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Experiment No: 10

PULSE CODE MODULATION AND DEMODULATION

Objective: To demonstrate the Pulse Code Modulation (PCM) and demodulation technique. Show the sampled, quantized/encoded and decoded time-domain signal for different bit codes. Show the input/output waveforms using Matlab code/Simulink in virtual mode

Software: Matlab

Theory:

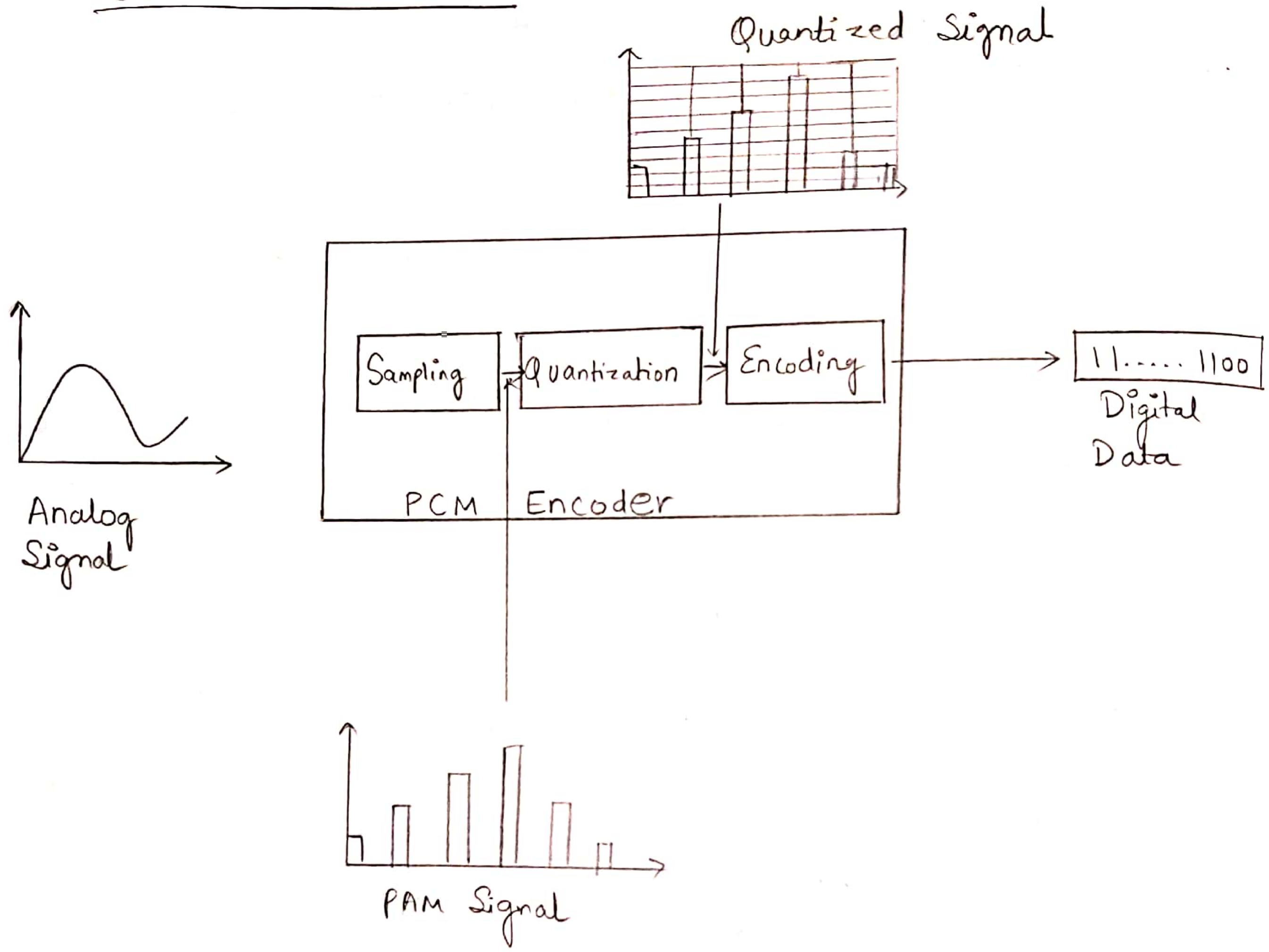
PCM (Pulse Code Modulation) is a technique that is used to convert an analog signal to digital signal. In this the amplitude of an analogue signal is converted to a binary value represented as a series of pulses. PCM is a preferred method of communication within the public switched telephone network (PSTN)

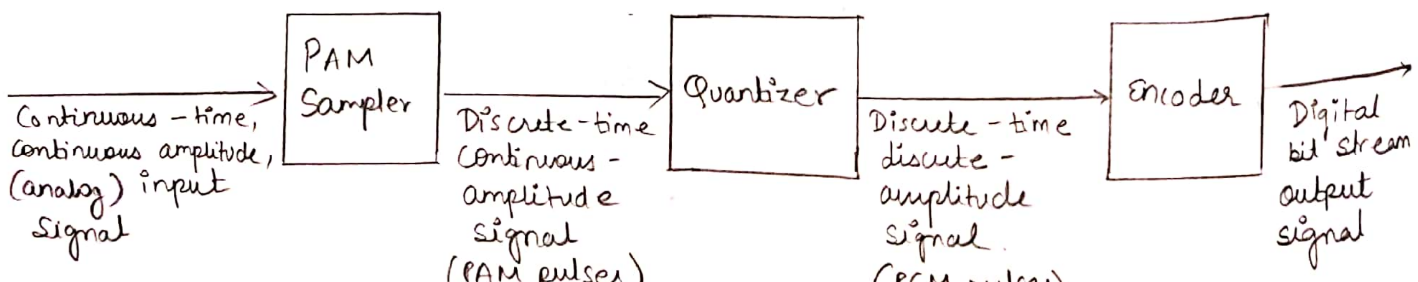
PCM is determined by two following steps:-

- **Sampling rate:** Which is the number of times per second that samples are taken.
- **Bit Depth:** Which determines the number of possible digital values that can be used to represent each sample.

Hence PCM resembles output of binary sequence.

