TE0323
COMMUNICATION SIMULATION LAB

Laboratory Manual

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TE0323 COMMUNICATION SIMULATION LAB
List of Experiments

Experiment No.1

AMPLITUDE SHIFT KEYING

Aim: To generate and demodulate amplitude shift keyed (ASK) signal using MATLAB

Theory

Generation of ASK

Amplitude shift keying - ASK - is a modulation process, which imparts to a sinusoid two or more discrete amplitude levels. These are related to the number of levels adopted by the digital message. For a binary message sequence there are two levels, one of which is typically zero. The data rate is a sub-multiple of the carrier frequency. Thus the modulated waveform consists of bursts of a sinusoid. One of the disadvantages of ASK, compared with FSK and PSK, for example, is that it has not got a constant envelope. This makes its processing (eg, power amplification) more difficult, since linearity becomes an important factor. However, it does make for ease of demodulation with an envelope detector.

Demodulation

ASK signal has a well defined envelope. Thus it is amenable to demodulation by an envelope detector. Some sort of decision-making circuitry is necessary for detecting the message. The signal is recovered by using a correlator and decision making circuitry is used to recover the binary sequence.

Algorithm

Initialization commands

ASK modulation

1. Generate carrier signal.
2. Start FOR loop
3. Generate binary data, message signal(on-off form)
4. Generate ASK modulated signal.
5. Plot message signal and ASK modulated signal.
6. End FOR loop.
7. Plot the binary data and carrier.

ASK demodulation

1. Start FOR loop
2. Perform correlation of ASK signal with carrier to get decision variable
3. Make decision to get demodulated binary data. If x>0, choose ‘1’ else choose ‘0’
4. Plot the demodulated binary data.

Program

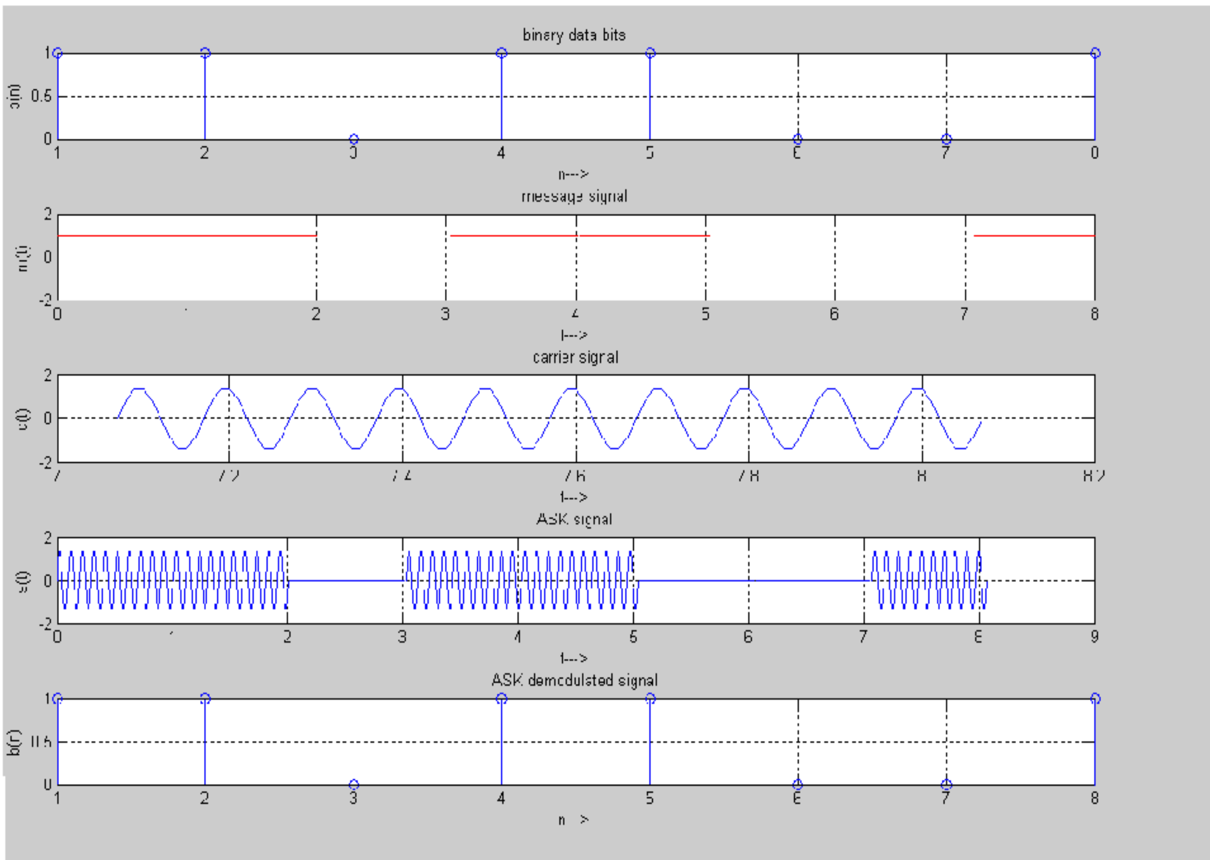
%ASK Modulation

```
clc;
clear all;
close all;
%GENERATE CARRIER SIGNAL
Tb=1; fc=10;
t=0:Tb/100:1;
c=sqrt(2/Tb)*sin(2*pi*fc*t);
%generate message signal
N=8;
m=rand(1,N);
t1=0;t2=Tb
for i=1:N
   t=[t1:.01:t2]
   if m(i)>0.5
      m(i)=1;
      m_s=ones(1,length(t));
   else
      m(i)=0;
      m_s=zeros(1,length(t));
   end
   message(i,:)=m_s;
   %product of carrier and message
   ask_sig(i,:)=c.*m_s;
   t1=t1+(Tb+.01);
   t2=t2+(Tb+.01);
   %plot the message and ASK signal
   subplot(5,1,2);axis([0 N -2 2]);plot(t,message(i,:),'r');
   title('message signal');xlabel('t--->');ylabel('m(t)');grid on
   hold on
   subplot(5,1,4);plot(t,ask_sig(i,:));
   title('ASK signal');xlabel('t--->');ylabel('s(t)');grid on
   hold on
 end
hold off
%Plot the carrier signal and input binary data
subplot(5,1,3);plot(t,c);
title('carrier signal');xlabel('t--->');ylabel('c(t)');grid on
subplot(5,1,1);stem(m);
title('binary data bits');xlabel('n--->');ylabel('b(n)');grid on
```

% ASK Demodulation

```
t1=0;t2=Tb
  for i=1:N
    t=[t1:Tb/100:t2]
    %correlator
    x=sum(c.*ask_sig(i,:));
    %decision device
    if x>0
        demod(i)=1;
    else
        demod(i)=0;
    end
     t1=t1+(Tb+.01);
    t2=t2+(Tb+.01);
  end
  %plot demodulated binary data bits
  subplot(5,1,5);stem(demod);
  title('ASK demodulated signal'); xlabel('n--->');ylabel('b(n)');grid on
```

Model Graphs



Result

The program for ASK modulation and demodulation has been simulated in MATLAB and necessary graphs are plotted.

