Experiment No.2

To study the various waveform coding scheme

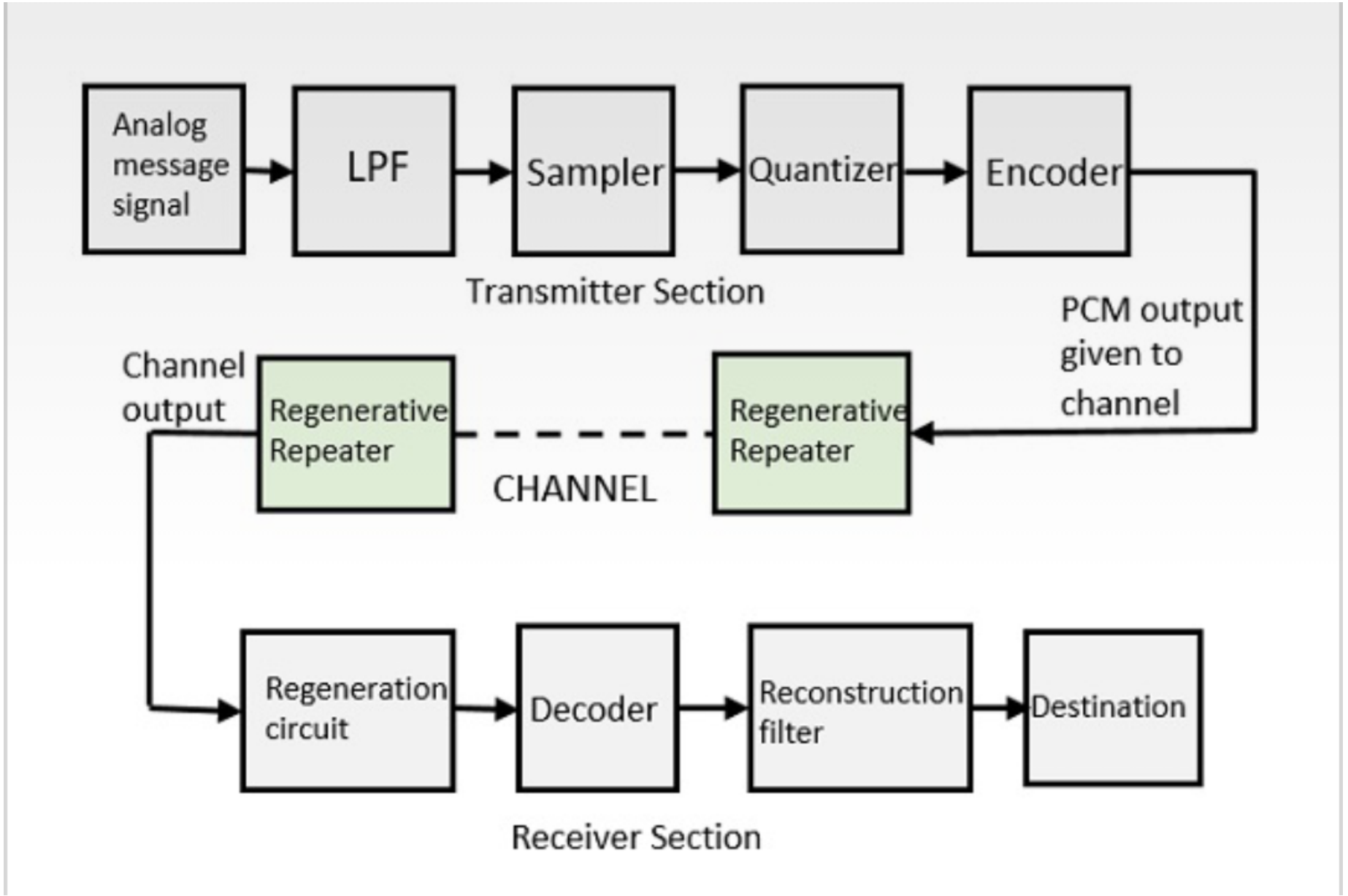
PCM, DPCM, Quantization, DM,ADM

- If you amplify analog signals, it also amplifies noise, and eventually analog connections become too noisy to use.
- Digital signals, having only "one-bit" and "zero-bit" states, are more easily separated from noise.
- They can be amplified without corruption. Digital coding is more immune to noise corruption on long-distance connections.
- Also, the world's communication systems have converted to a digital transmission format called pulse code modulation (PCM). PCM is a type of coding that is called "waveform" coding because it creates a coded form of the original voice waveform.

