IT CookBook, 핵심이 보이는 신호 및 시스템 : 기본 이론부터 MATLAB 실습까지

[연습문제 답안 이용 안내]

Chapter 01 연습문제 답안

1.1 ㈏

1.2 ㈑

1.3 (a) ㈑ (b) ㈐ (c) ㈎ (d) ㈏

1.4 ㈐

1.5 ㈎

1.6 ㈏

1.7 ㈐

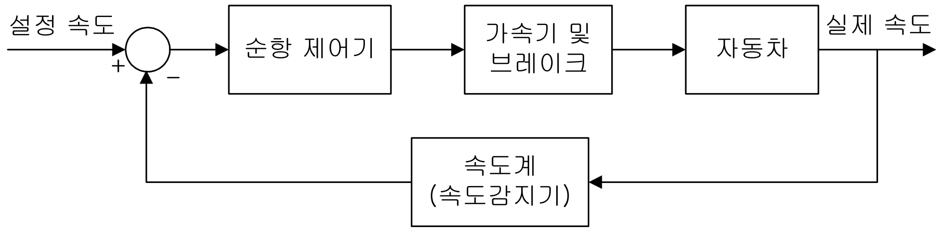
1.8 ㈐

1.9 ㈑

1.10 ㈐

1.11 $$\frac{d^2y(t)}{dt^2}+(a+b)\frac{dy(t)}{dt}+ab\,y(t)=ax(t)$$

1.12



1.13 (a) 진폭 $A=2$, 주기 $T=6$, 주파수 $f_0=\frac{1}{6}$, 각주파수 $\omega_0=\frac{\pi}{3}$, 위상 $\phi=-\frac{\pi}{3}$

(b) 진폭 $A=4$, 주기 $T=12$, 주파수 $f_0=\frac{1}{12}$, 각주파수 $\omega_0=\frac{\pi}{6}$, 위상 $\phi=-\frac{\pi}{3}$

(c) 진폭 $A=3$, 주기 $T=6$, 주파수 $f_0=\frac{1}{6}$, 각주파수는 $\omega_0=\frac{\pi}{3}$, 위상 $\phi=\frac{\pi}{3}$

1.14 (a) 에너지 $\frac{2}{3}$, 전력 0

(b) 에너지 $\frac{2A^2}{a}$, 전력 0

(c) 에너지 ∞, 전력 $\frac{A^2}{2}$

(d) 에너지 ∞, 전력 5

1.15 (a) 에너지 63, 전력 0

(b) 에너지 ∞, 전력 $\frac{1}{2}$

(c) 에너지 ∞, 전력 1

(d) 에너지 ∞, 전력 ∞

1.16 $10\log\frac{P_{x_3}}{P_{x_4}}=10\,[\mathrm{dB}]$

Chapter 02 연습문제 답안

2.1 ㉯

2.2 ㉱

2.3 ㉰

2.4 ㉱

2.5 (a) ㉰ ㉲ ㉴ (b) ㉯ ㉳ ㉵ (c) ㉮ ㉱ ㉵ (d) ㉱

2.6 ㉮

2.7 ㉯

2.8 ㉱

2.9 ㉯

2.10 ㉱

2.11 ㉮

2.12 (a) ㉮ ㉰ ㉲ ㉴ ㉵ (b) ㉮ ㉱ ㉲
(c) ㉯ ㉰ ㉲ ㉳ (d) ㉮ ㉰ ㉳ ㉴ ㉵

2.13 (a) 주기 신호
(b) 주기 신호
(c) 비주기 신호
(d) 주기 신호
(e) 주기 신호
(f) 주기 신호

2.14 (a) 주기 신호, 주기 8

(b) 주기 신호, 주기 20

(c) 비주기 신호

(d) 주기 신호, 주기15

(e) 비주기 신호

(f) 주기 신호, 주기 24

2.15 (a) 주기 신호, 주기 $T' = T/2$

(b) 비주기 신호

(c) 주기 신호, 주기 $T' = T$

(d) 주기 신호, 주기 $T' = T$

(e) 주기 신호이, 주기 $N_1 = \begin{cases} N/2, & N = \text{짝수} \\ N, & N = \text{홀수} \end{cases}$

(f) 주기 신호, 주기 $N_2 = N^2$

(g) 비주기 신호

(h) 주기 신호, 주기 $N_4 = N$

2.16 (a) $x_e(t) = \frac{1}{2}[x(t) + x(-t)] = \frac{1}{2}[(at^2 + bt + c) + (a(-t)^2 + b(-t) + c)] = at^2 + c$

$x_o(t) = \frac{1}{2}[x(t) - x(-t)] = \frac{1}{2}[(at^2 + bt + c) - (a(-t)^2 + b(-t) + c)] = bt$

(b) $x_e(t) = \frac{1}{2}[x(t) + x(-t)] = \frac{1}{2}[e^{at}u(t) + e^{a(-t)}u(-t)]$

$= \frac{1}{2}[e^{at}u(t) + e^{-at}u(-t)] = \frac{1}{2}(e^{a|t|} + \delta[n])$

$x_o(t) = \frac{1}{2}[x(t) - x(-t)] = \frac{1}{2}[e^{at}u(t) - e^{a(-t)}u(-t)] = \frac{1}{2}[e^{at}u(t) - e^{-at}u(-t)]$

(c) $x_e(t) = \frac{1}{2}[x(t) + x(-t)] = \frac{1}{2}[2\cos(\pi t - \frac{\pi}{4}) + 2\cos(\pi(-t) - \frac{\pi}{4})]$

$= \cos(\pi t - \frac{\pi}{4}) + \cos(-(\pi t + \frac{\pi}{4}))$

$= \cos(\pi t - \frac{\pi}{4}) + \cos(\pi t + \frac{\pi}{4})$

$= 2\cos(\pi t)\cos(\frac{\pi}{4}) = \sqrt{2}\cos(\pi t)$

$x_o(t) = \frac{1}{2}[x(t) - x(-t)] = \frac{1}{2}[2\cos(\pi t - \frac{\pi}{4}) - 2\cos(\pi(-t) - \frac{\pi}{4})]$

$= \cos(\pi t - \frac{\pi}{4}) - \cos(-(\pi t + \frac{\pi}{4}))$

$= \cos(\pi t - \frac{\pi}{4}) - \cos(\pi t + \frac{\pi}{4})$

$= 2\sin(\pi t)\sin(\frac{\pi}{4}) = \sqrt{2}\sin(\pi t)$

(d) $x_e(t)=\frac{1}{2}[x(t)+x(-t)]=\frac{1}{2}[\frac{\sin(\pi t)}{\pi t}+\frac{\sin(\pi(-t))}{\pi(-t)}]=\frac{\sin(\pi t)}{\pi t}$

$x_o(t)=\frac{1}{2}[x(t)-x(-t)]=\frac{1}{2}[\frac{\sin(\pi t)}{\pi t}-\frac{\sin(\pi(-t))}{\pi(-t)}]=0$

(e) $x_e[n]=\frac{1}{2}(x[n]+x[-n])=\frac{1}{2}(u[n]+u[-n])=\frac{1}{2}+\frac{1}{2}\delta[n]=\begin{cases}1, & n=0\\ \frac{1}{2}, & n\neq 0\end{cases}$

$x_o[n]=\frac{1}{2}(x[n]-x[-n])=\frac{1}{2}(u[n]-u[-n])=\frac{1}{2}sgn[n]=\begin{cases}\frac{1}{2}, & n>0\\ 0, & n=0\\ -\frac{1}{2}, & n<0\end{cases}$

(f) $x_e[n]=\frac{1}{2}(x[n]+x[-n])=\frac{1}{2}(a^n u[n]+a^{-n}u[-n])$

$=\frac{1}{2}a^{|n|}+\frac{1}{2}\delta[n]=\begin{cases}\frac{1}{2}a^n, & n>0\\ 1, & n=0\\ \frac{1}{2}a^{-n}, & n<0\end{cases}$

$x_o[n]=\frac{1}{2}(x[n]-x[-n])=\frac{1}{2}(a^n u[n]-a^{-n}u[-n])$

$=\frac{1}{2}a^{|n|}sgn[n]=\begin{cases}\frac{1}{2}a^n, & n>0\\ 0, & n=0\\ -\frac{1}{2}a^{-n}, & n<0\end{cases}$

(g) $x_e[n]=\frac{1}{2}(x[n]+x[-n])=\frac{1}{2}(e^{j\Omega n}+e^{-j\Omega n})=\cos(\Omega n)$

$x_o[n]=\frac{1}{2}(x[n]-x[-n])=\frac{1}{2}(e^{j\Omega n}-e^{-j\Omega n})=j\sin(\Omega n)=e^{j\frac{\pi}{2}}\sin(\Omega n)$

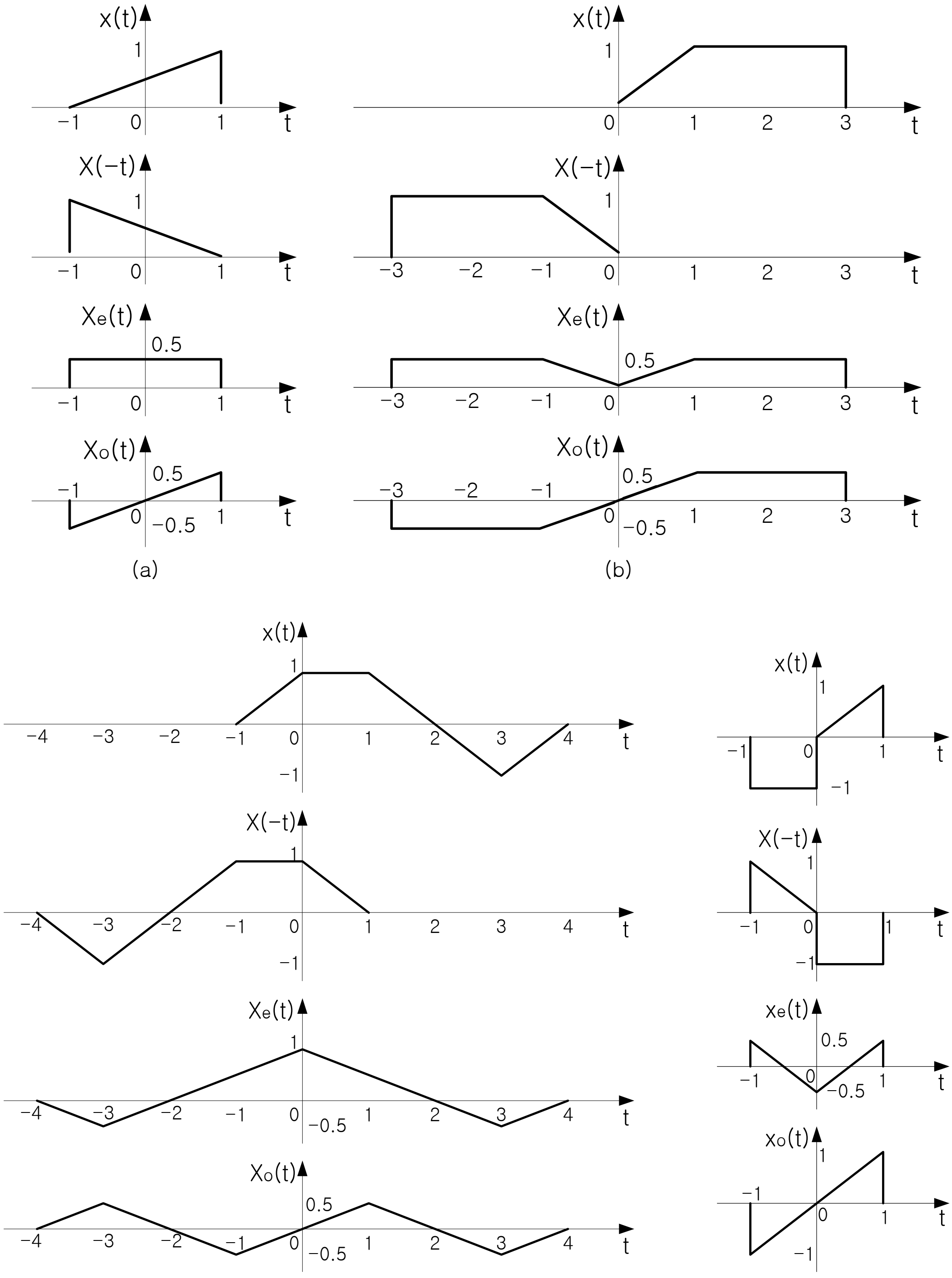
(h) $x_e[n]=\frac{1}{2}(x[n]+x[-n])=\frac{1}{2}\{n^2(u[n]-u[n-5])+(-n)^2(u[-n]-u[-n-5])\}$

$=\frac{1}{2}n^2(u[n+4]-u[n-5])$

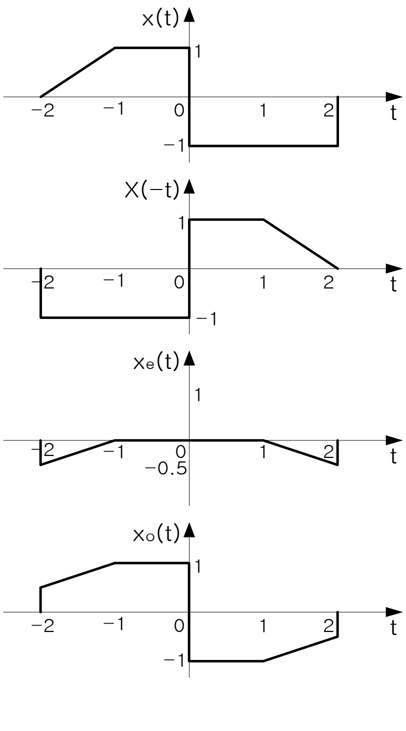
$x_o[n]=\frac{1}{2}(x[n]-x[-n])=\frac{1}{2}\{n^2(u[n]-u[n-5])-(-n)^2(u[-n]-u[-n-5])\}$

$=-\frac{1}{2}n^2(u[n+4]-u[n-1])+\frac{1}{2}n^2(u[n]-u[n-5])$

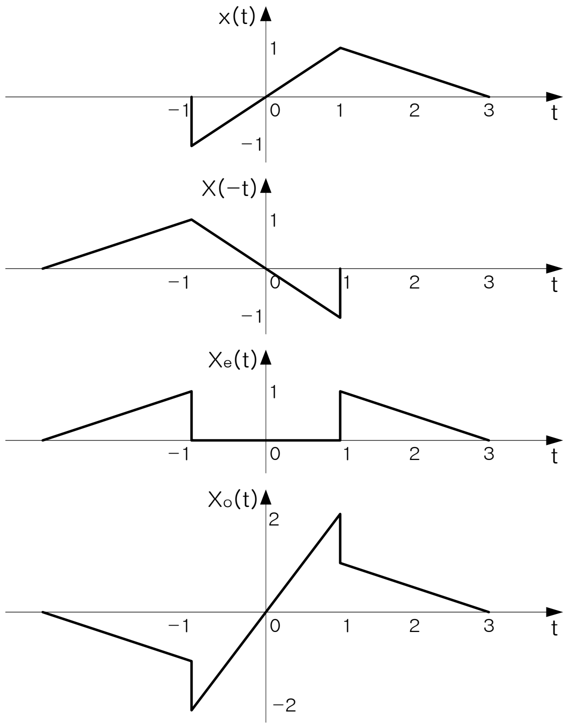
2.17



(a) (b) (c) (d)

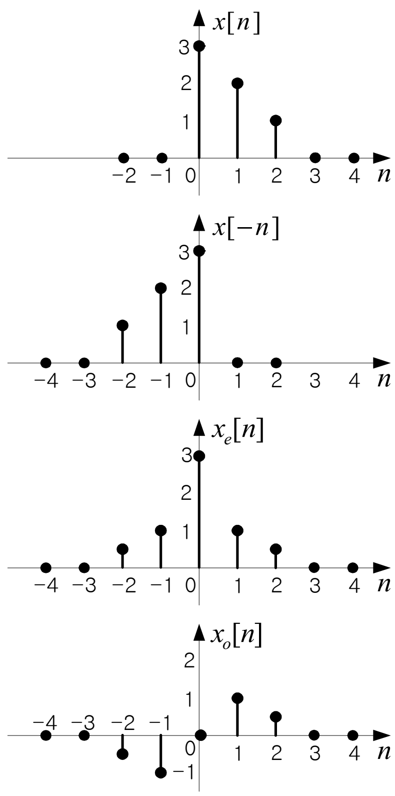


(e)

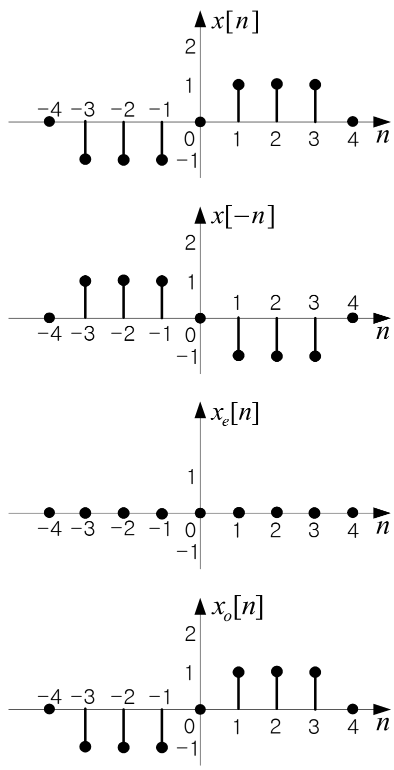


(f)

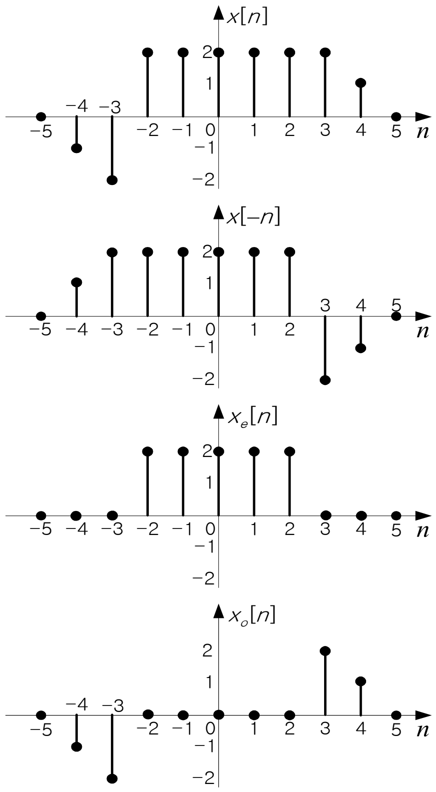
2.18



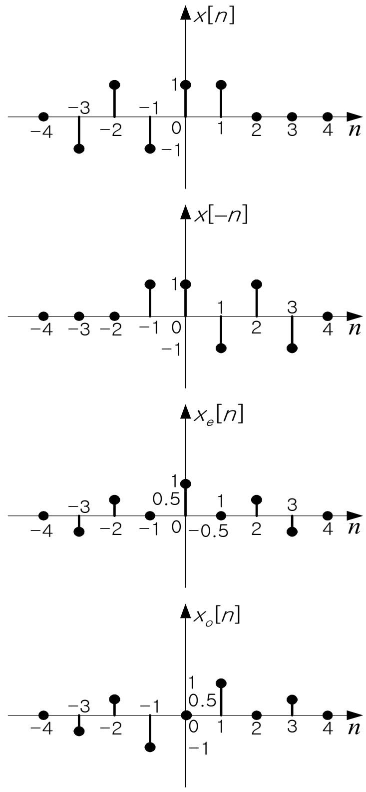
(a)



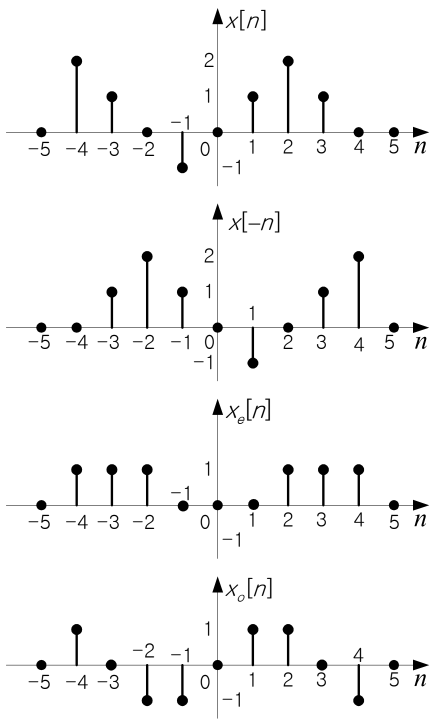
(b)



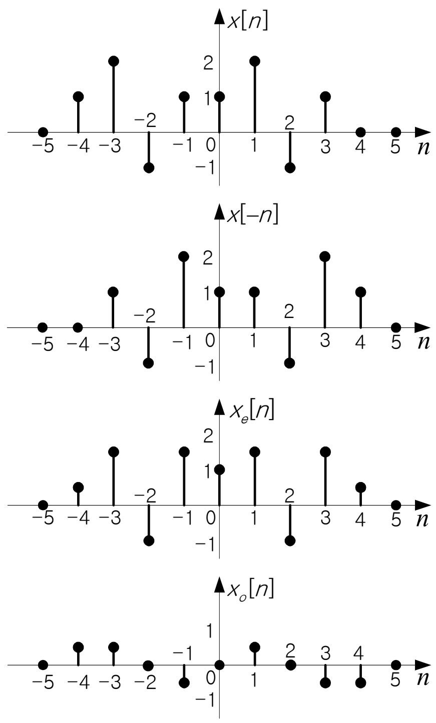
(c)



(d)



(e)



(f)

2.19 (a) 에너지 신호, 에너지 $\frac{16}{3}$

(b) 전력 신호, 전력 $\frac{3}{8}$

(c) 비에너지 비전력 신호

(d) 전력 신호, 전력 1

2.20 (a) 에너지 신호, 에너지 63

(b) 에너지 신호, 에너지 2.78

(c) 전력 신호, 전력 $\frac{1}{2}$

(d) 비에너지 비전력 신호

2.21
$$\begin{aligned} y_1(t) &= y(t) - 2y(t-1) + y(t-2) \\ &= [tu(t) - (t-1)u(t-1)] - 2[(t-1)u(t-1) - (t-2)u(t-2)] \\ &\qquad + [(t-2)u(t-2) - (t-3)u(t-3)] \\ &= tu(t) - 3(t-1)u(t-1) + 3(t-2)u(t-2) - (t-3)u(t-3) \end{aligned}$$

$$\begin{aligned} y_2(t) &= y(t) + y(t-1) + y(t-2) - 3y(t-3) \\ &= tu(t) - 4(t-3)u(t-3) + 3(t-4)u(t-4) \end{aligned}$$

2.22
$$\begin{aligned} y_1[n] &= y[n] + y[n-1] + 2y[n-2] \\ &= \delta[n] + \delta[n-1] + 2\delta[n-2] + \delta[n-3] \\ &\quad + \delta[n-1] + \delta[n-2] + 2\delta[n-3] + \delta[n-4] \\ &\quad + 2\delta[n-2] + 2\delta[n-3] + 4\delta[n-4] + 2\delta[n-5] \\ &= \delta[n] + 2\delta[n-1] + 5\delta[n-2] + 5\delta[n-3] + 5\delta[n-4] + 2\delta[n-5] \end{aligned}$$

$$\begin{aligned} y_2[n] &= 2y[n] - 4y[n-1] + 2y[n-2] \\ &= 2\delta[n] + 2\delta[n-1] + 4\delta[n-2] + 2\delta[n-3] \\ &\quad - 4\delta[n-1] - 4\delta[n-2] - 8\delta[n-3] - 4\delta[n-4] \\ &\quad + 2\delta[n-2] + 2\delta[n-3] + 4\delta[n-4] + 2\delta[n-5] \\ &= 2\delta[n] - 2\delta[n-1] + 2\delta[n-2] - 4\delta[n-3] + 2\delta[n-5] \end{aligned}$$

2.23 (a)
$$\begin{aligned} y_2[n] &= x_2[n-1] - 2x_2[n-3] = y_1[n-1] - 2y_1[n-3] \\ &= (x_1[n-1] + 2x_1[n-3]) - 2(x_1[n-3] + 2x_1[n-5]) \\ &= x_1[n-1] - 4x_1[n-5] \end{aligned}$$

(b)
$$\begin{aligned} y_1[n] &= x_1[n] + 2x_1[n-2] = y_2[n] + 2y_2[n-2] \\ &= (x_2[n-1] - 2x_2[n-3]) + 2(x_2[n-3] - 2x_2[n-5]) \\ &= x_2[n-1] - 4x_2[n-5] \end{aligned}$$

(c) 선형 시스템, 시불변 시스템, 인과 시스템

2.24 (a) 거짓
(b) 참
(c) 참
(d) 거짓
(e) 거짓

2.25 (a) 선형성 : 만족
시불변성 : 만족
인과성 : 만족
기억성 : 만족
가역성 : 만족
안정성 : 불만족

(b) 선형성 : 만족
시불변성 : 만족
인과성 : 만족
기억성 : 만족
가역성 : 만족
안정성 : 불만족

(c) 선형성 : 불만족
시불변성 : 만족
인과성 : 만족
기억성 : 불만족
가역성 : 불만족
안정성 : 불만족

(d) 선형성 : 불만족
시불변성 : 만족
인과성 : 만족
기억성 : 불만족
가역성 : 불만족
안정성 : 불만족

(e) 선형성 : 만족
시불변성 : 불만족
인과성 : 만족
기억성 : 불만족
가역성 : 불만족
안정성 : 만족

(f) 선형성 : 불만족
시불변성 : 만족
인과성 : 불만족
기억성 : 만족
가역성 : 불만족
안정성 : 만족

2.26 (a) 거짓
(b) 참
(c) 참
(d) 거짓
(e) 거짓

2.27 (a) 선형성 : 불만족
시불변성 : 만족
인과성 : 만족
기억성 : 불만족
가역성 : 불만족
안정성 : 만족

(b) 선형성 : 만족
시불변성 : 만족
인과성 : 불만족
기억성 : 불만족
가역성 : 불만족
안정성 : 만족

(c) 선형성 : 불만족
시불변성 : 만족
인과성 : 만족
기억성 : 만족
가역성 : 불만족
안정성 : 만족

(d) 선형성 : 불만족
시불변성 : 만족
인과성 : 만족
기억성 : 불만족
가역성 : 불만족
안정성 : 만족

(e) 선형성 : 만족
시불변성 : 불만족
인과성 : 만족
기억성 : 만족
가역성 : 불만족
안정성 : 불만족

(f) 선형성 : 만족
시불변성 : 불만족
인과성 : 만족
기억성 : 불만족
가역성 : 불만족
안정성 : 만족

2.28 (a) 선형성 : 만족
시불변성 : 만족
인과성 : 만족
기억성 : 만족
가역성 : 만족

(b) 선형성 : 불만족
시불변성 : 만족
인과성 : 만족
기억성 : 만족
가역성 : 불만족

(c) 선형성 : 만족
시불변성 : 불만족
인과성 : 만족
기억성 : 만족
가역성 : 불만족

(d) 선형성 : 불만족
시불변성 : 만족
인과성 : 불만족
기억성 : 만족
가역성 : 불만족

2.29 (a) 선형성 : 만족
시불변성 : 만족
인과성 : 만족
기억성 : 만족
가역성 : 불만족

(b) 선형성 : 만족
시불변성 : 만족
인과성 : 만족
기억성 : 만족
가역성 : 만족

(c) 선형성 : 만족
시불변성 : 불만족
인과성 : 만족
기억성 : 만족
가역성 : 불만족

(d) 선형성 : 만족
시불변성 : 불만족
인과성 : 불만족
기억성 : 만족
가역성 : 불만족

Chapter 03 연습문제 답안

3.1 ㉮

3.2 ㉰

3.3 ㉯

3.4 ㉰

3.5 ㉮

3.6 ㉮

3.7 ㉰

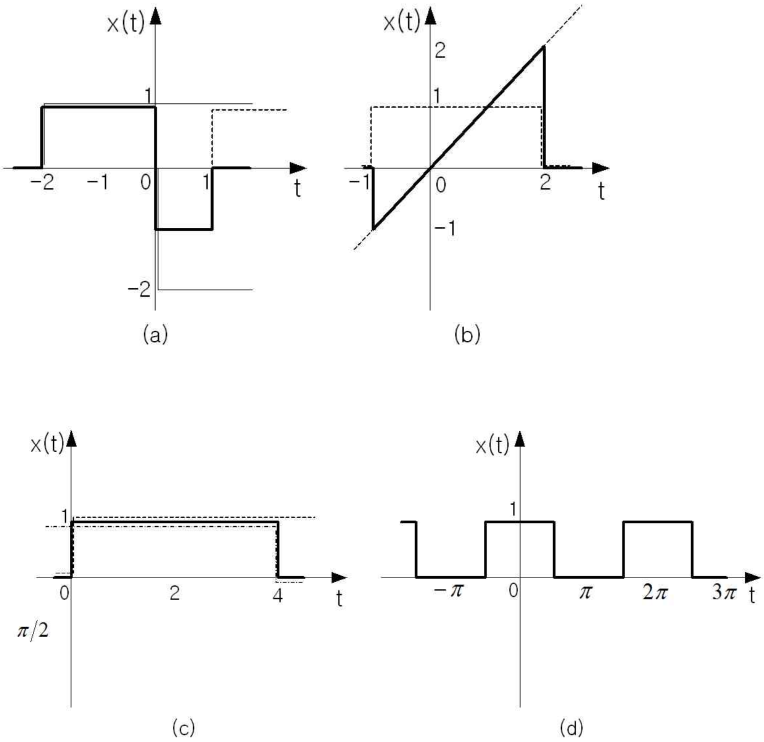
3.8 ㉰

3.9 ㉰

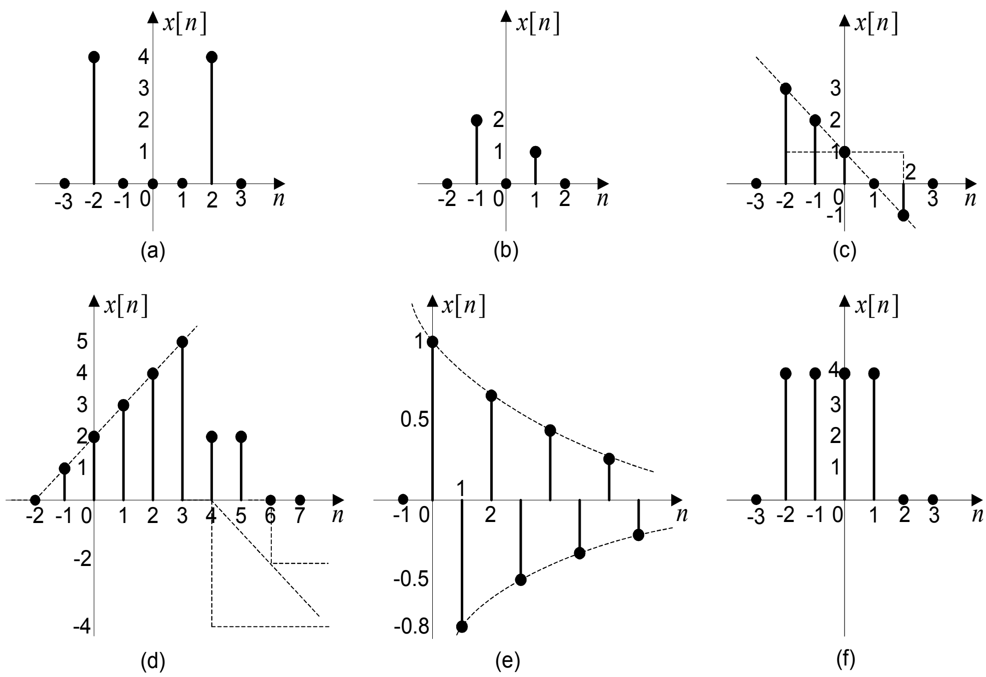
3.10 ㉯

3.11 ㉯, ㉱

3.12


x(t)
1
−2
−1
0
1
t
−2
(a)
x(t)
2
1
−1
0
2
t
−1
(b)
x(t)
1
0
2
4
t
π/2
(c)
x(t)
1
−π
0
π
2π
3π
t
(d)

