Homework

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Final Project

Problem 2

The computed deficiency angle is $90°$.

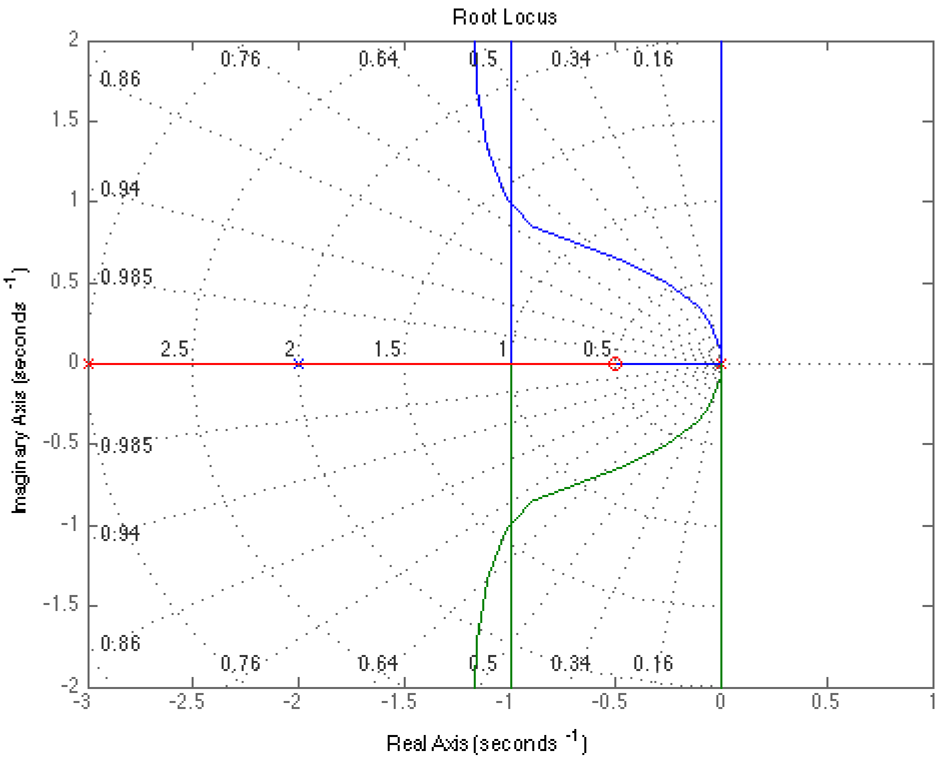
Solution 1

One solution is to choose a pole-zero pair that cancels a pole at the origin: $G_c(s) = \frac{s+0}{s+2} \times \frac{1}{s^2}$. This corrects the angle deficiency as follows: $135 + 135 + 45 - 135 = 180$.

Solution 2

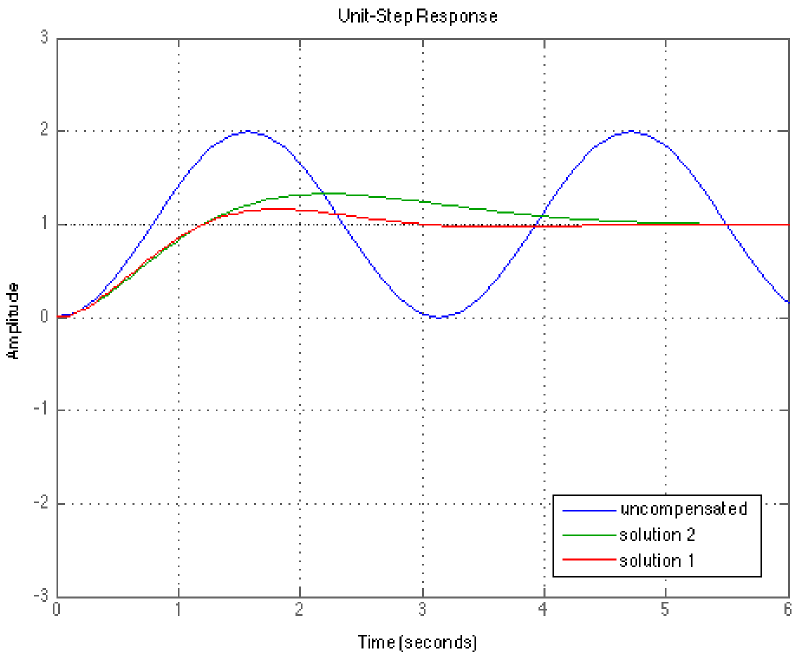
Another solution is $G_c(s) = \frac{s+0.5}{s+3} \times \frac{1}{s^2}$. This corrects the angle deficiency as follows: $135+135+30-120 = 180$.

