DIGITAL CONTROL OF POWER ELECTRONICS

Integral Controller

The integral controller is shown below. The gain of the controller is K_i and the sample time is $T = 0.5$.

$$G_c(z) = K_i \frac{T}{2} \frac{z+1}{z-1} \tag{1}$$

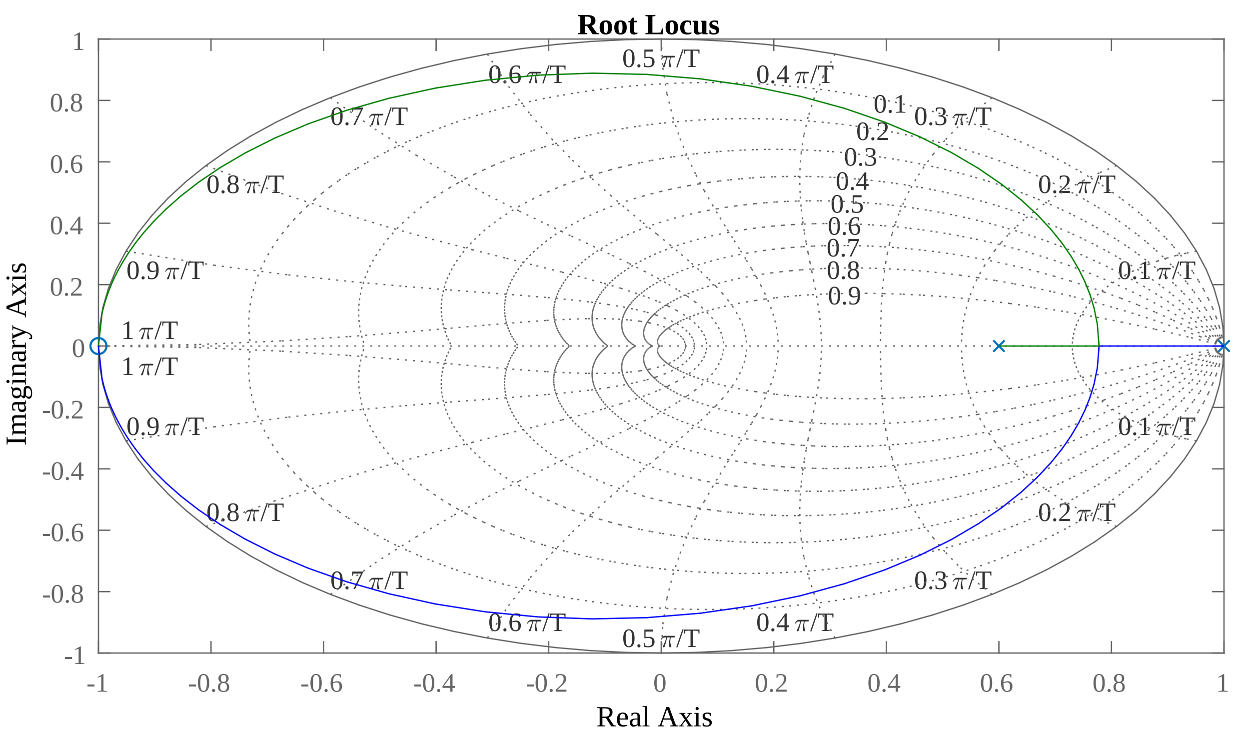
Let the plant be

$$G_p(z) = \frac{z+1}{z-0.6} \tag{2}$$

Lets assess the stability of the system based on selection of the integrator gain K_i.
Find the open loop expression

$$G_{ol} = K_i \frac{T}{2} \frac{z+1}{z-1} \frac{z+1}{z-0.6} \tag{3}$$

$$G_{cl} = \frac{0.5K_i(z+1)(z+1)}{0.5K_i(z+1)(z+1) + 2(z-1)(z-0.6)} \tag{4}$$



$$a \tag{5}$$

The roots must remain inside the unit circle in order for the system to be stable
The closed loop system is stable for gains of

$$0 < K_i < \text{inf} \tag{6}$$

What happens when K=0.06?