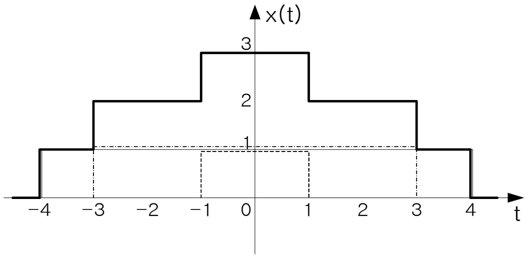
3.13


x[n]
(a)
(b)
(c)
(d)
(e)
(f)
n
0.5
-0.5
-0.8

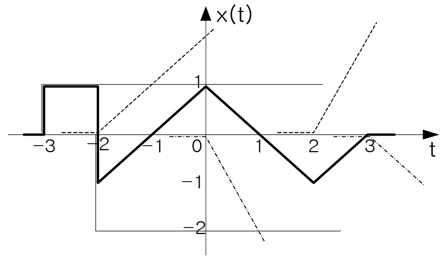
3.14

(a) $x(t) = (u(t+4) - u(t-4)) + (u(t+3) - u(t+3)) + (u(t+1) - u(t-1))$
$\quad = u(t+4) + u(t+3) + u(t+1) - u(t-1) - u(t-3) - u(t-4)$

(b) $x(t) = (u(t+3) - u(t+2)) + (t+1)(u(t+2) - u(t))$
$\quad + (-t+1)(u(t) - u(t-2)) + (t-3)(u(t-2) - u(t-3))$
$\quad = u(t+3) + t\,u(t+2) - 2t\,u(t) + 2(t-2)u(t-2) - (t-3)u(t-3)$
$\quad = u(t+3) - 2u(t+2) + (t+2)u(t+2) - 2t\,u(t) + 2(t-2)u(t-2) - (t-3)u(t-3)$



(a)

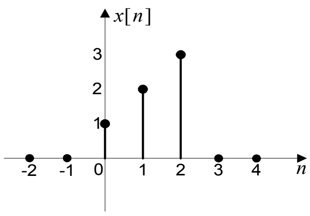


(b)

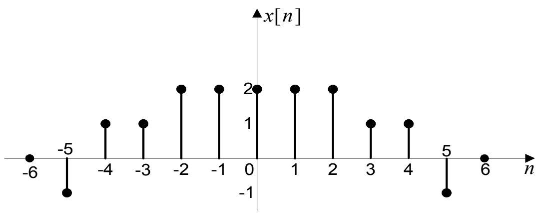
3.15

(a) $x[n] = \delta[n] + 2\delta[n-1] + 3\delta[n-2]$

(b) $x[n] = -\delta[n+5] + \delta[n+4] + \delta[n+3] + 2\delta[n+2] + 2\delta[n+1]$
$\quad + 2\delta[n] + 2\delta[n-1] + 2\delta[n-2] + \delta[n-3] + \delta[n-4] - \delta[n-5]$

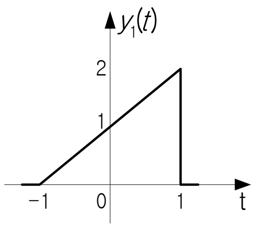


(a)

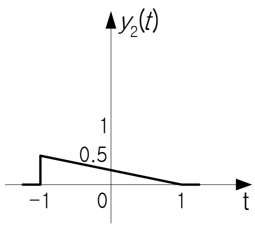


(b)

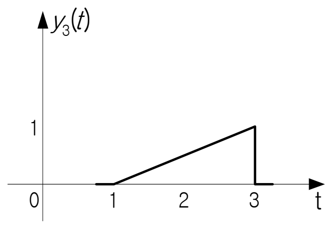
3.16 (a) 진폭 척도 조절(2배)



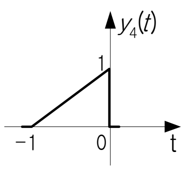
(a)



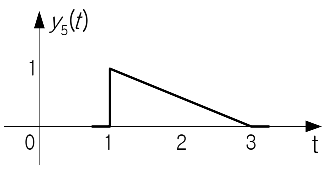
(b)



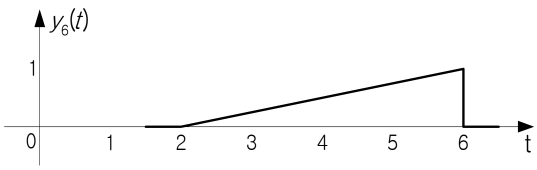
(c)



(d)

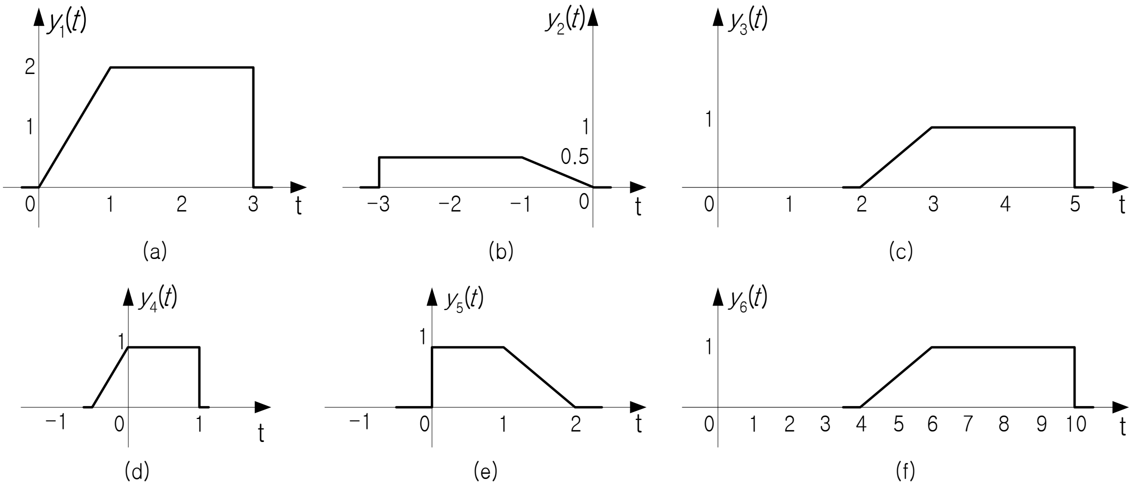


(e)

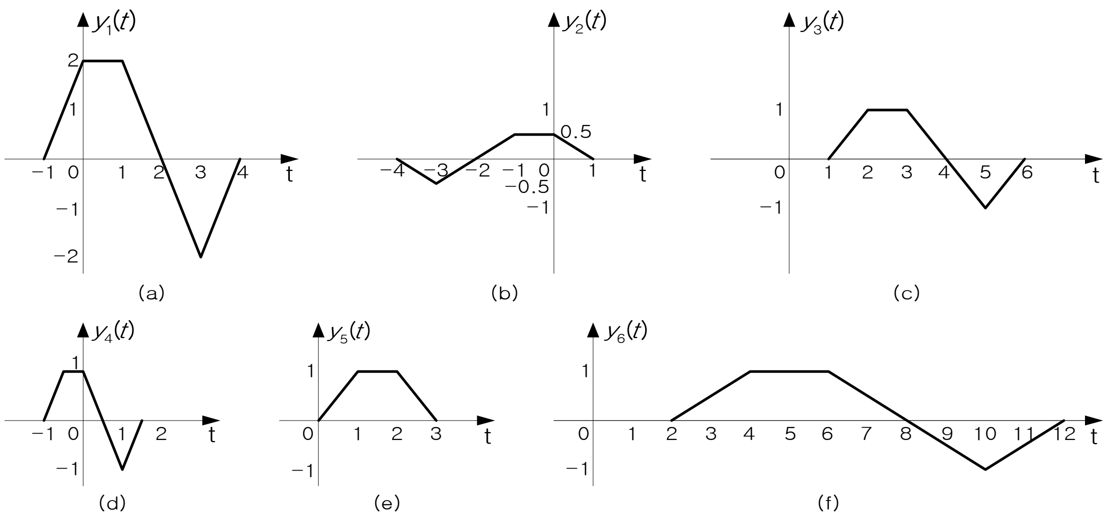


(f)

(b) 진폭 척도 조절(0.5배) - 시간 반전

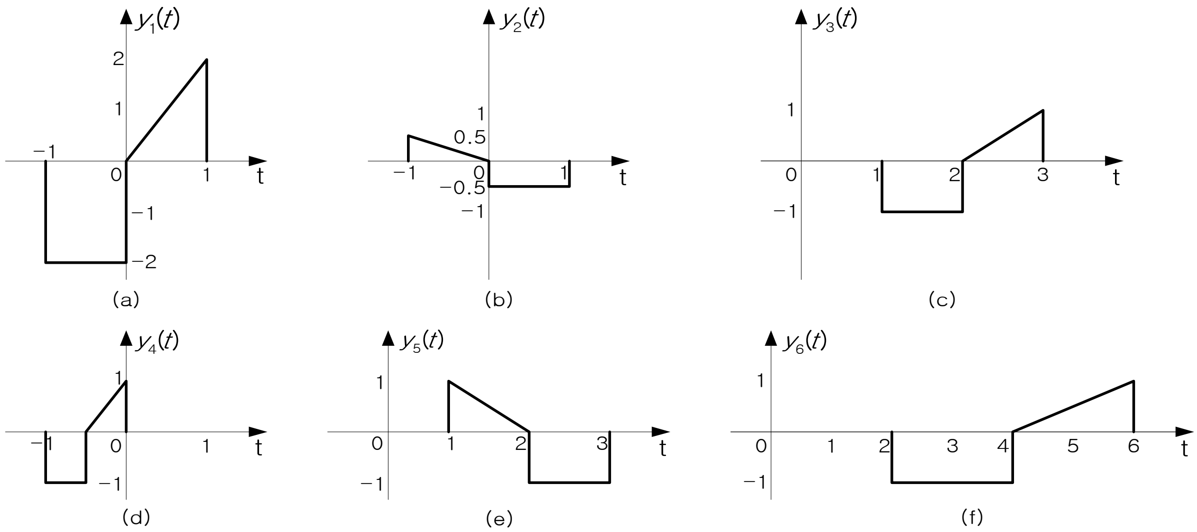


(c) 시간 이동($t=2$만큼 지연)



(d) 시간 이동($t=1$만큼 선행) - 시간 척도 조절(반으로 압축)

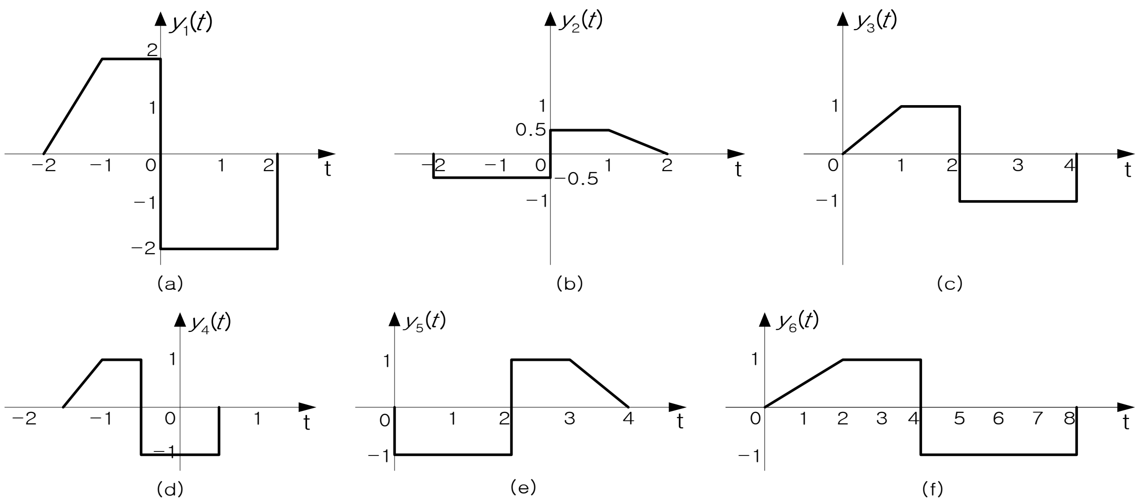
또는 $y_4(t)=x\left(2(t+1/2)\right)$ 시간 척도 조절(반으로 압축)-시간 이동($t=1/2$만큼 선행)



(e) 시간 이동($t=2$만큼 선행) - 시간 반전 - $u(t)$와의 곱($t<0$ 부분 삭제)

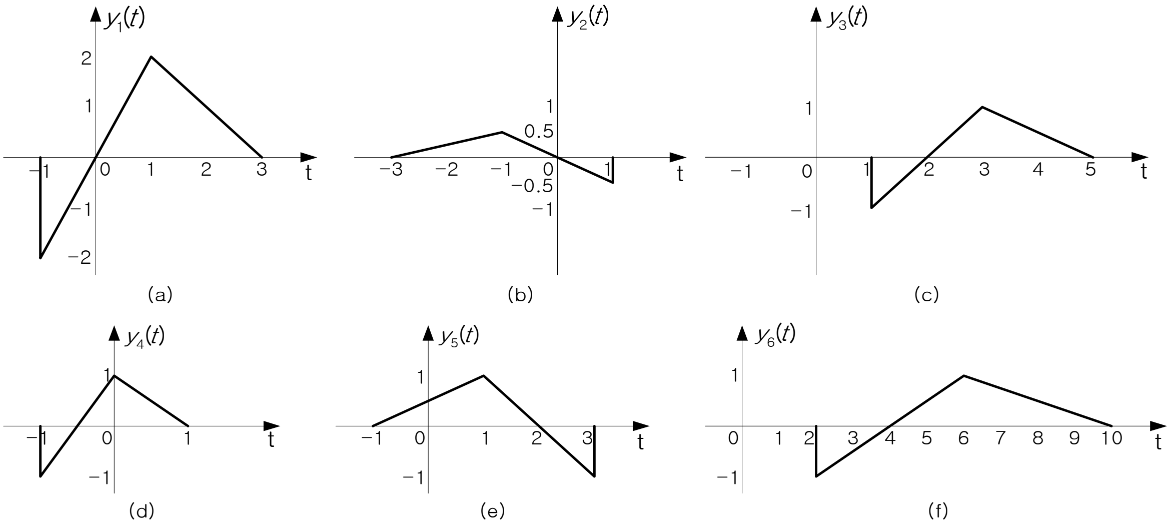
또는 $y_5(t)=x\left(-(t-2)\right)u(t)$ 시간 반전 - 시간 이동($t=2$만큼 지연)

- $u(t)$와의 곱($t<0$ 부분 삭제)

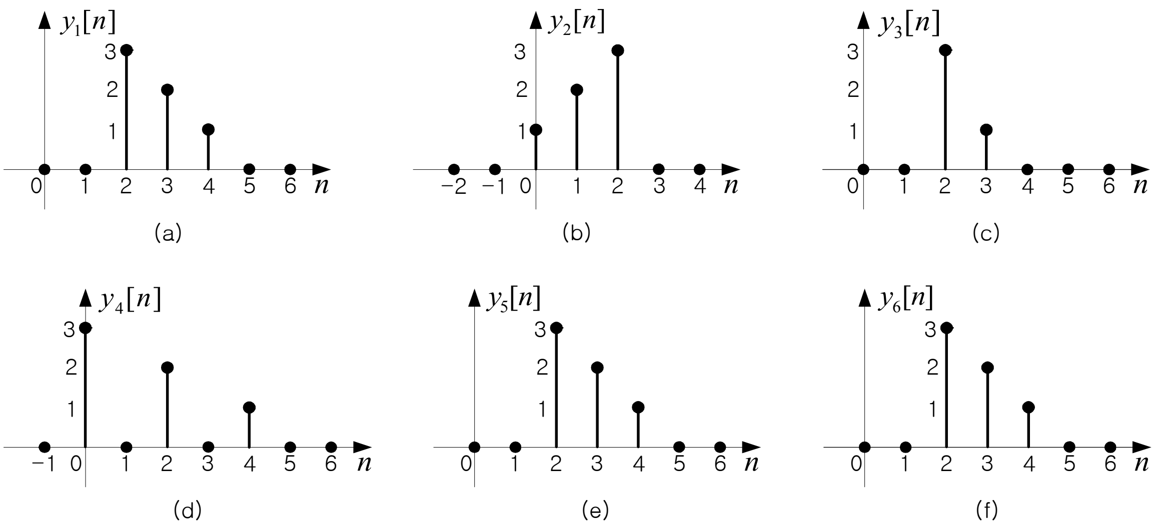


(f) 시간 이동($t=2$만큼 지연) – 시간 척도 조절(배로 늘임)

또는 $y_6(t)=x\left(\frac{1}{2}(t-4)\right)$ 시간 척도 조절(배로 늘임) – 시간 이동($t=4$만큼 지연)

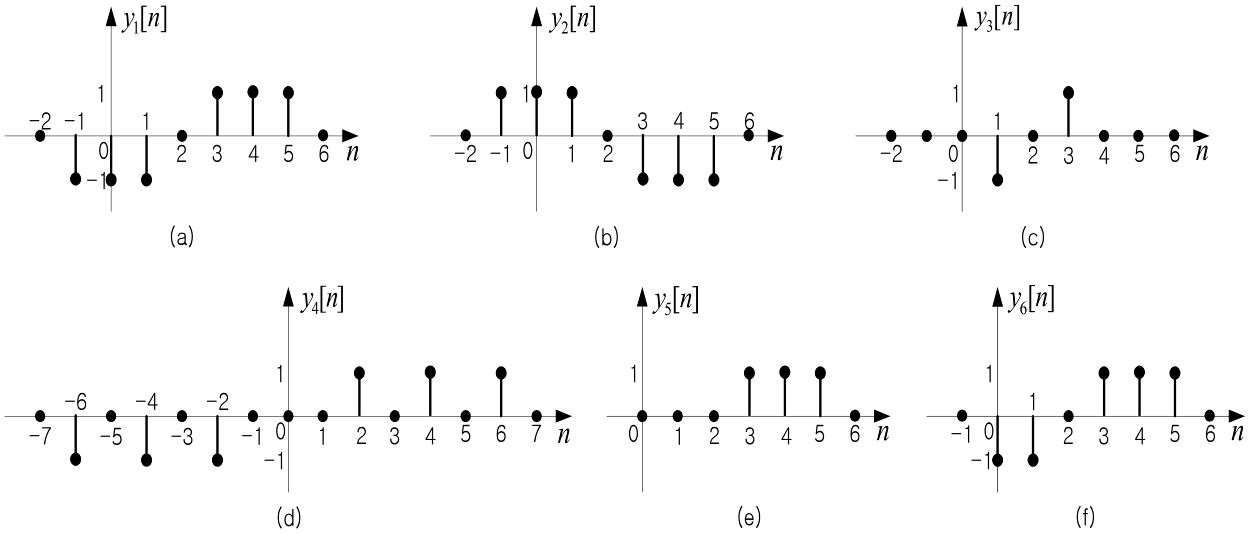


3.17 (a) 시간 이동($n=2$만큼 지연)



(b) 시간 이동($n=2$만큼 선행) - 시간 반전

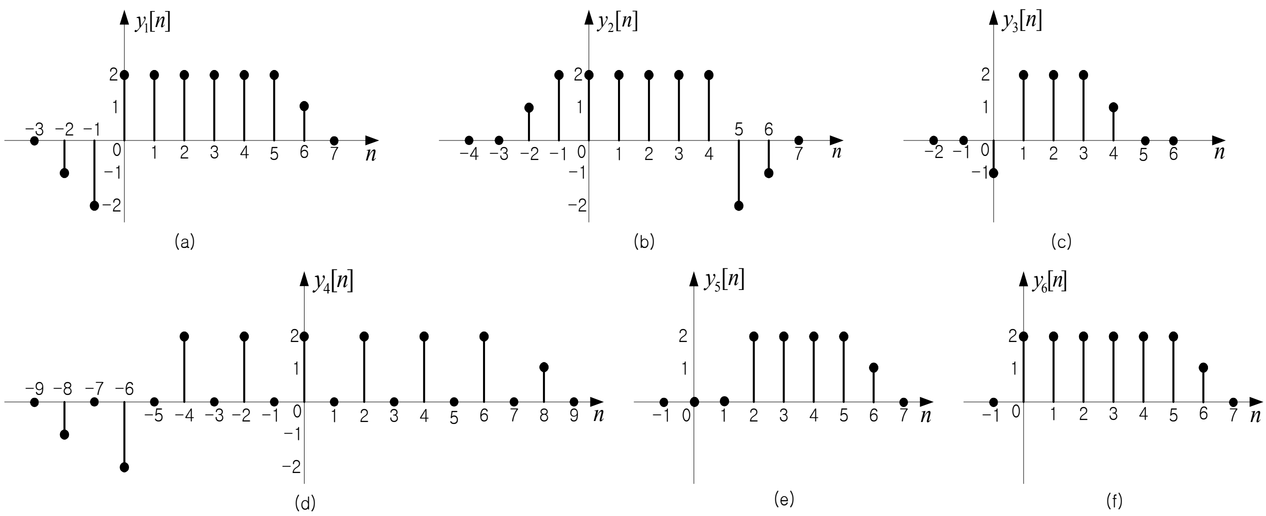
또는 $y_2[n]=x[-(n-2)]$ 시간 반전 - 시간 이동($n=2$만큼 지연)



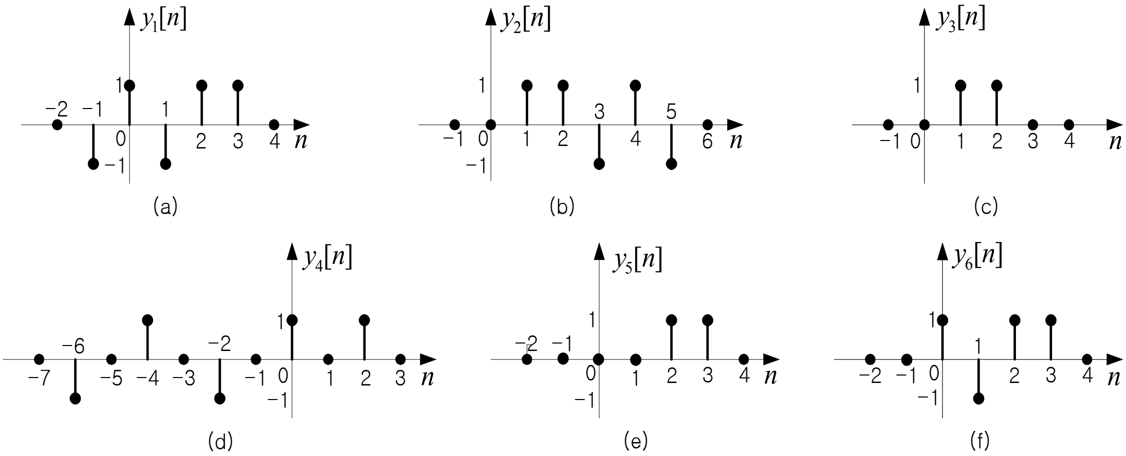
(c) 시간 이동($n=4$만큼 지연) - 시간 척도 조절(반으로 압축(솎음))

또는 $y_3[n]=x[2(n-2)]$ 시간 척도 조절(반으로 압축(솎음))

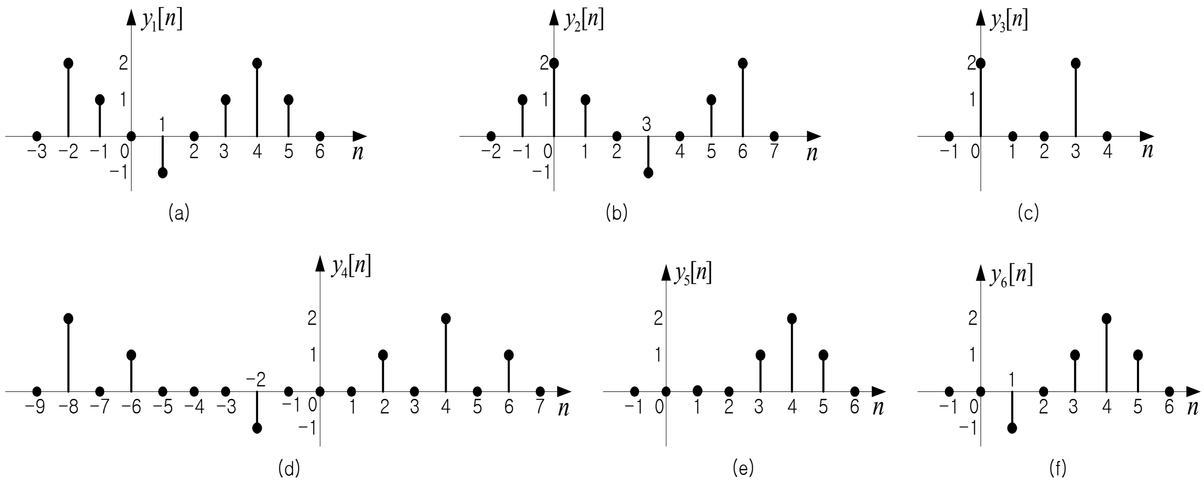
- 시간 이동($n=2$만큼 지연)



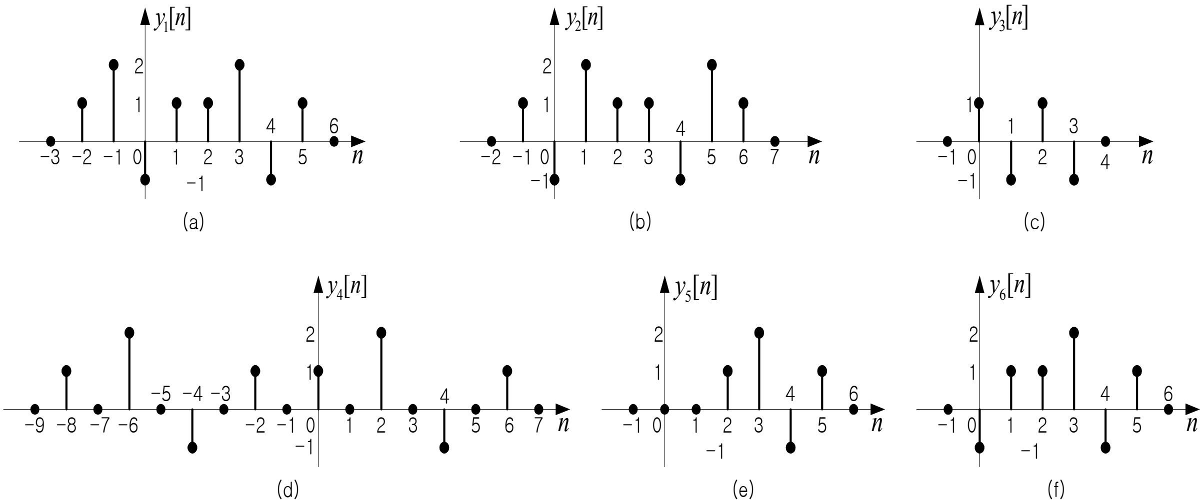
(d) 시간 척도 조절(2배로 늘임(보간))



(e) $x[n]$에 $u[n]$을 곱해 $x[n]u[n]$을 만든 뒤($n<0$에서 $x[n]=0$) 이를 시간 이동 ($n=2$만큼 지연)



(f) $x[n]$을 시간 이동($n=2$만큼 지연)시켜 $x[n-2]$ 구한 뒤 $u[n]$을 곱함 ($n<0$의 값 삭제)



3.18 (a) $x(t)=u(t)-u(t-1)+u(t-2)$

(b) $y(t)=u(-t)-u(t)+2u(t-2)-2u(t-4)$

(c) $y(t)=y_4(t)-1=2x(-(t-4)/2)-1$

3.19 (a) $\displaystyle\int_{-\infty}^{\infty}(t^2-3t+2)\delta(t-2)dt=t^2-3t+2\Big|_{t=2}=2^2-3\cdot2+2=0$

(b) $\displaystyle\int_{-\infty}^{\infty}(t-2)\delta(t^2-4t+4)dt=t-2\Big|_{t=2}=2-2=0$

(c) $\displaystyle\int_{-\infty}^{\infty}(\delta(t)\cos(t)+\delta(t-\frac{\pi}{2})\sin(t))dt=\cos(t)\Big|_{t=0}+\sin(t)\Big|_{t=\frac{\pi}{2}}$

$$=\cos(0)+\sin(\frac{\pi}{2})=1+1=2$$

(d) 0

(e) $\displaystyle\int_{-\infty}^{\infty}e^{-t}u(t)(\delta(t+2)+\delta(t-1))dt=e^{-t}u(t)\Big|_{t=-2}+e^{-t}u(t)\Big|_{t=1}$

$$=0+e^{-1}=e^{-1}$$

(f) $\int_{-\infty}^{\infty} \cos(3(t+2))\delta(2t+4)dt = \cos(3(t+2))\Big|_{t=-2} = \cos(0) = 1$

3.20 (a) $x(t) = e^{-0}\cos(0)\delta(t) = \delta(t)$

(b) $x(t) = \sin(2\pi t)[\delta(t) + \delta(t-1) + \delta(t-2) + \cdots]$
$= \sin(0)\delta(t) + \sin(2\pi)\delta(t-1) + \sin(4\pi)\delta(t-2) + \cdots = 0$

(c) $x[n] = 1, \quad n = 0,\ 10,\ 20,\ 30,\ 40,\ \cdots$

(d) $x[3] = \sum_{n=-\infty}^{\infty} (2)^n \delta[n-3] = 2^3\delta[n-3] = 8$, 나머지 n에 대해서는 $x[n] = 0$

Chapter 04 연습문제 답안

4.1 ㉯

4.2 ㉰

4.3 ㉱

4.4 ㉮

4.5 ㉯

4.6 ㉮

4.7 ㉰

4.8 ㉯

4.9 ㉯, ㉳

4.10 ㉱, ㉳

4.11 (a) $y(t)=\int_{-\infty}^{\infty} h(t-\tau)x(\tau)d\tau=\int_{-\infty}^{\infty} e^{\tau-t}u(t-\tau)e^{-2\tau}u(\tau)d\tau \quad , \quad t>0$

$$=\int_{0}^{t} e^{-t}e^{-\tau}d\tau = e^{-t}(-e^{-\tau})\Big|_{0}^{t} = -e^{-2t}+e^{-t} = e^{-t}(1-e^{-t})$$

(b) $y(t)=\int_{-\infty}^{\infty} h(t-\tau)x(\tau)d\tau=\int_{-\infty}^{\infty} e^{\tau-t}u(t-\tau)e^{-2(\tau-3)}u(\tau)d\tau, \quad t>0$

$$=\int_{0}^{t} e^{-t}e^{-(\tau-6)}d\tau = e^{6-t}(-e^{-\tau})\Big|_{0}^{t}$$

$$=-e^{6-2t}+e^{6-t} = e^{6-t}(1-e^{-t}) = e^{6}e^{-t}(1-e^{-t})$$

(c) ① $t<0$: $y(t)=\int_{-\infty}^{\infty} h(t-\tau)x(\tau)d\tau=\int_{-\infty}^{\infty} e^{\tau-t}u(t-\tau)e^{2\tau}u(-\tau)d\tau$

$$=\int_{-\infty}^{t} e^{-t}e^{3\tau}d\tau = e^{-t}(\frac{1}{3}e^{3\tau})\Big|_{-\infty}^{t} = \frac{1}{3}e^{2t}$$

