

Lab 5

ECE 380 W21

Group 8

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Declaration of Authorship

We acknowledge and promise that:

- a) We are the sole authors of this lab report and associated simulation files/code.
- b) This work represents our original work.
- c) We have not shared detailed analysis or detailed design results, computer code, or Simulink diagrams with any other student.
- d) We have not obtained or looked at lab reports from any other current or former student of ECE/SE 380, and we have not let any other student access any part of our lab work.
- e) We have completely and unambiguously acknowledged and referenced all persons and aids used to help us with our work.

Student1 Name and Signature:

Arjun Bawa

Handwritten signature of Arjun Bawa in black ink.

Student2 Name and Signature:

Andrew Tran

Handwritten signature of Andrew Tran in black ink.

5.1

$$1/(1+K) \leq 0.02 \implies 1/0.02 - 1 \leq K \implies K = 49$$

5.2

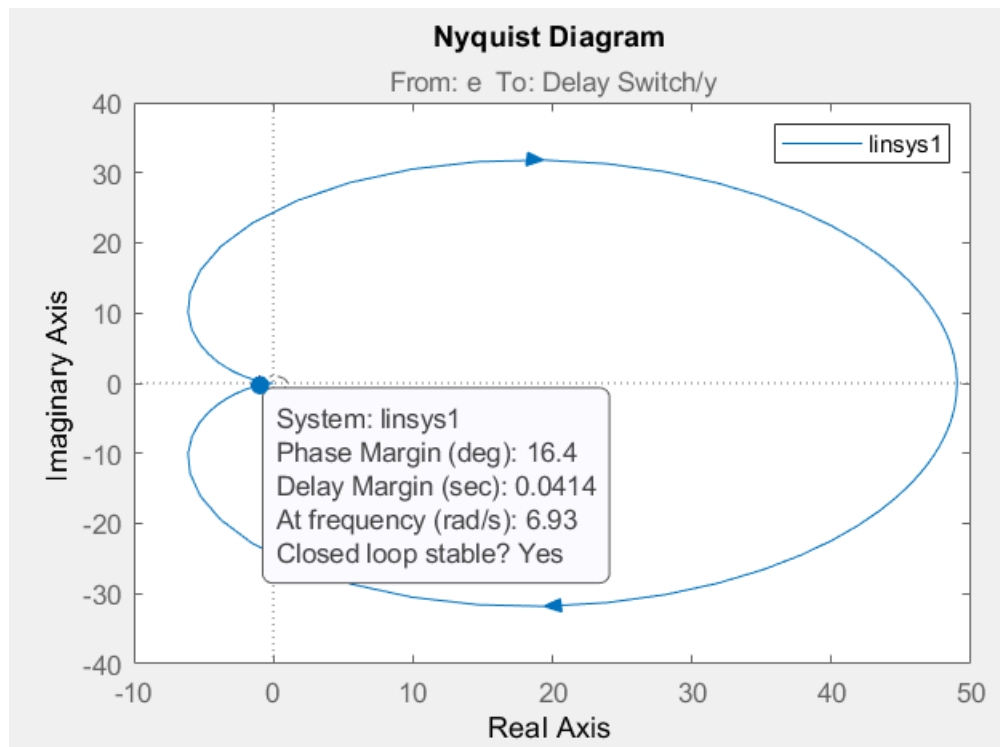


Figure 1 No delay

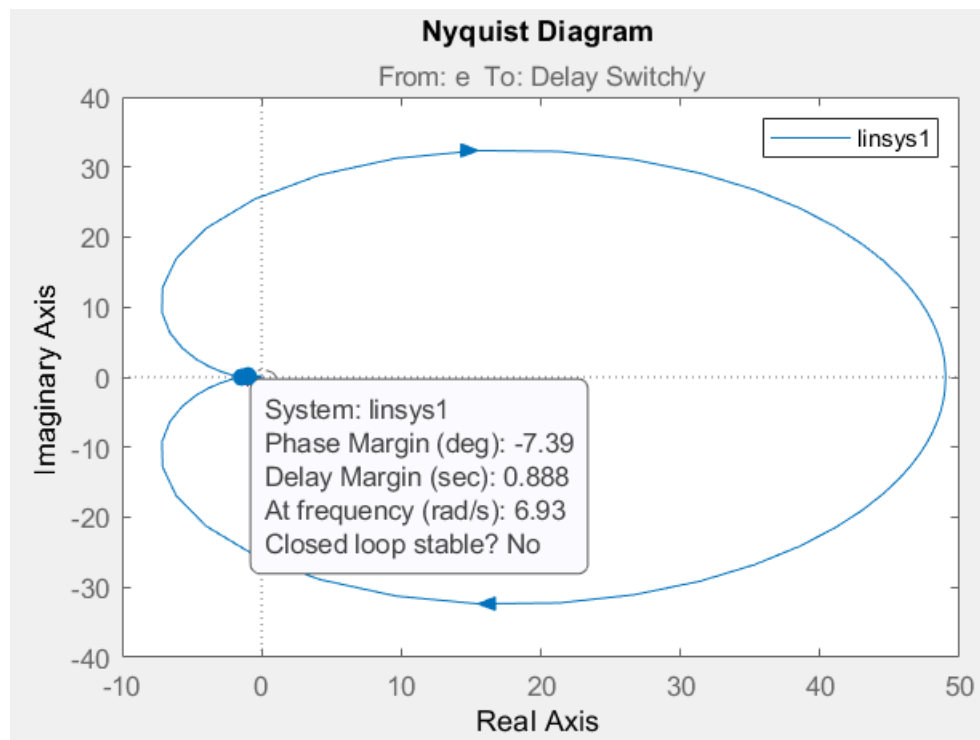


Figure 2 With delay

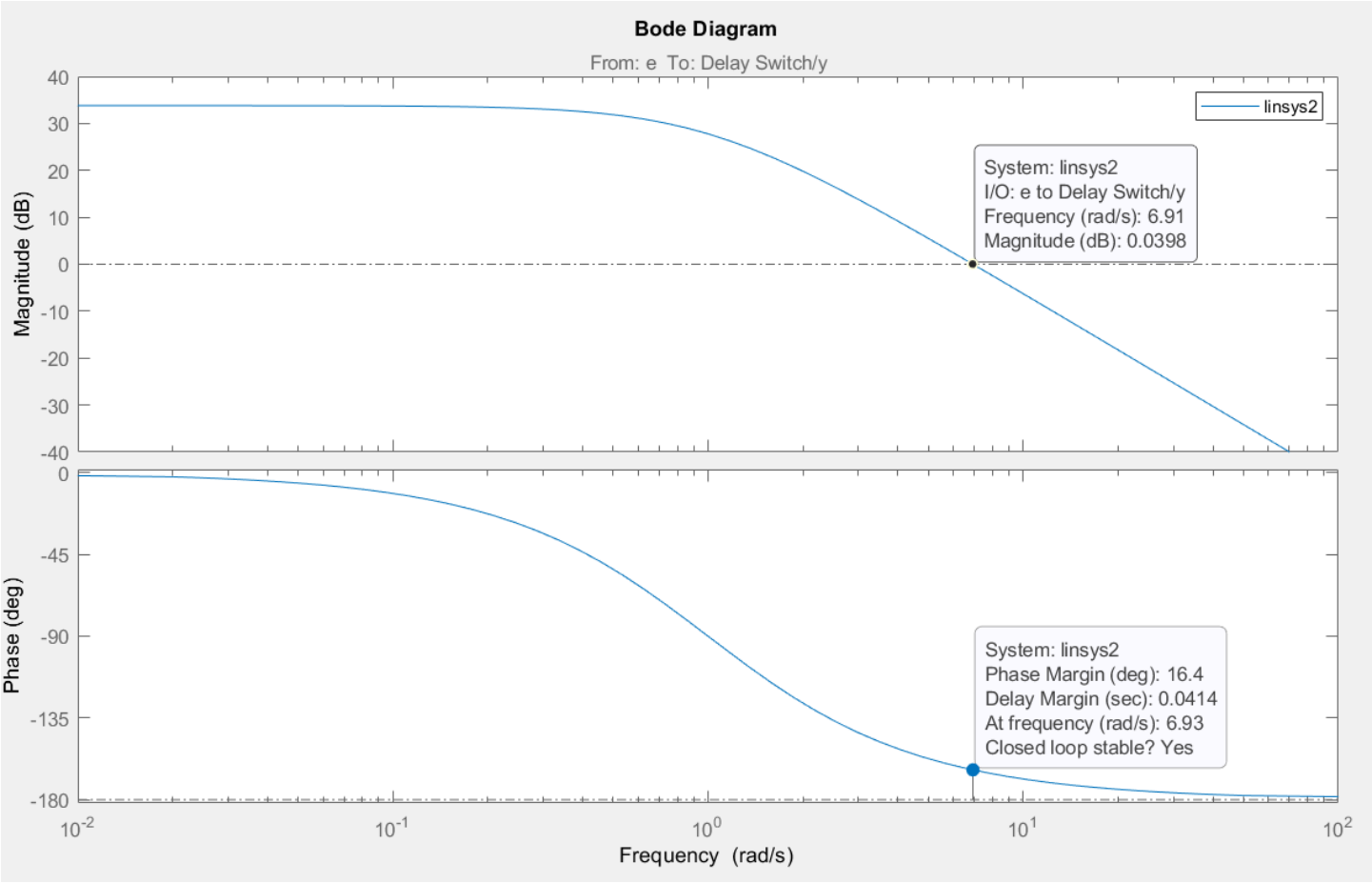


Figure 3

5.4 Lag

$$K = 49$$

$$\begin{aligned} \text{PM (from deliverable 5.3, Bode Plot)} \\ = 16.4^\circ \end{aligned}$$

$$\begin{aligned} \text{spec: } \text{PM}_{\text{desired}} &> \frac{12 \omega_{gc}}{100} \Rightarrow \frac{12 (6.91)}{100} \\ &+ 10^\circ \text{ buffer} \Rightarrow \text{PM}_{\text{desired}} > \frac{12 (6.91)(180)}{100\pi} + 10 \end{aligned}$$

This $\text{PM}_{\text{desired}}$ occurs when

$$\angle P(j\omega) = \text{PM}_{\text{desired}} - 180^\circ = -169.74^\circ$$

$$\Rightarrow \omega = 10.6 \frac{\text{rad}}{\text{s}} \text{ (see Bode Plot below),}$$

$$|P(j\omega)| \doteq 7.23 \text{ dB} \quad @ \quad \omega = 10.6 \frac{\text{rad}}{\text{s}}$$

$$\Rightarrow K_c \doteq 10^{\frac{-7.23}{20}} = 0.435 \quad \left(C_{\text{lag}}(s) = K_c \beta \frac{(\beta p)^{-1}s + 1}{p^{-1}s + 1} \right)$$

$$K = K_c \beta \Rightarrow \beta = \frac{K}{K_c} \doteq 112.64$$

$$\Rightarrow \alpha \doteq 8.8778 \times 10^{-3}$$

$$z = \beta p = \frac{10.6}{10} = 1.06 \Rightarrow p = \frac{1.06}{\beta} \doteq 9.41 \times 10^{-3}$$

