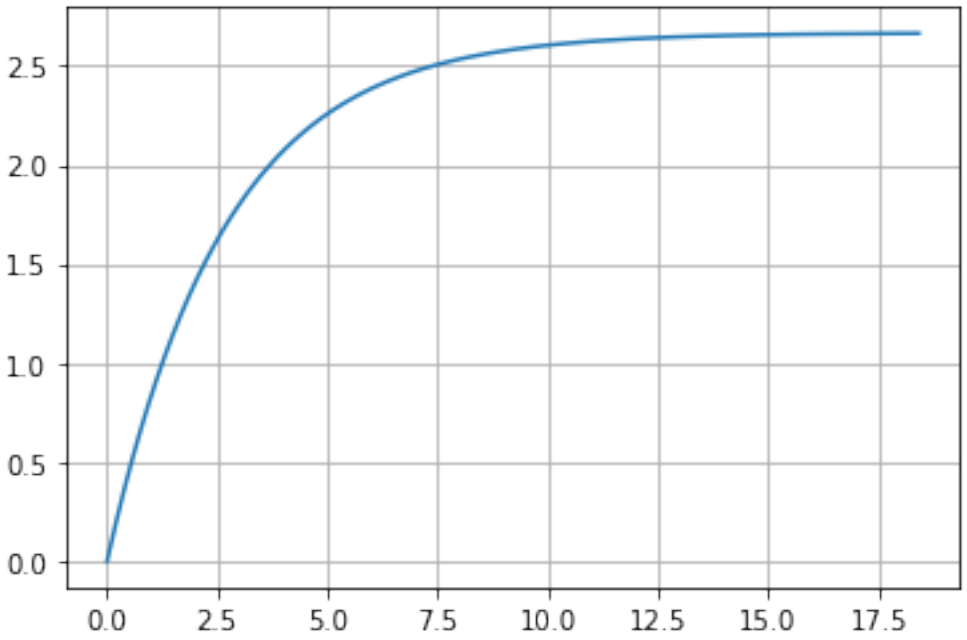
[3]:
$$\left\{K_p : \frac{2\omega_n\tau\zeta - 1}{K_G},\ T_i : \frac{2\zeta}{\omega_n} - \frac{1}{\omega_n^2\tau}\right\}$$

1.1 Example

[4]:
```
import control as ct
from control.matlab import *
import numpy as np
```

[5]:
```
# System
num = [1]
den = [1, 0.375]
G = ct.tf(num,den)
print('Process: ')
print(G)

t, out = ct.step_response(G)
print('Step response:')
plt.plot(t, out)
plt.grid()
plt.show()

print('Step info: ')
stepinfo(G)
```

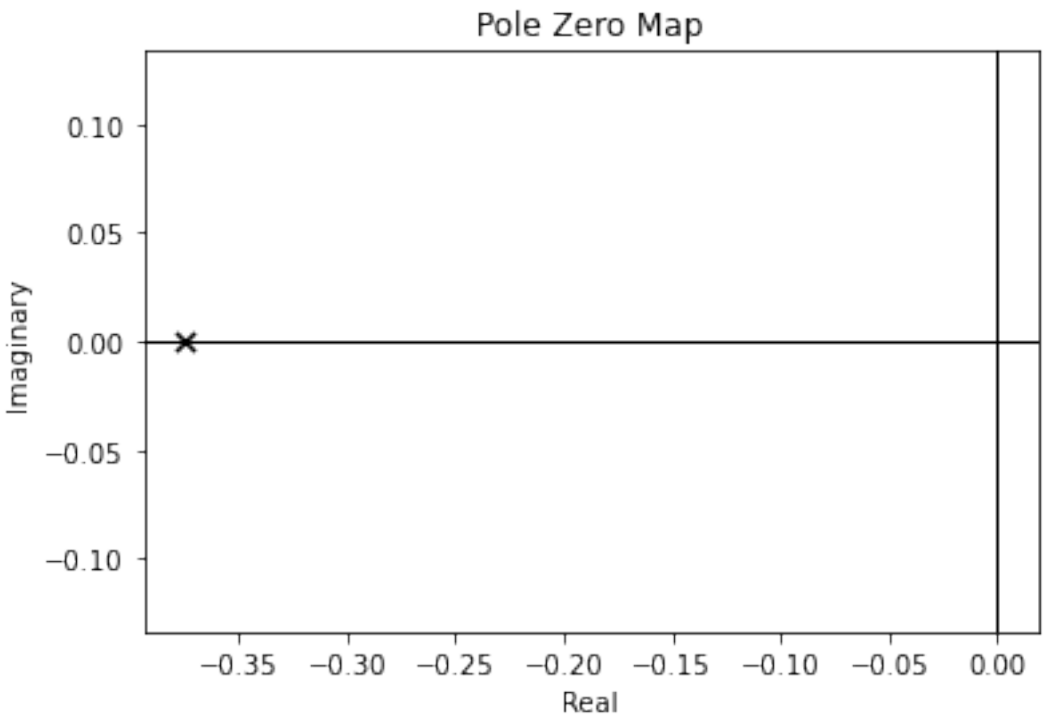
```
Process:

    1
---------
s + 0.375

Step response:
```




```
Step info:
```

