4. PRE –EMPHASIS AND DE-EMPHASIS CIRCUITS USING FM

4.1 OBJECTIVE

To design a pre emphasis circuit to boost the input signal level for a FM transmitter for a cut off frequency of 1KHz. Attenuate the boosted high frequency signals at the receiver side using a deemphasis circuit with a cutoff frequency of 1.6KHz. Analyze the frequency response characteristics of pre emphasis and de emphasis circuits.

4.2 HARDWARE REQUIRED

S.No	Equipment/Component name	Specifications/Value	Quantity
1	Cathode Ray Oscilloscope	(0 – 20MHz)	1
2	Audio Frequency Oscillator	(0-2) MHz	1
3	Regulated power supply	(0 -30V), 1A	1
4	Resistors	1K Ω 2K Ω 10K Ω 68K Ω 100K Ω	1 1 2 1 1
5	capacitors	0.1 μf 0.001 μf	2 3
6	Semiconductor Device(Transistor)	Q2N2222	1
7	Decade Inductance Box	0.3H	1

PRE – EMPHASIS CIRCUIT DIAGRAM

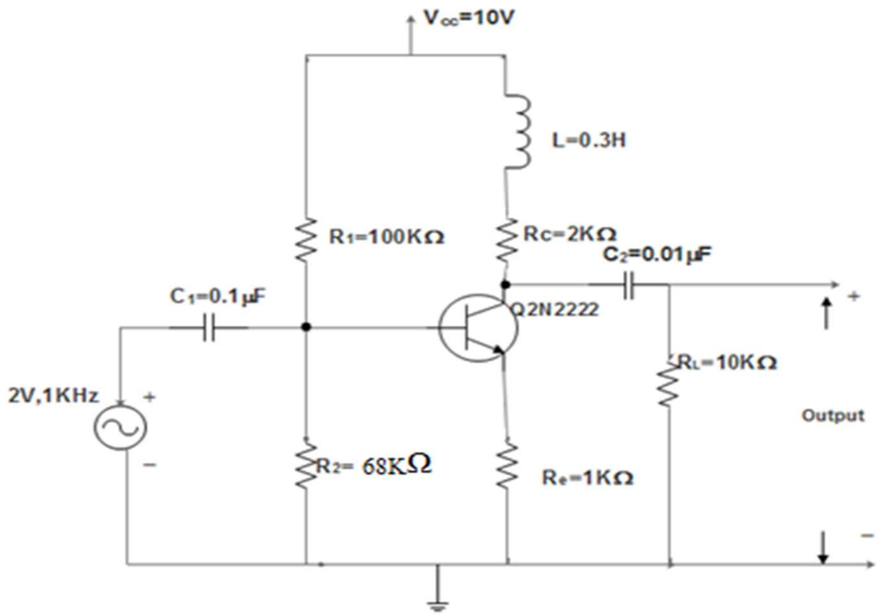


Fig. 4.1 Pre Emphasis Circuit

DE – EMPHASIS CIRCUIT DIAGRAM

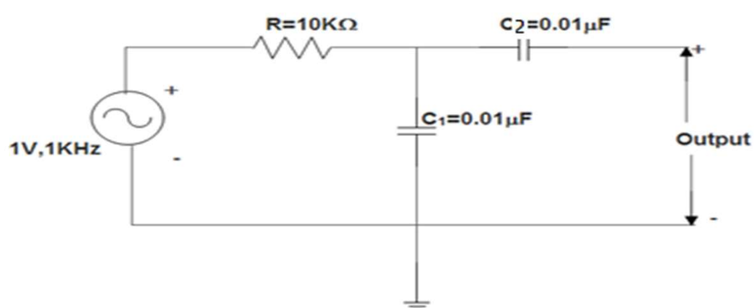


Fig. 4.2 De Emphasis Circuit

4.3 THEORY

During the transmission over a channel, the received signal contains interference (high frequency noise). For demodulated FM signals, the interference power increases as the frequency goes up. Thus,

de-emphasis is applied to the demodulated signal to decrease the power of the interference in high frequency. However, in order to keep the high frequency component of the demodulated message, pre-emphasis must be applied to the message before going through the FM modulator.

4.3.1 PRE-EMPHASIS

Pre-emphasis refers to boosting the relative amplitudes of the modulating voltage for higher audio frequencies. Pre-emphasis is done at the transmitting side of the frequency modulator.

Signals with higher modulation frequencies have lower SNR. In order to compensate this, the high frequency signals are emphasised or boosted in amplitude at the transmitter section of a communication system prior to the modulation process. That is, the pre- emphasis network allows the high frequency modulating signal to modulate the carrier at higher level, this causes more frequency deviation.

The circuit consist of a transistor, resistor and an inductor. It is basically a high pass filter or Differentiator. A pre-emphasis circuit produces a constant increase in the amplitude of the modulating signal with an increase in frequency.

The cut off frequency is determined by the RC or L/R time constant of the network. Normally, the cut off frequency occurs at the frequency where capacitive reactance or inductive reactance equals R. The cut off frequency is given by the formula

$$f_c = \frac{R}{2\pi L}$$

By the use of an active pre-emphasis network we can reduce the signal loss and distortion with the increase of SNR. Also the output amplitude of the network increases with frequencies above cut off frequency.

4.3.2 DE-EMPHASIS

De-emphasis is the complement of pre-emphasis, in the anti-noise system called emphasis. This circuit is used to attenuate the high frequency signal that is boosted at the transmitter section. The circuit is placed at the receiving side. It acts as a low pass filter. The cut off frequency is given by the formula

$$f_c = \frac{1}{2\pi RC}$$

The circuit consists of a passive network consisting of a resistor and a capacitor. It is basically a low pass filter or integrator. The pre- emphasis network in front of the FM modulator and a de-emphasis network at the output of the FM demodulator improves the Signal to Noise Ratio for higher modulating signal frequencies, thus producing a more uniform SNR at the output of demodulator.

4.4 DESIGN

4.4.1 PRE- EMPHASIS

The cut off frequency is given by the formula

$f_c = R/(2\pi L)$

Let f_c =1KHz

Assume R=2KΩ

Therefore $L = R/(2\pi f_c)$

$L = 2000/(2*3.14*1000)$

$L = 0.3H$

4.4.2 DE- EMPHASIS

The cut off frequency is given by the formula

$f_c = 1/(2\pi RC)$

Let f_c =1.6KHz

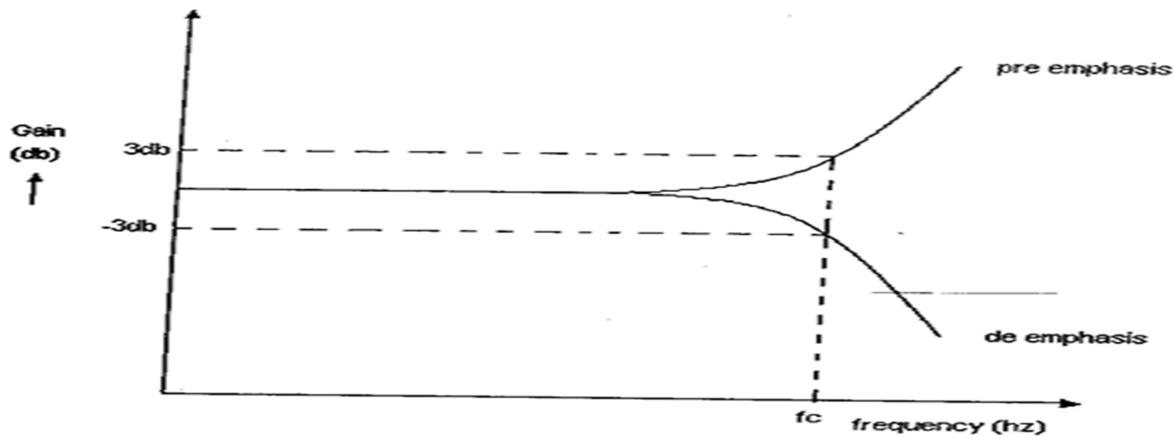
Assume R=10KΩ

Therefore $C_1 = 1/(2\pi f_c R)$

$C_1 = 1/(2*3.14*1600*10000)$

$C_1 = 0.01\mu F$

MODEL GRAPH



OBSERVATION FOR PRE-EMPHASIS:

Vi=

Frequency(Hz)	Vo	Gain= Vo/Vi	Gain in dB=20log(Vo/Vi)

OBSERVATION FOR DE-EMPHASIS

Vi=

Frequency(Hz)	Vo	Gain= Vo/ Vi	Gain in dB =20log(Vo/Vi)

4.5 PRE LAB QUESTIONS

- What is meant by threshold effect?

1. What is pre-emphasis?
2. How the threshold effect can be avoided?
3. What is fidelity?
4. What is sensitivity and selectivity?

4.6 LAB PROCEDURE

1. The circuit connections are made as shown in the circuit diagram for the pre-emphasis and de-emphasis circuits.

1. A power supply of 10V is given to the pre-emphasis circuit.
2. Set the input voltage at 2V, 1 KHz for pre-emphasis and 1V, 1 KHz for de-emphasis using AFO.
3. For this constant value of input voltage the values of the frequency is varied and the output voltage is noted on the CRO.
4. A graph is plotted between gain and frequency in a semilog graph sheet for both pre emphasis and de-emphasis outputs.

4.7 VIRTUAL LAB

4.7.1 Equipment / Apparatus

SCILAB Software 6.0.2

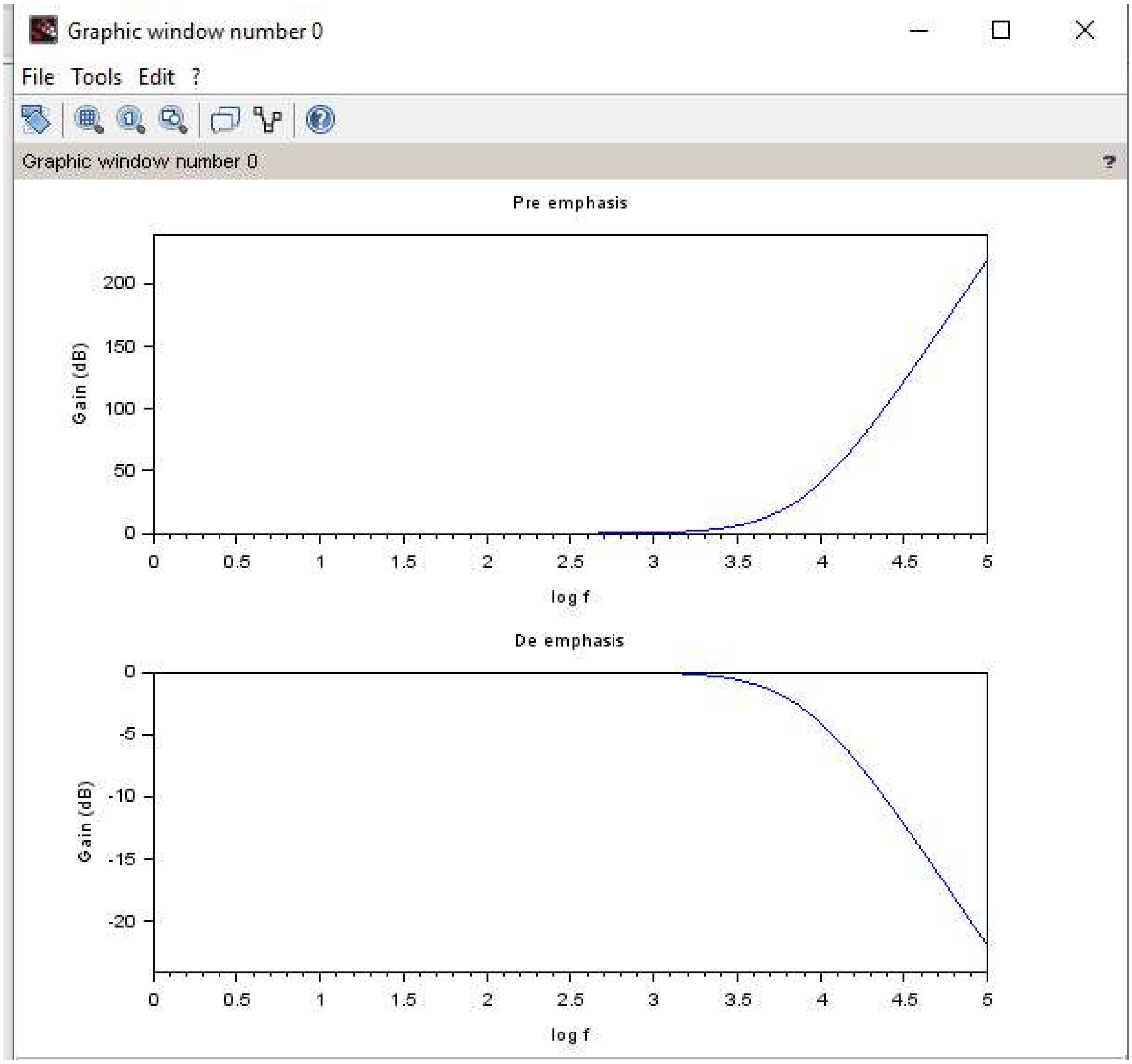
4.7.2 Exercise

Use Scilab software to plot the Pre emphasis and Deemphasis curve with frequency Versus Gain .Cut off frequency =1 KHz.

4.7.3 Solution:

```
clc ;
clear ;
xdel ( winsid () ) ;//xdel(0)//xdel()
r=160000;
j=sqrt(-1);
C=0.1*10^-6;

for i=1:100000
   k(i)=log10(i)
   f=i;
   w=2*3.1414*f;
   w1=1/(r*C);
   pre_emp(i)=20*log10(sqrt(1+(w/w1)^2))
   de_emp(i)=-20*log10(sqrt(1+(w/w1)^2))
end
subplot(211)
plot(k,pre_emp);
title("Pre emphasis");
xlabel('log f');
ylabel('Gain (dB)')
subplot(212)
plot(k,de_emp);
title("De emphasis");
xlabel('log f');
ylabel('Gain (dB)')
```

Model Graph :



Simulated Pre emphasis and De emphasis waveforms

4.8 POST LAB QUESTIONS

1. What is de-emphasis?
2. How to reduce the noise during transmission in FM ?
3. What should be the time constant for de-emphasis circuit?
4. Why pre-emphasis is done after modulation?
5. List some applications of pre-emphasis circuit.

6. Write a program in scilab to design a circuit to boost the baseband signal amplitude in the FM transmitter for the cut off frequency f_c =10 KHz

4.9 LAB RESULT

The Pre-emphasis and De-emphasis graphs were plotted using Scilab.

5 (a) Pulse Amplitude Modulation (PAM) & Demodulation

5a.1 Objective

Study of Pulse Amplitude Modulation & Demodulation with Sample, Sample & Hold & Flat Top

5a.2 Equipment required

Scientech 2110 with Power Supply cord

Scientech Oscilloscope with connecting probe

Connecting cords

5a.3 Wiring Diagram

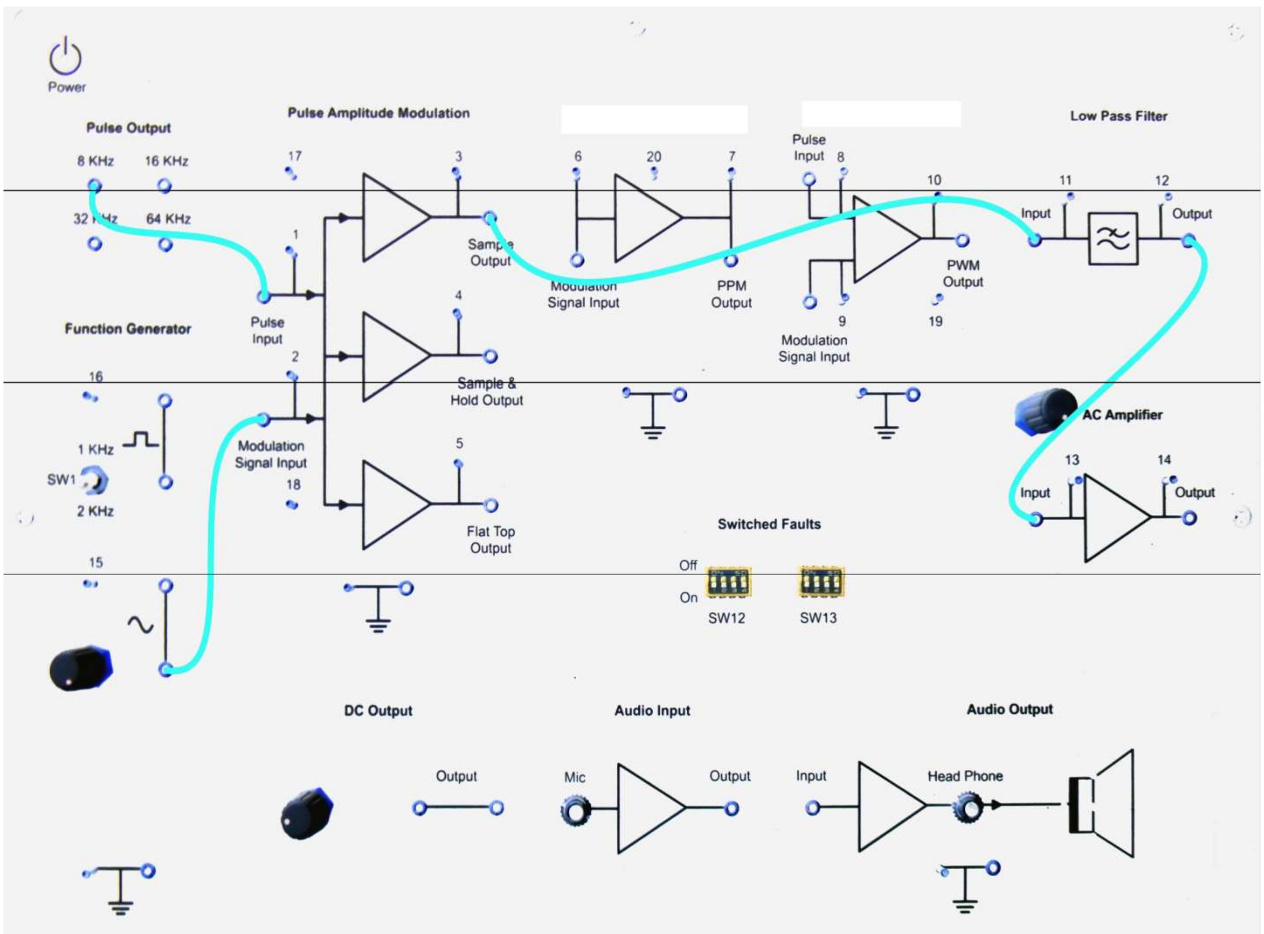


Figure 5a.1 Pulse Amplitude Modulation and Demodulation

5a.4 Procedure

1. Connect the circuit as shown in Figure 1.1
2. Output of sine wave to modulation signal input in PAM block keeping the switch in 1 KHz position.
3. 8 KHz pulse output to pulse input

4. Output of low pass filter to input of AC Amplifier. Keep the gain pot in AC Amplifier block in anti clock wise position.

5. Switch 'On' the Power Supply & Oscilloscope.

6. Observe the outputs at TP (3) together with Modulation signal input TP (3) and Pulse input TP (1). This is a Natural sampling output.

7. Connect the Sample output to the input of low pass filter. Observe the output of the Low pass filter TP (12) together with Modulation signal input TP (2).

8. Observe the output of the AC Amplifier TP (14) together with Modulation signal input TP (2). Vary the Gain of AC Amplifier to get the unclipped output. Vary the amplitude of input; the amplitude of output will vary.

9. Observe the Flat Top output at TP (5), together with Modulation signal input TP (2) and Pulse input TP (1). This is Flat Top Sampling output.

10. Connect the Flat top output to the input of low pass filter Observe the output of the Low pass filter TP (12) together with Modulation signal input TP (2).

11. Observe the output of the AC Amplifier TP (14) together with Modulation signal input TP (2). Vary the Gain of AC Amplifier to get the unclipped output. Vary the amplitude of input; the amplitude of output will vary.

12. Observe the output of Sample & Hold circuit at TP4, together with Modulation signal input TP (2) and Pulse input TP (1). This is Sample & Hold output.

13. Connect the Sample & Hold output to the input of low pass filter. Observe the output of the Low pass filter TP (12) together with Modulation signal input TP (2).

14. Observe the output of the AC Amplifier TP (14) together with Modulation signal input TP (2). Vary the Gain of AC Amplifier to get the unclipped output. Vary the amplitude of input; the amplitude of output will vary.

15. Vary the amplitude potentiometer and frequency change over switch & observe the effect on these three outputs.

16. Vary the frequency of pulse, by connecting the pulse input to the 4 frequencies available i.e. 8, 16, 32, 64 kHz in Pulse output block.

