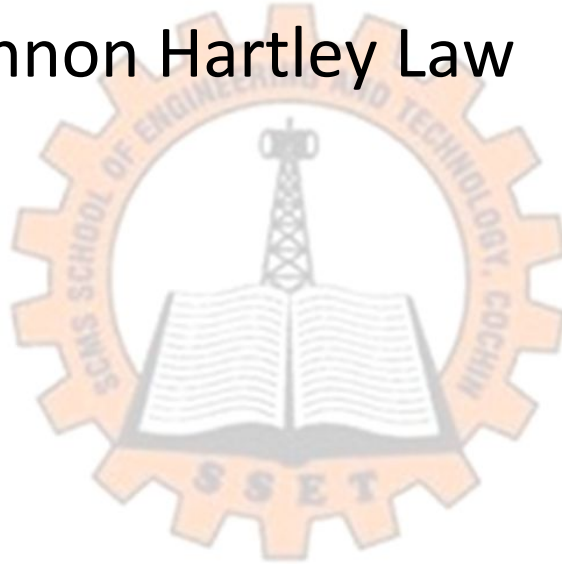


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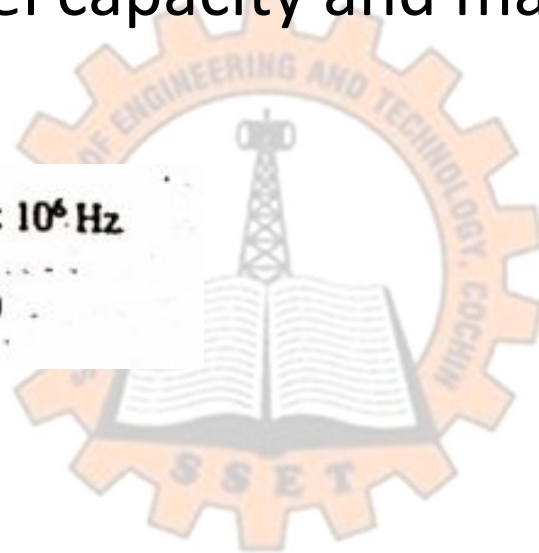
- Quick recap
- Problems based on Shannon Hartley Law



# Example 1

- A gaussian channel has a 10 MHz Bandwidth. If S/N ratio is 100. Calculate the channel capacity and maximum rate of information?

Given  $B = 10 \times 10^6 \text{ Hz}$   
 $\frac{S}{N} = 100$



$$\therefore C = B \log \left( 1 + \frac{S}{N} \right) = 10 \times 10^6 \log(1 + 100)$$

$$\therefore C = 66.59 \times 10^6 \text{ bits/sec}$$

$$N = B$$

$$= N/B$$

Maximum Information rate  $R_{\max} = C = \left( \frac{S}{N} \right) B \log_2 e$

$$\therefore R_{\max} = (100) (10 \times 10^6) \log_2 e$$

$$\therefore R_{\max} = 1.44 \times 10^9 \text{ bits/sec}$$

## Example 2

1. A Gaussian channel has 1 MHz BW. Calculate the channel capacity if the signal power to the noise power spectral density ratio  $(S/N) = 10^5 \text{ Hz}$ . Also find max. information rate.



$$C = B \log_2 \left( 1 + \frac{S}{N} \right)$$

$$N = \eta B$$

$$= B \log_2 \left( 1 + \frac{S}{\eta B} \right)$$

$$= 1 \text{ MHz} \cdot \log_2 \left( 1 + \frac{10^5}{10^6} \right)$$

$$= 137.5 \text{ kbits/sec.}$$

137.5 kbits/sec.

Max Information Rate  $R_{\max} = \frac{S}{\eta} 1.44$   
 $= 1.44 \times 10^5 = \underline{\underline{144 \text{ Kbits/sec}}}$





# Example 3

**Example 4.27 :** A Gaussian channel has a bandwidth of 4 KHz and a two sided noise power spectral density  $\eta/2$  of  $10^{-14}$  watts/Hz. Signal power at the receiver has to be maintained at a level less than or equal to 0.1 milli watt. Calculate the capacity of the channel.

