EE3304 DIGITAL CONTROL SYSTEMS PART II
TUTORIAL FOUR

Q.1. Consider the system given by the transfer function

$$G(z) = \frac{z+0.9}{z^2 - 2.5z + 1}$$

Design a pole placement controller in the form of

$$U(z) = \frac{T(z)}{R(z)} U_c(z) - \frac{S(z)}{R(z)} Y(z)$$

such that the closed-loop system has the desired characteristic polynomial

$$A_m(z) = z^2 - 1.8z + 0.9$$

Let the polynomial Ao(z) have as low order as possible and place all of its poles in the origin. Design the controller such that the steady-state gain from the command signal $u_c(k)$ to the output y(k) is one. Consider the following two cases:

a) The process zero is canceled.

b) The process zero is not canceled.

Simulate the step responses of the two cases (letting uc(k) = 1), and plot out the corresponding output and input signals. Discuss the differences between the two controllers. Which one should be preferred?

Q.2. Assume that the process is described by the transfer function

$$G(z) = \frac{0.4z + 0.3}{z^2 - 1.6z + 0.65}$$

Design a pole placement controller in the form of

$$U(z) = \frac{T(z)}{R(z)} U_c(z) - \frac{S(z)}{R(z)} Y(z)$$

to satisfy the following specifications:

- Static gain = 1
- Cancellation of process zero
- Disturbance rejection for constant disturbance
- Desired characteristic polynomial

$$A_m(z) = z^2 - 0.7z + 0.25$$

Q.3. Assume that the process is described by the transfer function

$$G(z) = \frac{z-0.5}{z^2-4z+3}$$

Design a pole placement controller in the form of

$$U(z) = \frac{T(z)}{R(z)}U_c(z) - \frac{S(z)}{R(z)}Y(z)$$

such that the closed loop transfer function from the command signal, $u_c(k)$, to the system output, $y(k)$, follows the reference model, $\frac{1}{z^2}$.

Q.4. In some systems the process output y(k) and the command signals $u_c(k)$ are not available because only the error $e = u_c - y$ is measured. This case is called error feedback. A typical case is a CD player in which only the deviation from the track can be measured. This means that a two-degree-of-freedom controller cannot be used. Mathematically it means that the polynomials S and T are identical and the control law becomes

$$U(z) = \frac{S(z)}{R(z)}(U_c(z) - Y(z))$$

Assume that the process is described by the same transfer function

$$G(z) = \frac{z-0.5}{z^2-4z+3}$$

as that for Q.3. Design an error feedback controller such that the closed loop transfer function from the command signal, $u_c(k)$, to the system output, $y(k)$, follows the reference model, $\frac{1}{z^2}$.