5a.5 Model Graph

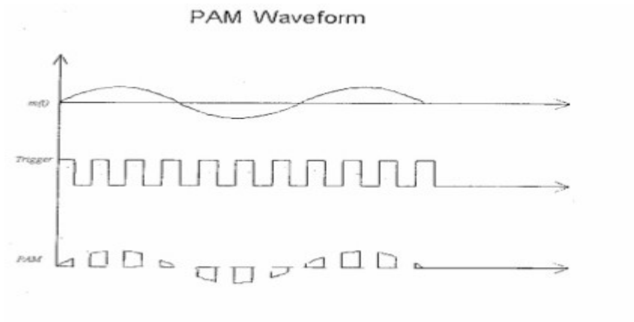
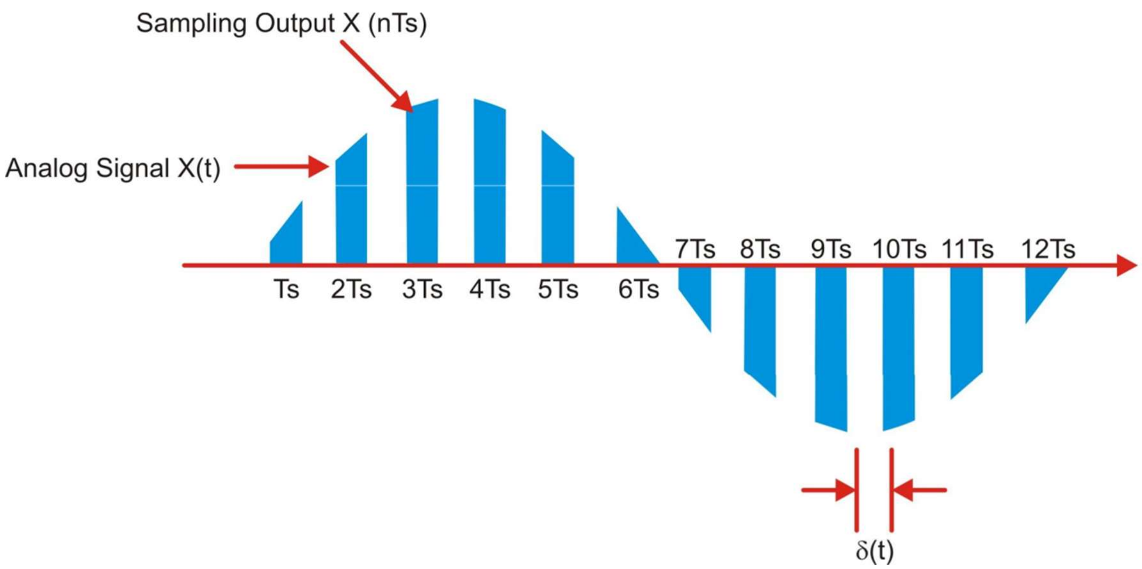


Fig. 5a.2 PAM Modulated Waveform

Natural Sampling Output



Flat top sampling Output

5a.6 Tabulation

Signal	Amplitude (V)	Time Period (ms)
Sinusoidal waveform		
Pulse Carrier waveform		
Sample Output		
Sample and Hold Output		
Flat Top Output		
Demodulated waveform		

5a.7 Lab Result

Thus the PAM and its demodulation were performed and graphs were plotted.

(B) PULSE POSITION MODULATION AND DEMODULATION

5b.1 Objective

To analyze a PPM system and interpret the modulated and demodulated waveforms

5b.2 Hardware Required

PPM Modulator and Demodulator Trainer Kit

Power supply Cord

Digital Oscilloscope

5b.3 Introduction

In Pulse Position Modulation both the pulse amplitude and pulse duration are held constant but the position of the pulse is varied in proportional to the sample values of the message signal .Pulse time modulation is a class of signaling techniques that encodes the sample values of the analog signal on to the time axis of a digital signal and it is analogous to angle modulation technique. The two types of PTM are PWM and PPM. In PPM the analog sample value determines the position of a narrow pulse relative to the clocking time. In PPM rise time of pulse decides the channel bandwidth it has low noise interference.

5b.4 Procedure

1. Connect the circuit as shown in Figure 2.1
2. A modulating signal is given to the PPM modulator
3. The amplitude and the time duration of the modulating signal are observed using CRO.
4. PPM output is observed from the output of PPM modulator stage and the amplitude and time duration of the PPM wave are noted down.
5. For Demodulation process, PPM signal is applied to the filter circuit and then to amplifier as shown in fig 2.3
6. After demodulation the original signal is recovered.

5b.5 Wiring Diagram

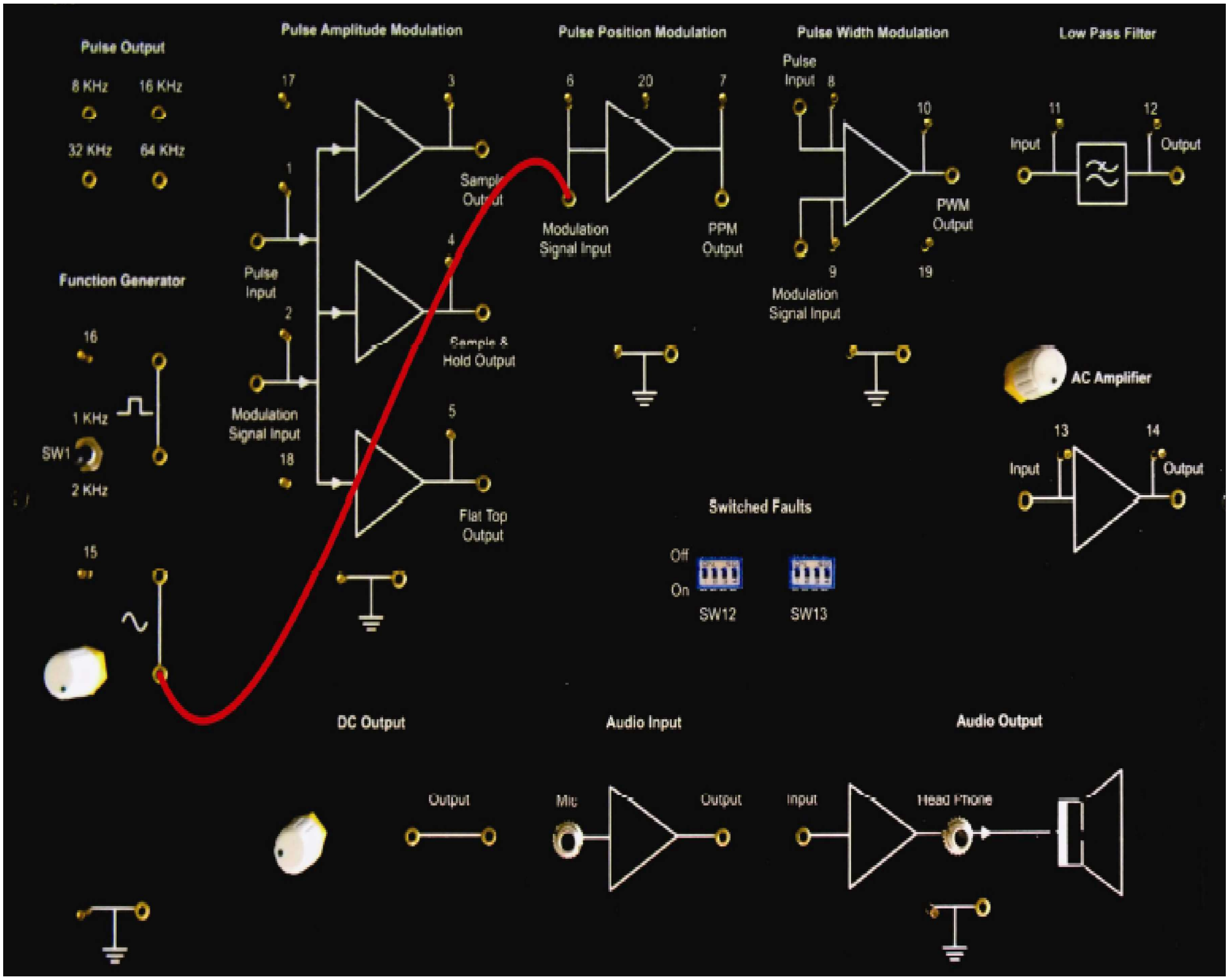


Figure 5b.2.1 Wiring Diagram for Modulation

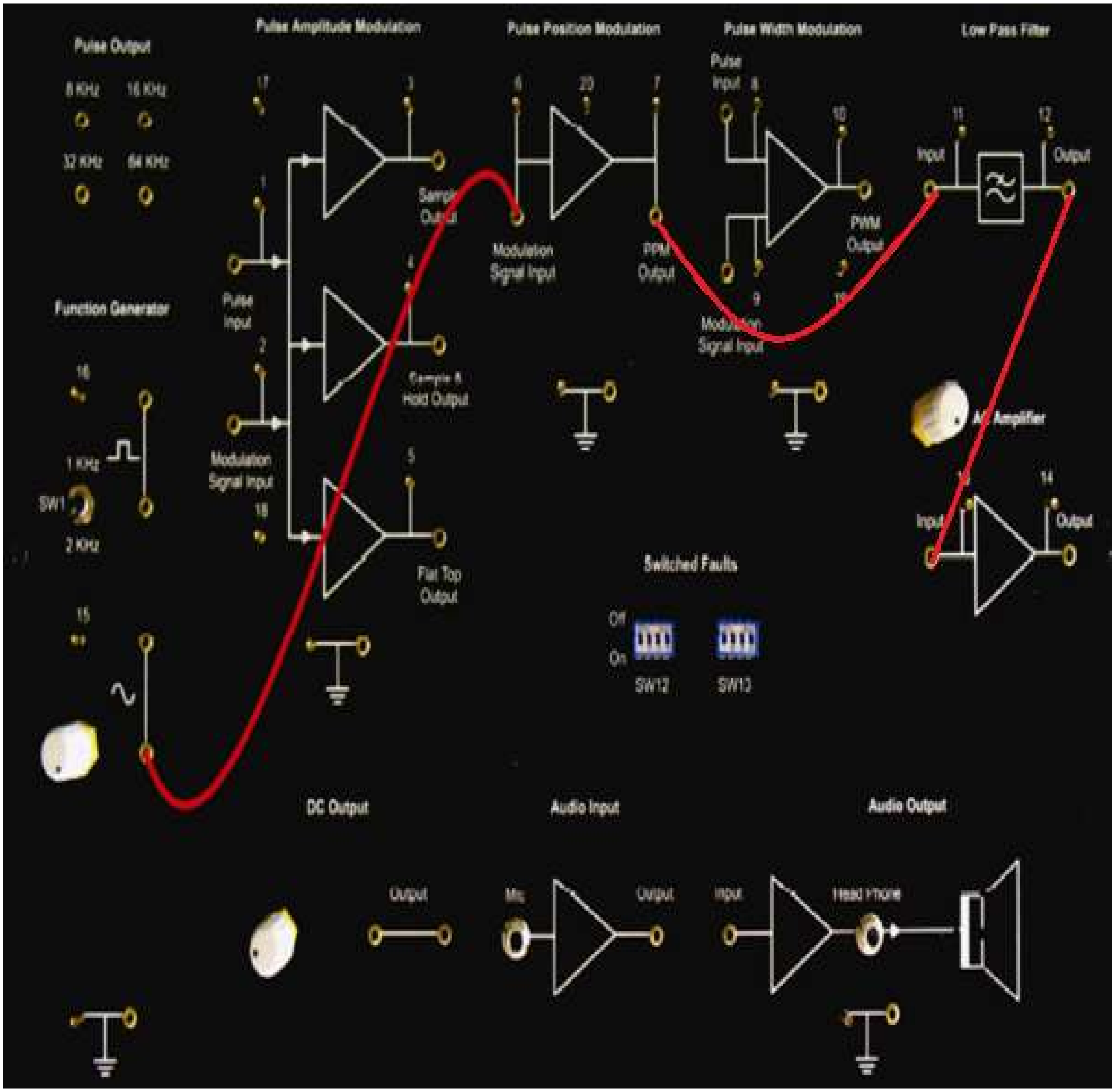
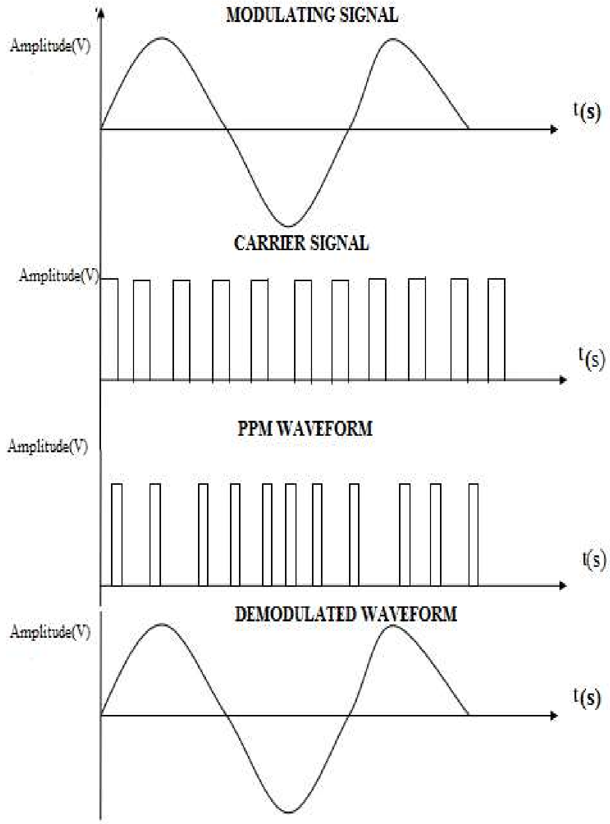


Figure 5b.2.2 Wiring Diagram for Demodulation

5b.6 Model Graph:



5b.7 PPM Modulation

Name of the Signal	Amplitude(V)	Time Period(ms)	Frequency(Hz)
Message signal			
Carrier Signal			
Modulated Signal			

PPM Demodulation

Name of the Signal	Amplitude(V)	Time Period(ms)	Frequency(Hz)
LPF Signal			
Demodulated signal			

5b.8 Lab Result

Thus the Pulse Position modulation and demodulation were performed and graphs were plotted.

5 (C) PULSE WIDTH MODULATIONS AND DEMODULATION

5c.1 Objective

Study of PWM using different Sampling Frequency and its demodulation

5c.2 Equipment Required

Scientech 2110 with Power Supply cord

Scientech Oscilloscope with connecting probe

Connecting cords

5c.3 Wiring Diagram

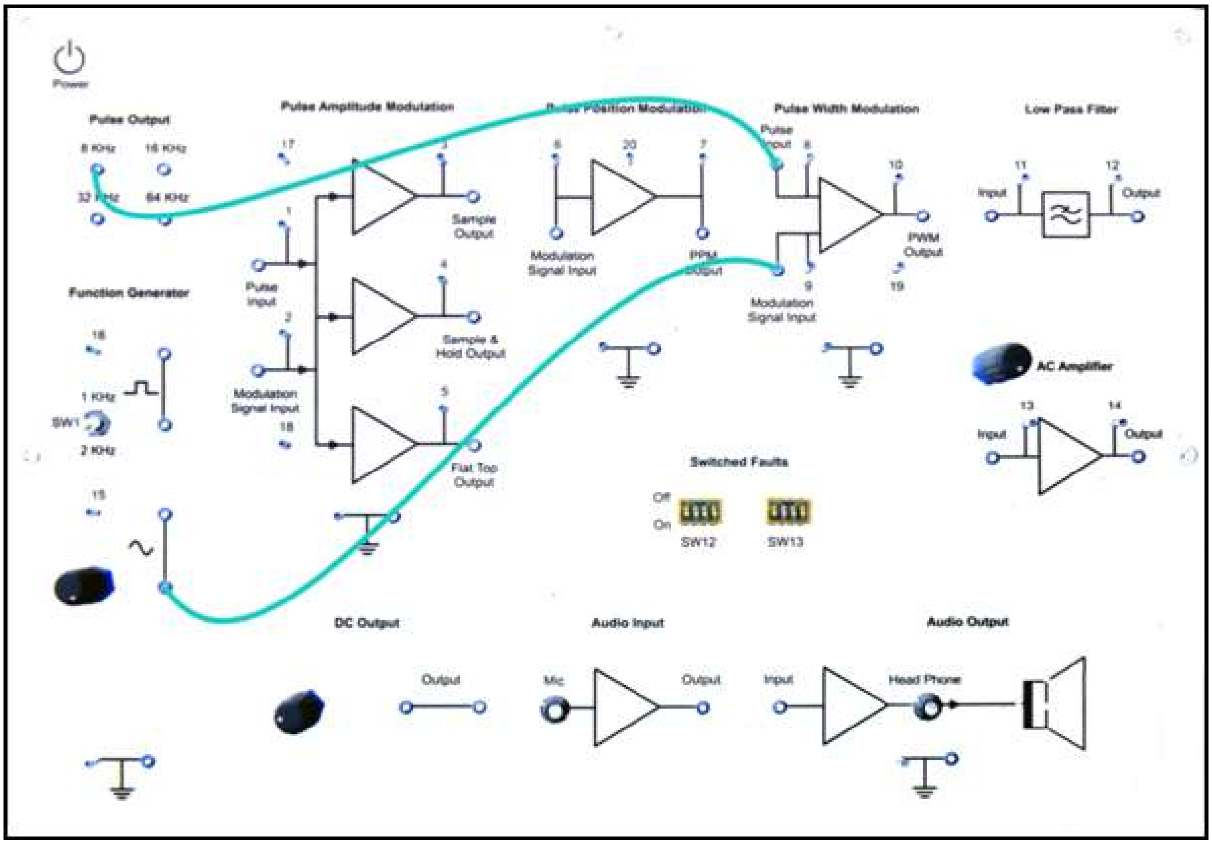


Figure 5c.3.1 Wiring Diagram for PWM Modulation

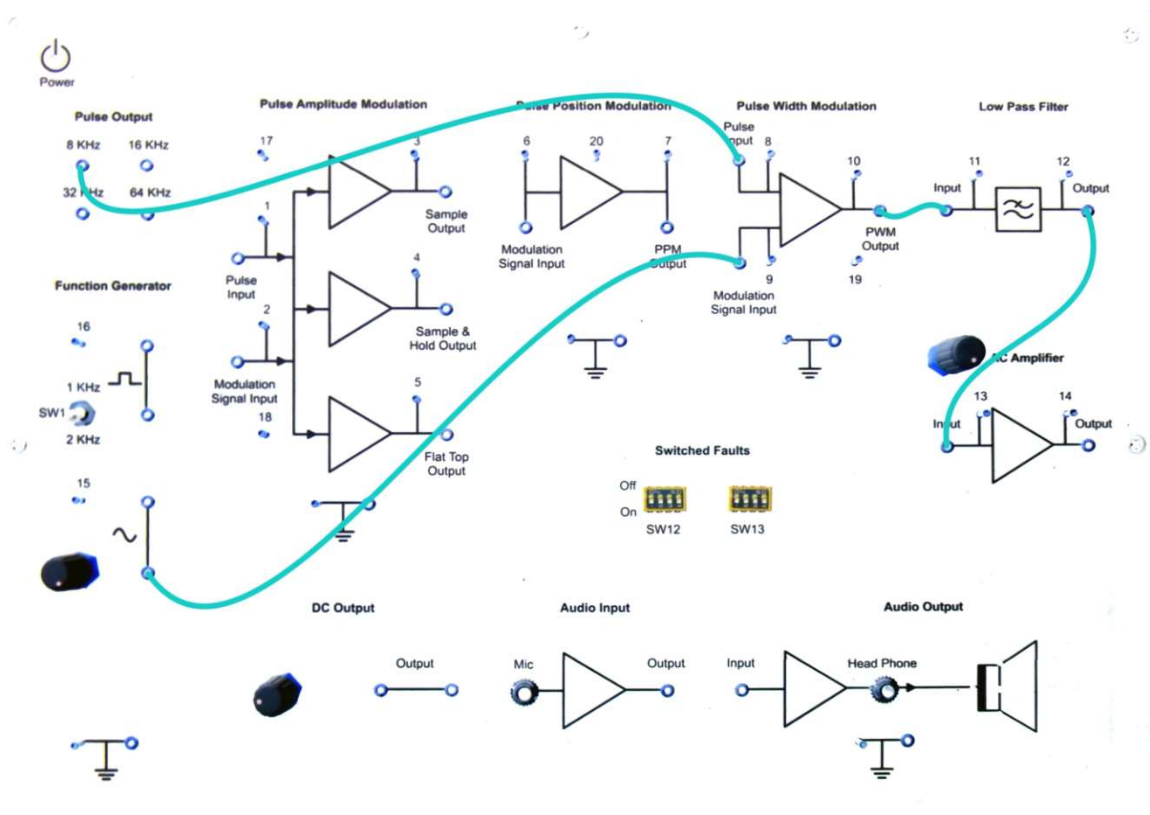


Figure 5c.3.2 Wiring Diagram for PWM Demodulation

5c.4 Procedure

1. Connect the circuit as shown in the Figure 1.3.1
2. 1 KHz sine wave output of Function Generator block to modulation input of PWM block.
3. 8 KHz square wave output to pulse input of PWM block.
4. Switch ‘On’ the Power Supply & Oscilloscope.
5. Observe the PWM outputs at TP (10) together with Modulation signal input TP (9).
6. Vary the amplitude of sine wave and see its effect on width of pulse output.
7. Also, change the frequency of the pulse by connecting the pulse input to different pulse frequencies viz. 8 KHz, 16 KHz, 32 KHz and see the variations in the PWM output.
8. Switch ‘On’ fault No. 1, 2, & 5 one by one & observes their effect on PWM Output and tries to locate them.
9. Output of low pass filter to input of AC Amplifier.
10. Switch ‘On’ the Power Supply & Oscilloscope.
11. Observe the waveform at the output of Low pass filter TP12 together with modulation signal input (9).

