Computerized control - Homework 3

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1 Polynomial controller design (RST)

1.1 Two-degree of freedom controller

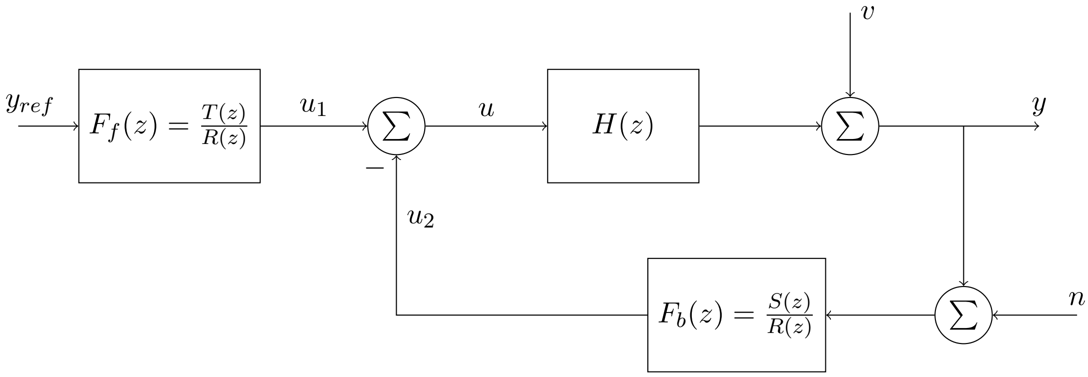

Figure 1: Two-degree-of-freedom controller

1.2 The plant model

A plant to be controlled is described by the pulse-transfer function

$$H(z) = \frac{\left(1 - \frac{\sqrt{3}}{2}\right)z - \left(\frac{\sqrt{3}}{2} - 1\right)}{z^2 - \sqrt{3}z + 1}.$$

1.2.1 Plot the poles and zeros of the system

You can use matlab for convenience

```
num = []; % numerator coefficients
den = []; % denominator coefficients
```

```
h = 1; % Normalized time scale
H = tf(num, den, h)
figure(1); clf;
pzmap(H)
zgrid
```

Include the pole-zero map in your report, and describe briefly some interesting properties of the plant.

1.3 Determine the desired closed loop poles

Assume that we want to achieve a closed-loop system from the reference signal $y_{ref}(k)$ to the output $y(k)$ that has two poles that are **equally fast as the plant**, but has a **damping ratio of 1** (critically damped poles).

Determine where the poles should be in the z-plane and calculate the desired characteristic polynomial $A_c(z)$.

1.4 Design a 2-DoF controller

Design a discrete-time controller with the structure given in figure 1. The controller is given by

$$R(q)u = -S(q)y + T(q)u_c$$

and the the plant-model is

$$A(q)y = B(q)u.$$

This gives the following difference equation for the closed-loop system

$$\big(A(q)R(q) + B(q)S(q)\big)y = B(q)T(q)u_c.$$

Assume a suitable order (as low as possible) of the controller polynomials $R(q)$ and $S(q)$ and solve the diophantine equation

$$A(q)R(q) + B(q)S(q) = A_c(q)A_o(q)$$

for R and S. Place all observer poles in the origin (deadbeat observer).

1.5 Implement the controller

Implement your controller and closed-loop system in matlab (or simulink), and test step plots both from the reference signal $y_{ref}(k)$ and from the disturbance $v(k)$. **Discuss the performance of the closed-loop system in 3-4 sentences. Is it what you expected?**.

Some code to help you

```
% The coefficients of the controller
R_coeffs =
S_coeffs =
T_coeffs =

% The forward part of the controller
TR = tf(T_coeffs, R_coeffs, h);
% The feedback part of the controller
SR = tf(S_coeffs, R_coeffs, h);

% The closed-loop system from reference to output
Hc =

% The closed-loop system from disturbance to output
Hv =

figure(1)
clf
pzmap(Hc) % Verify that the closed-loop poles are as desired

figure(2)
clf
step(Hc, Hv) % Expected performance?
```