

ECS 332: Principles of Communications 2018/1

HW 9 — Due: Not Due

Lecturer: Prapun Suksompong, Ph.D.

Problem 1. State the Nyquist's (first) criterion for zero ISI

(a) In the time domain.

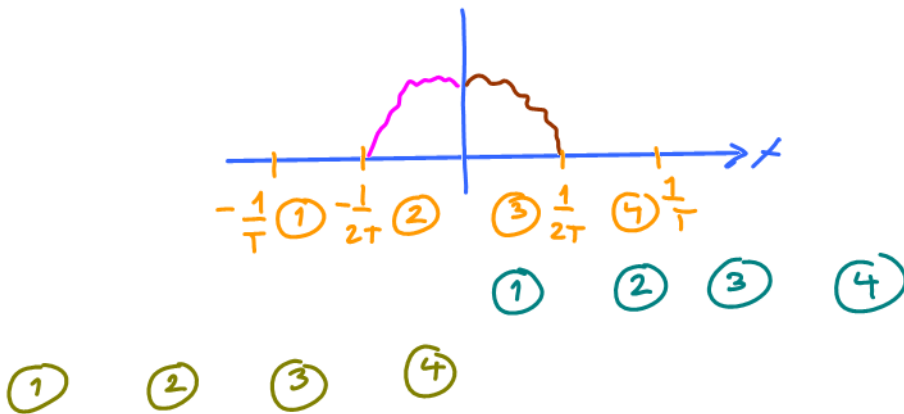
$$p(t) = \begin{cases} 1, & t=0 \\ 0, & t = \pm T, \pm 2T, \pm 3T, \dots \end{cases} \quad \left| \quad p(t) \Big|_{t=nT} = \begin{cases} 1, & n=0 \\ 0, & n = \pm 1, \pm 2, \pm 3, \dots \end{cases}$$

(b) In the frequency domain.

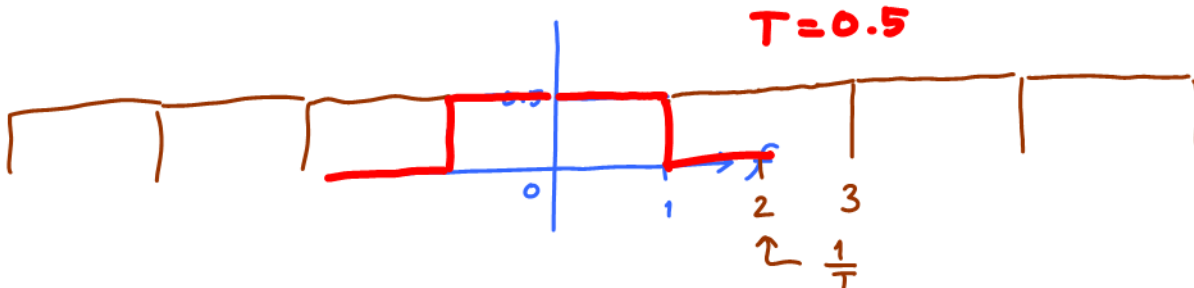
$$\sum_{k=-\infty}^{\infty} P(f - \frac{k}{T}) \equiv T$$

Problem 2. In each part below, a pulse $P(f)$ is defined in the frequency domain from $f = 0$ to $f = 1$. Outside of $[0, 1]$, your task is to assign value(s) to $P(f)$ so that it becomes a Nyquist pulse. Of course, you will also need to specify the symbol interval T as well.

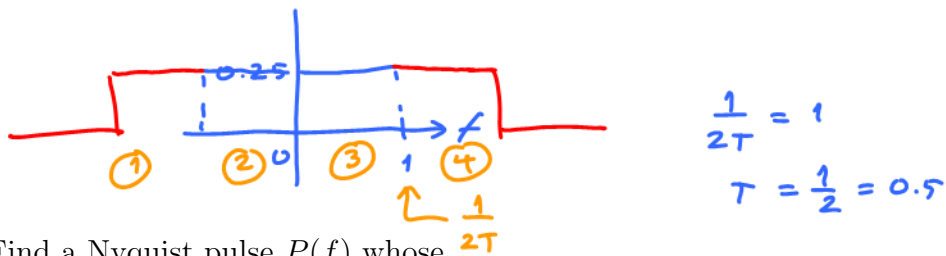
Hint: To avoid dealing with complex-valued $P(f)$, you may assume that $p(t)$ is real-valued and even; in which case $P(f)$ is also real-valued and even.