12. Then observe the demodulated output at the output of AC Amplifier TP14 together with modulation signal input TP (9). Vary the Gain of AC Amplifier to get the unclipped output. Vary the amplitude of input; the amplitude of output will vary.

13. Try varying the amplitude of sine wave signal; you will observe that the output signal varies similarly.

14. Switch 'On' fault no, 1, 2, 5 & 8 one by one at a time. Observe their effects on final output and try to locate them.

15. Switch 'Off' the Power Supply

5c.5 Model Graph

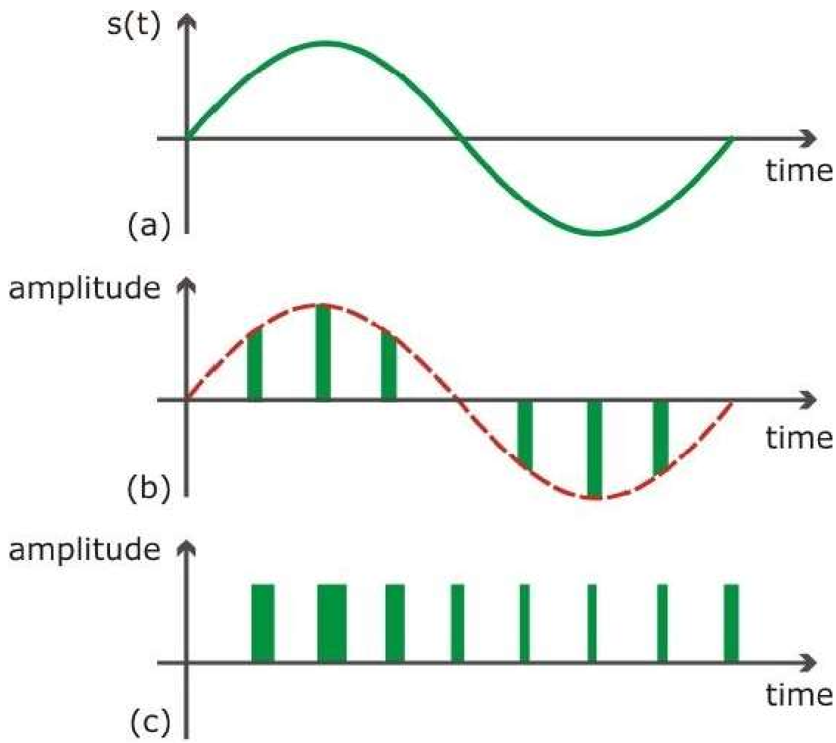


Figure 5c.3 (a) Input Waveform (b) PAM Waveform (c) PWM Waveform

5c.6 Tabulation

Signal	Frequency	Amplitude
Sinusoidal waveform		
Pulse waveform		
Demodulated waveform		

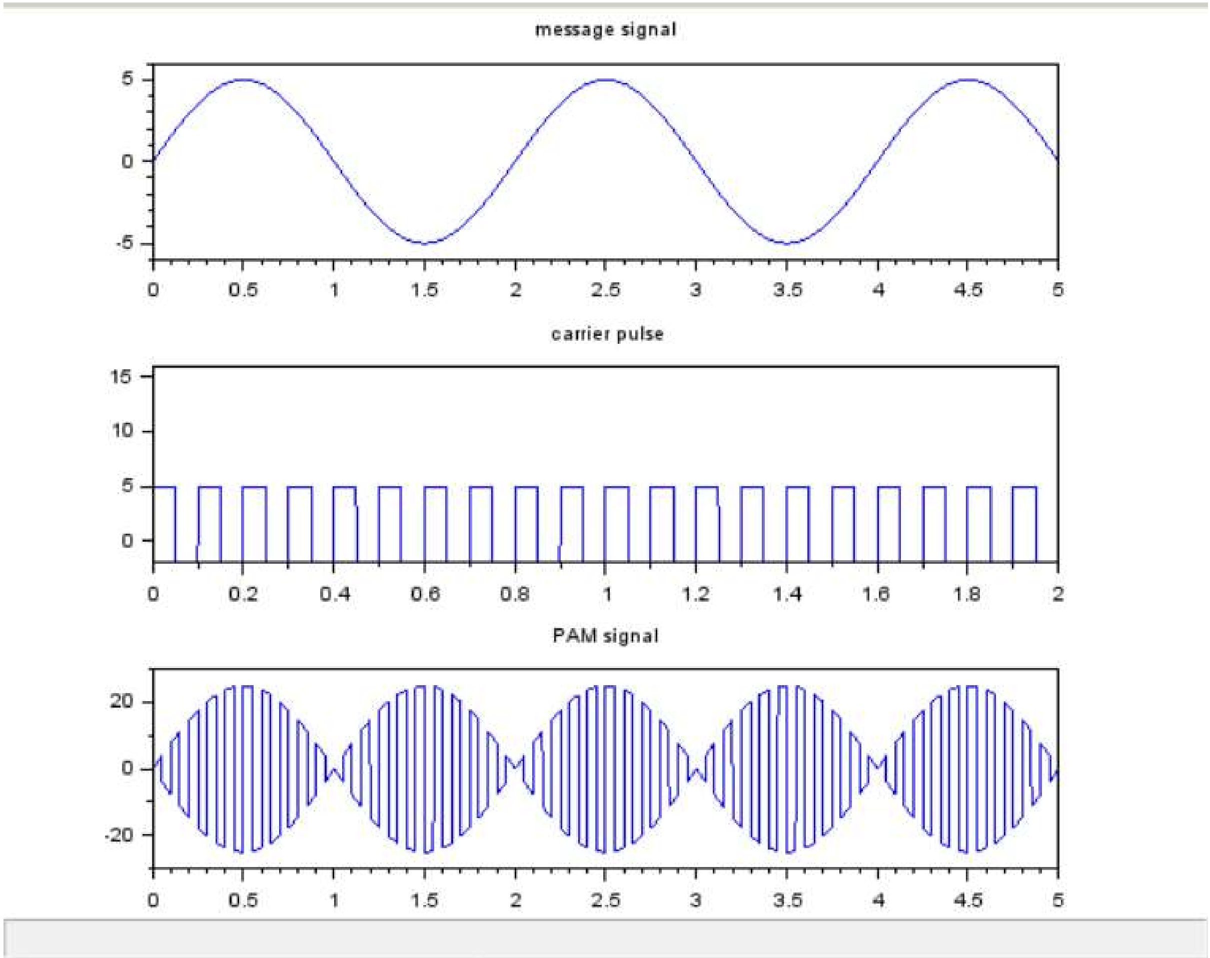
5c.7 Pre Lab Questions

1. Why flat top sampling is better than natural sampling?
2. What do you understand by sample and hold circuit?
3. What is the importance of doing sample and hold of signals?
4. What are the applications of PPM?
5. Compare PAM, PPM, and PWM

5c.8 SCILAB PROGRAM:

```
clc;
clear;
xdel ( winsid ());
// generate modulating signal
fm = 2;
Am = 5;
t = 0:0.001:5;
Vm = Am*sin(((2*%pi)*fm)*t/4);
subplot(311)
plot(t,Vm)
title('message signal');
// generate carrier signal
fc = 10;
Ac = 5;
Vc = Ac*squarewave (((2*%pi)*fc)*t);
subplot(312)
plot(t,Vc)
title('carrier pulse');
h=gca();
h.data_bounds=[0,-1;2,3*Ac]
// generate pam
pam_mod=Vm.*Vc
subplot(313)
plot(t,pam_mod);
title('PAM signal');
```

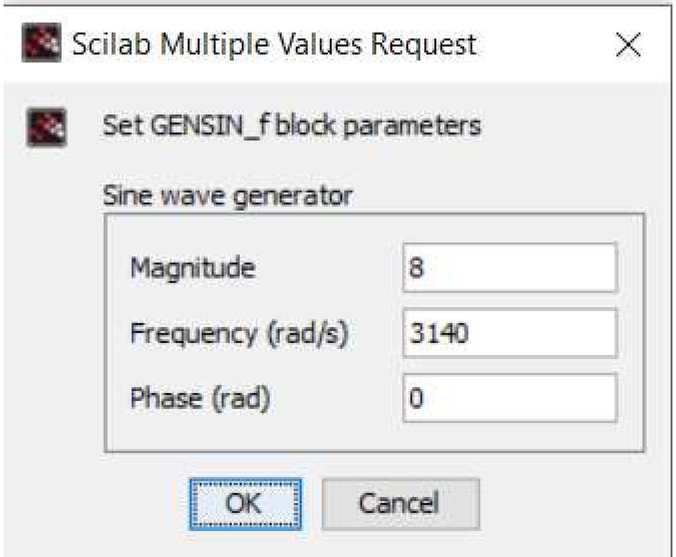
OUTPUT:



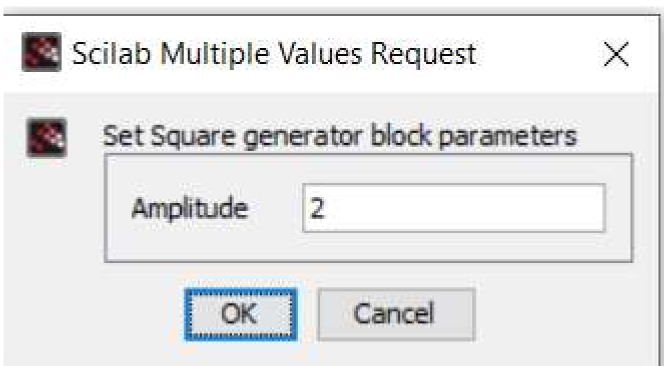
Generation of PAM in Scilab by using XCOS

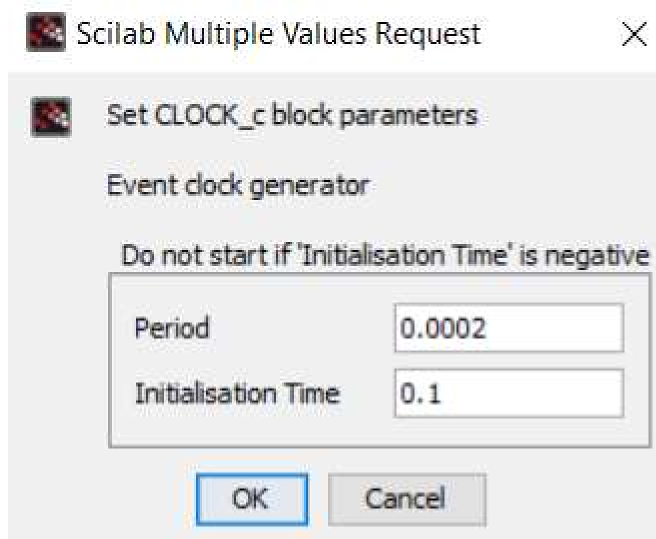
1.Click the XCOS icon 
2.In the palette browser, click source, choose the sine and square wave generator and clock
3.In the sink choose the cscope & In mathematical operation select PROD-f (ie multiplier).Then connect all the blocks as shown below.

4.click on the message signal generator, set the values of message signal as

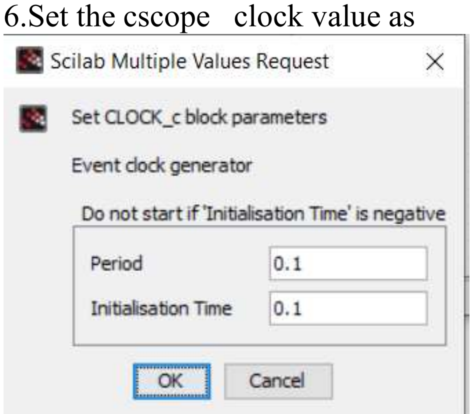


5. click on the carrier signal generator, set the values of carrier signal as

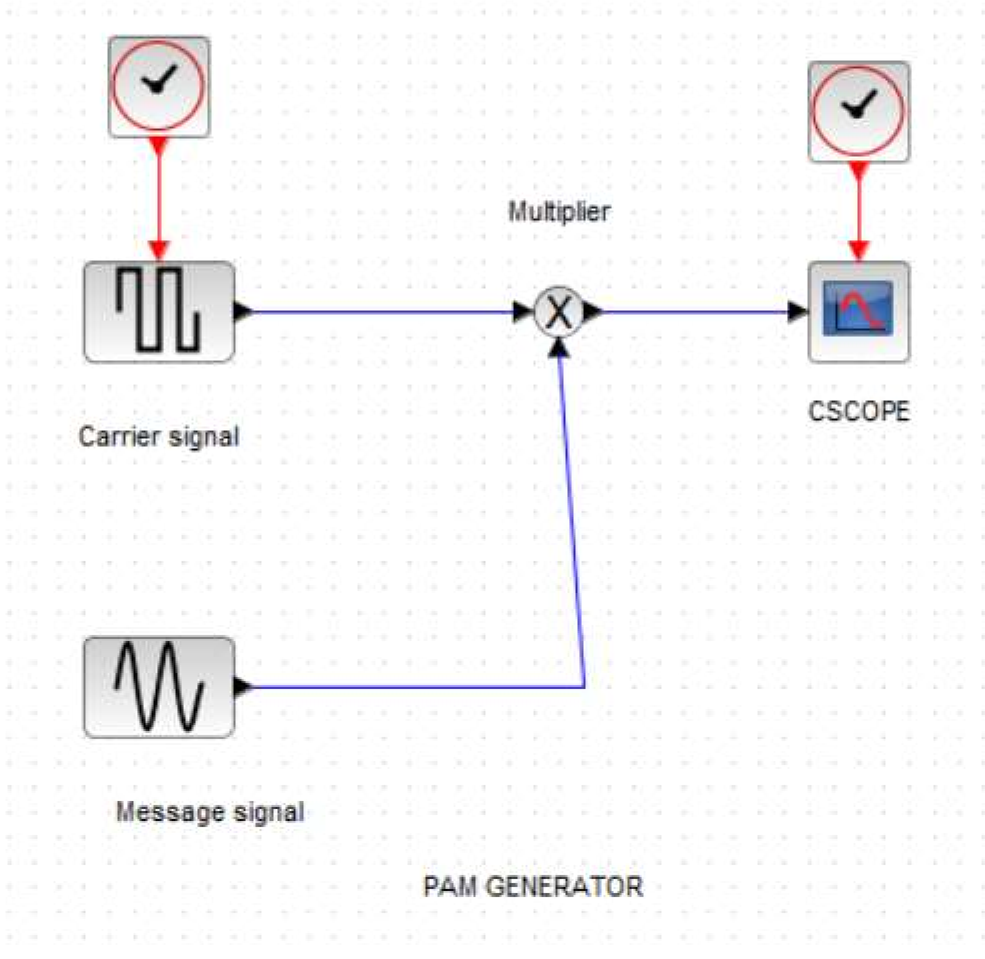




6.Set the cscope clock value as

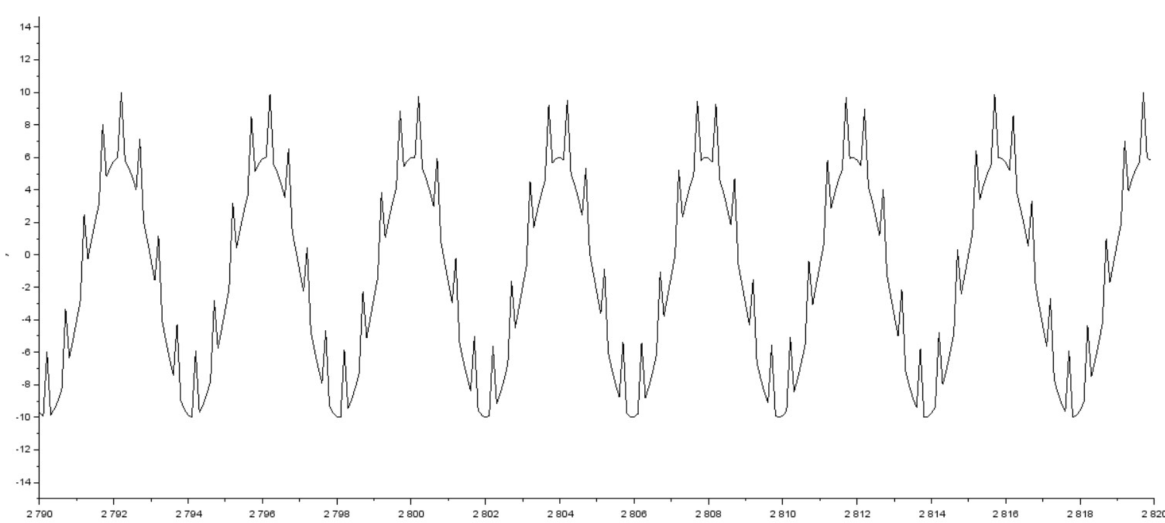


7. Save and execute the PAM generator



8.The generated pam signal will be displayed in the graphical window

9.Vary the parameter of message and carrier ,check your plot.



5c.9 Postlab Questions

1. List the real time applications of PWM.
2. What are the real time constraints of PPM signal?
3. What will happen to output signal frequency while the pulse frequency is varied?
4. What should be done to smoothen the edges of the flat top sampled waveform?
5. What are the applications of PAM?

5c.10 Lab Result

Thus the PWM and its demodulation were performed and the graphs were plotted.

6 PULSE CODE MODULATION AND DEMODULATION

6.1 Objective

To analyze PCM system and interpret the modulated and demodulated waveforms for various sampling frequency and to find the Signal to Quantization Noise Ratio of PCM system.

6.2 Hardware Required

PCM modulator trainer kit-AET-68M

PCM Demodulator trainer kit-AET-68D

Storage oscilloscope

Digital multimeter

6.3 Wiring Diagram

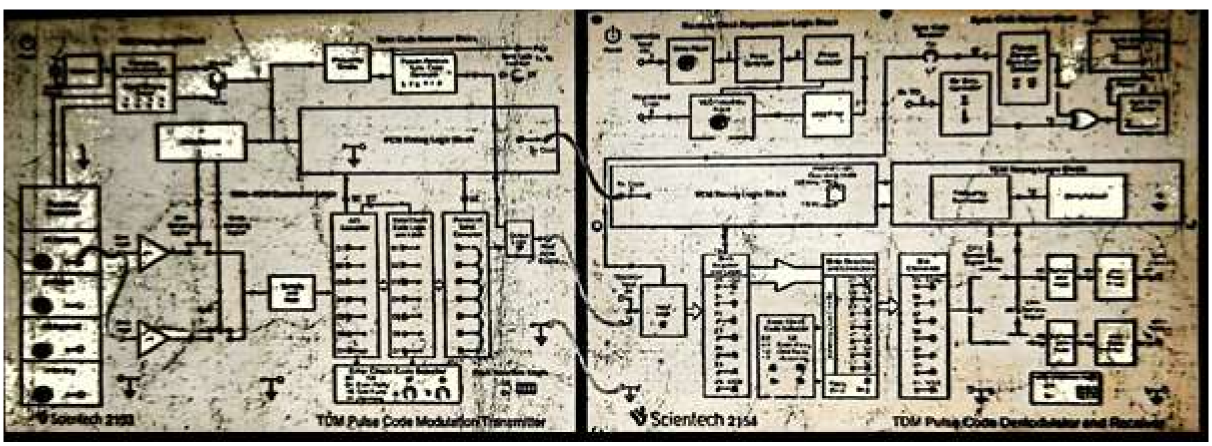


Figure 6.1 Wiring Diagram for PCM Modulation and Demodulation

6.4 Introduction

In Pulse code modulation (PCM) only certain discrete values are allowed for the modulating signals. The modulating signal is sampled, as in other forms of pulse modulation. But any sample falling within a specified range of values is assigned a discrete value. Each value is assigned a pattern of pulses and the signal transmitted by means of this code. The electronic circuit that produces the coded pulse train from the modulating waveform is termed a coder or encoder. A suitable decoder must be used at the receiver in order to extract the original information from the transmitted pulse train.

