ECE 486: Control Systems

Lecture 10A: Dominant Pole Approximation

Dominant-Pole Approximation

The dominant poles of a higher-order system are the slowest poles (largest time constant).

We can often approximate a higher-order system by a:

1. First-order approximation if the dominant pole is real
2. Second-order approximation if the dominant pole(s) are a complex pair.

The approximation is accurate if the dominant pole(s) are significantly slower than the remaining poles.

(Dominant pole time constant is 5x larger than other poles)

Example

Consider the fifth-order system:

$$G_2(s) = \frac{2.7 \times 10^5}{s^5 + 98s^4 + 2194s^3 + 36555s^2 + 107100s + 2.7 \times 10^5}$$

Poles: $s = \boxed{-1.5 \pm 2.6j,} -10 \pm 17.3j, -75$

$\omega_n = 3\frac{rad}{sec}$ and $\zeta = 0.5$

Approximation: $G_{low,2}(s) = \frac{b_0}{s^2+3s+9}$

Select b_0 to match the DC gain: $G_2(0)=G_{low,2}(0)$

$$b_0 = 9 \Rightarrow G_{low,2}(s) = \frac{9}{s^2+3s+9}$$

Example

Fifth-order system and dominant pole approximation

$$G_2(s) = \frac{2.7 \times 10^5}{s^5 + 98s^4 + 2194s^3 + 36555s^2 + 107100s + 2.7 \times 10^5}$$

$$G_{low,2}(s) = \frac{9}{s^2+3s+9}$$