Chapter 13

Digital Control Systems

Figure 13.1
Conversion of antenna azimuth position control system from:
a. analog control to;
b. digital control

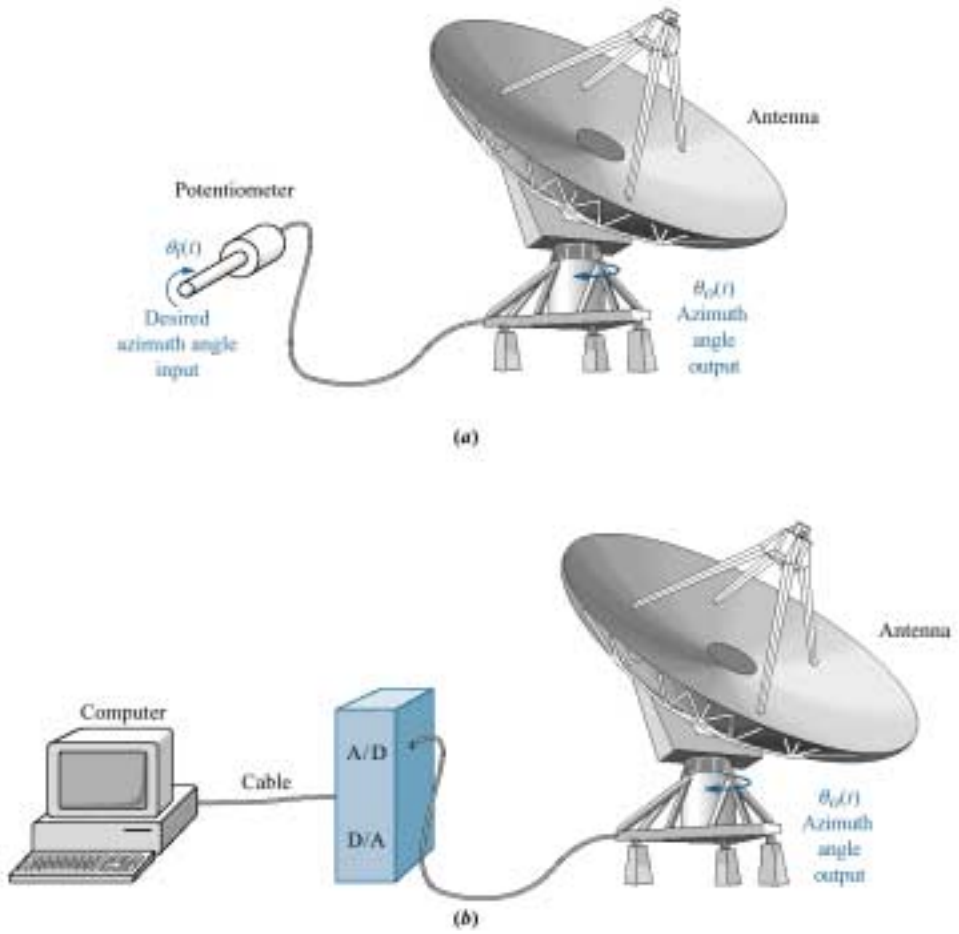


Figure 13.2
a. Placement of the digital computer within the loop;
b. detailed block diagram showing placement of A/D and D/A converters

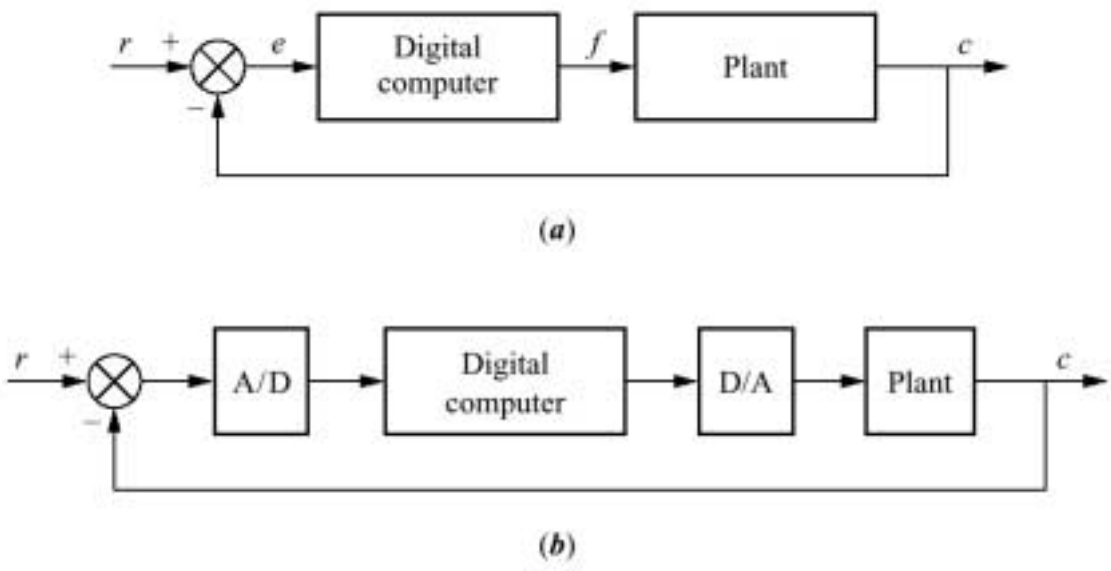


Figure 13.3
Digital-to-analog converter

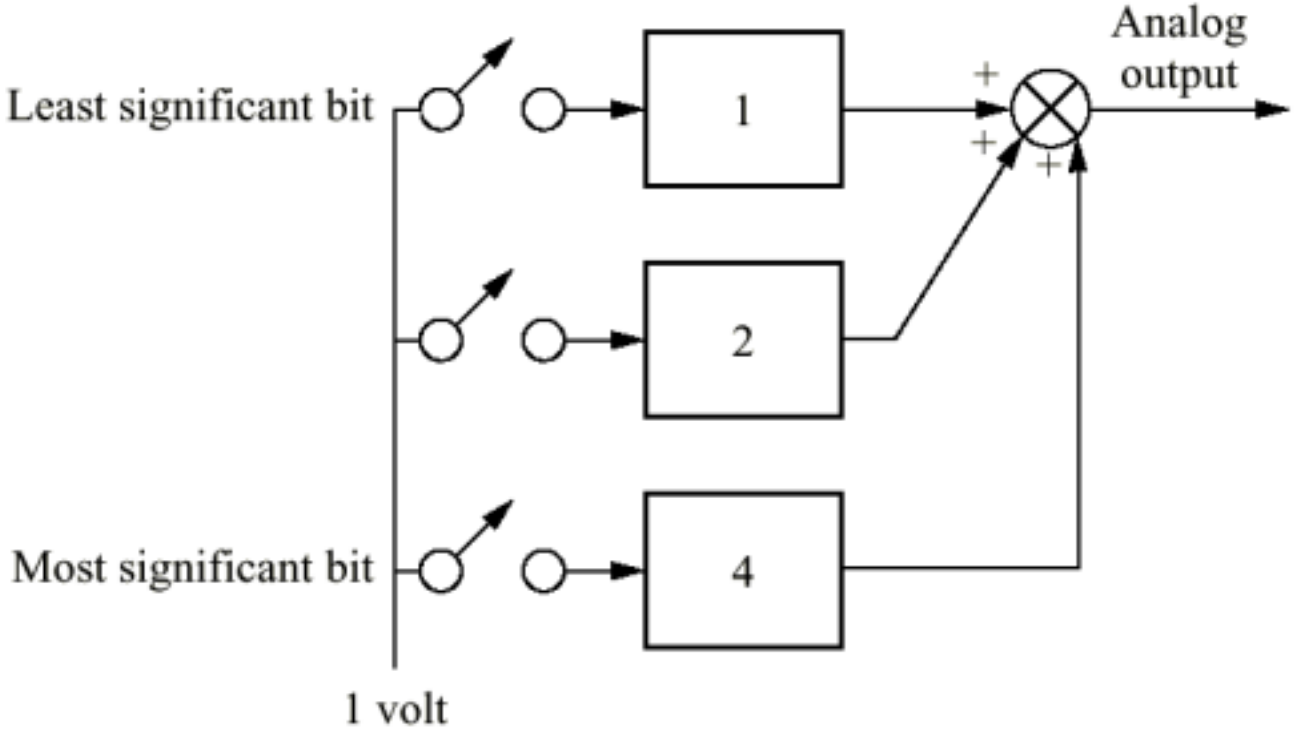


Figure 13.4
Steps in analog-to-digital conversion:
a. analog signal;
b. analog signal after sample-and-hold;
c. conversion of samples to digital numbers

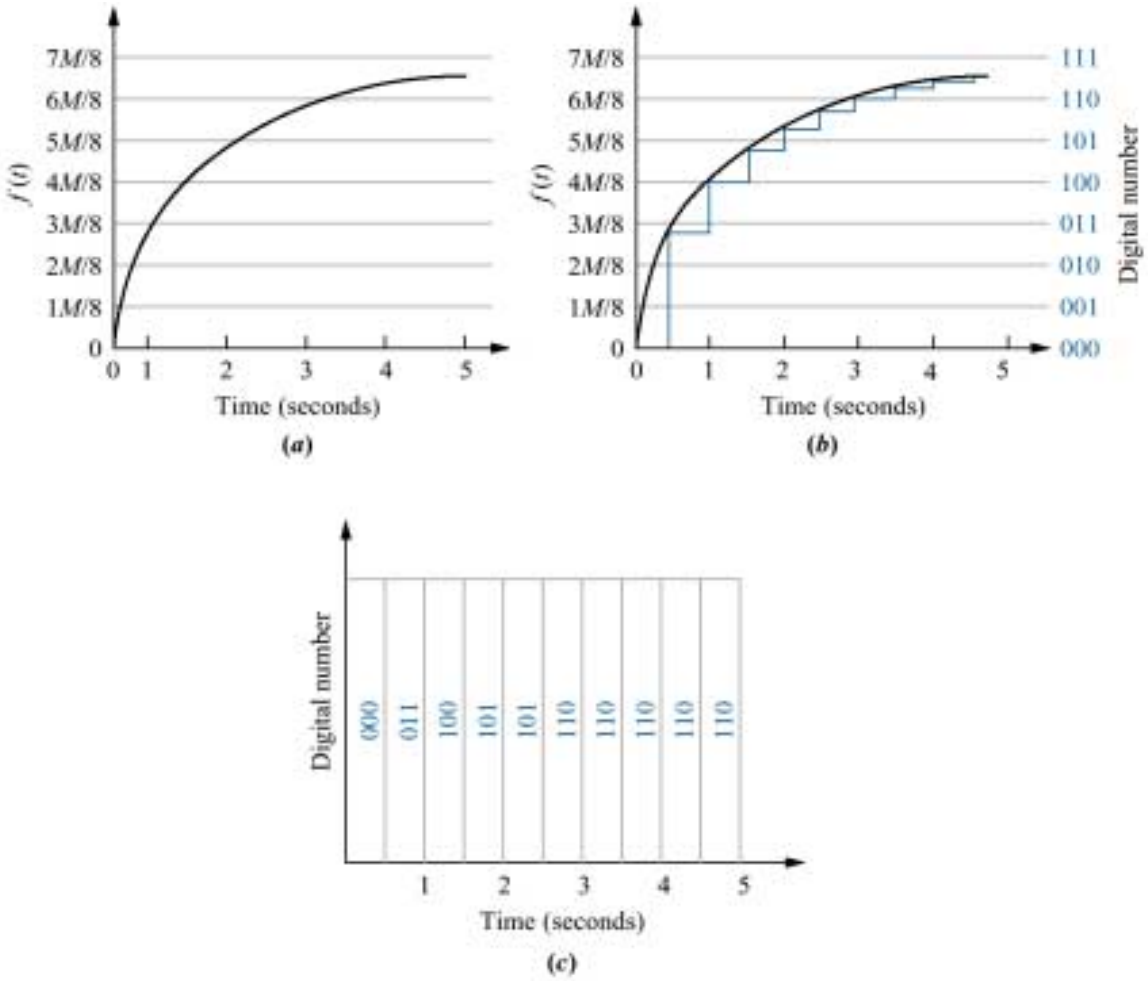


Figure 13.5
Two views of uniform-rate sampling:
a. switch opening and closing;
b. product of time waveform and sampling waveform