BLOCK DIAGRAM

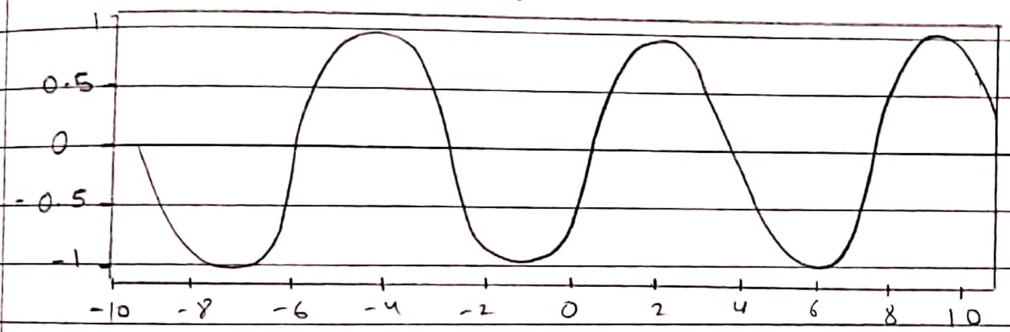




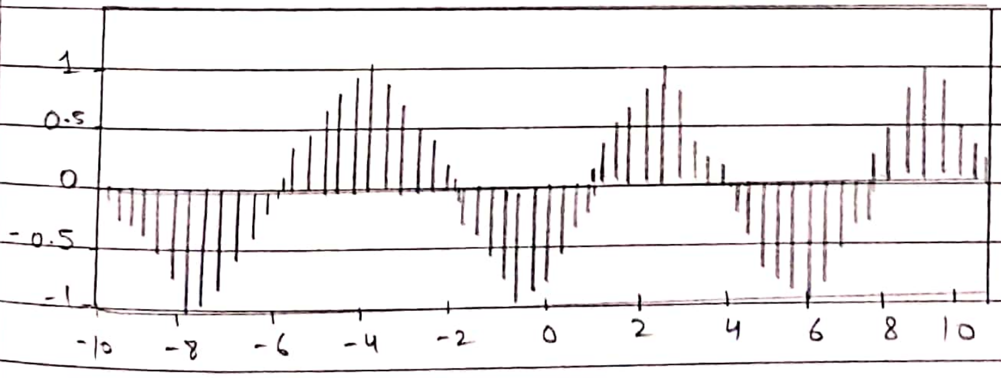
The transmitter section of a Pulse Code modulator circuit consists of sampling, Quantizing and Encoding

Sampling →

- The samples extracts samples of a continuous signal
- Sampler produces samples that are equivalent to the instantaneous value of the continuous signal at the specified various points
- The sampling process generates flat-top Pulse Amplitude Modulated (PAM) signal.



Analog Signal

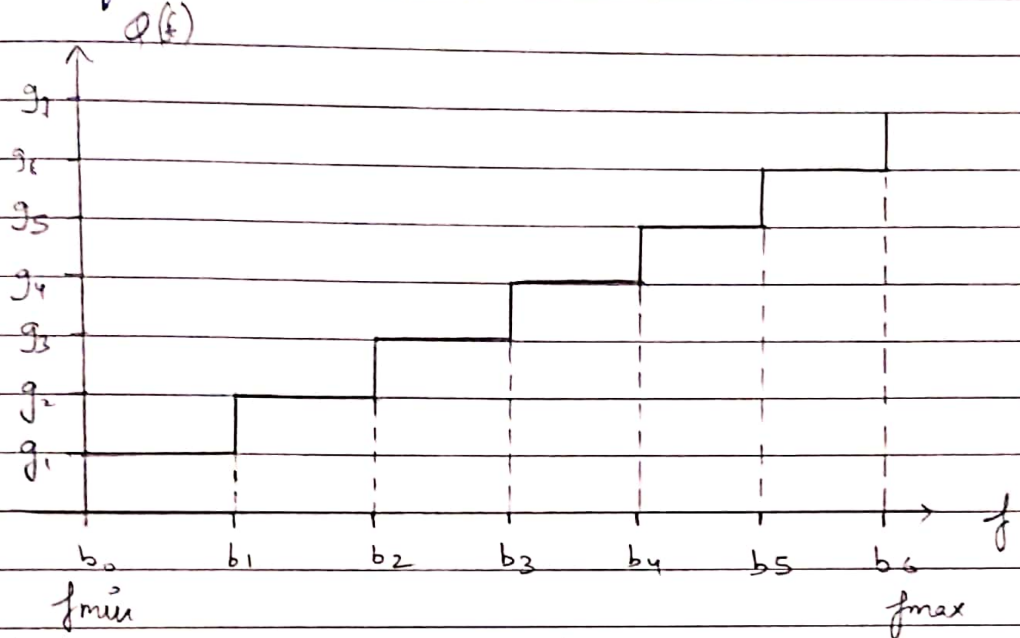


Discrete time Signal

Quantization →

- Quantization is done by dividing the range of possible Values of the analog samples into some different levels and assigning the center value of each level to any sample in the quantization interval.

- Quantization approximates the analog sample values with the nearest quantization values.



(Uniformly Quantized Signal)

Encoder →

An encoder performs the conversion of the quantized signal into binary codes. This unit generates a digitally encoded signal which is a sequence of binary pulses that acts as the modulated output.

Process in PCM transmitter :-

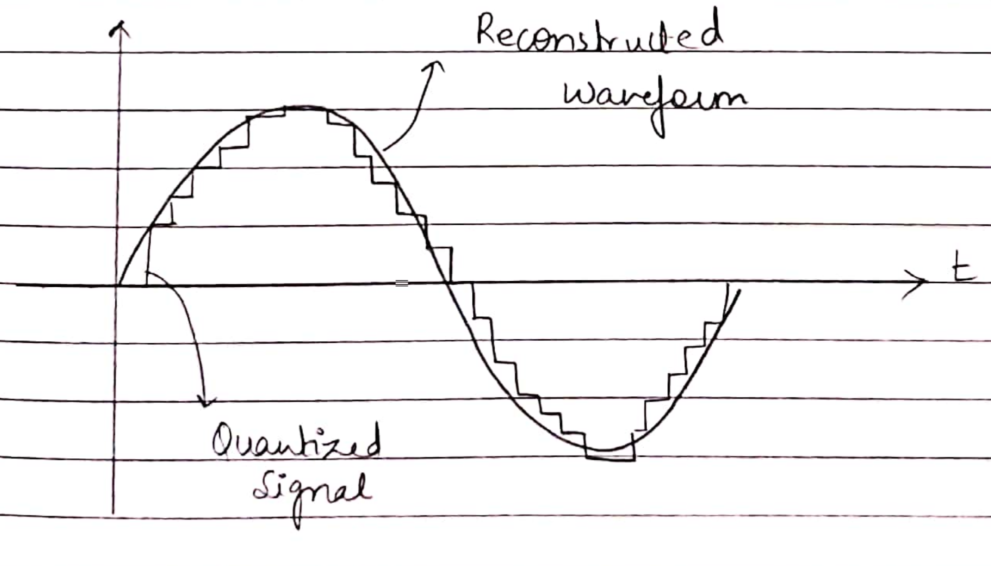
- In PCM transmitter, the signal $x(t)$ is first passed through the low pass filter of cut-off frequency f_m Hz. This low pass filter blocks all frequency components above f_m Hz.
- The sample and hold circuit then samples this signal at the rate of f_s. Sampling freq f_s is selected sufficiently above

Nyquist rate to avoid aliasing. The output from the sample and hold circuit is denoted by $x(nT_s)$.

