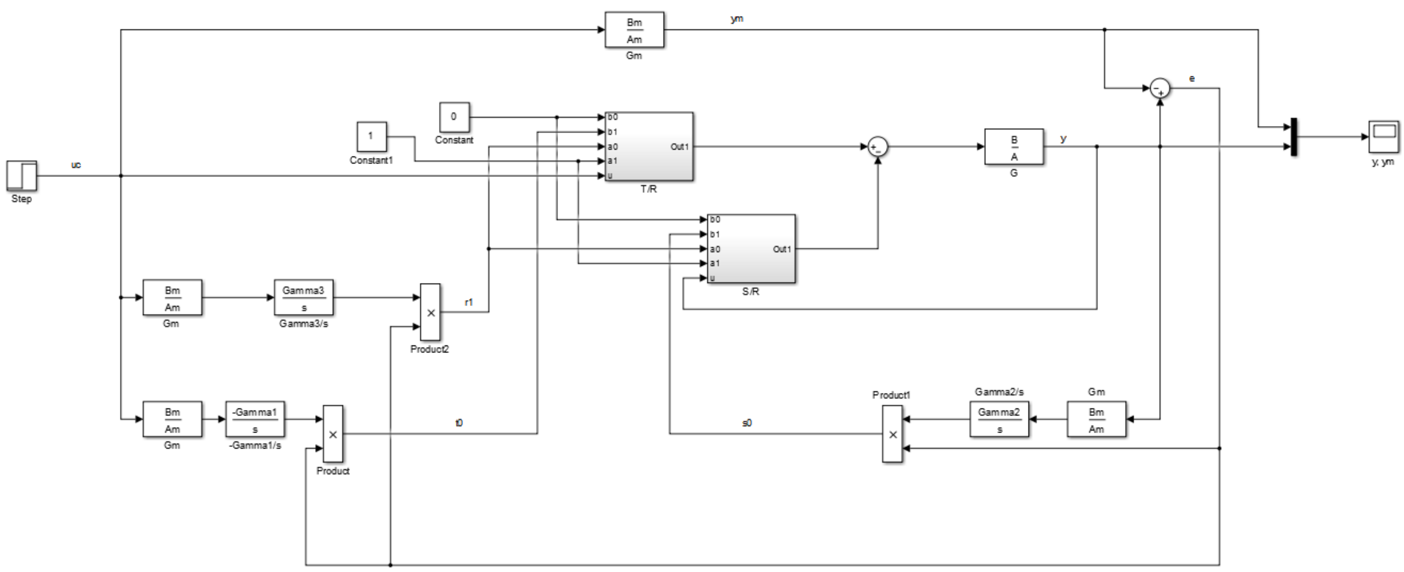
Second Order System Adjustment with First Order Controller:

$$
\begin{aligned}
G(s) &= \frac{y}{u} = \frac{s+b}{s^2+a_1 s+a_0} = \frac{N}{D} \\
G_m(s) &= \frac{y_m}{u_c} = \frac{s+b_m}{s^3+a_{2m}s^2+a_{1m}s+a_{0m}} \\
\textit{Let the control law} : u(t) &= \frac{t_0}{1+r_1 s}u_c(t) - \frac{s_0}{1+r_1 s}y(t) \\
y &= \frac{t_0 G(s)}{1+r_1 s}u_c - \frac{s_0 G(s)}{1+r_1 s}y \\
\frac{y}{u_c} &= \frac{t_0 N}{D(1+r_1 s)+s_0 N} \\
e &= y = y_m \\
\frac{\partial e}{\partial t_0} &= \frac{N}{D(1+r_1 s)+s_0 N}u_c \approx G_m u_c \\
\frac{\partial e}{\partial s_0} &= \frac{-N^2}{[D(1+r_1 s)+s_0 N]^2}u_c \approx -G_m\frac{y}{u_c}u_c = -G_m y \\
\frac{\partial e}{\partial r_1} &= \frac{-NDs}{[D(1+r_1 s)+s_0 N]^2}u_c \approx -G_m\frac{Ds}{D(1+r_1 s)+s_0 N}u_c \approx -G_m u_c \\
\frac{\partial \theta}{\partial t} &= -\gamma\frac{\partial e}{\partial \theta}e \\
\frac{\partial t_0}{\partial t} &= -\gamma_1[G_m u_c]e \;\Rightarrow\; t_0 = -\frac{\gamma_1}{s}[G_m u_c]e \\
\frac{\partial s_0}{\partial t} &= \gamma_2[G_m y]e \;\Rightarrow\; \frac{\gamma_2}{s}[G_m y]e \\
\frac{\partial r_1}{\partial t} &= \gamma_3[G_m u_c]e \;\Rightarrow\; \frac{\gamma_3}{s}[G_m u_c]e
\end{aligned}
$$

Let:

