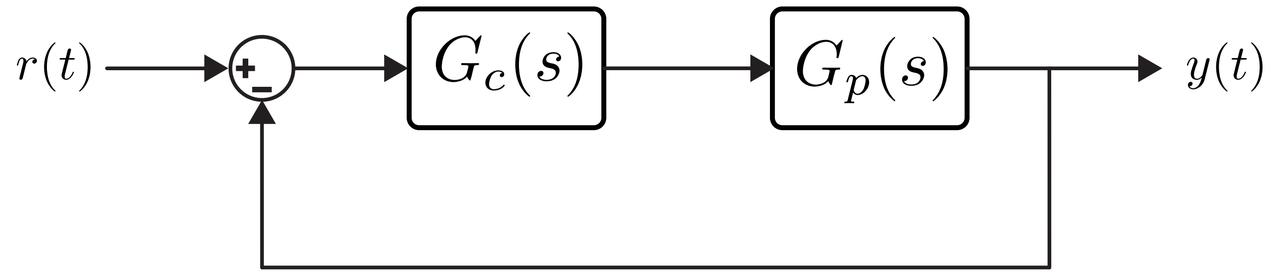
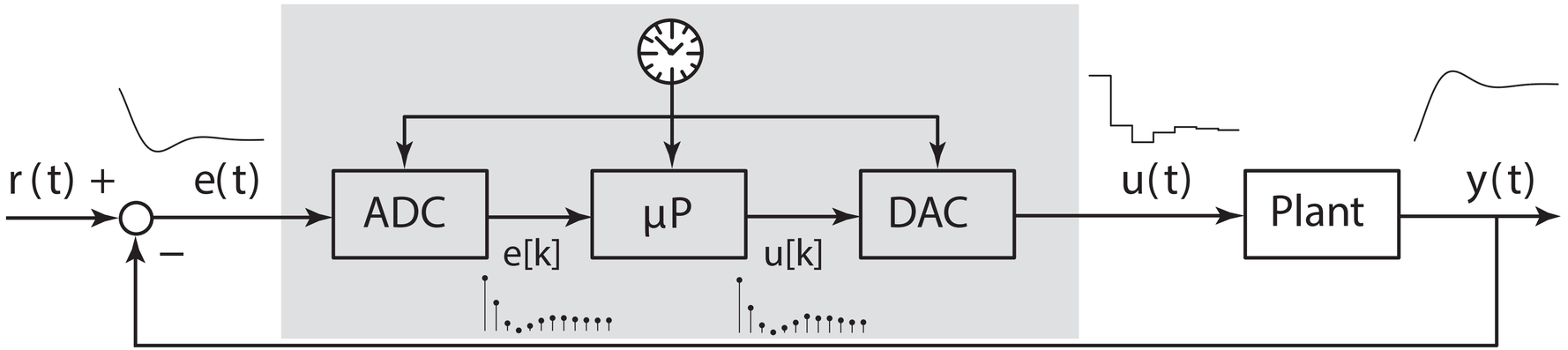
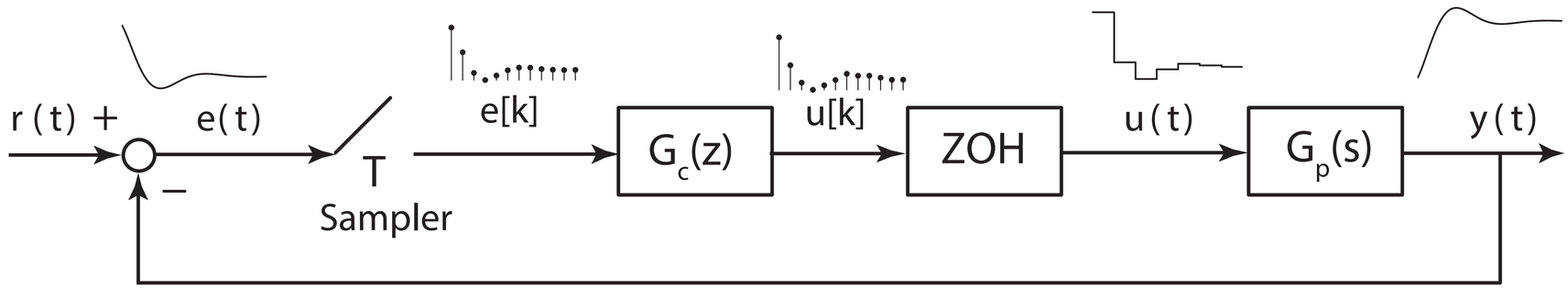
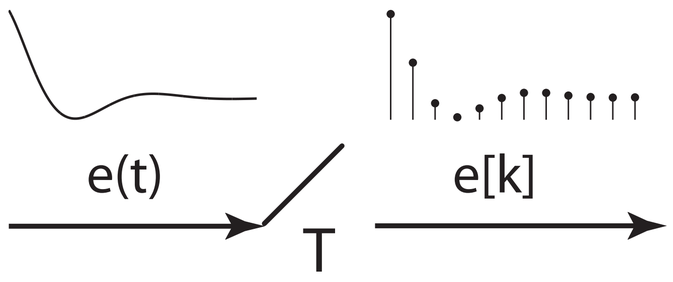
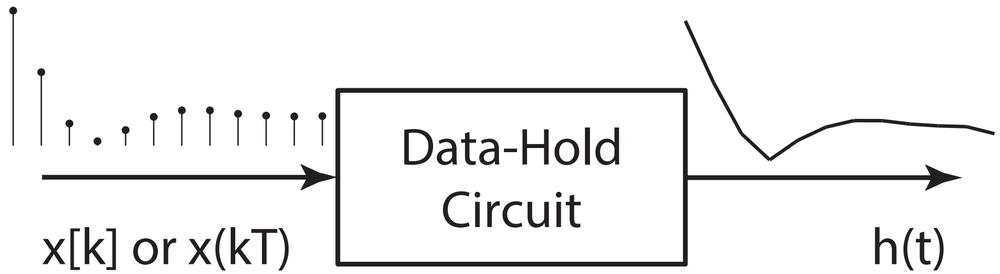

