Theory

Several important characteristics of the output response to a unit step change in input signal are:

1. Rise time t_r : For overdamped responses, rise time is the time taken by the plant output to go from 10% to 90% of final (steady state) response value. For underdamped responses, the rise time is the time taken to go from 0% to 100% of final steady state response value.

2. Settling timet_s: It is the time taken to reach and stay within 2% (or 5%) of final response value.

3. Peak Overshoot PO: It is the difference between the peak and final response values.

These characteristics are helpful when designing controllers to meet time-domain specifications.

The Maglev plant model is given by the second order transfer function

$$P(s) = (DC)\frac{{\omega_n}^2}{s^2+2\zeta\omega_n s+{\omega_n}^2} \ , \qquad (1)$$

where the parameters ω_n, ζ , and DC have been explained in the previous experiment. The output response characteristics can be calculated in terms of the parameters ω_n and ξ as *(see page 181 of the textbook by Norman S. Nise, Control Systems Engineering, sixth edition, Wiley, 2010).*

- Rise time:$t_r = (1.76\xi^3 - 0.417\xi^2 + 1.039\xi + 1)/\omega_n$, (approximate relation) (2)

- Settling time (for 2%): $t_s \approx \frac{4}{\xi\omega_n}$, (approximate relation) (3)
  (the numerator value actually varies from 3.91 to 4.74 as ξ varies from 0 to 0.9)

- Peak Overshoot (PO):$PO = e^{-\xi\pi/\sqrt{1-\xi^2}}$, (0< ξ<1) (4)