Mid-semester Assignment for Advanced Control Systems
(EEET 2100 and EEET 1368)

Instructions

1. Your submission of the assignment paper consists only one word document with your name and student number and the document will be sent to my email address: liuping.wang@rmit.edu.au.

2. You can copy and paste your MATLAB programs into the same document. However, you do not need to include the MATLAB functions.

3. The submission time is 9:30 AM on the 16th of April. You are only permitted to submit your assignment paper once.

Design and simulation of PID and resonant controllers.

1. (**25 marks**) The transfer function model for level control of a water tank system is described by a first order transfer function:

$$G(s) = \frac{0.01}{10s+1}$$

where the input is the flow rate and the output is the fluid level in the tank. Design a PI controller to regulate the fluid level, where the desired closed-loop performance is specified by the closed-loop polynomial $s^2 + 2\xi w_n s + w_n^2$, $\xi = 0.707$ and $w_n = 1$. Simulate the closed-loop output response to a unit step set-point signal.

2. (**25 marks**) The transfer function of a process unit in a resource company is described by the first order plus delay model:

$$G(s) = \frac{0.5}{s+1}e^{-6s}$$

Design a PID controller to control this time delay system. Since there is an approximation used to approximate the time delay and there is a difference between the design model and the actual plant, we may need to adjust the desired closed-loop performance in order to obtain stable closed-loop control system. You may start with all desired closed-loop poles positioned at the plant pole -1, then simulate the closed-loop response with unit step set-point signal by suitably choosing the sampling interval and simulation time. If the closed-loop system is oscillatory or unstable, then you reduce the magnitude of the poles by half, and repeat the design and simulation, until you get the stable closed-loop system with fastest response possible yet without oscillation. You may use the pole-zero cancellation technique to simplify the computation.

3. (**25 marks**) A mechanical system is severely underdamped with unstable zero, with the transfer function

$$G(s) = \frac{-s+1}{s^2+0.2s+10}$$

where the input is voltage and the output is vibration speed. Design a PID controller to control this mechanical system, where all desired closed-loop poles are positioned at -10. Simulate the closed-loop output response to a unit step set-point signal and the response to an input disturbance with amplitude -3, which occurs at time $t = 3$. Because the system is oscillatory, you can not cancel any plant pole. Also, you need to suitably choose your simulation time and sampling interval in order to obtain good simulation results (check the configuration parameters in Simulink and choose a smaller sampling interval if it does not behave well).

4. (**25 marks**) The position of a robot arm is described by the transfer function

$$G(s) = \frac{10}{(0.1s+1)s}$$

design a resonant controller so that the position of the arm will track a sinusoidal reference signal $r(t) = 3sin(\omega_0 t)$, where $\omega_0 = \sqrt{2}$. All closed-loop poles are positioned at -8. Simulate the output of the closed-loop system with the sinusoidal reference signal $r(t)$ where you are free to choose the sampling interval and simulation time. Use final value theorem to show that indeed the error between the reference signal $r(t)$ and the closed-loop controlled robot arm position $y(t)$ will converge to zero as t increases.

In the PID controller simulations, you may choose to use either the original PID or the alternative IPD controller structure. Or you would like to use both and compare the results. In your report, include your MATLAB/Simulink programs together with your solutions, simulation results and discussions.