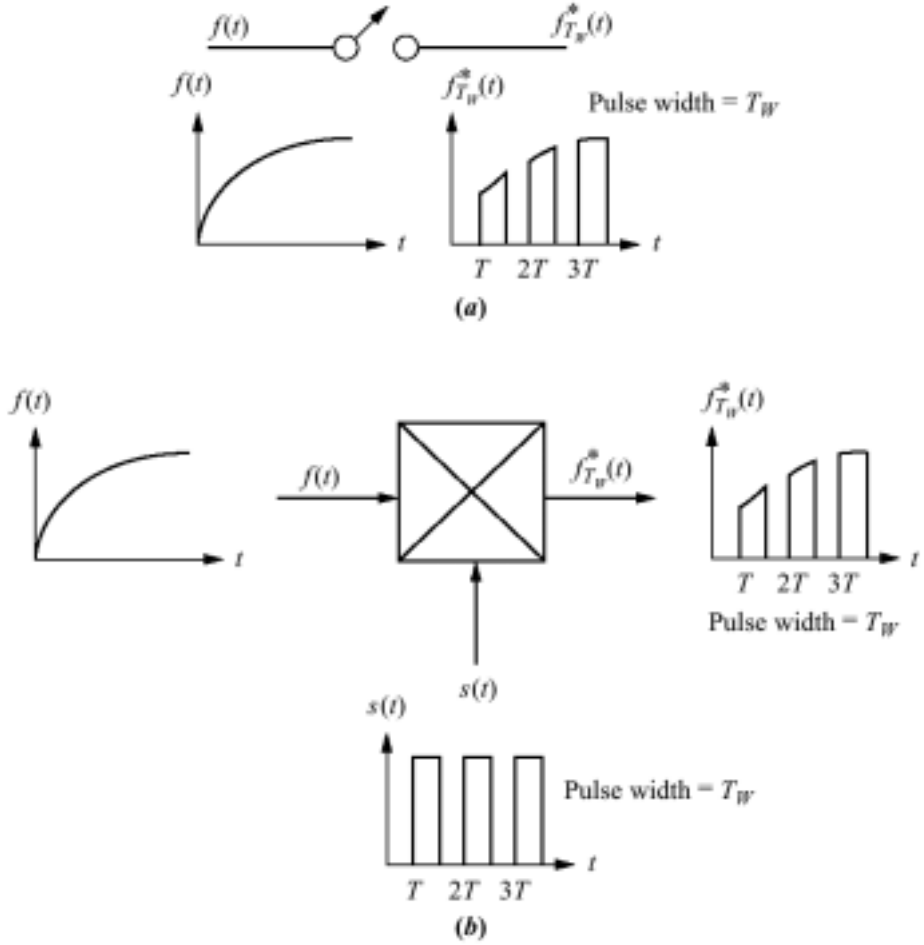


Figure 13.6
Model of sampling with a uniform rectangular pulse train

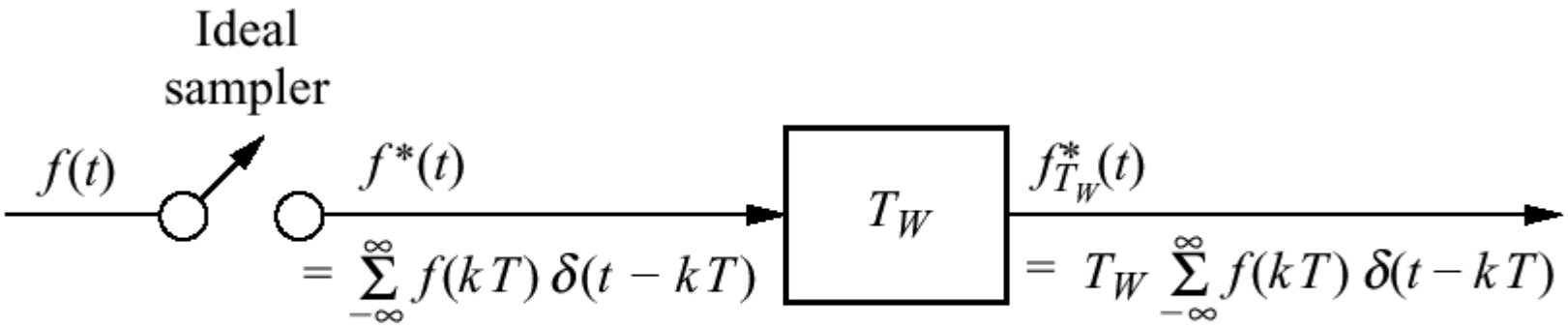


Figure 13.7
Ideal sampling and the zero-order hold

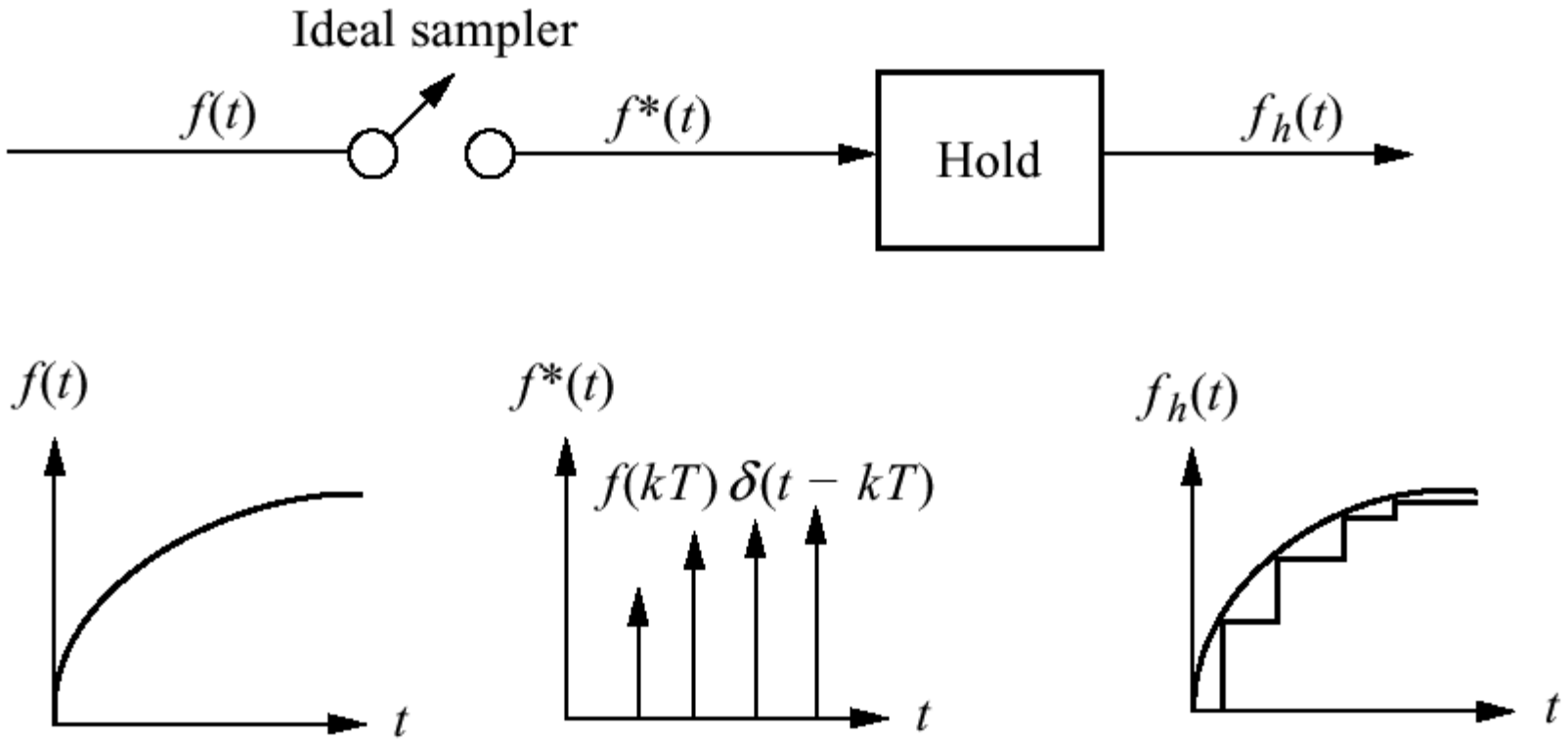


Figure 13.8
Sampled-data systems:
a. continuous;
b. sampled input;
c. sampled input and output

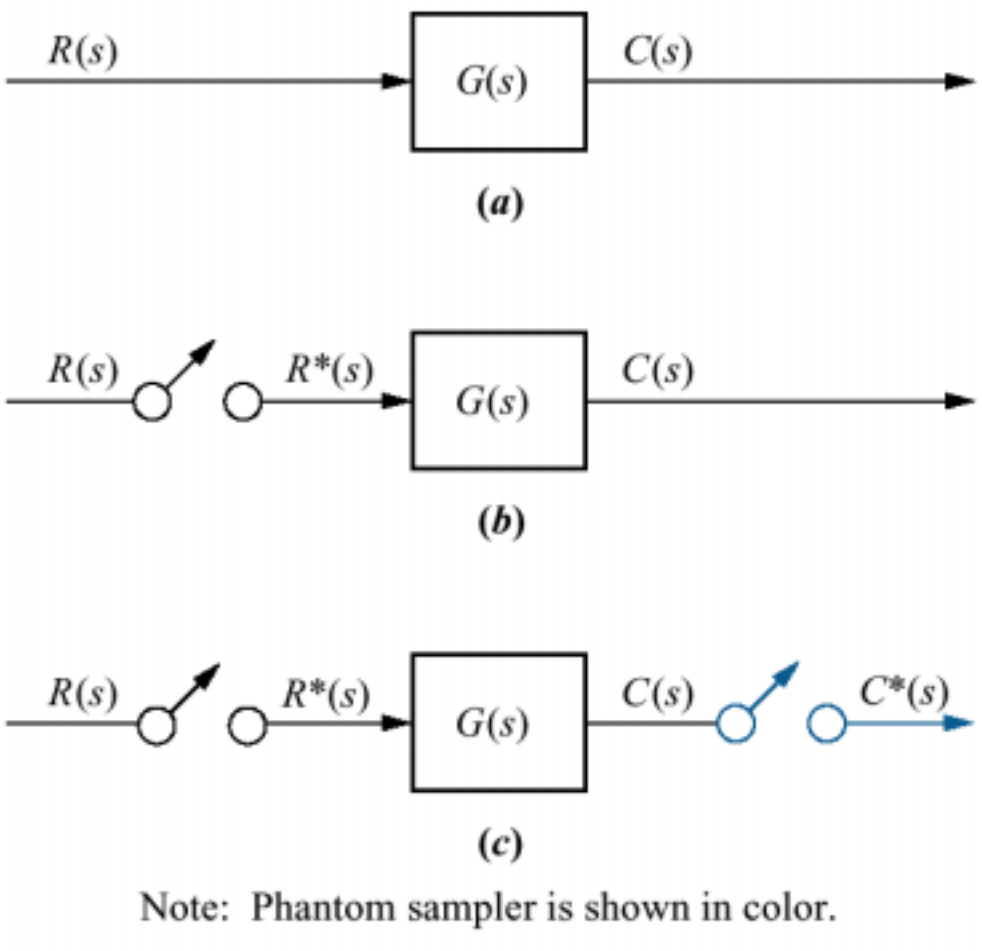


Figure 13.9
Sampled-data systems and their z-transforms

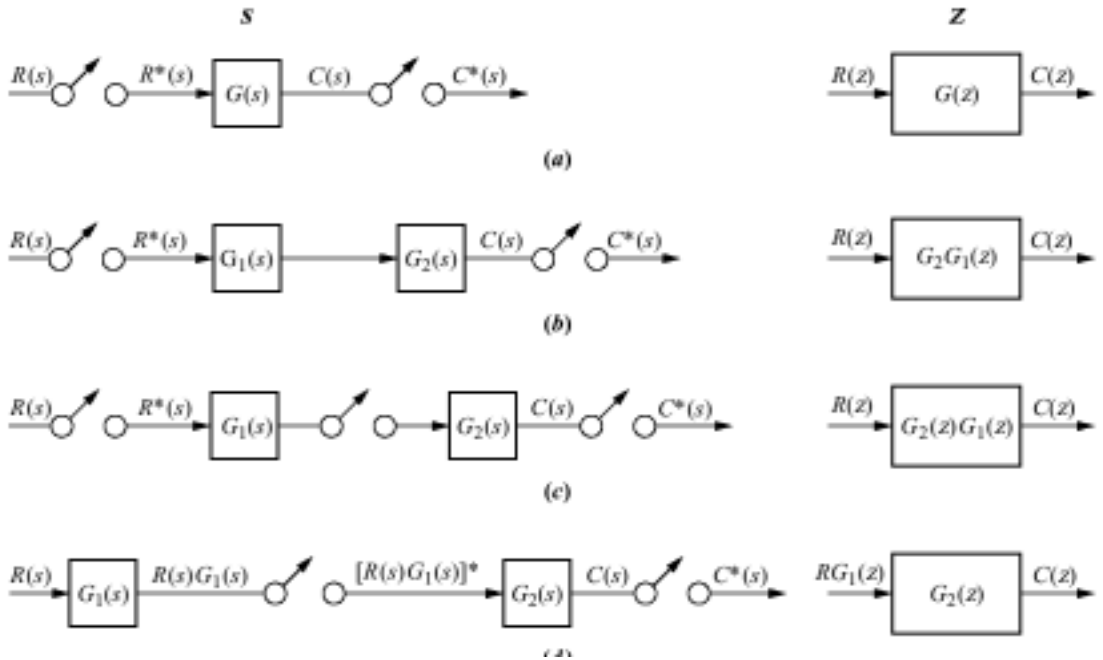


Figure 13.10
Steps in block diagram reduction of a sampled-data system

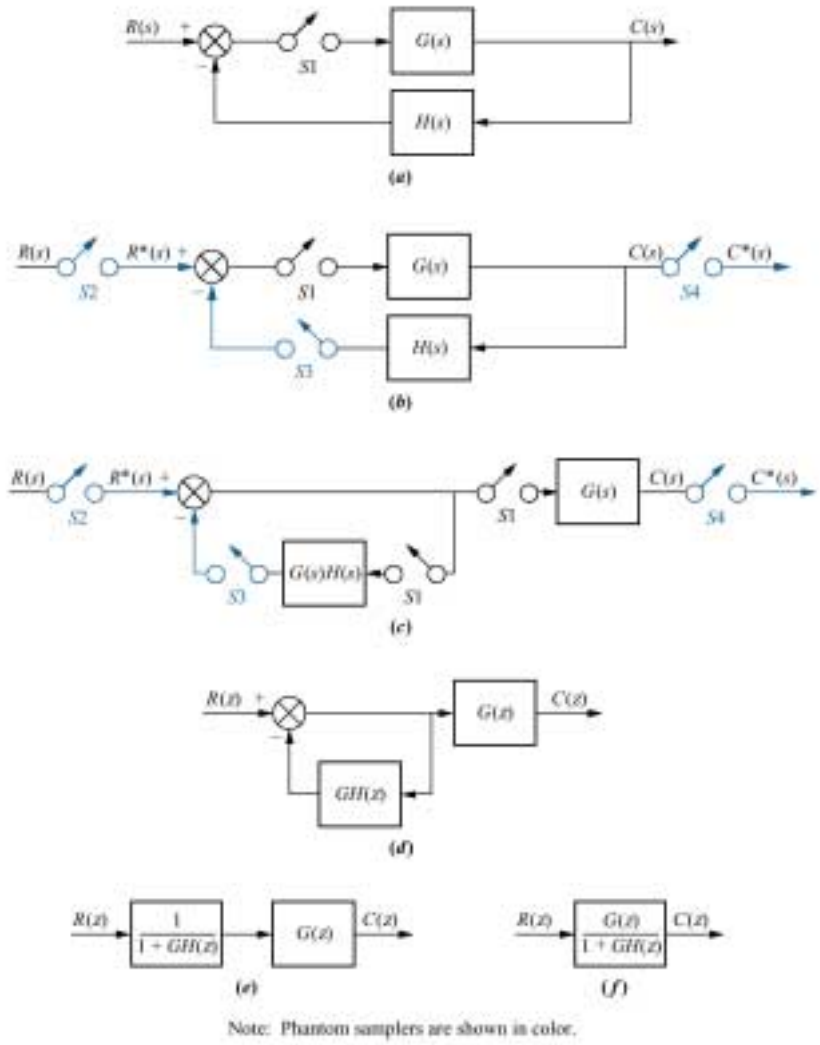


Figure 13.11
Digital system for Skill-Assessment Exercise 13.4

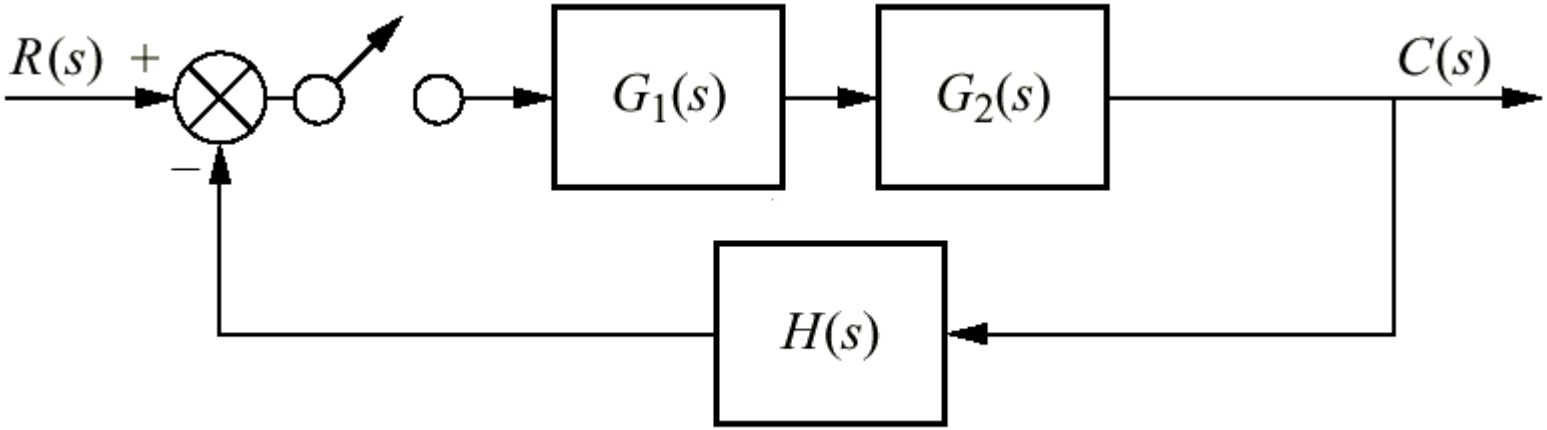


Figure 13.12
Computer-controlled torches cut thick sheets of metal used in construction

