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Example 6:

5) An analog signal has a 4KHz bandwidth. The signal is sampled at 2.5 times the nyquist rate and each sample is quantized into 256 equally likely levels. Assume that the successive samples are statistically independent.

i) find the information rate of this source.

iii) can the output the of source be transmitted without errors over an analog channel having (S/N) of 10dB. Compute the BW required for the channel.

iv) Calculate channel capacity if S/N = 20dB. If to be transmitted without errors

$B = 4000 Hz$

Nyquist rate $= 2B$

$= 2 \times 4000$

$= \underline{8 KHz}$.

Sampling Rate $=$ (2.5) Nyquist rate

$r_s = 2.5 \times 8K$

$= 20 K$ samples/sec.

a) Information Rate $R_s = r_s \cdot H_{max}$

$$H_{max} = \log_2 q$$

$$= \log_2 256$$

$$= 8 \text{ bits/sample}$$

$$R_s = 20 \times 8 = 160\text{K bits/sec}$$

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

$10\log_2 S/N = 20\text{dB}$.

$\log_{10} S/N = 2$

$\frac{S}{N} = \cancel{2}\,10^2$

$= 100$

$B = 50\text{KHz}$

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

$= 50\text{KHz} \log_2(1+100)$.

$= 332.91\times10^3$ bits/sec.

$R_s < C$, according to Shannon's theorem, it is possible to transmit over the given channel. Without errors (iii). $10 \log_{10} S/N = 10\,dB$

$$\log_{10} S/N = 10^1$$

$$= \underline{10}$$

From Shannon Hartley theorem

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

$$= R_s$$

$$B = \frac{R_s}{\log_2 (1+S/N)} = \frac{160 \times 10^3}{\log_2 (1+10)} = \underline{\underline{46.25\,KHz}}$$

Example 7

Example 4.24 : A black and white television picture may be viewed as consisting of approximately 3×10^5 elements, each one of which may occupy one of 10 distinct brightness levels with equal probability. Assume (a) the rate of transmission is 30 picture frames per second and (b) the signal-to-noise ratio is 30 dB.

Using the channel capacity theorem (Shannon-Hartley law), calculate the minimum bandwidth required to support the transmission of the resultant video signal.

Given number of elements/picture frame $= 3 \times 10^5$

Number of brightness levels $= 10$

$\therefore$ Number of different frames possible $= 10^{3 \times 10^5}$ frames.

Since all the levels are equiprobable, the maximum average information content per frame is given by

$$I = \log_2 10^{3 \times 10^5} \text{ bits/frame}$$

$$= 3 \times 10^5 \log_2 10 \text{ bits/frame}$$

$$\mathbf{I = 9.96 \times 10^5 \text{ bits/frame}}$$

The maximum rate of information is given by

$$R_{s_{max}} = r_s I$$

$$= (30 \text{ frames/sec})(9.96 \times 10^5 \text{ bits/frame})$$

$$= 29.88 \times 10^6 \text{ bits/sec}$$

According to Shannon's second theorem, $R_{s_{max}}$ is equal to channel capacity C. And accordi[ng] to Shannon-Hartley law.

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

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

$$\therefore \quad \frac{S}{N} = 1000$$

$$\therefore \quad B = \frac{C}{\log_2\left(1+\frac{S}{N}\right)} = \frac{29.88\times10^6}{\log_2(1+1000)}$$

$$\therefore \quad B = 3\,\text{MHz}$$

Example 7:

⑥. A friend of urs says he can ~~transmit~~ design a sys to transmit o/p of a mini computer to a line printer operating at a speed of 30 lines/minute over a voice grade telephone line with BW 3.5 KHz and (S/N) of 30 dB. Assume that the line printer needs 8 bits of data per character and prints out 80 characters per line. Would you believe him?

Given

$B = 3.5 KHz$.

$10 \log_{10} (S/N) = 30$.

$\log_{10} S/N = 3$.

$\underline{\underline{S/N = 1000}}$

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

$$= 34885.292 \text{ bits/sec.}$$

Given R_s = 30 lines / minute

= 0.5 lines/sec.

R_s = Has

= (8 bits / character) (80 character / line) (0.5 lines/sec)

= 320 bits/sec.

- Since Rs<C, your friend is right

CONCLUSION

- Problems on Shannon Hartley law