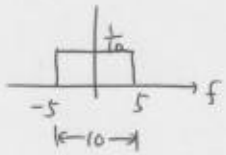
제 7 장

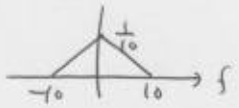
7.1 (a) $\mathrm{sinc}(10t) \longleftrightarrow \frac{1}{10}\Pi\left(\frac{f}{10}\right)$



$B = 5\,Hz$

$\Rightarrow$ Nyquist rate는 $f_s = 2B = 10\,Hz$

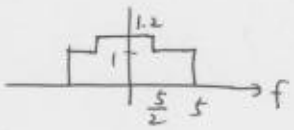
(b) $\mathrm{sinc}^2(10t) \longleftrightarrow \frac{1}{10}\Lambda\left(\frac{f}{10}\right)$



$B = 10\,Hz \Rightarrow f_s = 2B = 20\,Hz$

(c) $10\,\mathrm{sinc}(10t) + \mathrm{sinc}(5t)$

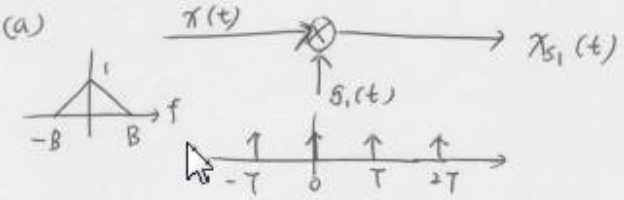
$\longleftrightarrow \Pi\left(\frac{f}{10}\right) + \frac{1}{5}\Pi\left(\frac{f}{5}\right)$



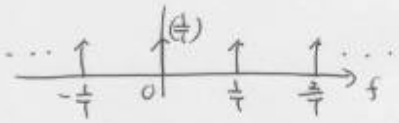
$B = \frac{5}{2}\,Hz \Rightarrow f_s = 10\,Hz$

7.5

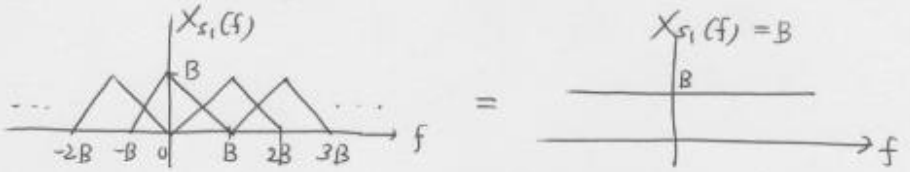
(a)



$$G_1(f) = \frac{1}{T}\sum_{n=-\infty}^{\infty}\delta\left(f-\frac{n}{T}\right)$$

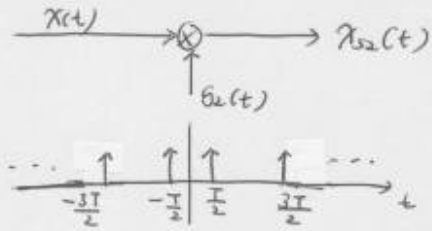


$$X_{s_1}(f) \triangleq \mathcal{F}\{x_{s_1}(t)\} = \frac{1}{T}\sum_{n=-\infty}^{\infty} X\left(f-\frac{n}{T}\right), \quad \frac{1}{T} = B$$



⇒ aliasing이 발생하여 원래 signal로 복원 안됨

(b)



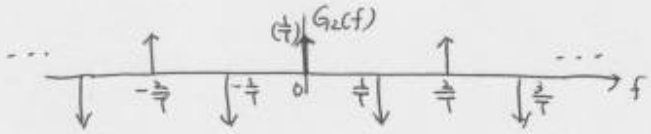
$s_2(t) = s_1(t-\frac{T}{2})$ 는 $s_1(t)$를 $\frac{T}{2}$만큼 오른쪽으로 shift시킨 신호이므로 Fourier transform은 다음과 같이 된다.

$$G_2(f) = G_1(f)\cdot e^{-j2\pi f\cdot\frac{T}{2}}$$

$$= \frac{1}{T}\sum_{n=-\infty}^{\infty}\delta\left(f-\frac{n}{T}\right)\cdot e^{-j\pi fT}$$

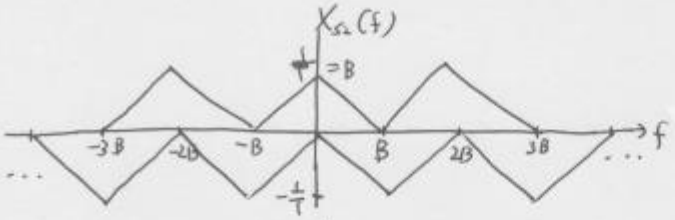
$$= \frac{1}{T}\sum_{n=-\infty}^{\infty}\delta\left(f-\frac{n}{T}\right)\cdot e^{j\pi n} \quad (\text{sampling property})$$

$$= \frac{1}{T}\sum_{n=-\infty}^{\infty}(-1)^n\,\delta\left(f-\frac{n}{T}\right)$$



$$X_{s_2}(f) \triangleq \mathcal{F}\{x_{s_2}(t)\} = X(f) * G_2(f)$$

$$= \frac{1}{T}\sum_{n=-\infty}^{\infty}(-1)^n X\left(f-\frac{n}{T}\right), \quad \frac{1}{T}=B$$