6.5 Block Diagram

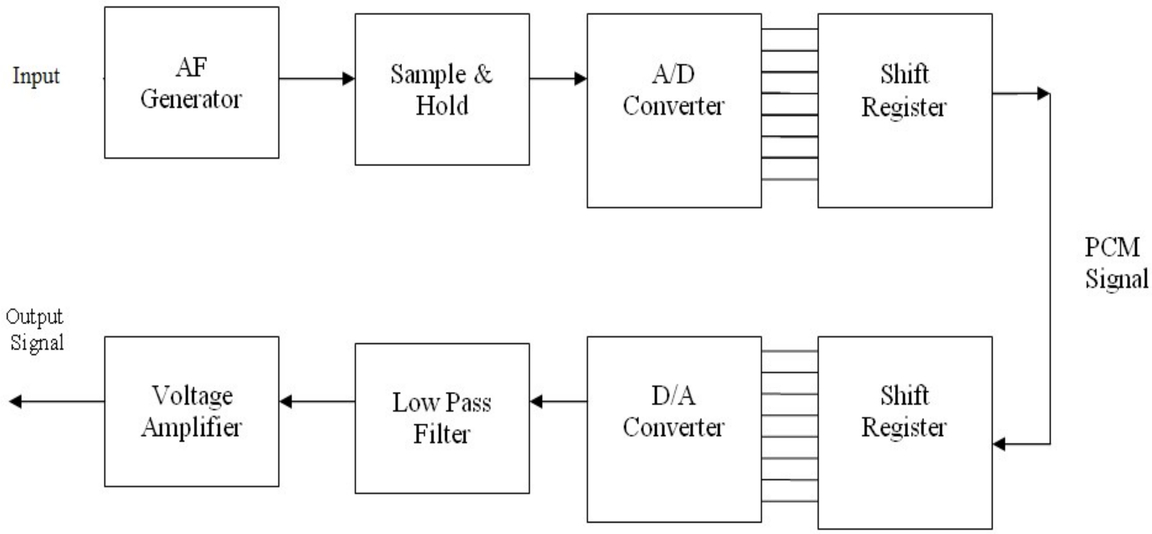


Figure 6.5.1 PCM Modulator AND Demodulator

6.6 Pre Lab Questions

1. State sampling theorem.
2. What are the various steps involved in A/D conversion.
3. List out the three basic functions of regenerative repeater.

6.7 Procedure

6.7.1 PCM Operation (with AC input)

1. Connect the modulator trainer to the mains and switch on the power supply.
2. Observe the output of the Sine generator using CRO, it should be a sine wave of 2KHz frequency with tuned amplitude.
3. Observe the Sample and Hold output using CRO.
4. Observe the output of the TDM PCM output using CRO.

6.7.2 PCM Operation (with DC input)

Modulation

5. Set DC source to some value say 4.4V with the help of the Knob and connect it to the A/D converter input and observe the output LED's
6. Note down the digital code i.e. output of the A/D converter and compare with the theoretical value.

Theoretical value can be obtained by: $\frac{A/D\ Input\ voltage}{1LSB\ Value} = X_{(10)} = Y_{(2)}$

Where

1 LSB Value	=	$V_{ref}/2^n$
Since V_{ref}	=	5 V and n=8
1 LSB Value	=	0.01953

Example:

A/D Input voltage	=	4.4 V
	=	$225.28_{(10)1}$
	=	$1110\ 0001_{(2)}$

So digital output is 1110 0001

7. Observe the Sample and Hold output using CRO.
8. Observe the output of the TDM PCM output using CRO.

Repeat the above steps for other Sampling frequencies.

Note: From this waveform you can observe the LSB bit enters the output first.

6.7.3 Demodulation

9. Connect TDM PCM signal of the modulator to the demodulators with the help of patch chord.
10. Connect transmitter clock to the receiver clock.
11. Observe the Sample and Hold output using CRO.
12. Observe the output of the LPF output using CRO.

Sample work sheet

1.	Modulating signal	:	4.4 V
2.	A/D Output (theoretical)	:	$1110\ 0001_{(2)}$
3.	A/D Output (practical)	:	$1110\ 0001_{(2)}$
4.	S-P Output	:	$1110\ 0001_{(2)}$
5.	D/A Converter output (Demodulated output)	:	4.4 V

6.8 Model Graph

i) With AC Input

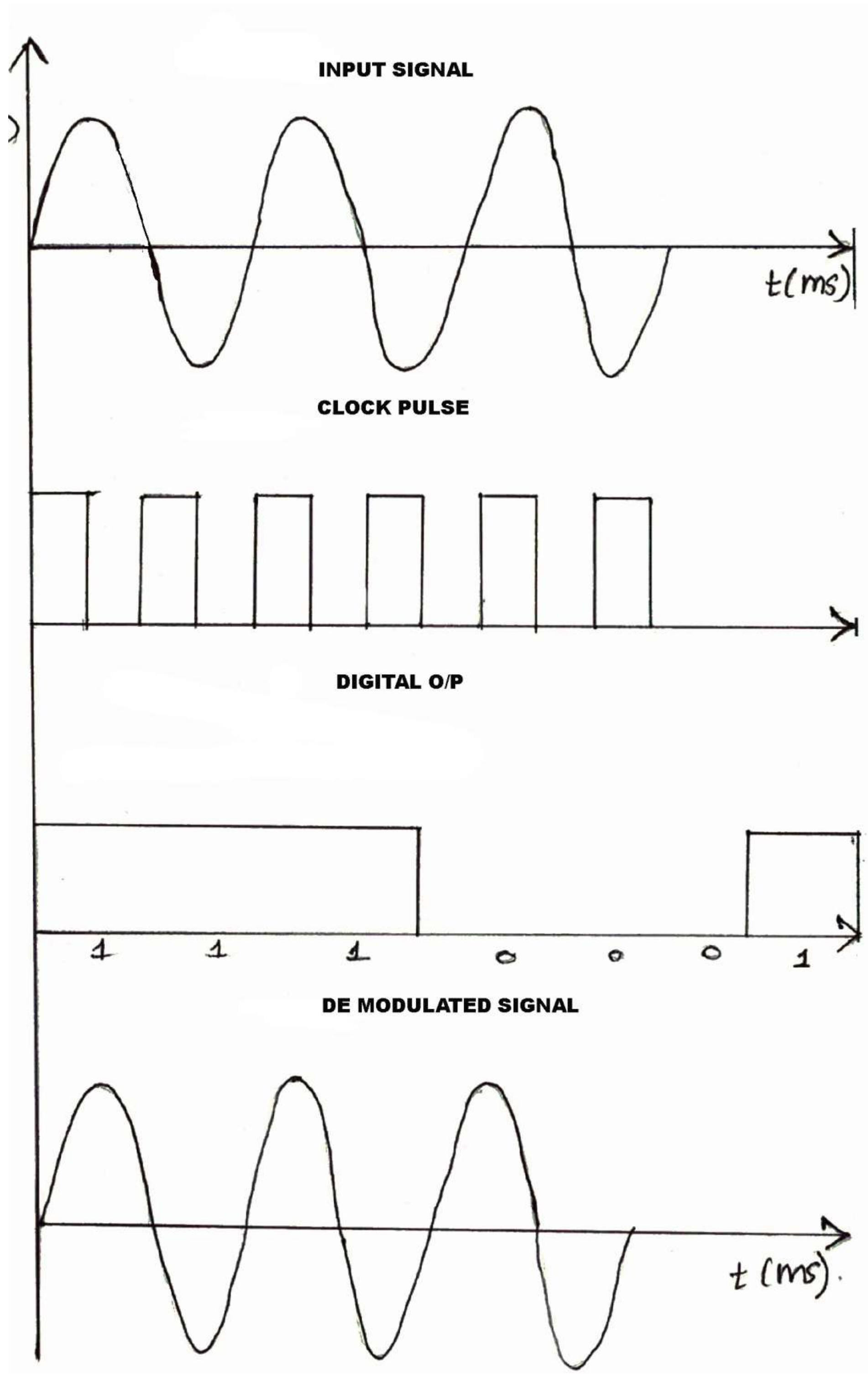


Figure 6.2 PCM Waveform with AC input

ii)With DC Input

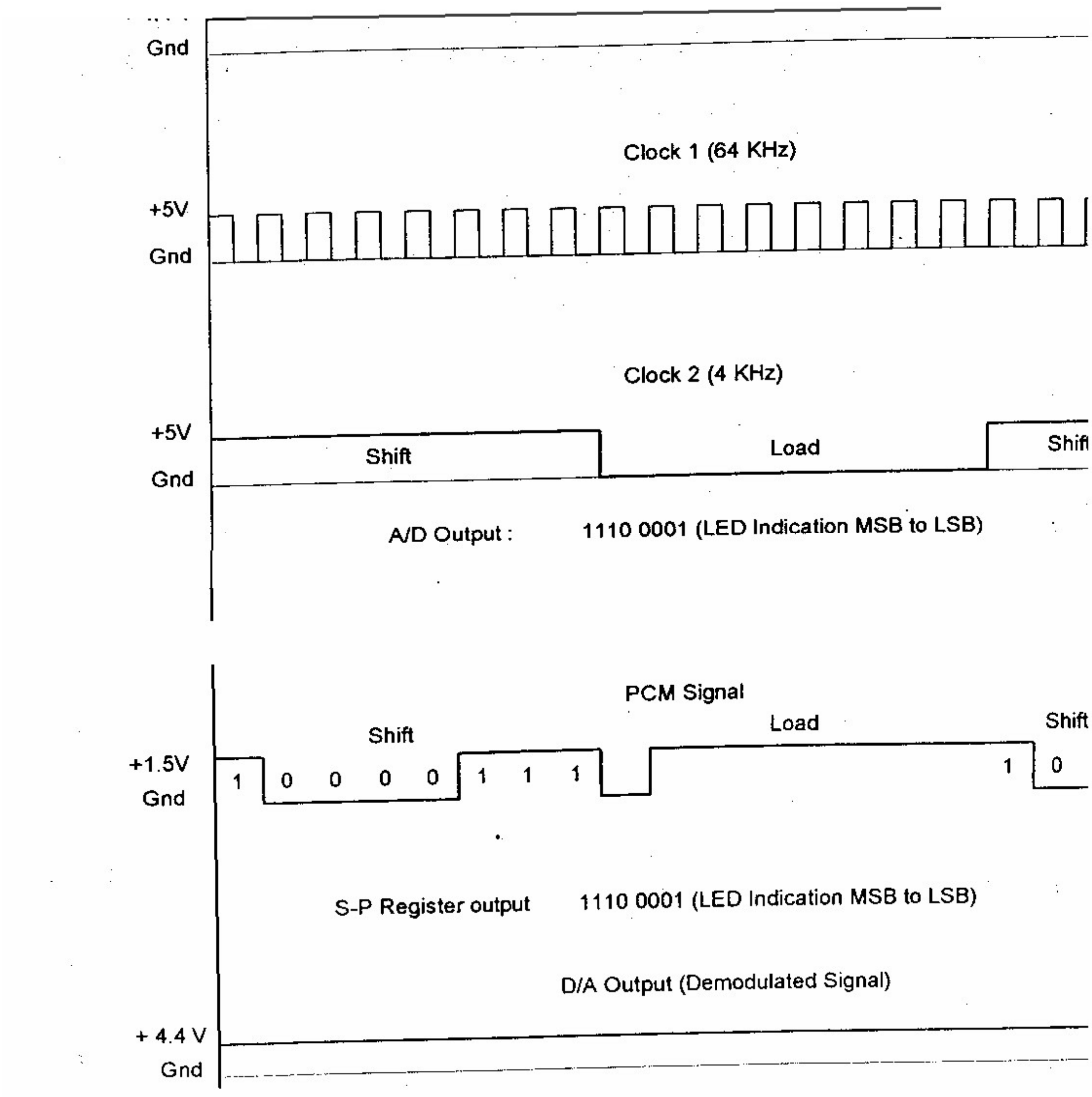


Figure 6.3 PCM Waveform with DC input

6.9 Observation

PCM Modulation (With AC input)

Signal	Amplitude	Time Period
AC input		
Clock Signal		
Sample and hold signal		
PCM Output		

PCM Demodulation (with AC input)

Signal	Amplitude	Time Period
D/A Converter output Signal		
LPF output signal		
Demodulated output		

PCM Modulation (With DC input)

Signal	Amplitude	Time Period
DC input		
Clock Signal		
PCM Output		

PCM Demodulation (With DC input)

Signal	Amplitude	Time Period
D/A Converter output Signal		
LPF output signal		
Demodulated Output		

6.10 VIRTUAL LAB

6.10.1 Equipment / Apparatus

SCILAB Software 6.0.2

6.10.2 Exercise

Consider a signal x(t) = sin 2π5t is to be quantized into 8 levels. The number of samples is 1000 .

Write a command using Scilab to plot the following signal :

(i) Original signal

(ii) Quantized signal

SOLUTION

```
clc;
close;
t = 0:0.001:1;
x = sin(2*%pi*5*t);
L = 8;

//quantization
xmax = max(abs(x));
xq = x/xmax;
```

```
en_code = xq;
d = 2/L;
q = d*[0:L-1];
q = q-((L-1)/2)*d;
for i = 1:L
xq(find(((q(i)-d/2)<=xq)&(xq<=(q(i)+d/2))))=q(i).*ones(1,length(find(((q(i)-
d/2)<=xq)&(xq<=(q(i)+d/2)))));
en_code(find(xq == q(i)))= (i-1).*ones(1,length(find(xq== q(i))));
end
xq = xq*xmax;
plot2d2(t*2*%pi,x);
plot2d2(t*2*%pi,xq,5);

//Encoding
n = log2(L);
c = zeros(length(x),n);
for i = 1:length(x)
for j = n:-1:0
if(fix(en_code(i)/(2^j))==1)
c(i,(n-j)) =1;
en_code(i) = en_code(i)-2^j;
end
end
end
disp(c)
```

6.10.3 Observation – Software

PCM Modulation (With AC input)

Signal	Amplitude	Time Period	Frequency
AC input			
Sample and hold signal			

6.10.4 Model graph

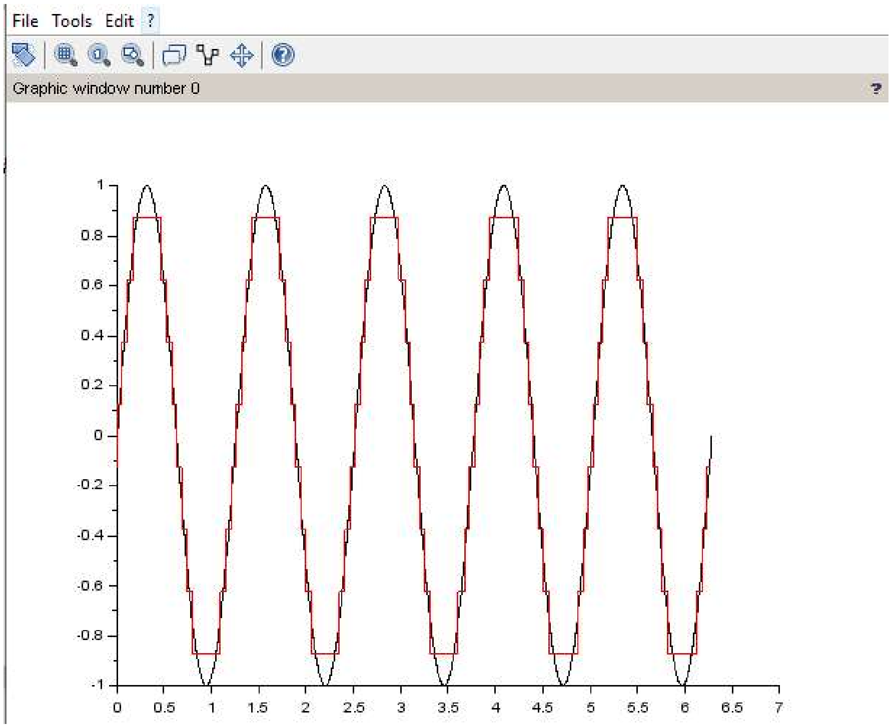


Fig 6.10.a:Message and Sample and Hold Signal

Scilab 6.1.0 Console

```
0.   1.   1.
1.   0.   0.
1.   0.   0.
1.   0.   0.
1.   0.   0.
1.   0.   0.
1.   0.   0.
1.   0.   0.
1.   0.   0.
1.   0.   1.
1.   0.   1.
1.   0.   1.
1.   0.   1.
1.   0.   1.
1.   0.   1.
1.   0.   1.
1.   0.   1.
1.   1.   0.
1.   1.   0.
1.   1.   0.
1.   1.   0.
1.   1.   0.
1.   1.   0.
1.   1.   0.
```

Fig 6.10.b:Encoded Value of the Sampled Signal

6.11: Exercise

Find the Signal to Noise ratio of PCM using Scilab

```
clear all;
clc;
f_m = 4.2*10^6//television signal of 4MHz
q = 512//quantization levels
//calculations
//number of bits and quantization levels are related in binary PCM as q = 2^v
//where v is code word length
v = (log10(q)/log10(2));//code word length
BW = v*f_m//transmission channel bandwidth which is greater than or equal to obtained value
f_s = 2*f_m//sampling frequency which is greater than or equal to obtained value
r = v*f_s//signaling rate of final bit rate
SQNR_dB = 1.8 + 6*v//output signal to noise ratio which is less than or equal to obtained value
//results
printf("\n\ni.  Code word length  = %.2f bits",v);
printf("\n\nii. Transmission bandwidth = %.2f Hz",BW);
printf("\n\niii.Final bit rate = %.2f bits/sec",r);
printf("\n\niv.Output signal to quantization noise ratio = %.2f dB",SQNR_dB);
```

OUTPUT

i. Code word length = 9.00 bits

ii. Transmission bandwidth = 37800000.00 Hz

iii.Final bit rate = 75600000.00 bits/sec

iv.Output signal to quantization noise ratio = 55.80 dB

6.12 Post Lab Questions

1. A sinusoidal input signal, m(t) having an amplitude of 1V is sampled at 100 samples and the samples are quantized to 8 evenly spaced levels. Use Scilab to plot the following signal :

(a) Use Scilab to plot the following signal :

(iii) Original signal

(iv) Quantizing signal.

(b) Determine the PCM code using SCILAB.

(c) Determine the voltage of input signal that represented by 010, 011, and 110.

2. What will happen when sampling rate is greater than Nyquist rate ?

3. Find the A/D Converter output for input DC voltage of 3.6V.

6.13 Lab Result

Thus the Pulse Code modulation and demodulation were performed and graphs were plotted and implemented Signal to Quantization Noise Ratio of PCM system using Scilab.

7 DIFFERENTIAL PULSE CODE MODULATION AND DEMODULATION

7.1 Objective

To analyze DPCM system and to interpret the modulated and demodulated waveforms for various sampling frequency and simulate DPCM wave in Scilab.

7.2 Hardware Required

Adcl-07 Kit

20 MHz Dual Trace Oscilloscope

Connecting Chords

Power Supply

Note: Keep the Switch faults in Off Position

7.3 Introduction

Differential PCM is quite similar to ordinary PCM. Each word in this system indicates the difference in amplitude, positive or negative, between this sample and the previous sample. Thus the relative value of each sample is indicated rather than, the absolute value in normal PCM.

Block Diagram

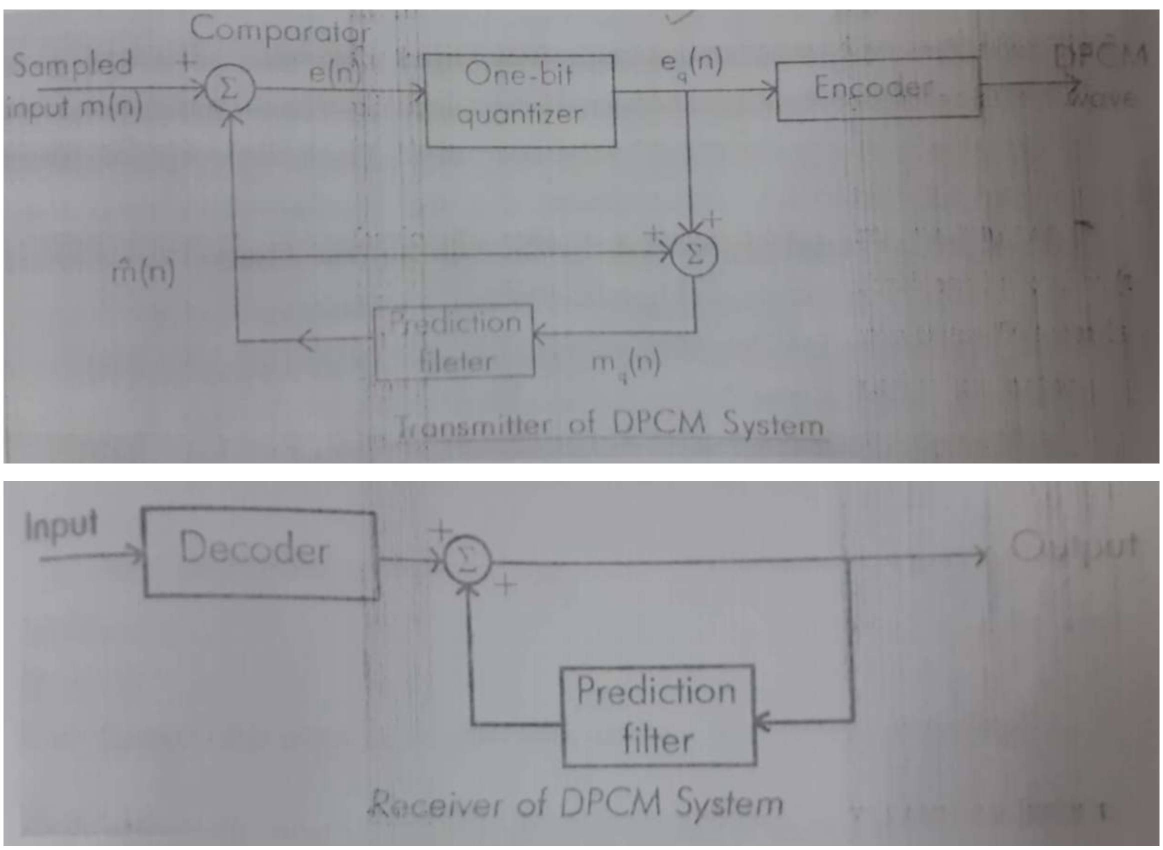


Figure 7.1 Block diagram of DPCM System

Figure 7.2 DPCM trainer kit

7.4 Prelab Questions

1. Compare DPCM and PCM.
2. What is the significance of predictor in DPCM?
3. What is the significance of accumulator in DPCM?
4. Why DPCM is used for speech compression?