$$T = p^{-1} \doteq 106.265$$

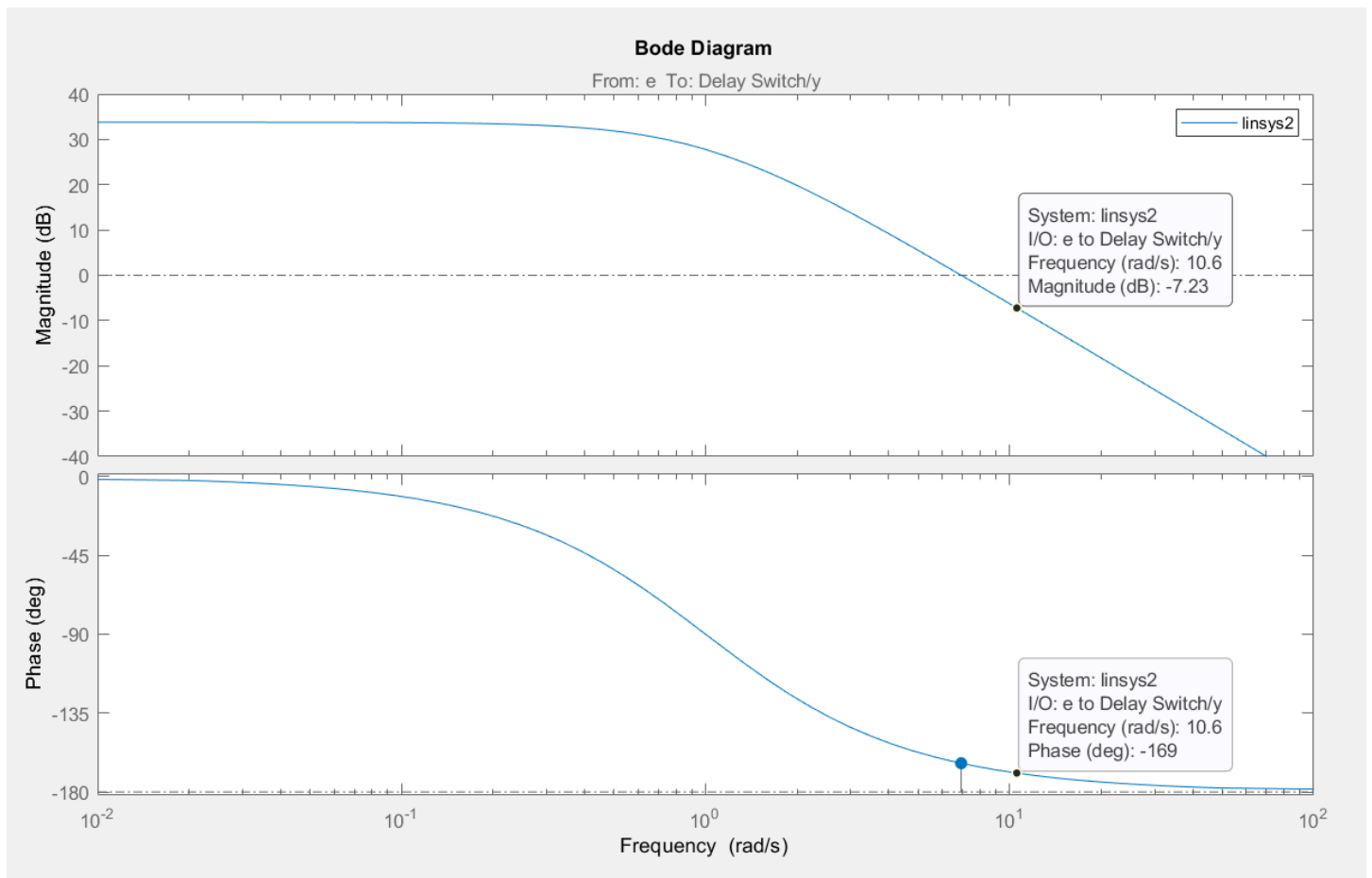


Figure 4

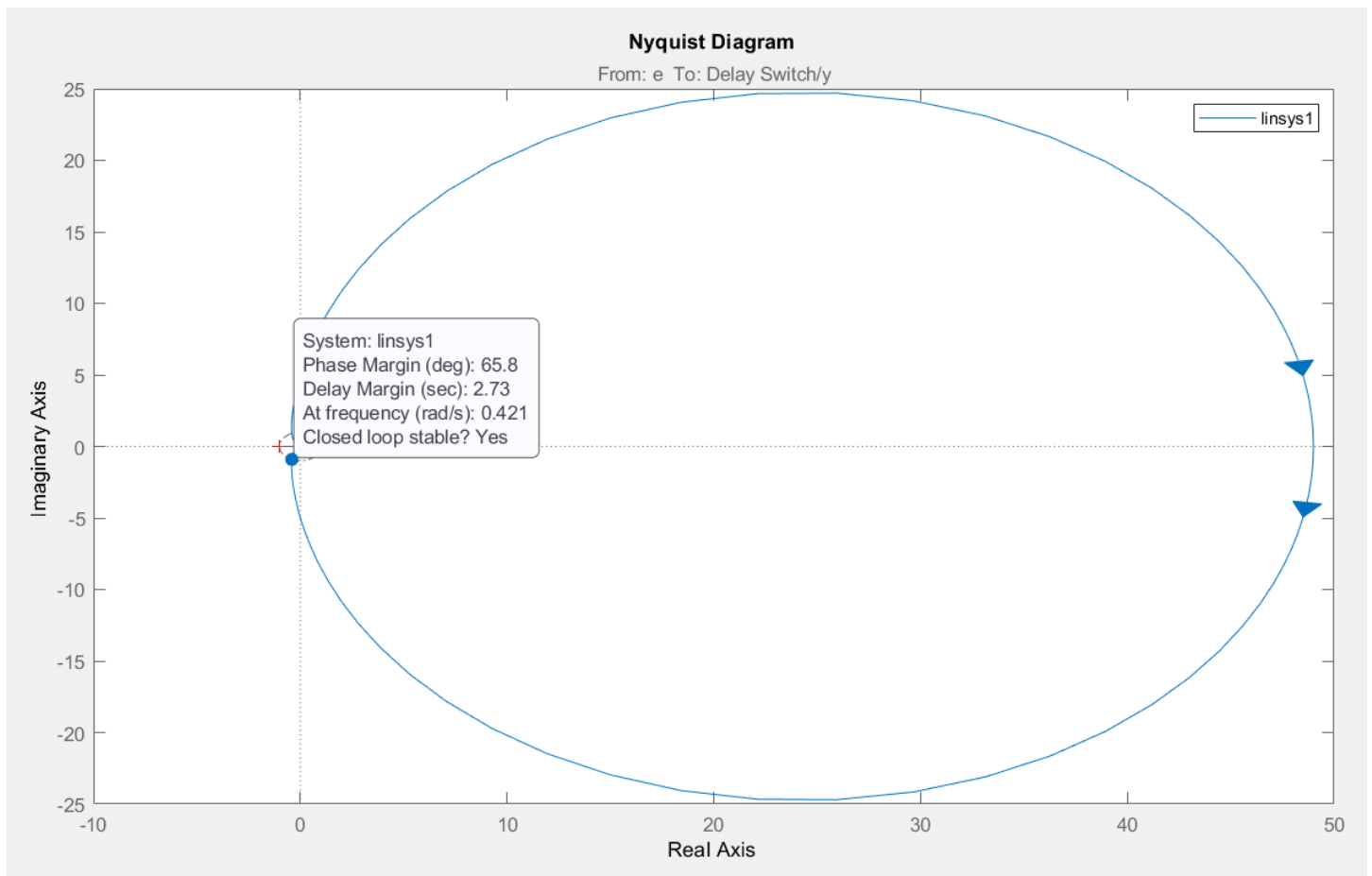


Figure 5 Lag compensated with delay

5.6 Lead

$$K = 49$$

$$\text{PM (from deliverable 5.3, Bode Plot)} \\ = 16.4^\circ$$

$$\text{spec: } \text{PM} > \frac{12 \omega_{gc}}{100} \Rightarrow \frac{12(6.91)}{100}$$

$$\Rightarrow \phi_{\max} = \frac{12(6.91)}{100} \times \frac{180}{\pi} - 16.4 + 10$$

$$\Rightarrow \tilde{\alpha} = \frac{1 - \sin \phi_{\max}}{1 + \sin \phi_{\max}} \quad \left(C_{\text{lead}}(s) = K \frac{(\tilde{\alpha} p)^{-1} s + 1}{p^{-1} s + 1} \right)$$

$$\omega_{gc} = 6.91 \frac{\text{rad}}{\text{s}}$$

$$\Rightarrow \alpha = \frac{1}{\tilde{\alpha}}$$

$$\Rightarrow \omega_{\max} = 6.91 \frac{\text{rad}}{\text{s}}$$

$$\Rightarrow p = \frac{\omega_{\max}}{\sqrt{\tilde{\alpha}}} \Rightarrow T = \frac{1}{p}$$

$$\text{spec: } \text{PM} > 0.8292 \Rightarrow \phi_{\max} = 41.11^\circ$$

$$\Rightarrow \tilde{\alpha} = 0.207 \Rightarrow \alpha = \tilde{\alpha}^{-1} = 4.84$$

$$\Rightarrow p = \frac{\omega_{\max}}{\sqrt{\tilde{\alpha}}} = 15.202 \Rightarrow T = p^{-1} = 0.0658$$

