Laboratory Two (Report is Required)

0.1. The objective of this simulation study is to compare different PID implementation schemes for reference following, disturbance rejection and noise attenuation.

Suppose that the plant is described by the transfer function

$$G(s) = \frac{1}{s(s+1)^3} \tag{0.1}$$

a PID controller is designed for this system with $K_c = 0.56$, $\tau_I = 8$ and $\tau_D = 0.3$. The filter for the derivative control is selected as $\frac{1}{0.1\tau_D s+1}$.

Case A. Implement this PID control system using MATLAB standard PID controller implementation object function (PID).

Case B. Implement this PID control system with the proportional and integral control on the feedback error $(r(t) - y(t))$, and the derivative control on the output only.

Case C. Implement this PID control system with the integral control on the feedback error $(r(t) - y(t))$, both proportional control and derivative control on the output only.

The simulation conditions for the closed-loop control system are given as below.

1. Reference input signal is a step with amplitude of 6. Choose your own sampling interval Δt and simulation time.
2. Add input disturbance signal with amplitude of -3 at half of your simulation time.
3. Add measurement noise with power of 0.001 at time $t = 0$.

In MATLAB, plot your reference signal, control signal and output signal for the three cases. Also, for the three cases, calculate the sum of squared errors, *i.e.* $\sum_{i=1}^{M}(r(t_i) - y(t_i))^2$, where M is the number of data samples used in the simulation studies. Discuss your observations and conclusions for the three implementation schemes in terms of reference following, disturbance rejection, and measurement noise attenuation.

0.2. The objective of this simulation study is to examine the selection of a desired closed-loop performance in the presence of modelling errors.

Given a first order plus delay system with the transfer function

$$G(s) = \frac{10e^{-5s}}{10s+1} \tag{0.2}$$

as shown in the lecture slides, we first approximated the time delay using Pade approximation, and then designed PID controllers for this time delay system.

There are three cases to be considered in the design and simulation studies.
Case A. The desired closed-loop bandwidth and the damping coefficient are selected as $w_n = 0.2, \xi = 0.707$. With pole-zero cancelation, the PID controller parameters are calculated as

$$K_c = .1793;\ \tau_I = 8.0323;\ \tau_D = 1.3375; \tau_f = 0.5581.$$

Case B. The desired closed-loop bandwidth is increased to 0.4 while ξ is unchanged. The PID controller parameters are calculated as

$$K_c = 0.332;\ \tau_I = 7.1;\ \tau_D = 1.43;\ \tau_f = 0.292.$$

Case C. Code your own PID controller parameter solutions by following the analytical expressions in the lecture slides. Find the desired closed-loop bandwidth w_n that will lead to sustained oscillations in the simulated output. This procedure needs to be performed by trial-and-errors with the MATLAB and Simulink programs you wrote.

The simulation conditions for the closed-loop control system are given as below.

1. Reference input signal is a step with amplitude of 3. Choose your own sampling interval Δt and simulation time.
2. Add input disturbance signal with amplitude of 1 at half of your simulation time.

In MATLAB, plot your reference signal, control signal and output signal for the three cases. Discuss your observations and conclusions on the relationships between the time delay and the selected desired closed-loop bandwidth.