Given  $B = 4000 \text{ Hz}$

$$\frac{\eta}{2} = 10^{-14} \text{ watts/Hz}$$

$$\therefore \text{Noise power} = N = \eta B = 2 \times 10^{-14} \times 4000$$

$$= 8 \times 10^{-11} \text{ watts.}$$

$$\text{Signal power } S \leq 0.1 \times 10^{-3} \text{ watts}$$

$$\left(\frac{S}{N}\right)_{\max} = \frac{0.1 \times 10^{-3}}{8 \times 10^{-11}} = 1.25 \times 10^6$$

$$\therefore \text{Channel capacity} = B \log \left(1 + \frac{S}{N}\right)$$

$$= 4000 \log (1 + 1.25 \times 10^6)$$

$$\therefore C = 81014 \text{ bits/sec}$$



## Example 4

③ Alphanumeric data are entered into a computer from a remote terminal through a voice grade telephone channel. The channel has a BW of 3.4 KHz and output SNR of 20 dB. The terminal has a total of 128 symbols. Assume that the symbols are equiprobable and the successive transmissions are statistically independent.

- calculate channel capacity
- Find the average information content per character
- calculate the max. symbol rate for which error-free transmission over the channel is possible.

Given :

$$B = 3.4 \text{ KHz} = 3400 \text{ Hz}.$$

$$10 \log_{10} \frac{S}{N} = 20 \text{ dB}$$

$$\frac{S}{N} = 100.$$

No: of characters =  $q = 128$  equiprobable characters.



a) Channel capacity  $C$   
 $C = B \log_2 \left( 1 + \frac{S}{N} \right)$

b) Avg information content per character  
(it is max since all the characters are equiprobable).

$$I_{\text{max}} = \log_2 q = \log_2 128 = \underline{\underline{7 \text{ bits/character}}}$$

c) avg info rate  $R_s = R_c H$

For error-free transmission  $R_s < C$ .

$$R_s H < C$$

$$R_s < \frac{C}{H}$$

$$R_s < \frac{22638}{7} \approx 3234 \text{ Symbols/sec.}$$

$\therefore$  maximum symbol rate for which error-free transmission over the channel is possible  ~~$R_s <$~~   $= 3234 \text{ symbols/sec}$

## Example 5

- 4) A voice grade channel of the telephone m/w has a BW 3.4KHz
- a) find  $C$  for  $\text{SNR} = 30\text{dB}$
  - b) find minimum SNR ratio required to support information transmission thru telephone channel at rate of 4800 bits/sec.



Given:

$$B = 3.4 \text{ kHz} = \underline{\underline{3400 \text{ Hz}}}$$

$$10 \log_{10} \frac{S}{N} = 30 \text{ dB} \Rightarrow$$

$$\Rightarrow \log_{10} \frac{S}{N} = 3$$

$$\therefore \underline{\underline{\frac{S}{N} = 10^3}} \quad \underline{\underline{10^3}} \quad \therefore$$



$$a) C = B \log_2 (1 + S/N)$$

$$= 3400 \log_2 (1 + 1000)$$

$$= \underline{\underline{33889 \text{ bits/sec}}}$$

$$b) C = 4800 \text{ bits/sec}$$

$$S/N = ?$$

$$C = B \log_2 (1 + S/N)$$

$$4800 = 3400 \log_2 \left(1 + \frac{S}{N}\right)$$

$$\log_2 (1 + S/N) = \frac{4800}{3400}$$

$$(1 + S/N) = 2 \quad 48/34$$

$$\frac{S}{N} = 2 \quad 24/17 - 1 = \underline{\underline{1.66}}$$

$$\text{or } \frac{S}{N} \text{ in dB} = 10 \log_{10} 1.66 = \underline{\underline{2.2 \text{ dB}}}$$

$$\underline{\underline{\frac{S}{N} = 2.2 \text{ dB}}}$$

# CONCLUSION

- Problems on channel capacity, S/N