Experiment No.2

PHASE SHIFT KEYING

Aim: To generate and demodulate phase shift keyed (PSK) signal using MATLAB

Generation of PSK signal

PSK is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave). PSK uses a finite number of phases, each assigned a unique pattern of binary digits. Usually, each phase encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data.

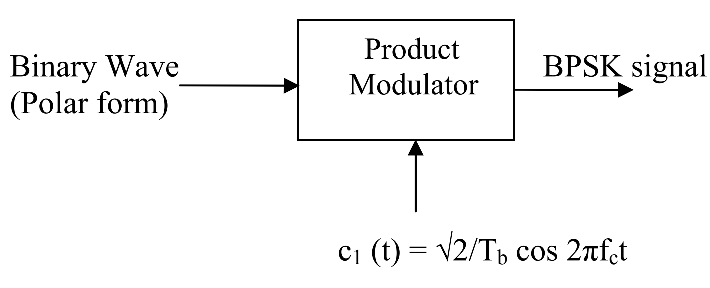
In a coherent binary PSK system, the pair of signal $S_1(t)$ and S_2 (t) used to represent binary symbols 1 & 0 are defined by

S_1 (t) = $\sqrt{2E_b/T_b}$ Cos $2\pi f_c t$
S_2 (t) =$\sqrt{2E_b/T_b}$ $(2\pi f_c t+\pi)$ = - $\sqrt{2E_b/T_b}$ Cos $2\pi f_c t$ where $0 \leq t< T_b$ and
Eb = Transmitted signed energy for bit
The carrier frequency fc =n/T_b for some fixed integer n.

Antipodal Signal:

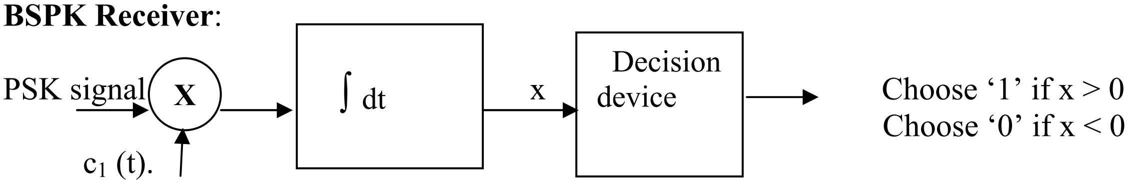
The pair of sinusoidal waves that differ only in a relative phase shift of 180° are called antipodal signals.

BPSK Transmitter



The input binary symbols are represented in polar form with symbols 1 & 0 represented by constant amplitude levels √Eb & -√Eb. This binary wave is multiplied by a sinusoidal carrier in a product modulator. The result in a BSPK signal.

BSPK Receiver:



The received BPSK signal is applied to a correlator which is also supplied with a locally generated reference signal c_1 (t). The correlated o/p is compared with a threshold of zero volts. If x> 0, the receiver decides in favour of symbol 1. If x< 0, it decides in favour of symbol 0.

Algorithm

Initialization commands

PSK modulation

1. Generate carrier signal.
2. Start FOR loop
3. Generate binary data, message signal in polar form
4. Generate PSK modulated signal.
5. Plot message signal and PSK modulated signal.
6. End FOR loop.
7. Plot the binary data and carrier.

PSK demodulation

1. Start FOR loop
   Perform correlation of PSK signal with carrier to get decision variable
2. Make decision to get demodulated binary data. If x>0, choose '1' else choose '0'
3. Plot the demodulated binary data.

Program

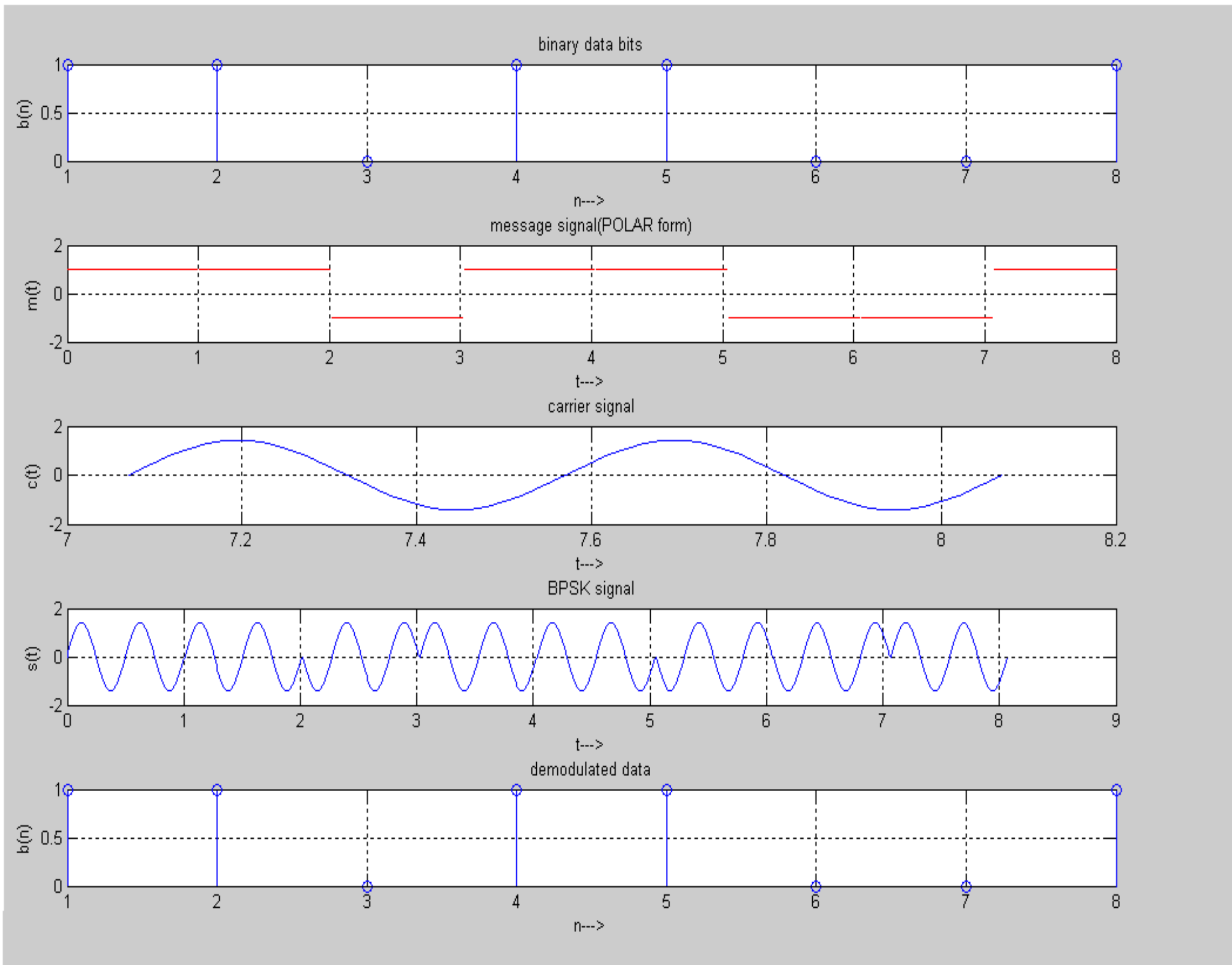
% PSK modulation

```
clc;
clear all;
close all;
%GENERATE CARRIER SIGNAL
Tb=1;
t=0:Tb/100:Tb;
fc=2;
c=sqrt(2/Tb)*sin(2*pi*fc*t);
%generate message signal
N=8;
m=rand(1,N);
t1=0;t2=Tb
for i=1:N
   t=[t1:.01: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
   message(i,:)=m_s;
   %product of carrier and message signal
   bpsk_sig(i,:)=c.*m_s;
   %Plot the message and BPSK modulated signal
   subplot(5,1,2);axis([0 N -2 2]);plot(t,message(i,:),'r');
   title('message signal(POLAR form)');xlabel('t--->');ylabel('m(t)');
   grid on;    hold on;
   subplot(5,1,4);plot(t,bpsk_sig(i,:));
   title('BPSK signal');xlabel('t--->');ylabel('s(t)');
   grid on;    hold on;
   t1=t1+1.01;    t2=t2+1.01;
end
hold off
%plot the input binary data and carrier signal
subplot(5,1,1);stem(m);
title('binary data bits');xlabel('n--->');ylabel('b(n)');
grid on;
subplot(5,1,3);plot(t,c);
title('carrier signal');xlabel('t--->');ylabel('c(t)');
grid on;
```