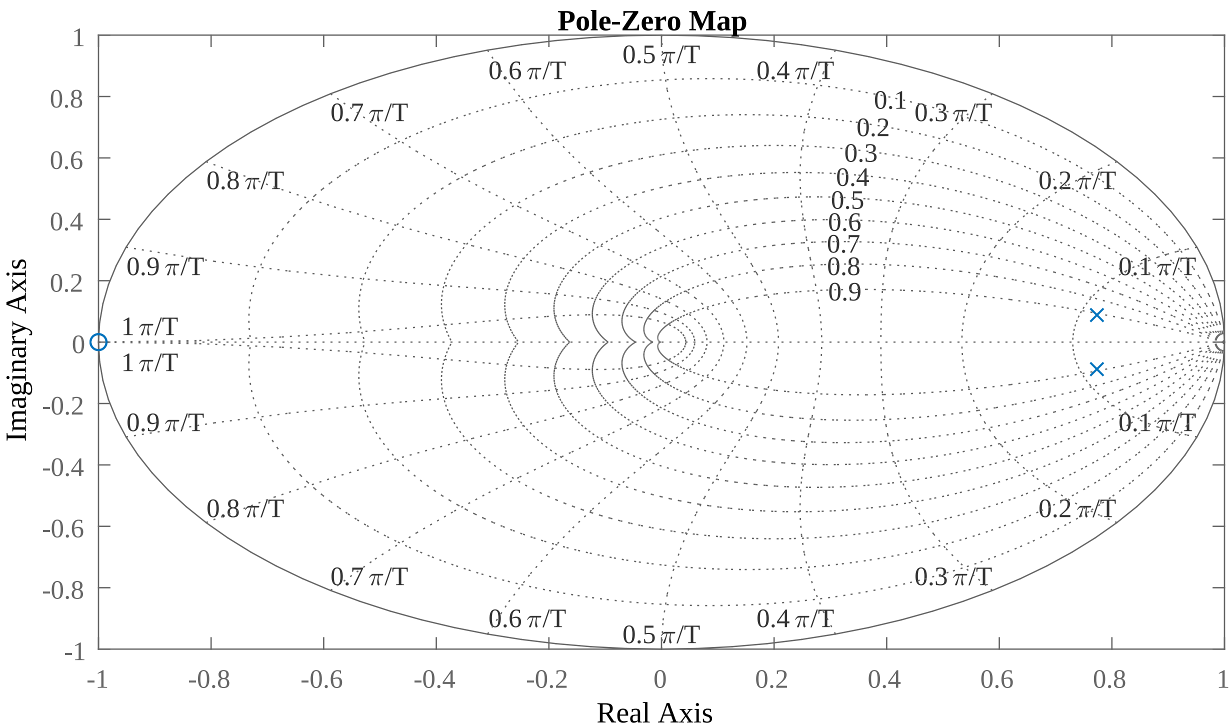
$$G_c = \frac{0.015z + 0.015}{z - 1} \tag{7}$$