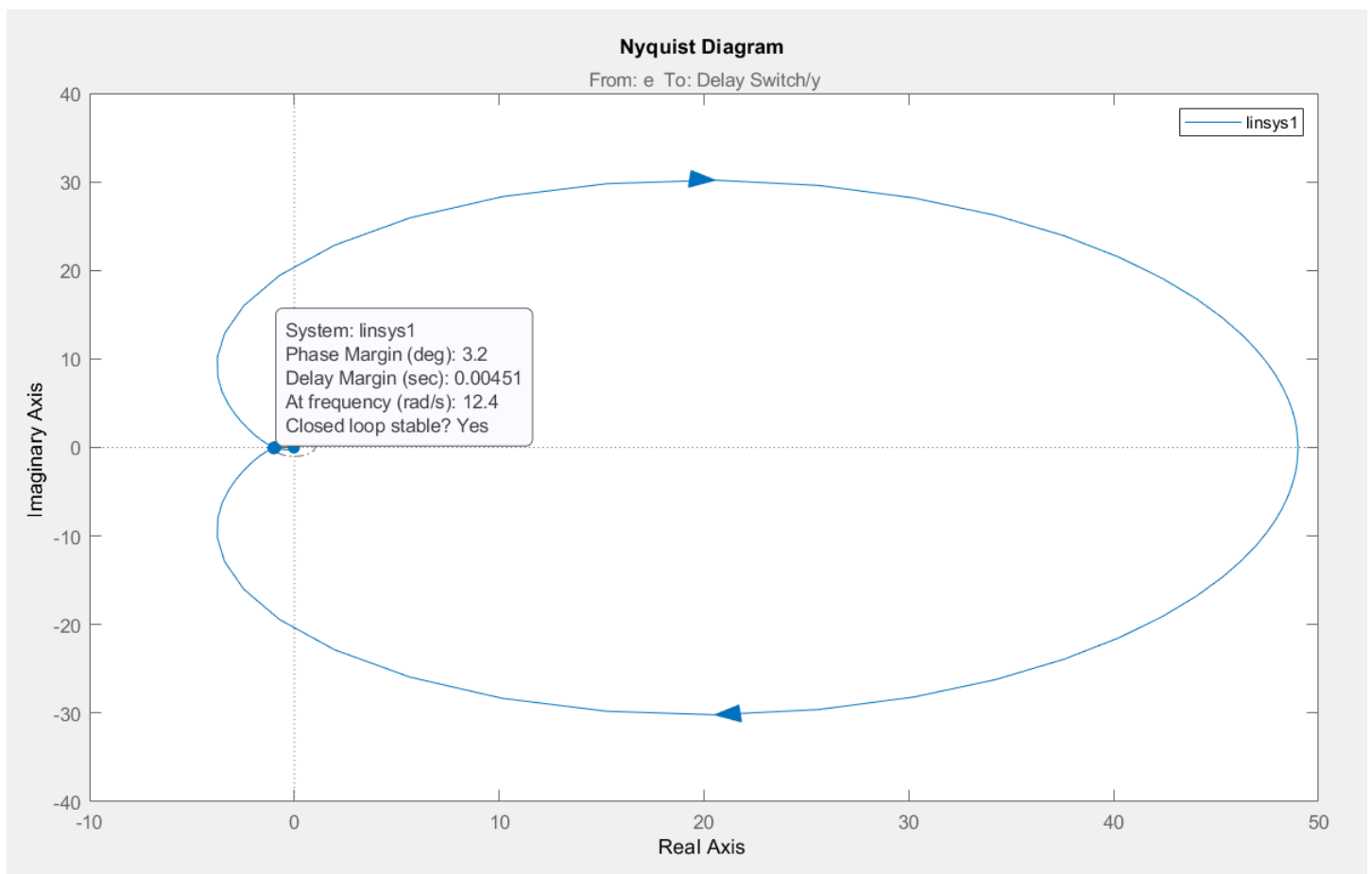


Figure 6 Lead compensated with delay

5.8

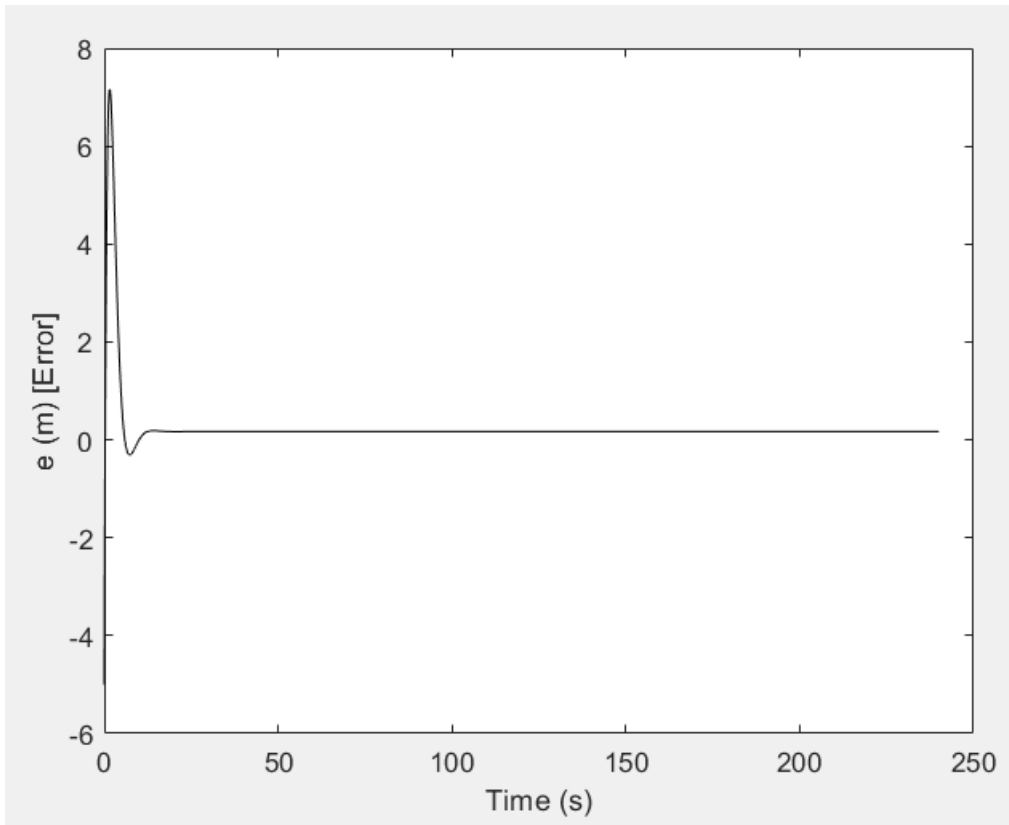