% PSK Demodulation

```
t1=0;t2=Tb
  for i=1:N
    t=[t1:.01:t2]
    %correlator
    x=sum(c.*bpsk_sig(i,:));
    %decision device
    if x>0
        demod(i)=1;
    else
        demod(i)=0;
    end
     t1=t1+1.01;
    t2=t2+1.01;
  end
  %plot the demodulated data bits
  subplot(5,1,5);stem(demod);
  title('demodulated data');xlabel('n--->');ylabel('b(n)');
  grid on
```

Modal Graphs



Result

The program for PSK modulation and demodulation has been simulated in MATLAB and necessary graphs are plotted.

Experiment No.3

FREQUENCY SHIFT KEYING

Aim: To generate and demodulate frequency shift keyed (FSK) signal using MATLAB

Theory

Generation of FSK

Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave. The simplest FSK is binary FSK (BFSK). BFSK uses a pair of discrete frequencies to transmit binary (0s and 1s) information. With this scheme, the "1" is called the mark frequency and the "0" is called the space frequency.

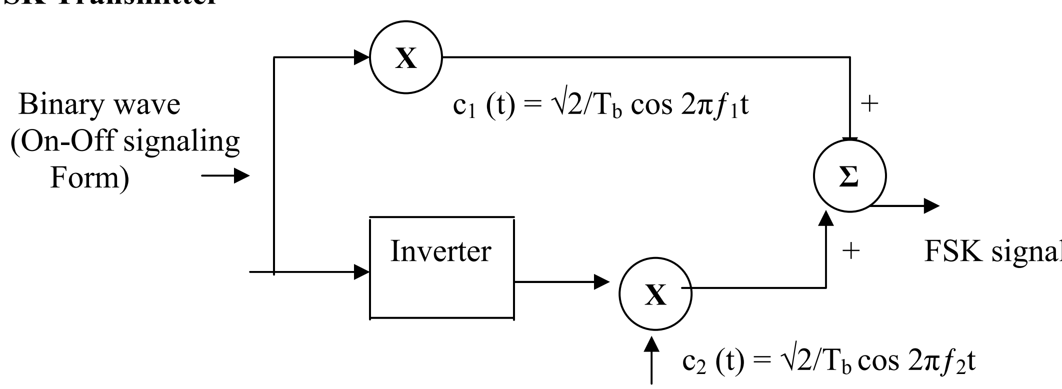
In binary FSK system, symbol 1 & 0 are distinguished from each other by transmitting one of the two sinusoidal waves that differ in frequency by a fixed amount.

$Si\ (t) = \sqrt{2E/T_b} \cos 2\pi f_1 t \qquad 0 \leq t \leq T_b$

$\qquad 0 \qquad\qquad$ elsewhere

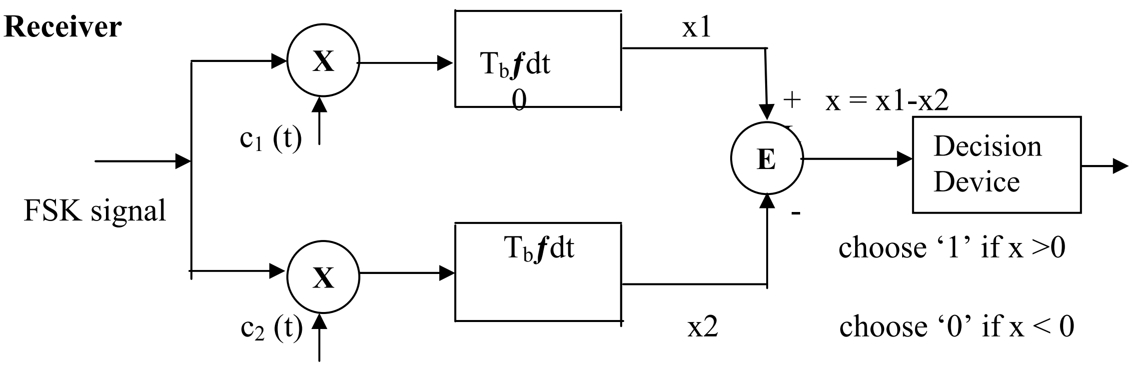
Where i=1, 2 & E_b=Transmitted energy/bit
Transmitted freq= $f i = (nc+i)/T_b$, and n = constant (integer), T_b = bit interval
Symbol 1 is represented by S_1 (t)
Symbol 0 is represented by S_0 (t)

BFSK Transmitter



The input binary sequence is represented in its ON-OFF form, with symbol 1 represented by constant amplitude of $\sqrt{E_b}$ with & symbol 0 represented by zero volts. By using inverter in the lower channel, we in effect make sure that when symbol 1is at the input, The two frequency f1& f2 are chosen to be equal integer multiples of the bit rate $1/T_b$.By summing the upper & lower channel outputs, we get BFSK signal.

BFSK Receiver



The receiver consists of two correlators with common inputs which are supplied with locally generated coherent reference signals $c_1(t)$ and c_2 (t).

The correlator outputs are then subtracted one from the other, and the resulting difference x is compared with a threshold of zero volts. If x >0, the receiver decides in favour of symbol 1 and if x <0, the receiver decides in favour of symbol 0.