Figure 13.13
Mapping regions of the s-plane onto the *z-plane*

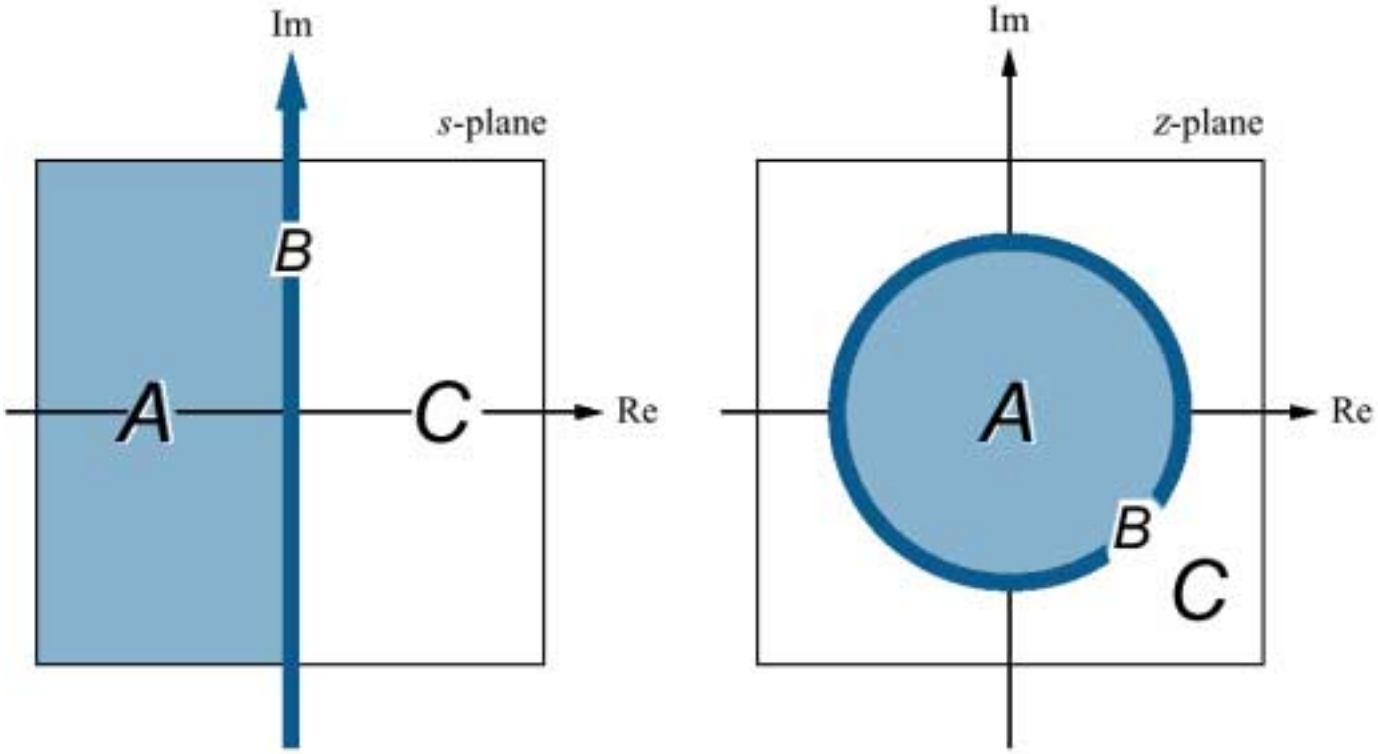


Figure 13.14
Finding stability of a missile control system:
a. missile;
b. conceptual block diagram;
c. block diagram;
d. block diagram with equivalent single sampler

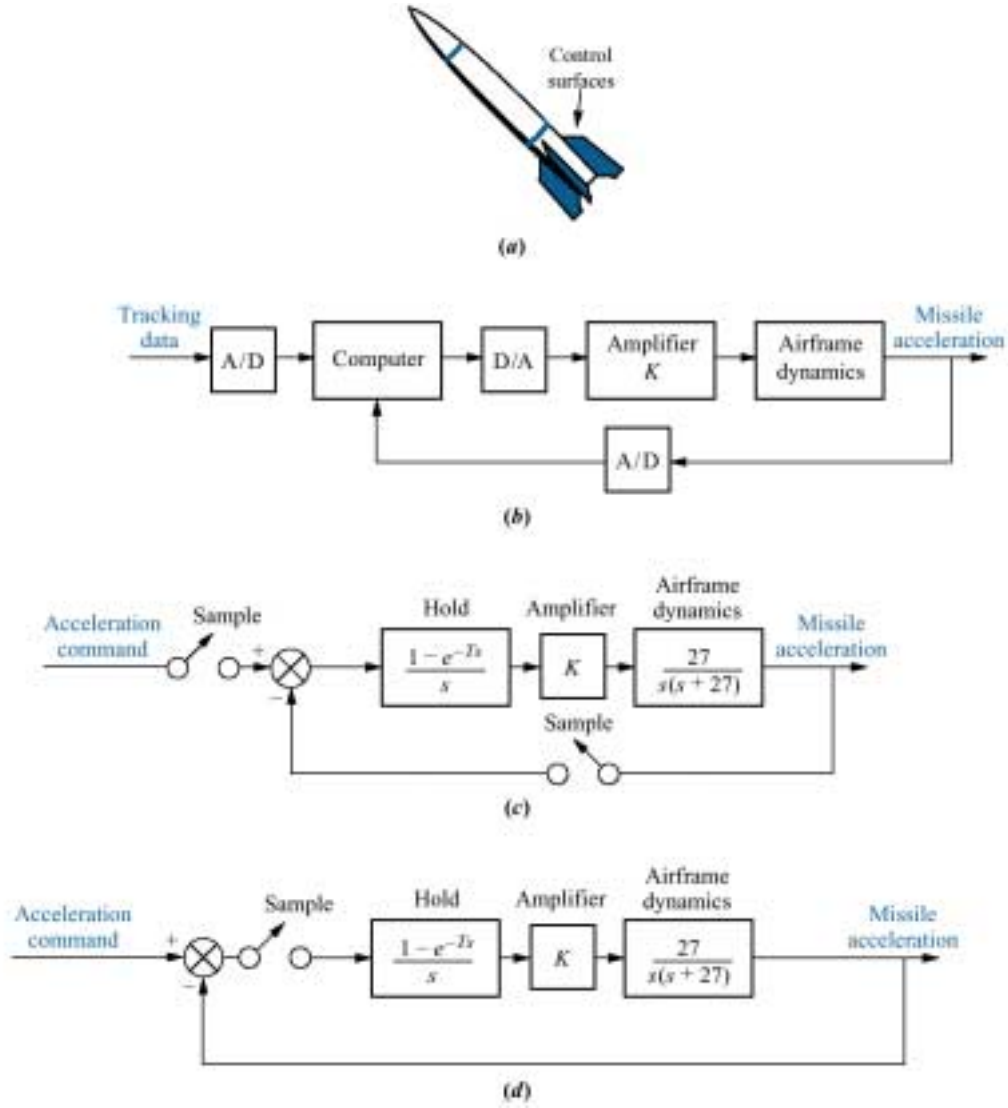


Figure 13.15
Digital system for
Example 13.7

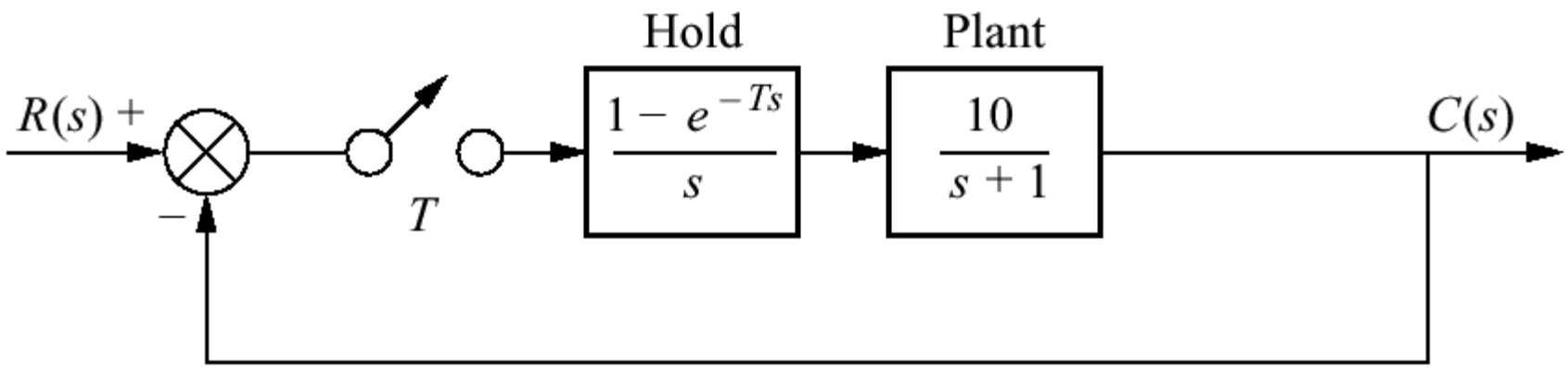


Figure 13.16
Digital system for Skill-Assessment Exercise 13.5

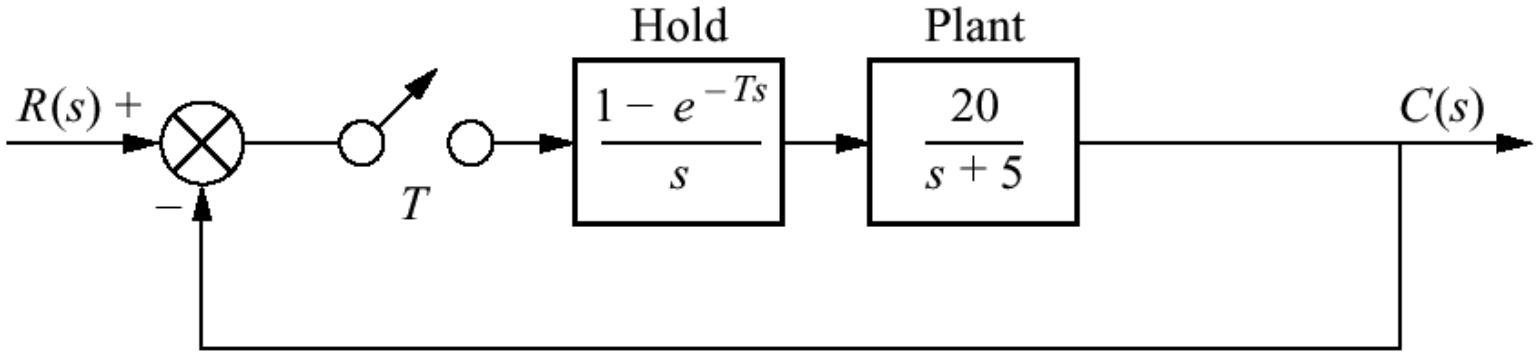
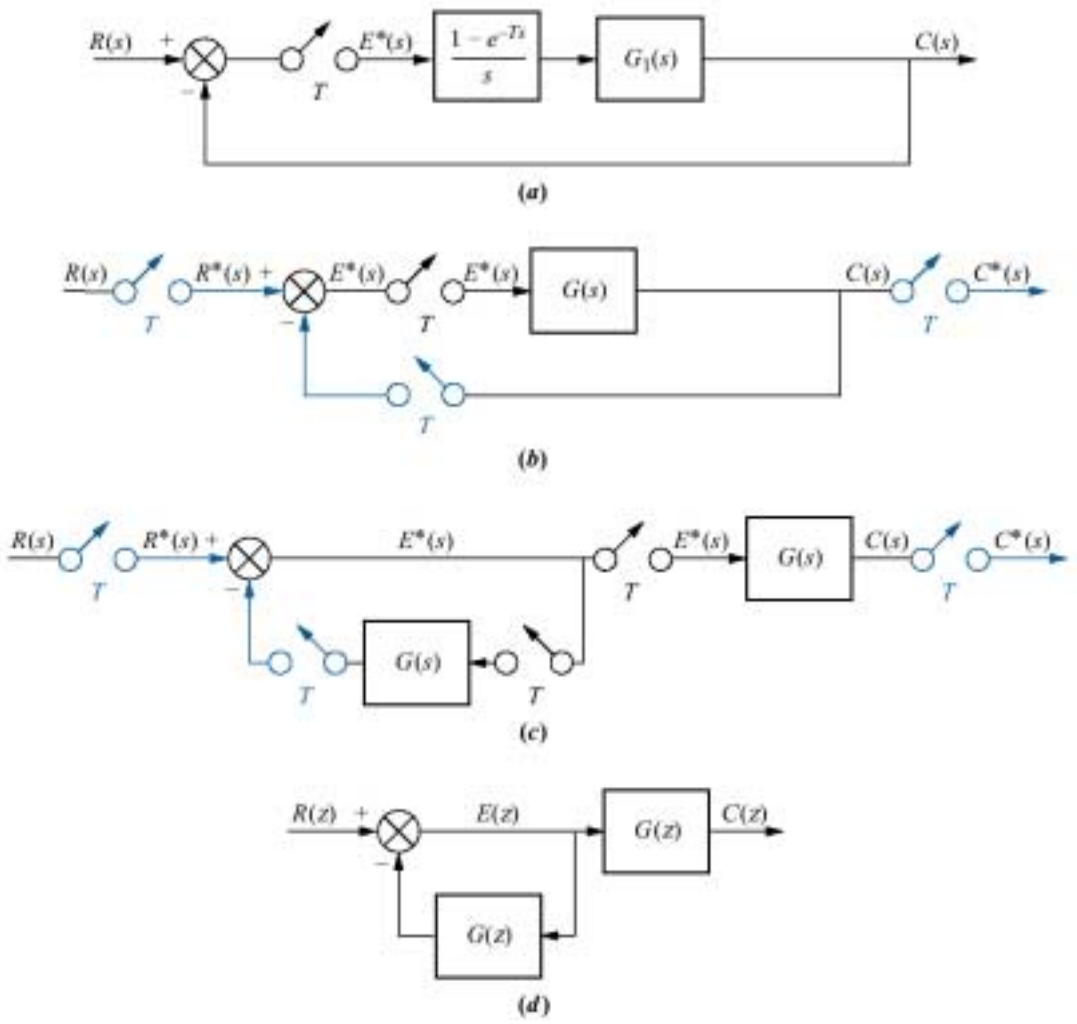