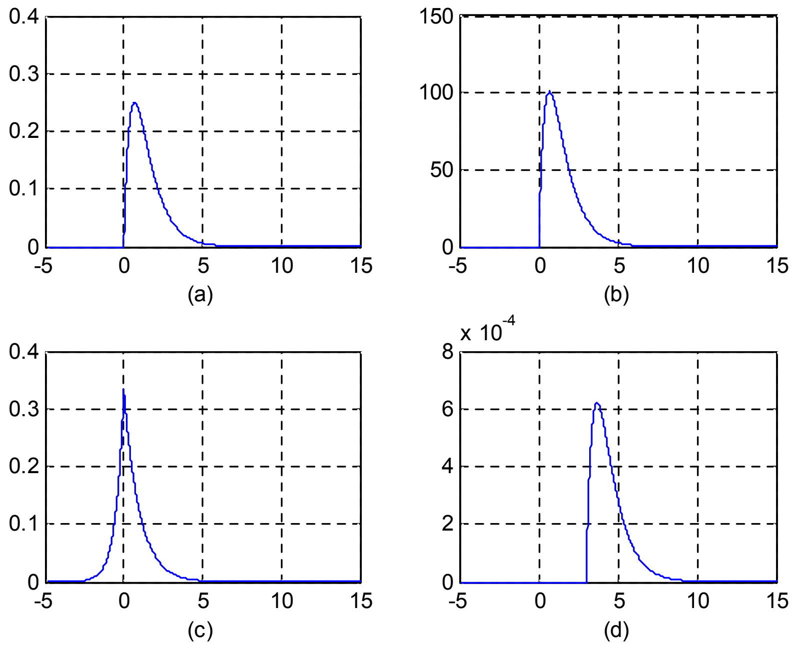
② $t > 0$: $y(t) = \int_{-\infty}^{\infty} h(t-\tau)x(\tau)d\tau = \int_{-\infty}^{\infty} e^{\tau - t}u(t-\tau)e^{2\tau}u(-\tau)d\tau$

$$= \int_{-\infty}^{0} e^{-t}e^{3\tau}d\tau = e^{-t}(\frac{1}{3}e^{3\tau})\Big|_{-\infty}^{0} = \frac{1}{3}e^{-t}$$

(d) $y(t) = \int_{-\infty}^{\infty} h(t-\tau)x(\tau)d\tau = \int_{-\infty}^{\infty} e^{\tau - t}u(t-\tau)e^{-2\tau}u(\tau-3)d\tau, \quad t > 3$

$$= \int_{3}^{t} e^{-t}e^{-\tau}d\tau = e^{-t}(-e^{-\tau})\Big|_{3}^{t} = e^{-t}(-e^{-t}+e^{-3})$$

$$= -e^{-2t} + e^{-(t+3)}$$



4.12 (a) ① $t < -2$: $y(t) = 0$

② $-2 \leqq t < 2$: $y(t) = \int_{-2}^{t} e^{-\tau}d\tau = (-e^{-\tau})\Big|_{-2}^{t}$

$$= -e^{-t} + e^{2} = e^{2}(1 - e^{-(t+2)})$$

③ $t \geqq 2$: $y(t) = \int_{-2}^{2} e^{-\tau}d\tau = -e^{-2} + e^{2} = e^{2}(1-e^{-4})$

(b) ① $t < -3$: $y(t) = 0$

② $-3 \leqq t < 1$: $y(t) = \int_{-2}^{t+1} e^{-\tau}d\tau = (-e^{-\tau})\Big|_{-2}^{t+1}$

$$= -e^{-(t+1)} + e^{2} = e^{2}(1 - e^{-(t+3)})$$

③ $1 \leqq t < 3$: $y(t) = \int_{-2}^{2} e^{-\tau} d\tau = -e^{-2} + e^{2} = e^{2}(1 - e^{-4})$

④ $3 \leqq t < 7$: $y(t) = \int_{-5+t}^{2} e^{-\tau} d\tau = (-e^{-\tau})\Big|_{-5+t}^{2}$

$$= -e^{-2} + e^{-(t-5)} = e^{-2}(e^{-(t-7)} - 1)$$

⑤ $t \geqq 7$: $y(t) = 0$

(c) ① $t < 0$: $y(t) = 0$

② $0 \leqq t < 3$: $y(t) = \int_{0}^{t} e^{-(t-\tau)} \delta(\tau)\, d\tau = e^{-t}$

③ $t \geqq 3$: $y(t) = \int_{0}^{t} e^{-(t-\tau)} (\delta(\tau) - \delta(\tau - 3)\, d\tau$

$$= e^{-t} - e^{-(t-3)} = e^{-t}(1 - e^{3})$$

(d) ① $t < -3$: $y(t) = 0$

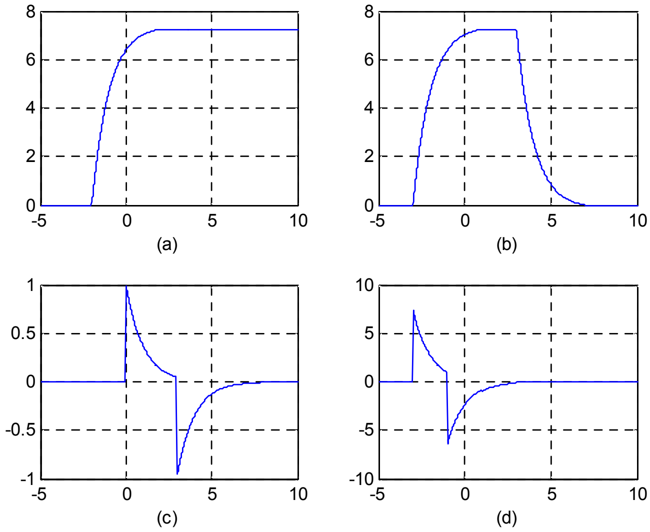
② $-3 \leqq t < -1$: $y(t) = \int_{t-2}^{t+2} e^{-(t-\tau)} \delta(\tau + 1) d\tau = e^{-(t+1)}$

③ $-1 \leqq t \leqq 1$: $y(t) = \int_{t-2}^{t+2} \{e^{-(t-\tau)} \delta(\tau + 1) - e^{-(t-\tau)} \delta(\tau - 1)\} d\tau$

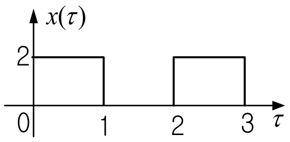
$$= e^{-(t+1)} - e^{-(t-1)} = e^{-t}(e^{-1} - e^{1})$$

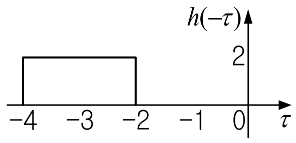
④ $1 < t \leqq 3$: $y(t) = \int_{t-2}^{t+2} - e^{-(t-\tau)} \delta(\tau - 1) d\tau = -e^{-(t-1)}$

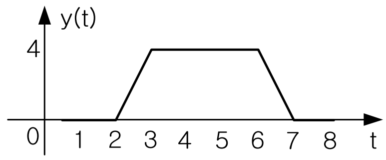
⑤ $t > 3$: $y(t) = 0$



4.13 (a) 시간축을 τ로 바꾸고 $h(\tau)$를 뒤집어 계산하면







① $t < 2$: $y(t) = x(t) * h(t) = 0$

② $2 \leqq t < 3$: $y(t) = \int_0^{t-2} 4\,d\tau = 4t - 8$

③ $3 \leqq t < 4$: $y(t) = \int_0^{1} 4\,d\tau = 4$

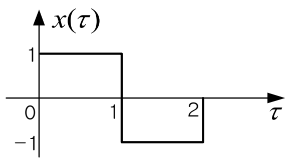
④ $4 \leqq t < 5$: $y(t) = \int_{t-4}^{1} 4\,d\tau + \int_2^{t-2} 4\,d\tau = 4$

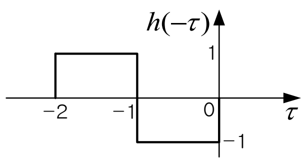
⑤ $5 \leqq t < 6$: $y(t) = \int_2^{3} 4\,d\tau = 4$

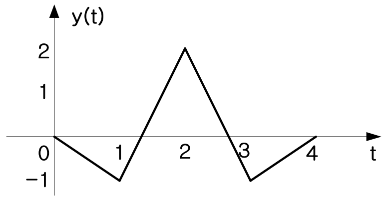
⑥ $6 \leqq t < 7$: $y(t) = \int_{t-4}^{3} 4\,d\tau = -4t + 28$

⑦ $t \geqq 7$: $y(t) = x(t) * h(t) = 0$

(b) 시간축을 τ로 바꾸고 $h(\tau)$를 뒤집어 계산하면







① $t < 0$: $y(t) = x(t) * h(t) = 0$

② $0 \leqq t < 1$: $y(t) = \int_0^{t} (-1)\,d\tau = -t$

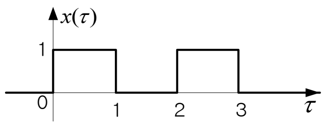
③ $1 \leqq t < 2$: $y(t) = \int_0^{t-1} 1\,d\tau + \int_{t-1}^{1} (-1)\,d\tau + \int_1^{t} 1\,d\tau = 3t - 4$

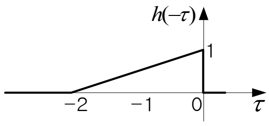
④ $2 \leqq t < 3$: $y(t) = \int_{t-2}^{1} 1\,d\tau + \int_1^{t-1} (-1)\,d\tau + \int_{t-1}^{2} 1\,d\tau = -3t + 8$

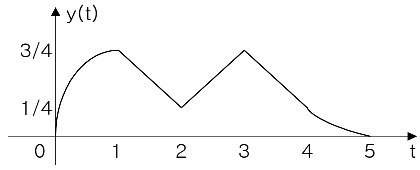
⑤ $3 \leqq t < 4$: $y(t) = \int_{t-2}^{2} (-1)\,d\tau = t - 4$

⑥ $t \geqq 4$: $y(t) = x(t) * h(t) = 0$

(c) 시간축을 τ로 바꾸고 $h(\tau)$를 뒤집어 계산하면







①$t < 0$: $y(t) = x(t) * h(t) = 0$

②$0 \leqq t < 1$: $y(t) = \int_0^t (\frac{1}{2}(\tau - t) + 1) d\tau = (-\frac{1}{2}t\tau + \frac{1}{4}\tau^2 + \tau)\Big|_0^t$

$$= -\frac{1}{2}t^2 + \frac{1}{4}t^2 + t = -\frac{1}{4}t^2 + t$$

③$1 \leqq t < 2$: $y(t) = \int_0^1 (\frac{1}{2}(\tau - t) + 1) d\tau = (-\frac{1}{2}t\tau + \frac{1}{4}\tau^2 + \tau)\Big|_0^1 = -\frac{1}{2}t + \frac{5}{4}$

④$2 \leqq t < 3$: $y(t) = \int_{t-2}^1 (\frac{1}{2}(\tau - t) + 1) d\tau + \int_2^t (\frac{1}{2}(\tau - t) + 1) d\tau$

$$= (-\frac{1}{2}t\tau + \frac{1}{4}\tau^2 + \tau)\Big|_{t-2}^1 + (-\frac{1}{2}t\tau + \frac{1}{4}\tau^2 + \tau)\Big|_2^t$$

$$= \frac{1}{2}t - \frac{3}{4}$$

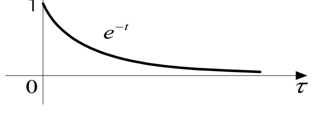
⑤$3 \leqq t < 4$: $y(t) = \int_2^3 (\frac{1}{2}(\tau - t) + 1) d\tau = (-\frac{1}{2}t\tau + \frac{1}{4}\tau^2 + \tau)\Big|_2^3 = -\frac{1}{2}t + \frac{9}{4}$

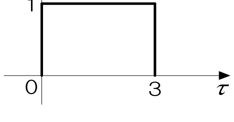
⑥$4 \leqq t < 5$: $y(t) = \int_{t-2}^3 (\frac{1}{2}(\tau - t) + 1) d\tau = (-\frac{1}{2}t\tau + \frac{1}{4}\tau^2 + \tau)\Big|_{t-2}^3$

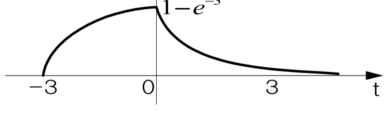
$$= \frac{1}{4}t^2 - \frac{5}{2}t + \frac{25}{4}$$

⑦$t \geqq 5$: $y(t) = x(t) * h(t) = 0$

(d) 시간축을 τ로 바꾸고 $h(\tau)$를 뒤집어 계산하면







①$t < -3$: $y(t) = x(t) * h(t) = 0$

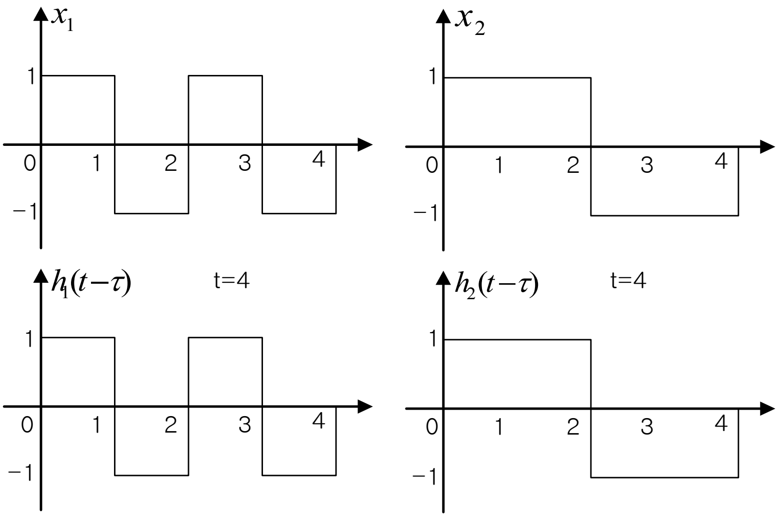
②$-3 \leqq t < 0$: $y(t) = \int_0^{t+3} e^{-\tau} d\tau = -e^{-(t+3)} + 1$

③$t \geqq 0$: $y(t) = \int_t^{t+3} e^{-\tau} d\tau = -e^{-(t+3)} + e^{-t} = e^{-t}(1 - e^{-3})$

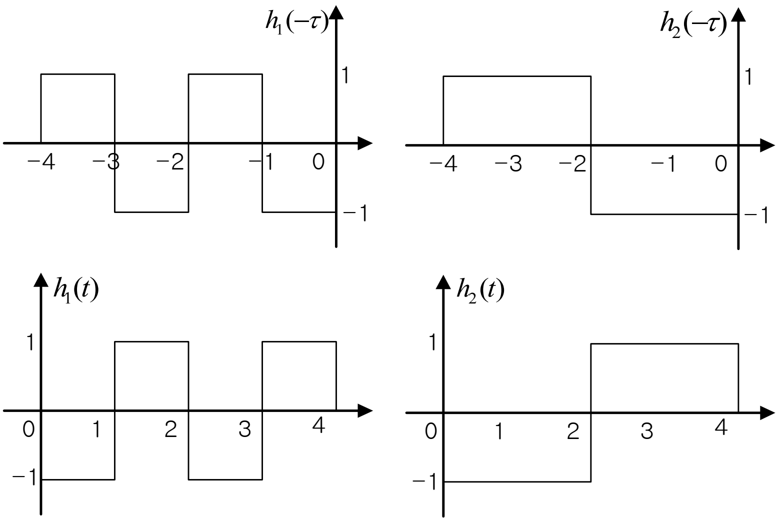
4.14 $h(t)=2\{u(t)-u(t-1)\}+\{u(t-1)-u(t-2)\}=2u(t)-u(t-1)-u(t-2)$

4.15 $(h_1(t)*h_3(t)+h_5(t))*h_5(t)+h_1(t)*h_2(t)$

4.16 (a) $t=4$에서 $x_1(t)*h_1(t)$가 최대가 되려면 $t=4$에서 두 파형($x_1(\tau)$와 $h_1(4-\tau)$)이 일치해야 하므로



위의 두 파형이 일치해야 출력이 최대



(b) $y_1(t) = x_1(t) * h_1(t)$

① $0 \leqq t < 1$: $\quad y_1(t) = -\int_0^t d\tau = -t$

② $1 \leqq t < 2$: $\quad y_1(t) = \int_0^{t-1} d\tau - \int_{t-1}^{1} d\tau + \int_1^t d\tau = 3t - 4$

③ $2 \leqq t < 3$: $\quad y_1(t) = -\int_0^{t-2} d\tau + \int_{t-2}^{1} d\tau - \int_1^{t-1} d\tau + \int_{t-1}^{2} d\tau - \int_2^t d\tau$

$= -5t + 12$

④ $3 \leqq t < 4$: $\quad y_1(t) = \int_0^{t-3} d\tau - \int_{t-3}^{1} d\tau + \int_1^{t-2} d\tau - \int_{t-2}^{2} d\tau$

$+ \int_2^{t-1} d\tau - \int_{t-1}^{3} d\tau + \int_3^t d\tau = 7t - 24$

⑤ $4 \leqq t < 5$: $\quad y_1(t) = \int_{t-4}^{1} d\tau - \int_1^{t-3} d\tau + \int_{t-3}^{2} d\tau - \int_2^{t-2} d\tau$

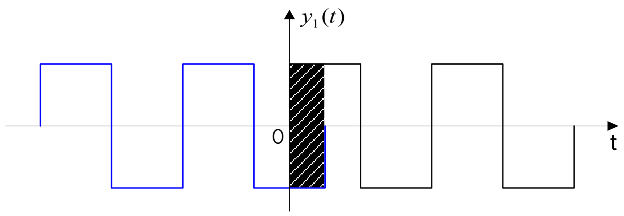
$+ \int_{t-2}^{3} d\tau - \int_3^{t-1} d\tau + \int_{t-1}^{4} d\tau = -7t + 32$

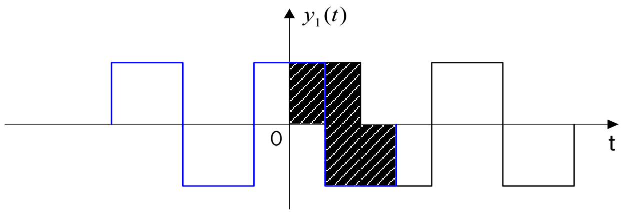
⑥ $5 \leqq t < 6$: $\quad y_1(t) = -\int_{t-4}^{2} d\tau + \int_2^{t-3} d\tau - \int_{t-3}^{3} d\tau + \int_3^{t-2} d\tau - \int_{t-2}^{4} d\tau$

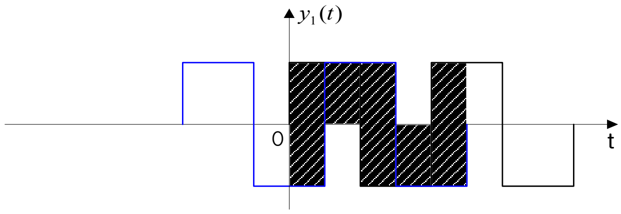
$= 5t - 28$

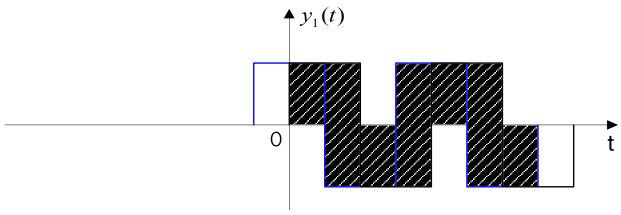
⑦ $6 \leqq t < 7$: $\quad y_1(t) = \int_{t-4}^{3} d\tau - \int_3^{t-3} d\tau + \int_{t-3}^{4} d\tau = -3t + 20$

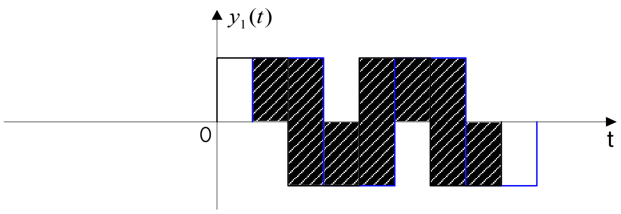
⑧ $7 \leqq t < 8$: $\quad y_1(t) = -\int_{t-4}^{4} d\tau = t - 8$

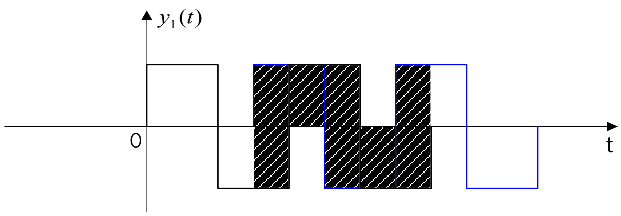


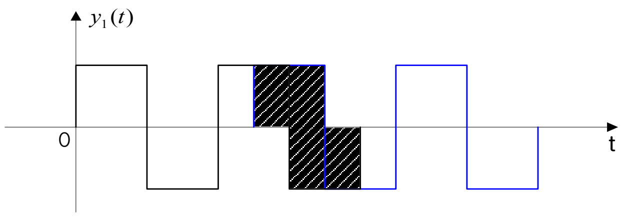


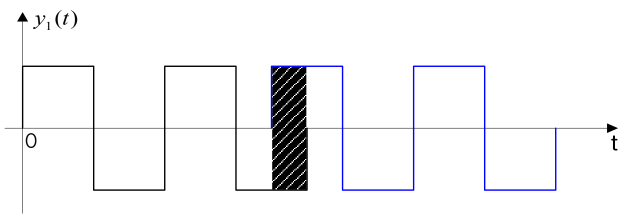

$y_1(t)$
0
t


$y_1(t)$
0
t


$y_1(t)$
0
t


$y_1(t)$
0
t


$y_1(t)$
0
t


$y_1(t)$
0
t

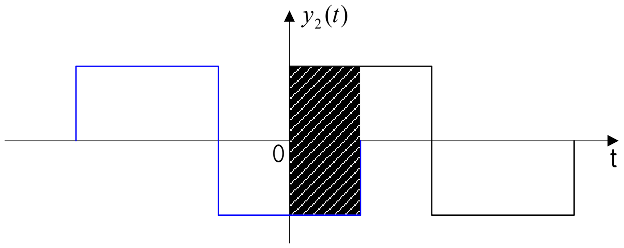
$y_2(t) = x_2(t) * h_2(t)$

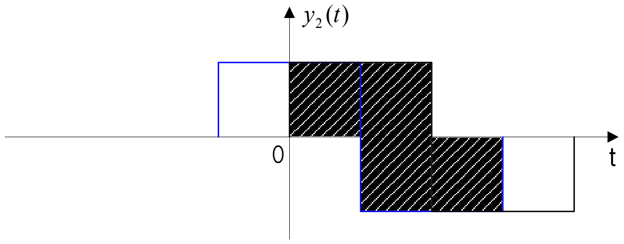
① $0 \leqq t < 2$:　 $y_2(t) = -\int_0^t d\tau = -t$

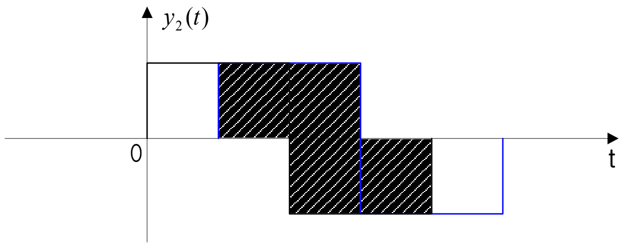
② $2 \leqq t < 4$:　 $y_2(t) = \int_0^{t-2} d\tau - \int_{t-2}^{2} d\tau + \int_2^t d\tau = 3t - 8$

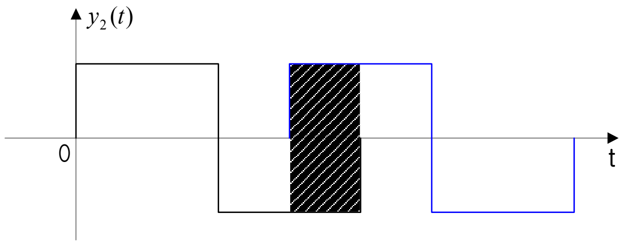
③ $4 \leqq t < 6$:　 $y_2(t) = \int_{t-4}^{2} d\tau - \int_2^{t-2} d\tau + \int_{t-2}^{4} d\tau = -3t + 16$

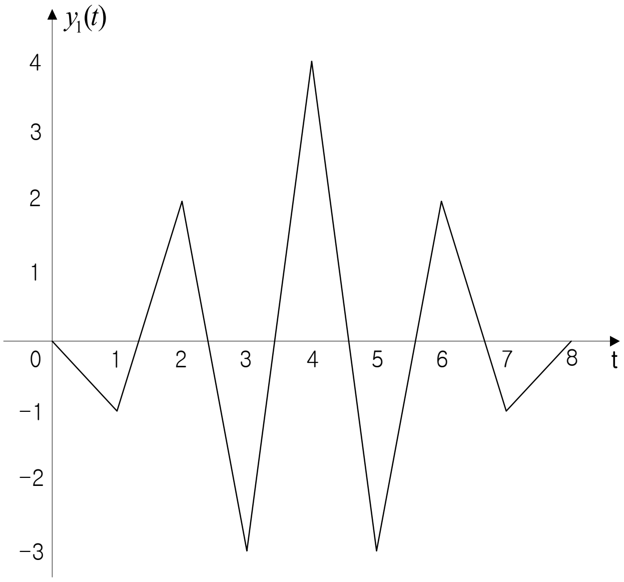
④ $6 \leqq t < 8$:　 $y_2(t) = -\int_{t-4}^{4} d\tau = t - 8$

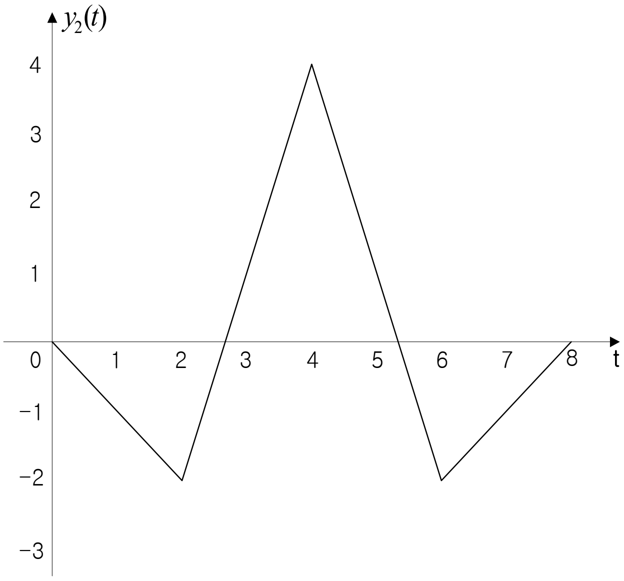









$y_1(t)$
4
3
2
1
0
1
2
3
4
5
6
7
8
t
−1
−2
−3


$y_2(t)$
4
3
2
1
0
1
2
3
4
5
6
7
8
t
−1
−2
−3

(c) $y_{12}(t)=x_1(t)*h_2(t)$

① $0\leqq t<1$: $y_{12}(t)=\int_0^t d\tau=t$

② $1\leqq t<2$: $y_{12}(t)=\int_0^1 d\tau-\int_1^t d\tau=1-(t-1)=-t+2$

③ $2\leqq t<3$: $y_{12}(t)=-\int_0^{t-2} d\tau+\int_{t-2}^1 d\tau-\int_1^2 d\tau+\int_2^t d\tau=-t+2$

④ $3\leqq t<4$: $y_{12}(t)=-\int_0^1 d\tau+\int_1^{t-2} d\tau-\int_{t-2}^2 d\tau+\int_2^3 d\tau-\int_3^t d\tau=t-4$

⑤ $4\leqq t<5$: $y_{12}(t)=-\int_{t-4}^1 d\tau+\int_1^2 d\tau-\int_2^{t-2} d\tau+\int_{t-2}^3 d\tau-\int_3^4 d\tau=-t+4$

⑥ $5\leqq t<6$일 때 $y_{12}(t)=\int_{t-4}^2 d\tau-\int_2^3 d\tau+\int_3^{t-2} d\tau-\int_{t-2}^4 d\tau=t-6$

⑦ $6\leqq t<7$일 때 $y_{12}(t)=-\int_{t-4}^3 d\tau+\int_3^4 d\tau=t-6$

⑧ $7\leqq t<8$일 때 $y_{12}(t)=\int_{t-4}^4 d\tau=-t+8$

$y_{21}(t)=x_2(t)*h_1(t)$

① $0\leqq t<1$: $y_{21}(t)=\int_0^t d\tau=t$

② $1\leqq t<2$: $y_{21}(t)=-\int_0^{t-1} d\tau+\int_{t-1}^t d\tau=-t+2$

③ $2\leqq t<3$: $y_{21}(t)=\int_0^{t-2} d\tau-\int_{t-2}^{t-1} d\tau+\int_{t-1}^2 d\tau-\int_2^t d\tau=-t+2$

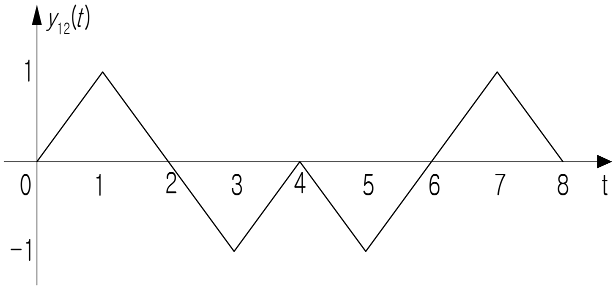
④ $3\leqq t<4$: $y_{21}(t)=-\int_0^{t-3} d\tau+\int_{t-3}^{t-2} d\tau-\int_{t-2}^2 d\tau+\int_2^{t-1} d\tau-\int_{t-1}^t d\tau=t-4$

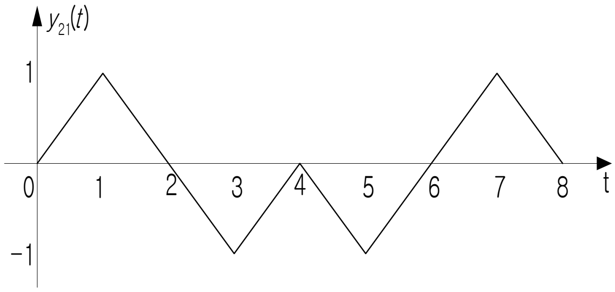
⑤ $4\leqq t<5$: $y_{21}(t)=-\int_{t-4}^{t-3} d\tau+\int_{t-3}^2 d\tau-\int_2^{t-2} d\tau+\int_{t-2}^{t-1} d\tau-\int_{t-1}^4 d\tau=-t+4$

⑥ $5\leqq t<6$: $y_{21}(t)=\int_{t-4}^2 d\tau-\int_2^{t-3} d\tau+\int_{t-3}^{t-2} d\tau-\int_{t-2}^4 d\tau=t-6$