$r(t)$
+
−
$G_c(s)$
$G_p(s)$
$y(t)$

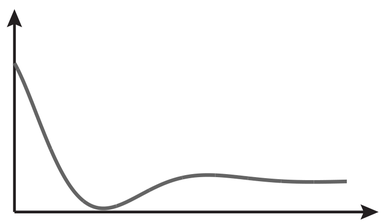

r(t) +
e(t)
ADC
μP
DAC
e[k]
u[k]
u(t)
Plant
y(t)
−

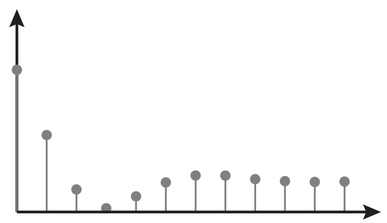

r(t)
+
−
e(t)
T
Sampler
e[k]
$G_c(z)$
u[k]
ZOH
u(t)
$G_p(s)$
y(t)

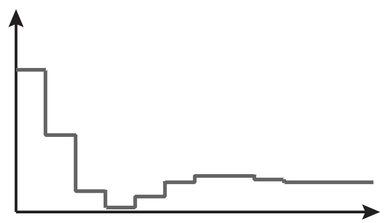


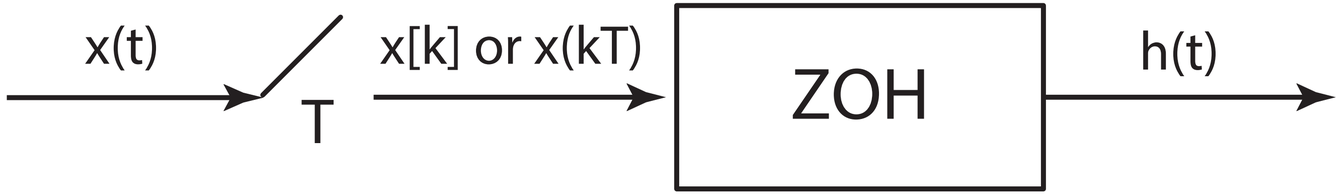
Ideal CT to DT Sampler



