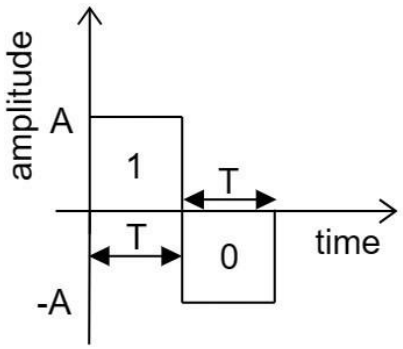
ET3223 Assignment 01 on Digital Base-band Transmission

Deadline: July 19, 2024

1. Draw the binary waveform output for the bit pattern 101110 for the following schemes.
   - Unipolar NRZ
   - Polar NRZ
   - Unipolar RZ
   - Bipolar RZ
   - Manchester NRZ
2. Both bipolar NRZ and RZ line coding schemes can present timing recovery challenges, especially when there are long runs of consecutive bits with the same value. Briefly explain the reason behind this?
3. The maximum peak pulse signal-to-noise ratio of a matched filter is given by

$$\eta_{max} = \frac{E}{No/2}$$

   Here, E and $N_o/2$ is the signal energy and power spectral density of the white noise. Given that a minimum peak pulse signal-to-noise ratio of 15 dB is required for the receiver to detect the pulse. Determine the minimum required signal energy for successful pulse detection, considering a noise power spectral density of $N_o/2 = 10^{-4}$ Watts/Hz.
4. Consider the signal shown in below.



   Draw impulse response of a matched filter to this signal as a function of a time.

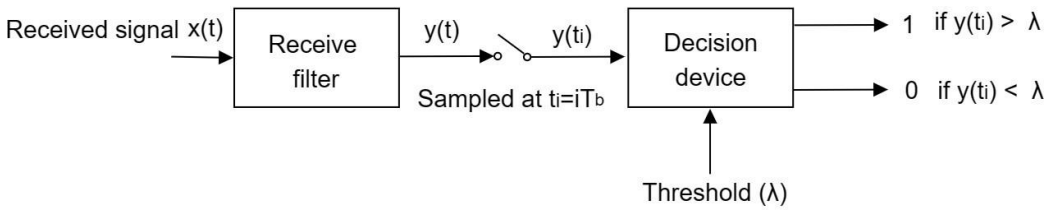


Figure 1: Receiver architecture.

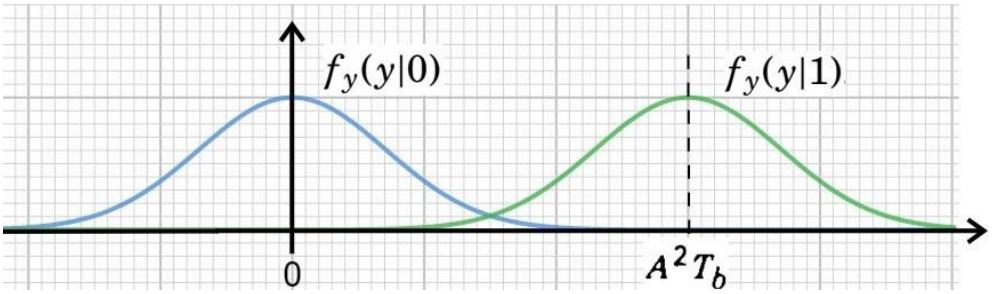


Figure 2: Probability density functions of $f_y(y|0)$ and $f_y(y|1)$

5. A binary Pulse Code Modulation (PCM) system waveform is transmitted using unipolar NRZ (Non-Return-to-Zero) signaling. In this scheme, symbol 1 is represented by a rectangular pulse with amplitude A and duration T_b. The channel noise is modeled as additive white Gaussian, with a zero mean and a power spectral density of $N_0/2$. Figure 1 show the architecture of the receiver. Here, the conditional probability density function of the random variable Y (sample value $y(t_i) = y$), obtained by sampling the matched filter output at the end of a signaling interval, is denoted by $f_y(y|0)$ when symbol 0 was transmitted. Similarly, $f_y(y|1)$ denotes the conditional probability density function of Y when symbol 1 was transmitted. Let's define the threshold used in the receiver as λ. If the sample value y exceeds the threshold λ, the receiver decides in favor of symbol 1. On the other hand, if the sample value y is less than or equal to the threshold λ, the receiver decides in favor of symbol 0. Figure 2 illustrates the probability density functions of $f_y(y|0)$ and $f_y(y|1)$.

   - Given that symbols 1 and 0 occur with equal probability, your task is to draw the optimal threshold value (λ) on the Figure 2. This threshold value is selected to obtain minimum probability of symbol error. Briefly explain why you have selected this threshold value.
   - It is given that symbols 1 and 0 occurring probabilities are p_1 and p_0, respectively. Here, it is given that $p_0 \gg P_1$, in this scenario, state in what direction λ need to be move (left or right on the Figure 2) to achieve minimum probability of symbol error. Briefly explain reasons for your answer.

Submission

- Upload a report (eight pages or less) named as "your_index_a01.pdf". Include the index number and the name within the pdf as well.
- Plagiarism will be checked and in cases of plagiarism, a penalty of 10% will be applied.