Second Order System Adjustment:

$G(s) = \frac{y}{u} = \frac{s+5}{(s-1)(s+3)} = \frac{s+5}{s^2+2s-3}$

$G_m(s) = \frac{y_m}{u_c} = \frac{s+2}{(s+1)(s+2)} = \frac{s+2}{s^2+3s+2}$

Let the control law : $u(t) = t_o u_c(t) + t_1 u_c(t-1) - s_o y(t) - s_1 y(t-1)$

$u = (t_o + t_1 s)u_c - (s_o + s_1 s)y$

$y\frac{s^2+2s-3}{s+5} = (t_o + t_1 s)u_c - (s_o + s_1 s)y \quad \Rightarrow \quad \frac{y}{u_c} = \frac{t_o+t_1 s}{\frac{s^2+2s-3}{s+5}+s_o+s_1 s} = \frac{t_1 s^2+(t_o+5t_1)s+5t_o}{(1+s_1)s^2+(2+s_o+5s_1)s-3+5s_o}$

$e = y - y_m = \frac{t_1 s^2+(t_o+5t_1)s+5t_o}{(1+s_1)s^2+(2+s_o+5s_1)s-3+5s_o}\ u_c - y_m$

$\frac{\partial e}{\partial t_o} = \frac{s+5}{(1+s_1)s^2+(2+s_o+5s_1)s-3+5s_o}\ u_c$

$\frac{\partial e}{\partial t_1} = \frac{s^2+5s}{(1+s_1)s^2+(2+s_o+5s_1)s-3+5s_o}\ u_c$

$\frac{\partial e}{\partial s_0} = \frac{-\left[t_1 s^2+(t_o+5t_1)s+5t_o\right](s+5)}{[(1+s_1)s^2+(2+s_o+5s_1)s-3+5s_o]^2}\ u_c = \frac{-(s+5)}{(1+s_1)s^2+(2+s_o+5s_1)s-3+5s_o}\ y$

$\frac{\partial e}{\partial s_1} = \frac{-\left[t_1 s^2+(t_o+5t_1)s+5t_o\right](s^2+5s)}{[(1+s_1)s^2+(2+s_o+5s_1)s-3+5s_o]^2}\ u_c = \frac{-(s^2+5s)}{(1+s_1)s^2+(2+s_o+5s_1)s-3+5s_o}\ y$

At steady state : $\frac{(s+5)}{(1+s_1)s^2+(2+s_o+5s_1)s-3+5s_o} = G_m(s)$

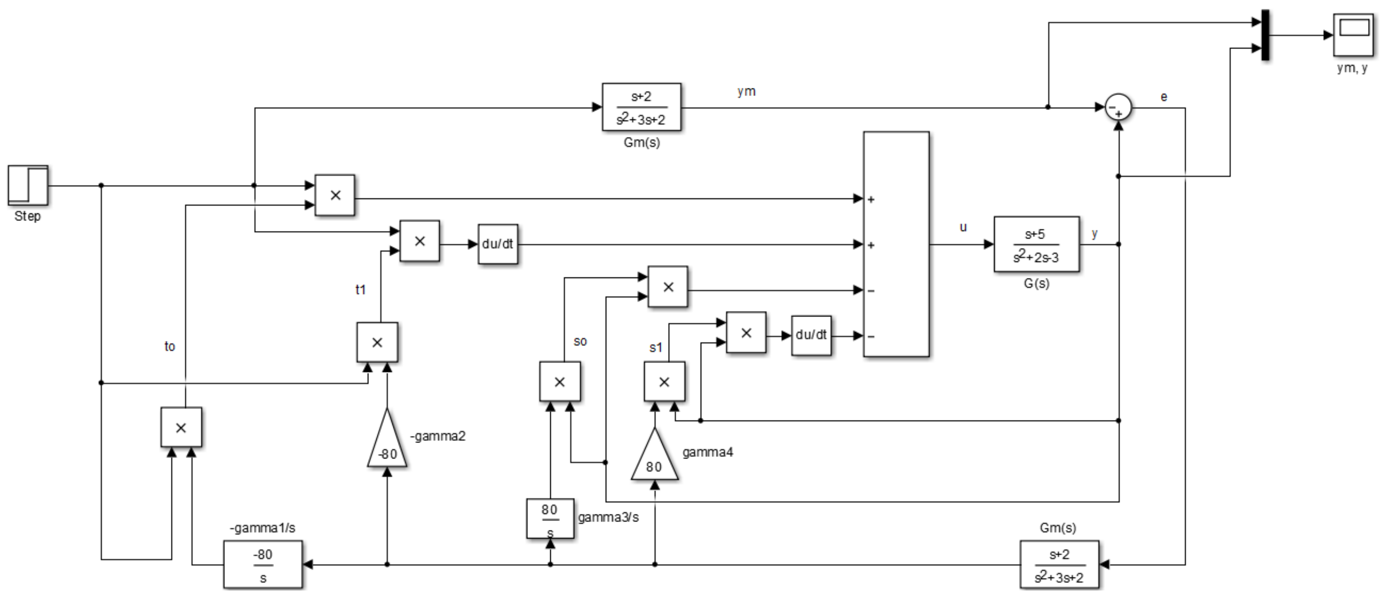
$\frac{d\theta}{dt} = -\gamma\frac{\partial e}{\partial \theta}e$