(a) Find a Nyquist pulse $P(f)$ whose $P(f) = 0.5$ on $[0, 1]$.

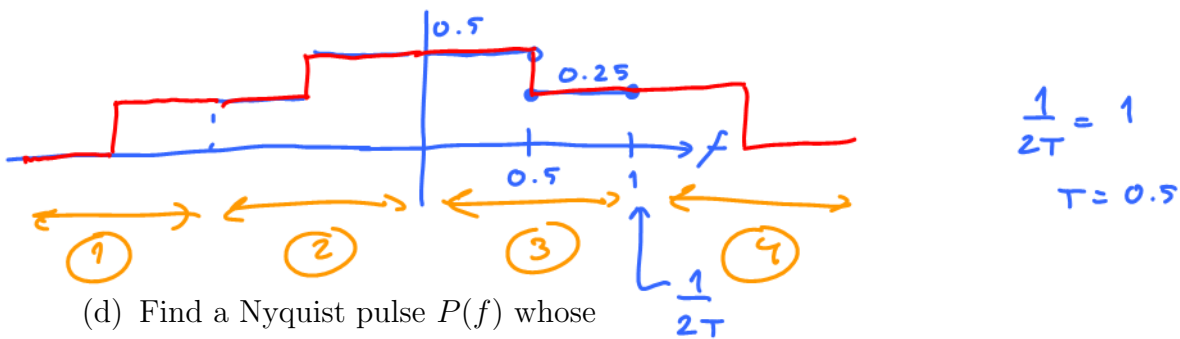


(b) Find a Nyquist pulse $P(f)$ whose $P(f) = 0.25$ on $[0, 1]$.



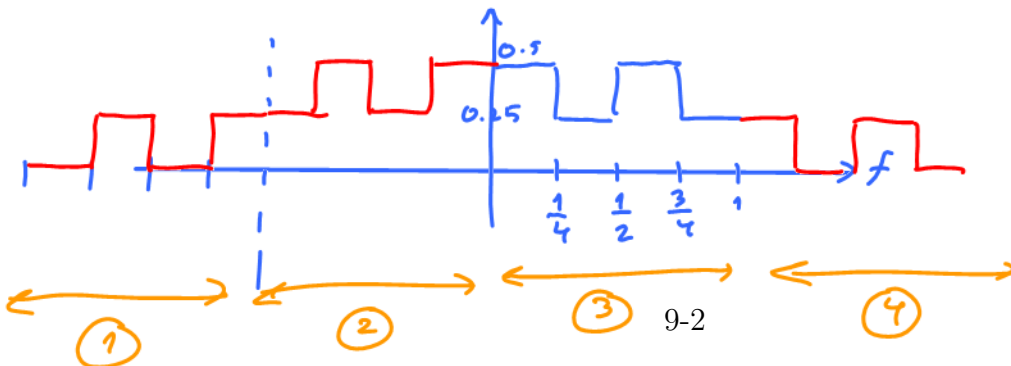
(c) Find a Nyquist pulse $P(f)$ whose

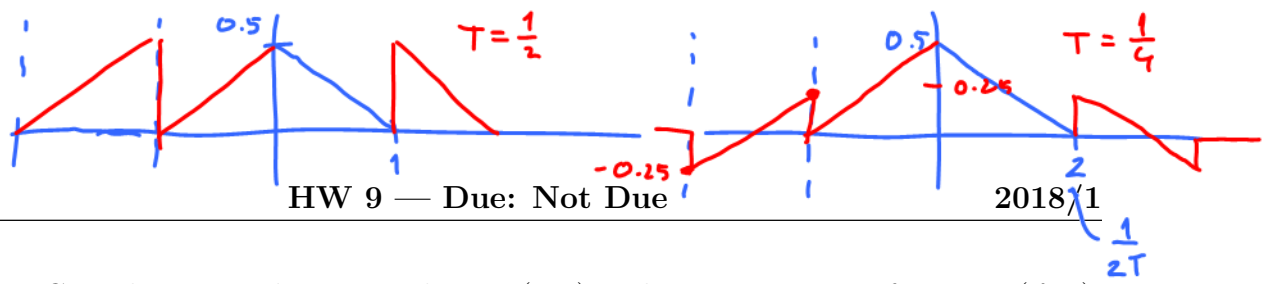
$$P(f) = \begin{cases} 0.5, & 0 \leq f < 0.5 \\ 0.25, & 0.5 \leq f \leq 1 \end{cases}$$



(d) Find a Nyquist pulse $P(f)$ whose

$$P(f) = \begin{cases} 0.5, & f \in [0, 0.25) \cup [0.5, 0.75) \\ 0.25, & f \in [0.25, 0.5) \cup [0.75, 1] \end{cases}$$





Problem 3. Consider a raised cosine pulse $p_{\text{RC}}(t; \alpha)$ and its Fourier transform $P_{\text{RC}}(f; \alpha)$. Assume the rolloff factor $\alpha = 0.3$ and the symbol “duration” $T = 1$.