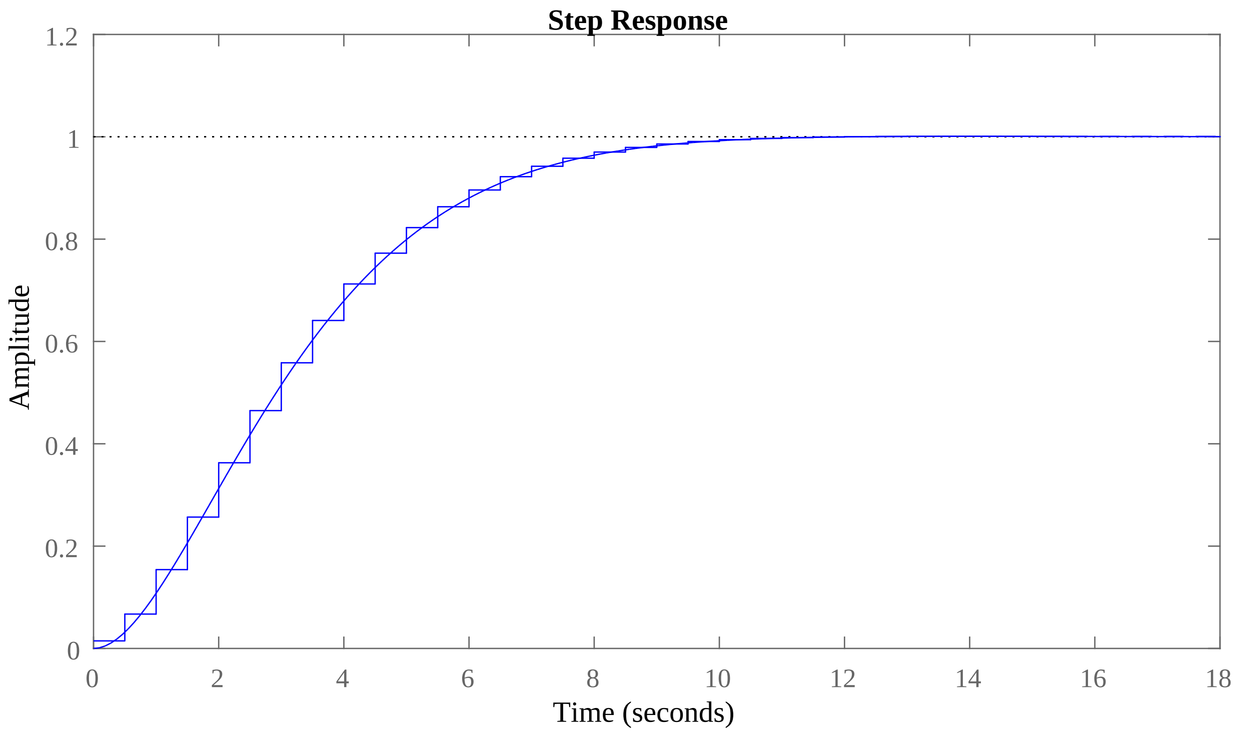
$$G_{cl} = \frac{0.01478z^2 + 0.02956z + 0.01478}{z^2 - 1.547z + 0.6059} \tag{8}$$

The roots are

$$r_1 = 0.7734 + 0.0881i \quad r_2 = 0.7734 - 0.0881i \tag{9}$$

The system is under-damped because there are two distinct