$\frac{dt_o}{dt} = -\gamma_1[G_m(s)u_c]e$

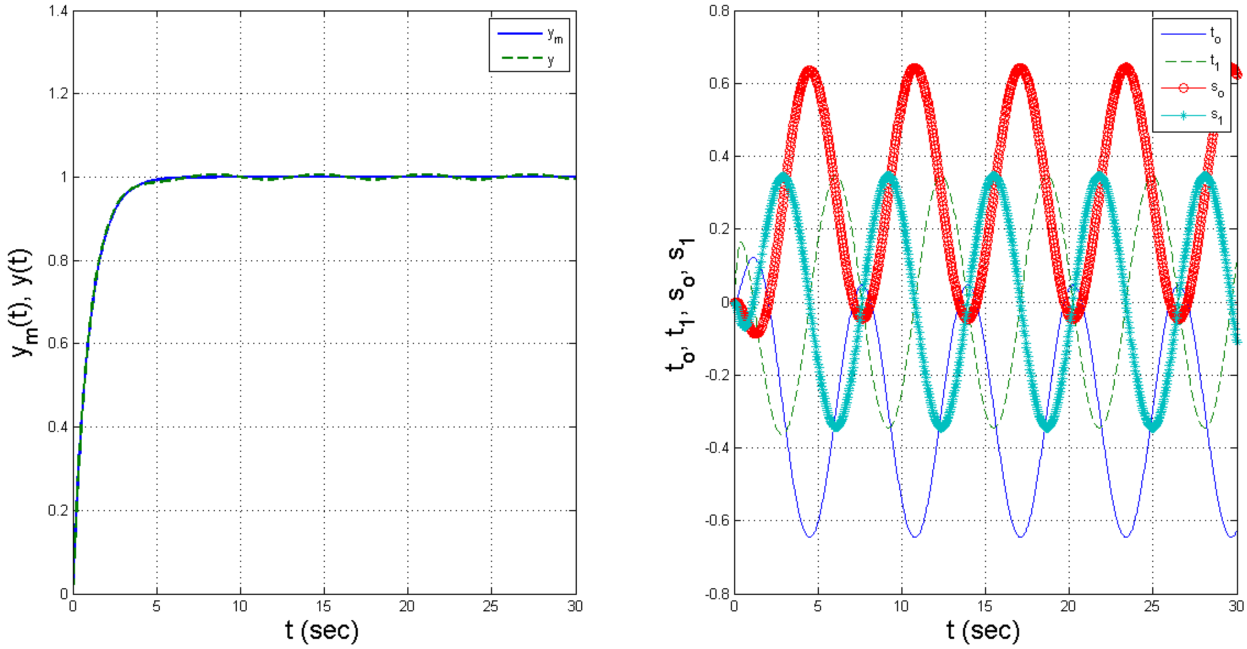
$\frac{dt_1}{dt} = -s\gamma_2[G_m(s)u_c]e$