Algorithm

Initialization commands

FSK modulation

1. Generate two carriers signal.
2. Start FOR loop
3. Generate binary data, message signal and inverted message signal
4. Multiply carrier 1 with message signal and carrier 2 with inverted message signal
5. Perform addition to get the FSK modulated signal
6. Plot message signal and FSK modulated signal.
7. End FOR loop.
8. Plot the binary data and carriers.

FSK demodulation

1. Start FOR loop
2. Perform correlation of FSK modulated signal with carrier 1 and carrier 2 to get two decision variables x1 and x2.
3. Make decisionon x = x1-x2 to get demodulated binary data. If x>0, choose '1' else choose '0'.
4. Plot the demodulated binary data.

Program

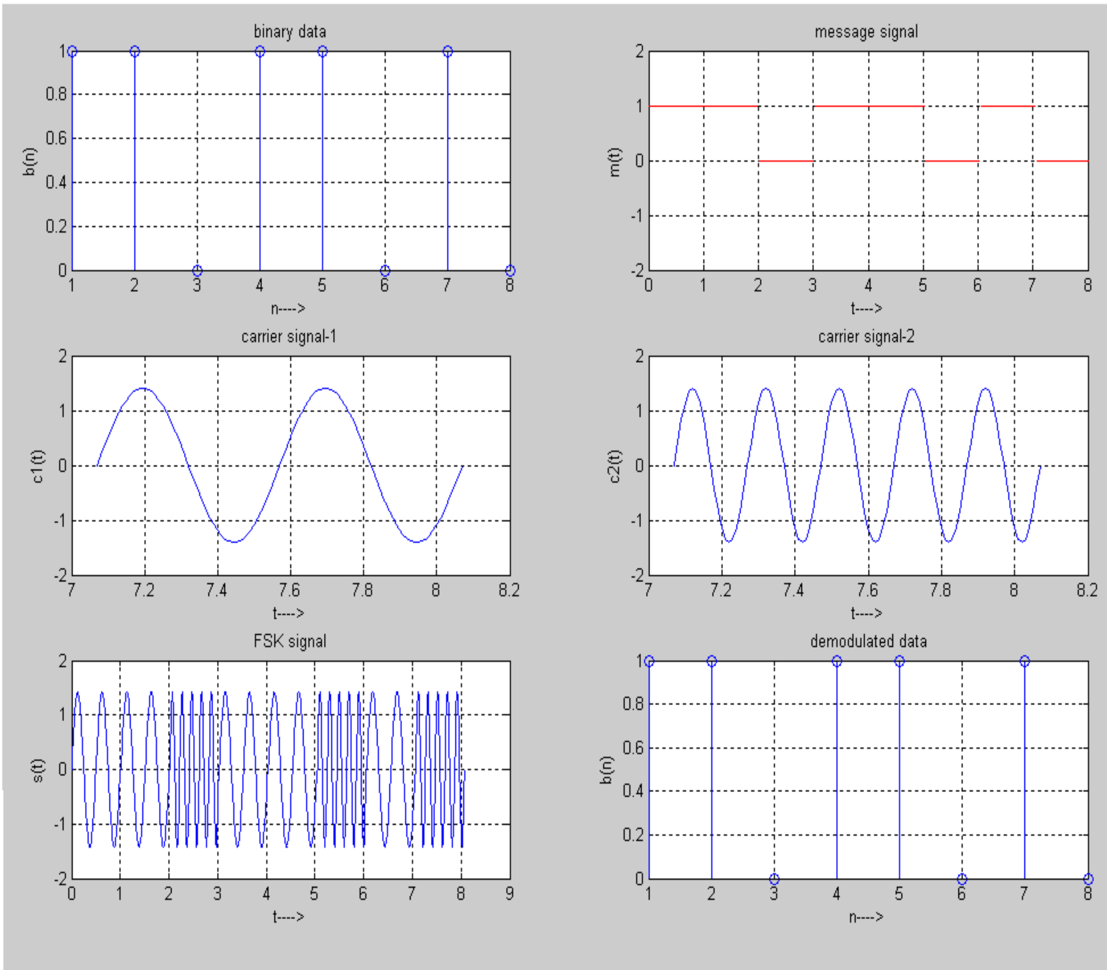
% FSK Modulation

```
clc;
clear all;
close all;
%GENERATE CARRIER SIGNAL
Tb=1; fc1=2;fc2=5;
t=0:(Tb/100):Tb;
c1=sqrt(2/Tb)*sin(2*pi*fc1*t);
c2=sqrt(2/Tb)*sin(2*pi*fc2*t);
 %generate message signal
N=8;
m=rand(1,N);
t1=0;t2=Tb
for i=1:N
    t=[t1:(Tb/100):t2]
    if m(i)>0.5
        m(i)=1;
        m_s=ones(1,length(t));
        invm_s=zeros(1,length(t));
    else
        m(i)=0;
        m_s=zeros(1,length(t));
        invm_s=ones(1,length(t));
    end
    message(i,:)=m_s;
    %Multiplier
    fsk_sig1(i,:)=c1.*m_s;
    fsk_sig2(i,:)=c2.*invm_s;
    fsk=fsk_sig1+fsk_sig2;
    %plotting the message signal and the modulated signal
    subplot(3,2,2);axis([0 N -2 2]);plot(t,message(i,:),'r');
    title('message signal');xlabel('t---->');ylabel('m(t)');grid on;hold on;
    subplot(3,2,5);plot(t,fsk(i,:));
    title('FSK signal');xlabel('t---->');ylabel('s(t)');grid on;hold on;
    t1=t1+(Tb+.01); t2=t2+(Tb+.01);
   end
hold off
%Plotting binary data bits and carrier signal
subplot(3,2,1);stem(m);
title('binary data');xlabel('n---->');  ylabel('b(n)');grid on;
subplot(3,2,3);plot(t,c1);
title('carrier signal-1');xlabel('t---->');ylabel('c1(t)');grid on;
subplot(3,2,4);plot(t,c2);
title('carrier signal-2');xlabel('t---->');ylabel('c2(t)');grid on;
```

% **FSK Demodulation**

```
t1=0;t2=Tb
 for i=1:N
   t=[t1:(Tb/100):t2]
    %correlator
   x1=sum(c1.*fsk_sig1(i,:));
   x2=sum(c2.*fsk_sig2(i,:));
   x=x1-x2;
   %decision device
   if x>0
       demod(i)=1;
   else
       demod(i)=0;
   end
    t1=t1+(Tb+.01);
   t2=t2+(Tb+.01);
 end
 %Plotting the demodulated data bits
 subplot(3,2,6);stem(demod);
 title(' demodulated data');xlabel('n---->');ylabel('b(n)');  grid on;
```

Modal Graphs



Result

The program for FSK modulation and demodulation has been simulated in MATLAB and necessary graphs are plotted.

Experiment No.4

QUADRATURE PHASE SHIFT KEYING

Aim: To generate and demodulate quadrature phase shifted (QPSK) signal using MATLAB

Theory

Generation of Quadrature phase shift keyed (QPSK) signal

QPSK is also known as quaternary PSK, quadriphase PSK, 4-PSK, or 4-QAM. It is a phase modulation technique that transmits two bits in four modulation states.