7.5 Procedure

7.5.1 DPCM modulation

1. Refer to the block diagram and carry out the following Connections and switch settings.
2. Connect power supply in proper polarity to the kit ADCL-07 and switch it ON.
3. Keep the clock frequency at 512 KHz by changing the jumper position of JP1 in the clock generator section
4. Keep the amplitude of the onboard sine wave, of frequency 500Hz to 1Vpp DPCM modulation.
5. Connect the 500Hz sine wave to the lN post of Analog Buffer.
6. Connect OUT post of Analog Buffer to lN post of DPCM modulator section.
7. Observe the sample output at the given test point the input signal is sampled at the clock frequency of 16 KHz.

8. Observe the linear predictor output at the PREDICTED OUT post of the Linear predictor in the DPCM modulator section.
9. Observe the differential pulse code modulate data (DPCM) at the DPCM OUT post of the DPCM modulator section.
10. Observe the DPCM data at DPCM OUT post by varying input signal from to 2V.

7.5.2 DPCM demodulation

1. Connect the DPCM modulated data from the DPCM OUT post of the DPCM Modulator to the lN post of the DPCM demodulator.
2. Observe the demodulated data at the output of summation block.
3. Observe the integrated demodulated data at the DEMOD OUT post of the DPCM demodulator.
4. Connect the demodulated data from the DEMOD OUT post of the DPCM demodulator to the lN post of the low-pass filter.
5. Observe the reconstructed signal at the OUT post of the filter. Use RST switch for clear observation of output.
6. Now, simultaneously reduce the clock frequencies from 512 KHz to 256 KHz,128 KHz and 64 KHz by changing the jumper position of JP1 and observe the difference in the DPCM modulated and demodulated data. As the frequency of clock decreases DPCM Demodulated data at DEMOD OUT becomes distorted.
7. Observe various waveform as mentioned below

7.6 Model Graph

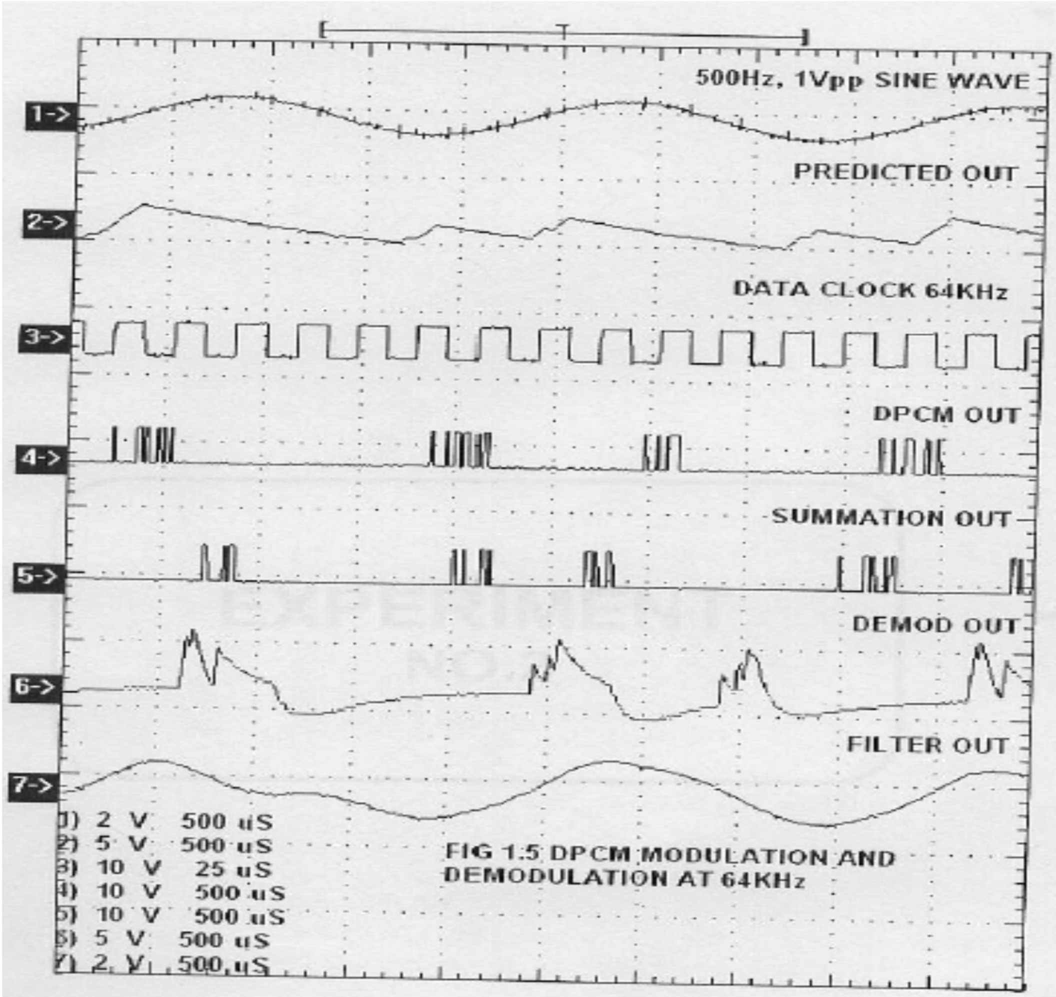


Figure 7.2 DPCM Operation (With Ac Input) Modulation & Demodulation

Observation

ON KIT ADCL-07

Observe the following waveforms on the oscilloscope and plot on the paper.

1. 500 Hz , l V pp input sine wave.
2. Sampled out at the provided test point SAMPLER OUT
3. Linear predictor out at PREDICTED OUT post.
4. DPCM data at DPCM OUT post
5. Line interface out at the given output test point of line interface block in DPCM Demodulator
6. Demodulated DPCM data at the output test point of summation block in DPCM demodulator.

7. Integrated demodulated data at the DEMOD OUT post of the DPCM demodulator
8. Reconstructed sine wave at the OUT post of the filter
9. Observe the data at different clock rates.

DPCM Operation - with AC input

Modulation		
	Amplitude	**Time Period**
AC Input		
Clock – 1 Output		
Sample and Hold Output		
DPCM Output		

Demodulation		
	Amplitude	**Time Period**
DPCM Input		
D/A Converter Output		
LPF Output		
Demodulated output Prediction Filter Output		

7.7 VIRTUAL LAB

Software : SCILAB 6.0.2

Exercise

Perform differential pulse code modulation using SCILab for the following specifications.

Amplitude of the signal : 2 V, message frequency is 4Hz, sampling frequency is 80Hz

7.7.1. Scilab Code

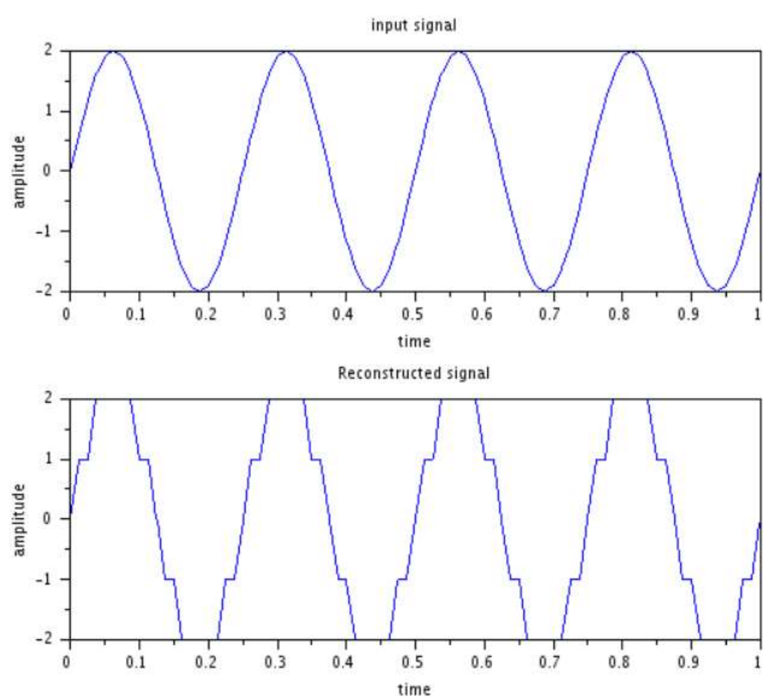
```
clc;
clear;
fm=4;
fs=20*fm;
am=2;
t=0:1/fs:1;
x=am*sin(2*%pi*fm*t);
subplot(2,1,1);
plot(t,x);
```

```
xlabel('time');
ylabel('amplitude');
title('input signal');
for n=1:length(x)
    if n==1
        e(n)=x(n);
        eq(n)=round(e(n))
        xq(n)=eq(n)
     else
         e(n)=x(n)-xq(n-1)
         eq(n)=round(e(n))
         xq(n)=eq(n)+xq(n-1)
     end
end
subplot(2,1,2);
plot(t,xq);
xlabel('time');
ylabel('amplitude');
title('quantized signal');
```

Observations

Signal	Amplitude	Time period
Input Signal		
Reconstructed Signal		

7.7.2 Model graph



7.8 Post Lab Questions

1. What is the need for compression? Mention the types of compression.
2. List the communication standards which use DPCM.
3. Name the circuit used to achieve synchronization between transmitter and receiver.
4. Use Scilab to perform differential pulse code modulation for the input signal of amplitude 10V and the frequency of 5K.

7.9 Lab Result

Thus the Differential Pulse code modulation and demodulation were performed using the trainer kit and Scilab.

8 DELTA MODULATION AND DEMODULATION

8.1 Objective

To analyze a Delta modulation system and interpret the modulated and demodulated waveforms. Simulate delta modulation (DM) wave in SCI lab.

8.2 Hardware Required

PCM Modulator trainer- AET-73M

PCM Demodulator trainer-AET-73D

Storage Oscilloscope

Digital Multimeter

Co-axial cables (standard accessories with AET-73 trainer)

8.3 Introduction

Delta Modulation is a form of pulse modulation where a sample value is represented as a single bit. This is almost similar to differential PCM, as the transmitted bit is only one per sample just to indicate whether the present sample is larger or smaller than the previous one. The encoding, decoding and quantizing process become extremely simple but this system cannot handle rapidly varying samples. This increases the quantizing noise.

Block Diagram

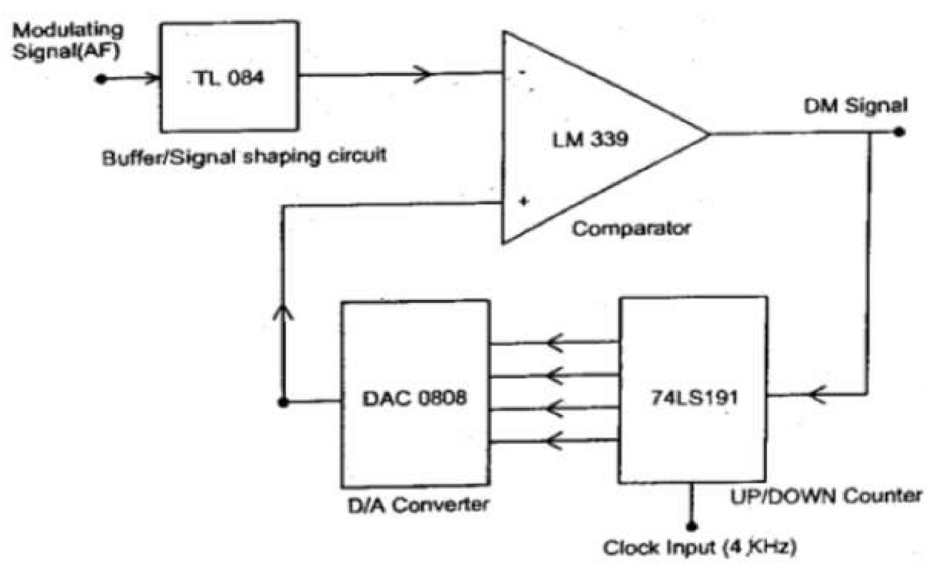


Figure 8.1 DM Modulator

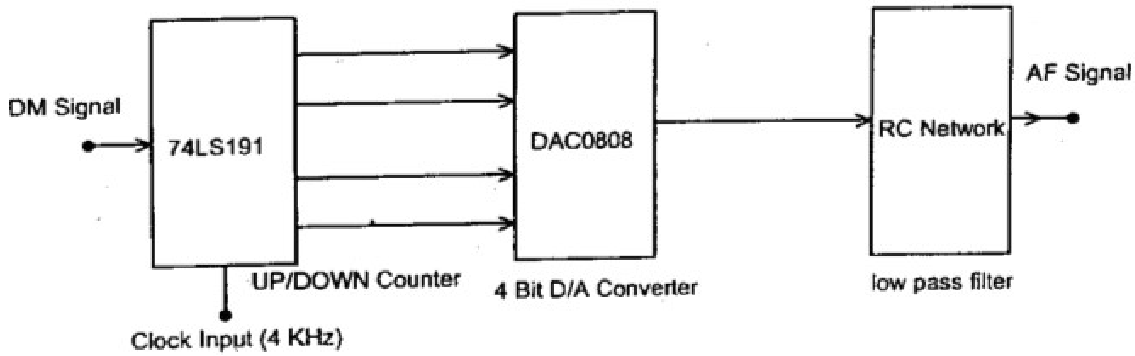


Figure 8.2. DM Demodulator

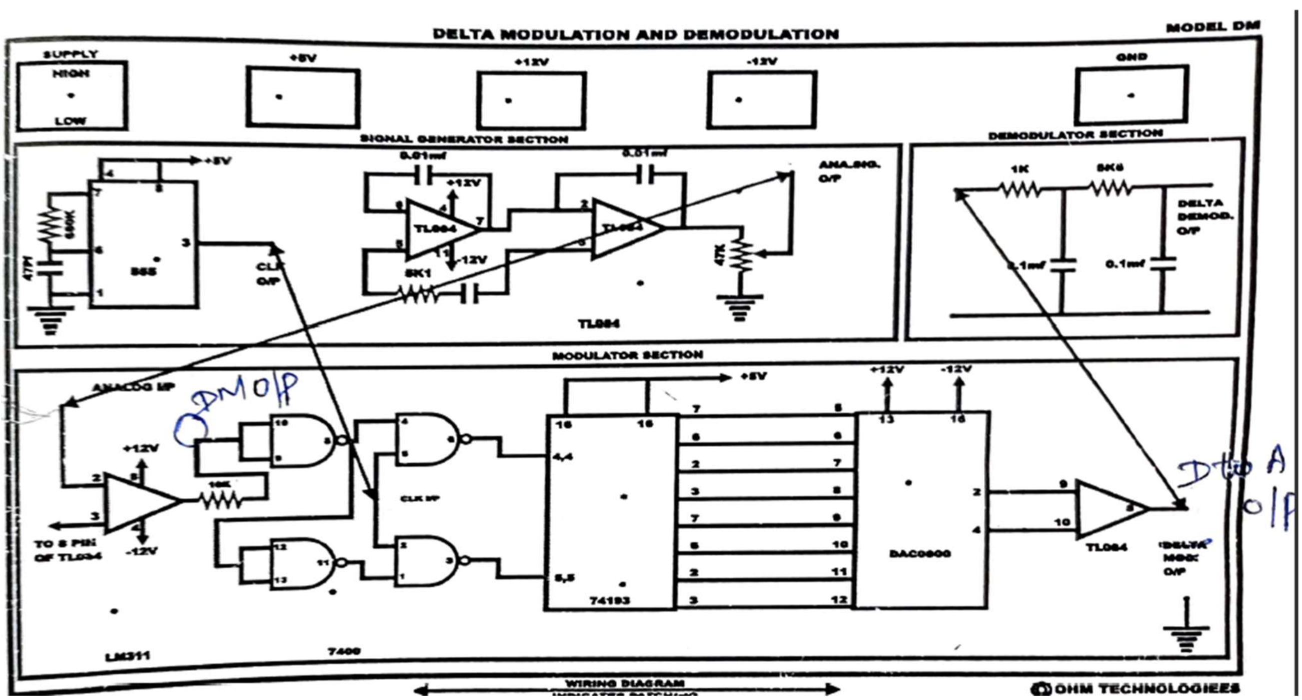


Figure 8.3. DM Wiring diagram

8.4 Prelab Questions

1. What is granular noise?
2. What is slope over distortion?
3. What happens to the output signal if the variation of the message signal is
   (i) Greater than the step size (ii) less than the step size

8.5 Procedure

8.5.1 DM Modulator

1. Study the theory of operation
2. Connect the trainer (AET-73M) -

3. Observe the output of AF generator using CRO; it should be a Sine wave of 100 Hz frequency with 3Vpp amplitude.
4. Verify the output of the DC source with multimeter/scope; output should vary 0 to +4V
5. Observe the output of the clock generator using Crotchety should be 4 KHz frequency of square wave with 5 Up amplitude.

   Note: This clock signal is internally connected to the up/down counter so no external connection is required.

8.5.2 DM With DC Voltage as modulating signal:

6. Connect DC signal from the DC source to the inverting input of the comparator and set some voltage says 3V.
7. Observe and plot the signals at D/A converter output (i.e. non-inverting input of the comparator), DM signal using CRO and compare them with the waveforms given in figure.
8. Connect DM signal (from 73M) to the DM input of the demodulator.
9. Connect clock (4KHz) from modulator (73M) to the clock input of the demodulator (73D). Connect clock input of UP/DOWN counter (in 73D) to the clock from transmitter with the help of springs provided.
10. Observe digital output (LED indication) of the UP/DOWN counter (in 73 D) and compare it with the output of the UP/DOWN (in 73M) .By this you can notice that the both the outputs are same.
11. Observe and plot the output of the D/A converter and compare it with the waveforms given in figure.
12. Measure the demodulated signal (i.e. output of the D/A converter 73D with the help of multimeter and compare it with the original signal 73 M. From the above observation you can notice that both the voltages are equal and there is no loss in process of modulation, transmission and demodulation.
13. Similarly you can verify the DM operation for different values of modulating signal.

8.5.3 DM With AF Voltage as modulating signal:

14. Connect AF signal from the AF source to the inverting input of the comparator and set some voltage says 3V.
15. Observe and plot the signals at D/A converter output (i.e. non-inverting input of the comparator), DM signal using CRO and compare them with the waveforms given in figure.
16. Connect DM signal (from 73M) to the DM input of the demodulator.
17. Connect clock (4 KHz) from modulator (73M) to the clock input of the demodulator (73D).
18. Connect clock input of UP/DOWN counter (in 73D) to the clock from transmitter with the help of springs provided.

19. Observe and plot the output of the D/A converter and compare it with the waveforms given in figure.
20. Observe and sketch the D/A output.
21. Connect D/A output to the LPF input.
22. Observe the output of the LPF/Amplifier and compare it with the original modulating signal (AET-73M).
23. From the above observation you can verify that there is no loss in information in conversion and transmission process.
24. Disconnect clock from transmitter (AET-73M) and connect to local oscillator (i.e. clock generator output from AET-73D) with remaining setup as it is. Observe demodulated signal output and compare it with the previous result. This signal is little bit distorted in shape. This is because lack of synchronization between clock at transmitter and clock at receiver.

