Control Engineering 2 – Project

Assignment 1

The transfer function of the process from the closed loop system shown in Fig. 1 is given as

$$H_f(s) = \frac{K_f}{s(T_f s + 1)}$$

Requirement: Compute the controller $H_r(s)$ using the Guillemin-Truxal method that satisfies the following specifications:

$$\begin{cases} \varepsilon_{stp} = 0 \\ t_r^* \le 40\,\text{sec} \\ \sigma^* \le 15\% \\ c_v \ge 0{,}2 \\ \Delta\omega_B^* \le 2\,\text{rad/sec} \end{cases}$$

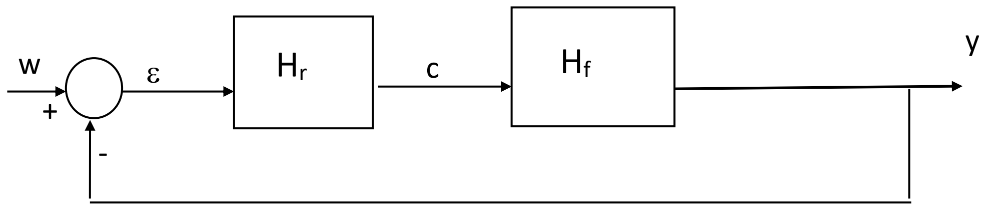

Figura 1 Closed loop system

Handout: A brief documentation (max 2 pages) containing:

- The actual performance values chosen to compute the controller
- The obtained controller
- Graphical proof of the closed loop system performance

Theoretical aspects:

The Guillemin-Truxal tuning strategy is a good choice for fast processes. The usual imposed closed loop performance is similar to

$$\begin{cases} \varepsilon_{stp} = 0 \\ \varepsilon_{stv} < \varepsilon_{stv}^{*} \\ t_r < t_r^{*} \\ \sigma < \sigma^{*} \\ \Delta\omega_B < \Delta\omega_B^{*} \end{cases}$$

The basic principle of the Guillemin-Truxal strategy considers the second order closed loop system given by

$$H_o(s) = H_{02} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2} \tag{1}$$

Knowing $H_f(s)$, usually denoted by:

$$H_f(s) = \frac{K_f}{s(T_f s + 1)} \tag{2}$$

The controller can be determined as:

$$H_R(s) = \frac{1}{H_f(s)} \cdot \frac{H_{02}(s)}{1 - H_{02}(s)} \tag{3}$$

The parameters ξ and ω_n are chosen with respect to the imposed performance specifications.

From the imposed overshoot value, $\sigma < \sigma^{*}$, the damping ratio, ξ can be computed as:

$$\xi = \frac{|\ln(\sigma)|}{\sqrt{\ln^2(\sigma) + \pi^2}} \tag{4}$$

Knowing the settling time, $t_r < t_r^{*}$, the natural frequency, ω_n is:

$$\omega_n = \frac{4}{t_r \cdot \xi} \tag{5}$$

One should check that the obtained values honor the imposed velocity coefficient specification

$$c_v = \frac{\omega_n}{2 \cdot \xi} \tag{6}$$

Note that the velocity coefficient gives the velocity steady state error

$$\varepsilon_{stv} = \frac{1}{c_v} \tag{7}$$

If the value from (7) doesn't honor $\varepsilon_{stv} < \varepsilon_{stv}^{*}$, different values should be chosen for the settling time and the overshoot (the new values should also honor the imposed performance specifications from the beginning), until the c_v specification is met.

Finally, the bandwidth is also verified using:

$$\Delta\omega_B = \omega_n \sqrt{1 - 2\xi^2 + \sqrt{2 - 4\xi^2 + 4\xi^4}} \tag{8}$$