Phase of the carrier takes on one of four equally spaced values such as π/4, 3π/4, 5π/4 and7π/4.

Si(t) = $\sqrt{2E/T} \cos \{2\pi f_c t + (2i - 1)\pi/4\}$, $0 \le t \le T$

0 , elsewhere

Where i = 1,2,3,4, & E= Tx signal energy per symbol
T= symbol duration

Each of the possible value of phase corresponds to a pair of bits called dibits.
Thus the gray encoded set of dibits: 10,00,01,11

Si (t) = $\sqrt{2E/T}\cos[(2i-1)\pi/4]\cos(2\pi f_c t) - \sqrt{2E/T}\sin[(2i-1)\pi/4)]\sin(2\pi f_c t)$, $0 \le t \le T_b$

0 , else where

There are two orthononormal basis functions

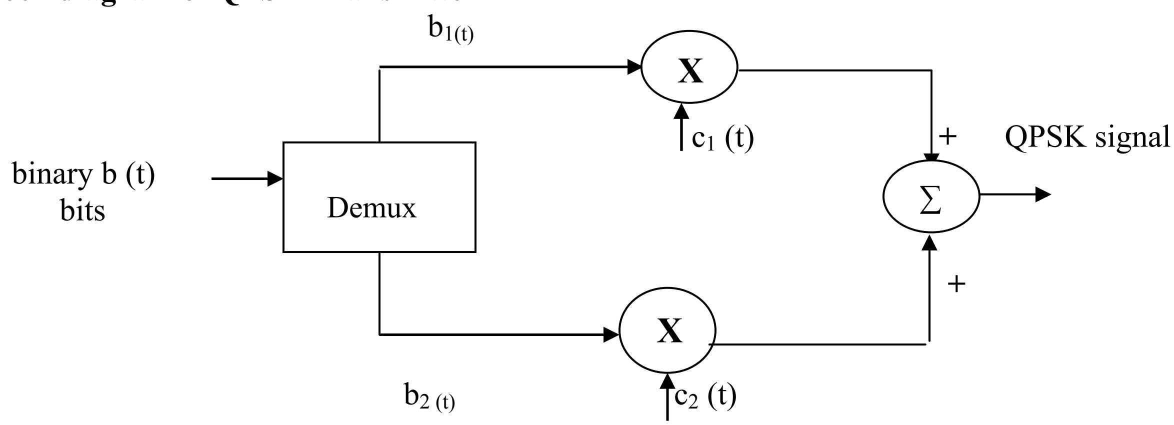
$c_1(t) = \sqrt{2/T}\cos 2\pi f_c t,\quad 0 \le t \le T_b$

$c_2(t) = \sqrt{2/T}\sin 2\pi f_c t,\quad 0 \le t \le T_b$

There are four message points

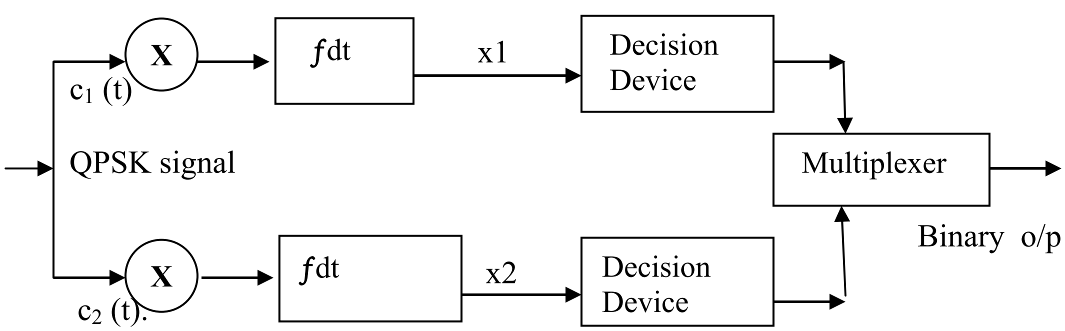
Input debits	Phase of QPSK signal	Co-ordinates of message signals	
		S1	S2
10	π/4	√E/2	-√E/2
00	3π/4	-√E/2	-√E/2
01	5π/4	-√E/2	+√E/2
11	7π/4	+√E/2	+√E/2

Block diagram of QPSK Transmitter



The I/p binary sequence b(t) is represented in polar from with symbols 1 & 0 represented as $+\sqrt{E/2}$ and $-\sqrt{E/2}$. This binary wave is demutiplexed into two separate binary waves consisting of odd & even numbered I/P bits denoted by b_1 (t) & b_2 (t). b_1 (t) & b_2(t) are used to modulate a pair of quadrature carrier. The result is two PSK waves .These two binary PSK waves are added to produce the desired QPSK signal

<u>QPSK Receiver</u>:



QPSK receiver consists of a pair of correlators with common I/P & supplied with locally generated signal c_1 (t) & c_2 (t). The correlator output, x_1, & x_2 are each compared with a threshold of zero volts.If $x_1 > 0$, decision is made in favour of symbol ‘1’ for upper channel and if $x_1 > 0$, decision is made in favour of symbol 0. Parallely if $x_2 >0$, decision is made in favour of symbol 1 for lower channel & if $x_2 <0$, decision is made in favour of symbol 0. These two channels are combined in a multiplexer to get the original binary output.

