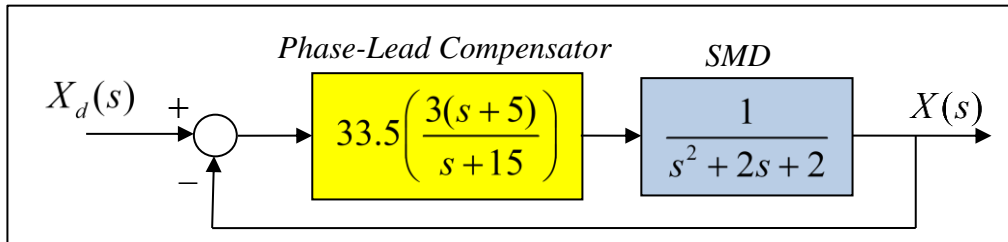


ME 4710 Motion and Control

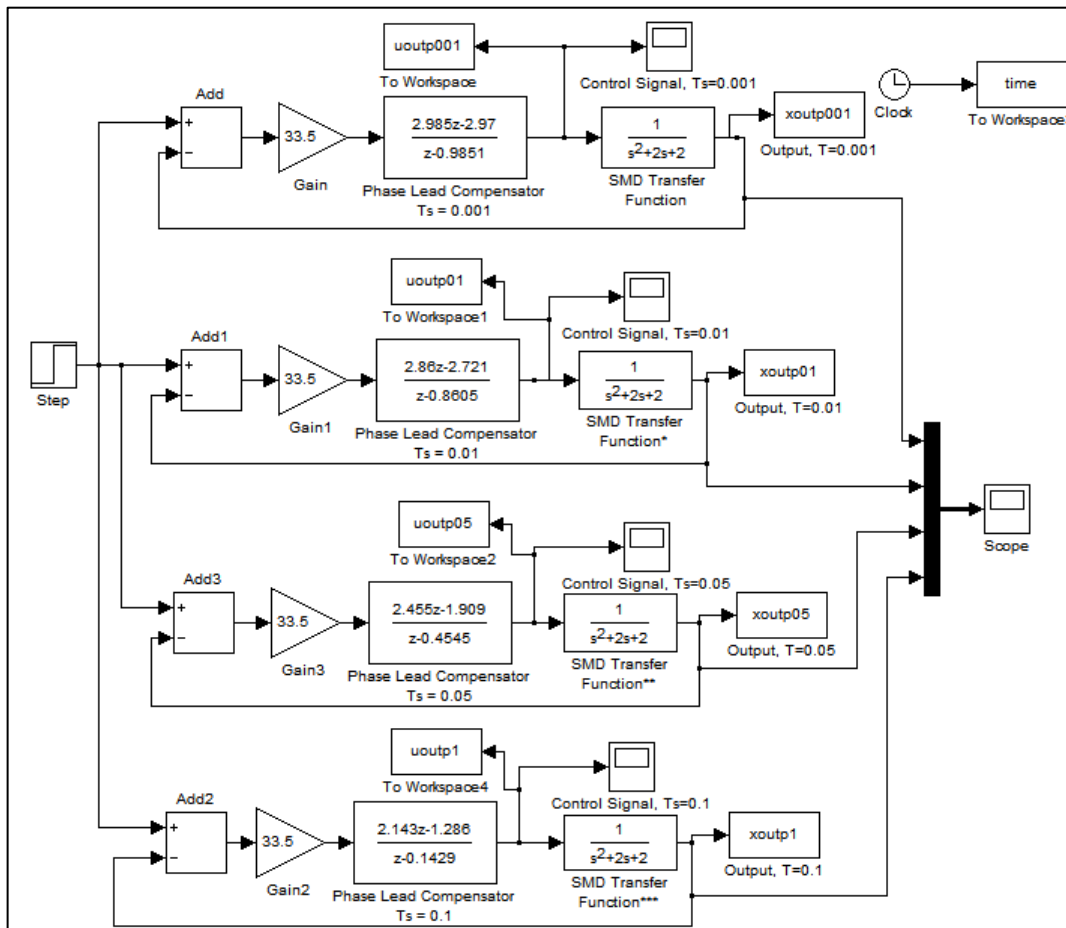
Example: Digital Phase-Lead Control of a Spring-Mass-Damper

Position control of a spring-mass-damper system using a *continuous phase-lead* compensator is shown in the diagram below.