Figure 13.17
a. Digital feedback control system for evaluation of steady-state errors;
b. phantom samplers added;
c. pushing G(s) and its samplers to the right past the pickoff point;
d. z-transform equivalent system



Note: Phantom samplers are shown in color.

Figure 13.18
Constant damping ratio, normalized settling time, and normalized peak time plots on the z-plane

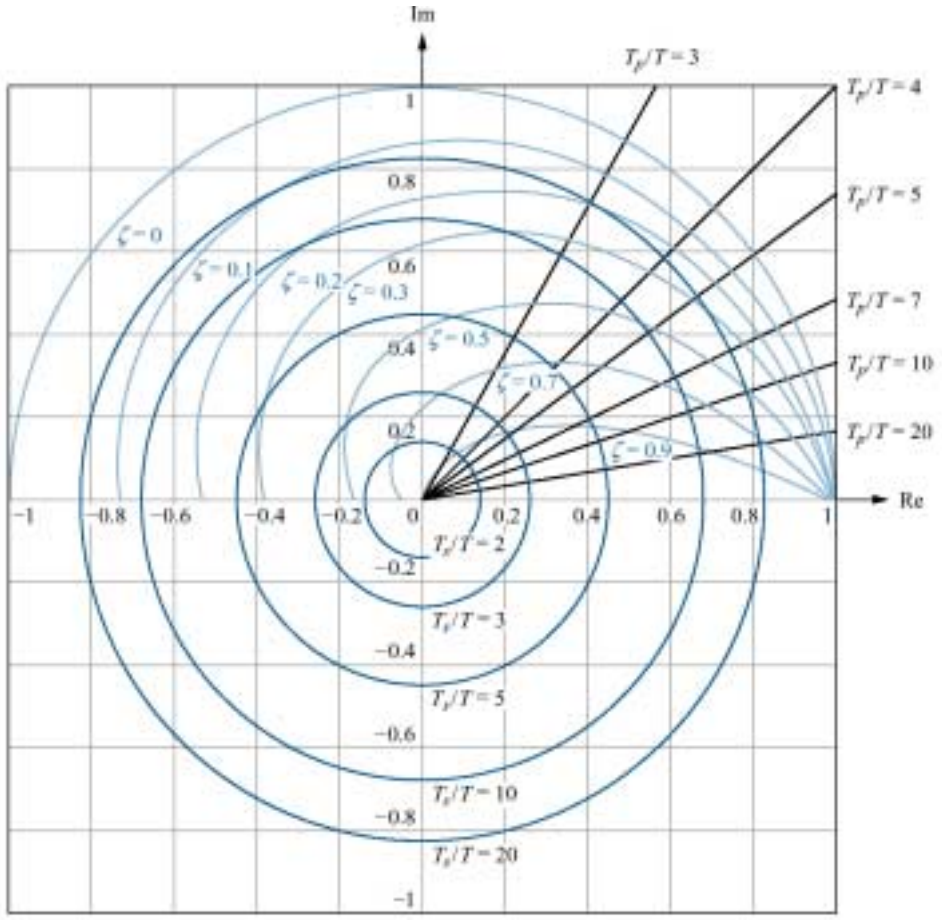


Figure 13.19
The *s*-plane sketch of constant percent overshoot line

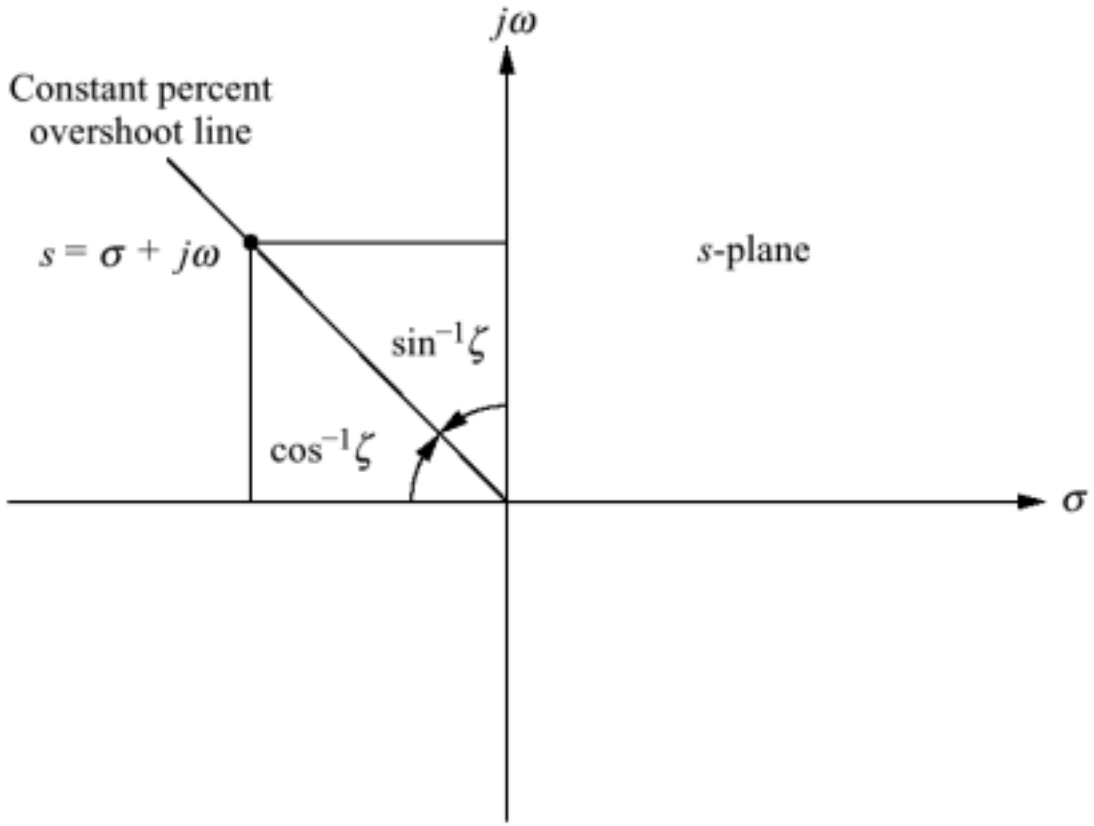


Figure 13.20
Generic digital feedback control system

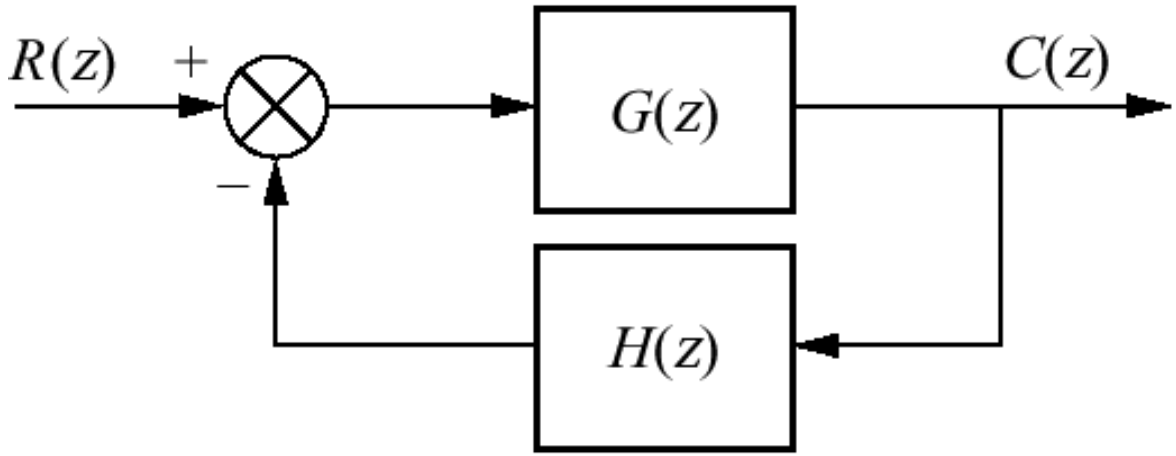


Figure 13.21
Digital feedback control for Example 13.10

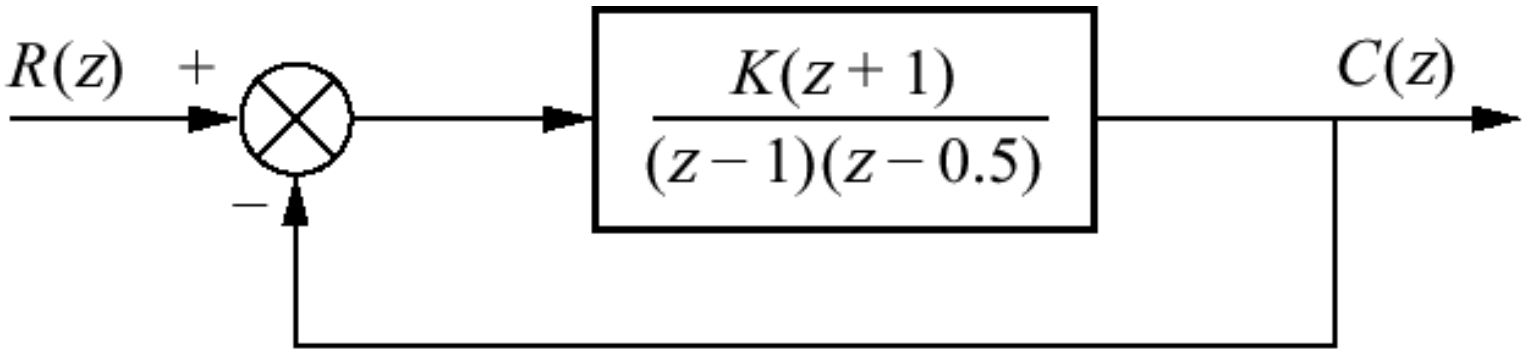


Figure 13.22
Root locus
for the system
of Figure 13.21

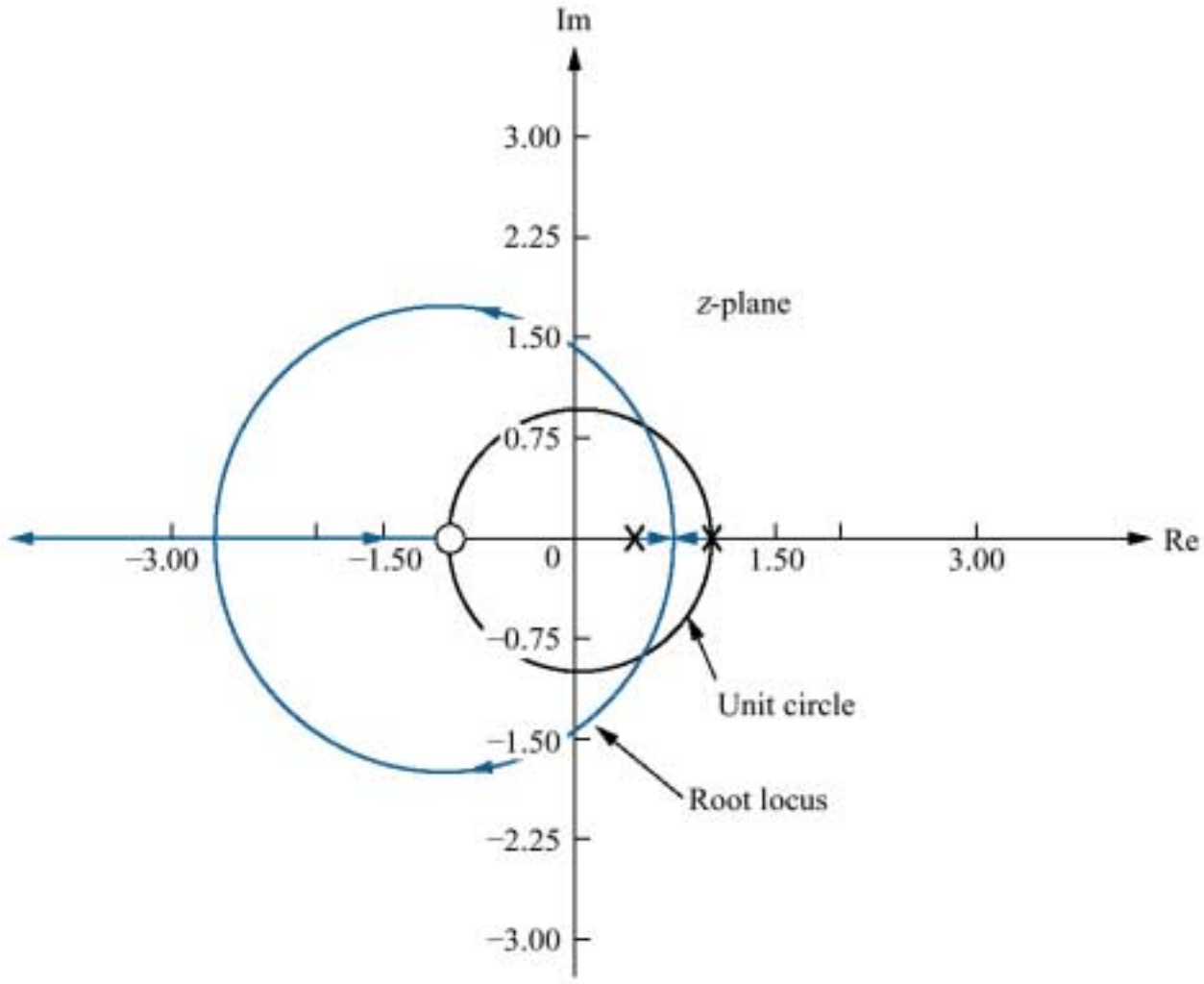


Figure 13.23
Root locus for the system of Figure 13.21 with constant 0.7 damping ratio curve