Algorithm

Initialization commands

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

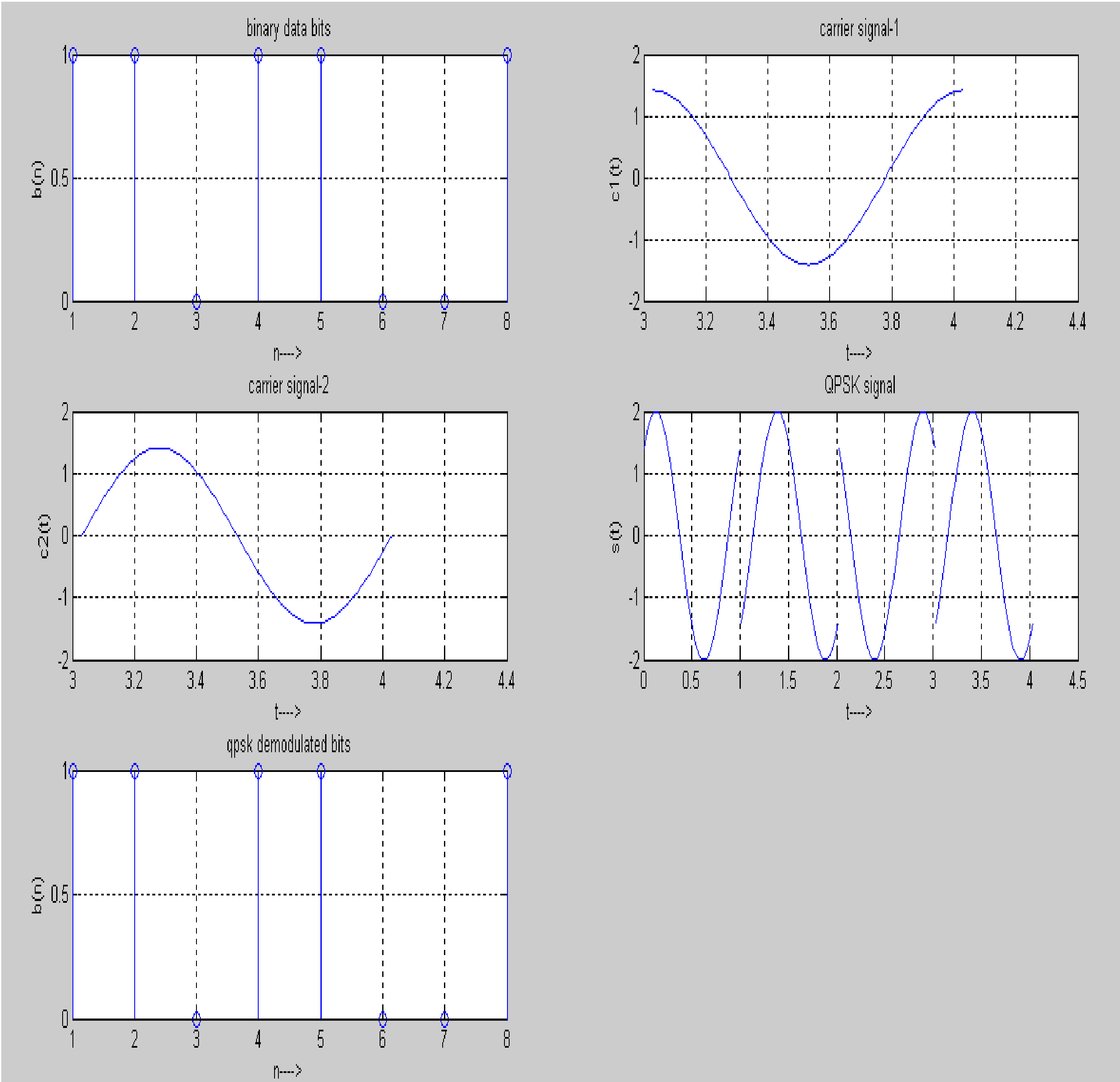
1. Start FOR loop
2. Perform correlation of QPSK modulated signal with quadrature carriers to get two decision variables x1 and x2.
3. Make decision on x1 and x2 and multiplex to get demodulated binary data.
   If x1>0and x2>0, choose '11'. If x1>0and x2<0, choose '10'. If x1<0and x2>0, choose '01. If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

Program

```
%  QPSK Modulation
clc;
clear all;
close all;
%GENERATE QUADRATURE CARRIER SIGNAL
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);
%generate message signal
N=8;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 bits modulated signal
   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 bits modulated signal
    even_sig(i,:)=c2.*m_s;
    %qpsk signal
    qpsk=odd_sig+even_sig;
    %Plot the QPSK modulated signal
    subplot(3,2,4);plot(t,qpsk(i,:));
    title('QPSK signal');xlabel('t---->');ylabel('s(t)');grid on; hold on;
    t1=t1+(Tb+.01); t2=t2+(Tb+.01);
 end
hold off
%Plot the binary data bits and carrier signal
subplot(3,2,1);stem(m);
title('binary data bits');xlabel('n---->');ylabel('b(n)');grid on;
subplot(3,2,2);plot(t,c1);
title('carrier signal-1');xlabel('t---->');ylabel('c1(t)');grid on;
subplot(3,2,3);plot(t,c2);
title('carrier signal-2');xlabel('t---->');ylabel('c2(t)');grid on;
  %   QPSK Demodulation
 t1=0;t2=Tb
  for i=1:N-1
    t=[t1:(Tb/100):t2]
     %correlator
    x1=sum(c1.*qpsk(i,:));
    x2=sum(c2.*qpsk(i,:));
    %decision device
    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);stem(demod);
  title('qpsk demodulated bits');xlabel('n---->');ylabel('b(n)');grid on;
```

Modal Graphs



Result

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

Experiment No.5

BER Simulation of DPSK modulation

Aim: To simulate bit error rate performance of DPSK modulation using Matlab.

Theory

DPSK involves 2 basic operations at the transmitter, differential encoding of the i/p binary wave and phase shift keying, hence the name DPSK. To send symbol 0 we phase advance the current signal waveform by 1800 and to send symbol 1 we leave the phase of the current signal unchanged.

In the differential encoding at the transmitter input starts with an arbitrary first bit serving as reference and thereafter the sequence is generated using

dk-1' previous value of differentially encoded digit.
bk' i/p binary digit at time kTb.
dk-1 ,bk' logical inversion.

Assuming reference bit added to {dk} is a'1'. {dk} is thus generated and used to phase shift key a carrier with phase angles 0 and ?.

BER -Bit Error Rate

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that have been altered due to noise, interference, distortion or bit synchronization errors.The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unitless performance measure, often expressed as a percentage.In a communication system, the receiver side BER may be affected by transmission channel noise, interference, distortion, bit synchronization problems, attenuation, wireless multipath fading, etc.

The BER may be analyzed using stochastic computer simulations. If a simple transmission channel model and data source model is assumed, the BER may also be calculated using Binary symmetric channel (used in analysis of decoding error probability in case of non-bursty bit errors on the transmission channel) and Additive white gaussian noise (AWGN) channel without fading.

Algorithm
Initialization commands

1. Generate the input data randomly
2. Implement differential encoding
3. Do BPSK modulation
4. Add AWGN noise
5. Calculate the no of bits in error
6. Plot the BER graph

Program

```
N = 10^4 % number of bits or symbols
rand('state',100); % initializing the rand() function
randn('state',200);% initializing the randn() function
ip = rand(1,N)>0.5;% generating 0,1 with equal probability

ipD = mod(filter(1,[1 -1],ip),2); % %differential encoding y[n]=y[n-1]+x[n]
s = 2*ipD-1; % BPSK modulation 0 -> -1; 1 -> 0
n = 1/sqrt(2)*[randn(1,N) + j*randn(1,N)]; % white gaussian noise, 0dB variance

Eb_N0_dB = [-3:10];                          % multiple Eb/N0 values
for ii = 1:length(Eb_N0_dB)
y = s + 10^(-Eb_N0_dB(ii)/20)*n;             % additive white gaussian noise

ipDHat_coh = real(y) > 0;                    % coherent demodulation
ipHat_coh = mod(filter([1 -1],1,ipDHat_coh),2);        %differential decoding
nErr_dbpsk_coh(ii) = size(find([ip - ipHat_coh]),2);   % counting the number of errors
end
simBer_dbpsk_coh = nErr_dbpsk_coh/N;
theoryBer_dbpsk_coh = erfc(sqrt(10.^(Eb_N0_dB/10))).*(1 - .5*erfc(sqrt(10.^(Eb_N0_dB/10))));

close all
figure
semilogy(Eb_N0_dB,theoryBer_dbpsk_coh,'b.-');
hold on
semilogy(Eb_N0_dB,simBer_dbpsk_coh,'mx-');
axis([-2 10 10^-6 0.5])
grid on
legend('theory', 'simulation');
xlabel('Eb/No, dB')
ylabel('Bit Error Rate')
title('Bit error probability curve for coherent demodulation of DBPSK')
```

Modal Graphs

Result
The Bit Error rate simulation of DPSK modulation was done using Matlab.