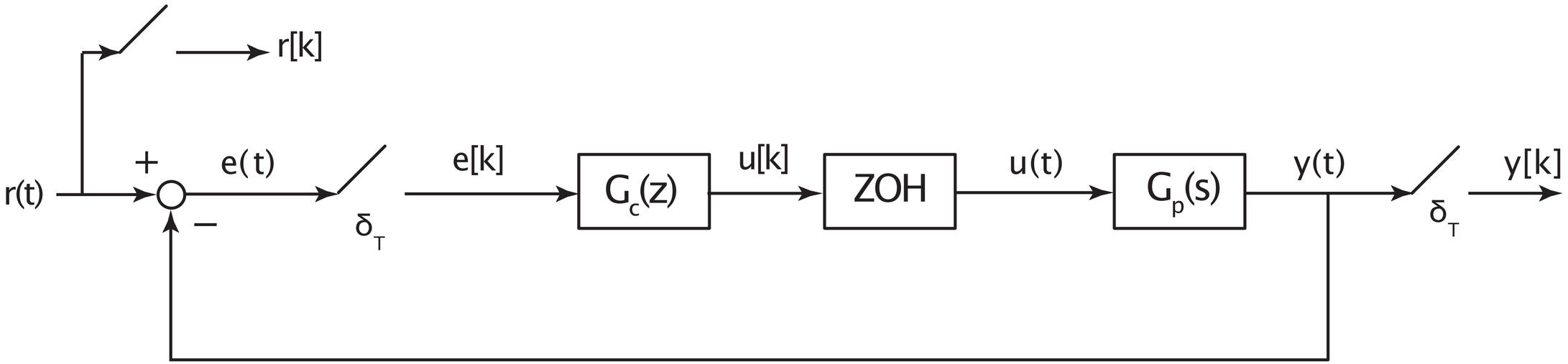


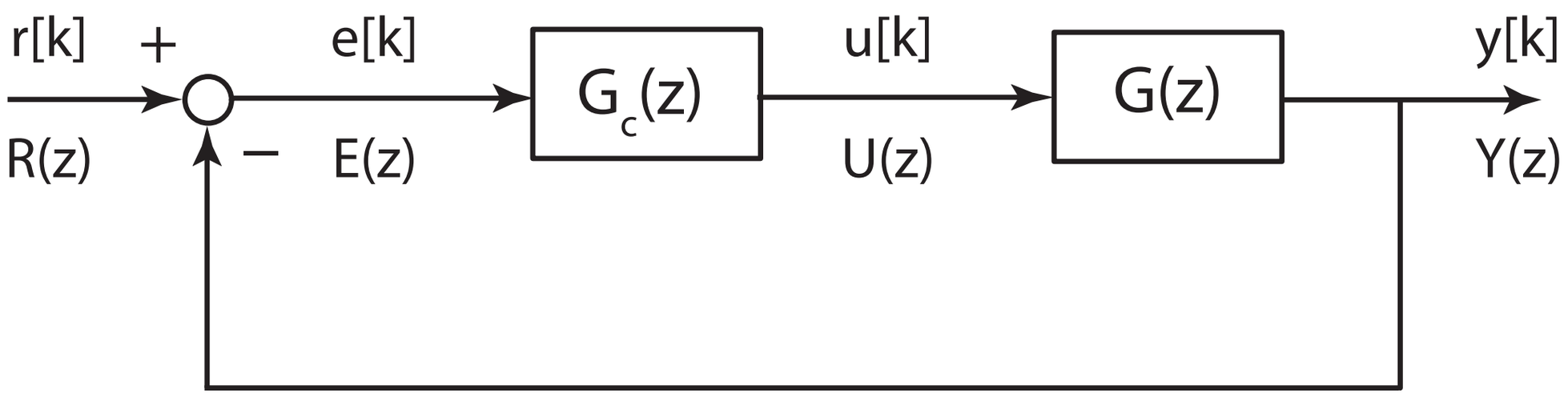


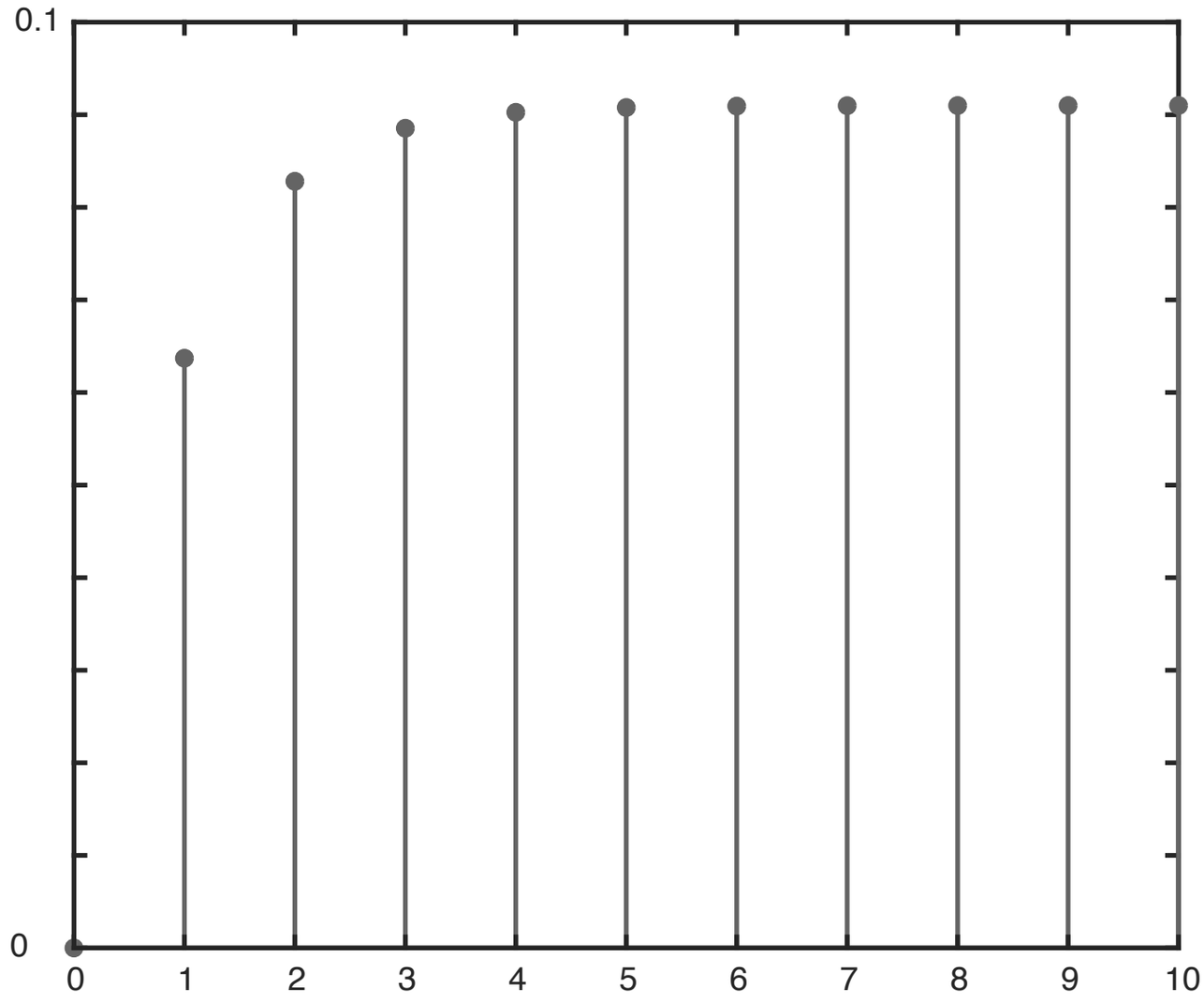


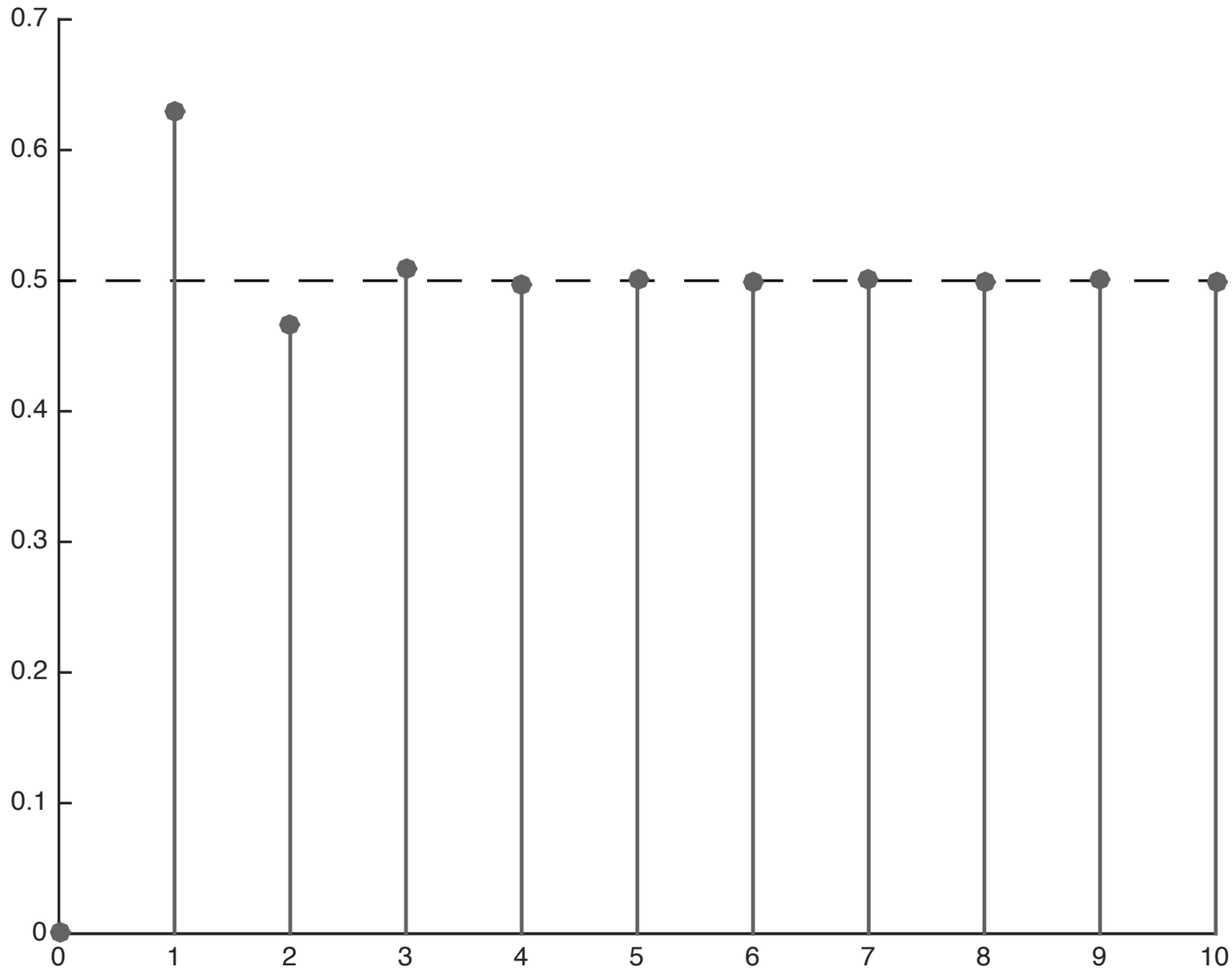

x(t)
T
x[k] or x(kT)
ZOH
h(t)