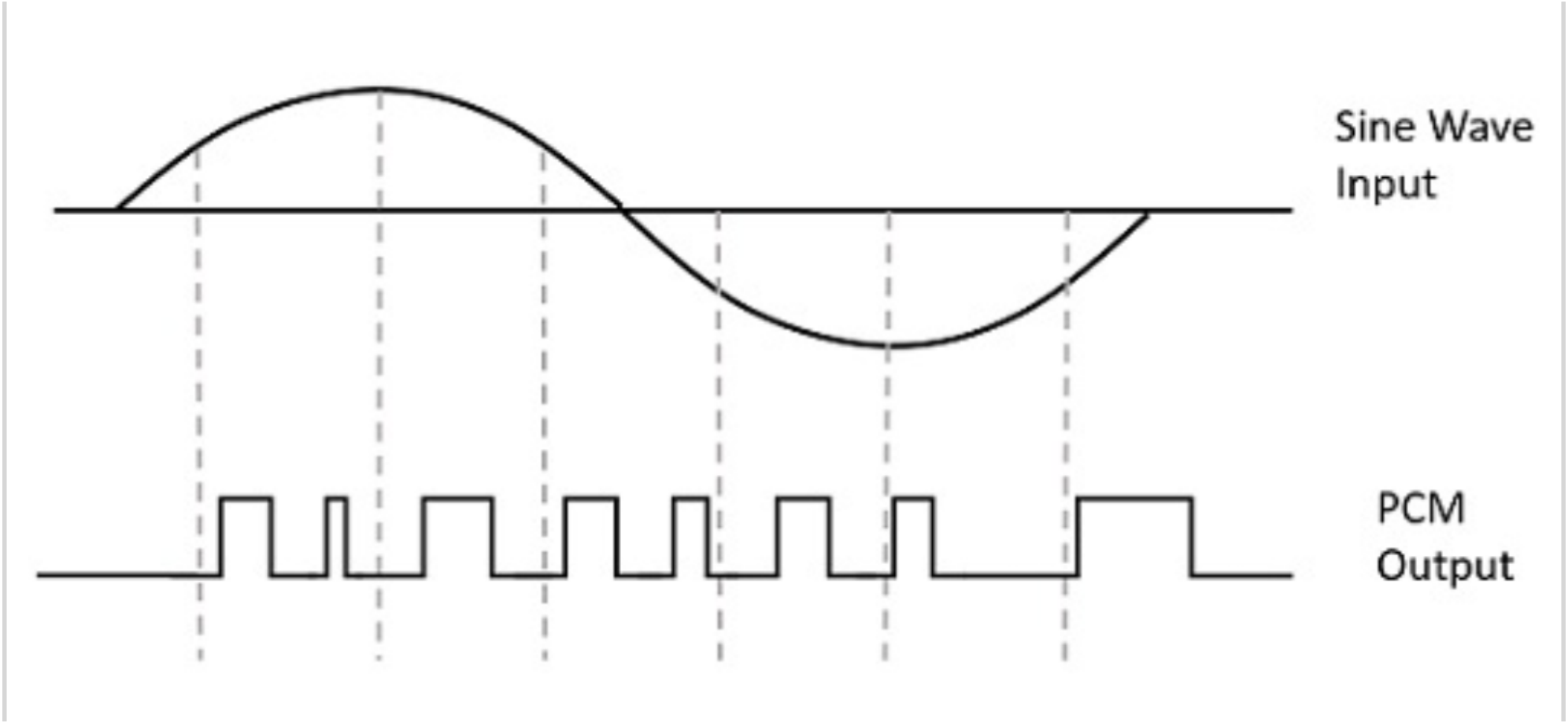
PCM:

- A signal is pulse code modulated to convert its analog information into a binary sequence, i.e., 1s and 0s.
  - The output of a PCM will resemble a binary sequence.
  - The following figure shows an example of PCM output with respect to instantaneous values of a given sine wave.

