과제 2

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maximum frequency $f_m = 3kHz$

$M = 16$

$p = 0.01$

(a) $|e| \le p V_{p.p}$

$|e|_{max} = \frac{q}{2} = \frac{V_{p.p}}{2(L-1)} \cong \frac{V_{p.p}}{2L}$

$\Rightarrow \frac{V_{p.p}}{2L} \le p V_{p.p}$

$\Rightarrow 2^b = L \ge \frac{1}{2p}$ (levels)

$\Rightarrow b \ge \log_2 (\frac{1}{2p})$ (bits)

$b \ge \log_2 (\frac{1}{0.02}) = \log_2 50 \cong 5.6$

$\therefore$ 6 bits / sample to meet the distortion requirement.

(b) Nyquist Sampling 에 따라

minimum sampling rate $f_s = 2f_m = 6000$ samples / second

한 sample 당 6 bit 로 되어있기 때문에

bit transmission rate 는 $6 \times 6000 = 36000$ bps 이다.

(c) $M = 2^b = 16$

$\therefore b = 4$ bits / symbol

즉, 하나의 symbol 당 4 bits 씩 보내기 때문에

$$\frac{36000}{4} = 9000 \text{ symbols / sec}$$

(d) Bandwidth efficiency $= \dfrac{\text{data throughput}}{\text{band width}}$

$$= \frac{36000 \text{ bps}}{12000 \text{ Hz}}$$

$$= 3 \text{ bps / Hz}$$