⑦ $6\leqq t<7$: $y_{21}(t)=-\int_{t-4}^{t-3} d\tau+\int_{t-3}^4 d\tau=t-6$

⑧ $7\leqq t<8$: $y_{21}(t)=\int_{t-4}^4 d\tau=-t+8$





4.17 (a) 인과성 : $h(t) = \delta(t-3)$이므로 $h(t) = 0,\ t < 0$ → ∴ 인과 시스템

안정성 : $\int_{-\infty}^{\infty} |h(t)|\, dt = \int_{-\infty}^{\infty} |\delta(t-3)|\, dt = 1 < \infty$ → ∴ 안정한 시스템

(b) 인과성 : $h(t) = u(t-3)$이므로 $h(t) = 0,\ t \leqq 0$ → ∴ 인과 시스템

안정성 : $\int_{-\infty}^{\infty} |h(t)|\, dt = \int_{-\infty}^{\infty} |u(t-3)|\, dt = \infty$ → ∴ 불안정한 시스템

(c) 인과성 : $h(t) = r(t-3)$이므로 $h(t) = 0,\ t \leqq 0$ → ∴ 인과 시스템

안정성 : $\int_{-\infty}^{\infty} |h(t)|\, dt = \int_{-\infty}^{\infty} |r(t-3)|\, dt = \infty$ → ∴ 불안정한 시스템

(d) 인과성 : $h(t) = e^{t-1}u(t-1)$이므로 $h(t) = 0,\ t \leqq 0$ → ∴ 인과 시스템

안정성 : $\int_{-\infty}^{\infty} |h(t)|\, dt = \int_{-\infty}^{\infty} |e^{t-1}u(t-1)|\, dt = \infty$ → ∴ 불안정한 시스템

4.18 (a) 인과성 : $h(t) = \frac{1}{t}u(t) = \begin{cases} 0, & t < 0 \\ \frac{1}{t}, & t \geqq 0 \end{cases}$ → $h(t) = 0,\ t < 0$

∴ 인과적 시스템

안정성 : $\int_{-\infty}^{\infty} |h(t)|\, dt = \int_{0}^{\infty} \left|\frac{1}{t}\right| dt = \ln x \Big|_{0}^{\infty} = \infty$

∴ 불안정한 시스템

(b) 인과성 : $h(t)=\dfrac{1}{(t-1)^2}u(-t)=\begin{cases}0, & t>0\\ \dfrac{1}{(t-1)^2}, & t<0\end{cases} \quad \rightarrow \quad h(t)\neq 0,\ t<0$

∴ 비인과적 시스템

안정성 : $\displaystyle\int_{-\infty}^{\infty}|h(t)|\,dt=\int_{-\infty}^{\infty}\left|\frac{1}{(t-1)^2}u(-t)\right|dt=\int_{-\infty}^{0}\frac{1}{(t-1)^2}\,dt=1$

∴ 안정한 시스템

(c) 인과성 : $h(t)=e^{2t}u(1-t)=e^{2t}u(-(t-1))=\begin{cases}0, & t>1\\ e^{2t}, & t\leqq 1\end{cases} \quad \rightarrow \quad h(t)\neq 0,\ t<0$

∴ 비인과적 시스템

안정성 : $\displaystyle\int_{-\infty}^{\infty}|h(t)|\,dt=\int_{-\infty}^{\infty}|e^{2t}u(1-t)|\,dt=\int_{-\infty}^{1}e^{2t}dt=\frac{1}{2}e^{2t}\Big|_{-\infty}^{1}=\frac{e^2}{2}<\infty$

∴ 안정한 시스템

(d) 인과성 : $h(t)=0,\ t<0$

∴ 인과적 시스템

안정성 : $\displaystyle\int_{-\infty}^{\infty}|h(t)|dt=\int_{0}^{\infty}te^{-2t}dt=-\frac{1}{2}te^{-2t}\Big|_{0}^{\infty}-\int_{0}^{\infty}-\frac{1}{2}e^{-2t}dt=\frac{1}{4}<\infty$

∴ 안정한 시스템

(e) 인과성 : $h(t)=0,\ t<0$

∴ 인과적 시스템

안정성 : $\displaystyle\int_{-\infty}^{\infty}|h(t)|dt=\int_{0}^{\infty}|\cos(2t)|\,dt=\infty$

∴ 불안정한 시스템

(f) 인과성 : $h(t)=0,\ t<0$

∴ 인과적 시스템

안정성 : $\displaystyle\int_{-\infty}^{\infty}|h(t)|dt=\int_{0}^{\infty}|e^{-2t}\cos(2t)|\,dt<\int_{0}^{\infty}e^{-2t}\,dt=\frac{1}{3}<\infty$

∴ 안정한 시스템

4.19 (a) 시스템은 불안정

(b) 시스템은 불안정

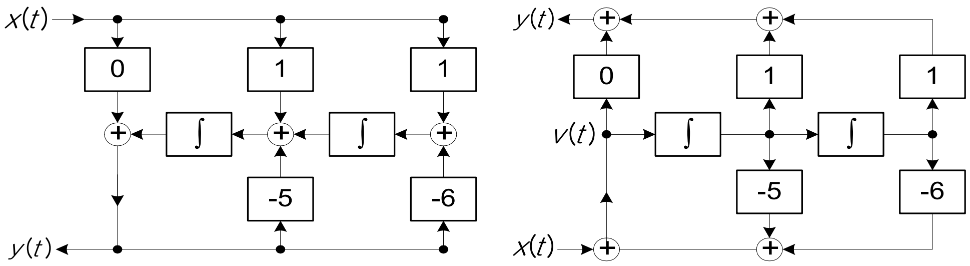
(c) 항상 $\displaystyle\int_{-\infty}^{\infty}|s(t)|dt<\infty$일 때에만 안정한 것은 아니다.

4.20 (a) 특성다항식 : $Q(\lambda)=\lambda^2+5\lambda+6$

특성방정식 : $Q(\lambda)=\lambda^2+5\lambda+6=(\lambda+2)(\lambda+3)=0$

특성근 : $\lambda=-2,\ -3$

특성모드 : $e^{-2t},\ e^{-3t}$



(a) 제1 표준형 (b) 제2 표준형

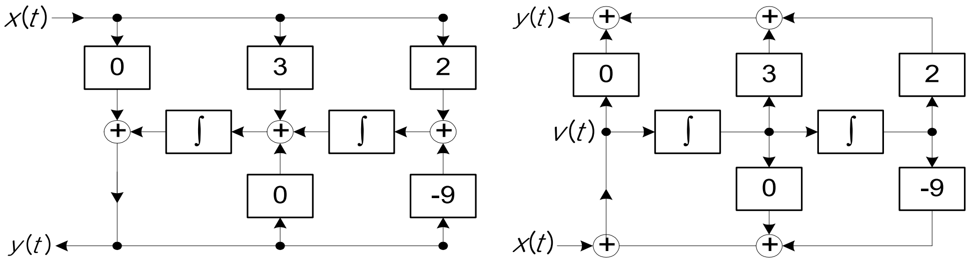
$\therefore\ y_s(t)=5e^{-2t}-3e^{-3t}$

(b) 특성다항식 : $Q(\lambda)=\lambda^2+9$

특성방정식 : $Q(\lambda)=\lambda^2+9=(\lambda+j3)(\lambda-j3)=0,$

특성근 : $\lambda=\pm j3$

특성모드 : $e^{j3t},\ e^{-j3t}$



(a) 제1 표준형 (b) 제2 표준형

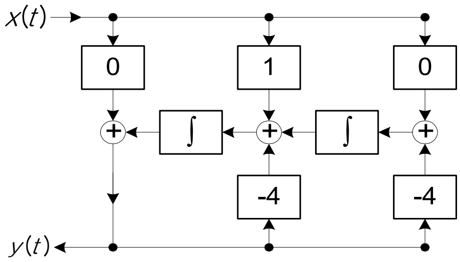
$\therefore\ y_s(t)=-je^{j3t}+je^{-j3t}=-j(e^{j3t}-e^{-j3t})=2\sin 3t$

(c) 특성다항식 : $Q(\lambda)=\lambda^2+4\lambda+4$

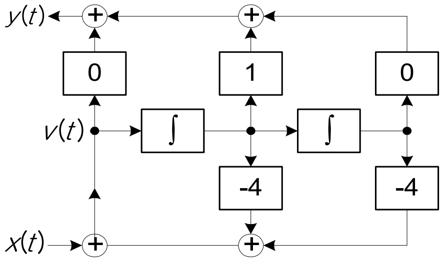
특성방정식 : $Q(\lambda)=\lambda^2+4\lambda+4=(\lambda+2)^2=0$

특성근 : $\lambda=-2$

특성모드 : $e^{-2t},\quad t\,e^{-2t}$



(a) 제1 표준형



(b) 제2 표준형

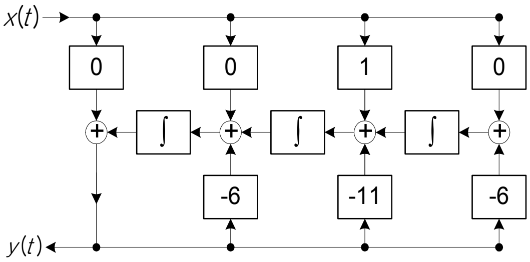
$\therefore\ y_s(t)=3e^{-2t}+2te^{-2t}$

(d) 특성다항식 : $Q(\lambda)=(\lambda+1)(\lambda^2+5\lambda+6)=\lambda^3+6\lambda^2+11\lambda+6$

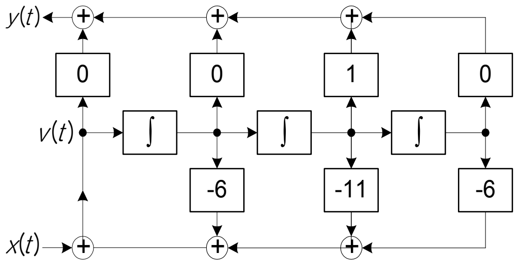
특성방정식 : $(\lambda+1)(\lambda^2+5\lambda+6)=(\lambda+1)(\lambda+2)(\lambda+3)=0$

특성근 : $\lambda=-1,\ -2,\ -3$

특성모드 : $e^{-t},\ e^{-2t},\ e^{-3t}$



(a) 제1 표준형



(b) 제2 표준형

$\therefore\ y_s(t)=6e^{-t}-7e^{-2t}+3e^{-3t}$

4.21 (a) $y(t) = -\dfrac{21}{10}e^{-10t} + \dfrac{1}{10}$

(b) $y(t) = \dfrac{17}{9}e^{-10t} + \dfrac{1}{9}e^{-t}$

(c) $y(t) = -\dfrac{1210}{101}e^{-10t} + \dfrac{200}{101}cos(t) + \dfrac{20}{101}sin(t)$

(d) $y(t) = -\dfrac{5}{4}e^{-t} + \dfrac{1}{4}e^{-5t} + 2$

(e) $y(t) = \dfrac{8}{3}e^{t} + \dfrac{5}{6}e^{-2t} - \dfrac{3}{2}$

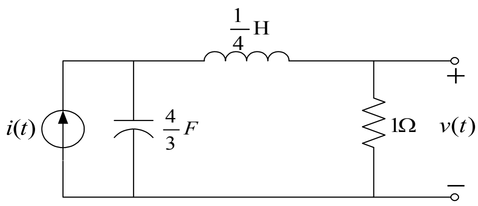
4.22 (a) $y(t) = \dfrac{1}{3}e^{-3t} - \dfrac{1}{2}e^{-4t} + \dfrac{1}{6}$

(b) $y(t) = \dfrac{1}{2}e^{-3t} - \dfrac{2}{3}e^{-4t} + \dfrac{1}{6}e^{-t}$

(c) $y(t) = e^{-3t} - e^{-4t}$

(d) $y(t) = 2e^{-3t} - 2e^{-4t} - te^{-3t}$

4.23 ※ 저항 값이 $R = 1\,[\Omega]$(초판 오류)



(a) $\dfrac{d^2v(t)}{dt^2} + 4\dfrac{dv(t)}{dt} + 3v(t) = 3i(t)$

(b) $v(t) = -\dfrac{3}{2}e^{-t} + \dfrac{1}{2}e^{-3t} + 1$

(c) $y(t) = \begin{cases} -3e^{-t} + e^{-3t} + 2, & 0 \leqq t < 1 \\ -3(1-e)e^{-t} + (1-e^3)e^{-3t}, & t \geqq 1 \end{cases}$

4.24 (a) $\frac{d^2y(t)}{dt}+4\frac{dy(t)}{dt}+4y(t)=\frac{dx(t)}{dt}+x(t)$

(b) $y(t)=\frac{3}{4}e^{-2t}+\frac{5}{2}te^{-2t}+\frac{1}{4}$

4.25 (a) 특성근이 복소평면의 좌반면에 위치 → 안정

(b) 특성근이 복소평면의 좌반면에 위치 → 안정

※ BIBO 안정도 판별에서는 $\lambda=1$의 특성근(시스템의 극)이 우변의 인자(시스템의 영점)과 상쇄되어 안정한 것으로 나타나지만 점근적 안정도에서는 이로 인해 불안정한 시스템으로 판정된다. 즉 외부적으로는 나타나지 않지만, 내부적으로는 발산하는 불안정한 모드가 존재하여 0이 아닌 초기조건에 대해서는 출력이 발산하는 수도 있어 시스템이 불안정해질 수 있다.

(c) 특성근이 복소평면의 좌반면에 위치 → 이 시스템은 안정

(d) 공액 복소근인 특성근이 복소평면의 허축상에 위치
→ 이 시스템은 불안정(임계 안정)

(e) 특성근이 복소평면의 우반면에 위치 → 이 시스템은 불안정

(f) 공액 복소근인 특성근이 복소평면의 우반면에 위치 → 이 시스템은 불안정

Chapter 05 연습문제 답안

5.1 ㉰

5.2 ㉯

5.3 ㉯, ㉱

5.4 ㉱

5.5 ㉯

5.6 ㉱

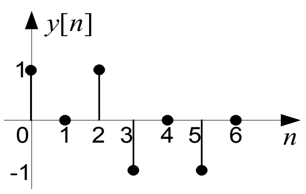
5.7

5.8 ㉰

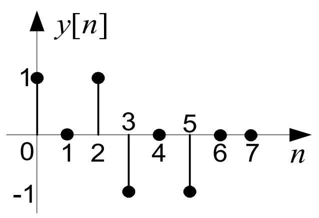
5.9 ㉰, ㉲, ㉳, ㉵

5.10 ㉮

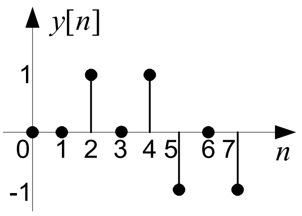
5.11 (a) $y[n] = [\check{1},\ 0,\ 1,\ -1,\ 0,\ -1]$



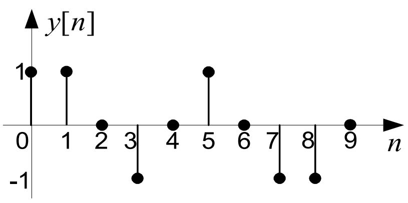
(b) $y[n] = [\check{0},\ 0,\ 1,\ 0,\ 1,\ -1,\ 0,\ -1]$



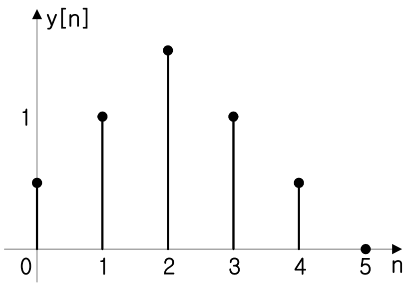
(c) $y[n] = [\check{0},\ 0,\ 1,\ 0,\ 1,\ -1,\ 0,\ -1]$



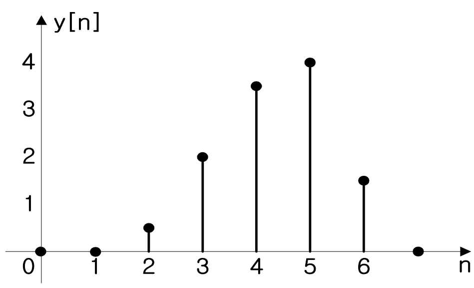
(d) $y[n] = [\check{1},\ 1,\ 0,\ -1,\ 0,\ 1,\ 0,\ -1,\ -1]$



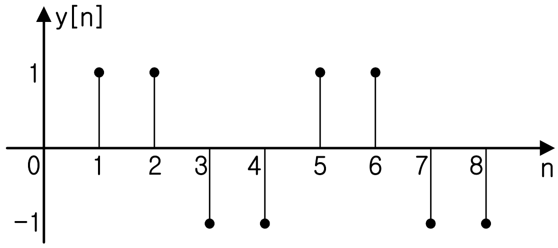
5.12 (a)



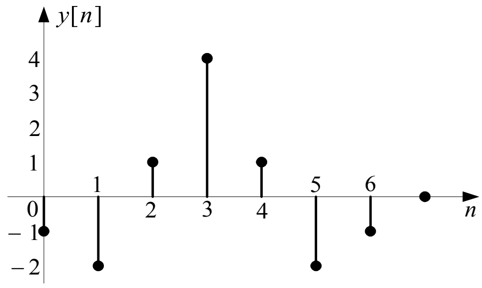
(b)



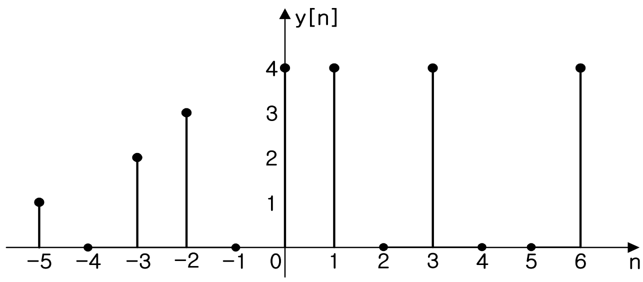
(c)



(d)



(e)



5.13 (a) $h[n]=[\check{1},\ -2,\ 3]$

(b) $h[n]=[\check{1},\ 2,\ 2,\ 3]$

(c) $h[n]=[\breve{0.5},\ 0.5]$

5.14 (a) ① $n < -2$: $y[n] = 0$

② $-2 \leqq n < 1$: $y[n] = \sum_{k=0}^{n+2} h[k]x[n-k]$

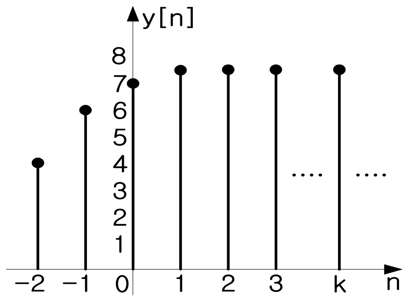
$y[-2] = x[-2] = 4$

$y[-1] = x[-2] + x[-1] = 6$

$y[0] = x[-2] + x[-1] + x[0] = 7$

③ $n \geqq 1$: $y[n] = \sum_{k=n-1}^{n+2} h[k]x[n-k]$

$y[n] = x[-2] + x[-1] + x[0] + x[1] = 7.5$



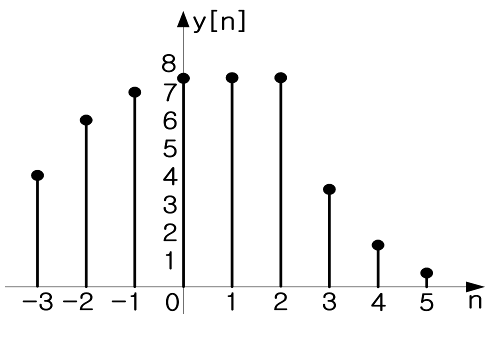
(b) ① $n < -3$: $y[n] = 0$

② $-3 \leqq n < 0$: $y[n] = \sum_{k=-1}^{n+2} h[k]x[n-k]$

③ $0 \leqq n < 3$: $y[n] = \sum_{k=n-1}^{n+2} h[k]x[n-k]$

④ $3 \leqq n < 6$: $y[n] = \sum_{k=n-1}^{4} h[k]x[n-k]$

⑤ $n \geqq 6$: $y[n] = 0$

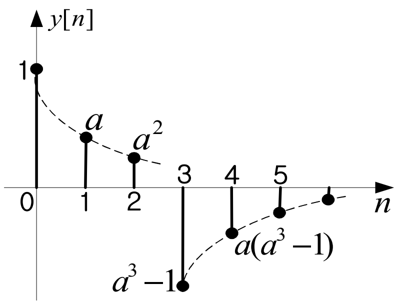


(c) $y[n]=a^n u[n]-a^{(n-3)}u[n-3]$

① $n<0$: $y[n]=0$

② $0 \leqq n < 3$: $y[n]=a^n$

③ $n \geqq 3$: $y[n]=a^n - a^{(n-3)}$



(d) $y[n]=\sum_{k=-2}^{1} a^k(\delta[n-k+1]-a^2\delta[n-k-1])$

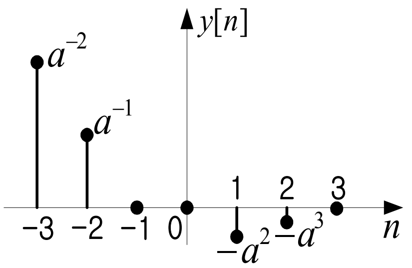
① $n<-3$: $y[n]=0$

② $-3 \leqq n < -1$: $y[n]=a^{n+1}$

③ $-1 \leqq n < 1$: $y[n]=a^{n+1}-a^2a^{(n-1)}=0$

④ $1 \leqq n < 3$: $y[n]=-a^2a^{(n-1)}$

⑤ $n \geqq 3$: $y[n]=0$



5.15 (a) $y[n]=[\check{1},\ 6,\ 13,\ 20,\ 28,\ 16,\ 16]$

(b) $y[n]=[4,\ 14,\ 17,\ \check{30},\ 17,\ 14,\ 4]$

(c) $y[n]=[16,\ 16,\ 28,\ 20,\ 13,\ 6,\ \check{1}]$

(d) $y[n]=[\check{1},\ 6,\ 13,\ 20,\ 28,\ 16,\ 16]$

5.16 (a) $y_1[n]=[\check{1},\ 1,\ 2,\ 2,\ 2,\ -4,\ 1,\ -5]$

(b) $y_2[n]=[\check{5},\ -1,\ 4,\ -2,\ -2,\ -2,\ -1,\ -1]$

(c) $y[n]=[\check{1},\ 1,\ 2,\ 2,\ 2,\ 1,\ 0,\ -1,\ -2,\ -2,\ -2,\ -1,\ -1]$

(d) 중첩의 원리를 적용하면

$$\begin{aligned} y[n] &= y_1[n]+y_2[n-5] \\ &= [\check{1},\ 1,\ 2,\ 2,\ 2,\ 1,\ 0,\ -1,\ -2,\ -2,\ -2,\ -1,\ -1] \end{aligned}$$

5.17 $h[n]=(h_1[n]+h_2[n])*h_3[n]+h_4[n]=u[n-4]+a^n u[n]$

5.18 (a) 왼쪽 그림의 경우 $y[n]=8[(0.5)^n-(0.5)^{2n+1}]u[n]$

오른쪽 그림의 경우 $y[n]=y_2^2[n]=4(n+1)^2(0.5)^{2n}u[n]$

시스템 1이 비선형 시스템이므로 두 부시스템의 순서를 바꾸어 종속 연결하면 출력이 달라진다.

(b) 시스템 1, 2 모두 선형 시스템이므로 어느 쪽으로 연결해도 출력은 같다.

$y[n]=2(n+1)(0.5)^n u[n]-2n(0.5)^{n-1}u[n-1]$

5.19 $h[n]=\dfrac{1}{6}\left[\left(-\dfrac{1}{2}\right)^n+\left(\dfrac{1}{4}\right)^n\right],\quad n\ge 0$

5.20 (a) $y[n]-7y[n-1]+10y[n-2]=14x[n]-85x[n-1]+111x[n-2]$

(b) $y[n]+3y[n-1]+2y[n-2]=x[n]$

5.21 $y[n]-0.25y[n-2]=2x[n]$

5.22 (a) $h[n]=\delta[n-3]$

(i) 인과성

$h[n]=0,\ n<0$을 만족하므로 이 시스템은 인과적인 시스템이다.

(ii) 안정성

$\sum_{n=-\infty}^{\infty}|h[n]|<\infty$를 만족하므로 이 시스템은 안정한 시스템이다.

(b) $h[n]=\sum_{k=-\infty}^{n}\delta[k-3]=\sum_{i=-\infty}^{n-3}\delta[i]=u[n-3]$

(i) 인과성

$h[n]=0,\ n<0$을 만족하므로 이 시스템은 인과적인 시스템이다.

(ii) 안정성

$\sum_{n=-\infty}^{\infty}|h[n]|<\infty$을 만족하지 않으므로 이 시스템은 불안정한 시스템이다.

(c) $h[n]=\sum_{k=-\infty}^{n}\sum_{m=-\infty}^{k}\delta[m-3]=\sum_{k=3}^{n}1=(n-2)u[n-3]$

(i) 인과성

$h[n]=0,\ n<0$을 만족하므로 이 시스템은 인과적인 시스템이다.

(ii) 안정성

$\sum_{n=-\infty}^{\infty}|h[n]|<\infty$을 만족하지 않으므로 이 시스템은 불안정한 시스템이다.

(d) $h[n]=\sum_{k=-\infty}^{n}2^{k-n}\delta[k-3]=2^{3-n}u[n-3]=(\frac{1}{2})^{n-3}u[n-3]$

($\because$ $2^{k-n}\delta[k-3]$은 $k=3$일 때만 값이 존재하므로 $n\geq 3$에서만 $h[n]$ 존재)

(i) 인과성

$h[n]=0,\ n<0$을 만족하므로 이 시스템은 인과적인 시스템이다.

(ii) 안정성

$\sum_{n=-\infty}^{\infty}|h[n]|<\infty$을 만족하므로 이 시스템은 안정한 시스템이다.

5.23 (a) (i) 인과성

$h[n]=(-1)^n u[n]$으로 $h[n]=0,\quad n<0$을 만족하는 인과적 시스템이다.

(ii) 안정성

안정성 조건을 만족하지 않으므로 불안정한 시스템이다.

(b) (i) 인과성

$h[n]=(2)^n u[1-n]$으로 $h[n]\neq 0,\quad n<0$이다. 따라서 비인과적 시스템이다.

(ii) 안정성

안정성 조건을 만족하므로 안정한 시스템이다.

(c) (i) 인과성

$h[n]=(n+1)(2)^{-n}u(n)$으로 $h[n]=0,\ n<0$이다. 따라서 인과적 시스템이다.

(ii) 안정성

안정성 조건을 만족하므로 안정한 시스템이다.

(d) (i) 인과성

$h[n]=(0.5)^{|n|}$으로 $h[n]\neq 0,\quad n<0$이다. 따라서 비인과적 시스템이다.

(ii) 안정성

안정성 조건을 만족하므로 안정한 시스템이다.

(e) (i) 인과성

$h[n]=(0.5)^{-n}u[-n]$으로 $h[n]\neq 0,\ n\leqq 0$이다. 따라서 비인과적 시스템이다.

(ii) 안정성

안정성 조건을 만족하므로 안정한 시스템이다.

(f) (i) 인과성

$h[n]=(0.5)^{n}\cos(2n)u[n]$으로 $h[n]=0,\quad n<0$이다. 따라서 인과적 시스템이다.

(ii) 안정성

안정성 조건을 만족하므로 안정한 시스템이다.

이 풀이의 파형 그림의 매트랩 프로그램은 다음과 같다.

```
function[x,n]=stepseq(n0,n1,n2)

% Generates x(n)=u(n-n0);  n1 <= n <= n2
%----------------------------------------
% [x,n]= stepseq(n0,n1,n2)

n=[n1:n2];
x=[(n-n0)>=0];
```

```
(a)
clc;
n=[-10:20];
x=((-1).^n).*stepseq(0,-10,20);
zero= 0;
pole= -1;
figure;
zplane(zero,pole);
figure;
stem(n,x)
```

```
(b)
clc;
n=[-10:20];
x=((2).^n).*stepseq(1,-10,20);
figure;
stem(n,x)
```

(c)
clc;
n=[-10:20];
x=(n+ 1).*(2.^-n).*stepseq(0,-10,20);
figure;
stem(n,x)
	(d)
	clc;
	n=[-10:20];
	k=abs(n);
	x=(0.5).^k;
	figure;
	stem(n,x)

(e)
clc;
n=[-10:20];
x=((0.5).^(-n)).*stepseq(0,-10,20);
figure;
stem(n,x)
	(f)
	clc;
	n=[-10:20];
	x=((0.5).^n).*cos(2*n).*stepseq(0,-10,20);
	figure;
	stem(n,x)

5.24 (a) $h[n] = (-2)^n u[n]$

(b) $h[n] = \begin{cases} 1, & n=0 \\ 2(-2)^{n-2} = \dfrac{1}{2}(-2)^n, & n \geqq 1 \end{cases}$

(c) $h[n] = (-1)^n - (-2)^n$

(d) $h[n] = (1+n)2^n$

5.25 (a) $y[n] = \sum_{k=0}^{n+1} (-a)^k$

(b) $y[n] = (-a)^{n+1} + 2\sum_{k=0}^{n} (-a)^k$

(c) $y[n] = 2\sum_{k=0}^{n+1} (-a)^k$

(d) $y[n] = (-a)^{n+1} + \dfrac{-2(-a)^{n+1} + (0.5)^n}{2a+1}$

(e) $y[n] = \sum_{k=0}^{n+1} (-a)^k + (-a)^{n+1} + \dfrac{-2(-a)^{n+1} + (0.5)^n}{2a+1}$

5.26 ※ (a), (b) 수식 부호 수정 → 책대로 해도 풀리지만 매우 복잡함

(a) $y[n]-y[n-1]-2y[n-2]=x[n]$

(i) 영입력 응답 + 영상태 응답

$$y[n]=y_s[n]+y_i[n]=\left[\frac{1}{3}(-1)^n+\frac{8}{3}(2)^n\right]+\left[\frac{1}{6}(-1)^n+\frac{4}{3}(2)^n-\frac{1}{2}\right]$$
$$=\frac{1}{2}(-1)^n+4(2)^n-\frac{1}{2}$$

(ii) 고유응답+ 강제응답

$$y[n]=y_h[n]+y_p[n]=\left[\frac{1}{2}(-1)^n+4(2)^n\right]+\left[-\frac{1}{2}\right]$$

※ 부호 수정 않고 원 문제 그대로 $y[n]-y[n-1]+2y[n-2]=x[n]$일 경우

(i) 영입력 응답 + 영상태 응답

$$y[n]=y_s[n]+y_i[n]=\left[\left(\frac{-1+j5/\sqrt{7}}{2}\right)\left(\frac{1+j\sqrt{7}}{2}\right)^n+\left(\frac{-1-j5/\sqrt{7}}{2}\right)\left(\frac{1-j\sqrt{7}}{2}\right)^n\right]$$
$$+\left[\left(\frac{1-j5/\sqrt{7}}{4}\right)\left(\frac{1+j\sqrt{7}}{2}\right)^n+\left(\frac{1+j5/\sqrt{7}}{4}\right)\left(\frac{1-j\sqrt{7}}{2}\right)^n+\frac{1}{2}\right]$$
$$=\left(\frac{-1+j5/\sqrt{7}}{4}\right)\left(\frac{1+j\sqrt{7}}{2}\right)^n+\left(\frac{-1-j5/\sqrt{7}}{4}\right)\left(\frac{1-j\sqrt{7}}{2}\right)^n+\frac{1}{2}$$

(ii) 고유 응답 + 강제 응답

$$y[n]=y_h[n]+y_p[n]=\left[\left(\frac{-1+j5/\sqrt{7}}{4}\right)\left(\frac{1+j\sqrt{7}}{2}\right)^n+\left(\frac{-1-j5/\sqrt{7}}{4}\right)\left(\frac{1-j\sqrt{7}}{2}\right)^n\right]+\left[\frac{1}{2}\right]$$

(b) $y[n]-y[n-1]-2y[n-2]=x[n-2]$

(i) 영입력 응답 + 영상태 응답

$$y[n]=y_s[n]+y_i[n]=\left[\frac{1}{3}(-1)^n+\frac{8}{3}(2)^n\right]+\left[\frac{1}{6}(-1)^n+\frac{1}{3}(2)^n-\frac{1}{2}\right]$$
$$=\frac{1}{2}(-1)^n+3(2)^n-\frac{1}{2}$$

(ii) 고유응답+ 강제응답

$$y[n]=y_h[n]+y_p[n]=\left[\frac{1}{2}(-1)^n+3(2)^n\right]+\left[-\frac{1}{2}\right]$$

※ 이 문제에서 구한 영상태 응답은 (a)에서 구한 영상태 응답을 시간 스텝 2만큼 지연시킨 것과 일치한다. 왜냐하면 (b)는 (a)와 동일한 시스템에 동일한 입력을 시간 2만큼 지연시켜서 인가한 것과 같기 때문이다. 그러나 전체적인 응답은 영상태 응답뿐만 아니라 초기상태에 의한 영입력 응답도 포함되어 있기 때문에 이와 같은 시불변 성질이 만족되지 않음을 (a)와 (b)의 결과를 비교하여 확인할 수 있다.

