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EEE/ECE F311
Communication Systems
Tutorial-8

Date : 25/09/2025
Date : 30/09/2025

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1. An analog signal is quantized and transmitted by using a PCM system. If each sample at the receiving end of the system must be known to within ±0.5% of the peak-to-peak full-scale value, how many binary digits must each sample contain?

Ans: n=7 bits

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2. In a binary PCM system, the output SQNR is to be held to a minimum of 40 dB. Determine the number of required levels and find the corresponding SQNR.

Ans: L=128, SNR= 43.9 dB

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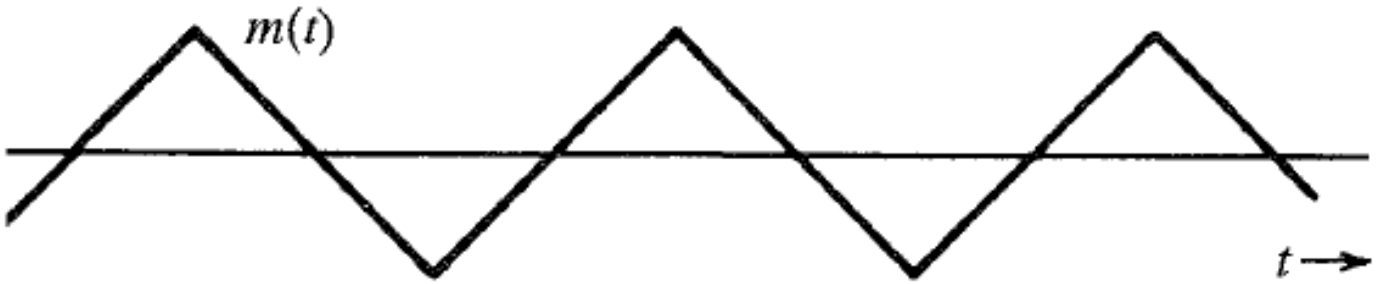
3. A signal m(t), as shown in figure, is transmitted by binary PCM without compression. If the SNR is required to be at least 47 dB, determine the minimum value of L required. Also, determine the value of SNR obtained with this minimum value of L.



Ans: L=256, SNR= 48.2 dB

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4. A signal with frequency f_m = 1.5 kHz, is to be transmitted using PCM. The quantization noise should not to exceed ± 10% of the peak to peak signal.

a) **What is the minimum required sampling rate ?**
b) **What is the minimum number of bits per sample or bits/PCM word that should be used in digitizing the analog waveform**
c) **What is the resulting bit transmission rate ?**
d) **What is the transmission Bandwidth ?**

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Solution 4

a) Min Sampling Rate = 3000 samples per second:

b) n = 3

c) Bit Transmission Rate= R_b = 9000 bits / second

d) Transmission BW = 4.5 KHz

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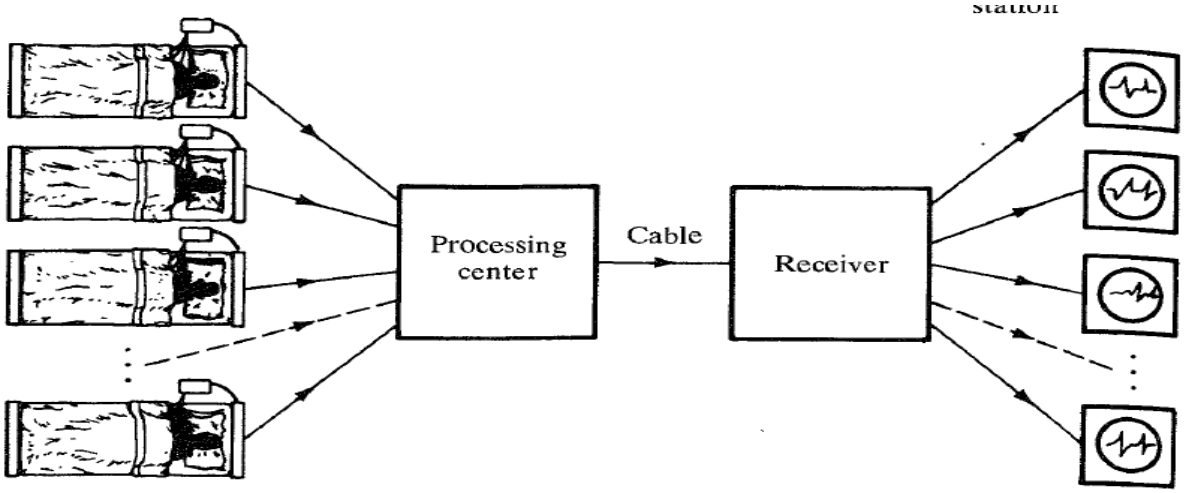
5. It is desired to set up a central station for simultaneous monitoring of the electrocardiograms (ECGs) of 10 hospital patients. The data from the rooms of the 10 patients are brought to a processing center over wires and are sampled, quantized, binary coded, and time-division multiplexed. The multiplexed data are now transmitted to the monitoring station. The ECG signal bandwidth is 100 Hz. The maximum acceptable error in sample amplitudes is 0.25% of the peak signal amplitude. The sampling rate must be at least twice the Nyquist rate. Determine the minimum cable bandwidth needed to transmit these data.



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Solution 5

Minimum cable bandwidth = 18 kHz.

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6. A waveform, $x(t) = 10 \cos(1000t+\pi/3) + 20 \cos(2000t+\pi/6)$ is to be uniformly sampled for digital transmission.

(a) What is the maximum allowable time interval between sample values that will ensure perfect signal reproduction?

(b) If we want to reproduce 1 hour of this waveform, how many sample values need to be stored?

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Solution 6

$T_s = 1/f_s \leq 0.00157$ sec

samples= 2.29×10^6 samples