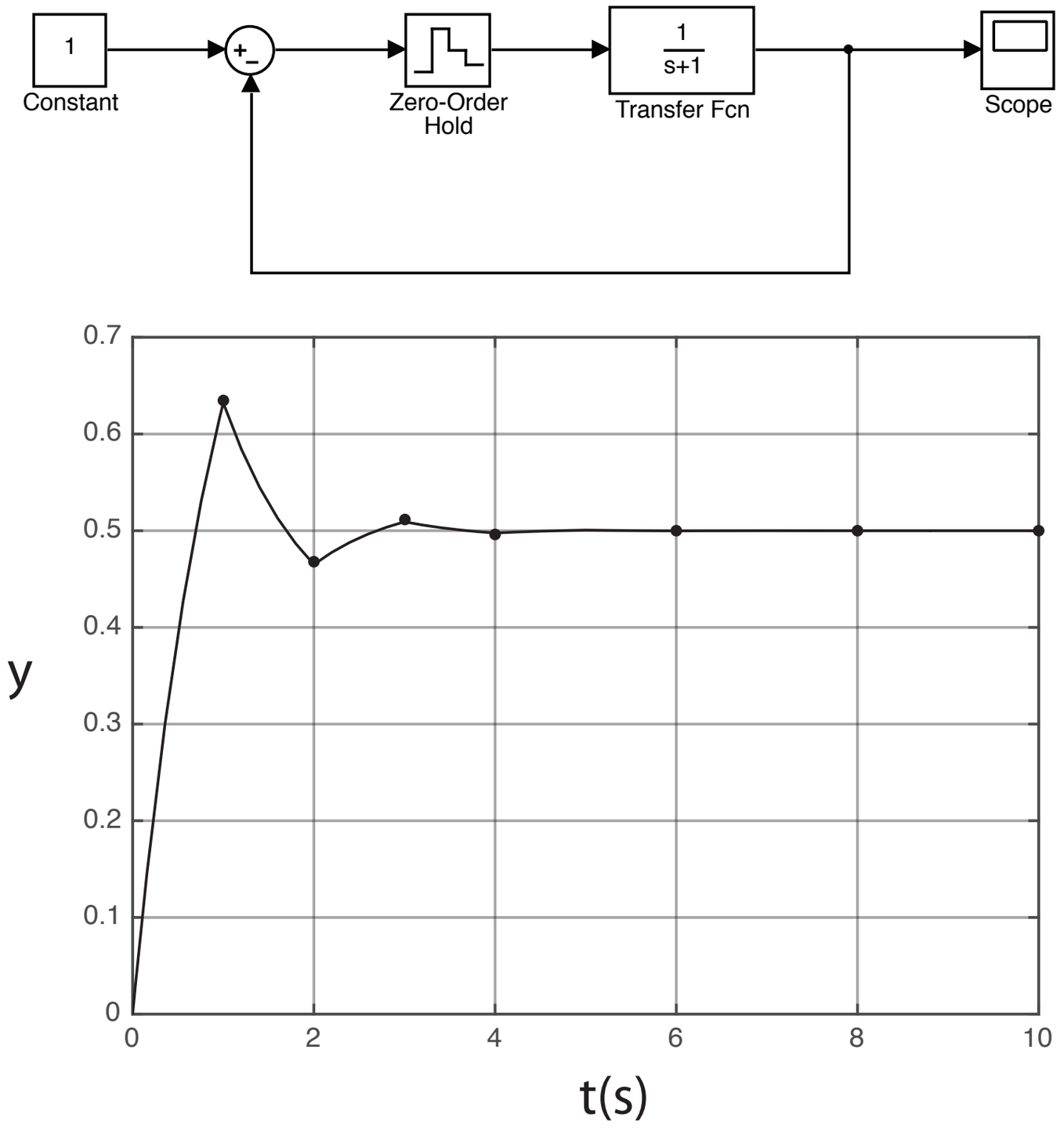
x[k] or x(kT)
ZOH
h(t)
G(s)
y(t)
T
y[k] or y(kT)