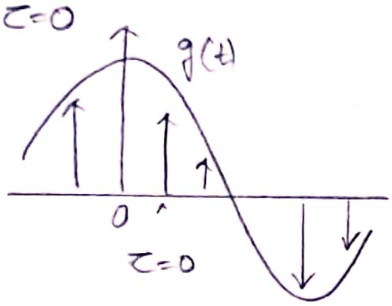
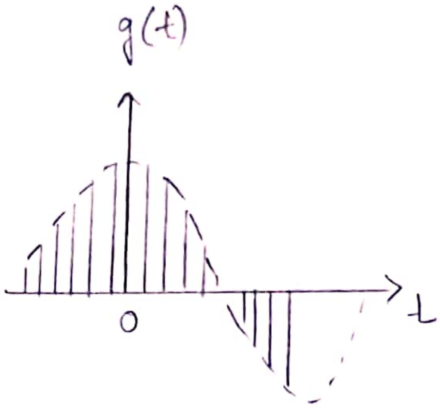
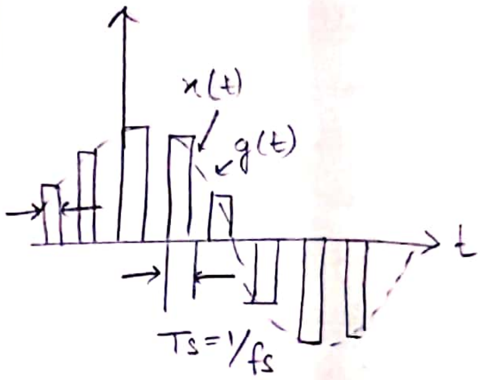
- This signal $x(nT_s)$ is discrete in time and continuous in amplitude.
- A q-level quantizer compares input $x(nT_s)$ with its fixed digital levels.
- Quantized signal is then encoded in PCM output using encoder.

PCM Receiver :

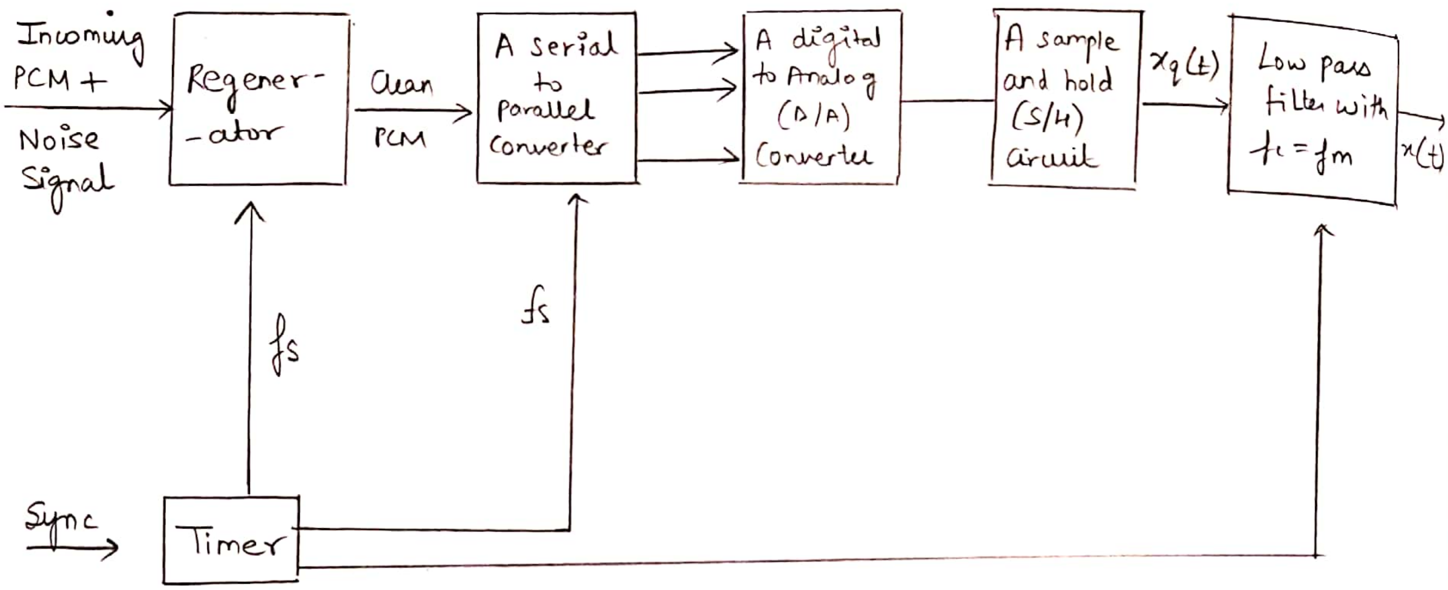
The process done at the transmitter is somewhat reversed at the receiver in order to generate the original analogue message. The figure below shows the reconstruction of the analog message signal at the receiver.



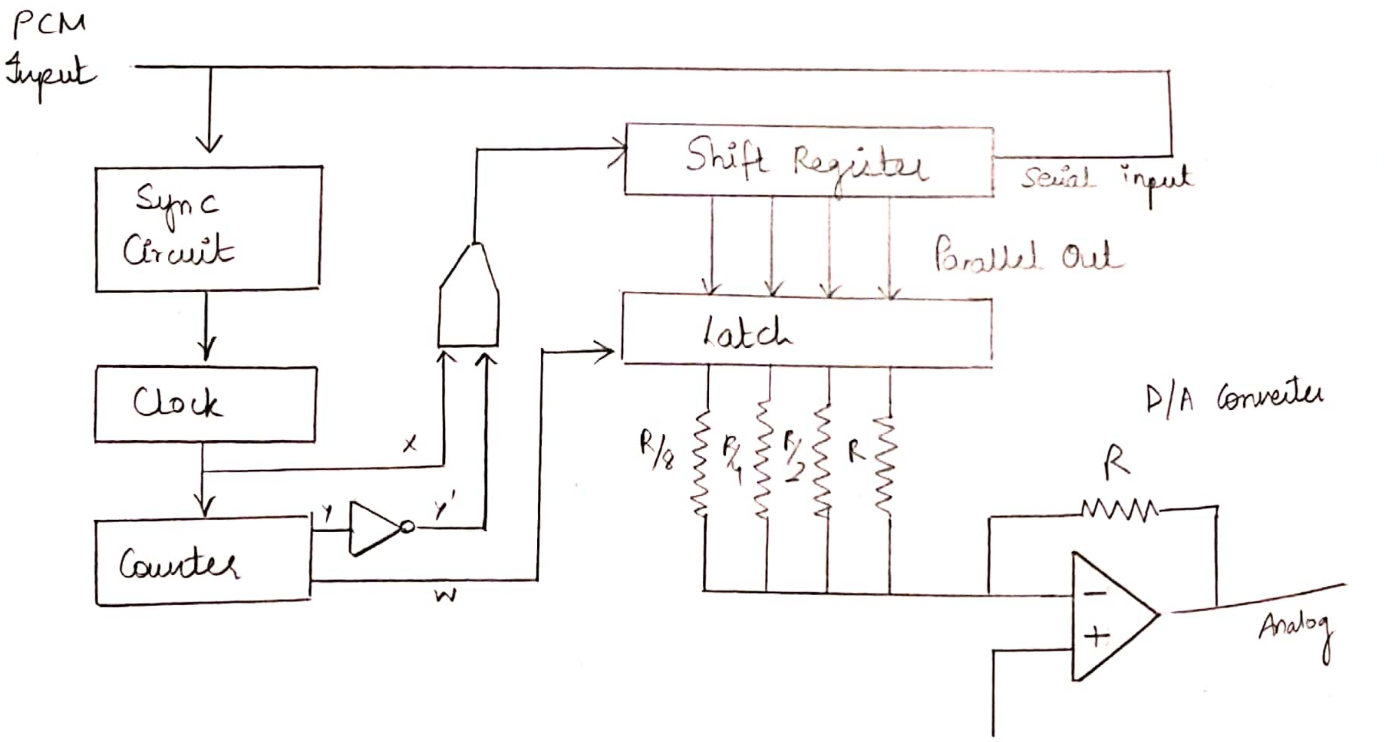
(RECONSTRUCTION OF ANALOG SIGNAL AT THE RECEIVER