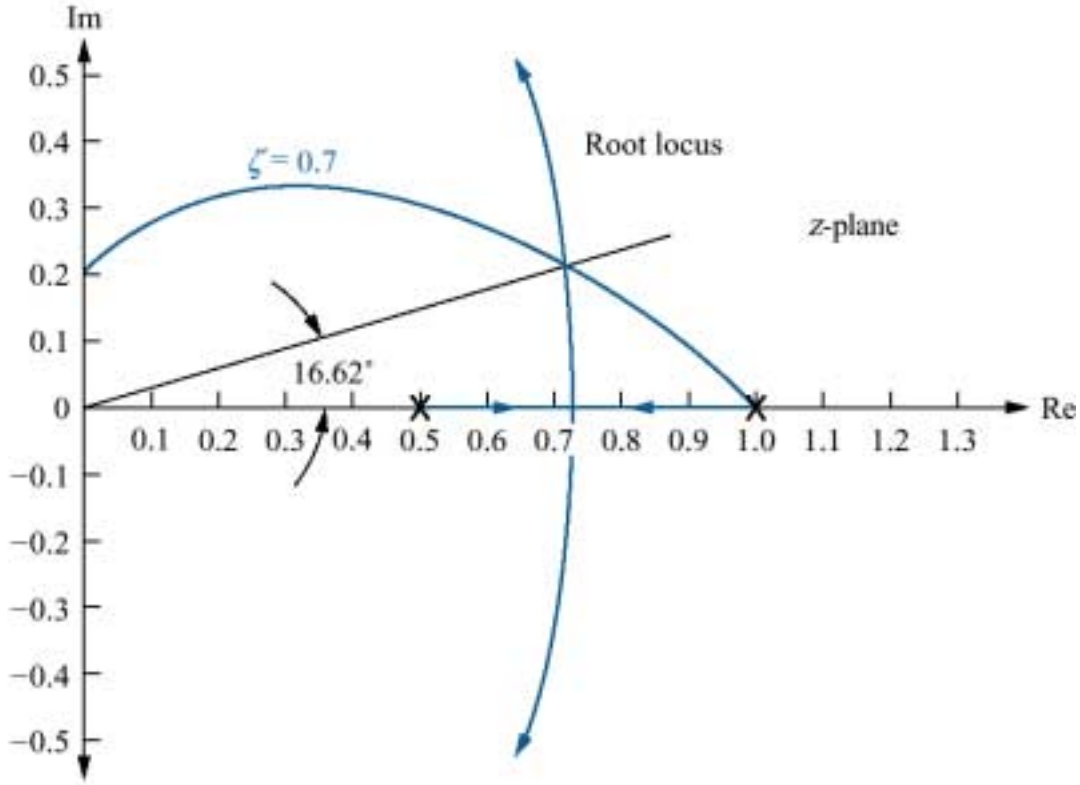
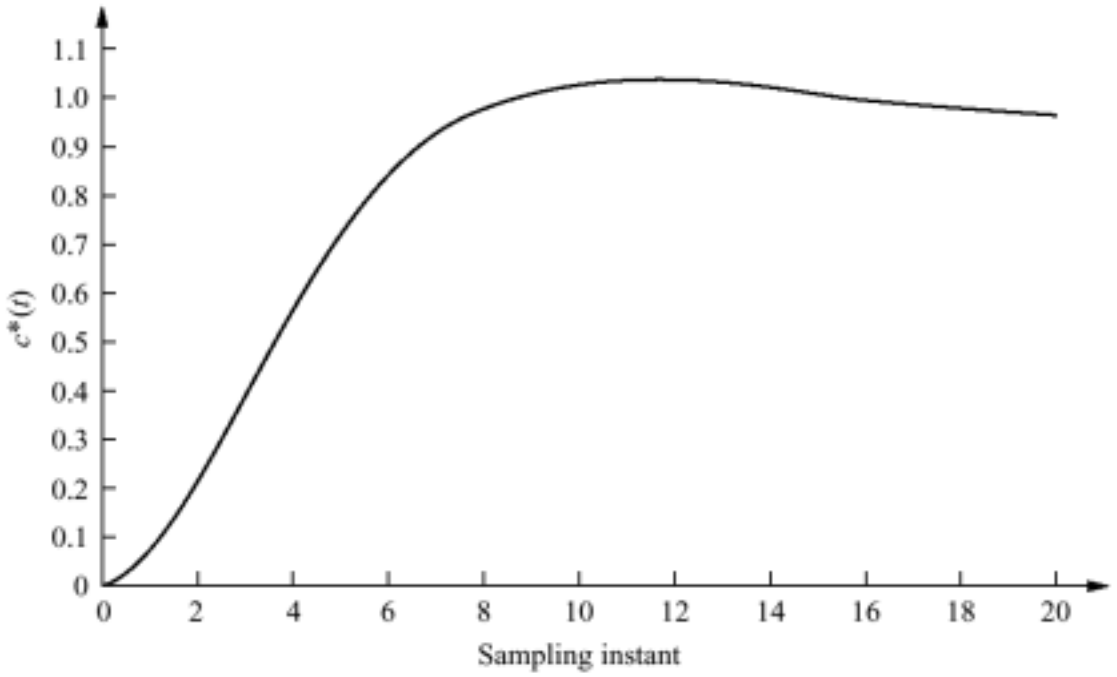


Figure 13.24
Sampled step response of the system of Figure 13.21 with K = 0.0627



Note: Valid only at integer values of sampling instant.

Figure 13.25
a. Digital control system showing the digital computer performing compensation;
b. continuous system used for design;
c. transformed digital system

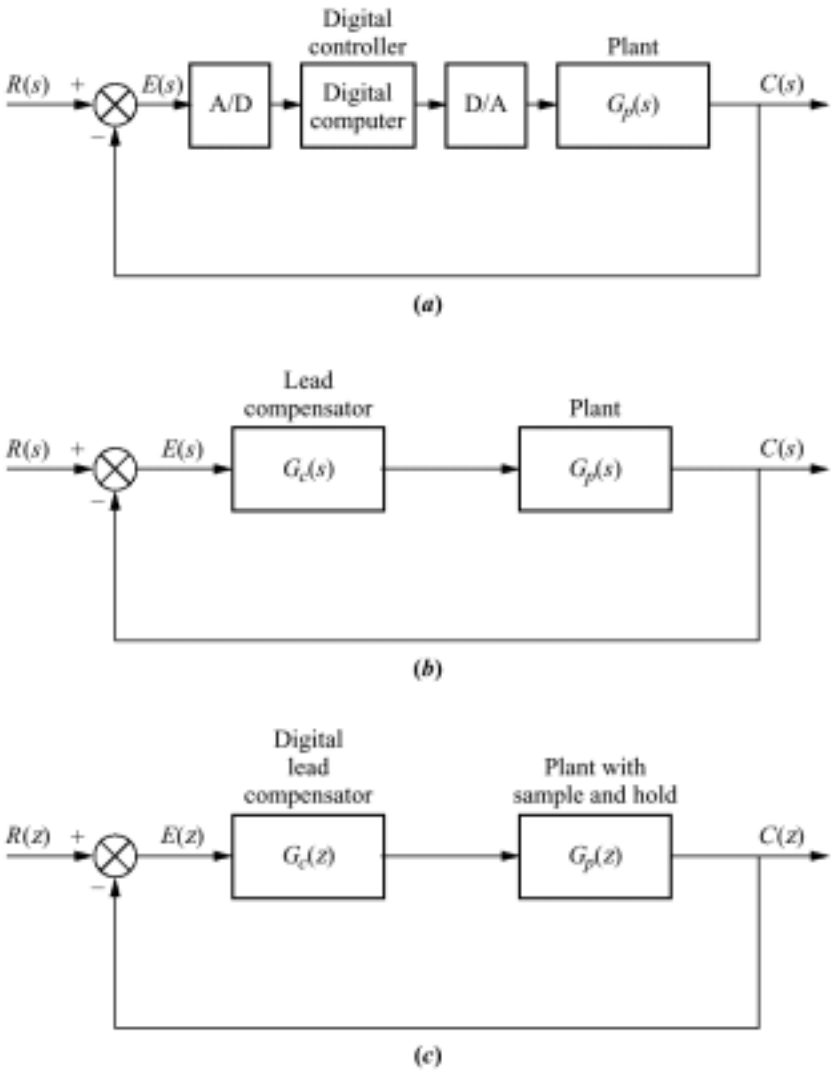


Figure 13.26
Closed-loop response for the compensated system of Example 13.12 showing effect of three different sampling frequencies

