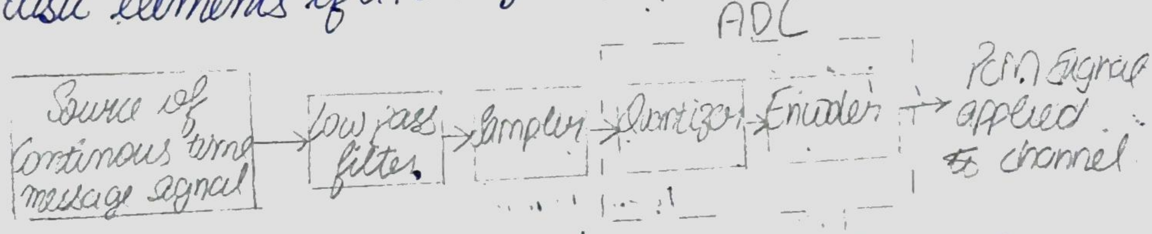
Experiment-2

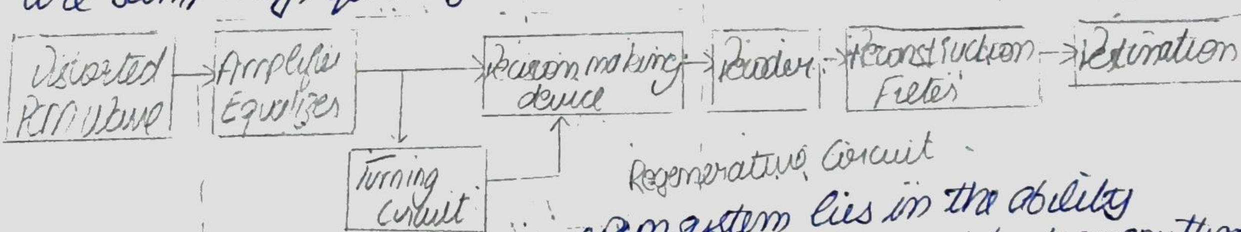
Aim:- To study Pulse Code Modulation (PCM) and Study Probability Error using Matlab/Octave.

Software Used:- Matlab/Octave.

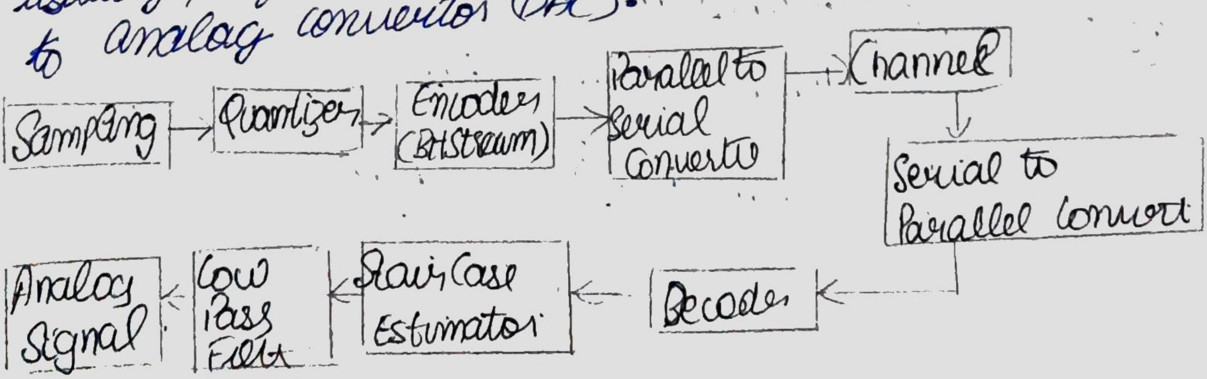
Theory:- Pulse Code Modulation is the Process in which the message signal is sampled & the amplitude of each sample is rounded off the nearest one of the finite set of allowable val.
The basic elements of a PCM system are as



The essential operation in the transmitter of a PCM system are sampling, quantization & encoding



The most important part of PCM system lies in the ability to control the effects of distortion & noise produced by transmitting a PCM through a channel. The essential operation in the receiver & regenerative of impaired signal, decoding & demodulation of the train of quantized samples. These operations are usually performed in the same circuit which is a digital to analog convertor (DAC).



Transmission of Bandwidth:

$L = 2^n$; 'n' no. of binary bits.

$f_s \geq 2f_m$

BW needed in PCM is 1/2 of signalling rate.

$$BW = \frac{1}{2} n f_s$$

$$\boxed{BW = n f_m}$$

Quantization Noise:

$$\frac{S}{N_q} = \frac{12 P_s}{\left(\frac{m_{max} - m_{min}}{L}\right)^2}$$

Case 1: m(t) is a sinusoid.

$m_{max} = m_{min} = A_m$; $P_s = \frac{A_m^2}{2}$

$$\frac{S}{N_q} = \frac{12 A_m^2}{2} \times \frac{2^{2n}}{(A_m - (A_m))^2} = \frac{3}{2} 2^{2n}$$

$$\left(\frac{S}{N_q}\right)_{dB} = 10 \log_{10} \frac{3}{2} 2^{2n} = 6.02n + 1.8\, dB$$

Case 2: m(t) is uniform RV with zero mean.