real roots. The anticipated response is a decaying exponential.





What happens when K=0.5?

$$G_c = \frac{0.125z + 0.125}{z - 1} \tag{10}$$

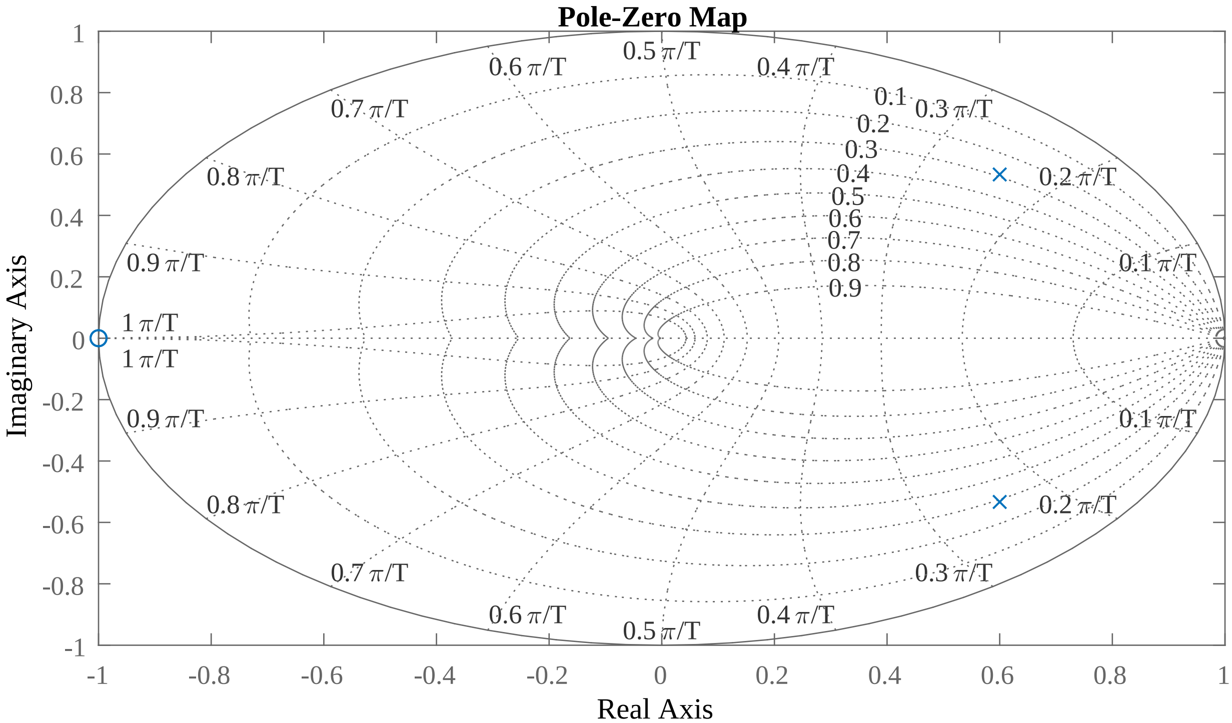
$$G_{cl} = \frac{0.1111z^2 + 0.2222z + 0.1111}{z^2 - 1.2z + 0.6444} \tag{11}$$

