Assignment-4

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1. A PCM system frequency is 2 KHz and pick amplitude is 10V. and number of bit is 10. Find-
(a) Sampling Rate (b) Sampling time (c) Bit Rate (d) Bit interval (e) Step size (f) Quantization level (g) Maximum level (h) Noise power (i) Signal Power (j) SNR_{db} (k) Max BW and Min BW.

Solution: Given, $f_m = 2KHz$
number of bit $= 10 = n$
Peak amplitude, $E_{max} = 10V$.

a) Sampling Rate, $f_s = 2 \times f_m = 2 \times 2kHz = 4KHz$

b) Sampling time, $T_s = \frac{1}{f_s} = \frac{1}{4} = 0.25ms$

c) Bit Rate, $R_b = n \times f_s = 10 \times 2 \times 10^3 = 20$ Kbps

e) Step Size, $\Delta = \frac{2 \times E_{max}}{L} = \frac{2 \times 10}{1024} = 0.019$

We know,
$L = 2^n$
$L = 2^{10}$
$= 1024$

d) Bit interval, $T_b = \frac{1}{R_b}$
$= \frac{1}{20 \times 10^3}$
$= 50 \mu s$

f) Quantization level, $L = 1024$

g) Maximum level, $L_M = 2^n - 1 = 1024 - 1 = 1023$

h) Noise power $= \frac{\Delta^2}{2} = \frac{0.019^2}{2} = 0.1805 \times 10^{-3}$

(i) Signal Power $= \frac{\text{Amplitude}^2}{2} = \frac{10^2}{2} = 50 \text{ mW}$

(j) $SNR_{db} = 10 \log_{10}(SNR)$

$= 10 \log_{10}(277)$

$= 24.42$ db.

$SNR = \frac{\text{Signal Power}}{\text{Noise/quantization noise Power}}$

$= \frac{50 \text{ mW}}{0.1805 \times 10^{-3}}$

$= \frac{50 \times 10^{-3}}{0.1805 \times 10^{-3}}$

$= 277$

(k) Maximum BW, $R_b = n \times f_s$

$= 10 \times 2 \times 10^3$

$= 20$ kbps

~~Max~~ Min BW, $= \frac{R_b}{2} = 10$ kbps

2. A television system (Video & ~~aud~~ audio) has a BW of 4.5 MHz. This signal sampled Quantized and Binary coded to obtain a PCM signal.

(a) Determining the sampling rate if the signal is to be sampled at a rate 20% above Nyquist rate

(b) If the samples are quantized into 1024 level determine the minimum BW required to transmit the signal.

Solution:- Given, Bandwidth = 4·5 MHz

a) Te nyquist rate, $f_s = 2 \times f_m$
$= 2 \times 4 \cdot 5$ MHz
$= 9$ MHz

To sample the signal at a 20% above nyquist rate, $\frac{20}{100} = 0 \cdot 2$

$\therefore$ 20% of $f_s = 9 \times 0 \cdot 2 = \cdot\cdot 5$ MHz.

$\therefore$ The sampling rate above 20% $= (9 + 1 \cdot 8)$ MHz.
$= 10 \cdot 8$ MHz

b) Given level of quantization $= 1024$.

$L = 2^n$

$\log_{10} L = n \log_{10} 2$

$\therefore n = \frac{\log_{10} 1024}{\log_{10} 2}$

$= 10$.

Minimum bandwidth, $f_{min} = \frac{n \times f_s}{2} = \frac{10 \times 10 \cdot 8}{2}$

$= 54$ MHz

3) A PCM-TDM system multiplexes 10 band limited voice channel (300 - 3400) Hz and uses a 256 level quantization. If the signal is sampled at a rate 17.647% higher than Nyquist Rate, then what will be the max bandwidth of the transmission channel?

Ans:- The bandwidth of each channel is ~~(3400 - 300)Hz~~
= ~~3100KHz~~.

∴ The message frequency, $f_m = 3\cancel{1}4 00\text{KHz}$.

∴ The sampling rate, $f_s = 2 \times f_m = 6\cancel{2}8 00\text{KHz}$.

the sampling rate, 17.647% higher than Nyquist rate.

∴ Sampling rate $= 6\cancel{2}800\left(1 + \frac{17.647}{100}\right) = \cancel{7294.114\text{Hz}}$

8KHz

Given, 256 level. ∴ $L = 2^n$

$\Rightarrow 256 = 2^n$

$\Rightarrow \log_{10} 256 = n \log_{10} 2$

$\Rightarrow n = \frac{\log_{10} 256}{\log_{10} 2} = 8$

∴ The maximum Bandwidth, $B_{max} = n \times f_s$.

$= 8 \times \cancel{7294.114}\ 8\ \text{Hz}$

$= \cancel{58352.912}\ \text{Hz}$

64 KHZ

There are 10 band limited,

∴ the maximum bandwidth of the transmission channel is $10 \times \cancel{58352.912}\ 64 = \cancel{583529\ \text{Hz}}$

~~= 583 KHz~~

= 640 KHz

Ans

4 A PCM System multiplexes 20 band limited voice channel (300 - 3400) Hz. 15 of them are multiplexes using a 256 level quantization considering the standered rate for telephone system. What will be the BW of binary coded signal?

Solution:- Given, total band = 20.

~~Bandwidth~~, $f_m = (3400 \cancel{- 300) \text{ Hz}}$

$= \cancel{3100 \text{ Hz}}$.

15 channels are multiplexed at 256 level quantization.

$\therefore L = 2^n$

$\Rightarrow \log_{10} L = n \log_{10} 2$

$\therefore n = \frac{\log_{10} 256}{\log_{10} 2}$

$= 8$ bits.

$\therefore F_s = 2 \times f_m$

$= 6800$ Hz

The standard rate for telephone System = 8 KHz

For 15 bands, $n = 8 \times 15 = 120$ bits.

~~The band~~ For

$\therefore$ Bandwidth for 15 bands, $B_W = n \times f_s$

$= 120 \times 6200$

$= 744000$ Hz

744 KHz

sinusoidal

5 In a binary PCM system the output signal to quantization noise ratio is 40db. Determine the required level.

Solution: Given, $SNR_{db} = 40db$.

$$SNR_{db} = (1.8 + 6n)\ db.$$

$$40 = 1.8 + 6n$$

$$n = \frac{40 - 1.8}{6} = 6.366 \approx 7$$

The minimum value of 'n' to maintain a minimum of 40db of SNR is 7 $\therefore n = 7$

The ~~qu~~ number of required levels of the quantizer will be; $L = 2^n = 2^7 = 128$ levels