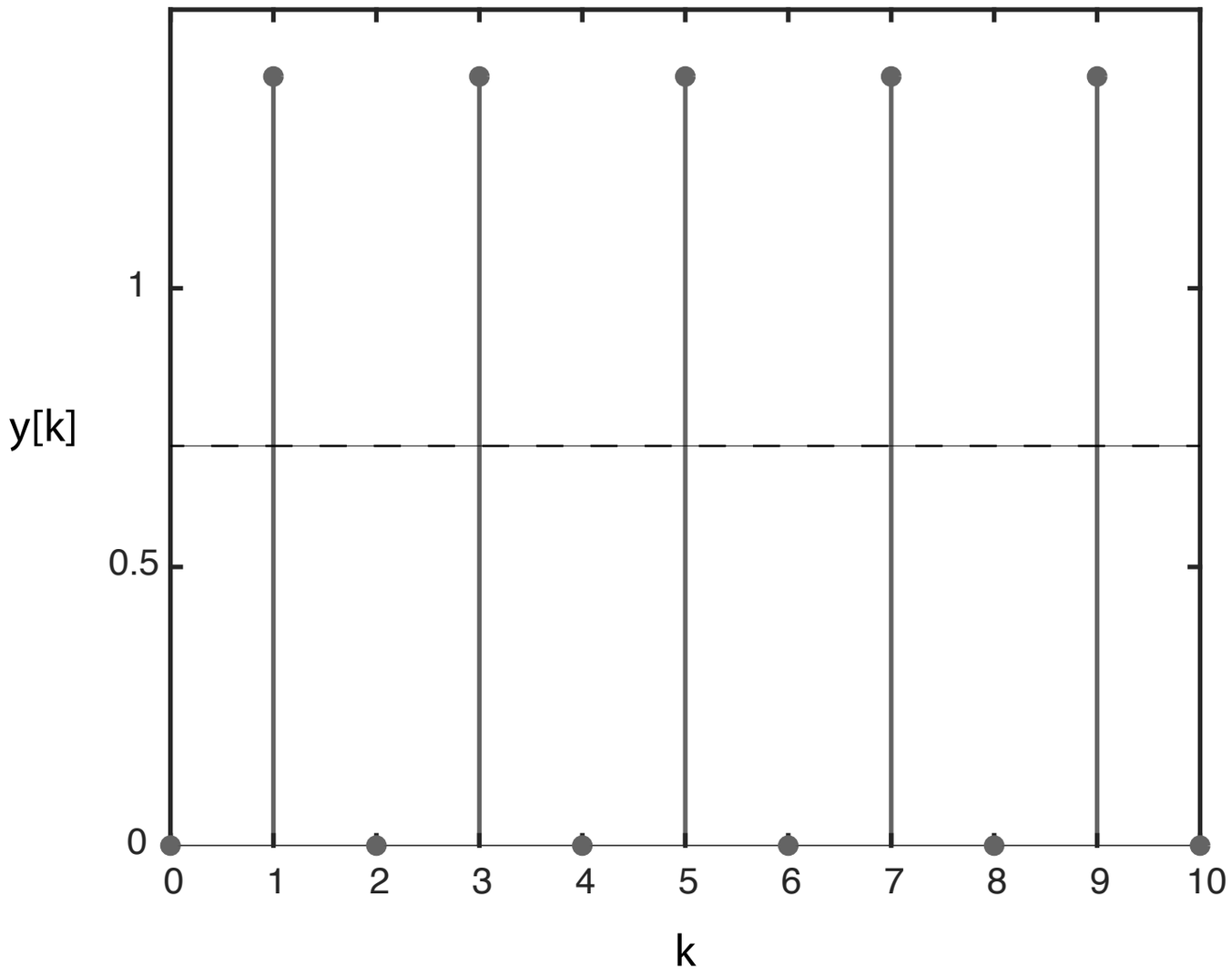

r[k]
r(t)
+
−
e(t)
δT
e[k]
Gc(z)
u[k]
ZOH
u(t)
Gp(s)
y(t)
δT
y[k]

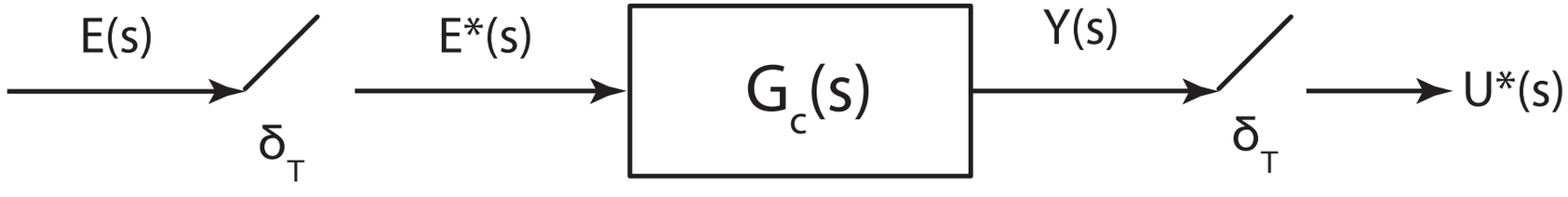

r[k]
+
e[k]
G_c(z)
u[k]
G(z)
y[k]
R(z)
−
E(z)
U(z)
Y(z)