[5]:
```
{'RiseTime': 5.954159432388643,
 'SettlingTime': 10.60584648894227,
 'SettlingMin': 2.4179724408311363,
 'SettlingMax': 2.663999999999991,
 'Overshoot': 0,
 'Undershoot': 0,
 'Peak': 2.663999999999991,
 'PeakTime': 18.420680743952364,
 'SteadyStateValue': 2.6666666666666665}
```

[6]:
```
# Root locust
ct.pzmap(G);
```



[7]:
```
# Data
ts = 8
Mp = 15
```

[8]:
```
# Requirements
z = np.sqrt(np.square(np.log(Mp/100))/(np.pi**2 + np.square(np.log(Mp/100))))
Wn = 4/(z*ts)
tau = 1/den[1]
Kg = num[0]/den[1]

print('z= ', z)
print('Wn= ', Wn)
```

```
z=  0.5169308662051555
Wn=  0.9672473297455677
```

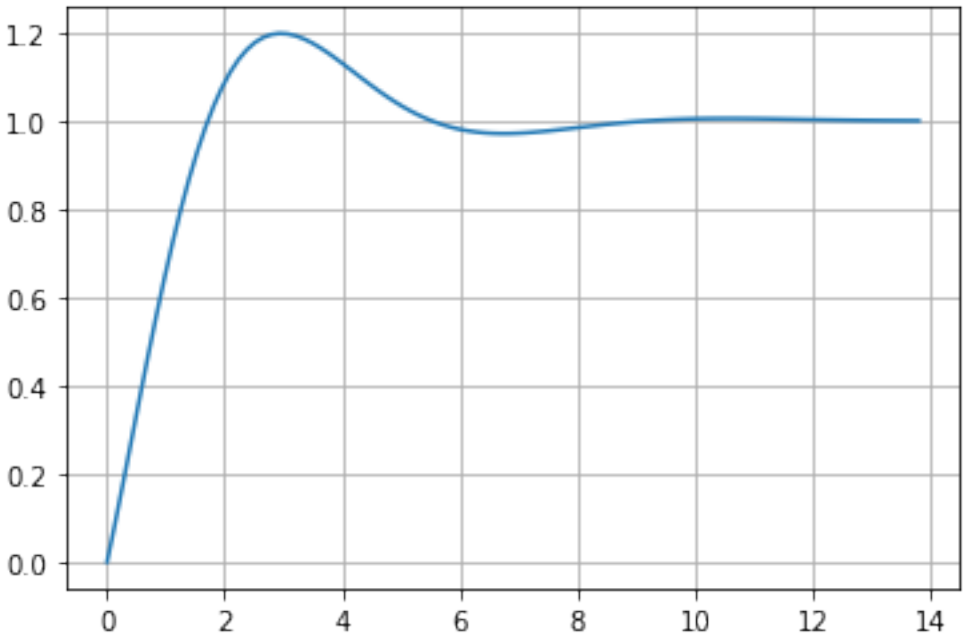
[9]:
```
# Desired characteristic equation and poles
print('delta = s² + {a}s + {b:1.4f}'.format(a=2*z*Wn,b=Wn**2))
print('s = {a} + j{b:1.4}'.format(a=-z*Wn, b=Wn*np.sqrt(1-z**2)))
```

```
delta = s² + 1.0s + 0.9356
s = -0.5 + j0.828
```