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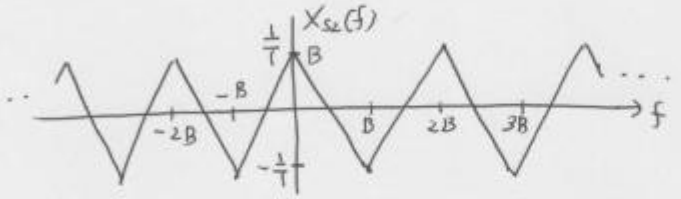


aliasing 발생

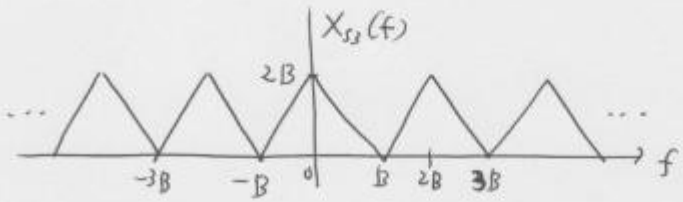
(c) $g_3(t) = g_1(t) + g_2(t) = \sum_{n=-\infty}^{\infty}\delta\left(t-\frac{nT}{2}\right) = \sum_{n=-\infty}^{\infty}\delta(t-nT_s)$

$$T_s = \frac{T}{2}$$

$$G_3(f) = \frac{1}{T_s}\sum_{n=-\infty}^{\infty}\delta\left(f-n\cdot\frac{1}{T_s}\right), \quad \frac{1}{T_s} = \frac{2}{T} = 2B$$

$$X_{s_3}(f) = \mathcal{F}\{x_{s_3}(t)\} = \frac{1}{T_s}\sum_{n=-\infty}^{\infty} X\left(f-\frac{n}{T_s}\right)$$

$$= 2B\sum_{n=-\infty}^{\infty} X(f-2Bn)$$



한편 $g_3(t) = g_1(t) + g_2(t)$ 이므로

$$x_{s_3}(t) = x\cdot g_1(t) + x\cdot g_2(t) = x_{s_1}(t) + x_{s_2}(t)$$

$$\leftrightarrow X_{s_3}(f) = X_{s_1}(f) + X_{s_2}(f) = B + X_{s_2}(f)$$

aliasing 발생하지 않음

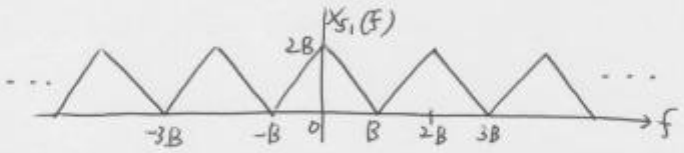
(a) 와 (b) 에서는 Nyquist rate의 1/2 주파수로 표본화하여 aliasing이 발생한다. 그러나 $g_1(t)+g_2(t)$ 의 e하여 임펄스열이 Nyquist rate의 주파수를 갖게되어 aliasing이 제거된다.

(d) $T=\frac{1}{2B}$ 인 경우

(a)' $g_1(t)=\sum_{n=-\infty}^{\infty}\delta(t-nT)=\sum_{n=-\infty}^{\infty}\delta(t-\frac{n}{2B})$

$\longleftrightarrow G_1(f)=\frac{1}{T}\sum_{n=-\infty}^{\infty}\delta(f-\frac{n}{T})=2B\sum_{n=-\infty}^{\infty}\delta(f-2Bn)$

$x_{s_1}(t)=x(t)\cdot g_1(t)\longleftrightarrow X_{s_1}(f)=2B\sum_{n=-\infty}^{\infty}X(f-2Bn)$

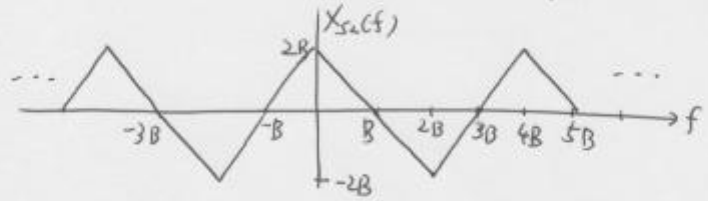


(b)' $g_2(t)=g_1(t-\frac{T}{2})\Rightarrow G_2(f)=G_1(f)\cdot e^{-j\pi f\cdot\frac{T}{2}}$

$=\frac{1}{T}\sum_{n=-\infty}^{\infty}(-1)^n\delta(f-\frac{n}{T})$

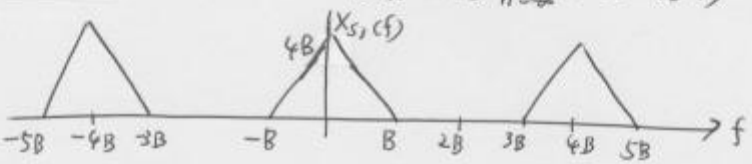
$=2B\sum_{n=-\infty}^{\infty}(-1)^n\delta(f-2Bn)$

$x_{s_2}(t)=x(t)\cdot g_2(t)\longleftrightarrow X_{s_2}(f)=2B\sum_{n=-\infty}^{\infty}(-1)^nX(f-2Bn)$



(c)' $g_3(t)=g_1(t)+g_2(t)=\sum_{n=-\infty}^{\infty}\delta(t-nT_s)\quad T_s=\frac{T}{2}=\frac{1}{4B}$

$\longleftrightarrow G_3(f)=4B\sum_{n=-\infty}^{\infty}\delta(f-4Bn)$



$X_{s_3}(f)=X_{s_1}(f)+X_{s_2}(f)$ 가 되는 것을 확인할 수 있다.

7.11

(a) $128 = 2^7$ ⇒ 문자당 7 bit 필요

⇒ Data rate = 7 bit/character × 10^5 characters/sec

= 700 kbit/sec

(b) $(BW)_{min} = \frac{1}{2} R_b = 350$ kHz