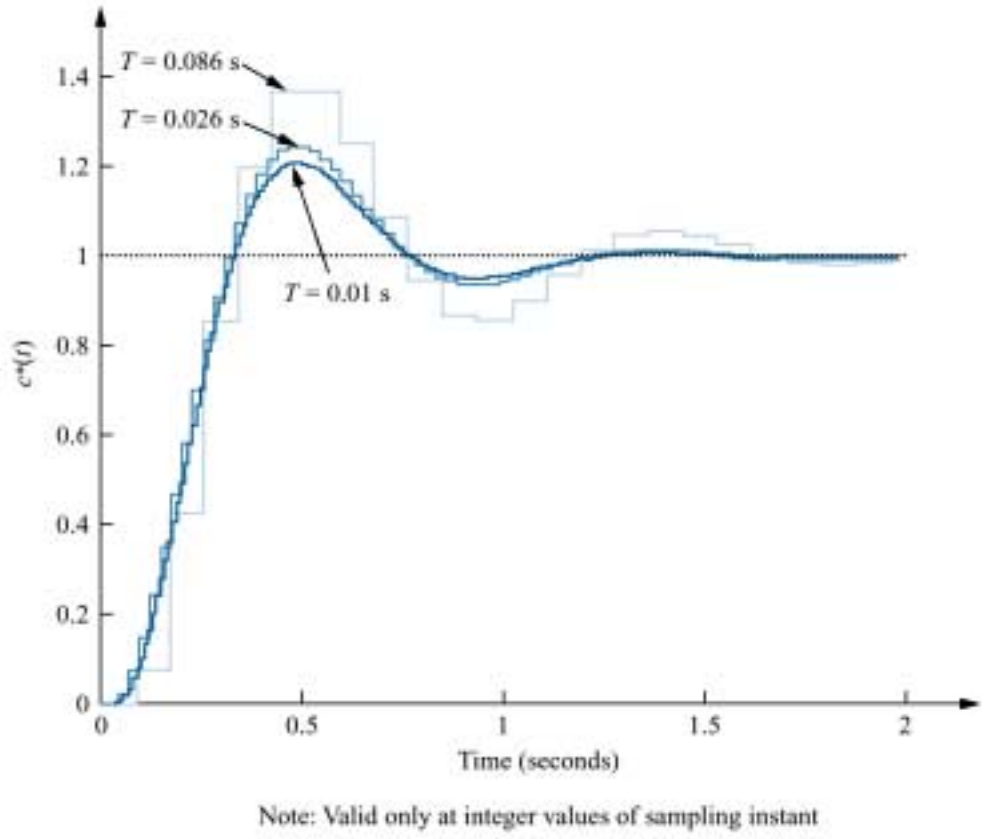


Figure 13.27
Block diagram showing computer emulation of a digital compensator

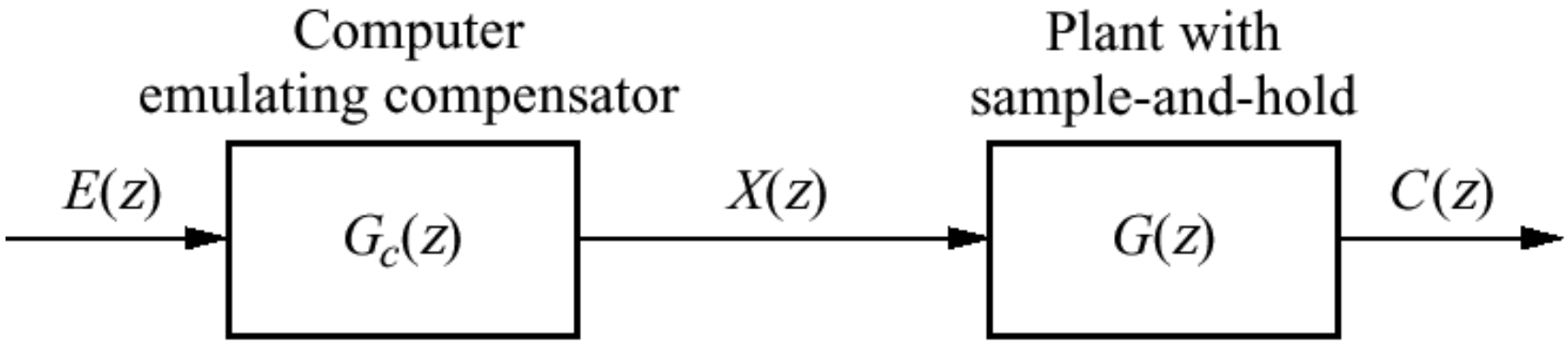


Figure 13.28
Flowchart for
a second-order
digital compensator

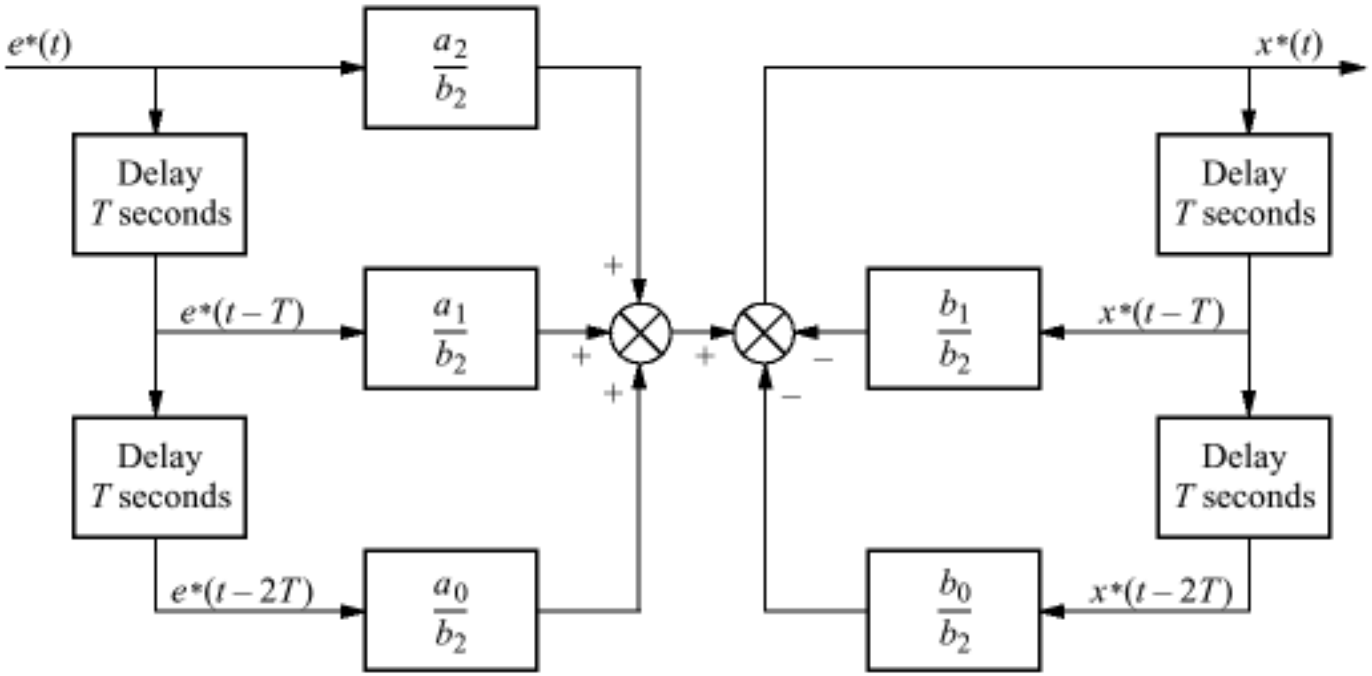


Figure 13.29
Flowchart to implement $G_c(z) = \dfrac{z + 0.5}{z^2 - 0.5z + 0.7}$

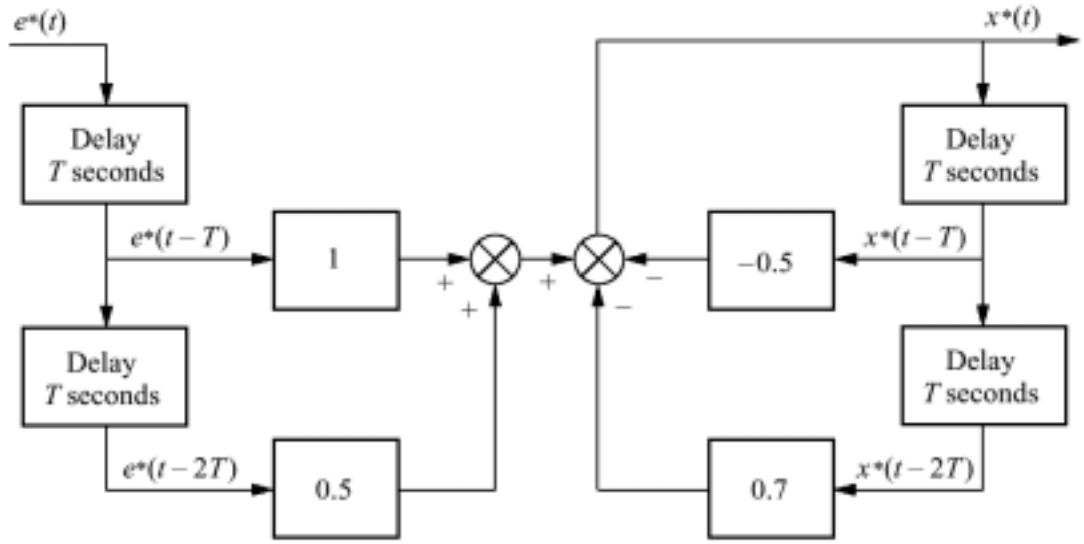


Figure 13.30
Antenna control system:
a. analog implementation;
b. digital implementation

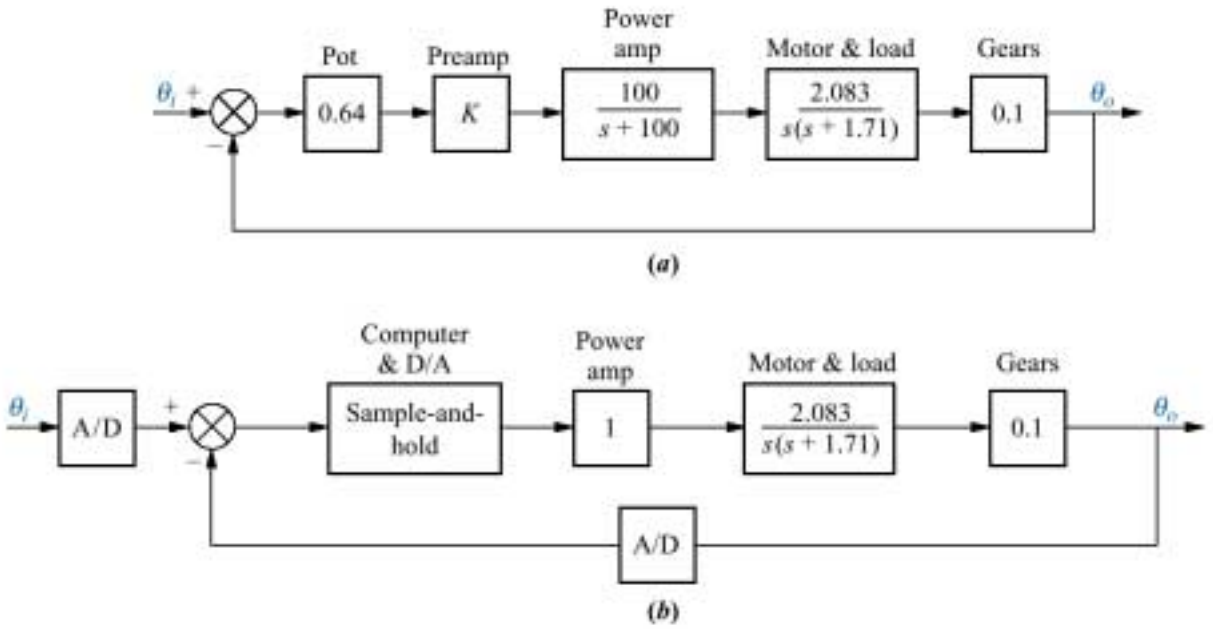


Figure 13.31
Analog antenna azimuth position control system converted to a digital system

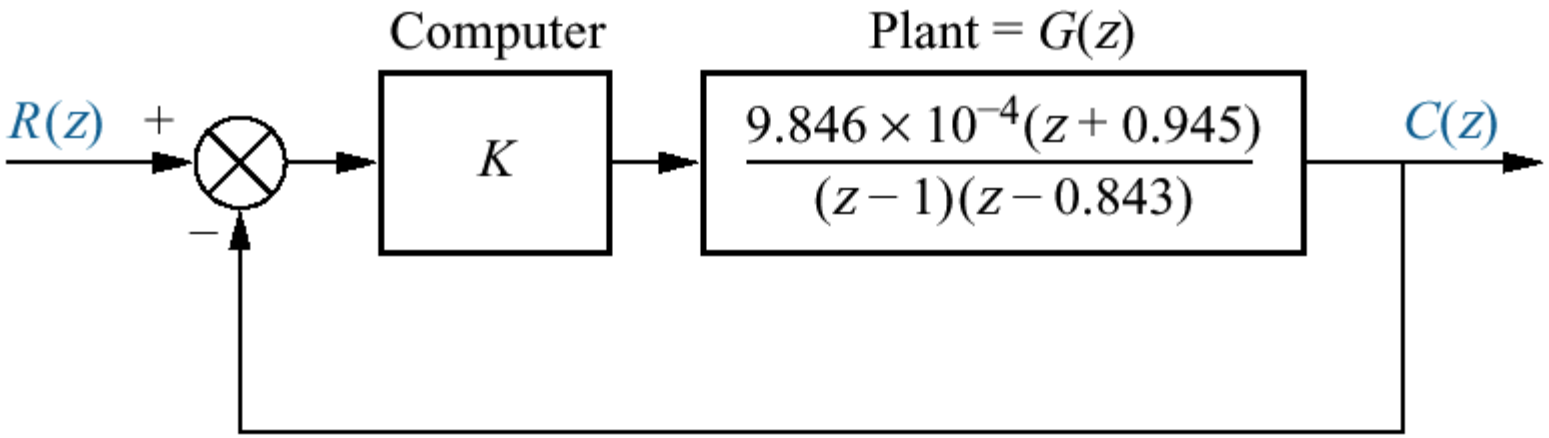


Figure 13.32
Root locus superimposed over constant damping ratio curve

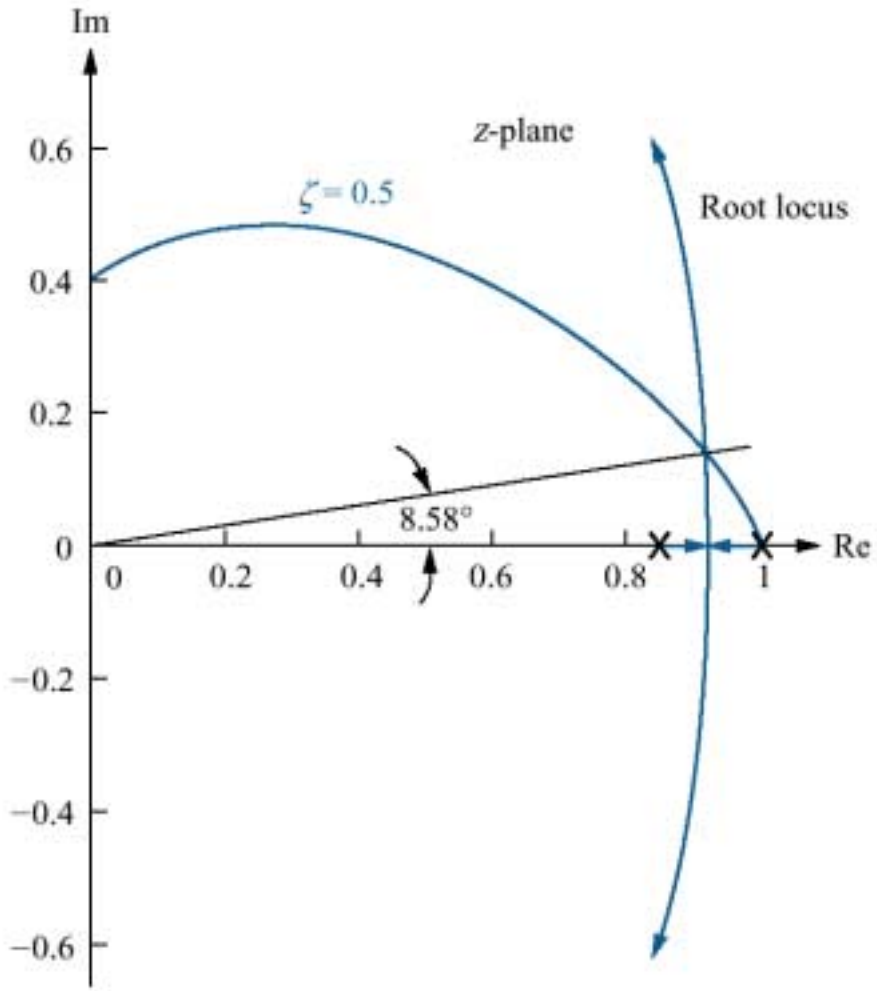
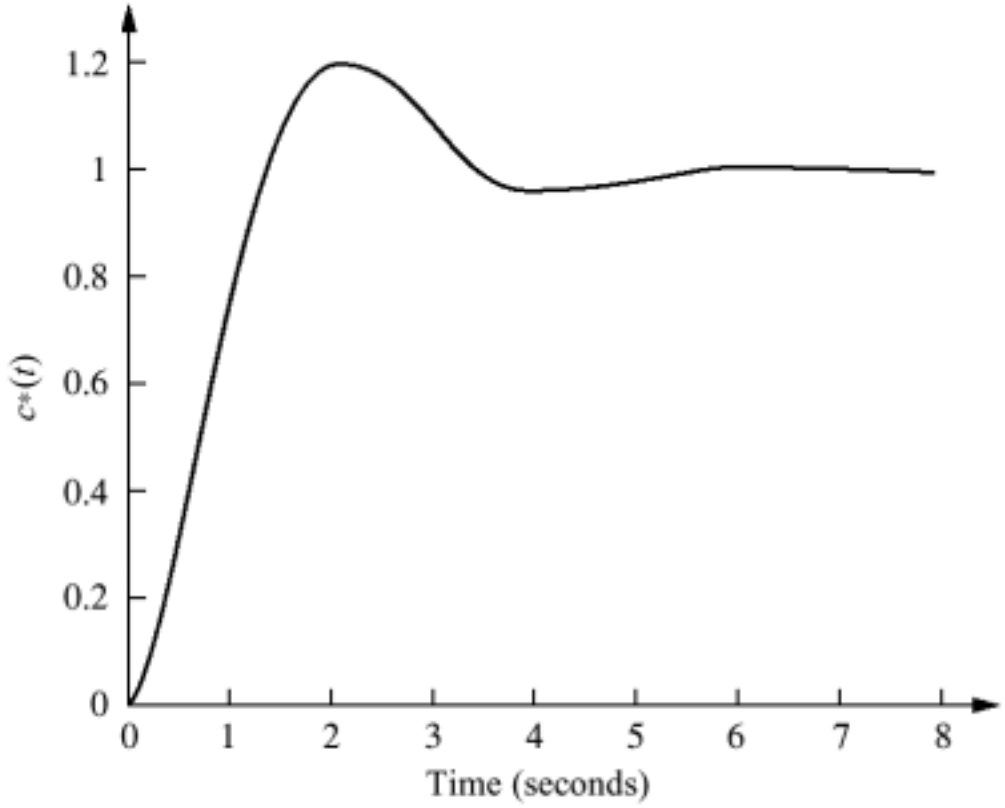