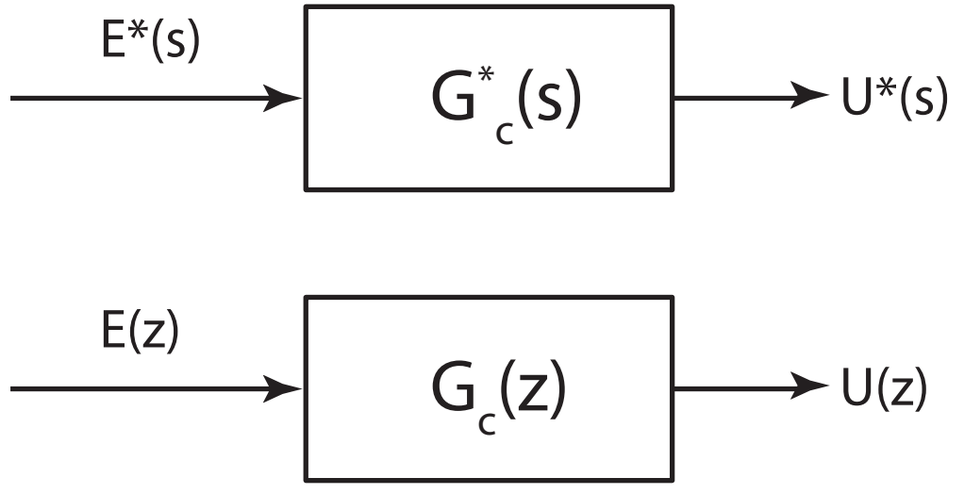

0.1
0
0
1
2
3
4
5
6
7
8
9
10


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9
10


1
Constant
+_
Zero-Order
Hold
1
s+1
Transfer Fcn
Scope
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
y
0
2
4
6
8
10
t(s)


y[k]
1
0.5
0
0
1
2
3
4
5
6
7
8
9
10
k


E(s)
δ T
E*(s)
G c (s)
Y(s)
δ T
U*(s)


E*(s)
G* c (s)
U*(s)
E(z)
G c (z)
U(z)