PCM Transmitter and receiver:



PCM Waveform:



- **Low Pass Filter:** This filter eliminates the high frequency components present in the input analog signal which is greater than the highest frequency of the message signal, to avoid aliasing of the message signal.
- **Sampler:** This is the technique which helps to collect the sample data at instantaneous values of message signal, so as to reconstruct the original signal. The sampling rate must be greater than twice the highest frequency component W of the message signal, in accordance with the sampling theorem.
- **Quantizer:** Quantizing is a process of reducing the excessive bits and confining the data. The sampled output when given to Quantizer, reduces the redundant bits and compresses the value.
- **Encoder:** The digitization of analog signal is done by the encoder. It designates each quantized level by a binary code. The sampling done here is the sample-and-hold process. These three sections (LPF, Sampler, and Quantizer) will act as an analog to digital converter. Encoding minimizes the bandwidth used.

- **Regenerative Repeater:** This section increases the signal strength. The output of the channel also has one regenerative repeater circuit, to compensate the signal loss and reconstruct the signal, and also to increase its strength.
- **Decoder:** The decoder circuit decodes the pulse coded waveform to reproduce the original signal. This circuit acts as the demodulator.
- **Reconstruction Filter:**
- After the digital-to-analog conversion is done by the regenerative circuit and the decoder, a low-pass filter is employed, called as the reconstruction filter to get back the original signal.
- Hence, the Pulse Code Modulator circuit digitizes the given analog signal, codes it and samples it, and then transmits it in an analog form.
- This whole process is repeated in a reverse pattern to obtain the original signal

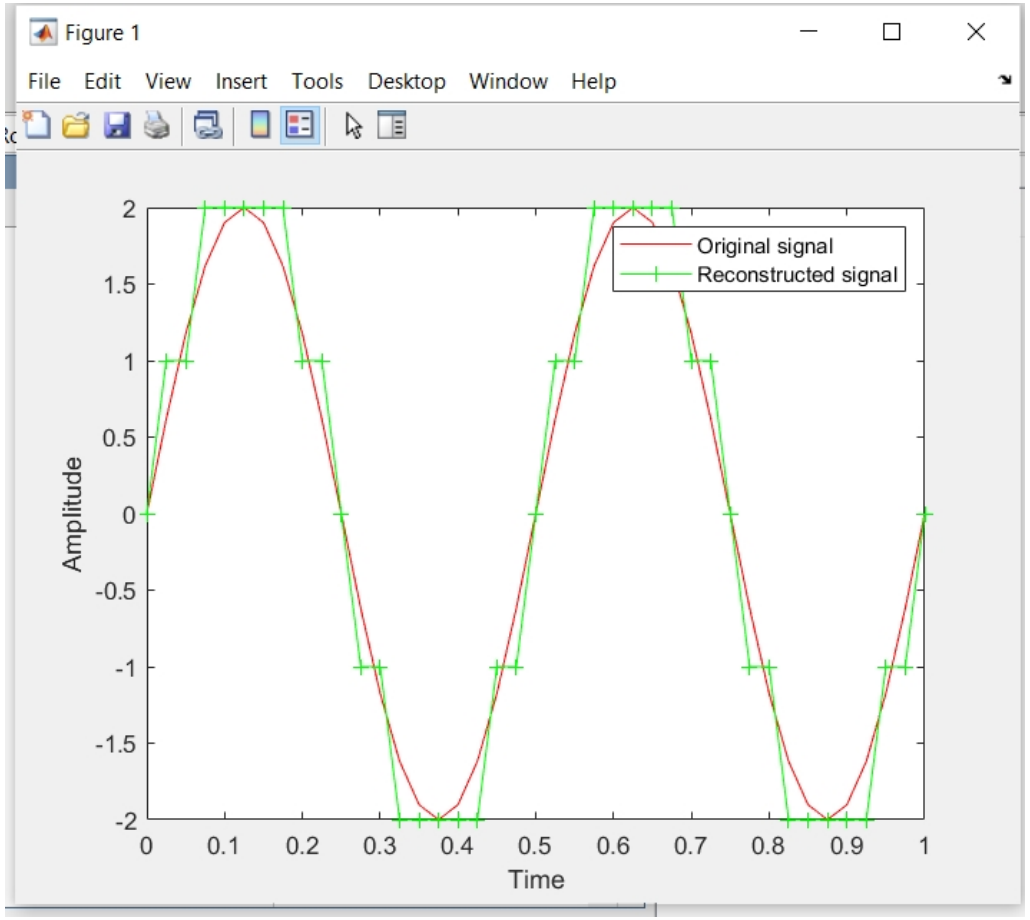
MATLAB code: PCM

```
% PCM
% Sinusoidal analog signal
f=2;              % maximum frequency of the input signal
fs=20*f;     % Nyquist sampling rate
t=0:1/fs:1;   % time
a=2;       % amplitude
x=a*sin(2*pi*f*t);
% level shifting
x1=x+a;
% Quantization
```