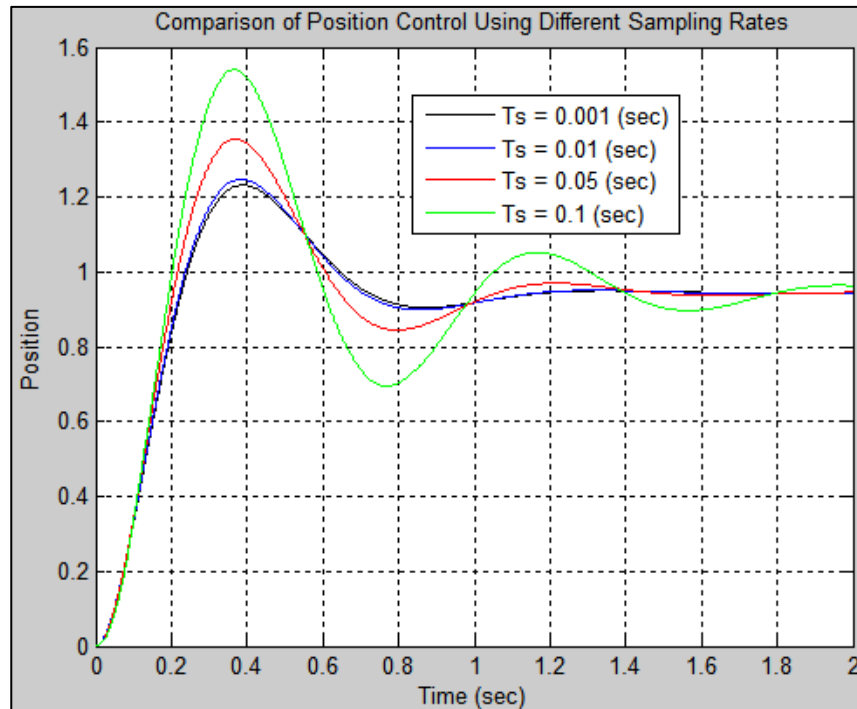
Closed-Loop Position Control of a Spring-Mass-Damper System

In the following results, the phase-lead compensator is converted to discrete form to examine the effects that *finite sampling times* have on performance. The compensator is converted using *Tustin's approximation* at sampling times of $T = 0.001$ (sec), $T = 0.01$ (sec), $T = 0.05$ (sec), and $T = 0.1$ (sec), and the resulting approximations are implemented in the Simulink model shown below.