Experiment No.6

PRE-EMPHASIS AND DE-EMPHASIS

Aim: To study the characteristics of pre-emphasis and de-emphasis circuits using PSPICE

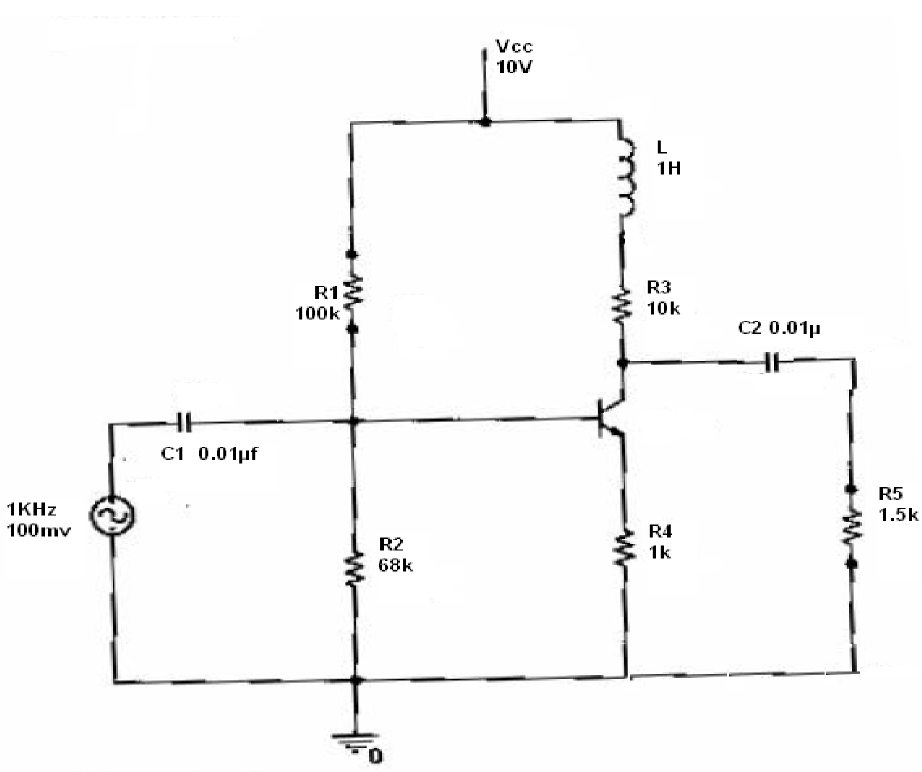
Theory

In telecommunication, a pre-emphasis circuit is inserted in a system in order to increase the magnitude of one range of frequencies with respect to another. Pre-emphasis is usually employed in FM or phase modulation transmitters to equalize the modulating signal drive power in terms of deviation ratio. In high speed digital transmission, pre-emphasis is used to improve signal quality at the output of a data transmission. In transmitting signals at high data rates, the transmission medium may introduce distortions, so pre-emphasis is used to distort the transmitted signal to correct for this distortion. When done properly this produces a received signal which more closely resembles the original or desired signal, allowing the use of higher frequencies or producing fewer bit errors.

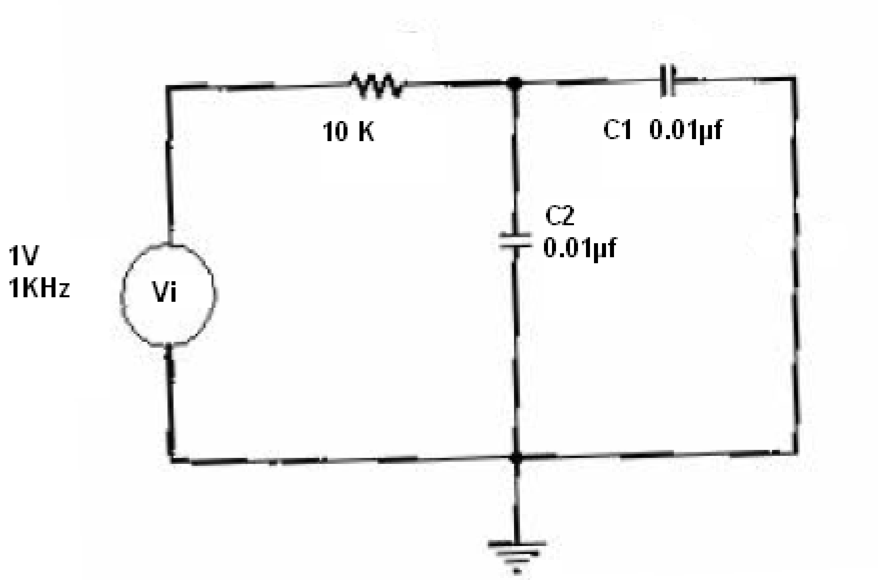
In telecommunication, de-emphasis is the complement of pre-emphasis. It is designed to decrease, (within a band of frequencies), the magnitude of some (usually higher) frequencies with respect to the magnitude of other (usually lower) frequencies in order to improve the overall signal-to-noise ratio by minimizing the adverse effects of such phenomena as attenuation differences

Circuit Diagram

PRE-EMPHASIS



DE-EMPHASIS



Program

PRE-EMPHASIS:

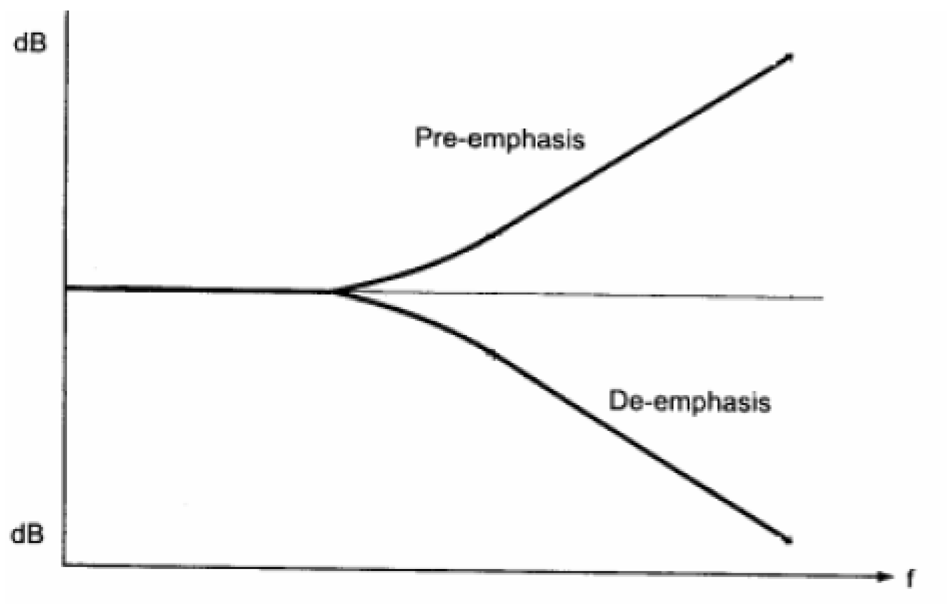
```
Vcc   1   0   dc    10V
P1    1   3   100k
L1    1   5   1H
P3    5   2   10k
P2    3   0   68k
P4    4   0   1k
P5    7   0   1.5k
C1    3   6   0.01µf
C2    2   7   0.01µf
V1    6   0   ac      100mv   sin ( 0 100mv 1KHz)
q2    2   3   4       q2N2222
. lib
. AC   DEC   10   1oHz   20KHz
. probe
. end
```