Instantaneous Sampling	Natural Sampling	Flat-Top Sampling
Pulse width = τ $\tau = 0$		Pulse width = τ
		
• It is not a practical Method • Sample rate is infinity	• This method is used practically • Sample rate satisfies Nyquist Criteria	• This method is also used practically • Sample rate satisfies Nyquist Criteria

PCM Receiver BLOCK DIAGRAM



PCM Demodulator



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Matlab Code :

```
% Sampling
clc;
clear all;
close all;
n= input('Enter n value for n-bit PCM system : ');
n1=input('Enter number of samples in a period:');
L = 2^n;
% % Signal generation
% y = 8*Sin(x) ;  %Amplitude of signal is 8V
%  x = 0:1/100:4*pi;
% Suplot (2,2,1);
%plot (x,y); grid on;
% Sampling Operation
x = 0:2*pi/n1:4*pi;
s = 8*Sin(x);
Subplot (3,1,1);
plot(s);
title ('Analog Signal');
ylabel ('Amplitude--->');
xlabel ('Time --->');
subplot (3,1,2);
stem(s); grid on; title ('Sampled Signal');
Ylabel ('Amplitude--->'); xlabel ('Time-->');

% Quantization process
Vmax = 8;
```

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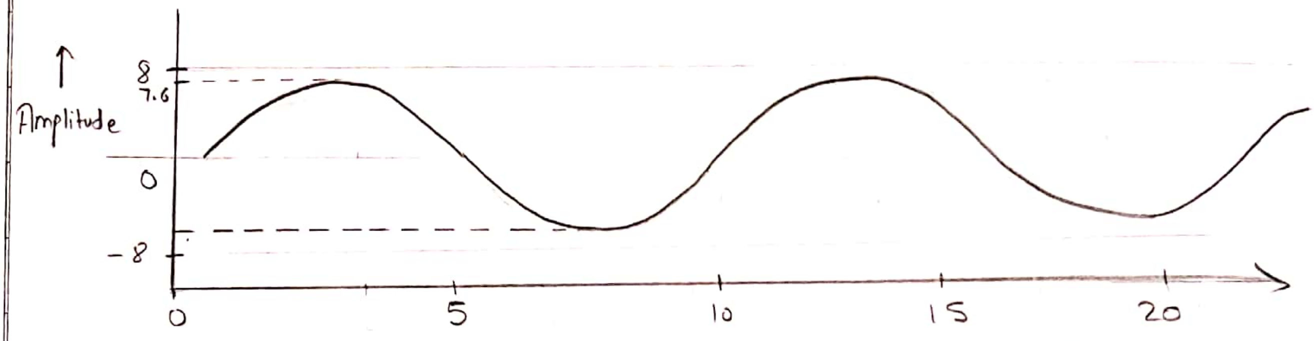
```
Vmin = -Vmax
del = (Vmax- Vmin)/L;   %Level are between vmin and vmax with
part = Vmin:del:Vmax;                  % difference of del
code = Vmin-(del/2):del:Vmax+(del/2); % Contain quantized values
[ind,q] = quantiz(S, part, code);  % Quantization process

l1 = length(ind);
l2 = length(q);

for i=1:11   % To make index as binary decimal so started from 0 to N
  if(ind(i)~=0)
      ind(i)=ind(i)-1;
  end
  i=i+1;
end
 for i=1:12
    if(q(i)==vmin-(del/2))
          q(i) = vmin+(del/2);
    end
 end
Subplot(3,1,3);  % Display the quantize values
Stem(q); grid on;
title('Quantized Signal');
ylabel('Amplitude-->');
Xlabel('Time -->');

% Encoding process
figure
```

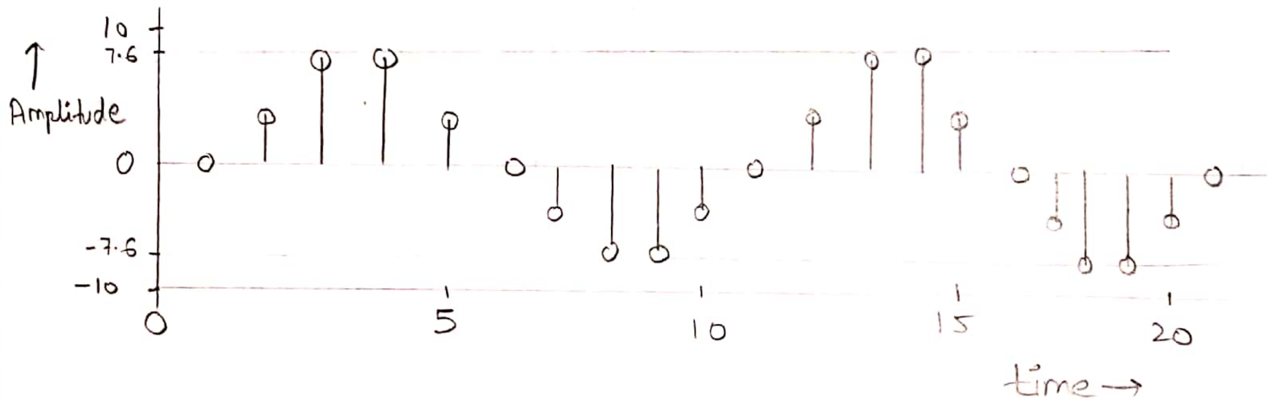
```
code = de2bi (ind,'left-msb'); % Convert decimal to binary
K=1;
for i=1:11
    for j=1:n
        coded (k)=code(i,j) % Convert code matrix to a coded row vector
        j=j+1;
        k=k+1;
    end
    i=i+1;
end
Subplot (2,1,1); grid on;
Stairs (coded);    % Display the encoded signal
axis ([0 100 -2 3]); title ('Encoded Signal');
ylabel ('Amplitude-->');
xlabel ('Time-->');

% Demodulation of PCM Signal
qunt = reshape (coded, n, length (coded) /n);
index = bi2de (qunt','left-msb'); % Getback the index in decimal form
q=del*index + Vmin+ (del/2);   % Getback quantized values
subplot(2,1,2); grid on;
plot (q);                 % Plot demodulated Signal
ylabel ('Amplitude-->');
xlabel('Time-->');
```