(c) (i) 영입력 응답+ 영상태 응답

$$y[n] = \left[\frac{1}{3}(-1)^n + \frac{8}{3}(2)^n\right] + \left[\frac{1}{3}(-1)^n + \frac{2}{3}(2)^n\right] = \frac{2}{3}(-1)^n + \frac{10}{3}(2)^n$$

(ii) 고유응답+ 강제응답

$$y[n] = y_h[n] + y_p[n] = \left[\frac{2}{3}(-1)^n + \frac{10}{3}(2)^n\right] + [0]$$

(e) $y[n] - \frac{3}{4}y[n-1] + \frac{1}{8}y[n-2] = x[n]$

(i) 영입력 응답 +영상태 응답

$$\begin{aligned} y[n] &= \left[\frac{3}{4}(\frac{1}{2})^n - \frac{1}{8}(\frac{1}{4})^n\right] + \left[-2(\frac{1}{2})^n + \frac{1}{3}(\frac{1}{4})^n + \frac{8}{3}\right] \\ &= -\frac{5}{4}(\frac{1}{2})^n + \frac{5}{24}(\frac{1}{4})^n + \frac{8}{3} \end{aligned}$$

(ii) 고유응답+ 강제응답

$$y[n] = \left[-\frac{5}{4}(\frac{1}{2})^n + \frac{5}{24}(\frac{1}{4})^n\right] + \left[\frac{8}{3}\right]$$

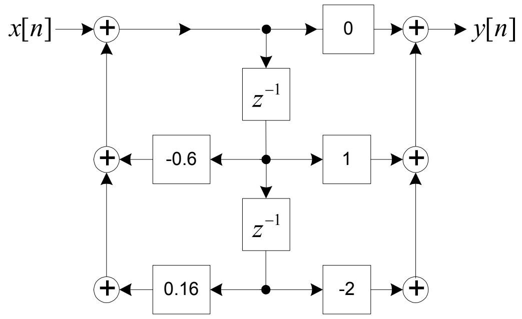
5.27 $\begin{cases} a_0 = -1 \\ a_1 = -1 \end{cases}$

5.28 (a) $y[n] + 2y[n-1] = x[n-2]$

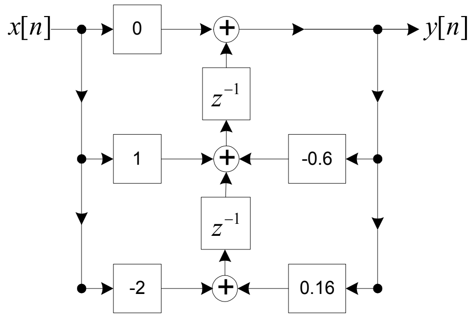
(b) $h[n] = \frac{1}{4}(-2)^n$

(c) $y[n] = 2(-2)^n + 2, \quad n \geqq 2$

5.29 (a) 안정

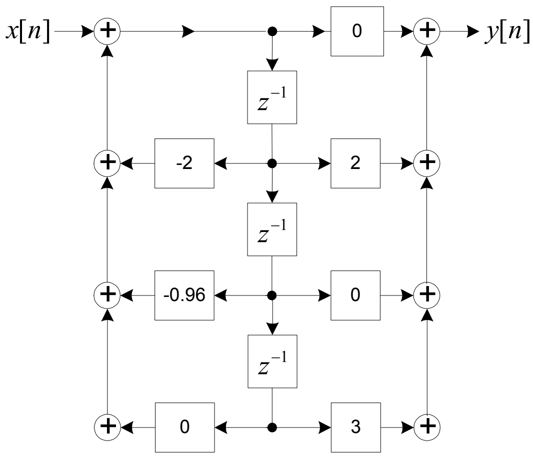


(a) 제2 직접형

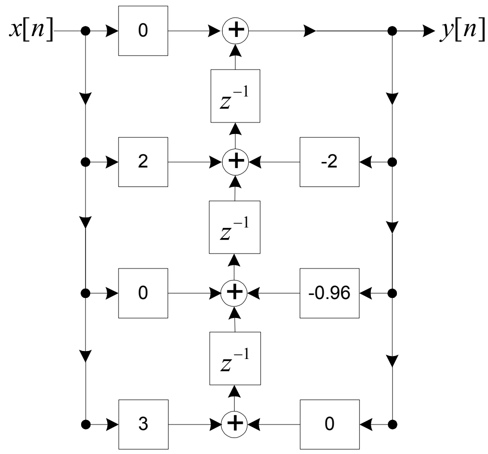


(b) 전치 제2 직접형

(b) 불안정

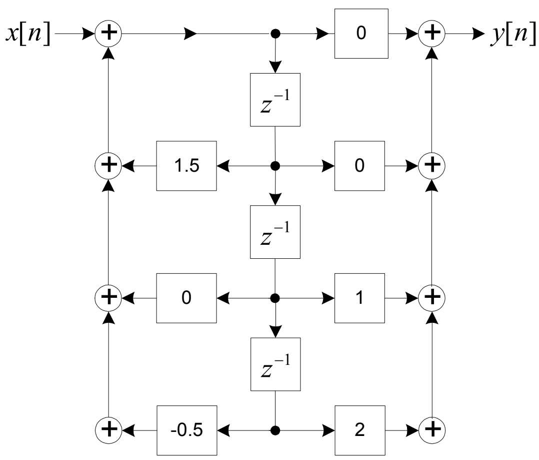


(a) 제2 직접형

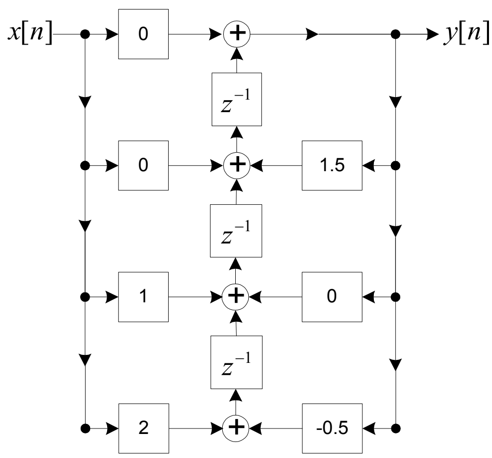


(b) 전치 제2 직접형

(c) 불안정



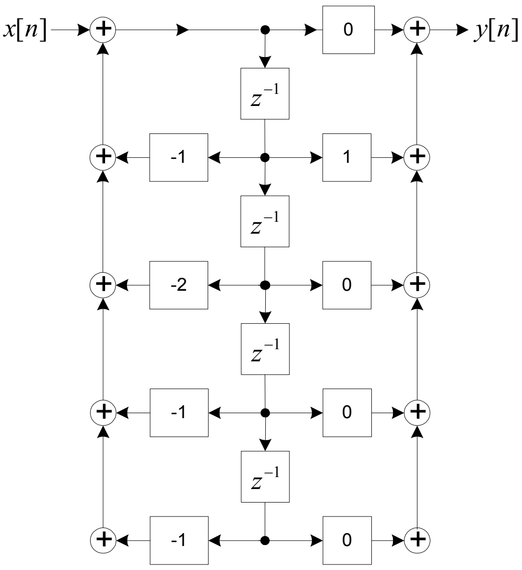
(a) 제2 직접형



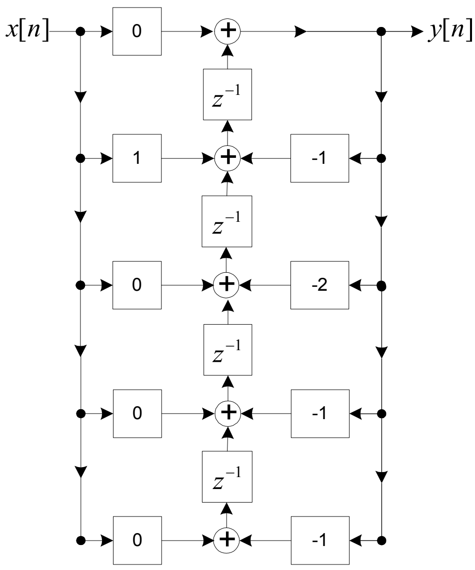
(b) 전치 제2 직접형

(d) 임계 안정

(안정 또는 불안정의 둘로 나눈다면 임계 안정은 불안정으로 분류된다.)

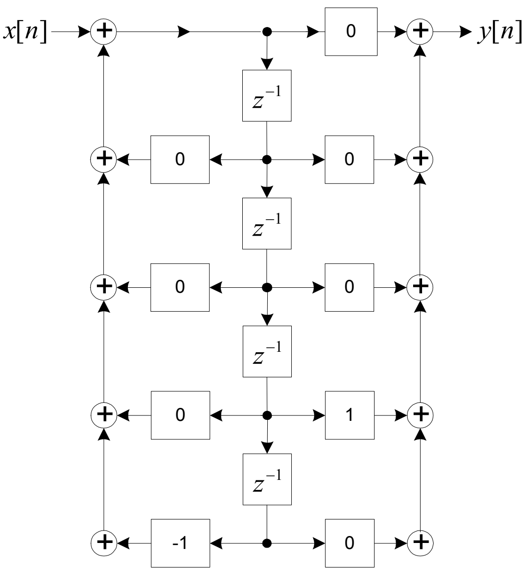


(a) 제2 직접형

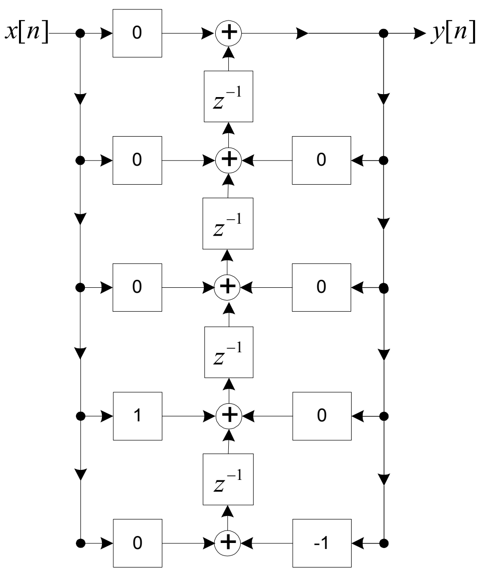


(b) 전치 제2 직접형

(e) 불안정



(a) 제2 직접형



(b) 전치 제2 직접형

Chapter 06 연습문제 답안

6.1 ㈏

6.2 ㈎

6.3 ㈐

6.4 ㈏

6.5 ㈐

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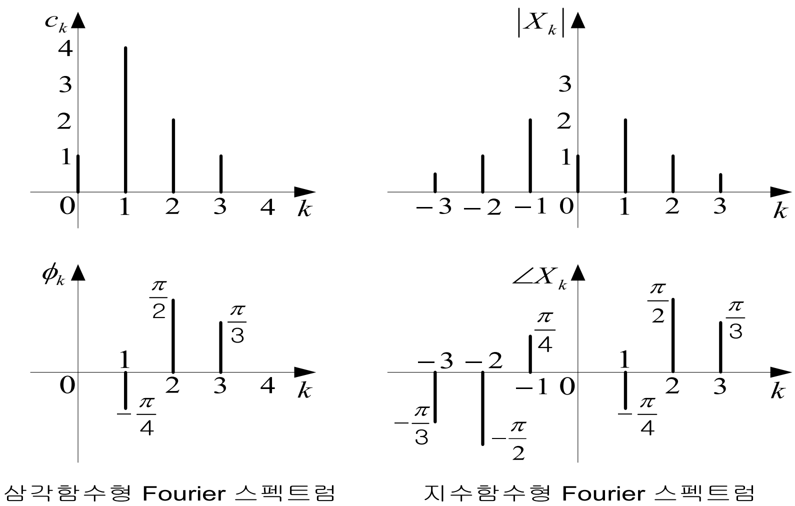
6.7 ㈑

6.8 ㈎

6.9 ㈐

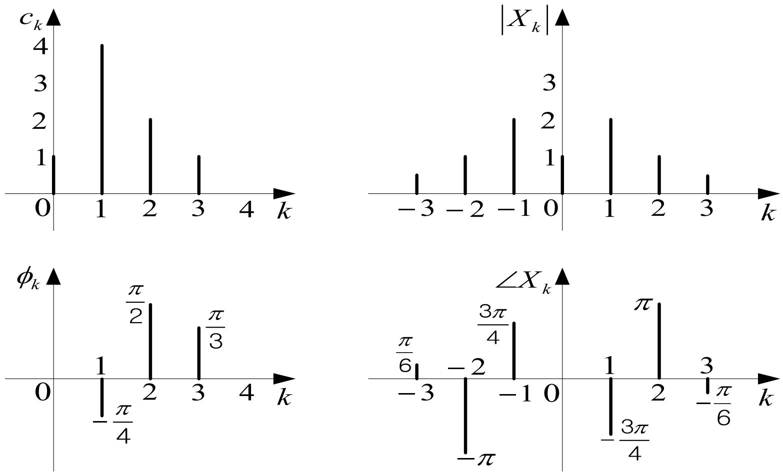
6.10 ㈎

6.11 (a)



(a)

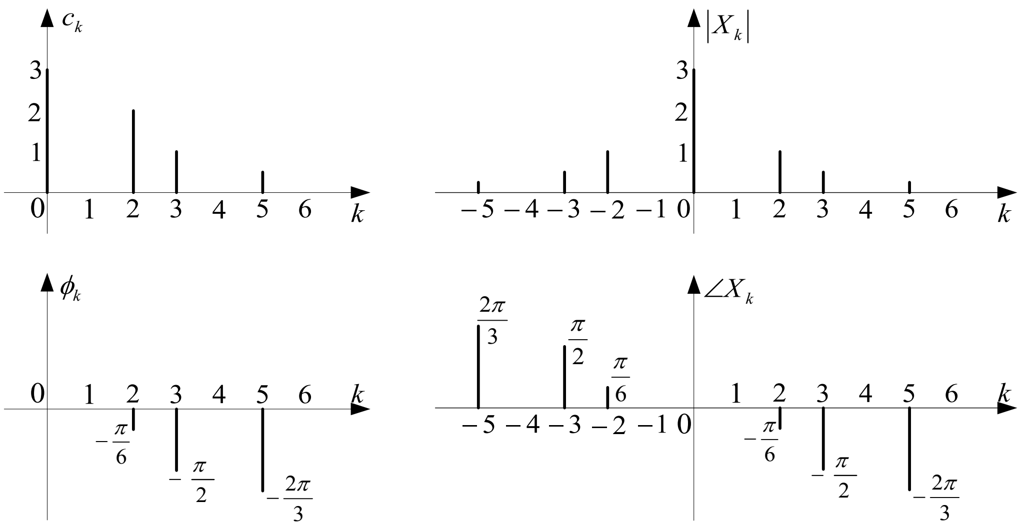
(b)



삼각함수형 Fourier 스펙트럼　　　지수함수형 Fourier 스펙트럼

(b)

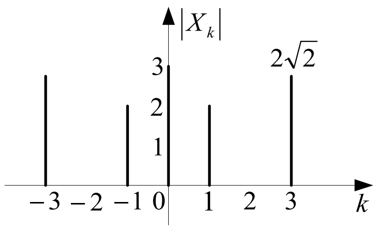
6.12 (a) (b)

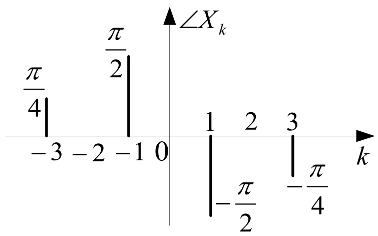


삼각함수형 Fourier 스펙트럼　　　지수함수형 Fourier 스펙트럼

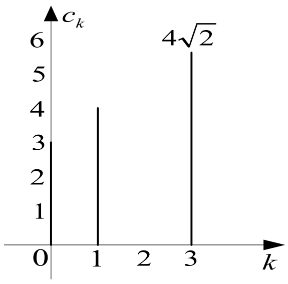
(c) $x(t) = \frac{1}{4}e^{j\frac{2\pi}{3}}e^{j5t} + \frac{1}{2}e^{j\frac{\pi}{2}}e^{j3t} + e^{j\frac{\pi}{6}}e^{j2t} + 3 + e^{-j\frac{\pi}{6}}e^{j2t} + \frac{1}{2}e^{-j\frac{\pi}{2}}e^{j3t} + \frac{1}{4}e^{-j\frac{2\pi}{3}}e^{j5t}$

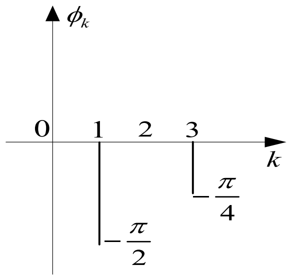
6.13 (a)





(b)





(c) $x(t) = 3 + 4\cos(t - \frac{\pi}{2}) + 4\sqrt{2}\cos(3t - \frac{\pi}{4})$

6.14 (a) (i) 삼각함수 형식 푸리에 급수

$$x(t) = \sin\left(2t + \frac{\pi}{4}\right) = \cos\left(2t + \frac{\pi}{4} - \frac{\pi}{2}\right) = \cos\left(2t - \frac{\pi}{4}\right) = \sum_{k=0}^{\infty} c_k \cos(k\omega_0 t + \theta_k)$$

$$\therefore\ c_1 = 1,\quad \theta_1 = -\frac{\pi}{4}$$

(ii) 지수 함수 형식 푸리에 급수

$$x(t) = \frac{1}{2}e^{-j\frac{\pi}{4}}e^{j2t} - \frac{1}{2}e^{-j\frac{3\pi}{4}}e^{-j2t} = \sum_{k=-\infty}^{\infty} X_k e^{jk2t}$$

$$\therefore\ X_{-1} = \frac{1}{2}e^{j\frac{\pi}{4}},\quad X_1 = \frac{1}{2}e^{-j\frac{\pi}{4}}$$

(b) (i) 삼각함수 형식 푸리에 급수

$$x(t) = a_0 + \sum_{k=1}^{\infty} a_k \cos k\omega_o t = \sum_{k=0}^{\infty} c_k \cos k\omega_o t$$

$$X_0 = a_0 = \frac{2}{\pi}$$

$$X_k = a_k = \frac{2}{T}\int_0^T x(t)\cos k\omega_0 t\, dt = \frac{4}{(1-4k^2)\pi}$$

(ii) 지수 함수 형식 푸리에 급수

$$\begin{cases} X_0 = \dfrac{2}{\pi} \\ X_k = \dfrac{2}{(1-4k^2)\pi}, \quad k = \pm 1,\ \pm 2,\ \cdots \end{cases}$$

(c) (i) 삼각함수 형식 푸리에 급수

$$x(t) = \sin 2t + \cos 4t = \cos(2t - \frac{\pi}{2}) + \cos 4t = \sum_{k=0}^{\infty} c_k \cos(k\omega_0 t + \theta_k)$$

$$\therefore\ c_1 = 1,\quad \theta_1 = -\frac{\pi}{2} \quad \& \quad c_2 = 1,\quad \theta_2 = 0$$

(ii) 지수 함수 형식 푸리에 급수

$$x(t) = \frac{1}{2}e^{-j4t} - \frac{1}{2j}e^{-j2t} + \frac{1}{2j}e^{j2t} + \frac{1}{2}e^{j4t} = \sum_{k=-\infty}^{\infty} X_k e^{j2kt}$$

$$\therefore\ X_{-2} = \frac{1}{2},\quad X_{-1} = -\frac{1}{2j} = \frac{1}{2}e^{j\frac{\pi}{2}},\quad X_1 = \frac{1}{2j} = \frac{1}{2}e^{-j\frac{\pi}{2}},\quad X_2 = \frac{1}{2}$$

(d) (i) 삼각함수 형식 푸리에 급수

$$x(t) = \frac{1}{4}\cos 3t + \frac{3}{4}\cos t = \sum_{k=0}^{\infty} c_k \cos(k\omega_0 t + \theta_k)$$

$$\therefore\ c_1 = \frac{3}{4},\quad \theta_1 = 0 \quad \& \quad c_3 = \frac{1}{4},\quad \theta_3 = 0$$

(ii) 지수 함수 형식 푸리에 급수

$$x(t) = \frac{3}{4}\cos t + \frac{1}{4}\cos 3t = \frac{3}{8}(e^{jt} + e^{-jt}) + \frac{1}{8}(e^{j3t} + e^{-j3t}) = \sum_{k=-\infty}^{\infty} X_k e^{jkt}$$

$$\therefore\ X_{-3} = \frac{1}{8},\quad X_{-1} = \frac{3}{8},\quad X_1 = \frac{3}{8},\quad X_3 = \frac{1}{8}$$

(e) (i) 삼각함수 형식 푸리에 급수

$$x(t) = \cos 2t + \cos 3t = \sum_{k=0}^{\infty} c_k \cos(k\omega_0 t + \theta_k)$$

$$\therefore\ c_2 = 1,\quad \theta_2 = 0 \quad \& \quad c_3 = 1,\quad \theta_3 = 0$$

(ii) 지수 함수 형식 푸리에 급수

$$x(t) = \cos 2t + \cos 3t = \frac{1}{2}(e^{j2t} + e^{-j2t}) + \frac{1}{2}(e^{j3t} + e^{-j3t}) = \sum_{k=-\infty}^{\infty} X_k e^{jkt}$$

$$\therefore\ X_{-3} = \frac{1}{2},\quad X_{-2} = \frac{1}{2},\quad X_2 = \frac{1}{2},\quad X_3 = \frac{1}{2}$$

(f) (i) 삼각함수 형식 푸리에 급수

$$x(t) = -\frac{1}{2}\cos(2t - \frac{\pi}{2}) + \frac{1}{2}\cos(8t - \frac{\pi}{2}) = \sum_{k=0}^{\infty} c_k \cos(k\omega_0 t + \theta_k)$$

$$\therefore\ c_1 = \frac{1}{2},\quad \theta_1 = \frac{\pi}{2} \quad \& \quad c_4 = \frac{1}{2},\quad \theta_4 = -\frac{\pi}{2}$$

(ii) 지수 함수 형식 푸리에 급수

$$x(t) = \frac{1}{2}\cos(2t + \frac{\pi}{2}) + \frac{1}{2}\cos(8t - \frac{\pi}{2}) = \sum_{k=-\infty}^{\infty} X_k e^{j2kt}$$

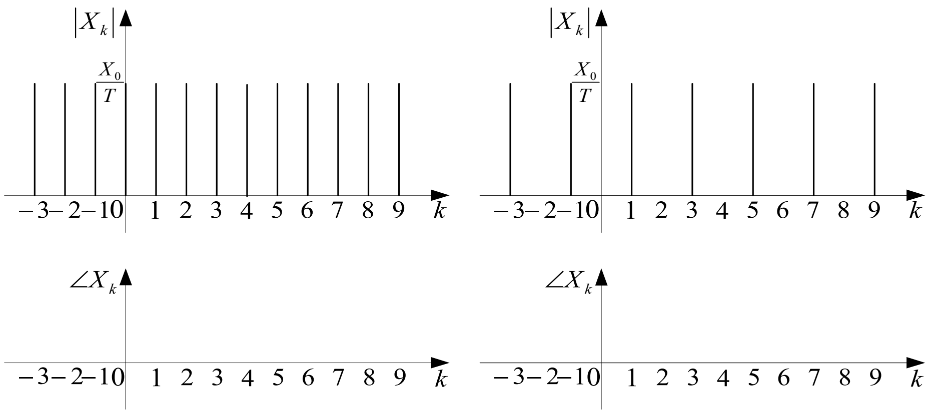
$$\therefore\ X_{-4} = \frac{1}{4}e^{j\frac{\pi}{2}},\quad X_{-1} = \frac{1}{4}e^{-j\frac{\pi}{2}},\quad X_1 = \frac{1}{4}e^{j\frac{\pi}{2}},\quad X_4 = \frac{1}{4}e^{-j\frac{\pi}{2}}$$

6.15 (a) $x(t) = \sum_{k=-\infty}^{\infty} X_k e^{jk\omega_0 t} = \sum_{k=-\infty}^{\infty} \frac{A}{T} e^{jk\omega_0 t}$

$$|X_k| = \frac{A}{T} \quad \& \quad \angle X_k = 0$$

(b) $x(t) = \sum_{k=-\infty}^{\infty} X_k e^{jk\omega_0 t} = \sum_{k=-\infty}^{\infty} \frac{A}{2T}(1 - e^{-jk\pi}) e^{jk\omega_0 t}$

$$|X_k| = \begin{cases} \frac{A}{T}, & k = \text{홀수} \\ 0, & k = \text{짝수} \end{cases} \quad \& \quad \angle X_k = 0$$



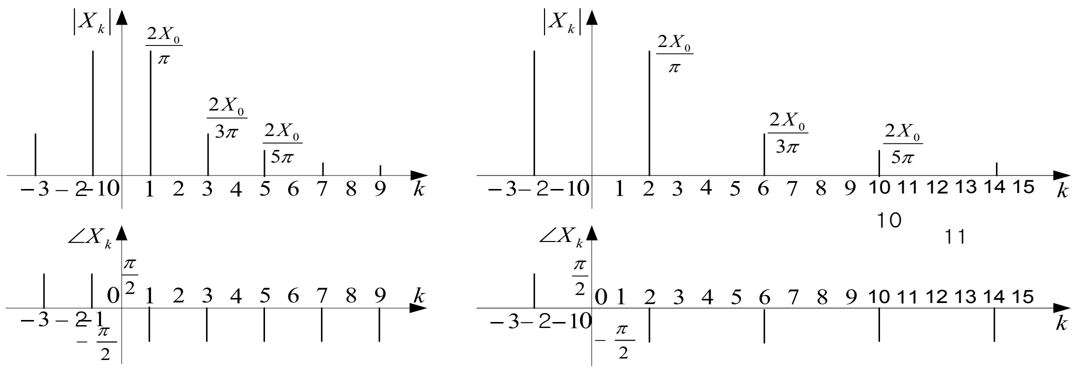
(a) (b)

(c) $x(t)=\sum_{k=-\infty}^{\infty} X_k e^{jk\omega_0 t}=\sum_{k=\text{홀수}} -j\frac{2X_0}{k\pi}e^{jk\omega_0 t}$

$$|X_k|=\begin{cases}\frac{2X_0}{k\pi}, & k=\text{홀수}\\ 0, & k=\text{짝수}\end{cases} \quad \& \quad \angle X_k=\begin{cases}-\frac{\pi}{2}, & k=\text{홀수}\\ 0, & k=\text{짝수}\end{cases}$$

(d) $x(t)=\sum_{k=-\infty}^{\infty} X_k e^{jk\omega_0 t}=\sum_{k=4m+2} -j\frac{2X_0}{k\pi}e^{jk\omega_0 t}$

$$|X_k|=\begin{cases}\frac{2X_0}{k\pi}, & k=4m+2\\ 0, & \text{그 외}\end{cases} \quad \& \quad \angle X_k=\begin{cases}-\frac{\pi}{2}, & k=4m+2\\ 0, & \text{그 외}\end{cases}$$



(c) (d)

6.16 (a) $X_k=\begin{cases} j\frac{3}{k\pi}, & k=1,\ 3,\ 5\ \cdots\\ j\frac{6}{k\pi}, & k=2,\ 6,\ 10\ \cdots\\ 0, & k=4,\ 8,\ 12,\ \cdots\end{cases}$

$$X_0=\frac{1}{T}\left(\int_0^1(-3)\,dt+\int_3^4 3\,dt\right)=\frac{1}{4}\left(-3t\Big|_0^1+3t\Big|_3^4\right)=0$$

(b) $X_k=\frac{1}{T}\int_0^T x(t)e^{-jk\omega_0 t}dt=\frac{1}{4}\int_2^3 e^{-jk\frac{\pi}{2}t}dt+\frac{1}{4}\int_3^4 2e^{-jk\frac{\pi}{2}t}dt$

$$=j\frac{1}{2k\pi}\left(-e^{-jk\frac{3}{2}\pi}-e^{-jk\pi}+2e^{j2k\pi}\right)$$

$$X_0=\frac{1}{T}\int_0^T x(t)\,dt=\frac{1}{4}\int_2^3 dt+\frac{1}{4}\int_3^4 2\,dt=\frac{1}{4}\left(t\Big|_2^3+2t\Big|_3^4\right)=\frac{1}{4}(3-2+8-6)=\frac{3}{4}$$

(c) $X_k = \frac{1}{T}\int_{-\frac{T}{2}}^{\frac{T}{2}} x(t)e^{-jk\pi t}\,dt = j\frac{e^{-jk\pi}}{k\pi} + \frac{e^{-jk\pi}}{k^2\pi^2} - \frac{1}{k^2\pi^2}$

$$X_0 = \frac{1}{T}\int_{-\frac{T}{2}}^{\frac{T}{2}} x(t)\,dt = \frac{1}{2}\int_0^1 2t\,dt = \frac{t^2}{2}\Big|_0^1 = \frac{1}{2}$$

(d) $X_k = \frac{1}{T}\int_{-\frac{T}{2}}^{\frac{T}{2}} x(t)e^{-jk\omega_0 t}\,dt = -j\frac{1}{k\pi} - \frac{3}{k^2\pi^2}e^{-jk\frac{\pi}{3}}(e^{-jk\frac{\pi}{3}} - 1)$

6.17 (a) $X_k = \begin{cases} -j\frac{1}{4}, & k=1 \\ \frac{1}{(1-k^2)\pi}, & k=even \\ 0, & k=odd,\ \ k\neq 1 \end{cases}$ & $X_{-k} = X_k^*$

(b) $y(t) = \sum_{k=-\infty}^{\infty} C_k e^{j4\pi kt} = \sum_{k=-\infty}^{\infty} \frac{2}{(1-4k^2)\pi} e^{j4\pi kt}$

6.18 (a) $X_k = \begin{cases} j\frac{1}{4}, & k=-2 \\ -j\frac{1}{4}, & k=2 \\ 0, & k=even(\neq \pm 2) \\ \frac{2}{(4-k^2)\pi}, & k=odd \end{cases}$

