



**BITS Pilani**

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Department of Electrical Engineering



# **EEE/ECE F311**

# **Communication Systems**

## **Tutorial-14**

**Date : 20/11/2025**

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# Tutorial-14

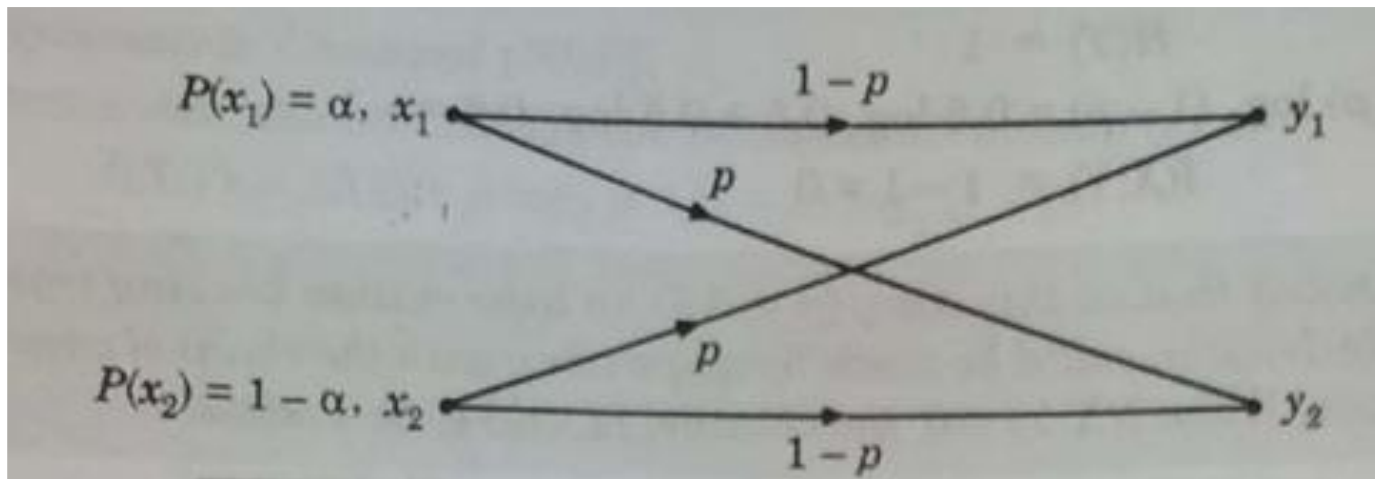
**1. A Binary symmetric channel (BSC) with  $P(x_1) = \alpha$ .**

**(i) Show that the mutual information  $I(X;Y)$  is given by**

$$I(X;Y) = H(Y) + p \log_2 p + (1-p) \log_2 (1-p)$$

**(ii) Calculate  $I(X;Y)$  for  $\alpha=0.5$  and  $p=0.1$**

**(iii) Repeat part (ii) for  $\alpha=0.5$  and  $p=0.5$ , and comment on the result.**



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## Solution 1

$$I(X; Y) = H(Y) - H(Y|X) = H(Y) + p \log_2 p + (1 - p) \log_2 (1 - p)$$

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**Solution 1 (ii)**

$$I(X;Y) = 0.531 \text{ bits/message}$$

**Solution 1 (iii)**

$$I(X;Y) = 0$$

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2. A DMS  $X$  has four symbols  $x_1, x_2, x_3, x_4$  with probability  $1/2, 1/4, 1/8$ , and  $1/8$ . Construct a Shannon Fano code for  $X$ ; show that this code has the optimum property  $n_i = I(x_i)$  and the code efficiency is 100 percent.

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## Solution 2

$$H(X)=1.75 \text{ bits/Message}$$

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- 3. A DMS X has five equally likely symbols.**
- (i) Construct a Shannon–Fano code for X, and calculate the efficiency of the code.**
  - (ii) Construct another Shannon–Fano code and compare the results.**
  - (iii) Repeat for the Huffman code and compare the results.**

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## Solution 3

$$H(X) = 2.32 \text{ bits/Message}$$

$$L = 2.4 \text{ bits/Message}$$

$$\eta = 96.7\%$$

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- 4. A DMS  $X$  has five symbols  $x_1, x_2, x_3, x_4, x_5$  with probabilities 0.4, 0.19, 0.16, 0.15 and 0.1.**
- (i) Construct a Shannon–Fano code for  $X$ , and calculate the efficiency of the code.**
  - (ii) Repeat for the Huffman code and compare the results.**

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## Solution 4

### Shannon Fano Code:

$H(X) = 2.15$  bits/Message

$L = 2.25$  bits/Message

$\eta = 95.6\%$

### Huffman Code:

$H(X) = 2.15$  bits/Message

$L = 2.2$  bits/Message

$\eta = 97.7\%$

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5. Given an AWGN channel with 4 kHz bandwidth and the noise power spectral density  $\eta/2=10^{-12}$  W/Hz. The signal power required at the receiver is 0.1 mW. Calculate the capacity of this channel.

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## Solution 5

$$C = 54.44 \text{ Kbps}$$

6.

An Analog signal having 4 kHz bandwidth is sampled at 1.25 times the Nyquist rate, and each sample is quantized into one of equally likely levels. Assume that the successive samples are statistically independent.

- (i) What is the information rate of this source?
- (ii) Can the output of this source be transmitted without error over an AWGN channel with a bandwidth of 10 kHz and an S/N ratio of 20 dB?
- (iii) Find the S/N ratio required for error-free transmission for part (i).
- (iv) Find the bandwidth required for an AWGN channel for error-free transmission of the output of this source if the S/N ratio is 20 dB?

Number of source symbols = 256

## Solution 6

- (i)  **$R = 80 \text{ Kbps}$**
- (ii)  **$R > C$  error-free transmission not possible**
- (iii)  **$S/N \geq 24.1 \text{ dB}$**
- (iv)  **$B \geq 12 \text{ KHz}$**

*Thank You !*