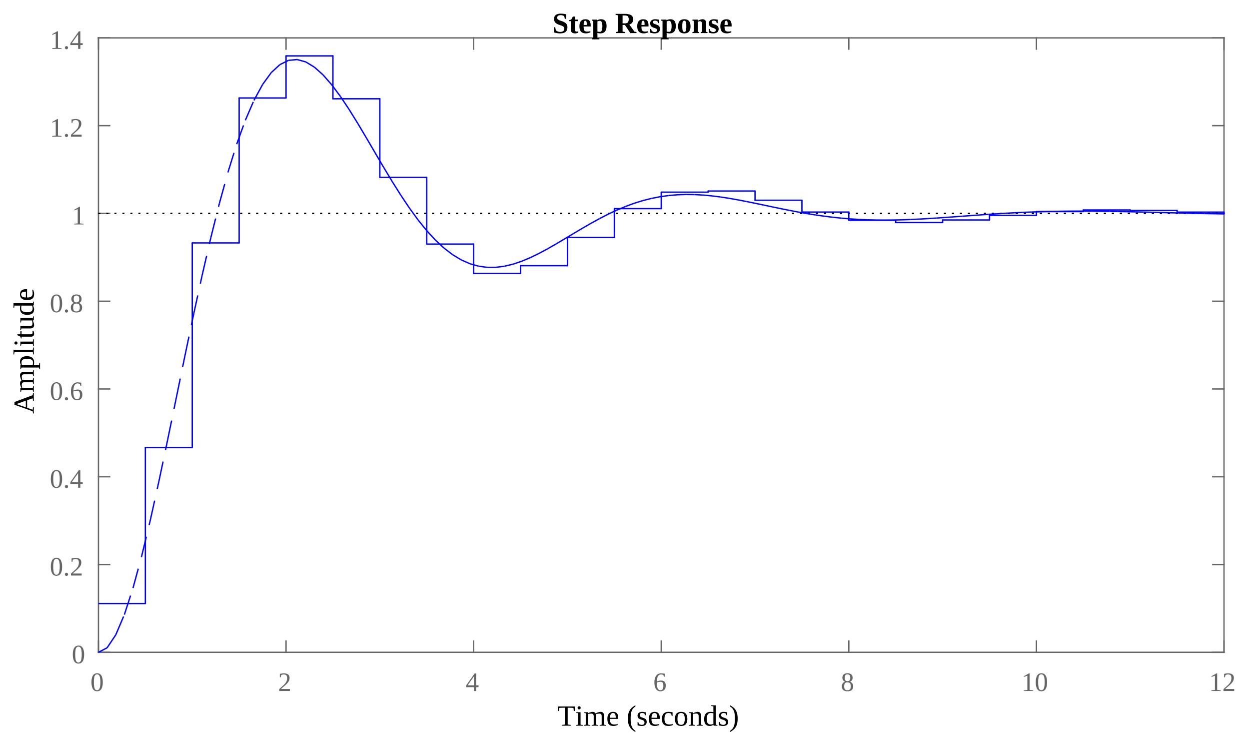
The roots are

$$r_1 = 0.6 + 0.5333i \quad r_2 = 0.6 - 0.5333i \tag{12}$$

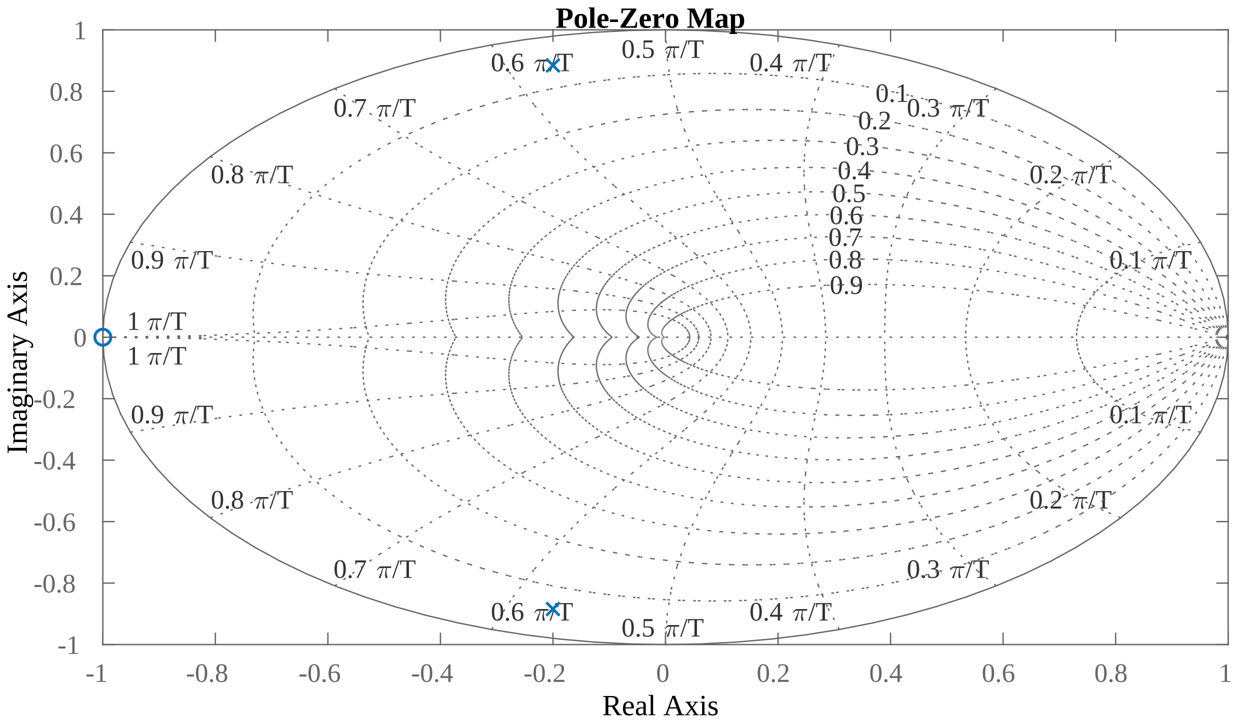
The system is under-damped because there are two distinct complex roots. The anticipated response should be a decaying sine wave.