$\frac{ds_o}{dt} = \gamma_3[G_m(s)y]e$

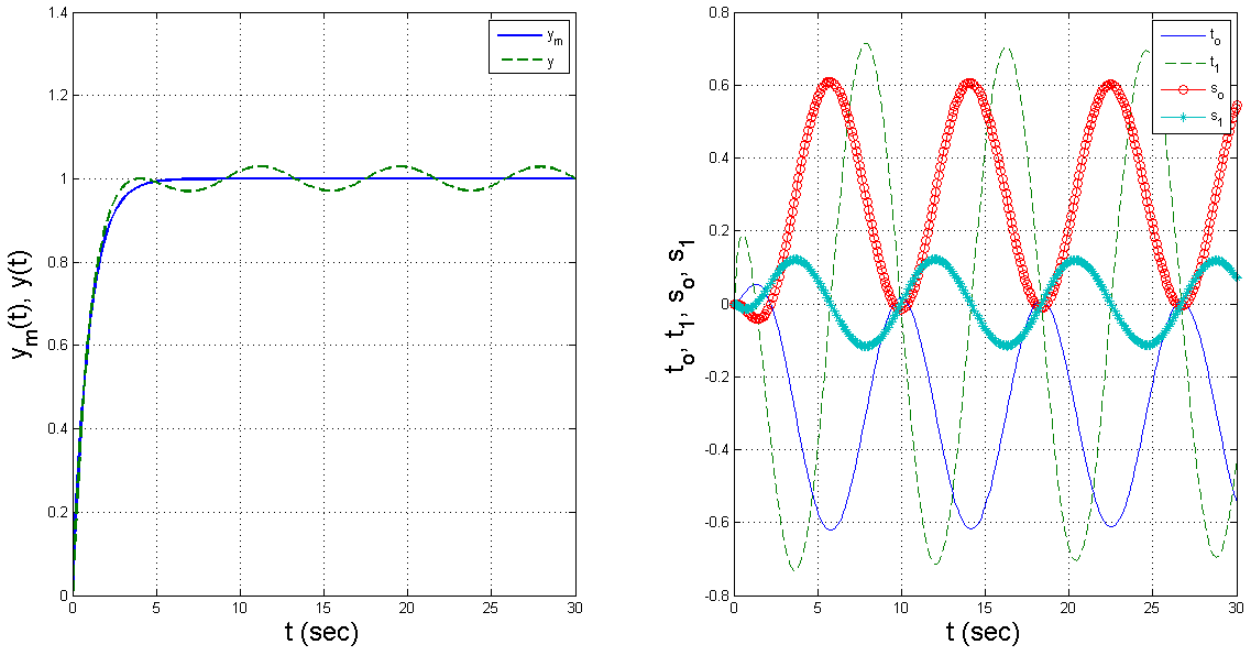
$\frac{ds_1}{dt} = s\gamma_4[G_m(s)y]e$



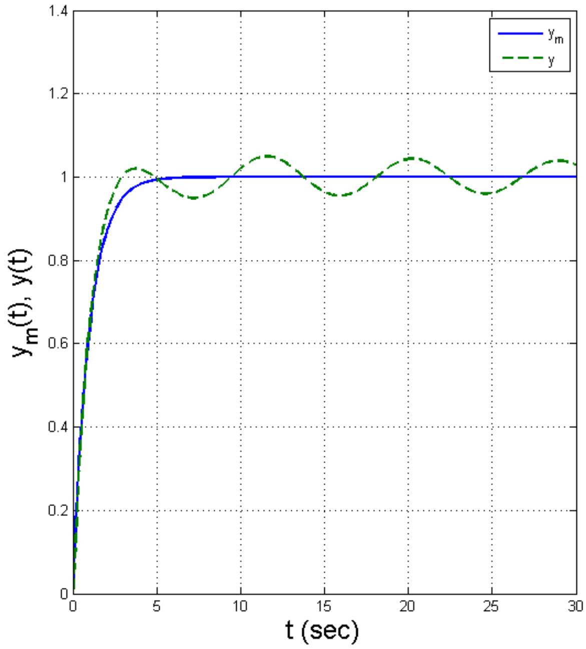
At $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 80$