(a) Carefully sketch $P_{\text{RC}}(f; \alpha)$.

(b) Find $p_{\text{RC}}(2; \alpha)$.

(c) Find $P_{\text{RC}}(0.5; \alpha)$.

(d) Find $P_{\text{RC}}(0.3; \alpha)$.

(e) *Find $P_{\text{RC}}(0.4; \alpha)$.

Remark: You should be able to solve this problem without referring to the “ugly” expression (9.1) below.

Problem 4 (F2016,Q12). In a PCM system, an analog message is sampled at 5,000 [Sa/s] and then uniformly quantized into 128 different levels. 2^7

- (a) What is the (theoretical) maximum frequency of the analog message that can be used under such system without aliasing?

$f_s > 2f_{max}$ $f_{max} < \frac{f_s}{2} = \frac{5,000}{2} = 2,500 \text{ [Hz]}$

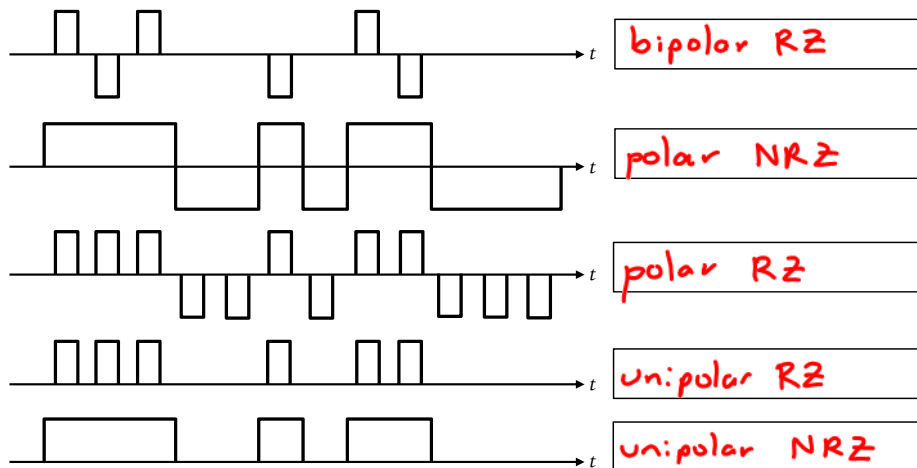
- (b) Calculate the bit rate of this system.

$R_b = 5000 \frac{\text{Sa}}{\text{s}} \times 7 \frac{\text{bits}}{\text{Sa}} = 35 \text{ [kbps]}$

- (c) Determine the signal-to-quantization-noise power ratio in dB when the message is a full-load sinusoidal modulating wave.

$SQNR \approx 1.76 + 6L = 43.76 \text{ [dB]}$
 $6 \times 7 = 42$

Problem 5 (F2016, Q14). For each of the plots below, indicate which type of line code is being used. Put your answer in the provided box to the right of each plot. In all cases, the bit sequence used is 1 1 1 0 0 1 0 1 1 0 0 0.



Possible answers are “Unipolar RZ”, “Unipolar NRZ”, “polar RZ”, “polar NRZ”, “bipolar RZ”, “bipolar NRZ”, “Manchester”

Extra Question

Here is an optional question for those who want more practice.

Problem 6. Consider a raised cosine pulse $p_{\text{RC}}(t; \alpha)$ with rolloff factor α and symbol “duration” T . Its time domain expression is

$$p_{\text{RC}}(t; \alpha) = \frac{\cos \frac{\alpha\pi t}{T}}{1 - \frac{4\alpha^2 t^2}{T^2}} \operatorname{sinc} \frac{\pi t}{T} = \frac{\cos \frac{\alpha\pi t}{T}}{1 - \frac{4\alpha^2 t^2}{T^2}} \frac{\sin \frac{\pi t}{T}}{\frac{\pi t}{T}}. \quad (9.1)$$

- (a) Find $p(T/2)$ as a function of α .
- (b) Use MATLAB to plot $p(T/2)$ as a function of α .
- (c) Find $\lim_{\alpha \rightarrow 1} p_{\text{RC}}\left(\frac{T}{2}; \alpha\right)$.