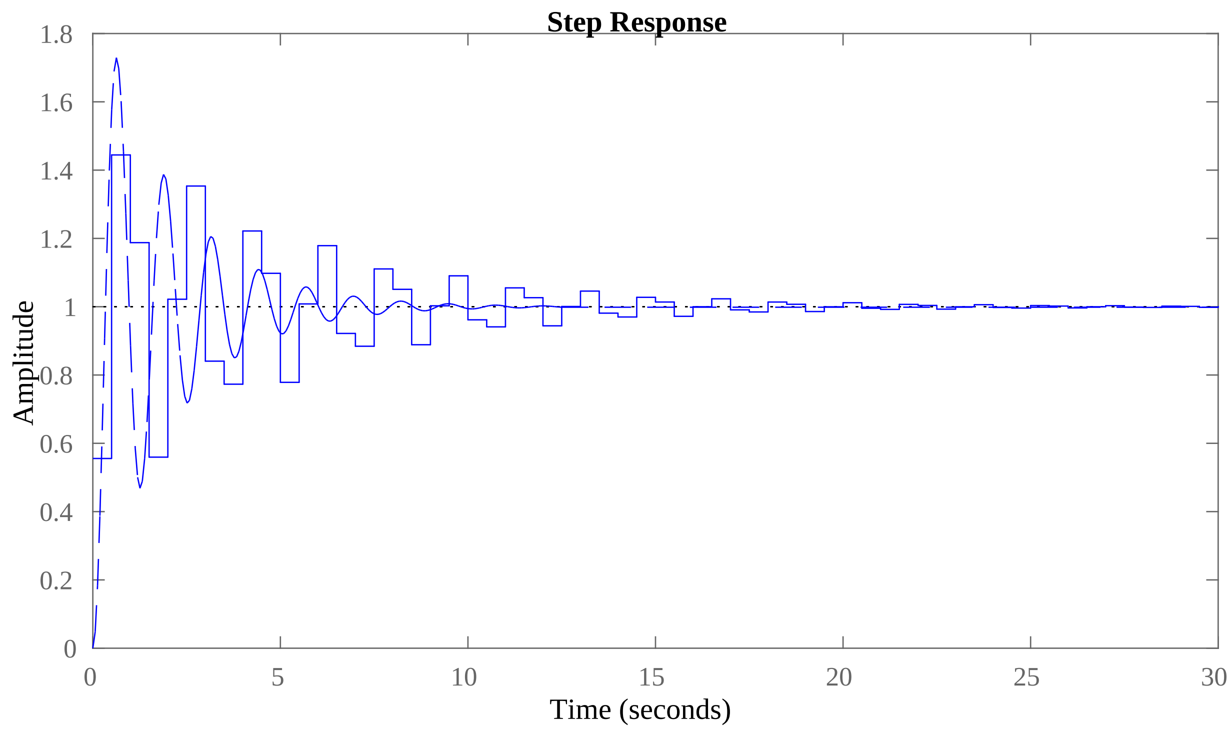
$$K_i = 0.5 \tag{13}$$


Pole-Zero Map
Imaginary Axis
Real Axis
0.5 π/T
0.6 π/T
0.4 π/T
0.7 π/T
0.3 π/T
0.8 π/T
0.2 π/T
0.9 π/T
0.1 π/T
1 π/T
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