CT-PID

DT-PID

Causal CT-PID

Imaginary Axis

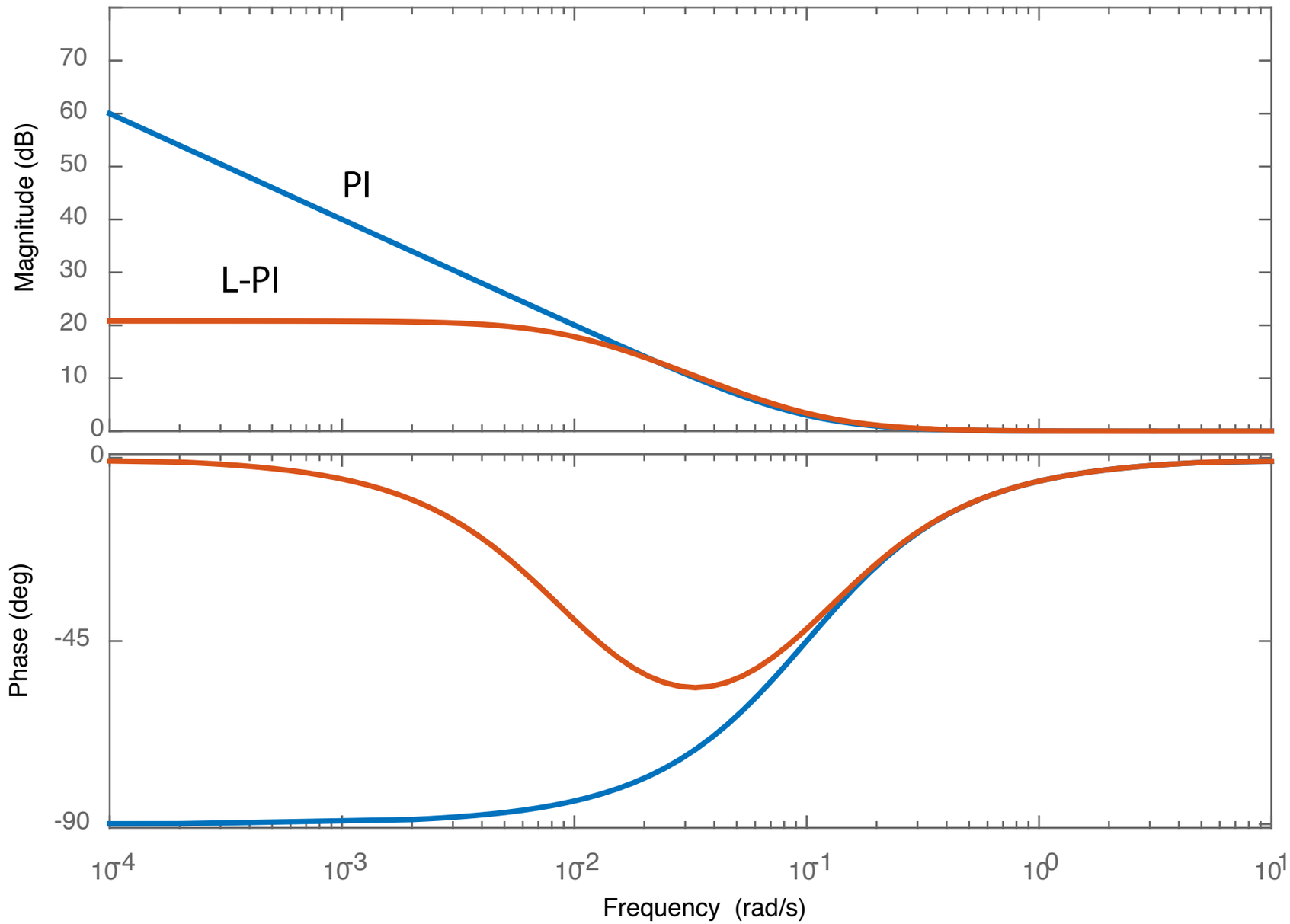
$\omega = \infty$

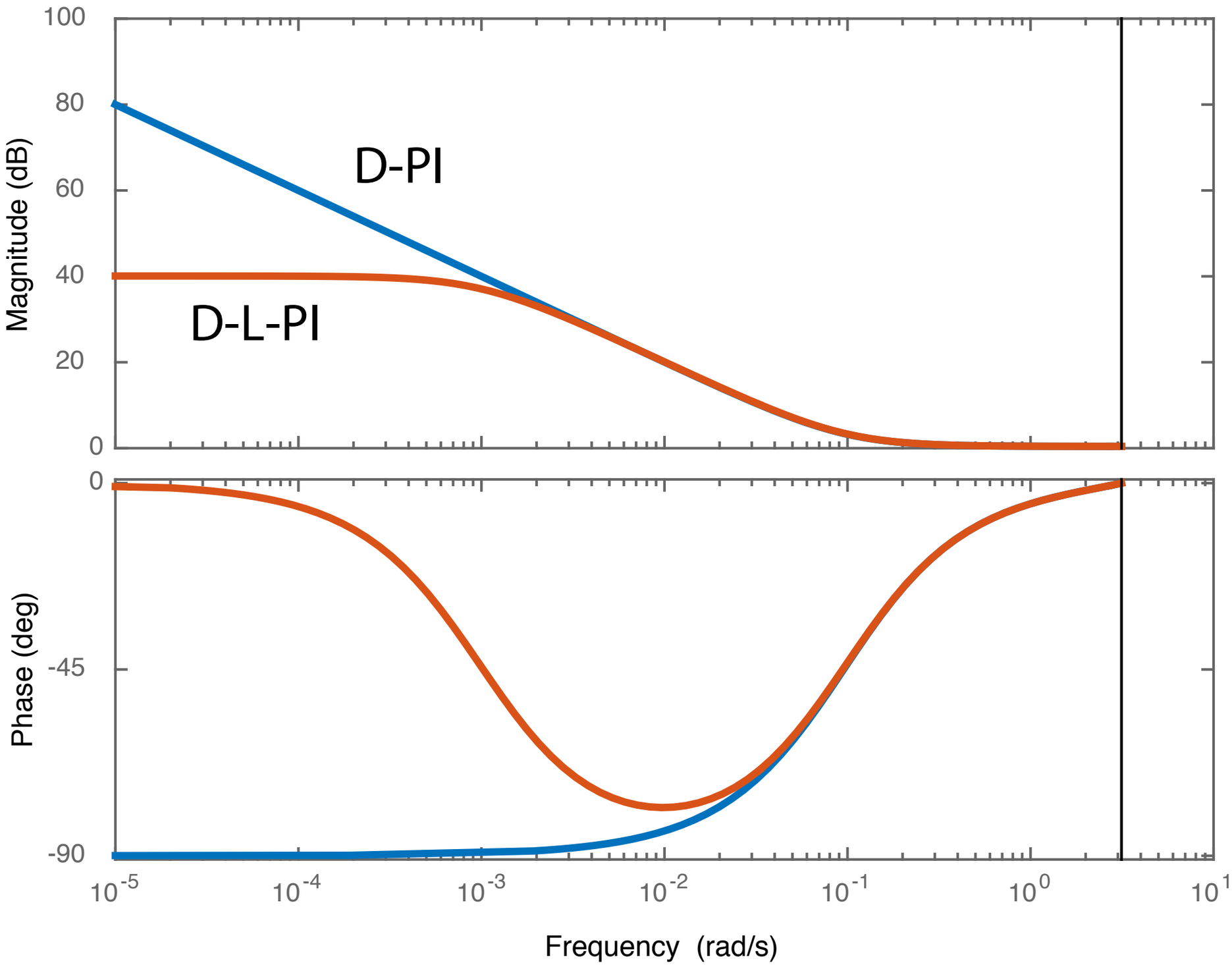
$\omega = 0$

$\omega = \frac{2\pi}{T}$

$\omega = \frac{\pi}{T}$

Real Axis


Magnitude (dB)
70
60
50
40
30
20
10
0
PI
L-PI
Phase (deg)
0
-45
-90
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
Frequency (rad/s)


100
80
60
40
20
0
Magnitude (dB)
D-PI
D-L-PI
0
-45
-90
Phase (deg)
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
Frequency (rad/s)