Name KEY

ELC 4350 – Principles of Communication

Quiz 7 – March 17, 2015

Open Book/Open Notes/10 minutes

You must circle or box your answers for full credit.

PROBLEM 1 (10 points): Consider the signals

$$f(t) = 2000sinc(2000\pi t)$$

and

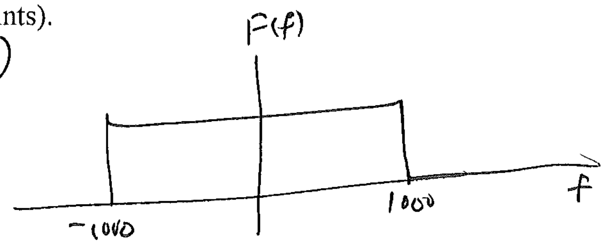
$$g(t) = 3000sinc^2(3000\pi t)$$

(a) Find the Nyquist sampling rate f_s for $f(t)$) (3 points).

Pair 18: $2B\,\text{sinc}(2\pi B t) \Leftrightarrow \Pi\left(\frac{f}{2B}\right)$

$2000\,\text{sinc}(2000\pi t) \Leftrightarrow \Pi\left(\frac{f}{2000}\right)$

$B = 1000\,Hz$



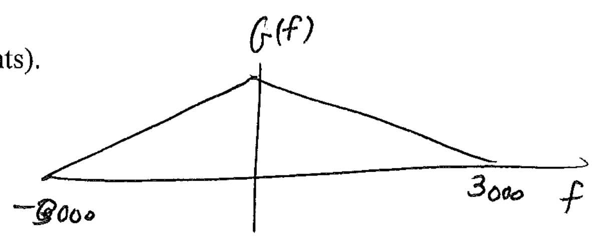
$f_s \geq 2B = 2(1000) = 2000\ Hz$

(b) Find the Nyquist sampling rate f_s for $g(t)$ (3 points).

Pair 20: $B\,\text{sinc}^2(\pi B t) \Leftrightarrow \Delta\left(\frac{f}{2B}\right)$

$3000\,\text{sinc}^2(3000\pi t) \Leftrightarrow \Delta\left(\frac{f}{6000}\right)$

$B = 3000\ Hz$



$f_s \geq 2B = 2(3000) = 6000\ Hz$

(c) What is the Nyquist sampling rate for $f(t) + g(t)$ (use the bandwidth rule for the sum of two functions to solve)? (2 points)

$B = \max(B_f, B_g) = 3000\ Hz$

$f_s \geq 2B = 2(3000) = 6000\ Hz$

(d) What is the Nyquist sampling rate for $f(t)g(t)$ (use the bandwidth rule for the time product of two functions to solve)? (2 points)

$B = B_f + B_g = 1000 + 3000 = 4000$

$f_s \geq 2B = 2(4000) = 8000\ Hz$

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ELC 4350 – Principles of Communication

Quiz 8 – March 24, 2015

Open Book/Open Notes/10 minutes

You must circle or box your answers for full credit.

PROBLEM 1 (10 points): A signal has a bandwidth of 10 MHz. The signal is sampled, quantized, and binary coded to obtain a pulse-code modulated (PCM) signal. The signal is sampled at the Nyquist rate.

(a) What is the Nyquist rate (2 points)?

$f_s = 2B = 2(10\times10^6) = 20\ MHz$

(b) If the samples are to be encoded into 128 levels, what is the number of binary pulses (bits) required to encode each sample (2 points)?

$2^n = 128$

$n = \log_2(128) = \frac{\ln(128)}{\ln(2)} = 7$ bits

(c) Based on your answers to parts (a) and (b), what is the minimum binary pulse rate (bits per second) of the binary-coded signal (3 points)?

$7(20\times10^6) = 140\ M\frac{\text{bits}~~\text{samples}~~}{\text{second}}$

(d) Using the knowledge that 2 bits can be transmitted per second over a 1 Hz bandwidth, determine the minimum transmission bandwidth B_T that can be used to successfully transmit this signal (3 points).

$B_T = nB = 7(10\times10^6) = 70\ MHz$

Name Key

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Quiz 9 – March 31, 2015

Open Book/Open Notes/10 minutes

You must circle or box your answers for full credit.