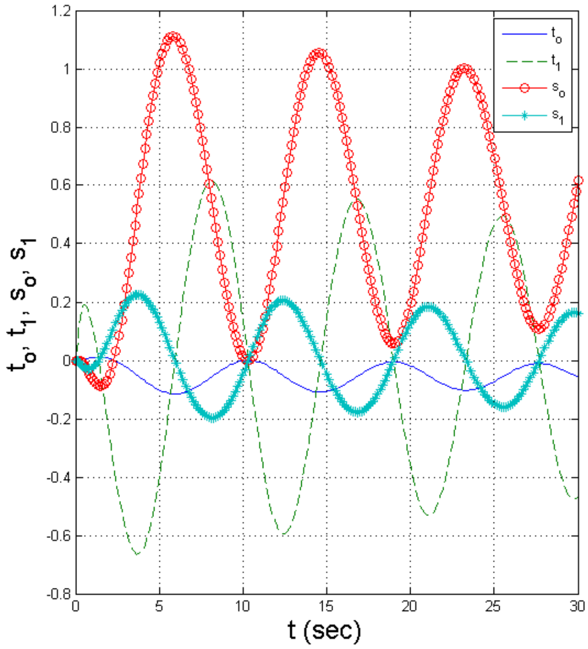


At $\gamma_1 = 10,\ \gamma_2 = 30,\ \gamma_3 = 10,\ \gamma_4 = 5$

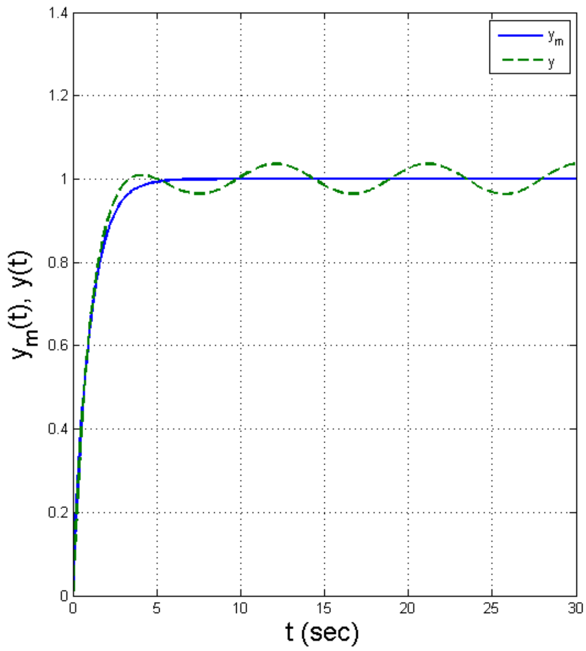


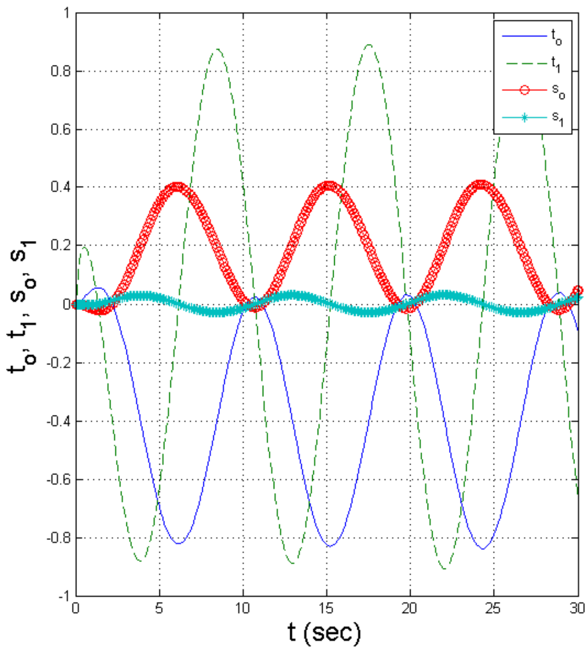
At $\gamma_1 = 1,\ \gamma_2 = 15,\ \gamma_3 = 10,\ \gamma_4 = 5$





At $\gamma_1 = 10,\ \gamma_2 = 30,\ \gamma_3 = 5,\ \gamma_4 = 1$





Conclusion:

$\gamma_1,\ \gamma_2,\ \gamma_3,\ and\ \gamma_4$ must be 80 or higher to get min. error.