(b) $Y_k = \begin{cases} \frac{4}{(4-k^2)\pi}e^{j\frac{k\pi}{4}}, & k=odd \\ 0 & k=even \end{cases}$

$$y(t) = \sum_{k=odd} \frac{4}{(4-k^2)\pi} e^{j\frac{k\pi}{4}} e^{j\frac{k\pi}{2}t}$$

6.19 (a) $x(t) = \sum_{k=odd} \frac{4}{k^2 \pi^2} e^{j\frac{k\pi}{4}t}$

(b) $x_1(t) = x(t-2) = \sum_{k=odd} \frac{4}{k^2 \pi^2} e^{j\frac{k\pi}{4}(t-2)} = \sum_{k=odd} X_k' e^{j\frac{k\pi}{4}t}$

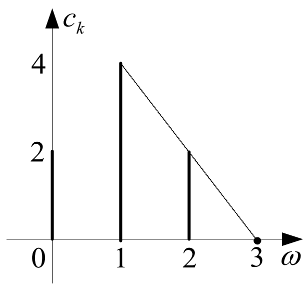
$$X_k' = \begin{cases} \frac{4}{k^2\pi^2} e^{-j\frac{k\pi}{2}}, & k = odd \\ 0, & k = even \end{cases}$$

(c) $x_2(t) = x(2t) = \sum_{k=odd} \frac{4}{k^2 \pi^2} e^{j\frac{k\pi}{4}(2t)} = \sum_{k=odd} \frac{4}{k^2 \pi^2} e^{j\frac{k\pi}{2}t} = \sum_{k=odd} X_k' e^{j\frac{k\pi}{2}t}$

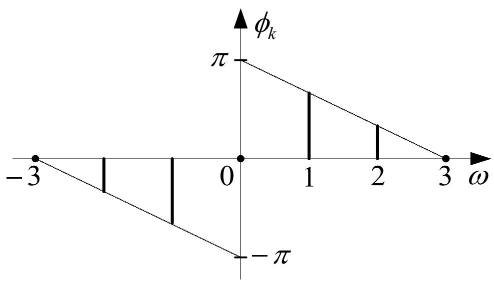
$$X_k' = \begin{cases} \frac{4}{k^2\pi^2}, & k = odd \\ 0, & k = even \end{cases}$$

6.20 (a) $x(t) = 2 + 2\left(e^{j(t+\frac{2\pi}{3})} + e^{-j(t+\frac{2\pi}{3})}\right) + \left(e^{j(2t+\frac{\pi}{3})} + e^{-j(2t+\frac{\pi}{3})}\right)$

(b) $c_k = 2|X_k|$ & $\phi_k = \angle X_k$



(a) 진폭 스펙트럼



(b) 위상 스펙트럼

(c) $x(t) = \sum_{k=0}^{2} c_k \cos(kt + \phi_k) = 2 + 4\cos(t + \frac{2\pi}{3}) + 2\cos(2t + \frac{\pi}{3})$

6.21 280

6.22 (a) $x(t)=\sum_{k=\text{홀수}}\frac{10}{k\pi}sin(2\pi kt)$

(b) $\frac{50}{\pi^2}\sum_{k=\text{홀수}}\frac{1}{k^2}$

(c) $\frac{50}{\pi^2}\left(\sum_{k=\text{홀수}}\frac{1}{k^2}-1\right)$

6.23 (a) $x(t)=\sum_{k=-\infty}^{\infty}X_k e^{jk\omega_0 t}=\sum_{k=-\infty}^{\infty}X_k e^{jk\pi t}$

$$X_0=\frac{1}{T}\int_T x(t)\,dt=\frac{1}{2}\int_0^1 1\,dt=\frac{1}{2}$$

$$X_k=\begin{cases}-j\frac{1}{k\pi}, & k=odd\\ 0, & k=even\end{cases}$$

(b) $y(t)=\sum_{k=-\infty}^{\infty}Y_k e^{jk\omega_0 t}=\sum_{k=-\infty}^{\infty}Y_k e^{jk\pi t}$

$$Y_k=\frac{1}{1+jk\pi}X_k=\begin{cases}\frac{1}{2}, & k=0\\ \frac{1}{-k^2\pi^2+jk\pi}, & k=odd\\ 0, & k=even\end{cases}$$

(c) $\left(\frac{1}{2}\right)^2+\sum_{m=1}^{\infty}\frac{2}{(2m-1)^2\pi^2(1-(2m-1)^2\pi^2)}$

6.24 (a) $\frac{E}{5}(1-e^{-5})$

(b) $\frac{2E(1-e^{-5})}{\sqrt{25+4\pi^2}}$

(c) $|y_{dc}|=\frac{E(1-e^{-5})}{5}$, $|y_1|=\frac{2ET(1-e^{-5})}{\sqrt{T^2+4\pi^2(RC)^2}\sqrt{25+4\pi^2}}$

Chapter 07 연습문제 답안

7.1 ㉰

7.2 ㉱ ㉲

7.3 ㉱

7.4 ㉮

7.5 ㉱

7.6 ㉮

7.7 ㉱

7.8 ㉰

7.9 ㉱

7.10 ㉯

7.11 (a) $X(\omega) = -\dfrac{e^{-(a+j\omega)T}-1}{a+j\omega}$

(b) $X(\omega) = \dfrac{e^{(a-j\omega)T}-1}{a-j\omega}$

(c) $X(\omega) = \dfrac{4-2(e^{-j\omega}+e^{-j2\omega})}{j\omega}$

(d) $X(\omega) = \dfrac{1-j\tau\omega}{\tau\omega^2}(e^{j\omega\tau}+e^{-j\omega\tau})$

7.12 (a) $X(\omega) = \dfrac{1}{j\omega}(1 - e^{-j5\omega})$

(b) $X(\omega) = \dfrac{1}{j\omega + 2}(1 - e^{-5(j\omega+2)})$

(c) $X(\omega) = \dfrac{1}{\omega^2}(e^{-j5\omega}(1 + j5\omega) - 1)$

(d) $X(\omega) = j\,sinc(\dfrac{\omega}{\pi} + 2) - j\,sinc(\dfrac{\omega}{\pi} - 2)$

7.13 (a) $X(\omega) = j\dfrac{\pi}{2}[\delta(\omega + \omega_0) - \delta(\omega - \omega_0)] - \dfrac{\omega_0}{\omega^2 - \omega_0^2}$

(b) $X(\omega) = \dfrac{\pi}{2}\delta(\omega) + \dfrac{\pi}{8}[\delta(\omega + 2\omega_0) + \delta(\omega - 2\omega_0)] - j\dfrac{1}{2\omega} - j\dfrac{\omega}{4(\omega^2 - 4\omega_0^2)}$

(c) $X(\omega) = \dfrac{j\omega}{j\omega + \pi} = \dfrac{\omega}{\omega - j\pi}$

(d) $X(\omega) = \dfrac{\omega_0}{j2\pi\omega + \omega_0^2 - \omega^2 + \pi^2}$

7.14 (a) $X(\omega) = \displaystyle\int_{-\infty}^{\infty} x(t)e^{-j\omega t}dt = \int_{-1}^{0}(1)e^{-j\omega t}dt + \int_{0}^{1}(-1)e^{-j\omega t}dt$

$$= -\frac{1}{j\omega}e^{-j\omega t}\bigg|_{-1}^{0} + \frac{1}{j\omega}e^{-j\omega t}\bigg|_{0}^{1} = \frac{2}{j\omega}\frac{e^{j\omega} + e^{-j\omega}}{2} - \frac{2}{j\omega}$$

$$= \frac{2}{j\omega}(\cos\omega - 1)$$

(b) $X(\omega) = e^{j\omega}\left\{\pi\delta(\omega) + \dfrac{1}{j\omega}\right\} - 2\left\{\pi\delta(\omega) + \dfrac{1}{j\omega}\right\} + e^{-j\omega}\left\{\pi\delta(\omega) + \dfrac{1}{j\omega}\right\}$

$$= (\pi\delta(\omega) + \frac{1}{j\omega})(e^{j\omega} + e^{-j\omega} - 2) = 2(\pi\delta(\omega) + \frac{1}{j\omega})(\cos\omega - 1)$$

$$= \frac{2}{j\omega}(\cos\omega - 1)$$

$$(\because (\cos\omega - 1)\pi\delta(\omega) = 0)$$

(c) $X(\omega) = \dfrac{e^{j\omega} + e^{-j\omega}}{j\omega} - \dfrac{2}{j\omega} = \dfrac{2}{j\omega}(\cos\omega - 1)$

7.15 (a) $X_1(\omega) = X(-\omega) = \frac{1}{\omega^2}\left[e^{-j\omega} + j\omega e^{-j\omega} - 1\right]$

(b) $X_2(\omega) = [X(\omega) + X(-\omega)]e^{-j\omega} = \frac{2e^{-j\omega}}{\omega^2}[\cos\omega + \omega\sin\omega - 1]$

(c) $X_3(\omega) = X(\omega)e^{-j\omega} + X(-\omega)e^{j\omega} = \frac{1}{2}\frac{2^2}{\omega^2}sin^2(\frac{\omega}{2}) = \frac{1}{2}sinc^{\,2}(\frac{\omega}{2\pi})$

(d) $X_3(\omega) = X(\omega)e^{-j\frac{\omega}{2}} + X(-\omega)e^{j\frac{\omega}{2}} = \frac{2}{\omega}sin(\frac{\omega}{2}) = sinc(\frac{\omega}{2\pi})$

(e) $X_5(\omega) = \frac{3}{2}2X(2\omega)e^{-j2\omega} = \frac{3}{\omega^2}(1 - j\omega - e^{-j2\omega})$

7.16 (a) $X_1(\omega) = \frac{j4\omega}{-\omega^2 + j10\omega + 24}$

(b) $X_2(\omega) = \frac{j\omega}{-\omega^2 + j15\omega + 54}e^{-j2\omega}$

(c) $X_3(\omega) = \frac{-j\omega}{\omega^2 - j5\omega + 6}$

(d) $X_4(\omega) = \frac{j(\omega - 10)}{-(\omega - 100)^2 + j5(\omega - 10) + 6}$

(e) $X_5(\omega) = -\omega^2\frac{e^{-j2\omega}}{\omega^4 - 37\omega^2 + 36 - j(10\omega^3 + 60\omega)}$

(f) $X_6(\omega) = -\frac{1}{2}\left(\frac{(\omega + 2\pi)}{-(\omega + 2\pi)^2 + 5j(\omega + 2\pi) + 6} - \frac{(\omega - 2\pi)}{-(\omega - 2\pi)^2 + 5j(\omega - 2\pi) + 6}\right)$

7.17 (a) $Y(\omega) = j\frac{d}{d\omega}\left(\frac{1}{2}X(\frac{\omega}{a})\right) = j\frac{1}{4}(\delta(\frac{\omega}{2}) - \delta(\frac{\omega}{2} - 2)) = j\frac{1}{4}(\delta(\omega) - \delta(\omega - 4))$

(b) $Y(\omega) = je^{j\omega}[\delta(\omega) - \delta(\omega - 2)] - 2e^{j\omega}[u(\omega) - u(\omega - 2)]$

(c) $Y(\omega) = X(\omega)e^{-j2\omega} = rect((\omega - 1)/2)e^{-j2\omega}$

(d) $Y(\omega) = (j\omega)X(\omega) = (j\omega)rect((\omega - 1)/2)$

(e) $Y(\omega) = -rect((\omega - 1)/2) - \omega(\delta(\omega) - \delta(\omega - 2))$

(f) $Y(\omega) = \frac{1}{j\omega}X(\omega) + \pi X(0)\delta(\omega) = \frac{1}{j\omega}rect((\omega - 1)/2) + \pi\delta(\omega)$

7.18 (a) $x(t) = \dfrac{1}{2\pi}\dfrac{2a}{a^2+t^2} = \dfrac{a}{\pi(a^2+t^2)}$

(b) $x(t) = \dfrac{1}{2}[\delta(t+1)+\delta(t-1)] * \dfrac{1}{2}P_2(t) = \dfrac{1}{4}[P_2(t+1)+P_2(t-1)]$

(c) $x(t) = \dfrac{d}{dt}\left(\dfrac{2}{\pi}sinc(\dfrac{t}{\pi})\right) = \dfrac{2}{\pi}\dfrac{t\cos t - \sin t}{t^2} = \dfrac{2}{\pi t}(\cos t - sinc(\dfrac{t}{\pi}))$

(d) $x(t) = e^{j\omega_0 t} + \dfrac{1}{2}\triangle\left(\dfrac{1}{2}(t-1)\right)$

(e) $x(t) = \dfrac{1}{2}P_2(t)(e^{j\omega_0 t}+e^{-j\omega_0 t}) = P_2(t)\cos\omega_0 t$

(f) $x(t) = j\dfrac{1}{2\pi}\dfrac{2}{jt} = \dfrac{1}{\pi t}$

7.19 (a), (b) $x(t) = e^{-at}\displaystyle\int_0^t d\tau = te^{-at}u(t)$

(c) $x(t) = \dfrac{1}{(N-1)!(-j)^{N-1}}(-j)^{N-1}t^{N-1}v(t) = \dfrac{1}{(N-1)!}t^{N-1}e^{-at}u(t)$

7.20 $X_1(\omega) = X(\omega) + X(\omega) * (\pi[\delta(\omega+2\omega_0)+\delta(\omega-2\omega_0)]$

$= X(\omega) + \pi X(\omega+2\omega_0) + \pi X(\omega+2\omega_0)$

대역폭이 W인 저역 통과 필터에 $x_1(t)$를 통과시키면 $X_1(\omega)$에서 $X(\omega \pm 2\omega_0)$ 성분은 필터의 통과 대역 바깥에 위치하므로 제거되고, $X(\omega)$만 남게 된다.
따라서 $x(t)$를 필터의 출력으로 얻게 되어 신호 $x(t)$를 복조할 수 있다.

7.21 (a) $x(t) = \dfrac{\omega_0}{\pi}sinc(\dfrac{\omega_0}{\pi}(t-t_0))$

(b) $x(t) = \dfrac{1-\cos\omega_0 t}{\pi t}$

7.22 (a) $x(t) = \dfrac{1}{\pi t}(\sin 2t + \sin t)$

(b) $x(t) = \dfrac{1}{\pi\omega_0 t^2}(\cos\omega_0 t + t\sin\omega_0 t - 1)$

(c) $x(t) = \dfrac{1}{4\pi}[sinc\left(\dfrac{1}{2\pi}(t+1)\right) + sinc\left(\dfrac{1}{2\pi}(t-1)\right)]$

(d) $x(t) = \dfrac{1}{2\pi t^3}\left[e^{j\omega_0 t}(2\omega_0 t + j(2-\omega_0^2 t^2)) - e^{-j\omega_0 t}(-2\omega_0 t + j(2-\omega_0^2 t^2))\right]$

7.23 (a) $E = \frac{1}{2\pi}\int_{-\infty}^{\infty} |X(\omega)|^2 d\omega = \frac{1}{2\pi}\int_{-\pi}^{\pi} d\omega = 1$

(b) $E = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{4\times 2^2}{(2^2+\omega^2)^2} d\omega = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{4\times 2^3 \sec^2\theta}{2^4 \sec^4\theta} d\theta = \frac{1}{2}$

※ $\sin 2\theta = 2\cos\theta\sin\theta = 2\frac{2}{\sqrt{2^2+\omega^2}}\frac{\omega}{\sqrt{2^2+\omega^2}}$ 임을 이용한 것이다.

※ 이 문제는 특수 치환 적분 때문에 계산이 까다로워, 시간 영역 적분으로 에너지를 계산하는 것이 더 쉽다.

$$E = \int_{-\infty}^{\infty} |x(t)|^2 dt = \int_{-\infty}^{\infty} e^{-4|t|} dt == \frac{1}{2}$$

(c) $x(t) = Sa^2(t) = \mathrm{sinc}^2(\frac{t}{\pi})$ <-문제 수정, 책대로 하면 (d)에 활용 못함

$$E = \frac{1}{2\pi}\int_{-\infty}^{\infty} |X(\omega)|^2 d\omega = \frac{1}{2\pi}\int_{-\infty}^{\infty} \pi^2 tri^2(\frac{\omega}{2}) d\omega = \frac{2\pi}{3}$$

(d) $E = \frac{8}{\pi}\int_{-\infty}^{\infty} \mathrm{sinc}^4(\frac{\omega}{\pi}) d\omega = \frac{8}{\pi}\frac{2\pi}{3} = \frac{16}{3}$

※ 시간 적분으로 삼각 펄스의 에너지를 계산해보면 다음과 같이 되어 위의 결과를 검증할 수 있다.

$$E = \int_{-2}^{0} (t+2)^2 dt + \int_{0}^{2} (-t+2)^2 dt = \frac{1}{3}((t+2)^3\Big|_{-2}^{0} - (-t+2)^3\Big|_{0}^{2} = \frac{16}{3}$$

7.24 (a) $H(\omega)\frac{Y(\omega)}{X(\omega)} = \frac{(j\omega)+2}{(j\omega)^2+7(j\omega)+12}$

(b) i) $y(t) = (2e^{-4t} - e^{-3t})u(t)$

ii) $y(t) = (\frac{1}{6}e^{-t} + \frac{1}{2}e^{-3t} - \frac{2}{3}e^{-4t})u(t)$

7.25 (1) (a), (f)

(2) (b), (c), (e)

(3) 해당 사항 없음

(4) (b), (c), (d), (e)

(5) (a), (b), (c), (e)

(6) (a), (d)

(7) (b), (c), (d)

(8) (d)($\tau = 0.5$), (e)($\tau = T$), (f)($\tau = 0.5T$)

7.26 $a = 2$

7.27 $\dfrac{T_1}{T} = 3$

7.28 (a) $H(\omega) = \dfrac{j\omega}{j\omega + 50}$, 고역통과 필터

(b) $h(t) = -50e^{-50t}u(t)$

(c) $Y(\omega) = \dfrac{j\omega}{j\omega + 50}\dfrac{1}{j\omega + 5}$

(d) $y(t) = -\dfrac{1}{9}e^{-5t}u(t) + \dfrac{10}{9}e^{-50t}u(t)$

Chapter 08 연습문제 답안

8.1 ㉰

8.2 ㉮

8.3 ㉱

8.4 ㉱

8.5 ㉯

8.6 ㉰

8.7 ㉰

8.8 ㉰

8.9 ㉰

8.10 ㉰ ㉱ ㉲

8.11 ㉯

8.12 (a) $Re(s) > -a$

(b) $Re(s) > -a$

(c) $Re(s) > 0$ ($\because$ $Re(\pm j\omega_0) = 0$)

(d) $(Re(s) > 2) \cap (Re(s) > -1) = (Re(s) > 2)$

(e) $Re(s) > 0$

(f) $(Re(s) > 0) \cap (Re(s) > -1) = (Re(s) > 0)$

8.13 (a) (i) $x(t) = tu(t) - (t-1)u(t-1) - u(t-1)$

(ii), (iii) $X(s) = \dfrac{1}{s^2}(1 - e^{-s}) - \dfrac{1}{s}e^{-s}$

(b) (i) $x(t) = \sin t(u(t) - u(t-\pi)) = \sin t\, u(t) + \sin(t-\pi)u(t-\pi)$

(ii), (iii) $X(s) = \dfrac{1}{s^2+1}(1 + e^{-\pi s})$

(c) (i) $x(t) = tu(t) - (t-1)u(t-1) - u(t-1) + e^{-1}e^{-(t-1)}u(t-1)$

(ii), (iii) $X(s) = \frac{1}{s^2}(1-e^{-s}) - \frac{1}{s}e^{-s} + \frac{1}{s+1}e^{-(s+1)}$

(d) (i) $x(t) = \frac{2}{5}tu(t) - \frac{2}{5}(t-5)u(t-5) - 3u(t-5) + u(t-10)$

(ii), (iii) $X(s) = \frac{2}{5}\frac{1}{s^2}(1-e^{-5s}) + \frac{1}{s}(e^{-10s} - 3e^{-5s})$

8.14 (a) $X(s) = 3\frac{1-s}{s^2}e^{-2s}$

(b) $X(s) = \frac{3}{s^2}(e^{-s} - e^{-3s}) + \frac{3}{s}(e^{-s} - 3e^{-3s})$

(c) $X(s) = \frac{1}{s+1}e^{-\tau s}$

(d) $X(s) = \frac{e^{\tau}}{s+1}$

8.15 (a) $Y(s) = \frac{2(s^3+4s^2+12s+16)}{s^4+4s^3+8s^2+16s+32}$

(b) $Y(s) = \frac{s^6+4s^5+11s^4+16s^3+8s^2-2}{(s^4+2s^3+2s^2+2s+2)^2}$

(c) $Y(s) = \frac{s(s^3+2s^2+3s+2)}{s^4+2s^3+2s^2+2s+2}$

(d) $Y(s) = \frac{s^3+2s^2+3s+2}{s(s^4+2s^3+2s^2+2s+2)}$

8.16 (a) $x(t) = \hat{x}(t) + \hat{x}(t-T) + \hat{x}(t-2T) + \cdots + \hat{x}(t-nT) + \cdots$

$X(s) = \hat{X}(s) + \hat{X}(s)e^{-Ts} + \hat{X}(s)e^{-2Ts} + \cdots + \hat{X}(s)e^{-nTs} + \cdots$

$\therefore X(s) = \frac{1}{1-e^{-Ts}}\hat{X}(s)$

(b) (i) $X(s) = \frac{3}{s(1-e^{-4s})}(e^{-s} + e^{-3s} - e^{-4s} - 1)$

(ii) $X(s) = \frac{1}{s^2(1+e^{-s})} - \frac{e^{-s}}{s(1-e^{-2s})}$

8.17 (a) $x(t)=(-\frac{3}{2}e^{-2t}+\frac{7}{2}e^{-4t})u(t)$

(b) $x(t)=(\frac{5}{2}t-\frac{5}{4}+\frac{5}{4}e^{-2t})u(t)$

(c) $x(t)=(16e^{-2t}-3t^2e^{-t}+18te^{-t}-16e^{-t})u(t)$

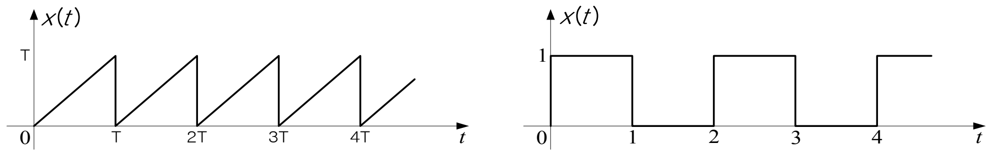
(d) $x(t)=e^{-t}(2\sqrt{5}\,cos(t+1.35\pi)-1)$

8.18 (a) $x(t)=x'(t-2)=(e^{-2(t-2)}+e^{-3(t-2)})u(t-2)$

(b) $x(t)=\frac{1}{2}e^{(t-1)}(\sin 2(t-1))u(t-1)+\frac{3}{2}e^{t}(\sin 2t)u(t)$

8.19 (a) $x'(t)=t[u(t)-u(t-T)]$, $x(t)$는 $x'(t)$를 주기 T로 반복한 주기 신호

(b) $x'(t)=\begin{cases}1, & 0<t<1\\ 0, & 1<t<2\end{cases}$, $x(t)$는 $x'(t)$를 주기 $T=2$로 반복한 주기 신호



(a) (b)

8.20 (a) $y(t)=tu(t)$

(b) $y(t)=u(t)+u(t-4)$

(c) $y(t)=u(t)-e^{-t}u(t)$

(d) $y(t)=(e^{-t}-e^{-2t})u(t)$

8.21 (a) $x(0)=\lim_{s\to\infty} sX(s)=\lim_{s\to\infty}\frac{s^2}{(s+1)(s+2)}=1$

$x(\infty)=\lim_{s\to 0} sX(s)=\lim_{s\to 0}\frac{s^2}{(s+1)(s+2)}=0$

$x(t)=(-e^{-t}+2e^{-2t})u(t)$

(b) $x(0)=\lim_{s\to\infty} sX(s)=\lim_{s\to\infty}\frac{s(s+4)}{s(s+2)}=1$

$x(\infty)=\lim_{s\to 0} sX(s)=\lim_{s\to 0}\frac{s(s+4)}{s(s+2)}=2$

$x(t)=(2-e^{-2t})u(t)$

(c) $x(0)=\lim_{s\to\infty} sX(s)=\lim_{s\to\infty}\dfrac{s(s+2)}{s(s+1)^2}=0$

$x(\infty)=\lim_{s\to 0} sX(s)=\lim_{s\to 0}\dfrac{s(s+2)}{s(s+1)^2}=2$

$x(t)=(2-2e^{-t}-te^{-t})u(t)$

(d) $x(0)=\lim_{s\to\infty} sX(s)=\lim_{s\to\infty}\dfrac{s(s^2+2s)}{s^2(s^2+2s+2)}=0$

$x(\infty)=\lim_{s\to 0} sX(s)=\lim_{s\to 0}\dfrac{s(s^2+2s)}{s^2(s^2+2s+2)}=1$

$x(t)=(1-e^{-t}\cos t)u(t)$

8.22 (a) i) $y(t)=\underbrace{(e^{-t}+e^{-2t})u(t)}_{\text{[영입력 응답]}}+\underbrace{(e^{-t}-e^{-2t})u(t)}_{\text{[영상태 응답]}}$

ii) $y(t)=\underbrace{2e^{-t}u(t)}_{\text{[고유 응답]}}$

(b) i) $y(t)=\underbrace{(2+5t)e^{-2t}u(t)}_{\text{[영입력 응답]}}+\underbrace{te^{-2t}u(t)}_{\text{[영상태 응답]}}$

ii) $y(t)=\underbrace{(2+6t)e^{-2t}u(t)}_{\text{[고유 응답]}}$

(c) i) $y(t)=(\cos 4t+\sin 4t)e^{-3t}u(t)+(2-(2\cos 4t-\dfrac{19}{4}sin4t)e^{-3t})u(t)$

$\underbrace{\sqrt{2}e^{-3t}\cos(4t-\dfrac{\pi}{4})u(t)}_{\text{[영입력 응답]}}+\underbrace{(2-\dfrac{5\sqrt{17}}{4}e^{-3t}\cos(4t+\phi))u(t)}_{\text{[영상태 응답]}}$

$\phi=\tan^{-1}\dfrac{19}{8}$

ii) $y(t)=-(\cos 4t-\dfrac{23}{4}sin4t)e^{-3t}u(t)+2u(t)$

$\underbrace{-\dfrac{\sqrt{545}}{4}e^{-3t}\cos(4t+\theta)u(t)}_{\text{[고유 응답]}}+\underbrace{2u(t)}_{\text{[강제 응답]}}$

$\theta=\tan^{-1}\dfrac{23}{4}$

8.23 (a) $H(s)=\dfrac{2}{(s+1)(s+4)}$

$h(t)=(\frac{2}{3}e^{-t}-\frac{2}{3}e^{-4t})u(t)$

$y(t)=(\frac{1}{2}-\frac{2}{3}e^{-t}+\frac{1}{6}e^{-4t})u(t)$

(b) $H(s)=\dfrac{2s+6}{s^2+5s+4}=\dfrac{2(s+3)}{(s+1)(s+4)}$

$h(t)=(\frac{4}{3}e^{-t}+\frac{2}{3}e^{-4t})u(t)$

$y(t)=(\frac{3}{2}-\frac{4}{3}e^{-t}-\frac{1}{6}e^{-4t})u(t)$

(c) $H(s)=\dfrac{2(s-3)}{(s+1)(s^2-2s+2)}$

$h(t)=(-\frac{8}{5}e^{-t}+2e^{t}\cos(t+\phi))u(t),\ \phi=\tan^{-1}\frac{3}{4}$

$y(t)=(-3+\frac{8}{5}e^{-t}+\sqrt{2}\,e^{-t}\cos(t-\theta))u(t),\ \theta=\tan^{-1}\frac{1}{7}$

8.24 (a) $H(s)=-\dfrac{2s+1}{s+1}$

$h(t)=-2\delta(t)+e^{-t}u(t)$

(b) $H(s)=\dfrac{s^2+4s+5}{(s+1)(s+2)}$

$h(t)=\delta(t)+2e^{-t}u(t)-e^{-2t}u(t)$

(c) $H(s)=\dfrac{-s^2+s+3}{s(s+3)}$

$h(t)=-\delta(t)+(1+3e^{-3t})u(t)$

8.25 RL 회로

(a) $L\dfrac{di(t)}{dt}+Ri(t)=v(t)$

(b) $h(t)=\dfrac{1}{L}e^{-\frac{R}{L}t}u(t)$

(c) $H(\omega)=\dfrac{1}{R+j\omega L}$

(d) $H(s)=\dfrac{I(s)}{V(s)}=\dfrac{1}{Ls+R}$

RC 회로

(a) $R\frac{di(t)}{dt}+\frac{1}{C}i(t)=\frac{dv(t)}{dt}$

(b) $h(t)=\frac{1}{R}\delta(t)-\frac{1}{R^2C}e^{-\frac{1}{RC}t}u(t)$

(c) $H(\omega)=H(s)|_{s=j\omega}=\frac{Cs}{RCs+1}\bigg|_{s=j\omega}=\frac{j\omega C}{1+j\omega RC}$

(d) $H(s)=\frac{I(s)}{V(s)}=\frac{s}{Rs+\frac{1}{C}}=\frac{Cs}{RCs+1}$

RLC 회로

(a) $L\frac{d^2i(t)}{dt^2}+R\frac{di(t)}{dt}+\frac{1}{C}i(t)=\frac{dv(t)}{dt}$

(b) $h(t)=\frac{r}{L}e^{\alpha t}\cos(\beta t+\phi)u(t)$

(c) $H(\omega)=\frac{j\omega C}{1-\omega^2LC+j\omega RC}$

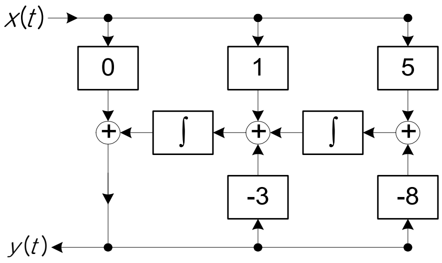
(d) $H(s)=\frac{Cs}{LCs^2+RCs+1}$

8.26 (a) $\frac{d^2y(t)}{dt^2}+3\frac{dy(t)}{dt}+8y(t)=\frac{dx(t)}{dt}+5x(t)$

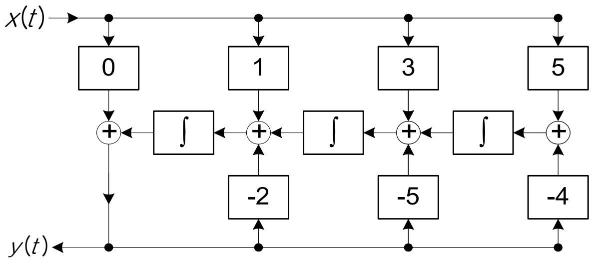
(b) $\frac{d^3y(t)}{dt^3}+2\frac{d^2y(t)}{dt^2}+5\frac{dy(t)}{dt}+4y(t)=\frac{d^2x(t)}{dt^2}+3\frac{dx(t)}{dt}+5x(t)$

(c) $\frac{d^2y(t)}{dt^2}-2\frac{dy(t)}{dt}+5y(t)=5\frac{d^2x(t)}{dt^2}+7\frac{dx(t)}{dt}+2x(t)$