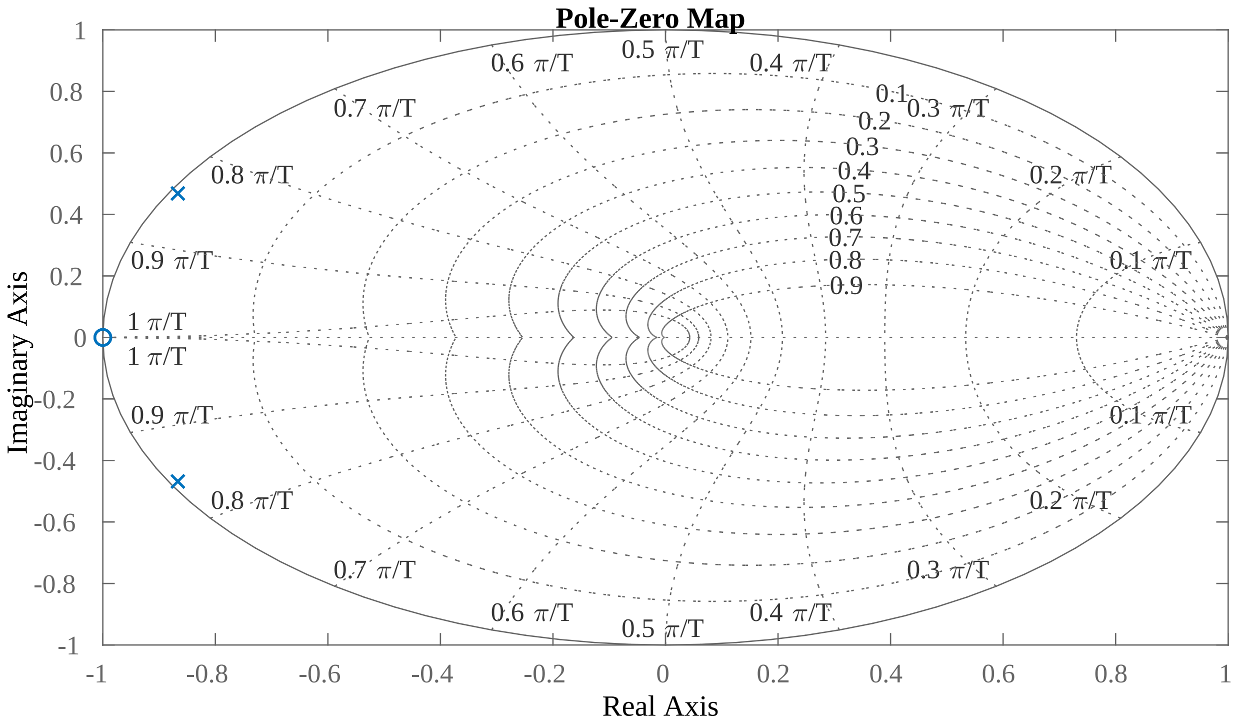

Step Response
Amplitude
Time (seconds)

$$K_i = 5 \tag{14}$$


Pole-Zero Map
Imaginary Axis
Real Axis


Step Response
Amplitude
Time (seconds)

$$K_i = 50 \tag{15}$$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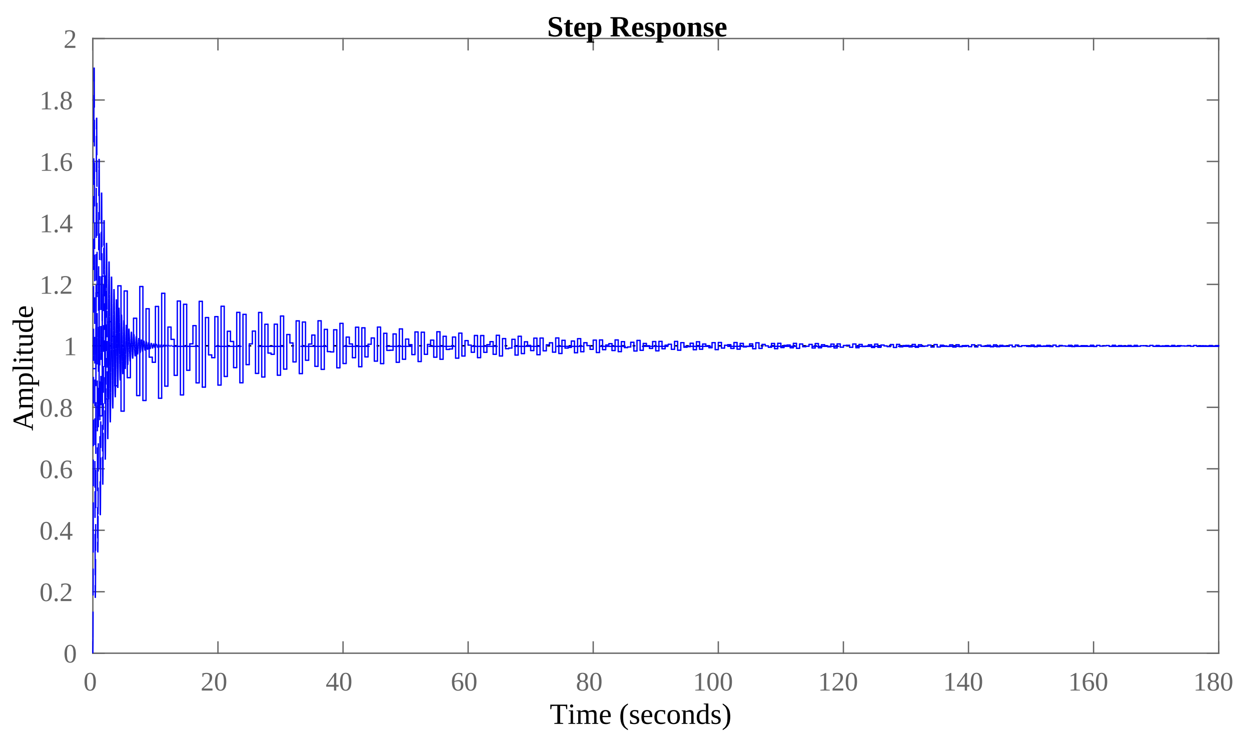
Step Response
Amplitude
Time (seconds)