[10]:
```
# PI controller
Kp = (2*z*Wn*tau-1)/Kg
Ti = (Kp*Kg)/(tau*Wn**2)

Gc = ct.tf([Kp*Ti, Kp],[Ti, 0])
print(Gc)
```

```
0.4175 s + 0.625
----------------
    0.668 s
```

[11]:
```
# PI response
sys = ct.feedback(Gc*G)
t, out = ct.step_response(sys)
plt.plot(t,out)
plt.grid()
plt.show()

print('Step info: ')
stepinfo(sys)
```

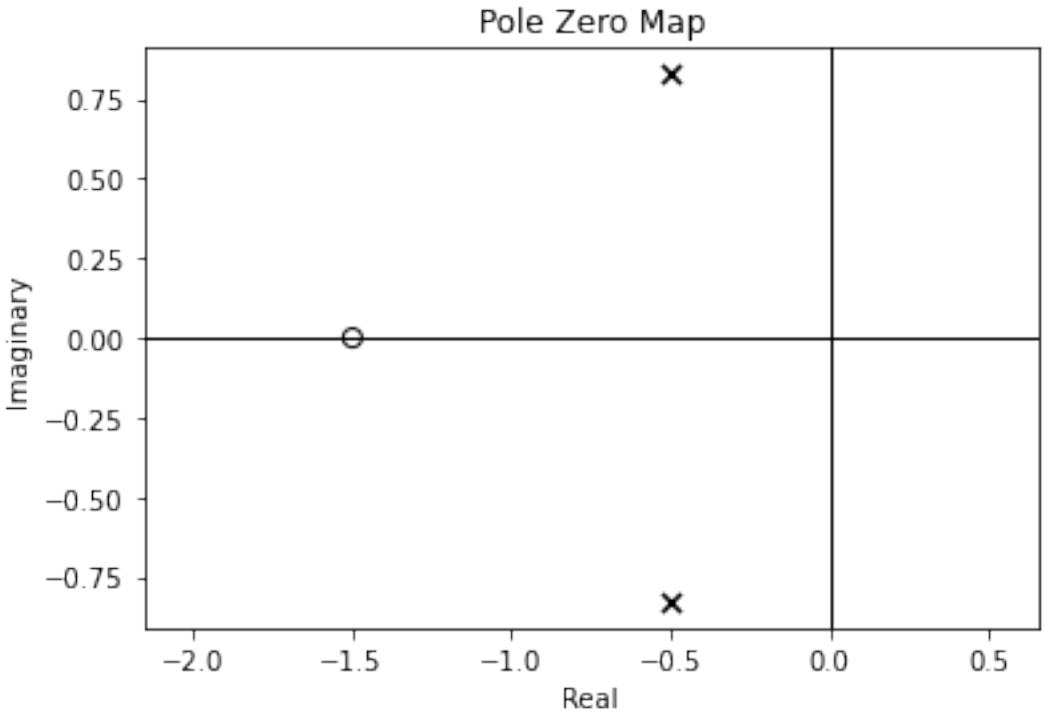



```
Step info:
```

[11]:
```
{'RiseTime': 1.2559555052694795,
 'SettlingTime': 7.814834255010095,
 'SettlingMin': 0.9298750106558097,
 'SettlingMax': 1.197286847173987,
 'Overshoot': 19.728684717398703,
 'Undershoot': 0,
 'Peak': 1.197286847173987,
 'PeakTime': 2.9305628456287858,
 'SteadyStateValue': 1.0}
```

[12]:
```
ct.pzmap(sys);
print('Poles: ',ct.pole(sys))
```

```
Poles:  [-0.5+0.82798997j -0.5-0.82798997j]
```



[ ]:
```

```