8.6 Model Graph

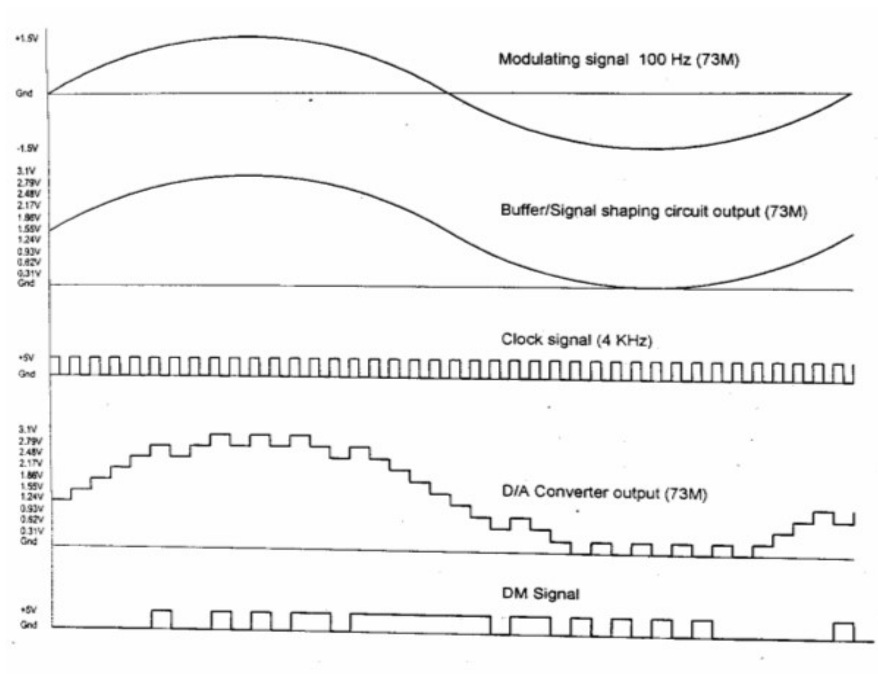


Figure 8.4 DM Waveforms for AC input signal

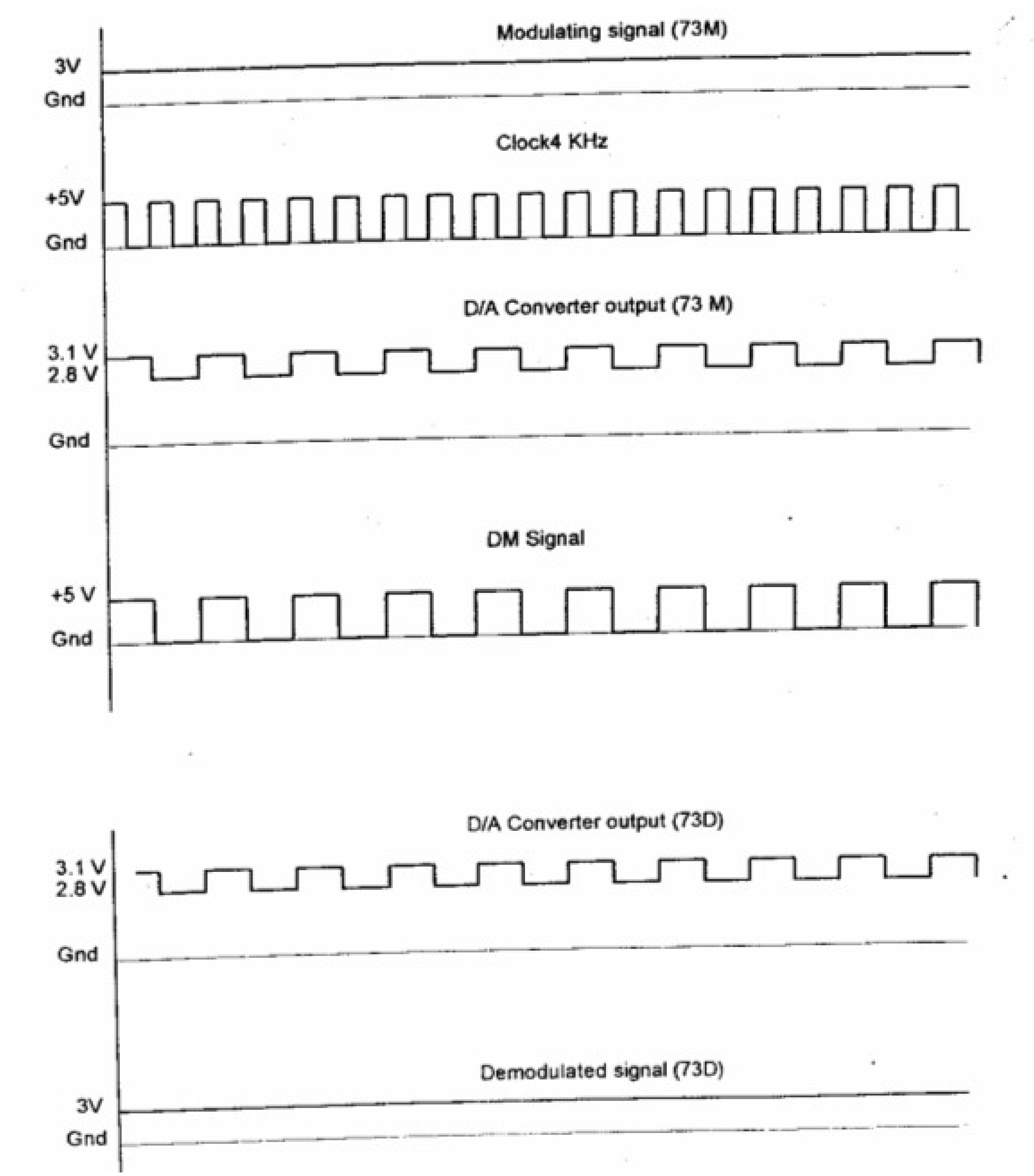


Figure 8.5 DM Waveforms/Timing Diagrams with DC input

Observation

DM Modulation (With AC input)

	Amplitude	Time Period
AC input		
D/A Converter Output		
Clock signal		
DM Output		

DM Demodulation (with AC input)

	Amplitude	Time Period
DM input		
D/A Converter output Signal		
Demodulated Output		
Clock signal		

DM Modulation (With DC input)

	Amplitude	Time Period
DC input		
D/A Converter Output		
Clock signa		
DM Output		

DM Demodulation (With DC input)

	Amplitude	Time Period
DM input		
D/A Converter output Signal		
Demodulated Output		
Clock signal		

8.7 Virtual lab

Software: SCI lab 6.0.2

Problem statement

Perform delta modulation using SCI lab for the following specifications

Amplitude of the signal: 12V
Step size=0.5V

8.7.1 SCILAB code

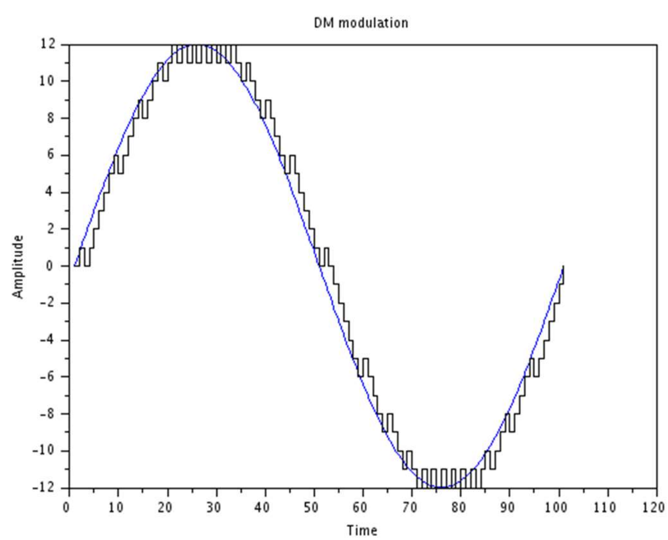
```
A=12;
del=0.5;
pi=3.14;
t=0:2*pi/100:2*pi;
x=A*sin(t);
plot(x)
y=[0];
xr=0;
for i=1:length(x)-1
    if xr(i)<=x(i)
```

```
        d=1;
        xr(i+1)=xr(i)+del;
    else
        d=0;
        xr(i+1)=xr(i)-del;
    end
    y=[y d];

end
plot2d2(xr);
xlabel('Time');
ylabel('Amplitude');
title('DM modulation');
```

8.7.2 Observations

Signal	Amplitude	Time period
Input signal		
Modulated signal		

8.7.3 Model graph



8.8 Post Lab Questions

1. Compare DPCM & Delta modulation.
2. How to reduce the quantization noise that occurs in DM?
3. A band pass signal has a spectral range that extends from 20 to 82 KHz. Find the acceptable sampling frequency.
4. Use SCILAB to perform delta modulation for
   (i) Input signal of amplitude 20V
   (ii) Step size of 0.25V

8.9 Lab Result

Thus the Delta modulation and demodulation were performed using the trainer kit and DM modulation is performed using SCILAB.

9. PSK MODULATION AND DEMODULATION

9.1 Objective

To analyze a PSK modulation system and interpret the modulated and demodulated waveforms. Simulate PSK modulated waveform to find the Probability of Error using SCILAB.

9.2 Hardware Required

PSK Trainer Kit

Dual Trace oscilloscope-POS-2020

Software Required

Scilab 6.1.0

9.3 Introduction

Phase shift keying is a modulation/data transmitting technique in which phase of the carrier signal is shifted between two distinct levels. In a simple PSK(ie., Binary PSK) un-shifted carrier Acosωt is transmitted to indicate a 1 condition, and the carrier shifted by 180^0 ie., – Acosωt is transmitted to indicate as 0 condition.

S(t)= Acos 2πfct for Binary 1

Acos (2πfct +π) for Binary 0

WIRING / TRAINER KIT DIAGRAM

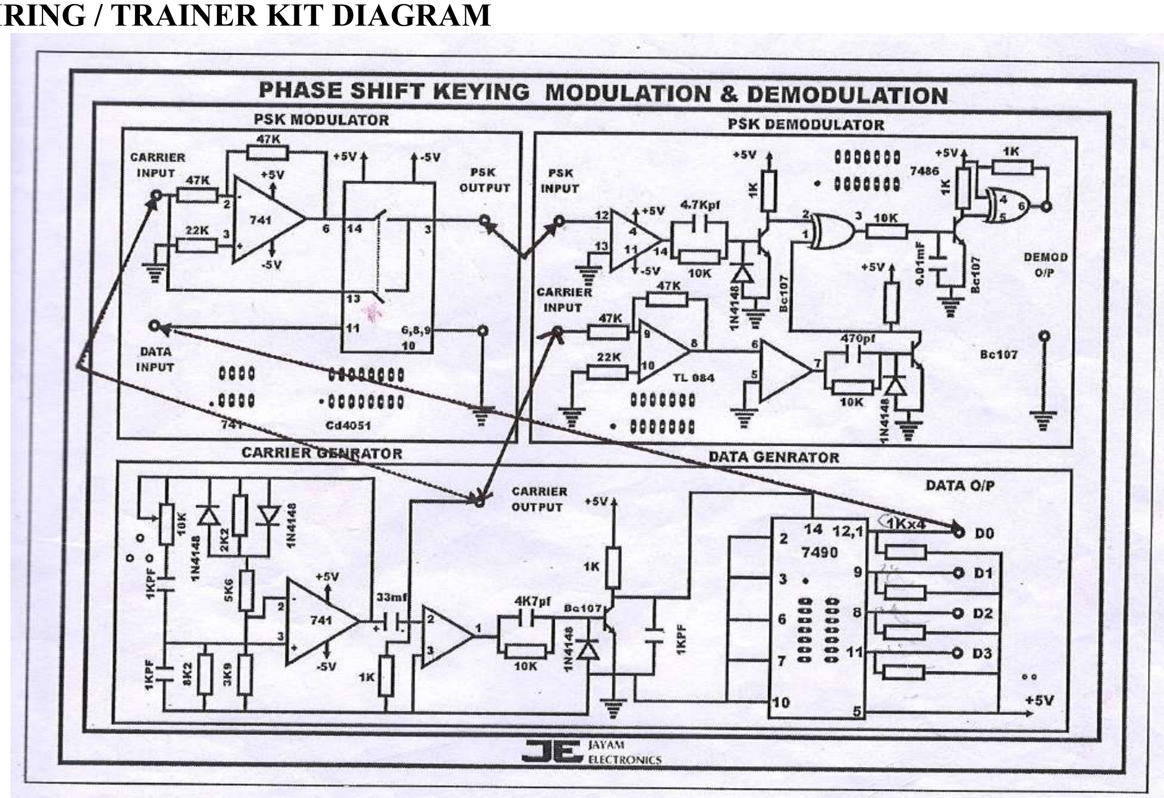


Fig 9.1 Wiring Diagram for PSK Modulation and Demodulation

9.4 Pre Lab Questions

1. What are antipodal signals?
2. Give the equation for average probability of symbol error for coherent binary PSK.
3. Give the expression for bandwidth for PSK.
4. Draw the constellation diagram for PSK.
5. In Binary Phase Shift Keying system, what would be the phase shift of the carrier for the binary symbols 1 and 0

9.5 Lab Procedure

1. Connect the trainer to mains and switch on the power supply.
2. Observe the output of the carrier generator using CRO,it should be an 17KHZ sine with 5Vpp amplitude.
3. Observe the various data signals(4KHZ and 8KHZ) using CRO

Modulation

4. Connect carrier signal to carrier input of the PSK modulator.
5. Connect data signal say 4KHZ from data source to data input of the modulator.
6. Keep CRO in dual mode and connect CH1 input of the CRO to data signal and CH2 to the output of the PSK modulator.
7. Observe the PSK output signal with respect to data signal and plot the waveforms.

Demodulation

8. Connect the PSK output to the PSK input of the demodulator.
9. Connect carrier to the carrier input of the PSK demodulator.
10. Keep CRO in dual mode and connect CH1 to data signal (at modulator) and CH2 to the output of the demodulator.
11. Compare the demodulated signal with the original signal. By this we can notice that there is no loss in modulation and demodulation process
12. Repeat the steps 5 to 11 with different data signal ie., 8KHZ

9.6 Model Graph

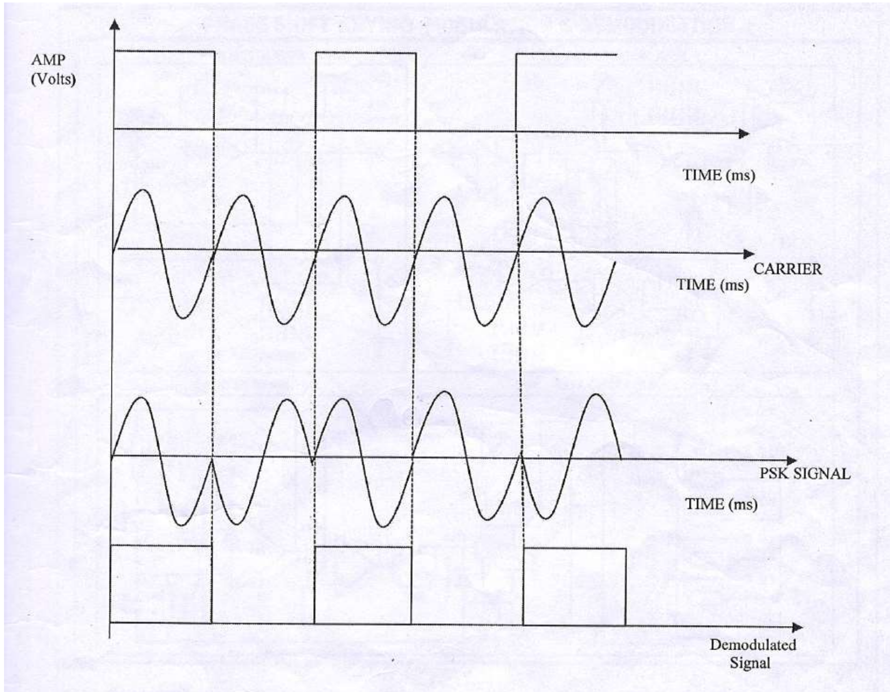


Figure 9.2 PSK Waveforms for different data input signals

9.7 Observation-Hardware

PSK Modulation

Signal Name	Amplitude	Time Period
Carrier signal		
Data source For 4KHz For 8KHz		
Modulated output For 4KHz For 8KHz		

PSK Demodulation

Signal Name	Amplitude	Time Period
Demodulated output For 4KHz For 8KHz		

9.8 VIRTUAL LAB

9.8.1 Software Required

SCILAB software 6.1.0

9.8.2 Exercise

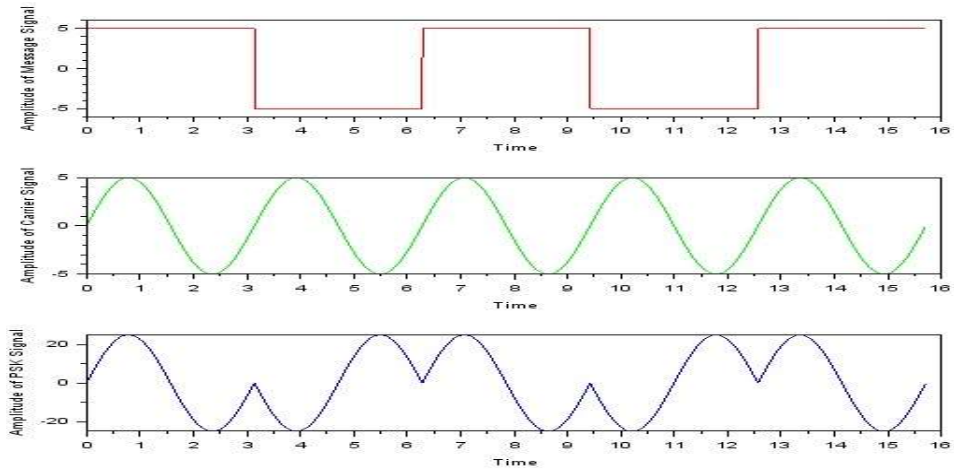
Use SCILAB to produce PSK waveform with the following specifications.

Modulating wave	Square wave, Amplitude A= 5V
Carrier frequency	2 KHz, Amplitude A= 5V

Solution

```
clc;
clearall;
clf;
t=[0:0.01:5*%pi];
A=5;
fc=2;

Vm=A.*squarewave(t);
Vc=A.*sin(fc.*t);
Vp=Vm.*Vc;

subplot (3,1,1);
plot(t,Vm,'red');
xlabel("Time")
ylabel("Amplitude of Message Signal")

subplot(3,1,2);
plot(t,Vc,'green');
xlabel("Time")
ylabel("Amplitude of Carrier Signal")

subplot(3,1,3);
plot(t,Vp,'blue');
xlabel("Time")
ylabel("Amplitude of PSK Signal")
```

Model Graph



Observation-Software

Signal Name	Amplitude	Frequency
Carrier signal		
Data sourc		
Modulated output		

9.8.3 Exercise: Use Scilab to find the Probability of Error of PSK signal

```
clc;
clear;
A=1*10^-3;
Tb=0.2*10^-3;
fb=1/Tb;
fc=5*fb;
N0=2*10^-11;// power sepctral density
Eb=(A^2*Tb)/2;//Eb=bit energy
z=sqrt(Eb/N0);
Pe=erfc(z)'//bit error probability
disp("Error probability of PSK is  P(e)")
disp(Pe);
```

output:

```
"Error probability of PSK is P(e)"

0.0015654
```

9.9 Post Lab Questions

1. Give the expression for bit error rate for BPSK
2. Show the PSK modulated waveform for the message 1101001
3. Give the constellation diagram of PSK
4. Use SCILAB to produce PSK waveform with the following specifications.
   Modulating wave Square wave, Amplitude A= 7V
   Carrier frequency 8 KHz , Amplitude A= 7V
5. Infer and tabulate the variation in Probability of error when there is change in Eb/No

9.10 Lab Result

Thus the PSK modulation and demodulation were performed and simulated to find Probability of error by using SCILAB.

10 Simulation of Quadrature Phase Shift Keying (QPSK) Modulation and Demodulation

10.1 Objective

To generate and demodulate quadrature phase shifted (QPSK) signal using SCI lab.

10.2 Algorithm:

QPSK modulation

1. Generate quadrature carriers.
2. Start FOR loop
3. Generate binary data, message signal (bipolar form)
4. Multiply carrier 1 with odd bits of message signal and carrier 2 with even bits of message signal
5. Perform addition of odd and even modulated signals to get the QPSK modulated signal
6. Plot QPSK modulated signal.
7. End FOR loop.
8. Plot the binary data and carriers.