MATLAB code: PCM

```
q_op=round(x1);
% decimal to binary conversion
enco=de2bi(q_op,'left-msb');
% PCM receiver
deco=bi2de(enco,'left-msb');
% Shifting the amplitude level to the original value
xr=deco-a;
% plotting
plot(t,x,'r-',t,xr,'g+-');
xlabel('Time');
ylabel('Amplitude');
legend('Original signal','Reconstructed signal');
```

Output waveform:



Advantages:

1. Effect of channel noise and interference is reduced.
2. PCM permits regeneration of pulses along the transmission path. This reduces noise interference.
3. BW and SNR are related by exponential law.
4. Multiplexing of various PCM signals is easily possible.
5. Encryption or decryption can be easily incorporated for security purpose.

Disadvantages:

1. PCM system are complex compared to analog pulse method.

2.The channel BW is also increased because of digital coding of analog pulses.

Modification of PCM:

1. PCM can be modified to “Delta Modulation”. It is more simplified method and implementation.

2. PCM can be used in wide band communications channel to overcome the BW problem.

Question Answers:

Q.1. How is the ‘information’ transmitted in a PCM system?

Ans. In PCM, the ‘information’ is transmitted in the form of ‘code words’. The amplitude, width and position of the pulses at the PCM transmitter output are always constant.

Q.2. What is quantization?

It is the process of approximation. The samples are approximated or rounded off to the nearest quantization level.

Question Answers:

Q.3. What is the relation between number of quantization levels and the number of bits per word?

Ans. $Q = 2N$

Q.4. What is quantization error? What is the maximum value?

Ans. It is the difference between quantized signal and original signal. Its maximum value is $\pm \Delta/2$.

Q.5. How can we reduce the quantization error?

Ans. By reducing the step size Δ. This is possible by increasing the number of quantization levels Q.

Question Answers:

Q.6. What are the advantages of PCM?

Ans. (i) High noise immunity

(ii) Repeaters can be used

(iii) Storage and processing of the signal is possible

Q.7. What is the disadvantage of PCM?

Ans. Very large bandwidth requirement.

Question Answers:

Q.8. What is the signaling rate in terms of N and fs?

Ans. Signaling rate = N fs

Q.9. Why is companding used?

Ans. In order to improve the signal to quantization noise ratio of weak signals.

Q.10. How bandwidth required for the DM signal is less than that of PCM?

Ans. In PCM, we have to transmit N bits per quantized sample but in DM, we have to transmit only 1 bit per sample. This reduces the bandwidth.

Q.11. What information do you transmit in DM system?

Ans. In delta modulation (DM), the information about the result of comparison between present and previous samples is transmitted.

Question Answers:

Q.12. What is the cause of slope overload error in DM?

Ans. When the slope of analog input signal is much higher than the slope of approximated staircase signal, the slope overload error is observed.

Q.13. How can we reduce the slope overload error?

Ans. By increasing the sampling frequency fs or by increasing the step size Δ.

Q.14. What is the signaling rate of a DM system?

Ans. As only one bit is transmitted per sample, the signaling rate is equal to sampling rate fs.

Q.15. What is granular noise?

Ans. Granular noise is similar to the quantization noise in PCM.

Q.16. How can we reduce granular noise?

Ans. By reducing the step size Δ.

Question Answers:

Q.17. Can we use DM practically as an alternative to PCM?

Ans. No, we can not use because in order to eliminate the slope overload, practically, the sampling rate f_s is required to be so high that the bandwidth requirement of DM exceeds that of PCM.

Q.18. How is slope overload reduced in ADM?

Ans. In ADM, the step size is increased or reduced progressively to track the analog signal faithfully. This reduces the possibility of slope overload.

