

# Appendix W7.8

## Digital Implementation of Example 7.31

### EXAMPLE W7.1

#### *Redesign of the DC Servo Compensator*

For Example 7.31, derive an equivalent discrete controller with a sampling period of  $T_s = 0.1$  sec (10 times the fastest pole), and compare the continuous and digital control outputs and control efforts. Verify the design by plotting the step response and commenting on the comparison of the continuous and discrete responses.

**Solution.** The discrete equivalent for the controller is obtained from Matlab with the `c2d` command, as in

```
nc=94.5*conv([1 7.98],[1 2.52]); % form controller numerator
dc=conv([1 8.56 59.5348],[1 10.6]); % form controller denominator
sysDc=tf(nc,dc); % form controller system description
ts=0.1;% sampling time of 0.1 sec
sysDd=c2d(sysDc,ts,'zoh'); % convert controller to discrete time
```

#### Discrete controller

The resulting controller has the discrete transfer function

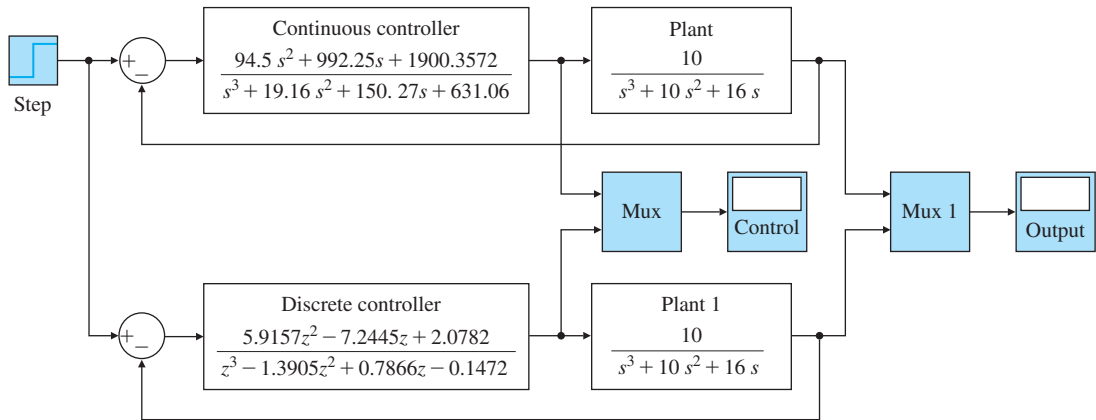
$$D_d(z) = \frac{5.9157(z + 0.766)(z + 0.4586)}{(z - 0.522 \pm 0.3903j)(z + 0.3465)}.$$

The equation for the control law (with the sample period suppressed for clarity) is

$$u(k+1) = 1.3905u(k) - 0.7866u(k-1) + 0.1472u(k-2) \\ + e(k) - 7.2445e(k-2) + 2.0782e(k-2).$$

#### Simulink simulation

A Simulink diagram for simulating both the continuous and discrete systems is shown in Fig. W7.1. A comparison of the continuous and discrete step responses and control signals is shown in Fig. W7.2. Better agreement between the two responses can be obtained if the sampling period is reduced.



**Figure W7.1**

Simulink block diagram to compare continuous and discrete controllers

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**Figure W7.2**

Comparison of step responses and control signals for continuous and discrete controllers: (a) step responses; (b) control signals