1) 5-bit system
No. of samples in a period = 10

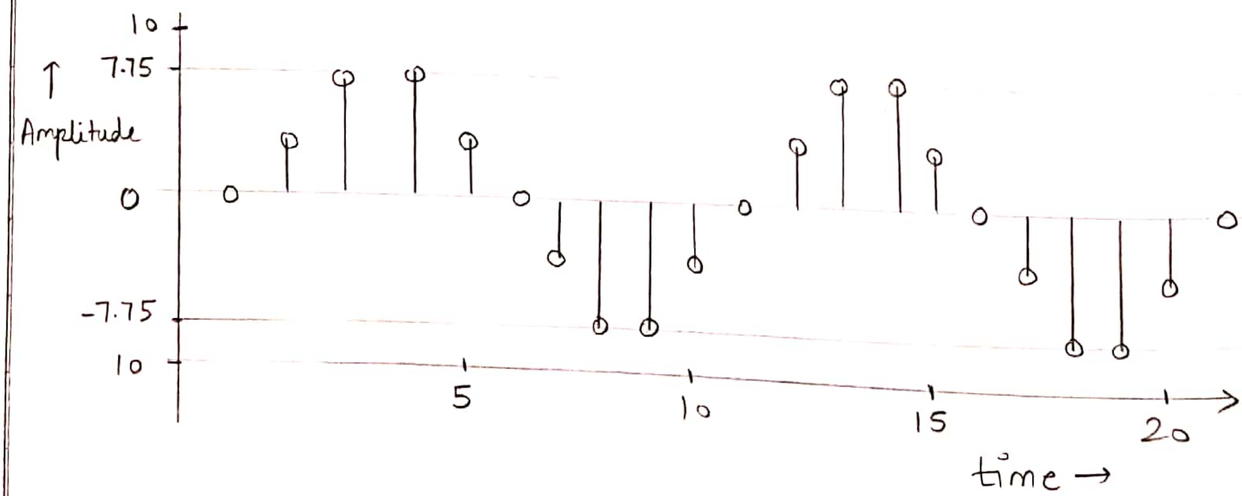
Analog Signal



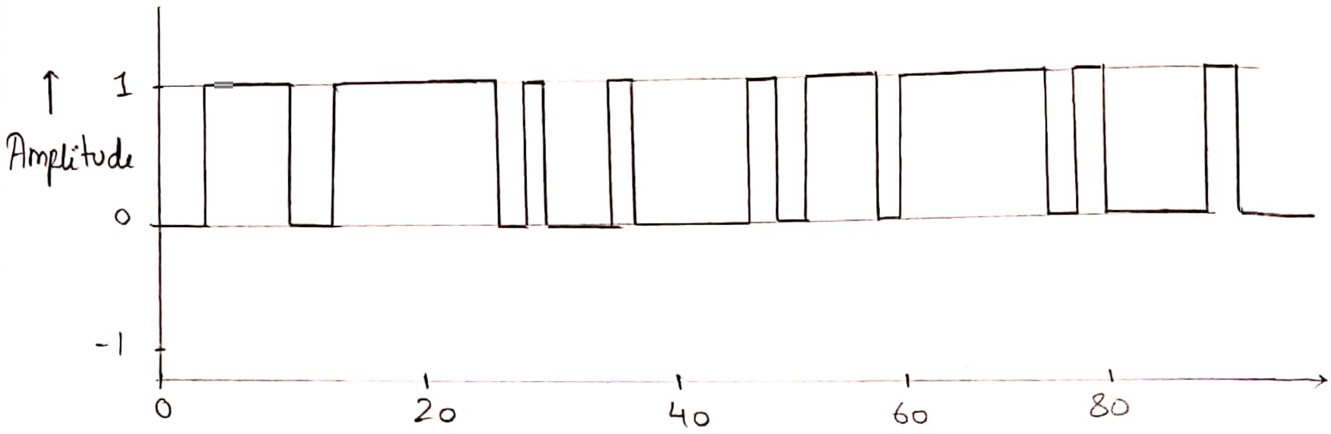
Sampled Signal



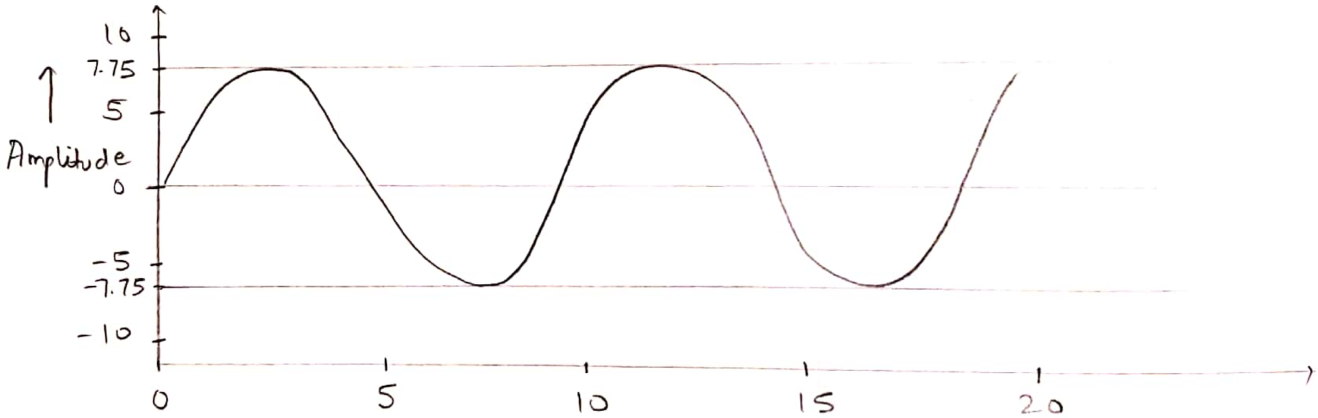
Quantized Signal



Encoded Signal →



