Ecole des JDMACS 2011- GT MOSAR
Synthèse de correcteurs : approche basée sur la forme observateur/retour d'état
MATLAB Tutorial session

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Let us consider the simplified model of a launcher:

$$G_0(s) = \frac{Y(s)}{U(s)} = \frac{1}{s^2 - 1} \; ,$$

and the following candidate controllers (positive feedback):

$$K_0(s) = \frac{-23s - 32}{s + 12} \; , \quad K_1(s) = -\frac{s^2 + 27s + 26}{s^2 + 7s + 18} \; , \quad K_2(s) = -\frac{1667s + 2753}{s^2 + 27s + 353} \; .$$

1 Observer-based realization

1.a) Give a state space realization of $G_0(s)$ with state vector $x = [y \quad \dot{y}]^T$,

1.b) Compute an observer-based realization of controller $K_1(s)$ (macro-function `cor2obr` or `cor2obra` and `obr2cor`).

1.c) Plot the closed-loop response of plant and controller states to initial conditions: $y(t = 0) = 1$; $\dot{y}(t = 0) = -1$.

1.d) Same things (1.b) and 1.c)) with controller $K_2(s)$.

2 Cross standard form

Let us consider $K_0(s)$. $K_0(s)$ was designed to assign the closed-loop dominant dynamics to $-1 \pm i$.

2.a) Compute the matrix $T_{1\times 2}$ of the linear combination of plant states observed by controller state: $x_K = T\widehat{x}$ (macro-function `cor2tfg` or `cor2tfga`),

2.b) Set-up the Cross Standard Problem associated with $G_0(s) \equiv \left[\begin{array}{c|c} A & B \\ \hline C & D \end{array}\right]$ and $K_0(s) \equiv \left[\begin{array}{c|c} A_K & B_K \\ \hline C_K & D_K \end{array}\right]$:

$$P_{CSF}(s) := \left[\begin{array}{c|cc} A & T^{\#}B_K - BD_K & B \\ \hline -C_K T - D_K C & D_K D D_K - D_K & I_m - D_K D \\ C & I_p - DD_K & D \end{array}\right]$$

2.c) Compute $\widehat{K}_\infty(s) = \arg\min_{K(s)} \|F_l(P_{CSF}(s), K(s))\|_\infty$ for various right inverses $T^{\#}$ of T and compare $\widehat{K}_\infty(s)$ with $K_0(s)$.

2.d) The frequency-domain response of the controller must now fit the following template:

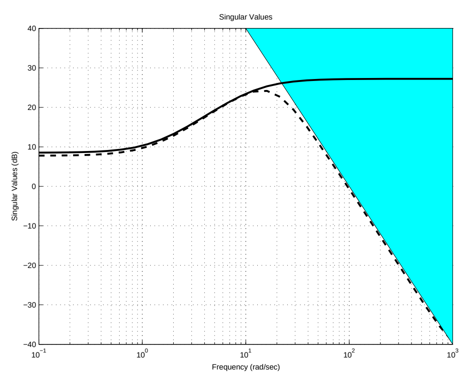

Figure 1: Frequency-domain responses (magnitude) of $K_0(s)$ (solid line) and $\widehat{K}_\infty(s)$ (dashed line) and template (grey patch).

Augment the standard problem $P_{CSF}(s)$ to take into account this frequency-domain specification (Figure 2) and compute such a controller $\widehat{K}_\infty(s)$. Check the closed-loop dynamics.

2.e) Now, the actuator dynamics $A(s) = \frac{5}{s+5} \equiv \left[\begin{array}{c|c} -5 & 5 \\ \hline 1 & 0 \end{array}\right]$ is taken into account. Compute stability margins of the controller $\widehat{K}_\infty(s)$ on the plant $G_0(s)A(s)$.

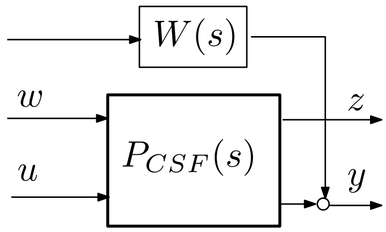

Figure 2: P_{CSF} with frequency weight.

2.f) Augment the previous standard problem with $A(s)$ (Figure 3) and tune $W(s)$ to find a controller $\widehat{K}(s)$ fitting the template (Figure 1) and such that the open loop transfer $-G_0(s)A(s)\widehat{K}(s)$ has at least a $30\,deg$ phase margin.

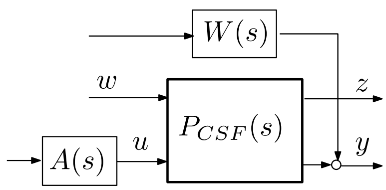

Figure 3: P_{CSF} with frequency weight and actuator dynamics.

2.g) Compute an observer-based realization of $\widehat{K}(s)$ on the plant $G_0(s)A(s)$.

2.h) Plot responses to initial conditons $\dot{y}(t = 0) = -1$ and to a square reference signal using the controller $\widehat{K}(s)$ directly (Figure 4) or using its observer based realization (Figure 5).

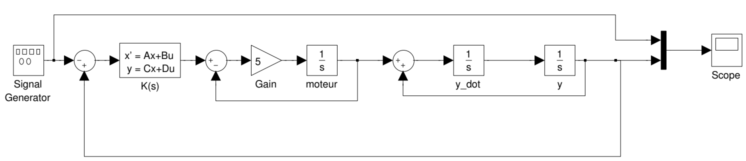

Figure 4: Closed-loop simulation with controller $\widehat{K}(s)$.

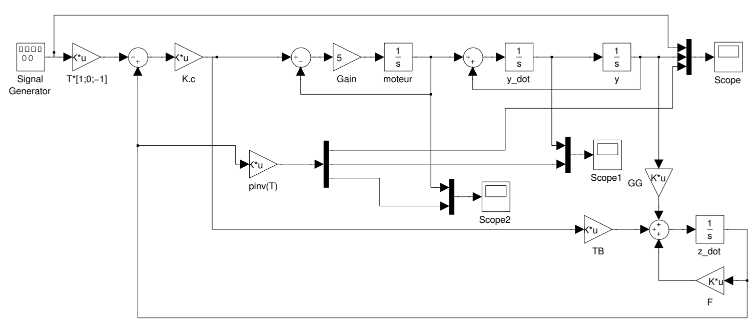

Figure 5: Closed-loop simulation with observer based realization of controller $\widehat{K}(s)$.