Q.19. Is it possible to use the baseband transmission in PCM?

Ans. Yes, it is possible.

Q.20. What are the advantages of digital representation of a signal?

Ans. The advantages of the digital representation are immunity to noise, regeneration of the coded signal is possible, communication can be kept secret or private due to the use of codes.

Question Answers:

Q.21. What are the disadvantages of digital representation of a signal?

Ans. Some of the disadvantages are: increased transmission bandwidth and increased system complexity.

Q.22. Why is PCM not used for radio broadcasting?

Ans. Due to higher BW requirement and complex circuitry.

Q.23. The granular noise in ADM will be …… than that in DM.

Ans. Higher

Q.24. In DM, we actually transmit ……

Ans. The encoded error signal.

Q.25. The predictive coding theory tells that ……..

Ans. It is possible to reconstruct the original message signal by accumulating a series of error signals.

Question Answers:

Q.26. For increasing the signal to quantization noise by 6 dB, we have to increase the number of bits per PCM word by ……..

Ans. 1

Q.27. Name different source coding techniques used in digital communication systems.

Ans. Various source coding techniques are pulse code modulation (PCM), delta modulation (DM), differential pulse code modulation (DPCM), adaptive delta modulation (ADM).

Q.28. Are the signal and noise separable in PCM?

Ans. Yes, the signal and noise are separable in PCM.

Q.29. Is it possible to use the repeaters (regenerators) in a PCM system?

Ans. Yes, it is possible to use repeaters which are actually regenerators. They can separate noise from the PCM signal and regenerate the original PCM signal.

Q.30. What is the advantage of using repeaters?

Ans. The advantage of using repeaters is reduced effect of noise.

Question Answers:

Q.31. What is the relation between number of quantization levels and the number of digits per word?

Ans. The relation is $Q = 2_N$, where, Q is the number of quantization levels and N is the number of digits per word.

Q.32. What is the relation between the quality of PCM signal and the number of digits per word?

Ans. The quality of signal will improve with increase in number of digits per word N.

Q.33. Why is quantization necessary?

Ans. If we do not use the quantization, then, we will have to convert each and every sampeld value into a separate digital word. This will need a large number of bits per word (N). This will increase the signaling rate (bits/sec), and hence the bandwidth requirement of the system.

Q.34. What is the maximum value of signal to quantization noise of a PCM system?

Ans. The maximum value of signal to quantization noise with a sinusoidal input signal is $SNR_{Q(max)} = (1.8 + 6N)$ dB.

Question Answers:

Q.35. How is uniform quantization is different from non-uniform quantization?

Ans. The quantization is called as uniforms quantization if the step size remains constants throughout the input range. However, if the step size varies depending on the size of input, then, the quantization is known as non-uniform quantization.

Q.36. Where is the non-uniform quantization used?

Ans. Non-uniform quantization is used to quantize the speech and music signals, as they have low values of crest factor.

Q.37. What is the bandwidth of a PCM system?

Ans. The minimum bandwidth of a PCM system is half the signaling rate i.e., it is $1/2\ N\ f_s$.

Q.38. For a PCM system having 128 quantization levels and sampling frequency of 8 kHz, what is the number of bits per word, signaling rate and minimum bandwidth?

Ans. $Q = 128,\backslash\ N = 7$ bits/word, signaling rate is 56 kbits/sec, and bandwidth $B_T =$ 28 kHz.

Question Answers:

Q.39. What is the relation between power contents and crest factor of a signal?

Ans. The relation between normalized signal power and its crest factor is given by, $P = 1/CF_2$

Q.40. State the types of nonuniform quantizers.

Ans. There are two types namely-the μ-law and A-law companding.

Q.41. What is the difference between the m-law and A-law compressor characteristics?

Ans. The μ-law compressor characteristics is linear characteristics for smaller amplitudes and it is logarithmic for the large values of the input signal. The A-law compressor characteristics is made up of piecewise linear segments for the low level inputs and piece-wise logarithmic segments for the high level inputs.

References:

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[3] https://electronicspost.com/waveform-coding-techniques-questions-and-answers/

[4]https://www.studocu.com/in/document/apj-abdul-kalam-technological-university/communication-systems-lab/expt-4-pcm-matlab/48163550

[5] https://www.youtube.com/watch?v=aEW1LHeTNm0

Thank you