Figure 7

5.9

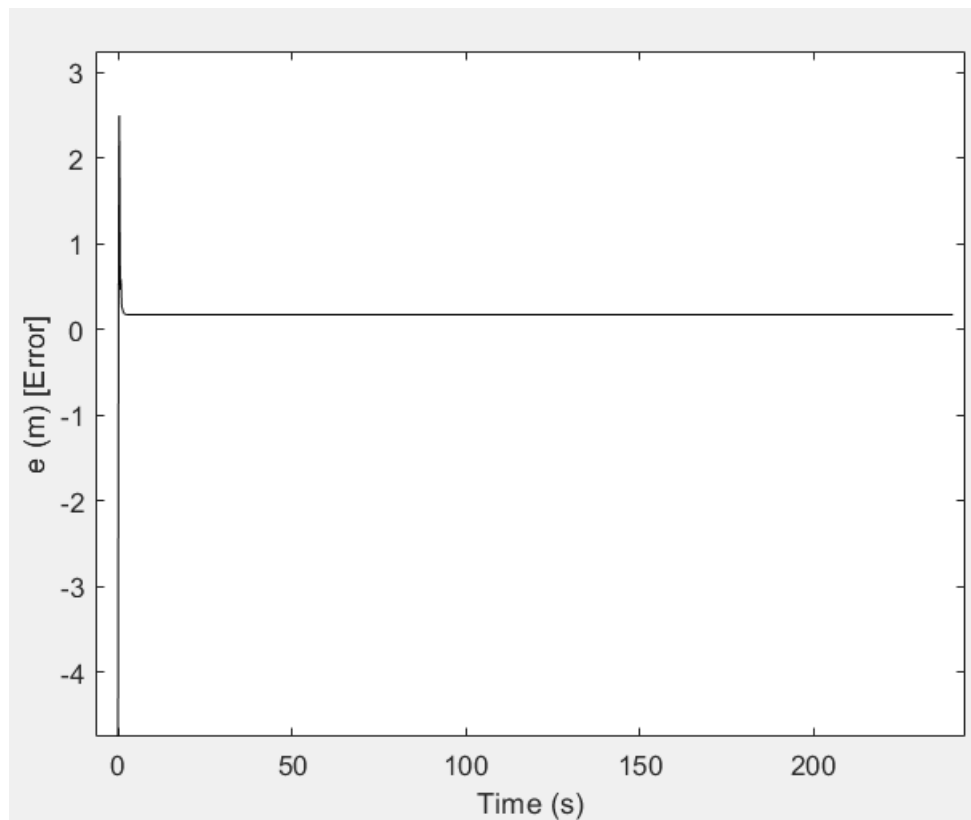


Figure 8

5.10

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