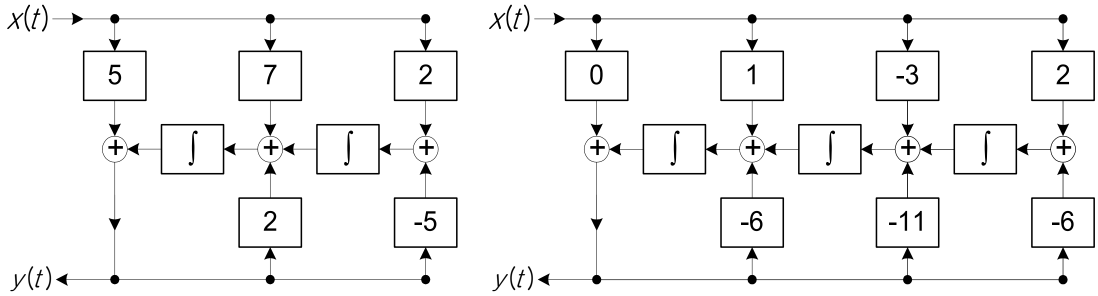
(d) $\frac{d^3y(t)}{dt^3}+6\frac{d^2y(t)}{dt^2}+11\frac{dy(t)}{dt}+6y(t)=\frac{d^2x(t)}{dt^2}-3\frac{dx(t)}{dt}+2x(t)$



(a)



(b)



(c) (d)

8.27 [연습문제 8.26]의 시스템의 안정도를 판별하라. <- 책의 문제가 잘못되었음

(a) 안정 (b) 안정

(c) 불안정 (d) 안정

8.28 (a) $H(s)=\dfrac{1}{(s+1)(s+2)}$

극 : $s=-1,\ -2$

(b) $H(s)=\dfrac{1}{(s-1)(s+2)}$

극 : $s=1,\ -2$

(c) $H(s)=\dfrac{2}{s^2+2s+2}$

극 : $s=-1\pm j1$

(d) $H(s)=\dfrac{1}{(s+1)(s+2)}$

극 : $s=-1,\ -2$

(e) $H(s)=\dfrac{s}{s^2+4}$

극 : $s=\pm j2$, 영점 : $s=0$

(f) $H(s)=\dfrac{1}{(s+1)(s+2)}$

극 : $s=-1,\ -2$

(g) $H(s)=\dfrac{s(s+3)}{(s+1)(s+2)}$

극 : $s=-1,\ -2$, 영점 : $s=0,\ -3$

8.29 회로방정식 : $\begin{cases} v_i(t)=9i_1(t)+18\displaystyle\int(i_1(t)-i_2(t))dt \\ 18\displaystyle\int(i_1(t)-i_2(t))dt=2\dfrac{di_2(t)}{dt}+4i_2(t)\end{cases}$, $y(t)=2$

Chapter 09 연습문제 답안

9.1 ㉰

9.2 ㉮

9.3 ㉰

9.4 ㉱

9.5 ㉯

9.6 ㉯, ㉱, ㉲

9.7 ㉱

9.8 ㉯

9.9 ㉯

9.10 ㉱

9.11 (a) $N = 10$개

(b) $f_0 = f + l f_s = 10 + 100\,l = 110,\ 210,\ 310,\ \cdots$

$\omega_0 = 2\pi f_0 = 220\pi,\ 420\pi,\ 620\pi,\ \cdots$

(c) $N = 10$

(d) $f_s = 40$

9.12 (a) $T_s = 0.01$

(b) $T_s' = T_s + 0.1k = 0.01 + 0.1k, \quad k = 1,\ 2,\ 3,\ \cdots$

9.13 (a) $x_0(t) = \cos(10\pi t)$
$x_1(t) = \cos(10\pi t + 20\pi t) = \cos(30\pi t)$

(b) $x_0(t) = \cos(\frac{5\pi}{4}t)$

$x_1(t) = \cos(\frac{5\pi}{4}t + 20\pi t) = \cos(\frac{85\pi}{4}t)$

9.14 $x[n] = 2\cos(0.2\pi n - \pi/4)$

$$\begin{cases} x_1(t) = 2\cos(20\pi t - \pi/4) \\ x_2(t) = 2\cos(220\pi t - \pi/4) \\ x_3(t) = 2\cos(-180\pi t - \pi/4) = 2\cos(180\pi t + \pi/4) \\ x_4(t) = 2\cos(-380\pi t - \pi/4) = 2\cos(380\pi t + \pi/4) \end{cases}$$

9.15 (a) $f_s = 2f_0 = 2 \times 200 = 400$ [samples/sec] 또는 $\omega_s = 2\pi f_s = 800\pi$
(b) $f_s = 2f_1 = 450$ [Hz] 또는 $\omega_s = 2\pi f_s = 900\pi$
(c) $f_s = 2f_3 = 400$ [Hz] 또는 $\omega_s = 2\pi f_s = 800\pi$
(d) $f_s = 2f_1 = 20$ [samples/sec] 또는 $\omega_s = 2\pi f_s = 40\pi$

9.16 (a) $\hat{f}_0 = 0.5, \quad \phi = -\frac{\pi}{2}$

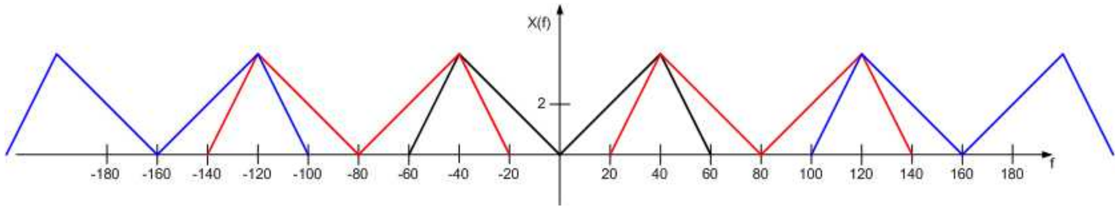
(b) $\hat{f}_0 = 0.75, \quad \phi = -\frac{\pi}{2}$

(c) $\hat{f}_0 = 0.5, \quad \phi = -\frac{\pi}{2}$

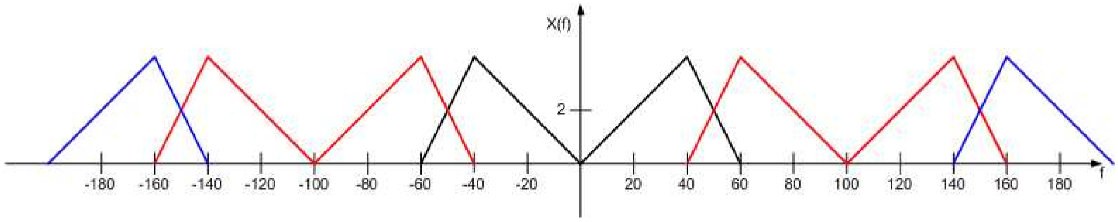
(d) $\hat{f}_0 = 0.375, \quad \phi = -\frac{\pi}{2}$

9.17 (a) $f_s' = 2f_b' = 2(2f_b) = 2f_s$
(b) $f_s' = 2f_b' = 2(f_b) = f_s$
(c) $f_s' = 2f_b' = 2(2f_b) = 2f_s$
(d) $f_s' = 2f_b' = 2(f_b + f_0) = f_s + 2f_0$

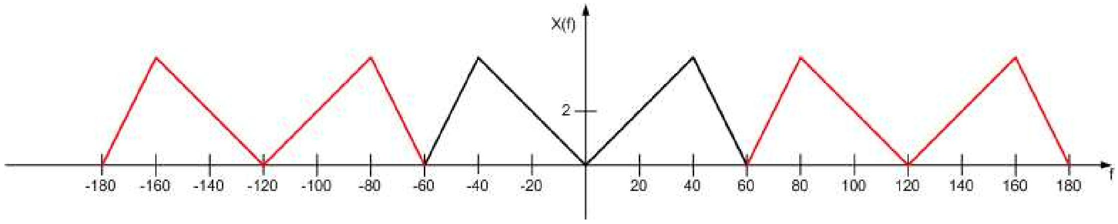
9.18



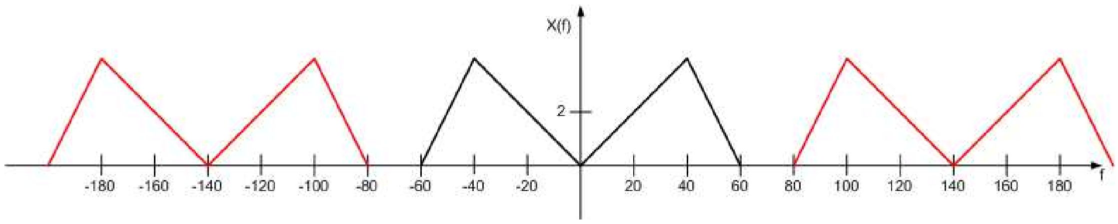
샘플링율 80Hz



샘플링율 100Hz



샘플링율 120Hz



샘플링율 140Hz

이상적인 저역통과 필터를 이용하여 신호를 복원하기 위해서는 스펙트럼의 중첩이 일어나지 않는 120 또는 140[Hz]의 샘플링율을 갖도록 해야 한다.

9.19 (a) $x_r(t) = \sin(2\pi t)$

(b) $x_r(t) = \sin(2\pi t)$

(c) $x_r(t) = \sin(2\pi t)$

(d) $x_r(t) = \sin(2\pi t) + \sin(6\pi t) + \sin(10\pi t)$

9.20 (a) 6개 : $f_A = 5$㎑, $f_B = 15$㎑, $f_C = 25$㎑, $f_D = 30$㎑, $f_E = 45$㎑, $f_F = 62.5$㎑

가청 가능 성분 : $x_{au}(t) = 2A\cos(10\pi t) + 2B\cos(30\pi t)$

(b) (i) $y(t) = x(t)$

$y_r(t) = 2(A+E)\cos(10\pi t) + 2(B+C)\cos(30\pi t) + 2D\cos(20\pi t) + 2F\cos(35\pi t)$

(ii) $y(t) = x_{au}(t)$

$y_r(t) = x_{au}(t) = 2A\cos(10\pi t) + 2B\cos(30\pi t)$

Chapter 10 연습문제 답안

10.1 ㉯

10.2 ㉱

10.3 ㉰

10.4 ㉮

10.5 ㉮

10.6 ㉱

10.7 ㉰

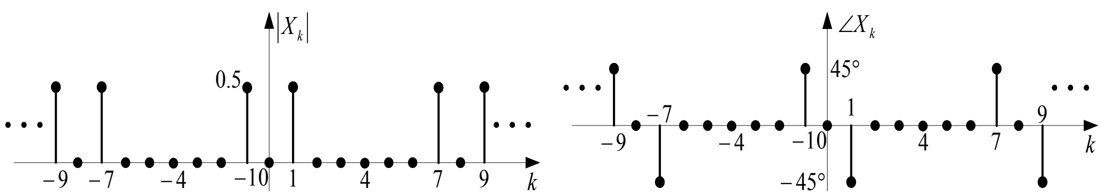
10.8 ㉮ ※ 문제 ㉱번에 오타 $\dfrac{0.5e^{-j2\Omega}}{(1-0.5e^{-j\Omega})^2}$ 가 되어야 맞음

10.9 ㉱

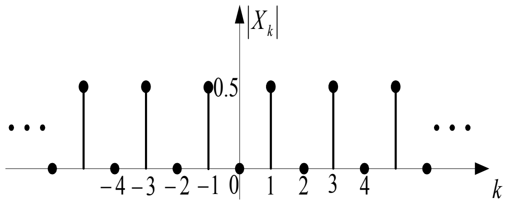
10.10 (a) $X_1 = \dfrac{1}{2}e^{-j\frac{\pi}{4}} = \dfrac{\sqrt{2}}{4} - j\dfrac{\sqrt{2}}{4}$

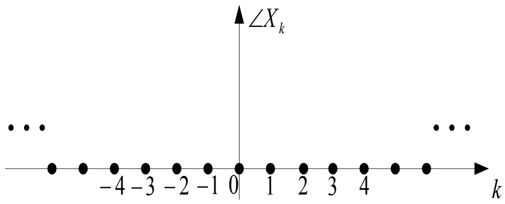
$$X_7 = \frac{1}{2}e^{j\frac{\pi}{4}} = \frac{\sqrt{2}}{4} + j\frac{\sqrt{2}}{4}$$

$$X_k = 0, \quad k = 0,\ 2,\ 3,\ 4,\ 5,\ 6$$



(b) $X_0 = 0$, $X_1 = \dfrac{1}{2}$, $X_2 = 0$, $X_3 = \dfrac{1}{2}$





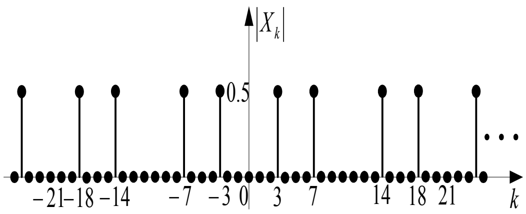
(c) $X_3 = \dfrac{1}{2} e^{-j\frac{\pi}{2}}$

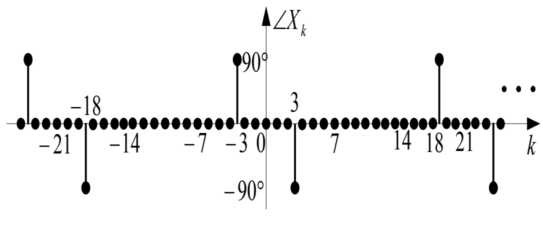
$X_7 = \dfrac{1}{2}$

$X_{14} = \dfrac{1}{2}$

$X_{18} = \dfrac{1}{2} e^{j\frac{\pi}{2}}$

$X_k = 0, \quad k = 0, 1, \cdots, 20, \quad k \neq 3, 7, 14, 18$





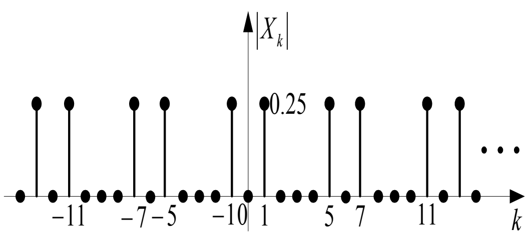
(d) $X_1 = \dfrac{1}{4} e^{-j\frac{\pi}{2}}$

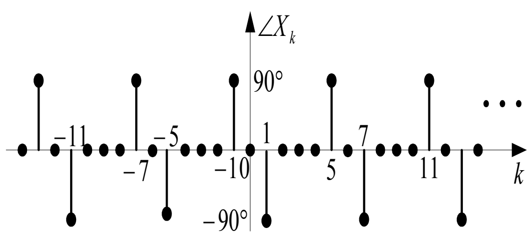
$X_5 = \dfrac{1}{4} e^{j\frac{\pi}{2}}$

$X_7 = \dfrac{1}{4} e^{-j\frac{\pi}{2}}$

$X_{11} = \dfrac{1}{4} e^{j\frac{\pi}{2}}$

$X_k = 0, \quad k = 0, 1, \cdots, 11, \quad k \neq 1, 5, 7, 11$





10.11 ㉰

10.12 (a) $x[n]=2+2\cos(\frac{3\pi}{4}n)$

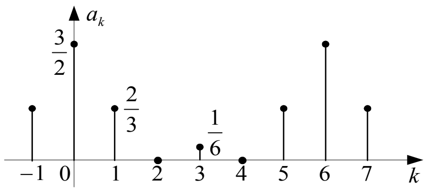
(b) $x[n]=[\cdots\ \check{0},\ 4,\ 0,\ j4,\ 0,\ -j4,\ 0,\ 4,\ 0,\ 4,\ 0,\ j4,\ 0,\ -j4,\ 0,\ 4,\ 0,\ \cdots]$

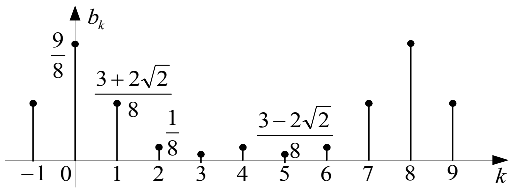
(c) $x[n]=[\cdots\ \check{0},\ 0,\ 0,\ 0,\ 8,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 8,\ 0,\ 0,\ 0,\ 0,\ \cdots]$

(d) $x[n]=[\cdots\ \check{6},\ 0,\ 2,\ 0,\ -2,\ 0,\ 2,\ 0,\ 6,\ 0,\ 2,\ 0,\ -2,\ 0,\ 2,\ 0,\ 6,\ \cdots]$

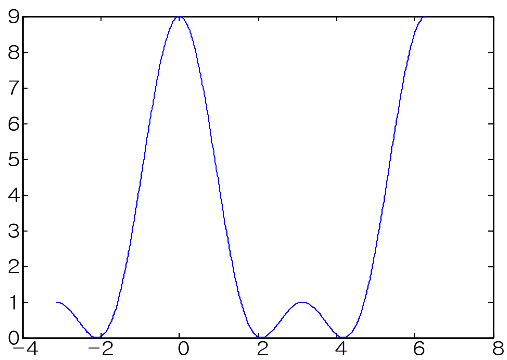
10.13 (a) $a_k=\frac{1}{N}\sum_{<N>}x_1[n]e^{-j2\pi nk/N}=\frac{1}{6}\sum_{n=-2}^{3}x_1[n]e^{-j\pi nk/3}$

(b) $b_k=\frac{1}{N}\sum_{<N>}x[n]e^{-j2\pi nk/N}=\frac{1}{8}\sum_{n=-2}^{5}x_2[n]e^{-j\pi nk/4}$





(c) $X_3(\Omega)=3+4\cos(\Omega)+2\cos(2\Omega)$



(d) $\begin{cases} c_1=\frac{1}{6}, & \Omega_1=\frac{\pi}{3} \\ c_2=\frac{1}{8}, & \Omega_2=\frac{\pi}{4} \end{cases}$

(e) $X_4(\Omega)=3+e^{-j3\Omega}[4\cos(2\Omega)+2\cos(\Omega)]$

$c_1=\frac{1}{6},\quad \Omega_1=\frac{\pi}{3}$

10.14 (a) $X_k{}' = e^{-j\frac{2\pi}{N}n_0 k} X_k$

(b) $X'_k = (1 - e^{-j\frac{2\pi}{N}k})X_k$

(c) $X'_k = (1 - e^{-j\pi k})X_k = (1 - (-1)^k)X_k$

(d) $X'_k = (1 + e^{j\pi k})X_k = (1 + (-1)^k)X_k$

(e) $X'_k = X_{-k}$

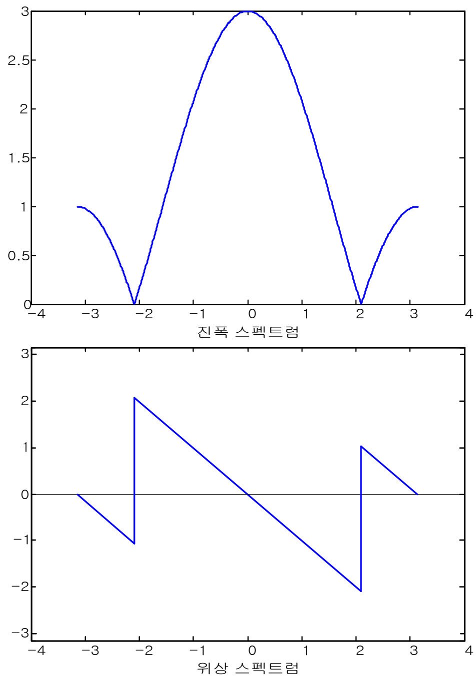
(f) $X'_k = X_{k - \frac{N}{2}}$

10.15 (a) $X(\Omega) = e^{-j\Omega}(1 + 2\cos(\Omega))$

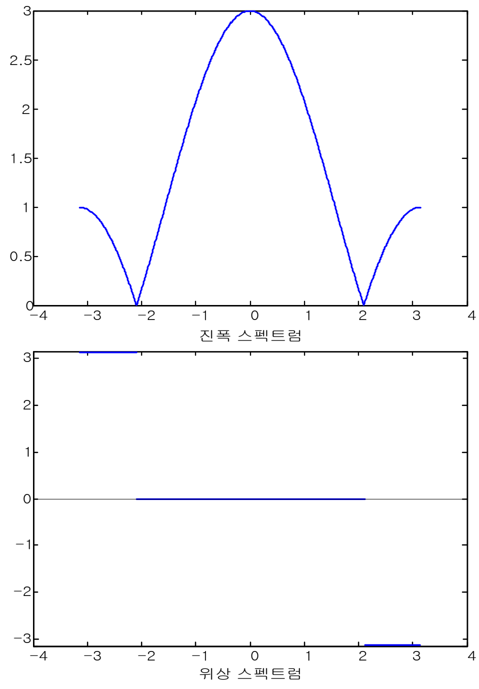
(b) $X(\Omega) = (1 + 2\cos(\Omega))$

(c) $X(\Omega) = 2\cos(\Omega)$

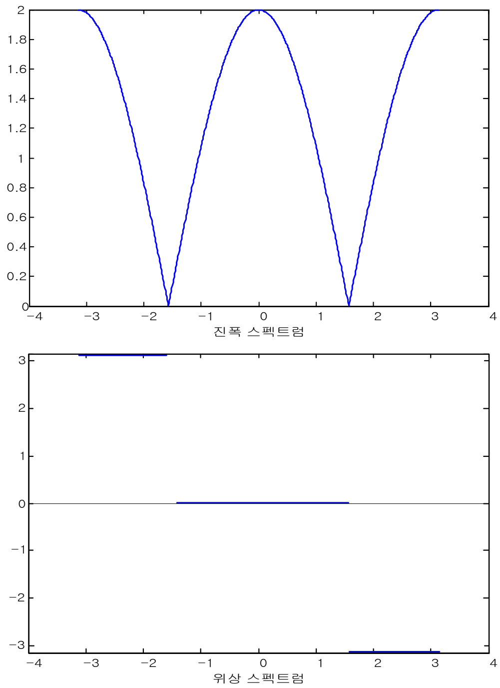
(d) $X(\Omega) = (-1 + 2\cos(\Omega))$



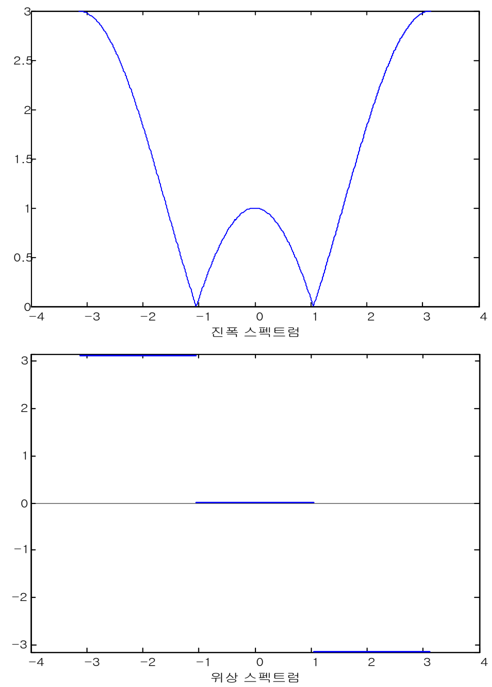
(a)



(b)



(c)



(d)

10.16 (a) $X(\Omega) = 4e^{-j\frac{3}{2}\Omega}\cos(\frac{1}{2}\Omega)\cos(\Omega)$

(b) $X(\Omega) = 3 + 4\cos(\Omega) + 2\cos(2\Omega)$

(c) $X(\Omega) = e^{-j3\Omega}(3 + 4\cos(\Omega) + 2\cos(2\Omega))$

(d) $X(\Omega) = -j\,[6\sin(\Omega) + 12\sin(2\Omega) + 18\sin(3\Omega)]$

10.17 (a) $X(\Omega) = \sum_{k=-\infty}^{\infty} 2\pi X_k \delta(\Omega - \frac{\pi}{5}k)$

(b) $X(\Omega) = \sum_{k=-\infty}^{\infty} \pi e^{-j\frac{3\pi}{8}k}(\cos\frac{\pi}{8}k)(\cos\frac{\pi}{4}k)\,\delta(\Omega - \frac{\pi}{4}k)$

(c) $X(\Omega) = \sum_{k=-\infty}^{\infty} \pi\,\delta(\Omega - k\pi)$

(d) $X(\Omega) = \sum_{k=-\infty}^{\infty} \frac{\pi}{2}(1 + e^{-j\frac{\pi}{2}k})\,\delta(\Omega - \frac{\pi}{2}k)$

(e) $X(\Omega) = \sum_{k=-\infty}^{\infty} 2\pi X_k \delta(\Omega - \frac{\pi}{3}k)$

(f) $X(\Omega) = \sum_{k=-\infty}^{\infty} 2\pi X_k \delta(\Omega - \frac{\pi}{4}k)$

10.18 (a) $X(\Omega) = \dfrac{1}{1-0.5\,e^{-j\Omega}}$

(b) $Y(\Omega) = \dfrac{0.5\,e^{-j\Omega}}{(1-0.5\,e^{-j\Omega})^2}$

(c) $Y(\Omega) = X(-\Omega) = \dfrac{1}{1-0.5\,e^{j\Omega}}$

(d) $Y(\Omega) = \dfrac{\frac{15}{16}}{(1+(0.5\,e^{-j\Omega})^2)(1+(0.5\,e^{j\Omega})^2)}$

(e) $X(\Omega) = \dfrac{\sin\left(\frac{7\Omega}{2}\right)}{\sin\left(\frac{\Omega}{2}\right)}$

(f) $X(\Omega) = -j2\sum_{k=1}^{N} k\sin(k\Omega)$

10.19 (a) $Y(\Omega) = X(-\Omega) = \dfrac{1}{1-0.5e^{-j\Omega}}$

(b) $Y(\Omega) = e^{-j\Omega}X(\Omega) = \dfrac{e^{-j\Omega}}{1-0.5\,e^{j\Omega}}$

(c) $Y(\Omega) = j\dfrac{dX(\Omega)}{d\Omega} = j\dfrac{j0.5e^{j\Omega}}{(1-0.5e^{j\Omega})^2} = -\dfrac{0.5e^{j\Omega}}{(1-0.5e^{j\Omega})^2}$

(d) $Y(\Omega) = X(\Omega)\,X(\Omega) = \dfrac{1}{(1-0.5e^{j\Omega})^2}$

(e) $Y(\Omega) = e^{j\Omega}X(\Omega) + e^{-j\Omega}X(\Omega) = \dfrac{e^{j\Omega}+e^{-j\Omega}}{1-0.5\,e^{j\Omega}} = \dfrac{2\cos(\Omega)}{1-0.5\,e^{j\Omega}}$

(f) $Y(\Omega) = \dfrac{1}{2\pi}X(\Omega) * W(\Omega) = \dfrac{1}{2}\left(\dfrac{1}{1-0.5e^{j(\Omega+\pi)}} + \dfrac{1}{2}\,\dfrac{1}{1-0.5e^{j(\Omega-\pi)}}\right)$

10.20 (a) $x[n] = \dfrac{1}{2\pi}\int_{-\pi}^{\pi} X(\Omega)e^{j\Omega n}\,d\Omega = \text{sinc}\ (\pi n) - \dfrac{3}{4}\text{sinc}\ \left(\dfrac{3\pi}{4}n\right)$

(b) $x[n] = \dfrac{1}{2\pi}\int_{-\pi}^{\pi} X(\Omega)e^{j\Omega n}\,d\Omega = \dfrac{2}{3}\text{sinc}\ \left(\dfrac{2\pi}{3}(n+2)\right) - \dfrac{1}{3}\text{sinc}\ \left(\dfrac{\pi}{3}(n+2)\right)$

(c) $x[n] = \delta[n] - 2\delta[n-3] + 4\delta[n+2] + 3\delta[n-6]$

(d) $x[n] = \dfrac{1}{2\pi}\sum_{k=-2}^{2}(-1)^k e^{j\frac{k\pi}{2}n} = \dfrac{1}{\pi}\left(1-2\cos\left(\dfrac{\pi}{2}n\right) + 2\cos(\pi n)\right)$

10.21 $X(\Omega)=\dfrac{1}{1-ae^{-j\Omega}}\dfrac{ae^{-j\Omega}}{1-ae^{-j\Omega}}=\dfrac{ae^{-j\Omega}}{(1-ae^{-j\Omega})^2}$

10.22 (a) $H(\Omega)=\dfrac{1-0.5e^{-j\Omega}}{1+0.8e^{-j\Omega}}$

(b) $H(\Omega)=\dfrac{e^{-j\Omega}}{1+0.64e^{-j2\Omega}}$

(c) $H(\Omega)=\dfrac{Y(\Omega)}{X(\Omega)}=\dfrac{2e^{-j\Omega}-e^{-j2\Omega}}{1-0.3e^{-j\Omega}-0.4e^{-j2\Omega}}$

(d) $H(\Omega)=\dfrac{Y(\Omega)}{X(\Omega)}=\dfrac{1-2e^{-j\Omega}-3e^{-j2\Omega}}{1-3e^{-j\Omega}-4e^{-j2\Omega}-6e^{-j3\Omega}}$

10.23 (a) $Y_k=\begin{cases}\dfrac{2-\sqrt{2}}{2}+j\dfrac{1}{2}, & k=-3(k=5)\\ \dfrac{2-\sqrt{2}}{2}-j\dfrac{1}{2}, & k=3\\ 0, & \text{그 외}\end{cases}$

(b) $Y_k=\begin{cases}Y_0=\dfrac{1}{4}\\ Y_1=\dfrac{1}{4}(1-j2)\\ Y_2=\dfrac{1}{4}\\ Y_3=\dfrac{1}{4}(1+j2)\end{cases}$

(c) $Y_k=\begin{cases}Y_0=\dfrac{1}{2}\\ Y_1=\dfrac{1}{3}(1-j\sqrt{3})\\ Y_2=0\\ Y_3=-\dfrac{1}{6}\\ Y_4=0\\ Y_5=\dfrac{1}{3}(1+j\sqrt{3})\end{cases}$

10.24 (a) $H(\Omega)=\dfrac{1}{1+0.5e^{-j\Omega}}$

(b) $h[n]=(-0.5)^n u[n]$

(c) (i) $y[n]=((-0.5)^{n-1}+(0.5)^{n+1})u[n]$

(ii) $y[n]=(-0.5)^n u[n]+(-0.5)^n u[n-1]$

(d) (i) $y[n]=\frac{1}{9}(0.25)^n u[n]+\frac{2}{9}(-0.5)^n u[n]+\frac{2}{3}(n+1)(-0.5)^n u[n]$

(ii) $y[n]=(-0.5)^n u[n]+2(-0.5)^{n-3} u[n-3]$

10.25 (a) $H(\Omega)=\frac{1-2e^{-j\Omega}-e^{-j2\Omega}}{1+0.5e^{-j\Omega}}$

(b) $h[n]=\delta[n]-2.5\delta[n-1]+(-0.5)^n u[n-2]$

(c) $y[n]+0.5y[n-1]=x[n]-2x[n-1]-x[n-2]$

10.26 (a) $b=0.5$

(b) $\Omega=0.23\pi$

10.27 (a) $X(\omega)=\frac{1}{a+j\omega}$

(b) $X_s(\omega)=\frac{1}{T_s}\sum_{k=-\infty}^{\infty}\frac{1}{a+j(\omega-k\omega_s)}$

(c) $X(\Omega)=\frac{1}{1-ae^{-j\Omega}}$

(d) 연속 신호의 푸리에 변환과 이산 신호의 푸리에 변환은 [그림 6-20]에 나타낸 것과 같은 관계를 갖는다.