$m_{max} = -m_{min} = A_m$.

$$P_s = \frac{(A_m - (A_m))^2}{12} = \frac{A_m^2}{3}$$

Experiment - 2

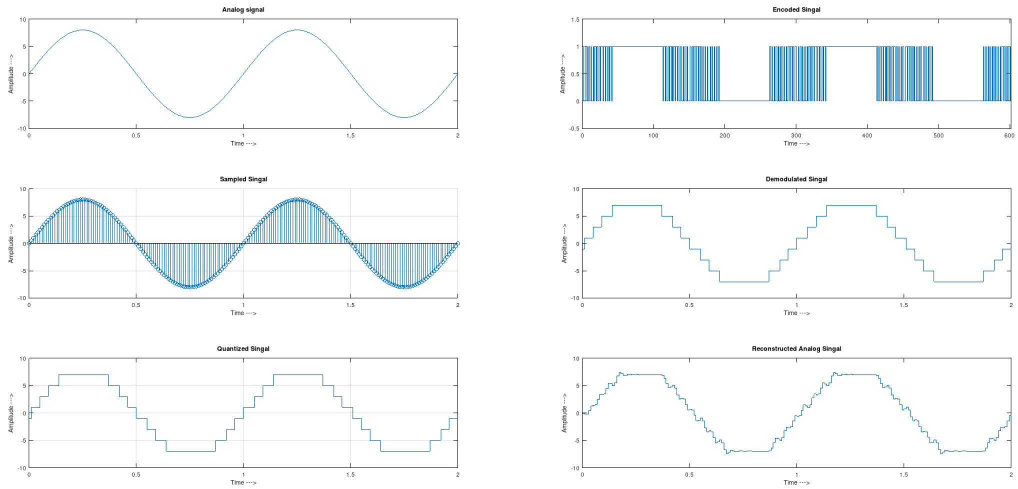
Aim: To Study Pulse Code Modulation (PCM) and Study Probability of Error using Matlab/Octave.

Code

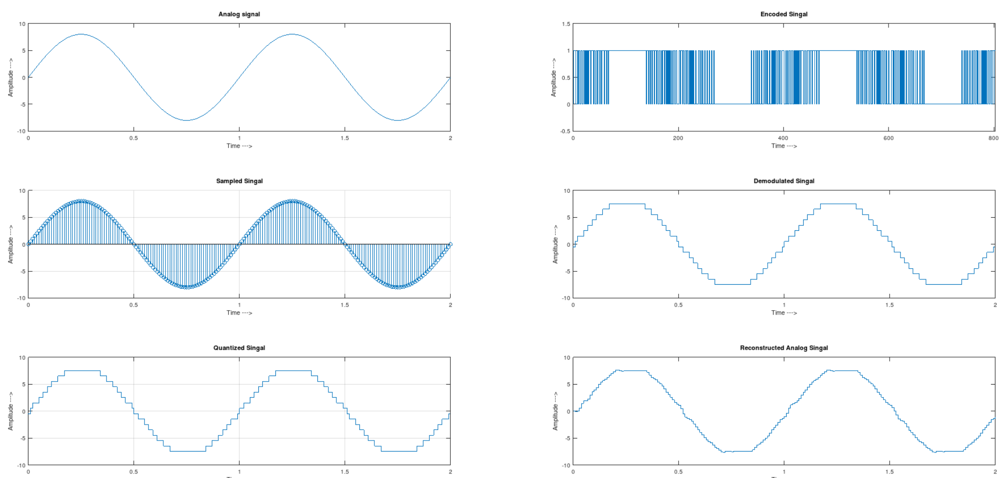
```
% octave pkg to load signal based utils
pkg load signal
pkg load communications

clc;
clear alll;
close all;

%Inputs
n = input('PCM system bits required: ')
fs = input('Sampling Rate: ')
L = 2^n;
t = 0:1/fs:2;
s = 8*sin(2*pi*t);

% Plotting

subplot(3, 1, 1);
plot(t, s);
title('Analog signal');
xlabel('Time --->');
ylabel('Amplitude --->');

subplot(3, 1, 2);
stem(t, s);
grid on;
title('Sampled Singal');
xlabel('Time --->');
ylabel('Amplitude --->');

% Quantization Process

vmax = max(s);
vmin = min(s);
del = (vmax - vmin)/L;
part = vmin + del : del : vmax - del;
code = vmin + del/2 : del : vmax - del/2;
[ind, q] = quantiz(s, part, code);

l_1 = length(ind);

subplot(3, 1, 3);
stairs(t, q);
grid on;
title('Quantized Singal');
xlabel('Time --->');
ylabel('Amplitude --->');

% Encoding process

figure

enc = de2bi(ind, n, 'left-msb');
k = 1;
for i=1:l_1
    for j=1:n
        coded(k) = enc(i, j);
        k = k + 1;
    end
end

subplot(3, 1, 1);
grid on;
stairs(0:(length(t)*n) - 1, coded);
axis([0 (length(t)*n)-1 -0.5 1.5]);
title('Encoded Singal');
xlabel('Time --->');
ylabel('Amplitude --->');

% Demodulation of PCM Signal

qunt = reshape(coded, n, length(coded)/n);
index = bi2de(qunt', 'left-msb');

q_1 = del * index + vmin + (del/2);

[n, d] = butter(5, 0.5);
de = filter(n, d, q);

subplot(3, 1, 2);
grid on;
stairs(t, q_1);
title('Demodulated Singal');
xlabel('Time --->');
ylabel('Amplitude --->');

subplot(3, 1, 3);
grid on;
stairs(t, de);
title('Reconstructed Analog Singal');
xlabel('Time --->');
ylabel('Amplitude --->');

%pause in octave
pause
```