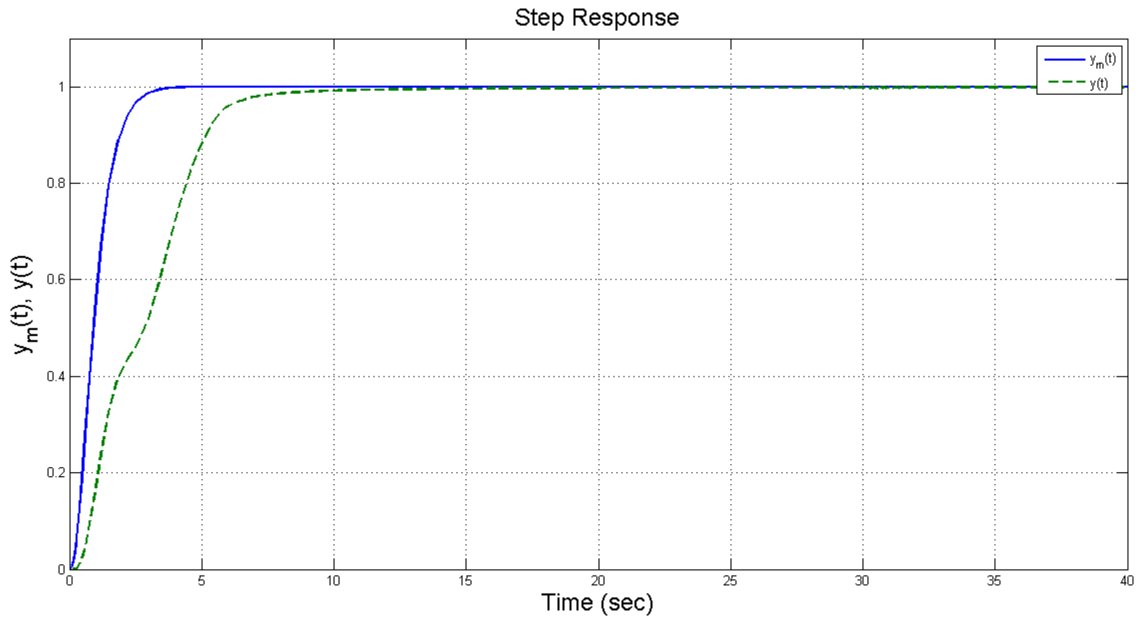
$$
G(s) = \frac{s+2}{s^2+s+6} \qquad G_m(s) = \frac{s+24}{s^3+9s^2+26s+24}
$$

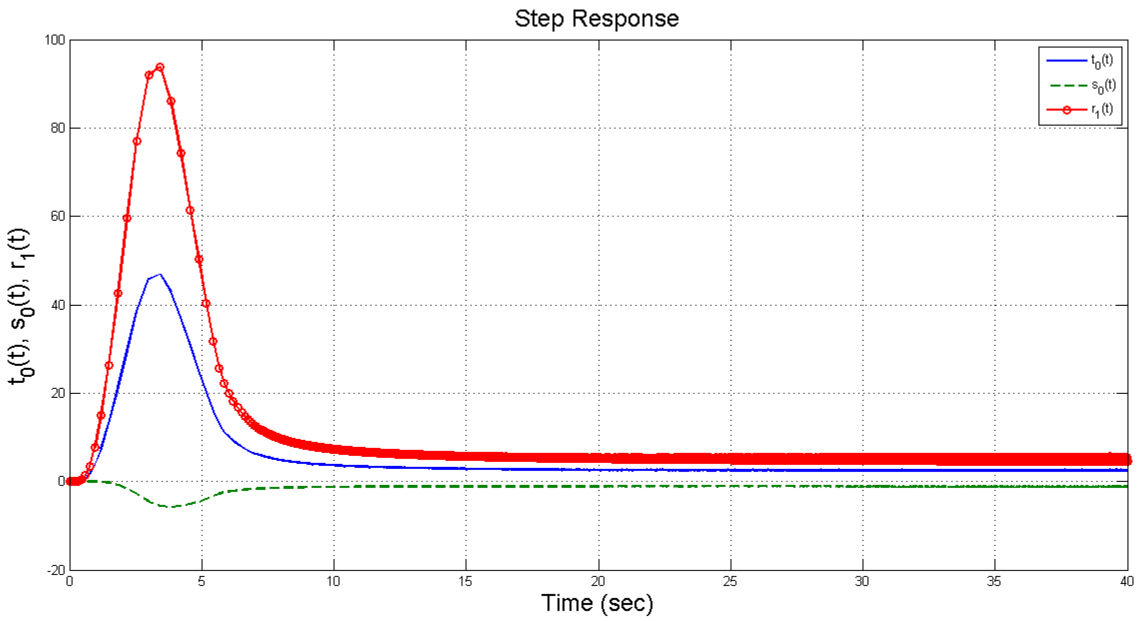
Block Diagram:



For Step Input:

