# EEE/ECE F311
# Communication Systems
## Tutorial-13

**Date : 13/11/2025**
**Date : 18/11/2025**

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1. **A Binary communication system transmits signals $s_i(t)$ (i=1, 2). The receiver test statistic $z(T)= a_i+n_0$, where the signal component $a_i$ is either $a_1=+1$ or $a_2=-1$ and the noise component $n_0$ is uniformly distributed, yielding the conditional density functions $p(z/s_i)$ given by**

$$p(z|s_1) = \begin{cases} \frac{1}{2} & \text{for } -0.2 \le z \le 1.8 \\ 0 & \text{otherwise} \end{cases} \quad \text{and} \quad p(z|s_2) = \begin{cases} \frac{1}{2} & \text{for } -1.8 \le z \le 0.2 \\ 0 & \text{otherwise} \end{cases}$$

Find the probability of a bit error, $P_B$, for the case of equally likely signaling and the use of an optimum decision threshold.

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## Solution 1

$$P_B = 1/2 \int_{-0.2}^{0} 0.5\, dz + 1/2 \int_{0}^{0.2} 0.5\, dz = 0.1$$

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**2.** Consider that NRZ binary pulses are transmitted along a cable that attenuates the signal power by 3 dB (from transmitter to receiver). The pulses are coherently detected at the receiver, and the data rate is 56 kbit/s. Assume Gaussian noise with $N_0 = 10^{-6}$ Watt/Hz. What is the minimum amount of power needed at the transmitter in order to maintain a bit-error probability of $P_B = 10^{-3}$?

| | $Q(x)$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $x$ | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| 2.9 | 0.0019 | 0.0018 | 0.0018 | 0.0017 | 0.0016 | 0.0016 | 0.0015 | 0.0015 | 0.0014 | 0.0014 |
| 3.0 | 0.0013 | 0.0013 | 0.0013 | 0.0012 | 0.0012 | 0.0011 | 0.0011 | 0.0011 | 0.0010 | 0.0010 |
| 3.1 | 0.0010 | 0.0009 | 0.0009 | 0.0009 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0007 | 0.0007 |

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## Solution 2

=> Power = $A^2 = (3.1)^2 \times 10^{-6} \times ½ \times 56000 = 0.269$ Watts

With 3db loss in the cable, Tx power should be twice,
i.e. power needed = 0.538 Watts.

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**3. A binary digital communication system employs the signal**

$$s(t) = \begin{cases} \dfrac{1}{\sqrt{T_s}} & 0 \le t \le T_s \\ 0 & otherwise \end{cases}$$

**(a) Determine the impulse response of a filter matched to this signal and sketch it as a function of time.**

**(b) Plot the matched filter output as a function of time.**

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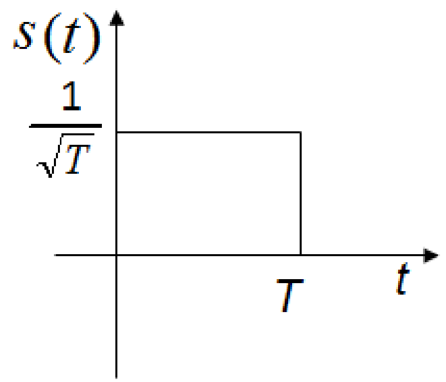
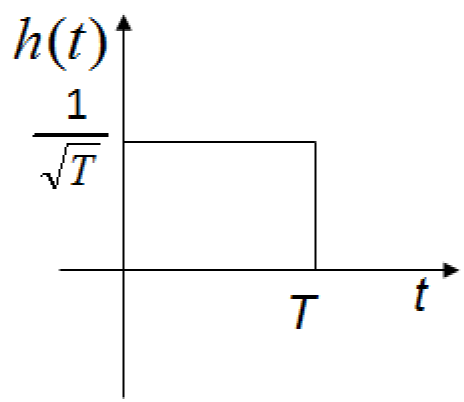
## Solution 3

The impulse response of the matched filter is $h(t) = s(T-t)$

(a)



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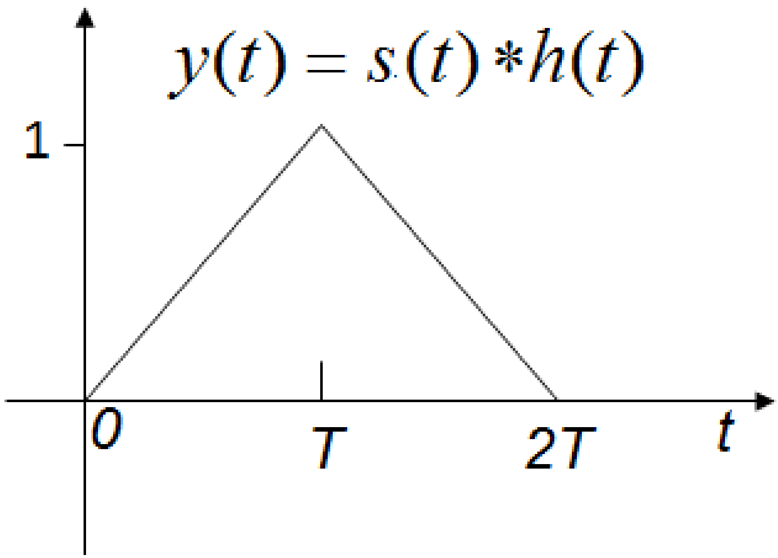
## Solution 3

(b)



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**4. A source emits seven messages with probabilities 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, and 1/64 respectively. Find the entropy of the source.**

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**Entropy of the source = H= $p_1 \log_2 (1/p_1) + \ldots\ldots + p_7 \log_2 (1/p_7)$**

**= 1.969 Bits/message**

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**5. Assume that normal speech rate is 250 words per minute. Also assume that the average word contains six characters and the character within a word are statistically independent. Based on these assumptions, compute the information rate.**

**(Note : Information rate =( Rs X H(X)) per sec )**

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## Solution 5

entropy of English text = H= [(1/26) $\log_2$ (1/1/26) ] x 26 = 4.7 bits /character

**R = 25X4.7=117.5 bits/sec**

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*Thank You !*