Outputs

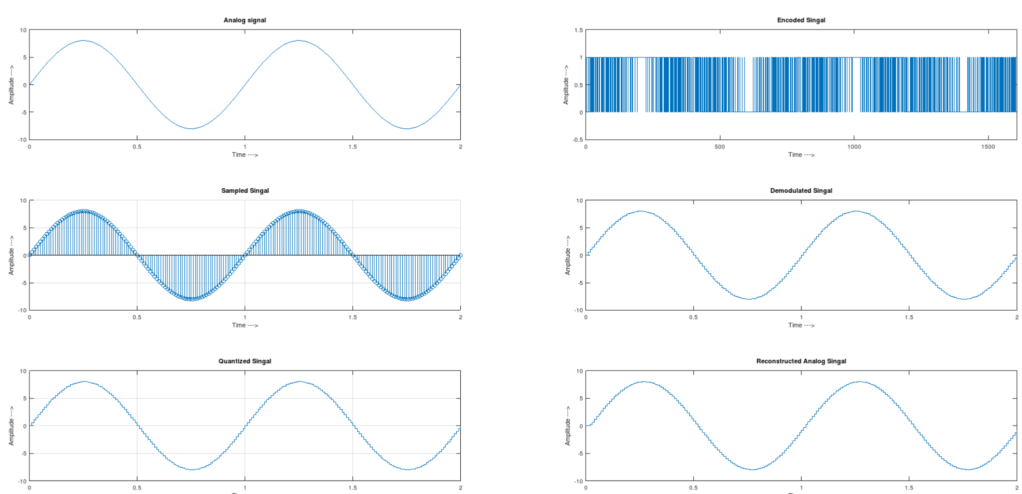
Case 1: Number of bits = 3



Case 2: Number of bits = 4



Case 3: Number of bits = 8



Q1. What are the advantages of using digital communication over standard analog communication? What is the same for disadvantages?

→ Advantages of Digital communication:

- Regenerative repeating
- Storage of signal is possiblle.
- Larger noise immunity.
- Computerised signal processing.
- Larger noise immunity.

→ Disadvantages over analog communication.

- Higher bandwidth requirement.

Q2. Why do we not expect any channel noise in transmission system of digital signal?

→ In case of Digital communication, at receiver's end, instead of amplyfing signal like in analog communication, the inputs are instead detected as input sequence bits and then regenerated to the specified line code. This process is known as regenerative repeating.

→ Regenerative repeating ensures minimal to no noise transmission

Q3. What are the various ways of reducing Quantization noise in digital Communication?

→ Ways of reducing quantisation noise :-

- Increasing the value/number of encoder bits.
- Non uniform Quantisation
- Use of differential Quantization.

Q4. What is the relationship between the signal to Quantization noise ratio & number of bits used in encoder system?

For a PCM System

$$\frac{S}{N_q} = \frac{3}{2} 2^{2n} \Rightarrow$$ n is number of encoder bits

$SNR \propto 2^{2n}$, hence doubling the number of bits will quadruple the SNR performance.

In decible system the relation is linear

$$SNR)_{db} = 6.02\underline{n} + 1.8$$

Q5. What is the relationship between the bandwidth of transmission & bit rate of transmission.

→ The minimum theoretical bandwidth required for transmission is equal to half the bit rate of transmission.

$$\boxed{BW = \frac{R_b}{2}}$$

Q6. Why is non uniform quantization called companding?

→ The representation of a non linear with similar signal to quantisation ratios results in a decreased no. of transmission bits [compression].

Thus the compressor reduces the no. of transmission bits per sample and the expander does the opposite.

Q7. What are some of the common application of PCM system & companding?

Ans Application of PCM:-

- Satellite transmission
- Telephony
- Compact Disk.

Application of companding:-

- Compression before input to ADC
- Expansion after ADC
- Digital telephony.

Q8. In practical use of PCM, what is usually the number of encoder bits that is used & why?

Ans. Practically the no. of encoder bits are used in 8-bit groups / combination called bytes.