PROBLEM 1 (10 points): Differential pulse code modulation (DPCM) can be used to encode the message

$$m(t) = 4\cos(1000\pi t)$$

Sampling is performed with $T_s = 1 \times 10^{-4}$ seconds. For all parts of this problem, if the sampled DPCM analog value exceeds d_p or is below $-d_p$, place it in the extreme bin closest to the value.

(a) (2 points) What are the first four analog sample values $m[1], m[2], m[3]$, and $m[4]$?

$m[1] = m(1\times10^{-4}) = 3.80423$

$m[2] = m(2\times10^{-4}) = 3.23607$

$m[3] = m(3\times10^{-4}) = 2.35114$

$m[4] = m(4\times10^{-4}) = 1.23607$

(b) (4 points) If DPCM is used with 2-bit quantization, $d_p = 2$, and the bin ranges being inclusive upward, find the bitstream representing the first four samples. Use the 2-bit PCM quantization of the actual value with $m_p = 4$ for the first two-bit word, followed by the DPCM representations to find the second, third, and fourth samples. Use the predictor $\hat{m}[k] = m[k-1]$.

4, 11 3, 2, 1, 0, -1, -2, -3, -4

2, 11, 1, 10, 0, 01, -1, 00, -2

$m_q[1] = 3 \Rightarrow \boxed{11}$

$d[2] = m[2] - m[1]$

$= 3.23607 - 3.80423$

$\simeq -0.56816 \Rightarrow \boxed{01}$

$d[3] = m[3] - m[2]$

$= 2.35114 - 3.23607$

$\simeq -0.88493 \Rightarrow \boxed{01}$

$d[4] = m[4] - m[3]$

$= 1.23607 - 2.35114$

$\simeq -1.11507 \Rightarrow \boxed{00}$

11 01 01 00

(continued on next page)

(c) (4 points) For the bitstream you obtained in part (b), perform decoding of the this bitstream at the receiver. Provide the four quantized signal values $m_q[1], m_q[2], m_q[3], m_q[4]$ in decimal representation that would be obtained by using DPCM and the predictor $\widehat{m_q}[k] = m_q[k-1]$. For decoding assume that the first word (2 bits) is PCM representation of the first value with $m_p = 4$, and that the following words are DPCM with $d_p = 2$. Find the values of the quantization error at each sample: $q[1], q[2], q[3], q[4]$.

11 01 01 00

$m_q[1] = 3$

$d_q[2] = -0.5$

$d_q[3] = -0.5$

$d_q[4] = -1.5$

$m_q[k] = m_q[k-1] + d_q[k]$

$m_q[2] = m_q[1] + d_q[2] = 3 - 0.5 = 2.5$

$m_q[3] = m_q[2] + d_q[3] = 2.5 - 0.5 = 2.0$

$\cancel{m_q[4] = m_q[3] + d_q[4] = 2.0 - 0.5 = 0.5}$

$q[1] = m_q[1] - m[1] = 3 - 3.80423 = -0.80423$

$q[2] = m_q[2] - m[2] = 2.5 - 3.23607 = -0.73607$

$q[3] = m_q[3] - m[3] = 2.0 - 2.35114 = -0.35114$

$q[4] = m_q[4] - m[4] = 0.5 - 1.23607 = -1.23343$

Name ~~KEY~~ KEY

ELC 4350 – Principles of Communication

Quiz 10 – April 9, 2015

Open Book/Open Notes/10 minutes

You must circle or box your answers for full credit.

PROBLEM 1 (10 points): Consider a pulse shape

$$p(t) = \Delta\left(\frac{t}{0.25T_b}\right)$$

(a) (7 points) Find an expression for the power spectral density (PSD) $S_y(f)$ of the line coded waveform in terms of T_b if polar signaling is used. Hint: $S_x(f)$ has been derived in your book already for polar signaling. Start with this expression; you do not need to derive it again.

