EN 312: Control Systems and Instrumentation
MATLAB simulation examples

Please note that we (the teaching assistants) may have made a mistake, please feel free to get back to us if you find any discrepancy.

Using commands in Matlab

Using suitable Matlab commands do the following:

1. Solve the differential equation with initial conditions:

   $d^2x/dt^2 = -5dx/dt - 3x + 7$, $x(0) = 0$, $x'(0) = 1$

2. Find the laplace transform for the following function:

   $f(t) = 7u(t) + 5e^{-3t}$

3. Find the inverse laplace transform for the following function:

   $F(s) = 7/(s^2 + 3s + 2)$

4. Obtain the pole zero plot of the following transfer function:

   $T(s) = 5s^3 + 7s^2 + 8s + 30/(s^4 + 15s^3 + 62s^2 + 85s + 25)$

5. Obtain the step response for a system whose transfer function is given as:

   $T(s) = 8s + 8/(s^3 + 3s^2 + 8s + 8)$

   Also find the step response specifications in the above case.

6. Obtain the time response of the above system for the following inputs:
   a) unit ramp input $u(t) = t$ b) acceleration $r(t) = 0.5t^2$ and c) exponential input $c(t) = e^{2t}$.

7. Obtain the root locus for a unity feedback system whose OL transfer function is given as:

   $G(s) = s^2 + 6s + 9/(s^4 + 8s^3 + 21s^2 + 40s + 80)$

   For any selected point on the locus display the step response and corresponding transfer function

8. Obtain the gain K and the corresponding step response for a damping ratio of $\delta = 0.707$ using the root locus technique for the negative feedback system with the following transfer functions:

   $G(s) = 1/(s(s + 3)(s + 5)(s + 7))$ $H(s) = s + 25/(s^2 + 10s + 100)$

9. Obtain the Bode plot and the corresponding specifications for the following transfer function:

   $G(s)H(s) = 5s^3 + 51s^2 + 20s + 400/(s^4 + 12s^3 + 60s^2 + 300s + 250)$

10. Obtain the Nyquist plot for the following transfer function:

    $G(s)H(s) = 6s + 9/(s^2 + 4s + 8)$

    Also obtain the polar plot for the above system.

11. Obtain the Nichols plot for the following transfer function:

    $G(s)H(s) = 4s + 8/(3s^2 + 6s + 7)$

Coding for RH Criterion

Write a generalized code in Matlab for obtaining the Routh array (Special cases can be excluded). Find the stability of the system by generating the array for the following characteristic equation:
$s^8 + 12s^7 + 60s^6 + 300s^5 + 25s^4 + 5s^3 + 6s^2 + 3s + 2$

Using Simulink for system time response

1. Demonstrate using Simulink the automatic tuning of a PID controller (assume step response parameters specified) for the unity feedback system having the following plant transfer function:

   $G(s)H(s) = 100/(s^2 + 20s + 100)$

2. For the above system considering only the open loop transfer function, find the time response for ramp and parabolic inputs and using Simulink.

3. Observe the effect of damping for a standard second order system using Simulink.

Control system design

Use the control system toolbox to design a) a simple integrator compensator and b) a lead compensator for a plant with the following transfer function (assume step response parameters specified):

$G_p(s) = 1/(s + 2)$