LL

Problem 1.

(a) Find α_0, α_1

3 conditions for $p(s)$

$$\begin{cases} \int_{-4}^{4} p(s)\,ds = 1 \\ -4\alpha_1 + \alpha_0 = 0 \\ \alpha_0 \geq 0 \end{cases}$$

$$\Rightarrow \begin{cases} 2 \times \frac{\alpha_0 + (-4\alpha_1 + \alpha_0)}{2} \times 4 = 1 \\ \alpha_0 = 4\alpha_1 \\ \alpha_0 \geq 0 \end{cases}$$

$$\Rightarrow \begin{cases} \alpha_0 - 2\alpha_1 = \frac{1}{8} \\ \alpha_0 = 4\alpha_1 \\ \alpha_0 \geq 0 \end{cases}$$

$$\Rightarrow \begin{cases} \alpha_0 = \frac{1}{4} \\ \alpha_1 = \frac{1}{16} \end{cases} \#$$

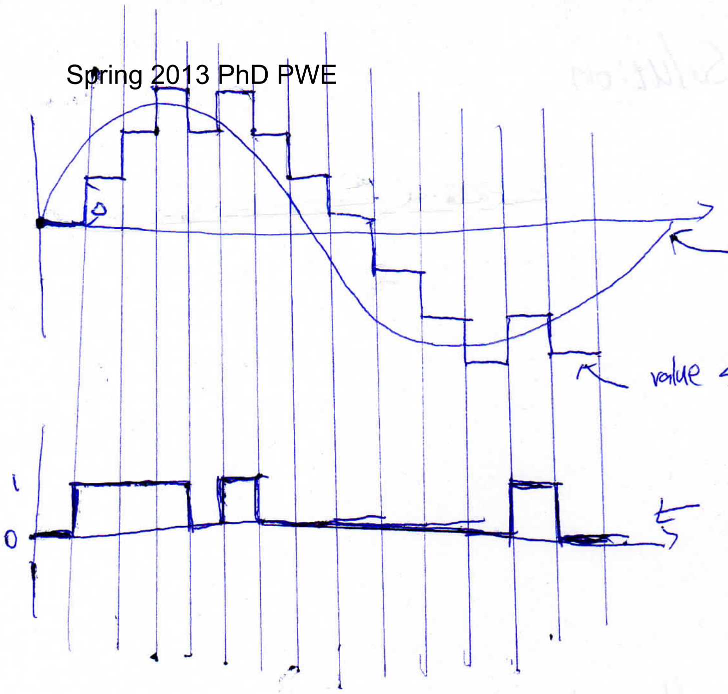
(b) 4 Quantization level $\Rightarrow \Delta = \frac{4-(-4)}{4} = 2$ #

Quantized signal level = $\{-3, -1, 1, 3\}$ #

(c) In delta modulation, the modulated signal is
- 1, if the sample value is larger than the transmitter memory
- 0, if the sample value is smaller than the transmitter memory

In other words, delta modulation use 1 bit to keep track of the original signal.

⇓



d)

To avoid slope overloading, we need the signal value change in adjacent samples to be less than Δ.

$$\Delta \geq |s((n+1)T) - s(nT)| \quad , \forall n \in N$$

$$= A\,|\sin(w(n+1)T) - \sin(wnT)|$$

$$= 2A\,|\sin(wnT + \tfrac{1}{2}wT)| \times |\cos(\tfrac{w}{2}T)|$$

$$\Rightarrow A \leq \frac{\Delta}{2|\cos(\frac{w}{2}T)|}$$

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- Problem 2.

(a). The highest bit rate without ISI is the Nyquist sampling rate, which is $2 \times B = 2 \times 1200 = \underline{2400 \ (Hz)}$ #

(b). Using BPSK, the error rate is

$$P_e = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) = \frac{1}{2}\operatorname{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$$

If we want $P_e = 10^{-7}$, we need $\frac{E_b}{N_0}$ at least equal to

$$\frac{E_b}{N_0} \geq \left[\operatorname{erfc}^{-1}(2 \times 10^{-7})\right]^2$$

$$= (3.6765)^2 = \underline{13.5166}$$ #

(c) Since the channel has 1 dB/km attenuation, the received signal power at each repeater is

$$E_b = \frac{r^{50} \times P}{R}, \text{ where } r = 10^{-0.1}$$

P is the transmitted power at each repeater
$R = 2400$ (bits/sec),

To meet the required $\frac{E_b}{N_0}$ in (b), we need

$$\frac{\frac{r^{50} \times P}{R}}{N_0} \geq 13.5166$$

$$\Rightarrow P \geq \frac{R \times N_0 \times 13.5166}{r^{50}} = \underline{1.33 \times 10^{-11}}$$ #