~~Pat~~ $\Delta\left(\frac{t}{\tau}\right) \Leftrightarrow \frac{\tau}{2}\,\text{sinc}^2\left(\frac{\pi f \tau}{2}\right)$ Pair 19 of Table 3.1

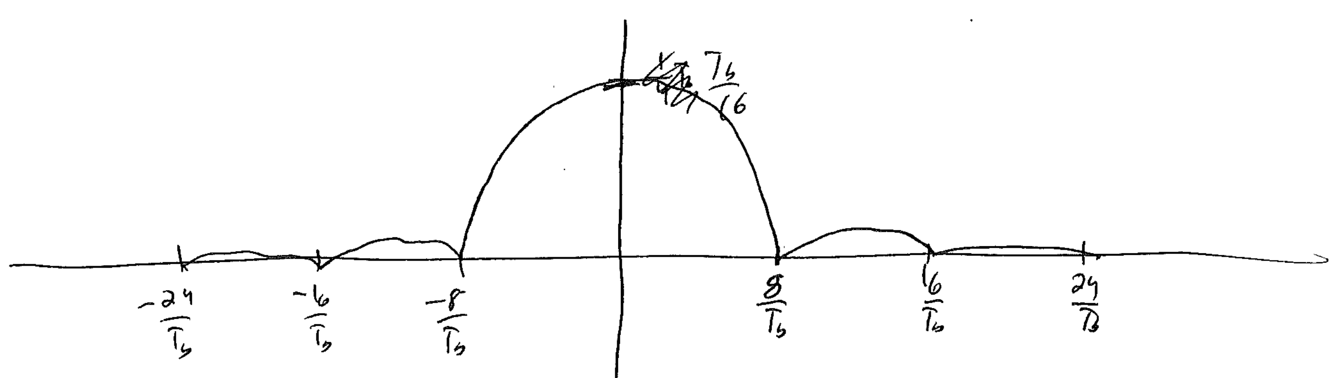
$\Delta\left(\frac{t}{0.25T_b}\right) \Leftrightarrow 0.\cancel{8}5T_b\,\text{sinc}^2\left[\frac{\pi f(0.25)T_b}{2}\right]$

$P(f) = 0.25\,T_b\,\text{sinc}^2\left[\frac{\pi T_b}{8}f\right]$

$S_y(f) = \frac{|P(f)|^2}{T_b} = \left(\frac{1}{16}T_b^{\cancel{2}}\right)\left(\frac{1}{\cancel{T_b}}\right)\text{sinc}^4\left[\frac{\pi T_b}{8}f\right]$

$S_y(f) = \frac{T_b}{16}\,\text{sinc}^4\left[\frac{\pi T_b}{8}f\right]$

(b) (3 points) Sketch roughly the PSD in terms of T_b and find the bandwidth in terms of T_b (if bandwidth is defined as the frequency width from 0 Hz to the first null in the PSD).



$B = \frac{8}{T_b}$ Hz

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Quiz 11 – April 21, 2015

Open Book/Open Notes/10 minutes

You must circle or box your answers for full credit.

PROBLEM 1 (10 points): Determine the PSD of quarternary (4-ary) baseband signaling when the message bits **1** and **0** are equally likely. Assume that the mapping is as follows:

Message bits **00** → $a_k = -6$

Message bits **01** → $a_k = -2$

Message bits **10** → $a_k = 2$

Message bits **11** → $a_k = 6$

Give the power spectral density $S_y(f)$ of this signaling in terms of $P(f)$, the Fourier Transform of the pulse shape, and T_s, the transmission interval.

$$R_0 = \lim_{N\to\infty} \frac{1}{N} \sum_k a_k^2 = \frac{1}{4}\left[(-6)^2 + (-2)^2 + (2)^2 + (6)^2\right] = 20$$

$$R_n = \lim_{N\to\infty} \sum_k a_k a_{k+n} = \frac{2}{16}(36) + \frac{4}{16}(12) + \frac{4}{16}(-12) + \frac{2}{16}(-36) + \frac{2}{16}(4) + \frac{2}{16}(-4)$$

$$= 0$$

	-6	-2	2	6
-6	36	12	-12	-36
-2	12	4	-4	-12
2	-12	-4	4	12
6	-36	-12	12	36

$$S_y(f) = \frac{|P(f)|^2}{T_b}\left[R_0 + 2\sum_{n=1}^{\infty} \underbrace{R_n}_{0} \cos 2\pi f n T_b\right]$$

$$= \frac{|P(f)|^2}{T_s}[20]$$