Figure 13.33
Sampled step response of the antenna azimuth position control system



Note: Valid only at integer values of sampling instant

Figure 13.34
Simplified block diagram of antenna azimuth control system

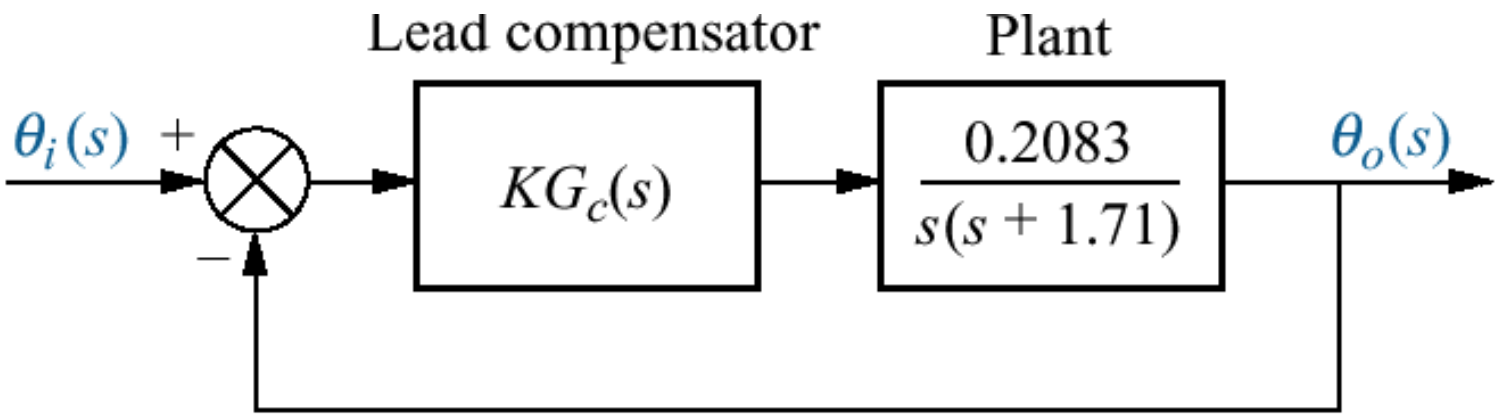


Figure 13.35
Closed-loop digital step response for antenna control system with a lead compensator.