QPSK demodulation

1. Start FOR loop
2. Perform correlation of QPSK modulated signal with quadrature carriers to get two decision variables x1 and x2.
3. Make decision on x1 and x2 and multiplex to get demodulated binary data.
   If x1>0and x2>0, choose '11'. If x1>0and x2<0, choose '10'. If x1<0and x2>0, choose '01. If x1<0and x2<0, choose '00'.
4. End FOR loop
5. Plot demodulated data

10.3 Program

```
clc ;
clear ;
xdel ( winsid () ) ;
Tb=1;
t=0:(Tb/100):Tb;
fc=1;
c1=sqrt(2/Tb)*cos(2*%pi*fc*t);
c2=sqrt(2/Tb)*sin(2*%pi*fc*t);
N=16;
m=rand(1,N);
t1=0;t2=Tb;
for i=1:2:(N-1)
   t=[t1:(Tb/100):t2]
if m(i)>0.5
   m(i)=1;
m_s=ones(1,length(t));
else
m(i)=0;
m_s=-1*ones(1,length(t));
end
odd_sig(i,:)=c1.*m_s;
if m(i+1)>0.5
m(i+1)=1;
m_s=ones(1,length(t));
else
m(i+1)=0;
m_s=-1*ones(1,length(t));
end
even_sig(i,:)=c2.*m_s;
qpsk = odd_sig+even_sig;
subplot(3,2,4);
plot(t,qpsk(i,:));
title('QPSK signal');
```

```
xlabel('t---->');
ylabel('s(t)');

t1=t1+(Tb+.01);
t2=t2+(Tb+.01);
end
subplot(3,2,1);
for N=1:16;
   plot2d3(N,m(N),style=2)
end
title('binary data bits');
xlabel('n---->');
ylabel('b(n)');
subplot(3,2,2);
plot(t,c1);
title('carrier signal-1');
xlabel('Time (sec)');
ylabel('Amplitude (volts)');
subplot(3,2,3);
plot(t,c2);
title('carrier signal-2');
xlabel('Time (sec)');
ylabel('Amplitude (volts)');
t1=0;
t2=Tb;
 for i=1:N-1
   t=[t1:(Tb/100):t2]
   x1=sum(c1.*qpsk(i,:));
   x2=sum(c2.*qpsk(i,:));
   if (x1>0&&x2>0)
      demod(i)=1;
      demod(i+1)=1;
elseif (x1>0&&x2<0)
   demod(i)=1;
```

```
    demod(i+1)=0;
elseif (x1<0&&x2<0)
    demod(i)=0;
    demod(i+1)=0;
elseif (x1<0&&x2>0)
    demod(i)=0;
    demod(i+1)=1;
    end
t1=t1+(Tb+.01);
t2=t2+(Tb+.01);
end
subplot(3,2,5);
for N=1:16;
    plot2d3(N,demod(N),style=2)
end
title('qpsk demodulated bits');
xlabel('n---->');
ylabel('b(n)');
```

10.4 Simulated Results:

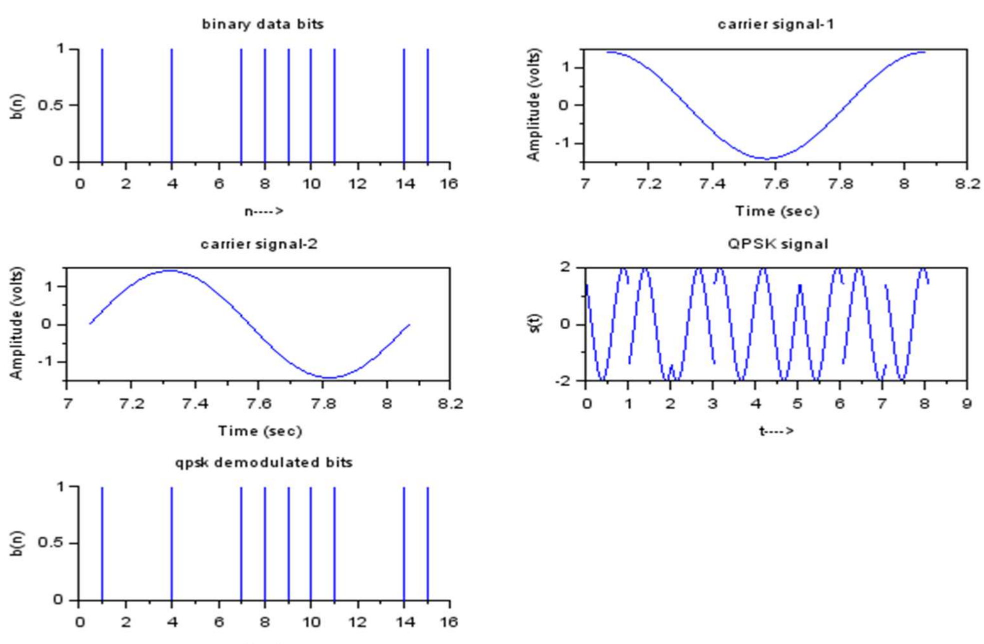


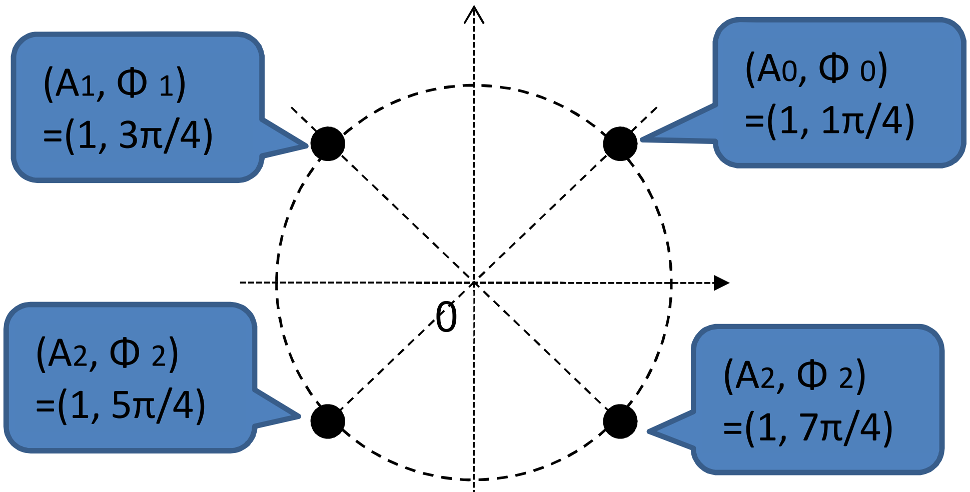
Fig. 7.2 Waveform of QPSK Modulation and Demodulation in SCI lab

10.5 Pre-lab Questions:

1. Draw the signal space diagram of coherent QPSK system
2. By using the BER equation, justify how the QPSK system supersedes the BPSK system?

10.6 Post-lab Questions:

1. State the difference between the plot and subplot?
2. Compare QPSK and OQPSK.
3. Make QPSK waveform using SCIlab as follows



n=0:32
fc=2Hz
fs=32Hz

10.7 Result

The program for QPSK modulation and demodulation has been simulated in SCI lab and necessary graphs are plotted.

11. Differential Phase Shift Keying (DPSK) Modulation and Demodulation

11.1 Objective

To construct a DPSK modulation and demodulation system and interpret the modulated and demodulated waveforms.
Simulate the DPSK modulation and demodulation using SCILAB.

11.2 Hardware Required

1. DPSK Trainer Kit – ST8112
2. Dual Trace oscilloscope-POS-2020
3. Digital Multimeter

11.3 Theory

Differential phase shift keying is a non-coherent version of PSK. It eliminates the need for a coherent reference signal at the receiver by combining two basic operations at the transmitter:

i) Differential encoding of the input binary wave

ii) Phase shift keying

In effect, to send symbol 0 we phase advance the current signal waveform by 180° , and to send symbol 1 we leave the phase of the current signal waveform unchanged. The DPSK transmitter consists of a logic network and a one-bit delay element interconnected so as to convert an input sequence $\{b_k\}$ into a differentially encoded sequence $\{d_k\}$. This sequence is amplitude level shifted and then used to modulate a carrier wave of frequency f_c, thereby producing the desired DPSK wave.

The received DPSK signal plus noise is passed through a band pass filter centered at the carrier frequency f_c , so as to limit the noise power. The filter output and a delayed version of it, with the delay equal to the bit duration T_b, are applied to a correlator. The resulting correlator output is proportional to the cosine of the difference between the carrier phase angles in the two correlator inputs. The correlator output is finally compared with a threshold of zero volts, and a decision is thereby made in favor of symbol 1 or symbol 0. If the correlator output is positive, the phase difference between the waveforms received during the pertinent pair of bit intervals lies inside the range $-\Pi/2$ to $\Pi/2$, and the receiver decides in favor of symbol 1. If, on the other hand, the correlator output is negative, the phase difference lies outside the range $-\Pi/2$ to $\Pi/2$, modulo-2Π, and the receiver decides in favor of symbol 0.

11.4 Pre-Lab Questions

1. What are the merits of DPSK over PSK?
2. List the operations performed in DPSK transmitter.
3. What is differential encoding technique?

11.5 Wiring Diagram

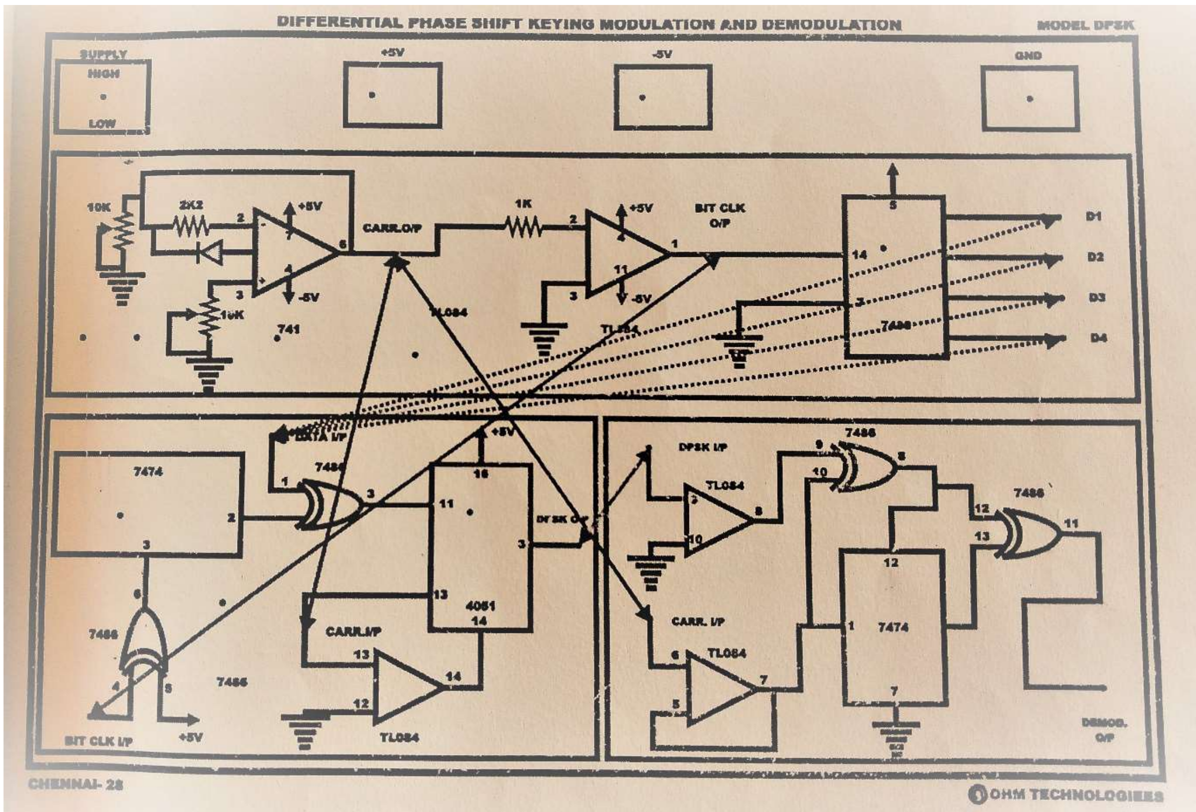


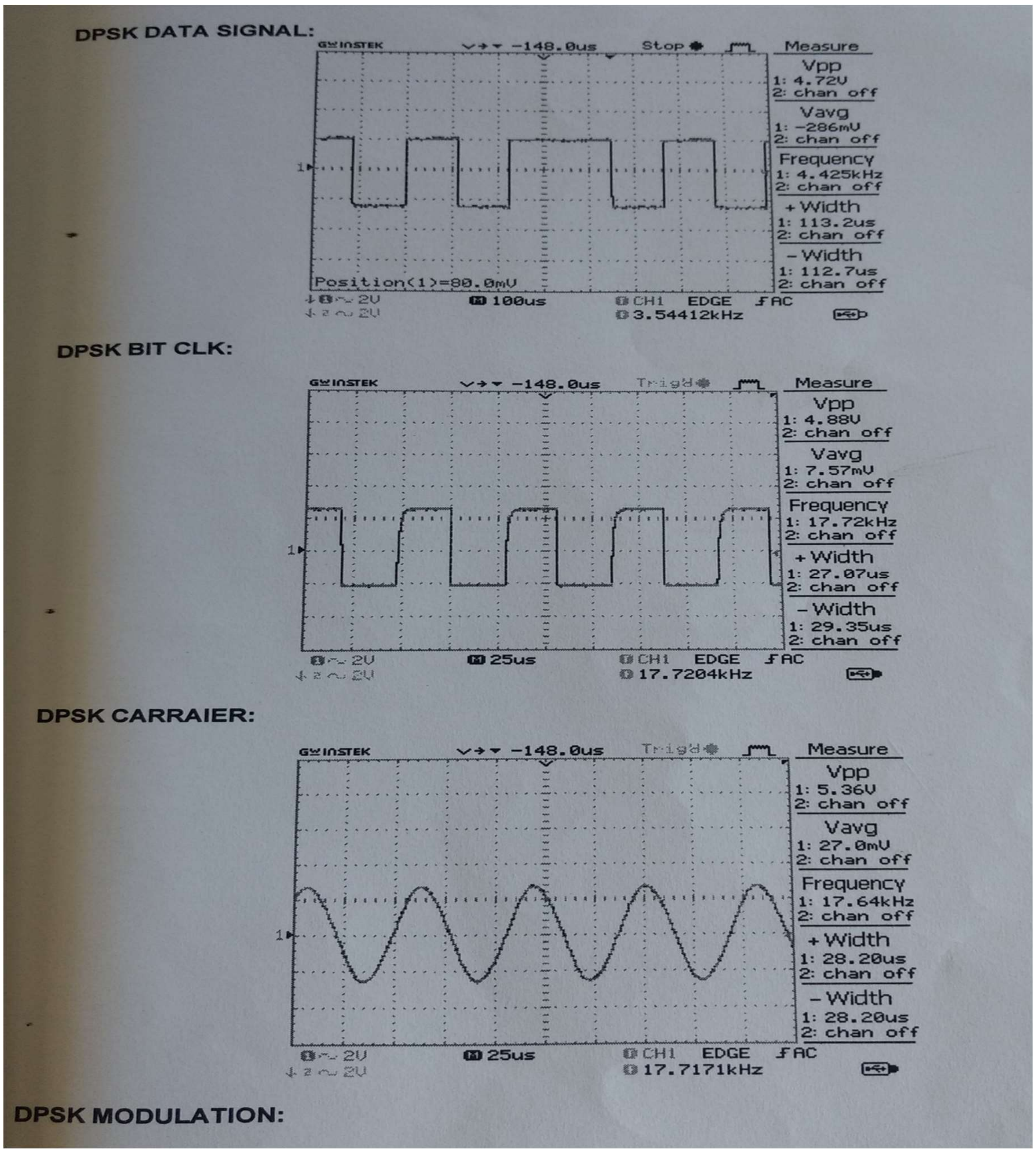
Figure 11.1 Wiring diagram for DPSK Modulation and Demodulation

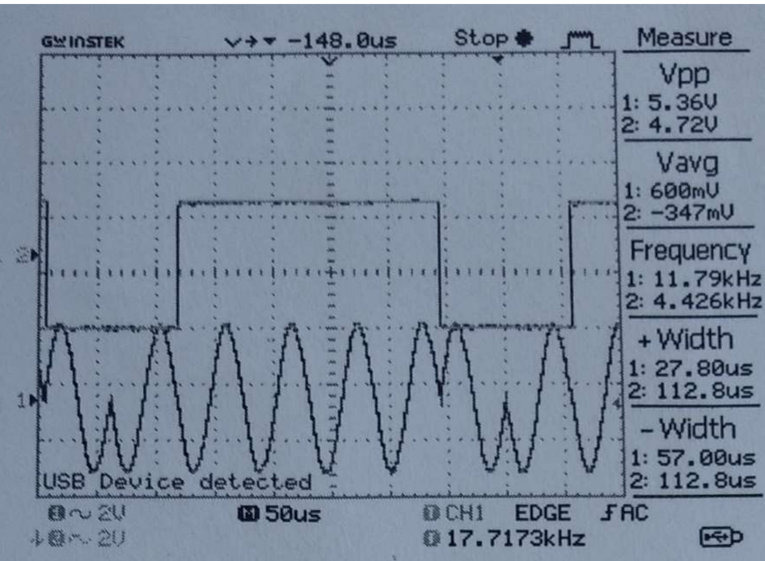
11.6 Procedure

1. Connect the AC Supply to the Kit.
2. Make connections and settings as shown in Block Diagram.
3. Connect the carrier signal output from carrier block to the 'Carrier Input' post of PSK Modulator block. Connect the 'D_0' from data block to the data input post of DPSK Modulator block.
4. Switch ON the power.
5. Connect the DPSK MOD O/P to the DPSK MOD I/P of DPSK demodulator section.
2. Connect the carrier signal output from carrier block to the 'Carrier Input' post of DPSK demodulator section.
3. Change the data I/P to D_1, D_2, D_3 and observe the DPSK
4. O/P changes accordingly.

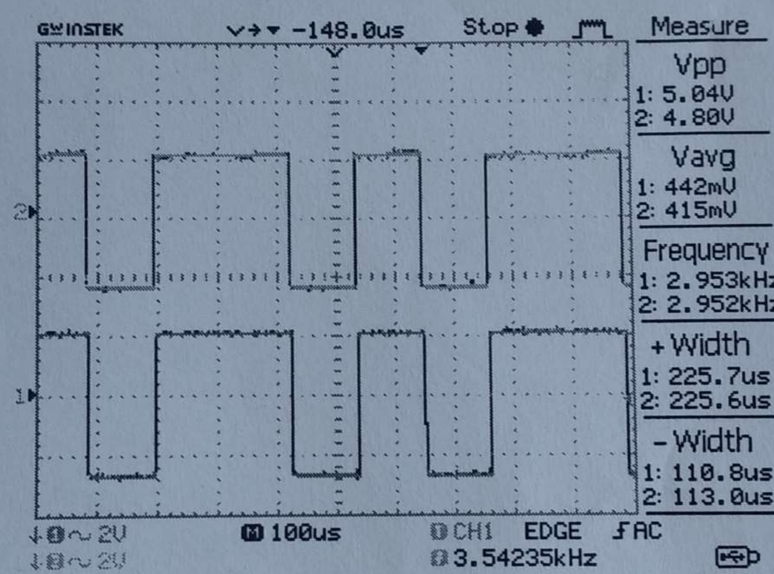
5. Observe the following waveforms on oscilloscope.
    a. Carrier signal O/P.
    b. Data O/P D_0, D_1, D_2, D_3.
    c. DPSK MOD O/P at DPSK Modulator.
    d. DPSK Demodulated signal at DPSK demodulator BLOCK.

11.7 Model Graph





DPSK DEMOD:



11.2 Model Graph

11. 8 Observation

DPSK (Modulation)

Data source	Amplitude (V)	Time Period (ms)
D_0		
D_1		
D_2		
D_3		
Carrier signal		
Modulated output		
D_0		
D_1		
D_2		
D_3		

Demodulation

Demodulated output	Amplitude (V)	Time Period (ms)
D_0		
D_1		
D_2		
D_3		

11.9 VIRTUAL LAB

11.9.1 Equipment / Apparatus

SCILAB Software 6.0.2

11.9.2 Exercise

For the given 8-bit data [1 0 1 0 1 0 1 0] and carrier signal of Cos(2*π*2*t) generate the DPSK Modulated , Demodulated Signal and obtain the corresponding output Bit stream.