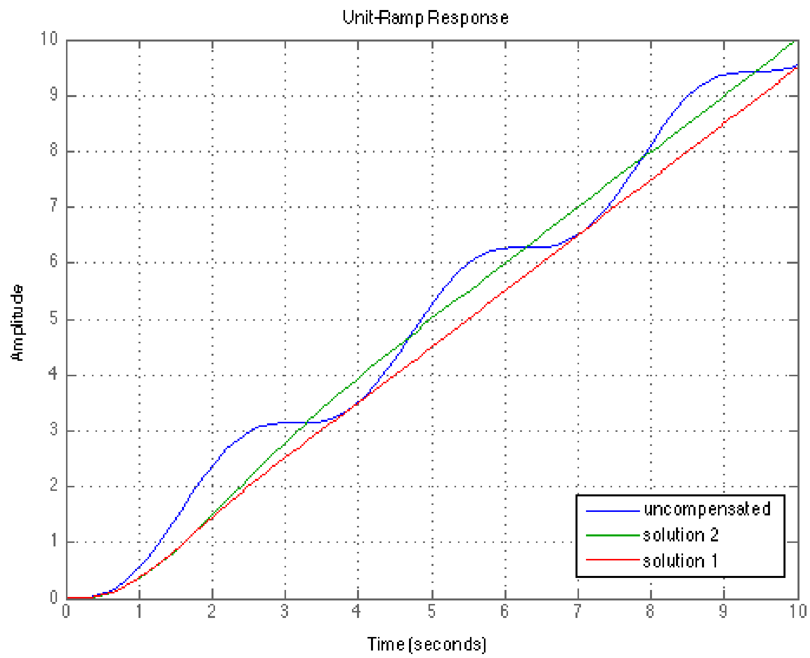
Root-Loci Plot



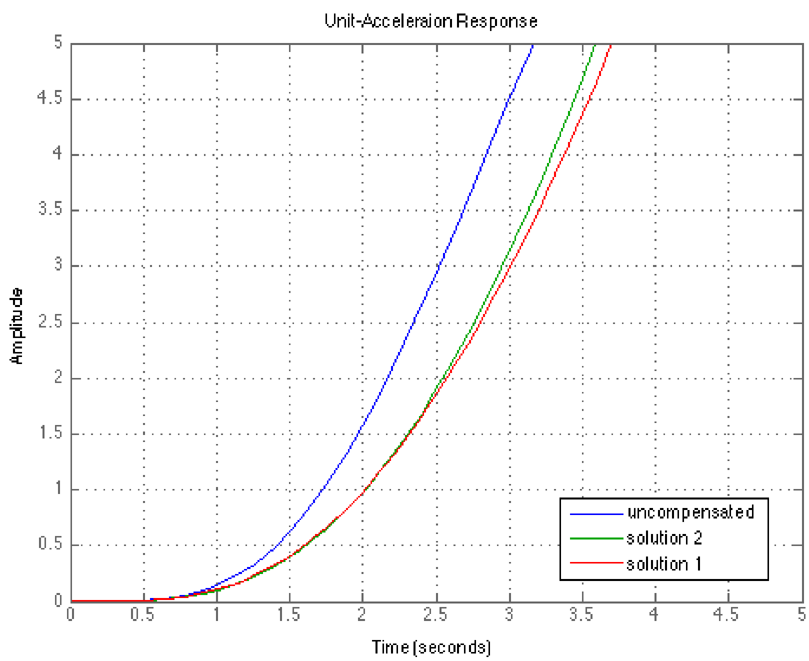
Both solutions pass through $s = -1 \pm j$ with a gain of $K = 4$.