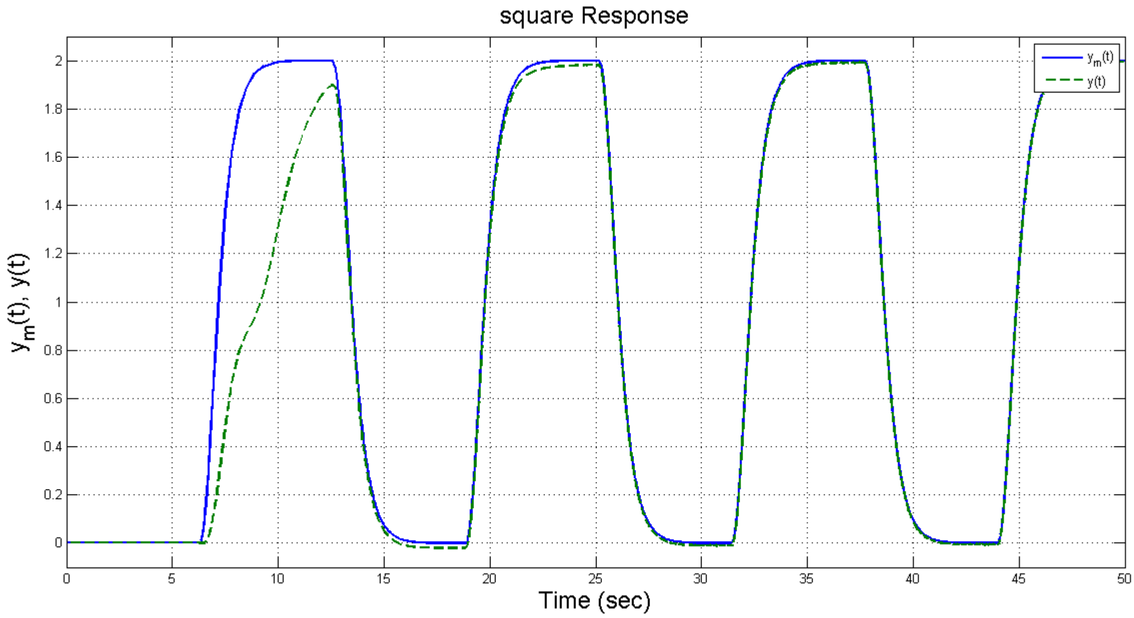
$$\gamma_1 = 50, \quad \gamma_2 = 25, \quad \gamma_3 = -100$$

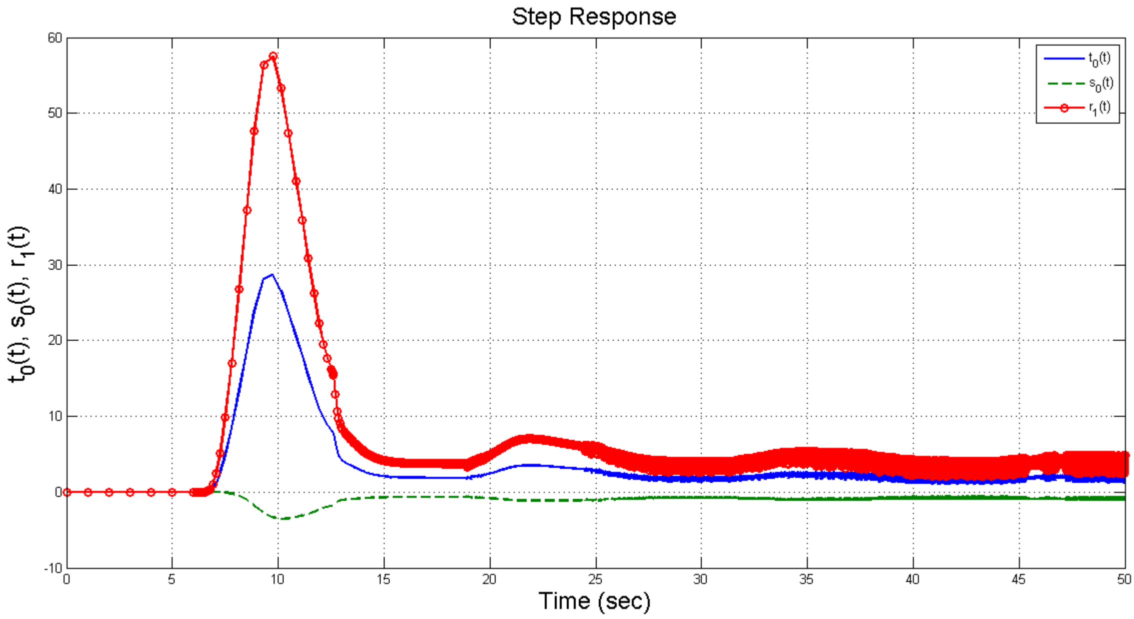




For square Input:

$$\gamma_1 = 7.5, \quad \gamma_2 = 3.75, \quad \gamma_3 = -15$$





For Sinusoidal Input:

$$\gamma_1 = 7.5, \quad \gamma_2 = 3.75, \quad \gamma_3 = -15$$