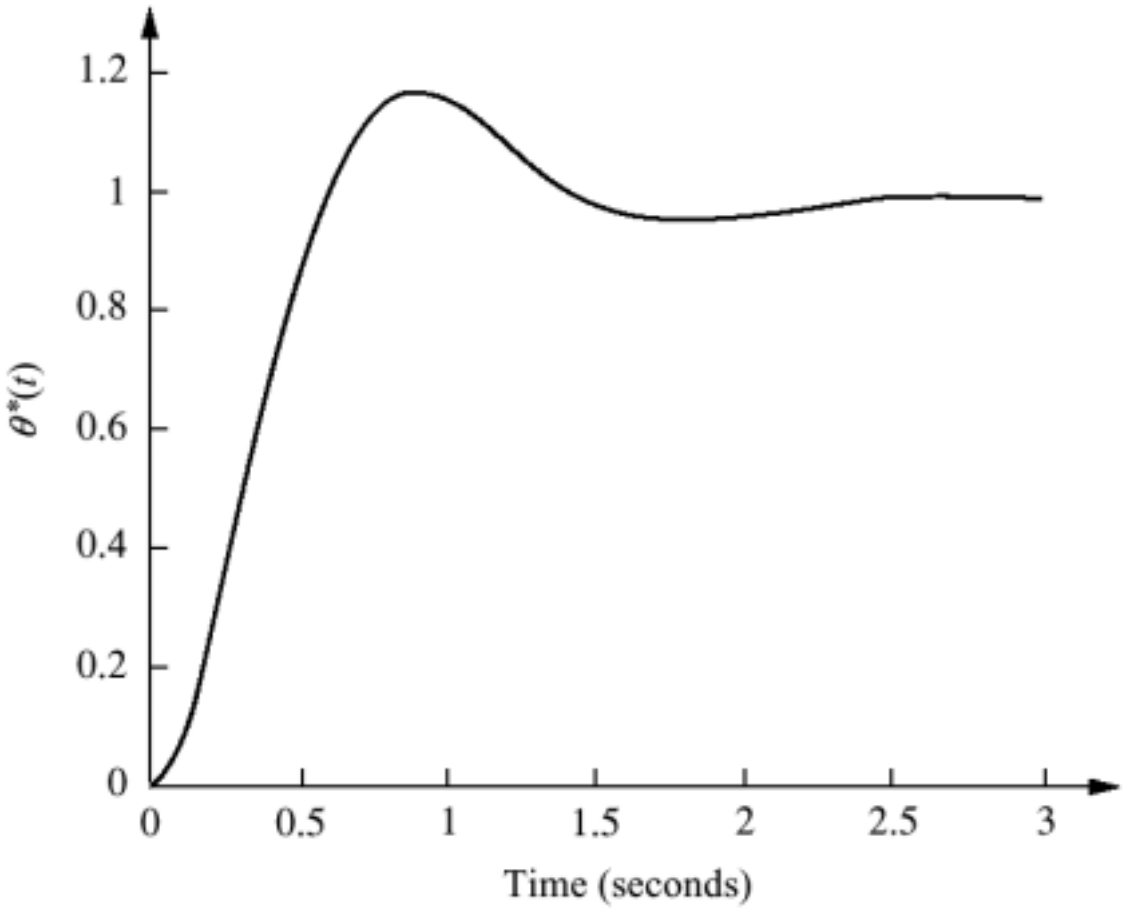


Figure 13.36
Flowchart for lead digital compensator

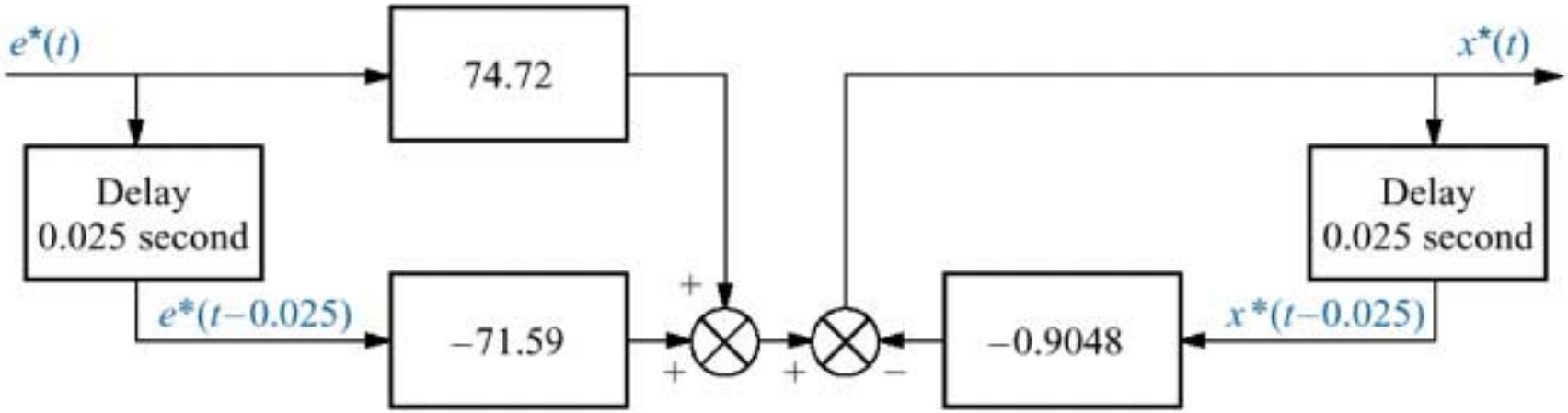


Figure P13.1

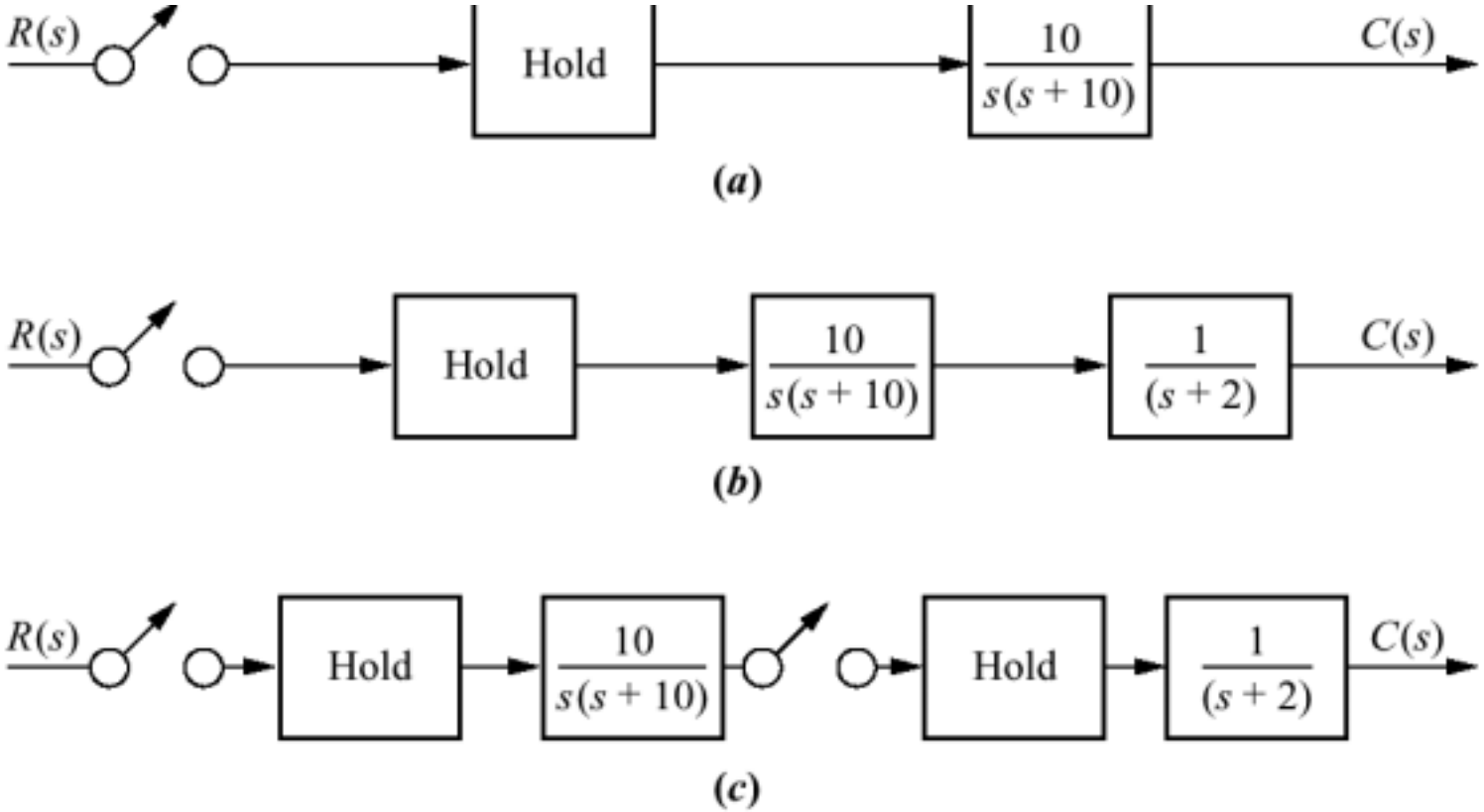


Figure P13.2

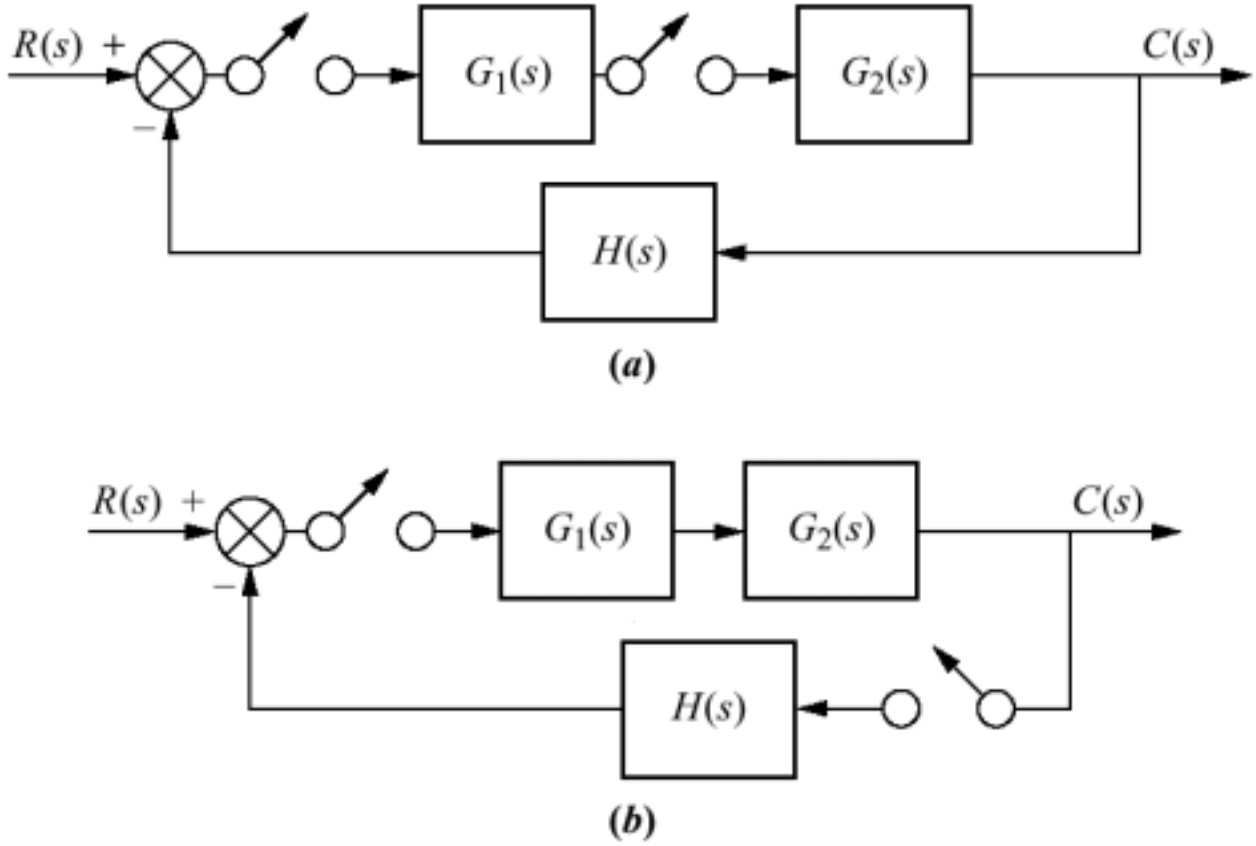


Figure P13.3

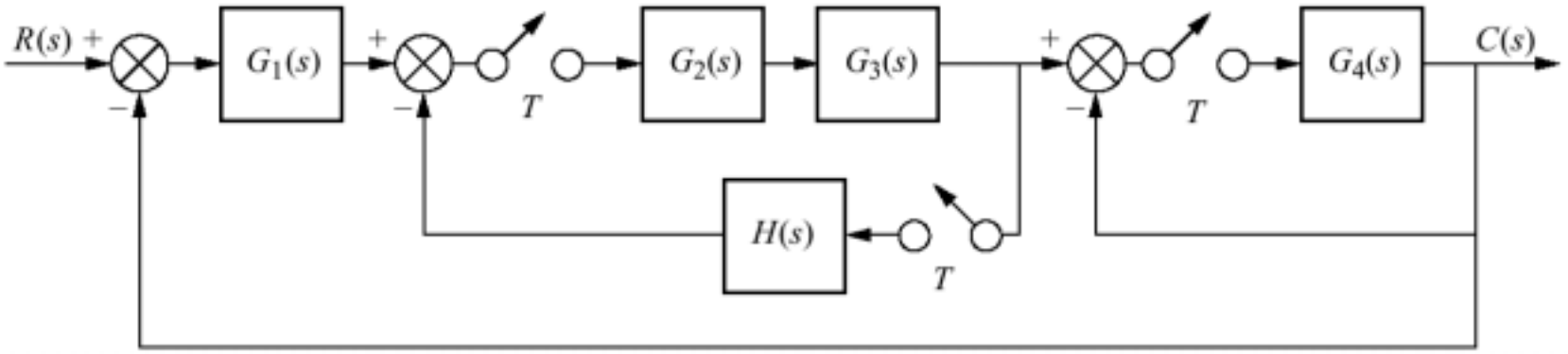


Figure P13.4

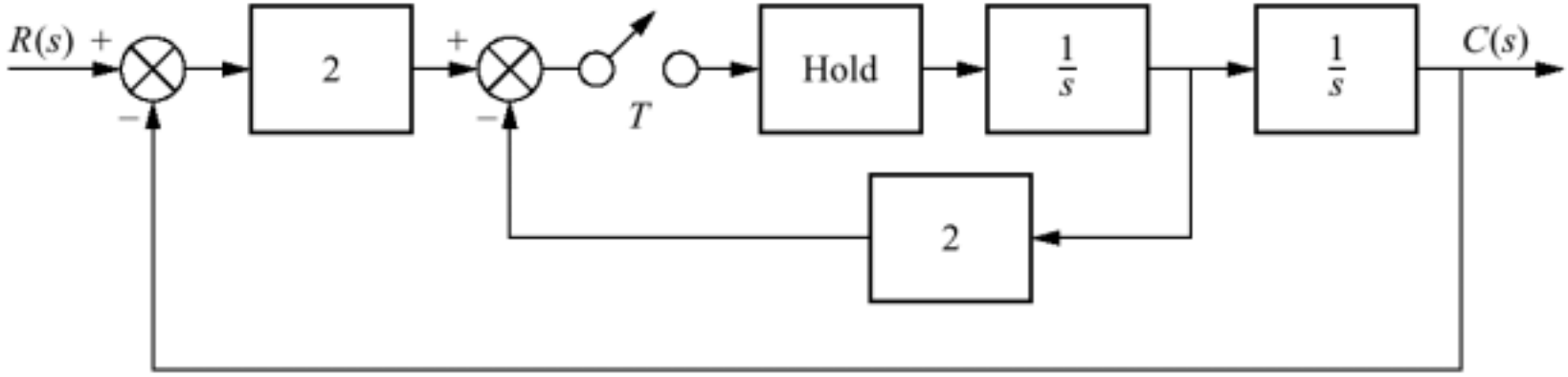


Figure P13.5

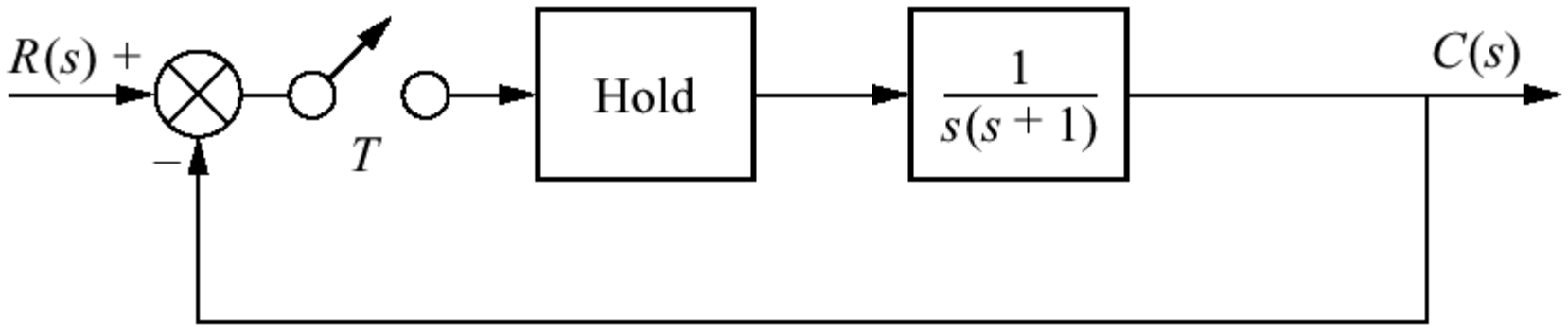


Figure P13.6

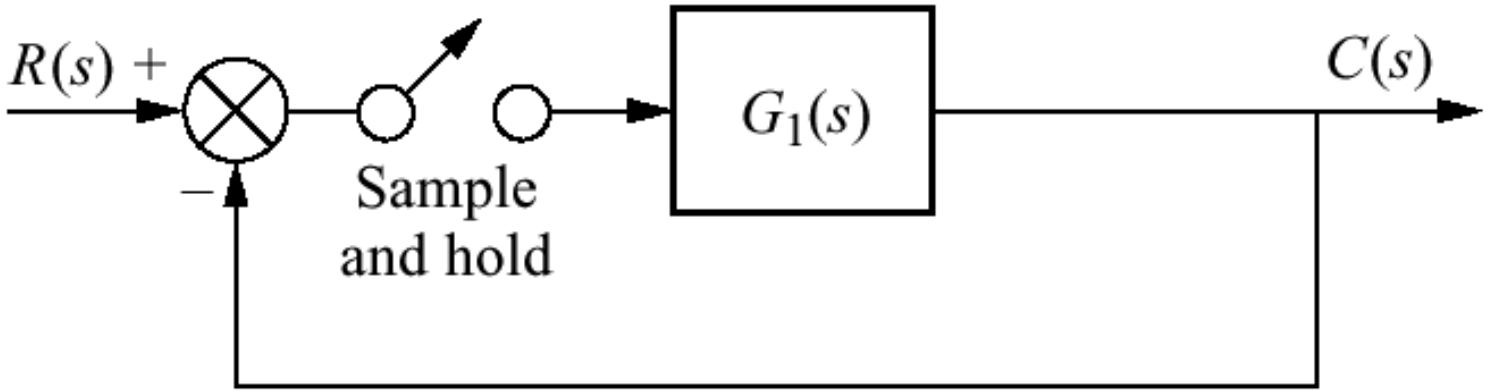


Figure P13.7

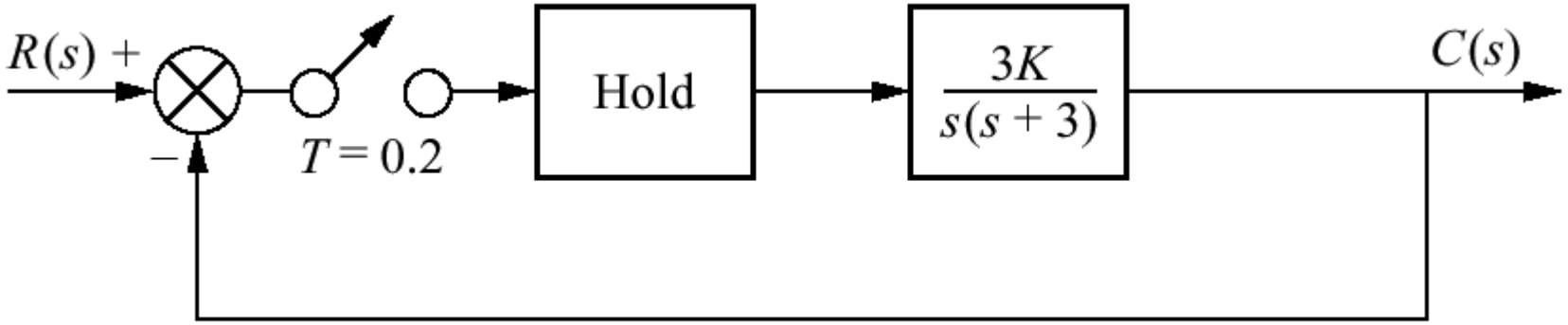


Figure P13.8

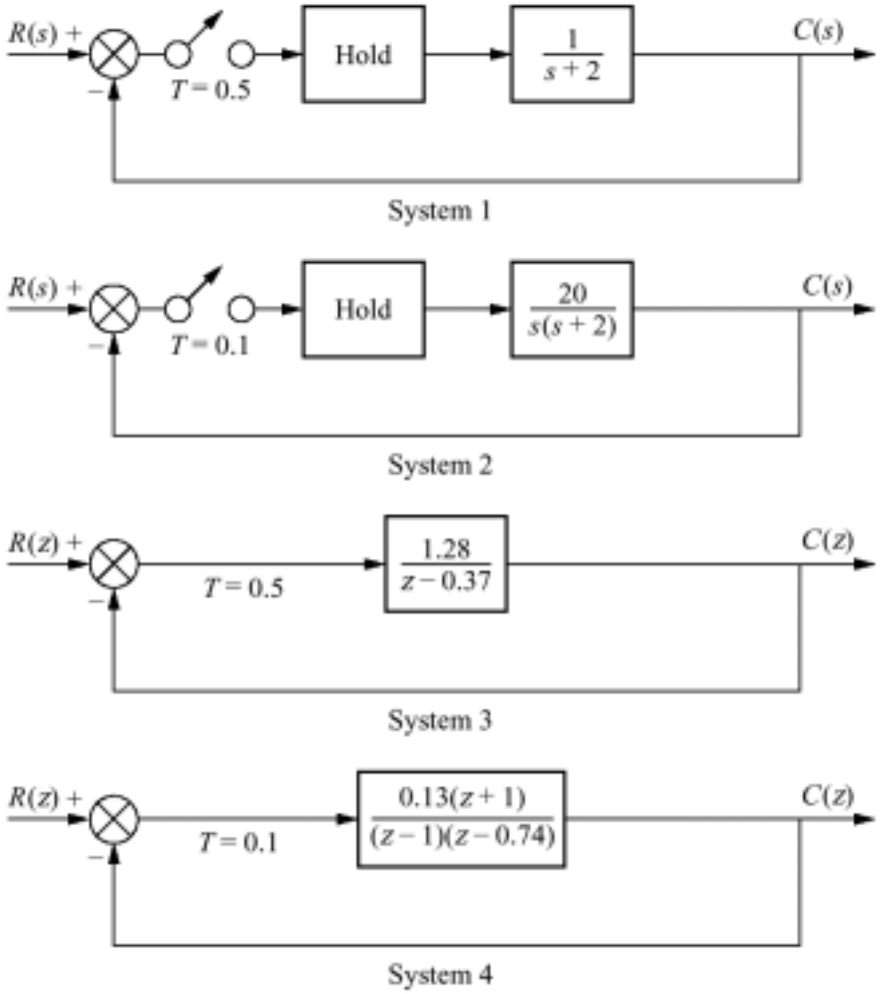


Figure P13.9
Simplified block diagram for robot swing motion

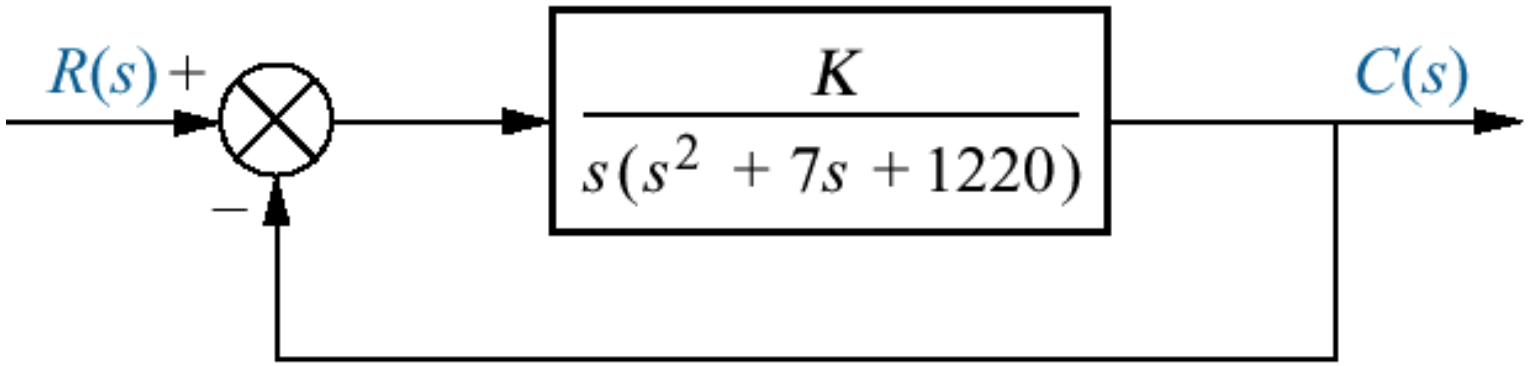


Figure P13.10
Simplified block diagram of a floppy disk drive