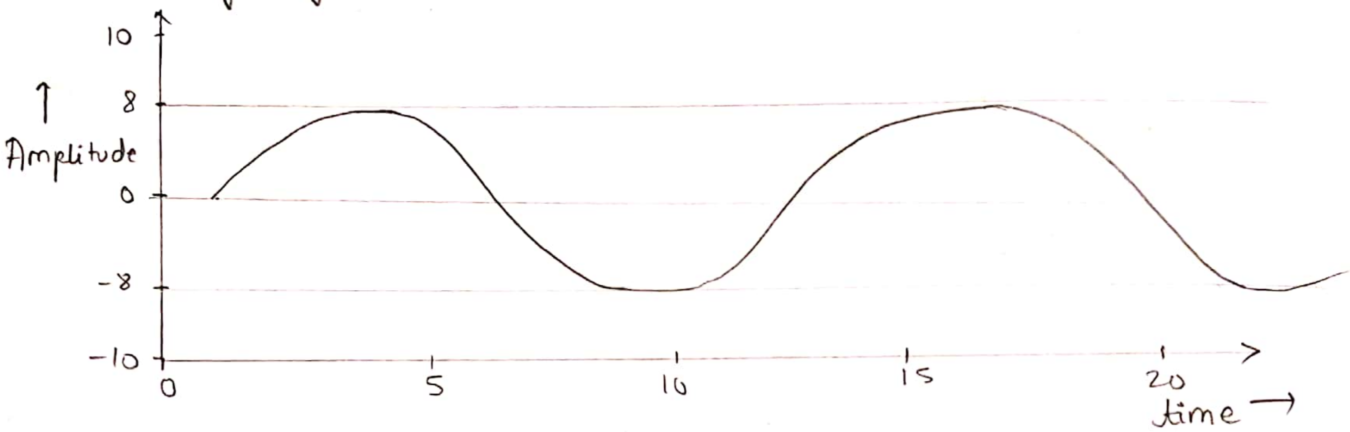
Demodulated signal →



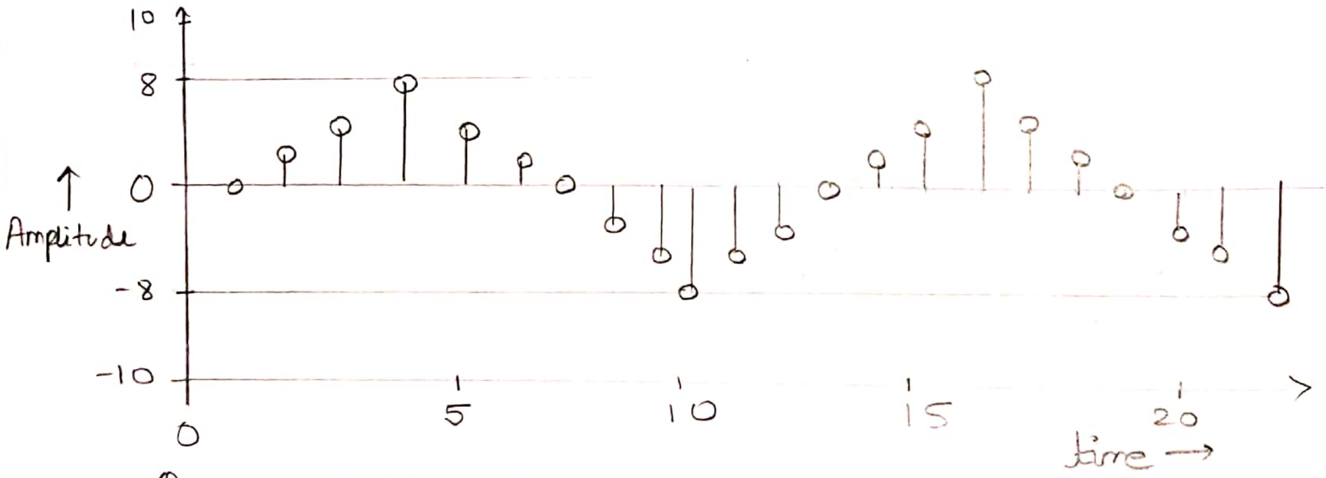
2) 6-bit System

Number of Samples in a period = 12

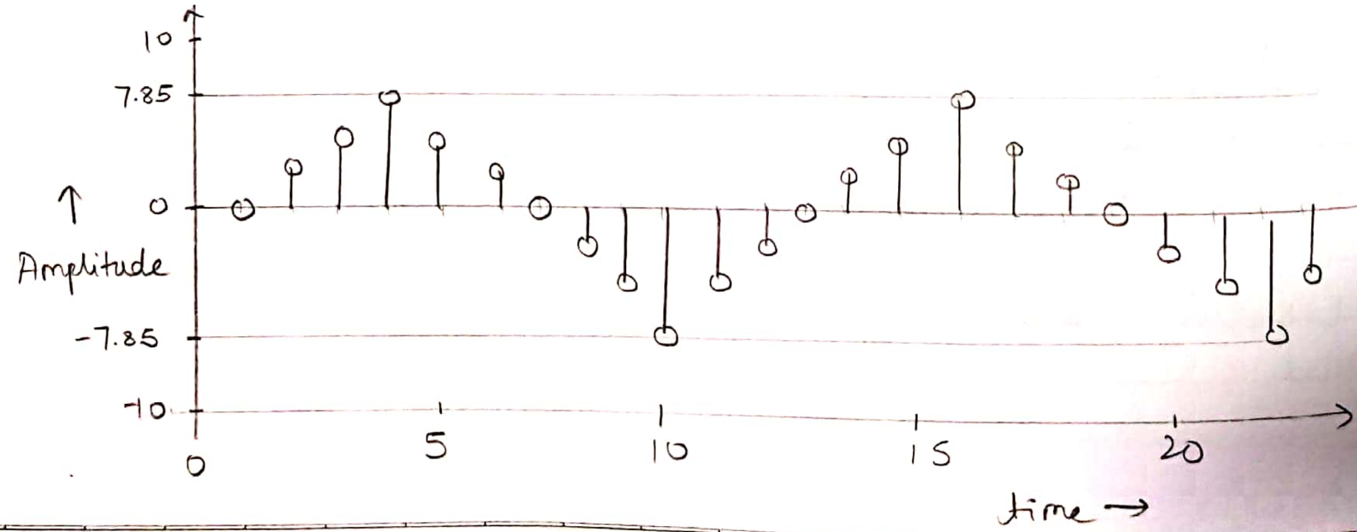
Analog Signal:



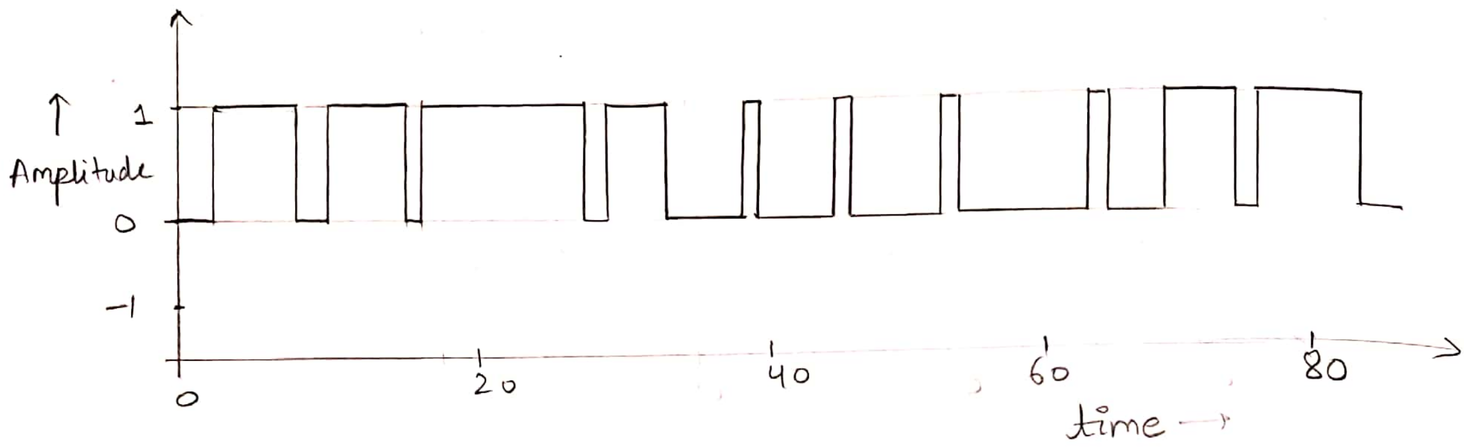
Sampled Signal:



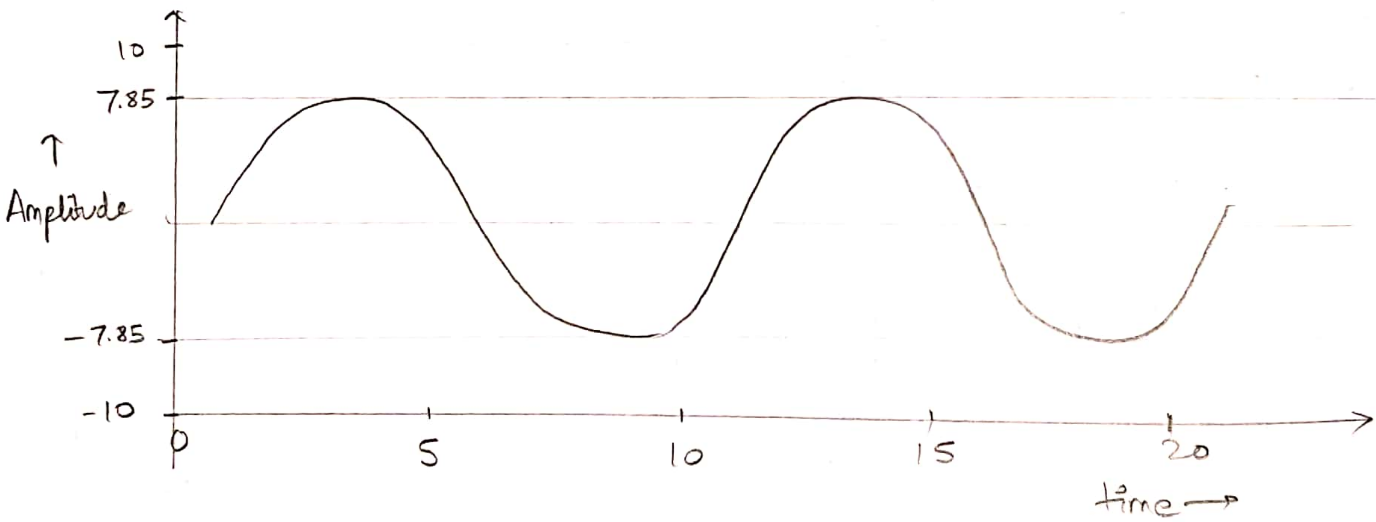
Quantized Signal:



Encoded Signal

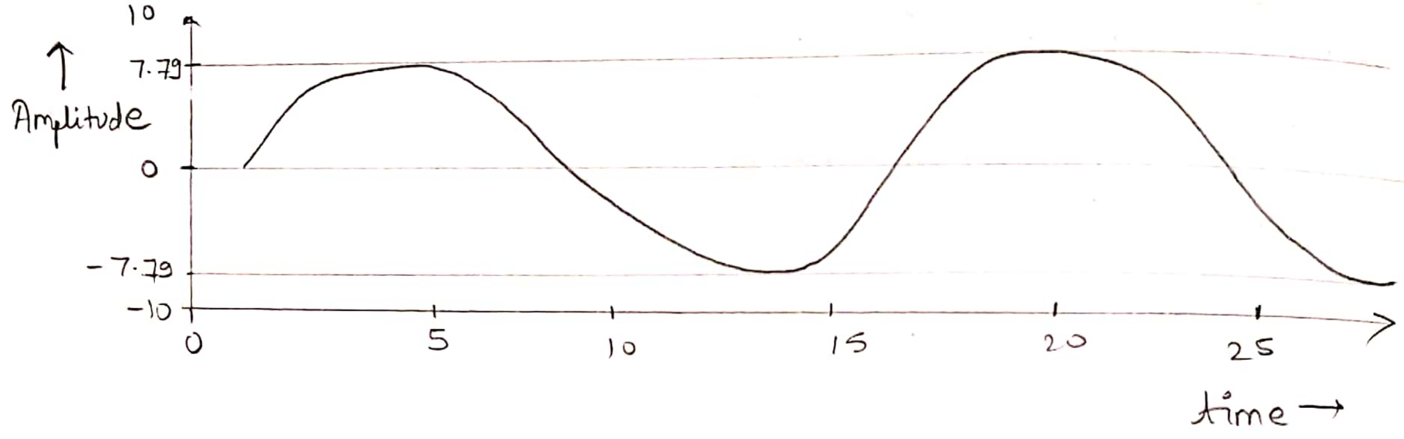


Demodulated Signal

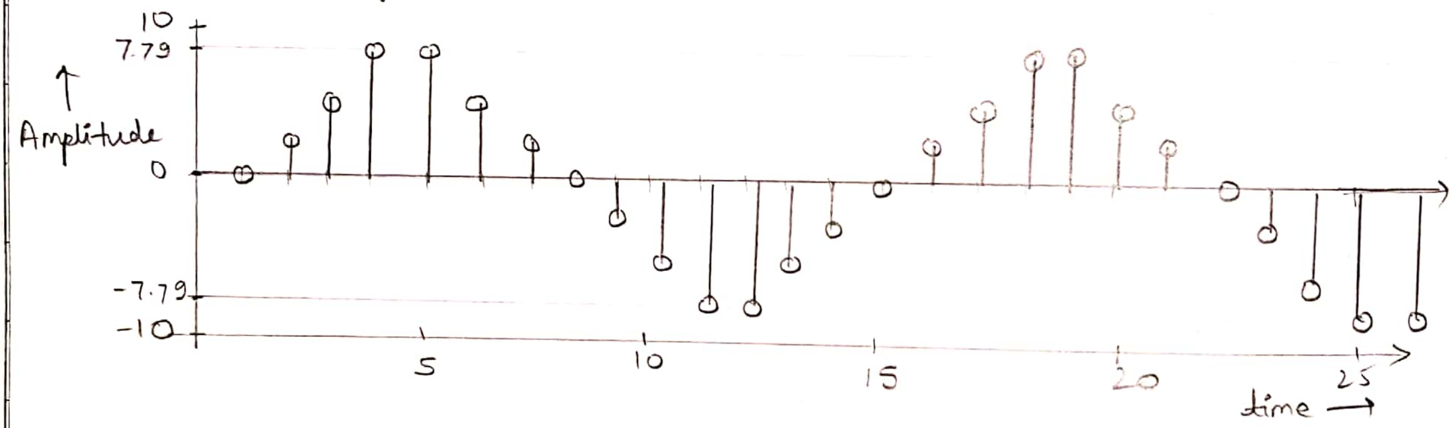


3) 8-bit System
Number of samples in a period = 14

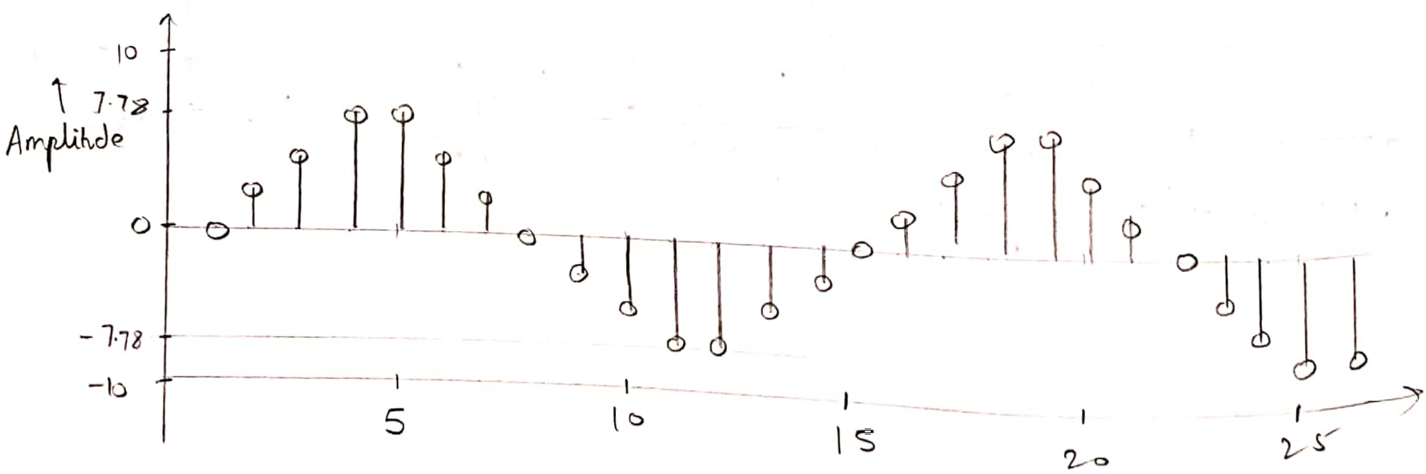
Analog Signal:



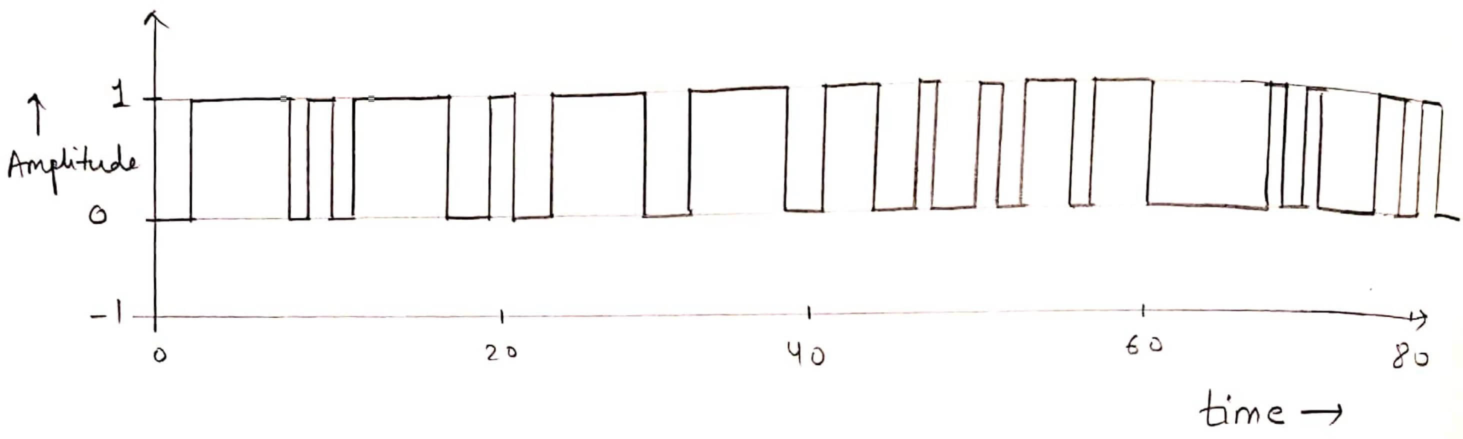
Sampled signal:



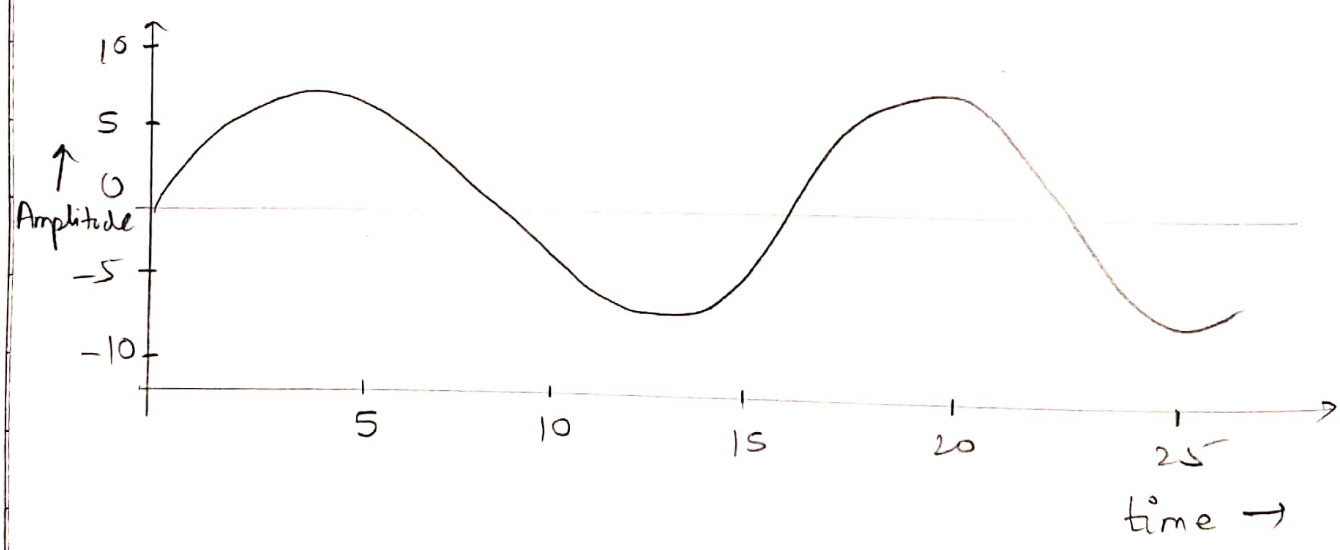
Quantized signal:



Encoded Signal :



Demodulated signal :



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Advantages of PCM:

1) Immune to channel induced noise and distortion
2) Repeaters can be employed along the transmitting channel.
3) Encoders allow secured data transmission
4) It ensures uniform transmission quality

Disadvantages of PCM:

1) Pulse Code Modulation increases the transmission bandwidth.
2) A PCM system is somewhat more complex than another system.

Application:

1) In compact disk
2) Digital telephony
3) Digital radio applications

Conclusion:

Succesfully demonstrated the Pulse Code Modulation technique and observed sampled, quantized, encoded and decoded time domain signal for different bit codes using matlab software.