11.9.3 Solution

```
clc;
clear;
xdel ( winsid () ) ;

//Differential Phase shift keying
b = [1 0 1 0 1 0 1 0];
//Diffreential Eccoding
d = 1;// Initial bit
dc=[];
for i = 1:length(b)
    dc = [dc d];
  d=~(bitxor(d,b(i)));
end
 dc=[dc d];

//Bit to symbol mapping
 for ii = 1:length(dc)
     if dc(ii)==1;
         nn(ii)=1;
     else nn(ii)=-1;
     end
 end

 // pulse shaping
 S = 100;
 i = 1;
 t=0:1/S:length(dc);
 for j = 1:length(t)
     if t(j)<=i;
         m(j)=nn(i);
     else
         m(j)=nn(i);
         i=i+1;
     end
 end

 //plotting
 subplot(411);
 plot2d2(t,m, style=[color("navy blue")]);
 xlabel('Time');
 ylabel('Amplitude');
 title('NRZ polar signal');

 // Carrier Signal
 c=cos(2*%pi*2*t);
 subplot(412);
 plot2d2(t,c, style=[color("navy blue")]);
```

```
 xlabel('Time');
 xlabel('Time');
 ylabel('Amplitude');
 title('Carrier Signal');

//BPSK Modulation
 x = m' .* c;
 subplot(413);
 plot2d2(t,x, style=[color("red")]);
 xlabel('Time');
xlabel('Time');
 ylabel('Amplitude');
 title('DPSK Modulated Signal');

 //Coherent Detection and reconstruction
 y=x;
 y1=y.*c; // Product Modulator
 subplot(414);
plot2d2(t,y1, style=[color("green")]);
 xlabel('Time');
 xlabel('Time');
 ylabel('Amplitude');
 title('DPSK Demodulated signal');

//Integrator output
 //k=1/S:1/S:1;
 int_op=[];
 for ii=0:S:length(y1)-S;
    int_o=(1/S)*inttrap(y1(ii+1:ii+S));
    int_op=[int_op int_o];
 end
  //Hard decision decoding
  for i = 1 : length(int_op);
      if int_op(i) >=0;
            detect(i) = 1;
        else
            detect(i)=0;
   end
end
disp('Input Bits:')
disp (b)
disp('DPSK Modulated Bits:')
detect1 = detect(2:length(detect));
disp(detect1')
  //Differential detection
 for ii = 1:length(detect)-1;
    if detect(ii)==detect(ii+1);
        op(ii)=1;
    else
        op(ii)=0;
```

```
   end
end
disp('DPSK Demodulated Bits:')
disp(op')
```

11.10 Observation- Software

	D0	D1	D2	D3	D4	D5	D6	D7
Input Data Bit								
DPSK Modulated Bit								
DPSK Demodulated Bit								

11.11 Model Graph

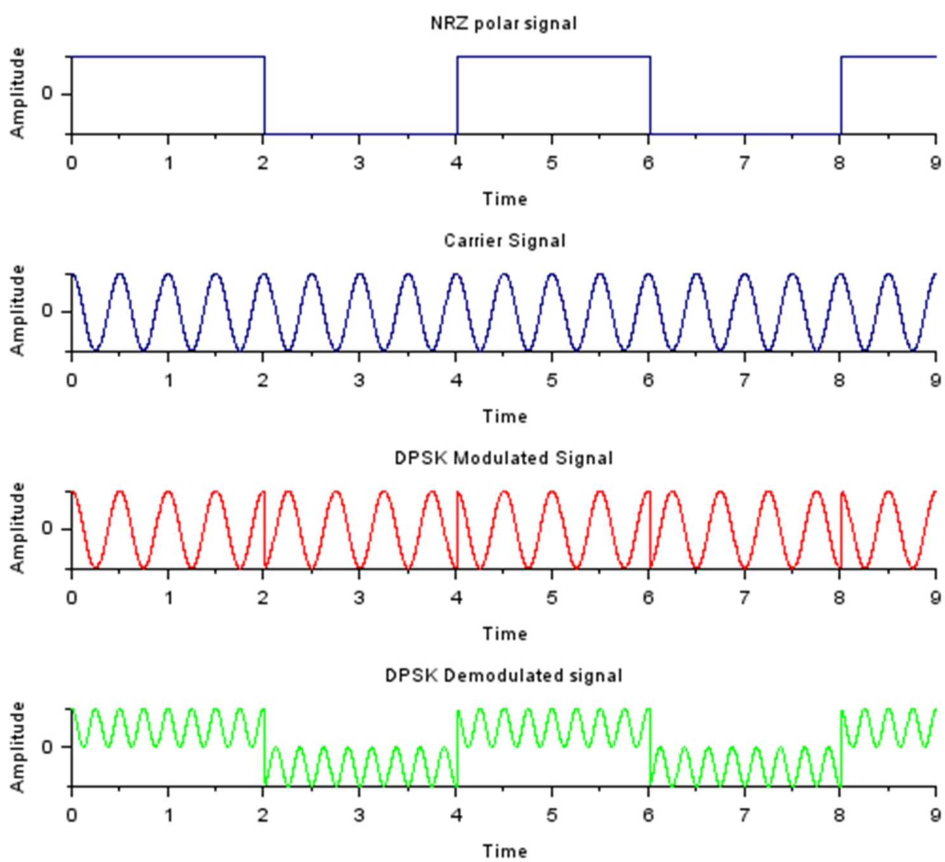


Fig 11.6 Simulated DPSK Modulated and Demodulated waveforms

11.12 Output Obtained

"Input Bits:"

1. 0. 1. 0. 1. 0. 1. 0.

"DPSK Modulated Bits:"

1. 0. 0. 1. 1. 0. 0. 1.

"DPSK Demodulated Bits:"

1. 0. 1. 0. 1. 0. 1. 0.

11. 13 Post Lab Questions

1. Binary data is transmitted at a rate of 10^6 bits/second over a channel having a bandwidth 3 MHz Assume that the noise PSD at the receiver is N0/2 = 10^{-10} W/Hz. Find the average carrier power required at the receiver input for DPSK to maintain a probability of error $P_e=10^{-4}$.
2. Compare DPSK and QPSK modulation scheme.
3. Generate a random stream of data of length N = 15 (use rand syntax) and obtain the DPSK Modulated, Demodulated Signal and corresponding output Bit stream using SCILAB.

11.14 Lab Result

Thus, the DPSK modulation and demodulation has been simulated in SCILAB and necessary graphs were plotted.

12 BER Performance Analysis of various modulation

12.1 Objective:

To analyze the BER performance of Communication System using QAM and 16-QAM scheme using MATLB 2017b.

12.2 BER Performance analysis of QAM

Algorithm:

1. Initialize the values for number of bit N=10,000, Modulation order M=4 and the signal energy Es=100
2. Assign the Signal constellation points to the variable map
3. Convert the SNR in dB to SNR in linear Scale using appropriate formula
4. Calculate the noise power $\sigma=\sqrt{\frac{E_s}{4SNR}}$
5. The bits to be transmitted are randomly generated and mapped to the signal constellation points.
6. At the receiver the Euclidean distance between the received symbol and points on the symbol map is calculated
7. The symbol with minimum distance is chosen and is detected at the receiver
8. The Detected bits are compared with the transmitted bit and Simulated BER is calculated which is number of bits in error to the total number of bits transmitted
9. Steps 3 to 8 is performed for varying SNR (dB) (0 to 20 db)
10. BER versus SNR graph plotted.

12.2.1 Simulation Flow Diagram:

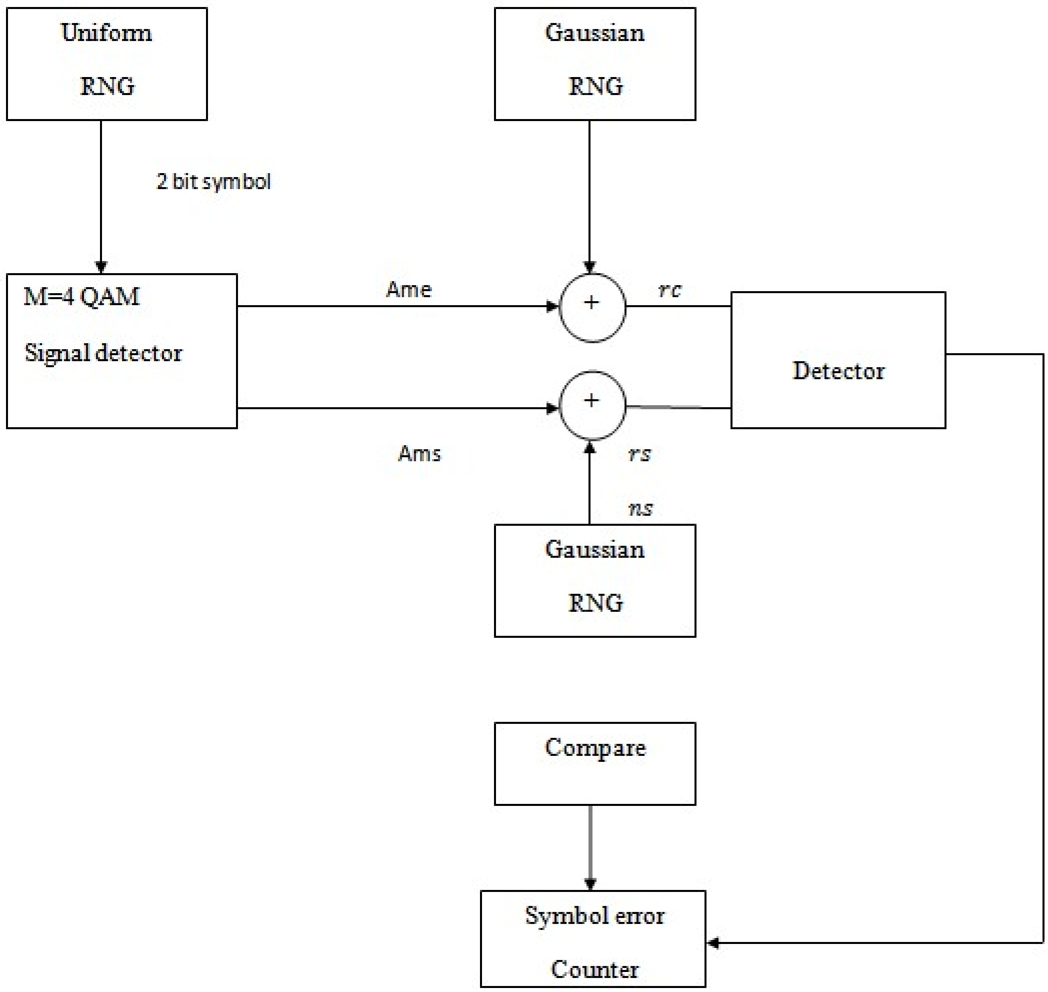


Fig 12.1 Flow diagram explaining the Simulation of Communication System using QAM Scheme

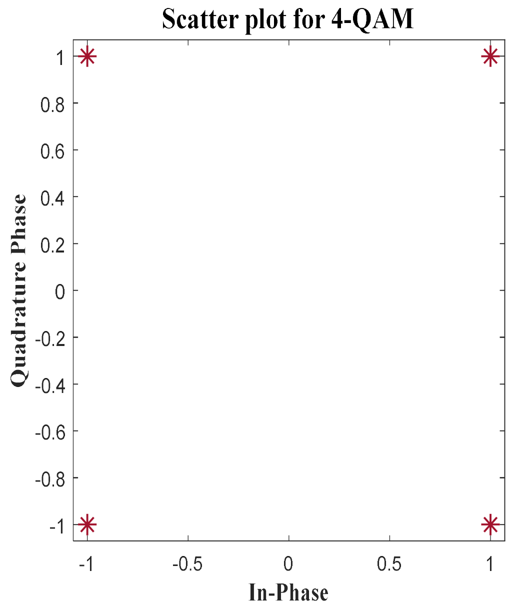
12.2.2 Program:

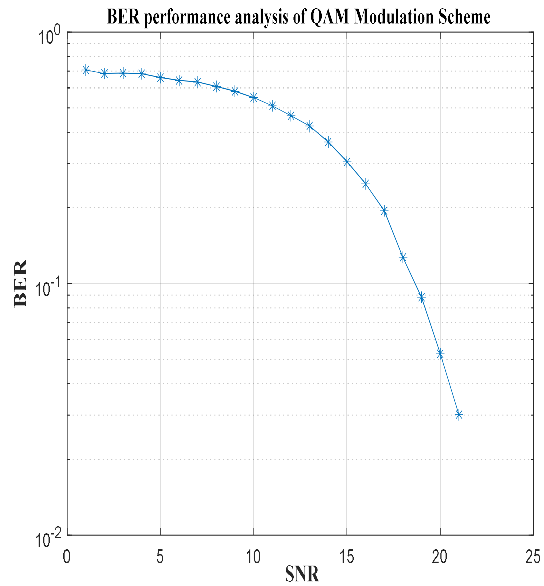
```
% BER performance analysis of QAM Scheme
clc;
clear all;
close all;
% Scatter Plot for QAM points
M = 4;
x = (0:M-1)';
w = qammod(x,M);
scatterplot(w)
% Input data
N=10000;
M=4;
Es=100;
snr_dB=1:21;
% Mapping to Signal Constellation Points
map=[-1,-1;
    1,-1;
```

```
    -1,1;
    1,1];
for a=1:21
    snr(a)=10^(snr_dB(a)/10);
    sigma(a)=sqrt(Es/(4*snr(a)));
end
for a=1:21
    err=0;
    % Generation of data sources
    for b=1:N
        temp=rand;
        data(b)=1+floor(M*abs(temp));
        sign(b,:)=map(data(b),:);
        n=sigma(a)*randn(1,2);
        rec(b,:)=sign(b,:)+n;
        for c=1:M
            x=map(c,:);
            y=rec(b,:);
            dist(c)=sqrt(((x(1)-y(1))^2)-((x(2)-y(2))^2));
            % detection
            if c==1
                dmin=dist(c);
            else
                dmin=min(dist(c),dmin);
            end
            if dmin==dist(c)
                detect(b)=c;
            end
        end
        if data(b)~=detect(b)
            err=err+1;
        end
    end
    BER(a)=err/N;
end
BER
snr_dB=1:21;
figure(2);
semilogy(snr_dB,BER,'-*');
grid on
xlabel('SNR');
ylabel('BER');
title('BER performance analysis of QAM Modulation Scheme');
```

12.2.3 Outputs:

BER= 0.7062 0.6848 0.6872 0.6828 0.6591 0.6420 0.6328 0.6074 0.5815 0.5494 0.5091 0.4649 0.4233 0.3656 0.3053 0.2494 0.1948 0.1272 0.0883 0.0526 0.0301





12.3 BER Performance analysis of 16-QAM

Algorithm:

1. Initialize the values for number of bit N=10,000, Modulation order M=16 and the signal energy Es=100
2. Assign the Signal constellation points to the variable map
3. Convert the SNR in dB to SNR in linear Scale using appropriate formula
4. Calculate the noise power σ= $\sqrt{\frac{E_s}{8SNR}}$
5. The bits to be transmitted are randomly generated and mapped to the signal constellation point.
6. At the receiver the Euclidean distance between the received symbol and points on the symbol map is calculated
7. The symbol with minimum distance is chosen and is detected at the receiver
8. The Detected bits are compared with the transmitted bit and Simulated BER is calculated which is number of bits in error to the total number of bits transmitted
9. Steps 3 to 8 is performed for varying SNR (dB) (0 to 20 db)
10. BER versus SNR graph plotted.

12.3.1 Simulation Flow Diagram:

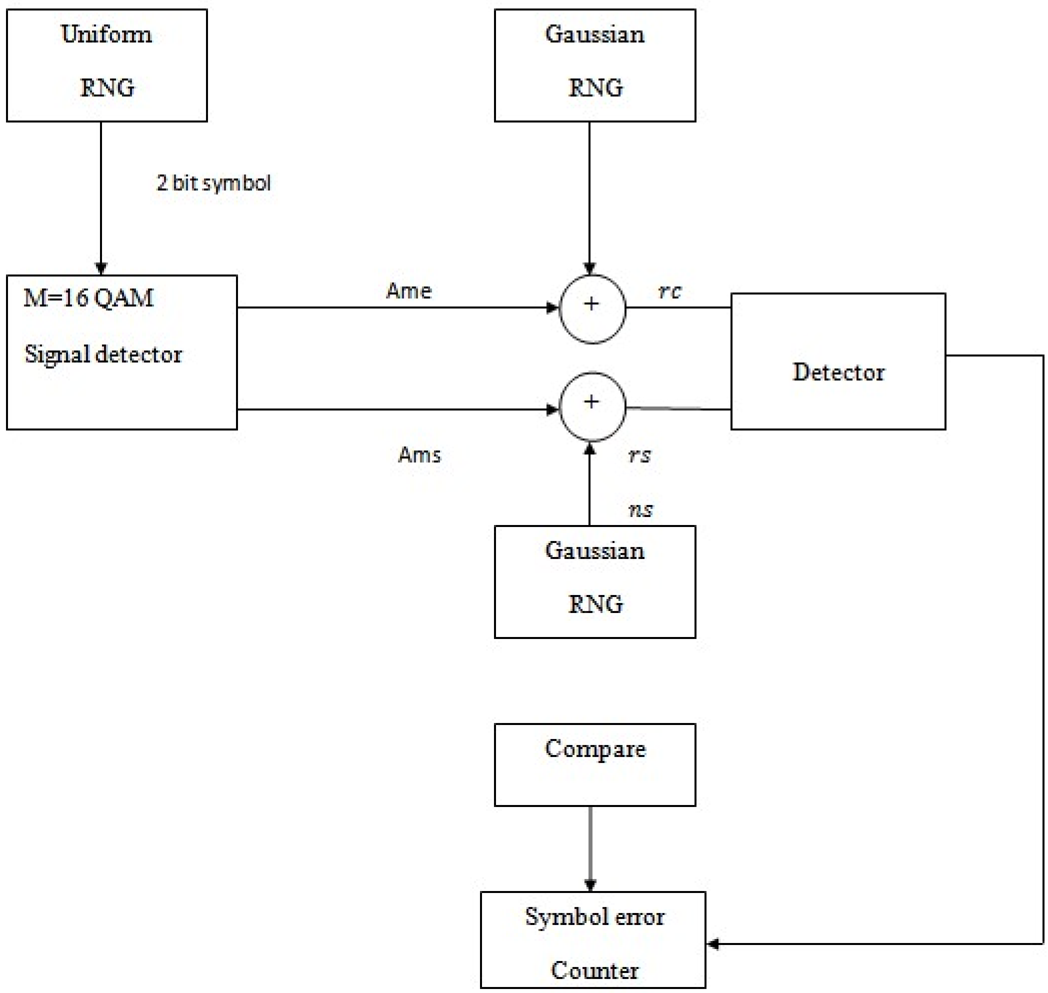


Fig 12.2 Flow diagram explaining the Simulation of Communication System using 16-QAM Scheme

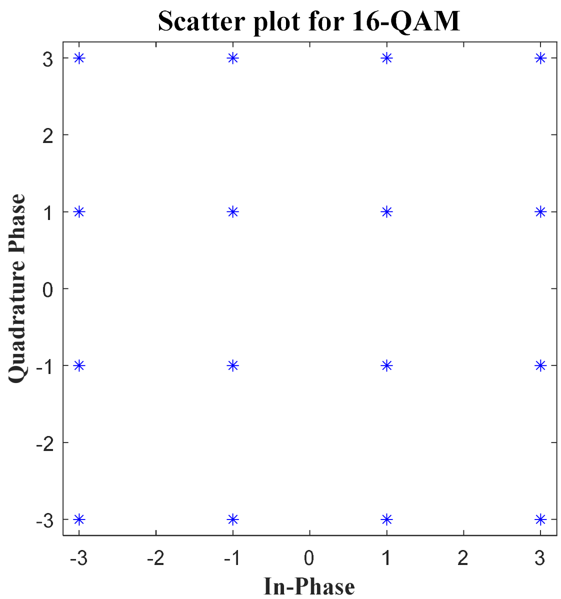
12.3.2 Program:

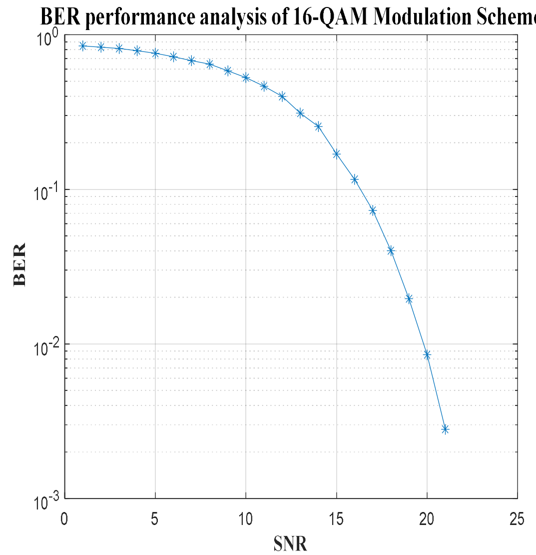
```
BER performance analysis of 16-QAM Scheme
clc;
clear all;
close all;
% Scatter Plot for 16 QAM points
M = 16;
x = (0:M-1)';
w = qammod(x,M);
scatterplot(w)
% Input data
N=10000;
M=16;
Es=100;
snr_dB=1:21;
% Mapping to Signal Constellation Points
map=[-3,3;
    -1 3;
     1 3
    3 3;
```

```
    -3,1;
    -1 1;
    1 1;
    3 1;
    -3 -1;
    -1 -1;
    1 -1;
    3 -1;
    -3 -3;
    -1 -3;
    1 -3;
    3 -3];
for a=1:21
    snr(a)=10^(snr_dB(a)/10);
    sigma(a)=sqrt(Es/(8*snr(a)));
end
for a=1:21
    err=0;
    % Generation of data sources
    for b=1:N
        temp=rand;
        data(b)=1+floor(M*abs(temp));
        sign(b,:)=map(data(b),:);
        n=sigma(a)*randn(1,2);
        rec(b,:)=sign(b,:)+n;
        for c=1:M
            x=map(c,:);
            y=rec(b,:);
            dist(c)=sqrt(((x(1)-y(1))^2)-((x(2)-y(2))^2));
            % detection
            if c==1
                dmin=dist(c);
            else
                dmin=min(dist(c),dmin);
            end
            if dmin==dist(c)
                detect(b)=c;
            end
        end
        if data(b)~=detect(b)
            err=err+1;
        end
    end
    BER(a)=err/N;
end
BER
snr_dB=1:21;
figure(2);
semilogy(snr_dB,BER,'-*');
grid on
xlabel('SNR');
ylabel('BER');
title('BER performance analysis of 16-QAM Modulation Scheme');
```

12.3.3 Output:

BER=0.8474 0.8300 0.8138 0.7881 0.7594 0.7205 0.6810 0.6446 0.5833 0.5273 0.4645 0.3981 0.3107 0.2543 0.1692 0.1159 0.0730 0.0401 0.0196 0.0085 0.0028





12.4 PRELAB:

1. What are quad bits?
2. Compute the bit rate for a 1000 baud16-QAM signal
3. In QAM, which parameters of the carrier signal are varied?

12.5 POSTLAB:

1. Draw the signal constellation diagram for QAM
2. Compare BPSK, QPSK and QAM in terms of bit rate and bandwidth

12.6 Result

Thus the BER performance analysis of communication system using QAM and 16-QAM was performed in MATLAB..