(e) $\Omega=\frac{2\pi}{\omega_s}\omega=T_s\omega$

Chapter 11 연습문제 답안

11.1 ㉰

11.2 ㉱

11.3 ㉰, ㉱, ㉲, ㉳

11.4 ㉮

11.5 ㉯

11.6 ㉱

11.7 ㉯

11.8 ㉰

11.9 ㉯

11.10 ㉯

11.11 (a) $X[k] = \sum_{n=0}^{N-1} \delta[n] W_N^{kn} = 1, \quad k = 0, 1, \cdots, N-1$

(b) $X[k] = \sum_{n=0}^{N-1} \delta[n-n_0] W_N^{kn} = W_N^{n_0 k}, \quad k = 0, 1, \cdots, N-1$

(c) $X[k] = \sum_{n=0}^{N-1} a^n W_N^{kn} = \dfrac{1-a^N}{1-a W_N^k}, \quad k = 0, 1, \cdots, N-1$

(d) $X[k] = \begin{cases} \dfrac{9}{2}N, & k=0 \\ \dfrac{1}{4}N, & k=2,\ N-2(-2) \\ 0, & \text{그 외} \end{cases}$

11.12 (a) $X[k] = \sum_{n=0}^{3} x[n]\, W_4^{kn}$

$$X[0] = (1)(1) + (1)(1) + (1)(1) + (1)(1) = 4$$
$$X[1] = (1)(1) + (1)(-j) + (1)(-1) + (1)(j) = 0$$
$$X[2] = (1)(1) + (1)(-1) + (1)(1) + (1)(-1) = 0$$
$$X[3] = X^*[1] = 0$$

(b) $X[k] = \sum_{n=0}^{3} x[n]\, W_4^{kn}$

$$X[0] = (1)(1) + (-1)(1) + (1)(1) + (-1)(1) = 0$$
$$X[1] = (1)(1) + (-1)(-j) + (1)(-1) + (-1)(j) = 0$$
$$X[2] = (1)(1) + (-1)(-1) + (1)(1) + (-1)(-1) = 4$$
$$X[3] = X^*[1] = 0$$

(c) $X[k] = \sum_{n=0}^{3} x[n]\, W_4^{kn}$

$$X[0] = (1)(1) + (2)(1) + (2)(1) + (1)(1) = 6$$
$$X[1] = (1)(1) + (2)(-j) + (2)(-1) + (1)(j) = -1 - j1$$
$$X[2] = (1)(1) + (2)(-1) + (2)(1) + (1)(-1) = 0$$
$$X[3] = X^*[1] = -1 + j1$$

(d) $X[k] = \sum_{n=0}^{3} x[n]\, W_4^{kn}$

$$X[0] = (1)(1) + (2)(1) + (1)(1) + (2)(1) = 6$$
$$X[1] = (1)(1) + (2)(-j) + (1)(-1) + (2)(j) = 0$$
$$X[2] = (1)(1) + (2)(-1) + (1)(1) + (2)(-1) = -2$$
$$X[3] = X^*[1] = 0$$

11.13 (a) $x_3[n]$이 실수값의 DFT를 만족한다.

(b) $x_2[n]$이 허수값의 DFT를 만족한다.

(c) $X[0] = \sum_{n=<N>} x[n]$

(d) $x_3[n]$만이 $k = 2, 4, 6$에 대해 $X[k] = 0$을 만족한다.

11.14 (a) $Y[k] = [1,\ -3,\ 2,\ -4]$

(b) $Y[k] = [3,\ 6 + j3,\ 2,\ 8 - j4]$

(c) $Y[k] = [1,\ 4,\ 2,\ 3]$

(d) $Y[k] = [1,\ 4,\ 2,\ 3]$

(e) $Y[k] = \left[\frac{29}{4},\ \frac{22}{4},\ \frac{29}{4},\ \frac{20}{4}\right]$

(f) $Y[K] = X[k]X[k] = [1,\ 9,\ 4,\ 16]$

11.15 (a) $X[k]=[0,\ -j,\ (2+j),\ -2,\ 2-j,\ (j)]$

$$x[0]=\frac{1}{3}$$

(b) $X[k]=[4,\ 2,\ (-1),\ 2+j,\ (0),\ 0,\ (2-j),\ -1,\ (2)]$

$$x[0]=\frac{10}{9}$$

11.16 (a) $x[n]=\frac{1}{N}\sum_{k=<N>}X[k]\,W_N^{-kn}$

$$x[0]=\frac{1}{4}[(1)+(j)+(0)+(-j)]=\frac{1}{4}$$
$$x[1]=\frac{1}{4}[(1)+(j)(j)+(0)(-1)+(-j)(-j)]=-\frac{1}{4}$$
$$x[2]=\frac{1}{4}[(1)+(j)(-1)+(0)(1)+(-j)(-1)]=\frac{1}{4}$$
$$x[3]=\frac{1}{4}[(1)+(j)(-j)+(0)(-1)+(-j)(j)]=\frac{3}{4}$$

(b) $x[n]=\frac{1}{N}\sum_{k=<N>}X[k]\,W_N^{-kn}$

$$x[0]=\frac{1}{4}[(1)+(1)+(1)+(1)]=1$$
$$x[1]=\frac{1}{4}[(1)+(1)(j)+(1)(-1)+(1)(-j)]=0$$
$$x[2]=\frac{1}{4}[(1)+(1)(-1)+(1)(1)+(1)(-1)]=0$$
$$x[3]=\frac{1}{4}[(1)+(1)(-j)+(1)(-1)+(1)(j)]=0$$

(c) $x[n]=\frac{1}{N}\sum_{k=<N>}X[k]\,W_N^{-kn}$

$$x[0]=\frac{1}{4}[(1)+(-1)+(1)+(-1)]=0$$
$$x[1]=\frac{1}{4}[(1)+(-1)(j)+(1)(-1)+(-1)(-j)]=0$$
$$x[2]=\frac{1}{4}[(1)+(-1)(-1)+(1)(1)+(-1)(-1)]=1$$
$$x[3]=\frac{1}{4}[(1)+(-1)(-j)+(1)(-1)+(-1)(j)]=0$$

(d) $x[n]=\frac{1}{N}\sum_{k=<N>}X[k]\,W_N^{-kn}$

$$x[0]=\frac{1}{4}[(2)+(0)+(-2)+(0)]=0$$
$$x[1]=\frac{1}{4}[(2)+(0)(j)+(-2)(-1)+(0)(-j)]=1$$
$$x[2]=\frac{1}{4}[(2)+(0)(-1)+(-2)(1)+(0)(-1)]=0$$
$$x[3]=\frac{1}{4}[(2)+(0)(-j)+(-2)(-1)+(0)(j)]=1$$

11.17 (a) $X[k]=[3,\ -1,\ 3,\ -1,\ 3,\ -1,\ 3,\ -1]$

(b) $y[n]=x[n-2]=\delta[n-2]+2\delta[n-6]$

11.18 (a) $Y[k]=[6,\ 0,\ -2,\ 0,\ 6,\ 0,\ -2,\ 0]$

(b) $Y[k]=[x[k],\ x[k]]=[3,\ -1,\ 3,\ -1,\ 3,\ -1,\ 3,\ -1]$

11.19 (a) 256[Hz]

(b) $f_{max}=256\,[\mathrm{Hz}]$

(c) $\triangle f=\dfrac{256}{256}=1Hz$

(d) $f_b=128\,[\mathrm{Hz}]$

11.20 (a) 20[㎑]

(b) $N=\dfrac{f_s}{\triangle f}=\dfrac{20\times10^3}{0.1}=2\times10^5$

(c) $N=2^{18}=262{,}144$

(d) $t_s\leqq N\times\dfrac{1}{f_s}=2^{18}\dfrac{1}{2\times10^4}=13.1072$

11.21 (a) $\triangle f=\dfrac{f_s}{N}=\dfrac{200}{200}=1\,[\mathrm{Hz}]$

(b) 400, 200개

(c) 512, 312개

(이미 (b)에서 200개의 영 채우기가 이루어져 있는 경우라면 112개 추가)

11.22 (a) $X[k]=[4,\ -1+j,2,\ -1-j]$

(b), (c) $y[n]=[\check{5},\ 4,\ 5,\ 2]$

11.23 (a) (i) $x[n]=[\check{2},\ 1],\ h[n]=[\check{1},\ 1,\ 2]$

	$n \backslash k$	0	1	-
$x[k]$		2	1	$y[n]$
$h[n-k]$	0	1	-	2
	1	1	1	3
	2	2	1	5
	3	-	2	2

(ii) $x_a[n]=[\check{2},\ 1,\ 0,\ 0],\ h_a[n]=[\check{1},\ 1,\ 2,\ 0]$

k	$X_a[k]$	$H_a[k]$	$Y[k]$
0	3	4	12
1	2+j	-1+j	-3+j
2	1	2	2
3	2-j	-1-j	-3-j

$y[n]=[2,\ 3,\ 5,\ 2]$

(b) (i) $x[n]=[\check{1},\ -1,\ 1],\ h[n]=[\check{1},\ 2,\ 3,\ 3]$

	$n \backslash k$	0	1	2	-
$x[k]$		1	-1	1	$y[n]$
$h[n-k]$	0	1	-	-	1
	1	2	1	-	1
	2	3	2	1	2
	3	3	3	2	2
	4	-	3	3	0
	5	-	-	3	3

(ii) $x[n]=[\check{1},\ -1,\ 1,\ 0,\ 0,\ 0],\ h[n]=[\check{1},\ 2,\ 3,\ 3,\ 0,\ 0]$

k	$X_a[k]$	$H_a[k]$	$Y[k]$
0	1	9	9
1	0	$-2.5+j2.5\sqrt{3}$	0
2	$1-j\sqrt{3}$	$1.5-j0.5\sqrt{3}$	$-j2\sqrt{3}$
3	3	-1	-3
4	$1+j\sqrt{3}$	$1.5+j0.5\sqrt{3}$	$j2\sqrt{3}$
5	0	$-2.5-j2.5\sqrt{3}$	0

$y[n]=[1,\ 1,\ 2,\ 2,\ 0,\ 3]$

11.24 (i) (a)

	n \ k	0	1	2	–
$x[k]$		1	2	1	$y[n]$
$h[n-k]$	0	2	–	–	2
	1	1	2	–	5
	2	2	1	2	6
	3	–	2	1	5
	4	–	–	2	2

(b) $x_a[n]=[1,\ 2,\ 1,\ 0,\ 0]$, $h_a[n]=[2,\ 1,\ 2,\ 0,\ 0]$

$Y[k]=X_a[k]H_a[k]$

k	$X_a[k]$	$H_a[k]$	$Y[k]$
0	4	5	20
1	0.81+j2.49	0.69+j2.13	-4.74+j3.44
2	-0.31+j0.23	1.81-j1.31	-0.26+j0.82
3	-0.31-j0.23	1.81+j1.31	-0.26-j0.82
4	0.81-j2.49	0.69-j2.13	-4.74-j3.44

$y[n]=[2,\ 5,\ 6,\ 5,\ 2]$

(c) 생략

(ii) (a) $y[0]=x[0]h[0]+x[1]h[2]+x[2]h[1]=7$

$y[1]=x[0]h[1]+x[1]h[0]+x[2]h[2]=7$

$y[2]=x[0]h[2]+x[1]h[1]+x[2]h[0]=6$

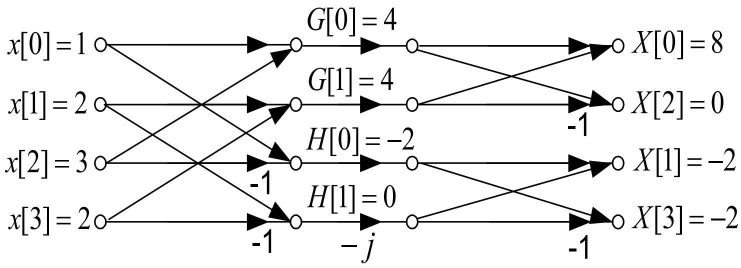
(b)

k	$X[k]$	$H[k]$	$Y[k]$
0	4	5	20
1	$-\frac{1}{2}+j\frac{\sqrt{3}}{2}$	$\frac{1}{2}-j\frac{\sqrt{3}}{2}$	$\frac{1}{2}+j\frac{\sqrt{3}}{2}$
2	$-\frac{1}{2}-j\frac{\sqrt{3}}{2}$	$\frac{1}{2}+j\frac{\sqrt{3}}{2}$	$\frac{1}{2}-j\frac{\sqrt{3}}{2}$

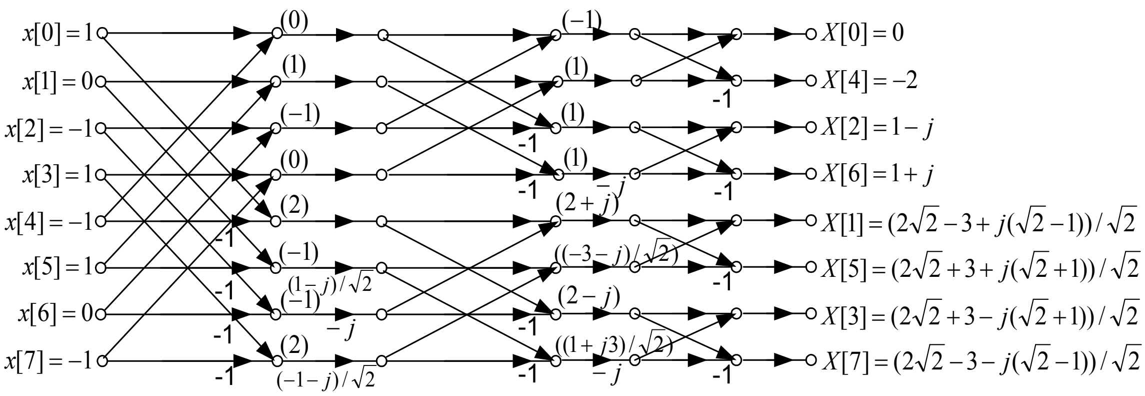
$y[n]=[7,\ 7,\ 6]$

(c) 생략

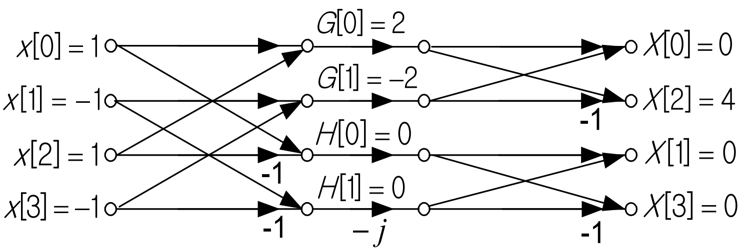
11.25 (a) $X[k]=[8,-2,0,-2]$



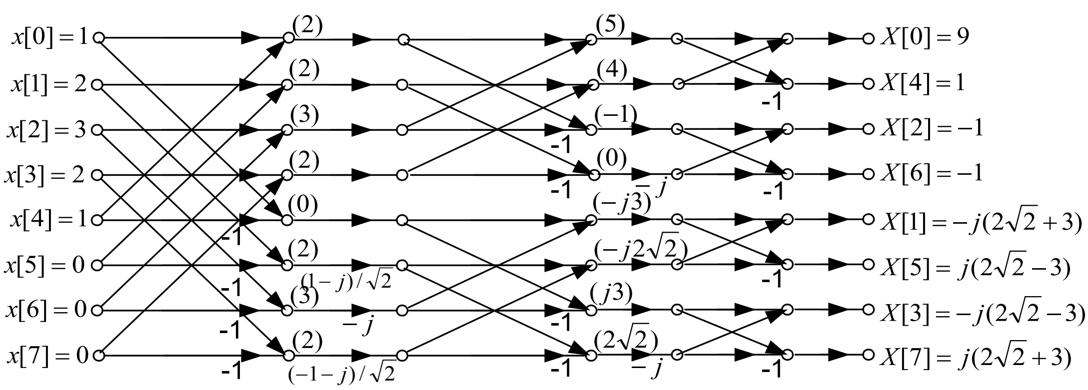
(b) $X[k]=[0,\dfrac{4-3\sqrt{2}}{2}+j\dfrac{2-\sqrt{2}}{2},1-j,\dfrac{4+3\sqrt{2}}{2}-j\dfrac{2+\sqrt{2}}{2},$
$-2,\dfrac{4+3\sqrt{2}}{2}+j\dfrac{2+\sqrt{2}}{2},1+j,\dfrac{4-3\sqrt{2}}{2}-j\dfrac{2-\sqrt{2}}{2}]$



(c) $X[k]=[0,0,4,0]$



(d) $X[k]=[9,-j(3+2\sqrt{2}),-1,j(3-2\sqrt{2}),1,-j(3-2\sqrt{2}),-1,j(3+2\sqrt{2})]$



Chapter 12 연습문제 답안

12.1 ㉯

12.2 ㉰

12.3 ㉰

12.4 ㉮

12.5 ㉱

12.6 ㉯

12.7 ㉱

12.8 ㉰

12.9 ㉰

12.10 ㉯

12.11 (a) $X(z) = z^2 + 2 + z^{-2}$, 수렴 영역 : $z \neq 0$, $|z| \neq \infty$ 인 z 평면

(b) $X(z) = 1 + z^{-1} + z^{-2} + z^{-3} + z^{-4}$, 수렴 영역 : $z \neq 0$ 인 z 평면

(c) $X(z) = -z^2 + 2z - 2z^{-1} + z^{-2}$, 수렴 영역 : $z \neq 0$, $|z| \neq \infty$ 인 z 평면

(d) $X(z) = 1 - z^{-1} + z^{-2} - z^{-3} + z^{-4}$, 수렴 영역 : $z \neq 0$ 인 z 평면

12.12 (a) $X(z) = \dfrac{1}{1-(0.5)z^{-1}}$, 수렴영역 : $|z| > 0.5$

(b) $X(z) = \dfrac{1}{1-(0.25)z^{-1}}$, 수렴영역 : $|z| > 0.25$

(c) $X(z) = \dfrac{0.25z^{-1}}{1-0.5z^{-1}}$, 수렴영역 : $|z| > 0.5$

(d) $X(z) = \dfrac{0.5z^{-1}}{(1-(0.5)z^{-1})^2}$, 수렴영역 : $|z| > 0.5$

12.13 (a) $Y(z) = z^{-1}X(z) = \dfrac{1}{(z+0.5)^2}, \quad |z| > 0.5$

(b) $Y(z) = X(\frac{z}{2}) = \dfrac{z/2}{(z/2+0.5)^2} = \dfrac{2z}{(z+1)^2}, \quad |z| > 1$

(c) $Y(z) = -\dfrac{z}{(z-0.5)^2}, \quad |z| > 0.5\, y[n] = (-1)^n x[n]$

(d) $Y(z) = \dfrac{z^2}{(z+0.5)^2} + \dfrac{1}{(z+0.5)^2} = \dfrac{z^2+1}{(z+0.5)^2}, \quad |z| > 0.5$

12.14 $X(z) = \dfrac{a/z}{\left(1-\dfrac{a}{z}\right)^2} = \dfrac{az}{(z-a)^2}$

12.15 (a) $X_1(z) = z^{-3}\dfrac{z^3}{z^3-3z^2+5z-9} = \dfrac{1}{z^3-3z^2+5z-9}$

(b) $X_2(z) = \dfrac{z^6}{z^3-3z^2+5z-9} - (z^3x[0]+z^2x[1]+zx[2])$

(c) $x[0]=1,\ x[3]=6$

$x_1[3]=1,\ x_2[0]=6$

(d) 생략

12.16 (a) $y[n] = x[-n] = (0.5)^{-n}u[-n]$

(b) $y[n] = (-1)^n x[n]$

(c) $y[n] = u[n] * x[n] = u[n] * (0.5)^n u[n] = \sum_{k=0}^{n}(0.5)^n$

(d) $y[n] = (0.5)^n u[n] * (0.5)^n u[n] = \sum_{k=0}^{n}(0.5)^k(0.5)^{n-k} = \sum_{k=0}^{n}(0.5)^n = (n+1)(0.5)^n$

12.17 (a) $x[n] = u[n-m] \Leftrightarrow \dfrac{z}{z^m(z-1)}$

(b) $x[n] = (0.5)^{n+1}u[n-1] \Leftrightarrow z^{-1}\dfrac{0.25z}{z-0.5} = \dfrac{0.25}{z-0.5}$

(c) $X(z) = zX_1(z^{-1}) = z(-2+4z\ln(z^{-1}+2)) = -2z+4z^2\ln\left(\dfrac{2z+1}{z}\right)$

(d) $\left((0.5)^n\cos\left(\dfrac{\pi}{3}n\right)\right)u[n-1] \Leftrightarrow \dfrac{0.25z^{-1}(1-z^{-1})}{1-0.5z^{-1}+0.25z^{-2}}$

12.18 (a) $x[0] = \lim_{z\to\infty} X(z) = \lim_{z\to\infty} \frac{z}{z^2 - 0.3z - 0.1} = 0$

$x[\infty] = \lim_{z\to 1}(z-1)X(z) = \lim_{z\to 1}(z-1)\frac{z}{(z-0.5)(z+0.2)} = 0$

(b) $x[0] = \lim_{z\to\infty} X(z) = \lim_{z\to\infty} \frac{z(z-0.5)}{x^2 - z + 1} = 1$

최종값 없음

(c) $x[0] = \lim_{z\to\infty} X(z) = \lim_{z\to\infty} \frac{z^2}{z^2 + 1.5z - 1} = 1$

최종값 없음

(d) $x[0] = \lim_{z\to\infty} X(z) = \lim_{z\to\infty} \frac{z(z-0.25)}{z^2 - 0.5z + 0.25} = 1$

$x[\infty] = \lim_{z\to 1}(z-1)X(z) = \lim_{z\to 1}(z-1)\frac{z(z-0.25)}{x^2 - 0.5z + 0.25} = 0$

12.19 (a) $x[n] = u[n] - (0.5)^n u[n] = (1 - (0.5)^n)u[n]$

(b) $x[n] = 2u[n] - 1.5(0.5)^n u[n] = (2 - 1.5(0.5)^n)u[n]$

(c) $x[n] = 2.5u[n] - 7 \cdot (2)^n u[n] + 4.5 \cdot (3)^n u[n]$

(d) $x[n] = u[n] + \frac{1}{4}n^2 \cdot 2^n u[n] - \frac{3}{4}n \cdot 2^n u[n] - 3 \cdot 2^n u[n]$

12.20 (a) $y[n] = [\check{1},\ 3,\ 6,\ 6,\ 3,\ 1,\ 0,\ 1]$

(b) $y[n] = [\check{1},\ 1.5,\ 4.75,\ 2.25,\ 1]$

(c) $y[n] = [\check{1},\ -1,\ 0,\ 0,\ 0,\ 0,\ -1,\ 1]$

12.21 (a) $H(z) = \frac{Y(z)}{X(z)} = \frac{1 - 0.5z^{-1}}{1 - 0.25z^{-1}} = \frac{z - 0.5}{z - 0.25}$

$h[n] = Z^{-1}\{H(z)\} = Z^{-1}\left\{\frac{z}{z-0.25}\right\} - Z^{-1}\left\{\frac{0.5}{z-0.25}\right\}$

$= (0.25)^n u[n] - 0.5(0.25)^{(n-1)}u[n-1] = \delta[n] - (0.25)^n u[n-1]$

$y[n] - 0.25y[n-1] = x[n] - 0.5x[n-1]$

(b) $H(z)=\dfrac{4\left(1+\frac{1}{3}z^{-1}\right)}{(1+z^{-1})(1-\frac{1}{3}z^{-1})}=\dfrac{4z\left(z+\frac{1}{3}\right)}{(z+1)(z-\frac{1}{3})}$

$$h[n]=Z^{-1}\{H(z)\}=Z^{-1}\left\{\frac{2z}{z+1}\right\}-Z^{-1}\left\{\frac{2z}{z-\frac{1}{3}}\right\}$$

$$=2(-1)^n u[n]+2\left(\frac{1}{3}\right)^n u[n]$$

$$y[n]+\frac{2}{3}y[n-1]-\frac{1}{3}y[n-2]=4x[n]+\frac{4}{3}x[n-1]$$

(c) $H(z)=\dfrac{Y(z)}{X(z)}=\dfrac{(0.5+2.25z^{-1})(1-z^{-1})}{(1-0.5z^{-1})(1+0.75z^{-1})}=\dfrac{(0.5z+2.25)(z-1)}{(z-0.5)(z+0.75)}$

$$h[n]=6\delta[n]-(2(0.5)^n+3.5(-0.75)^n)u[n]$$

$$y[n]-0.25y[n-1]-0.375y[n-2]=0.5x[n]+1.75x[n-1]-2.25x[n-2]$$

12.22 (a) $y_1[n]=\left(12\left(\frac{1}{4}\right)^n+36\left(\frac{1}{2}\right)^n-48\left(\frac{1}{3}\right)^n\right)u[n]$

(b) $y_2[n]=y_1[n-2]=\left(12\left(\frac{1}{4}\right)^{n-2}+36\left(\frac{1}{2}\right)^{n-2}-48\left(\frac{1}{3}\right)^{n-2}\right)u[n-2]$

(c) $y_3[n]=16y_1[n]=16\left(12\left(\frac{1}{4}\right)^n+36\left(\frac{1}{2}\right)^n-48\left(\frac{1}{3}\right)^n\right)u[n]$

(d) $y_4[n]=\frac{1}{16}y_2[n]=\frac{1}{16}\left(12\left(\frac{1}{4}\right)^{n-2}+36\left(\frac{1}{2}\right)^{n-2}-48\left(\frac{1}{3}\right)^{n-2}\right)u[n-2]$

12.23 (a) $H(z)=\dfrac{Y(z)}{X(z)}=\dfrac{1}{1-z^{-1}+0.5z^{-2}}=\dfrac{z^2}{z^2-z+0.5}$

$$h[n]=\sqrt{2}(\sqrt{0.5})^n\cos\left(\frac{\pi}{4}n-\frac{\pi}{4}\right)u[n]$$

시스템의 극 : $z=\dfrac{1\pm j1}{2}$ & 영점 : $z=0$(중근)

시스템의 극이 모두 단위원 안에 있으므로 시스템은 안정하다.

(b) $H(z)=\dfrac{Y(z)}{X(z)}=\dfrac{-1+2z^{-1}}{1-\frac{1}{4}z^{-1}-\frac{3}{8}z^{-2}}=\dfrac{-z^2+2z}{z^2-\frac{1}{4}z-\frac{3}{8}}$

$h[n]=-2\left(-\dfrac{1}{2}\right)^n u[n]+\left(\dfrac{3}{4}\right)^n u[n]$

시스템의 극 $z=-\dfrac{1}{2},\ \dfrac{3}{4}$ & 시스템의 영점 $z=2$

시스템의 극이 모두 단위원 안에 있으므로 시스템은 안정하다.

(c) $H(z)=\dfrac{Y(z)}{X(z)}=\dfrac{0.5+0.4z^{-1}+0.2z^{-2}}{1-0.7z^{-1}-0.3z^{-2}}=\dfrac{0.5z^2+0.4z+0.2}{z^2-0.7z-0.3}$

$h[n]=-\dfrac{2}{3}\delta[n]+\dfrac{11}{13}u[n]+\dfrac{25}{78}(-0.3)^n u[n]$

시스템의 극 $z=1,\ -0.3$

시스템의 영점 $z=-0.4\pm j\sqrt{0.24}=-0.4\pm j0.49$

시스템이 $z=1$의 극을 가지므로 시스템은 안정하지 못하다.

(d) $H(z)=\dfrac{Y(z)}{X(z)}=\dfrac{1+z^{-1}}{1+2z^{-1}+2z^{-2}}=\dfrac{z^2+z}{z^2+2z+2}$

$h[n]=(\sqrt{2})^n\left(\cos\dfrac{3\pi}{4}n\right)u[n]$

시스템의 극 $z=-1\pm j1$ & 영점 $z=0,\ -1$

단위원 밖에 극을 가지므로 안정하지 못하다.

12.24 (a) (i) $y[n]=\underbrace{[0.25(0.25)^n u[n]]}_{\text{영입력응답}}+\underbrace{\left[-\dfrac{1}{3}(0.25)^n u[n]+\dfrac{4}{3}u[n]\right]}_{\text{영상태응답}}$

(ii) $y[n]=\underbrace{\left[-\dfrac{1}{12}(0.25)^n u[n]\right]}_{\text{고유응답}}+\underbrace{\left[\dfrac{4}{3}u[n]\right]}_{\text{강제응답}}$

(b) (i) $y[n]=\underbrace{\left[-\dfrac{5}{4}\left(\dfrac{1}{2}\right)^n u[n]+\dfrac{3}{8}\left(\dfrac{1}{4}\right)^n u[n]\right]}_{\text{영입력응답}}+\underbrace{\left[-2\left(\dfrac{1}{2}\right)^n u[n]+\dfrac{1}{3}\left(\dfrac{1}{4}\right)^n u[n]+\dfrac{8}{3}u[n]\right]}_{\text{영상태응답}}$

(ii) $y[n]=\underbrace{\left[-\dfrac{13}{4}\left(\dfrac{1}{2}\right)^n u[n]+\dfrac{17}{24}\left(\dfrac{1}{4}\right)^n u[n]\right]}_{\text{고유응답}}+\underbrace{\left[\dfrac{8}{3}u[n]\right]}_{\text{강제응답}}$

(c) (i) $y[n] = \underbrace{\left[6.5(0.5)^n u[n] - 4.8(0.4)^n u[n]\right]}_{\text{영입력응답}} + \underbrace{\left[-5(0.5)^n u[n] + \frac{8}{3}(0.4)^n u[n] + \frac{10}{3}u[n]\right]}_{\text{영상태응답}}$

(ii) $y[n] = \underbrace{\left[1.5(0.5)^n u[n] - \frac{32}{15}(0.4)^n u[n]\right]}_{\text{고유응답}} + \underbrace{\left[\frac{10}{3}u[n]\right]}_{\text{강제응답}}$

(d) (i) $y[n] = \underbrace{\left[0.5(0.5)^n u[n] - u[n]\right]}_{\text{영입력응답}} + \underbrace{\left[-(0.5)^n u[n] + (n+3)u[n]\right]}_{\text{영상태응답}}$

(ii) $y[n] = \underbrace{\left[-0.5(0.5)^n u[n] + 2u[n]\right]}_{\text{고유응답}} + \underbrace{\left[n u[n]\right]}_{\text{강제응답}}$

12.25 (a) 안정하다.

(b) $y[n] = (\frac{5}{7}(0.5)^n + \frac{2}{7}(-0.2)^n) \ + \ ((0.5)^n - 0.2(-0.2)^n)$

[영상태응답] + [영입력응답]

(c) 생략

12.26 (a) $y[n] - ay[n-1] = ax[n-1]$

(b) $H(z) = \frac{Y(z)}{X(z)} = \frac{az^{-1}}{1 - az^{-1}} = \frac{a}{z-a}$

(c) $|a| < 1$

(d) $h[n] = Z^{-1}\{H(z)\} = a^n u[n-1]$

(e) $y[n] = u[n] - (0.5)^n u[n]$

12.27 (a) $H(z) = H_1(z) + H_2(z) = \frac{z}{z-a} + \frac{z+b}{z} = \frac{2z^2 + (b-a)z - ab}{z(z-a)}$

(b) $H(z) = H_1(z) + H_2(z) = \frac{z}{z-a} + \frac{1}{z-b} = \frac{z^2(1-b)z - a}{(z-a)(z-b)}$

12.28 (a) $X(z) = \frac{1}{1 - e^{-0.2}z^{-1}} = \frac{z}{z - e^{-0.2}}$

(b) $X(z) = \frac{1}{1 - e^{-0.2}z^{-1}} = \frac{z}{z - e^{-0.2}}$

(c) 생략

(d) $aT = 0.2$