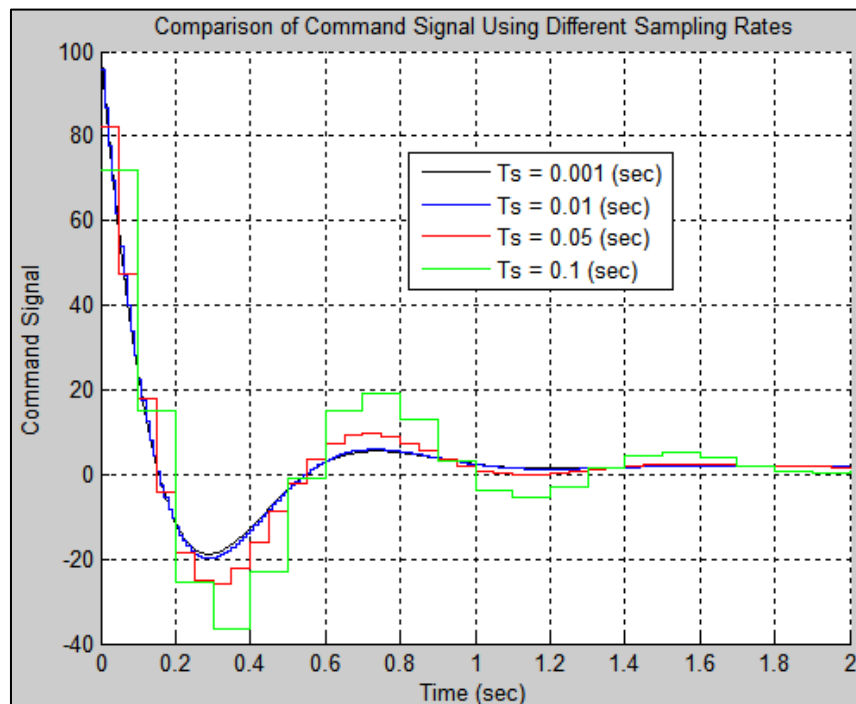


Simulink Model with Discrete Compensators

The compensator is *modeled* as if it were *implemented* using digital hardware at each of the *four sample rates*, and the *SMD* is *modeled* as a *continuous system*. The *results* for the *four different systems* are shown below. Note that the position control *degrades* as the sampling time becomes *too large*.

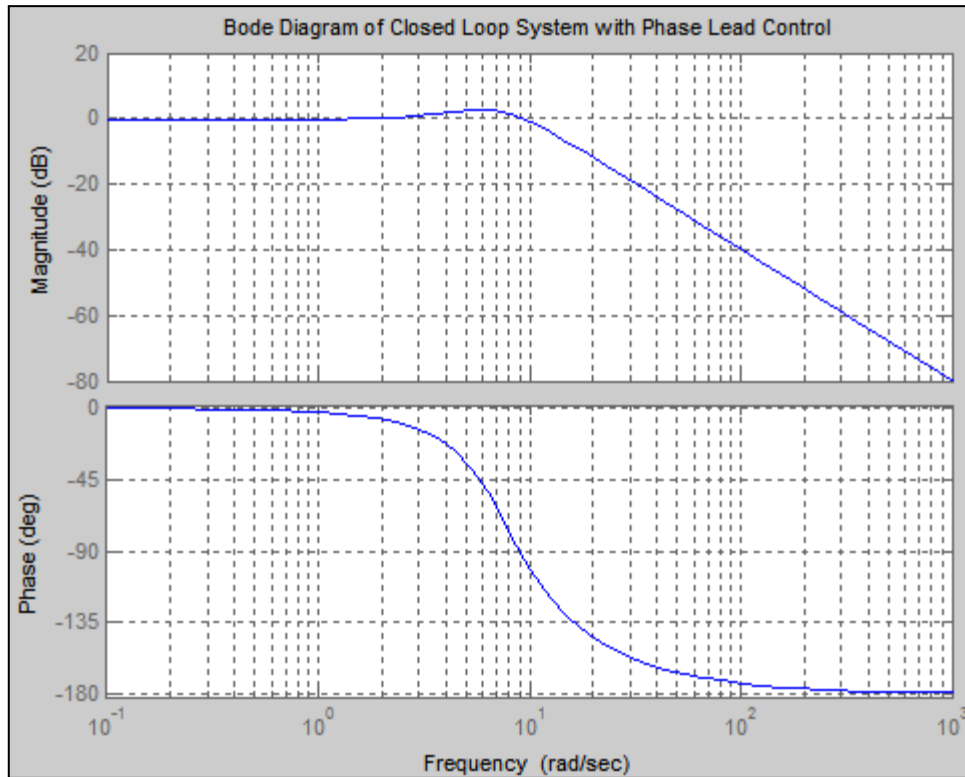


Comparison of Position Control for the Different Sample Times



Comparison of Control Signals for the Different Sample Times

In general, *reasonable results* are expected when the sample rate is *at least 20 times* the *closed loop system bandwidth*. The Bode diagram of the closed loop system is shown below, indicating a *bandwidth* of approximately 10 (rad/s) = 1.6 (Hz). This result suggests that the sample rate for this system should be at least $f = 20(1.6) \approx 32$ (Hz). This correlates to *sample times* of $T \leq 0.03$ (sec). This is consistent with the results shown above.



Bode Diagram of the Closed-Loop System with Phase-Lead Control