System Responses





Unit-Ramp Response
Amplitude
Time (seconds)
uncompensated
solution 2
solution 1



Unit-Acceleraion Response
Amplitude
Time (seconds)
uncompensated
solution 2
solution 1

Given the response curves, solution 1 (pole-zero cancellation) seems the better option.

Problem 3

We calculate the steady state error, E_{ss}...

$$E_{ss} = \frac{10 \times 20}{10 \times 20 + 820} \approx 0.2$$

This gives us a desired steady state error of $E_{ss_c} = 0.02$. Then we use E_{ss_c} to calculate the desired pole-zero ratio...

$$\frac{z}{p} = \frac{10 \times 20 - 0.02 \times 10 \times 20}{0.02 \times 820} \approx 11.95$$

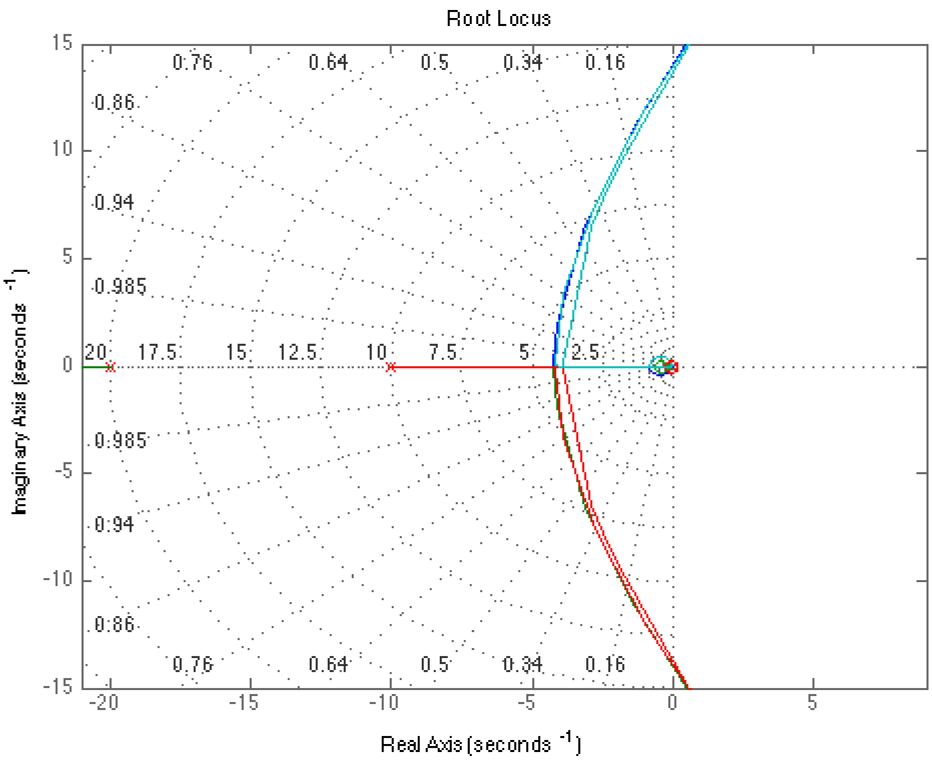
We use a rule of thumb to find the placement of our zero, $z = 20/50 = 0.4$ and apply our pole-zero ratio to arrive at

$$\frac{z}{p} = \frac{0.4}{0.03}$$

To get closer to the origin, we ignore manufacturing constraints and also choose

$$\frac{z}{p} = \frac{0.04}{0.003}$$

Root-Locus Plot



System Responses