DE-EMPHASIS;

```
V1   1   0   ac   1V   sin ( 0  1V  1KHz)
P1   1   2   10K
```

C1 2 0 0.01µf
C2 2 0 0.01µf
. lib
. AC DEC 10 10Hz 20KHz
. probe
. end

Modal Graphs



Result

The characteristics of pre –emphasis and de emphasis circuits were studied

Experiment No.7

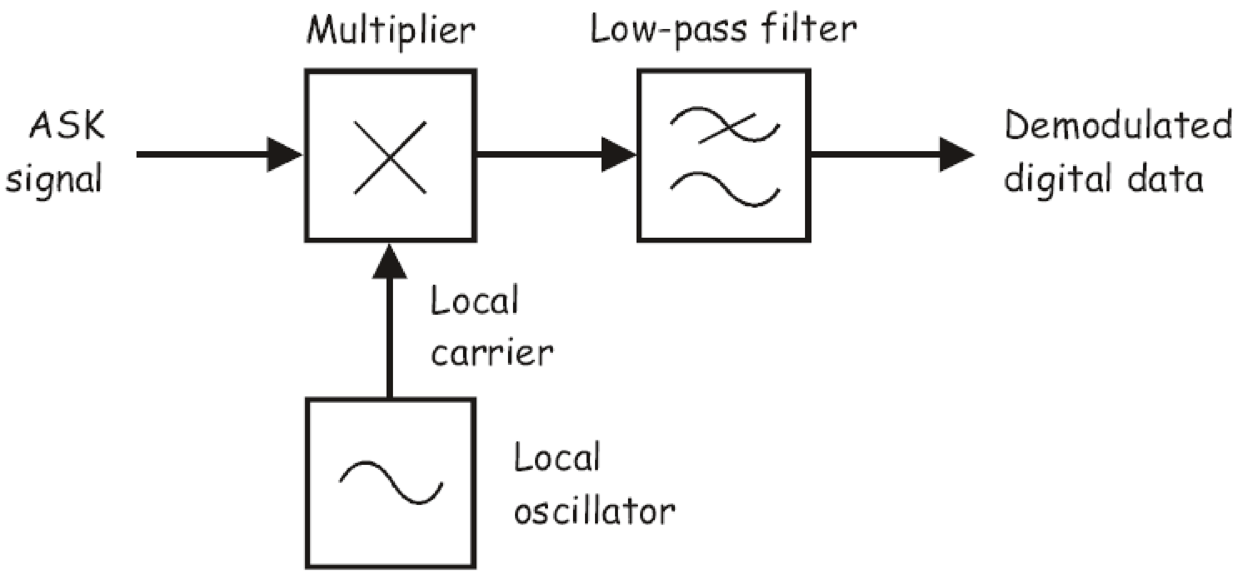
ASK DEMODULATION USING PRODUCT DETECTION

Aim: To demodulate ASK signal through product detection technique using the Communication Trainer Kit.

Theory

Amplitude shift keying is one of several digital modulation techniques used for frequency division multiplexing of communications channel. Despite its grand name, ASK is basically amplitude modulation (AM) with digital data for the message instead of speech and/or music.

The product detector is a method of demodulating AM and ASK signals .The below figure shows the product detector used as an ASK demodulator.



The incoming ASK signal is one input to a functional block called a multiplier. The Multipliers other input is a pure sine wave (called the local carrier) that is generated by the receiver and must be the same frequency as the ASK signal's carrier for the demodulation to be successful. Mathematically, the multiplication of the multiplier's inputs can be described as:

Product detector's output = the ASK signal x the local carrier.

Equipment Required

- Emona Telecoms-Trainer 101 (plus power-pack)

- Dual-channel 20MHZ oscilloscope
- Three Emona Telecoms-Trainer 101 oscilloscope leads
- Assorted Emona Telecoms-Trainer 101 patch leads

PROCEDURE:

Generating ASK signal

1. Connect the set-up shown in the Figure 1 below.

   Note: Insert the black plugs of the oscilloscope leads into a ground (GND) socket.

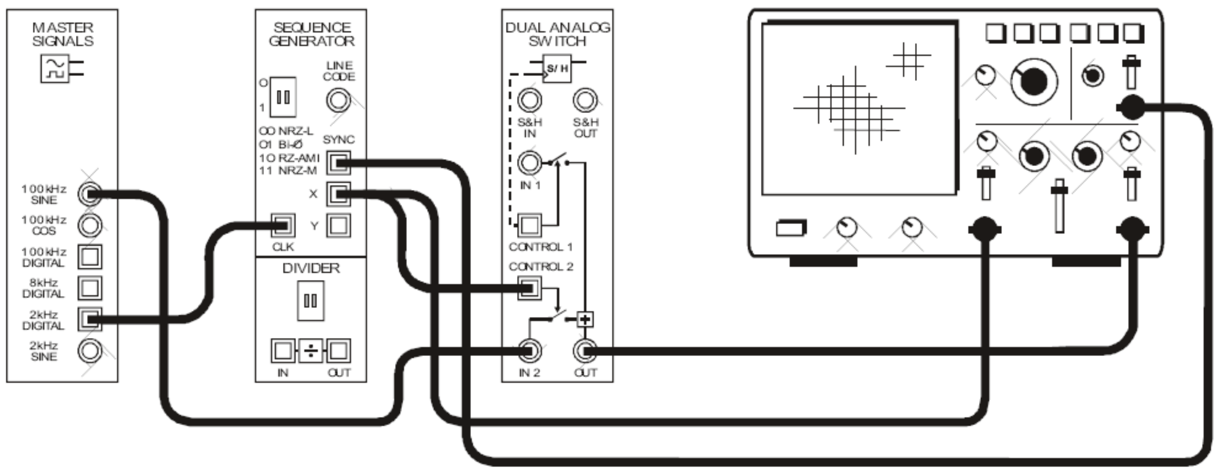


Figure 1

This set-up can be represented by the block diagram as in the Figure 2. The sequence Generator module is used to model a digital signal and its SYNC output is used to trigger the scope to provide a stable display. The Dual Analog switch module is used to generate the ASK signal with a 100 kHz carrier.

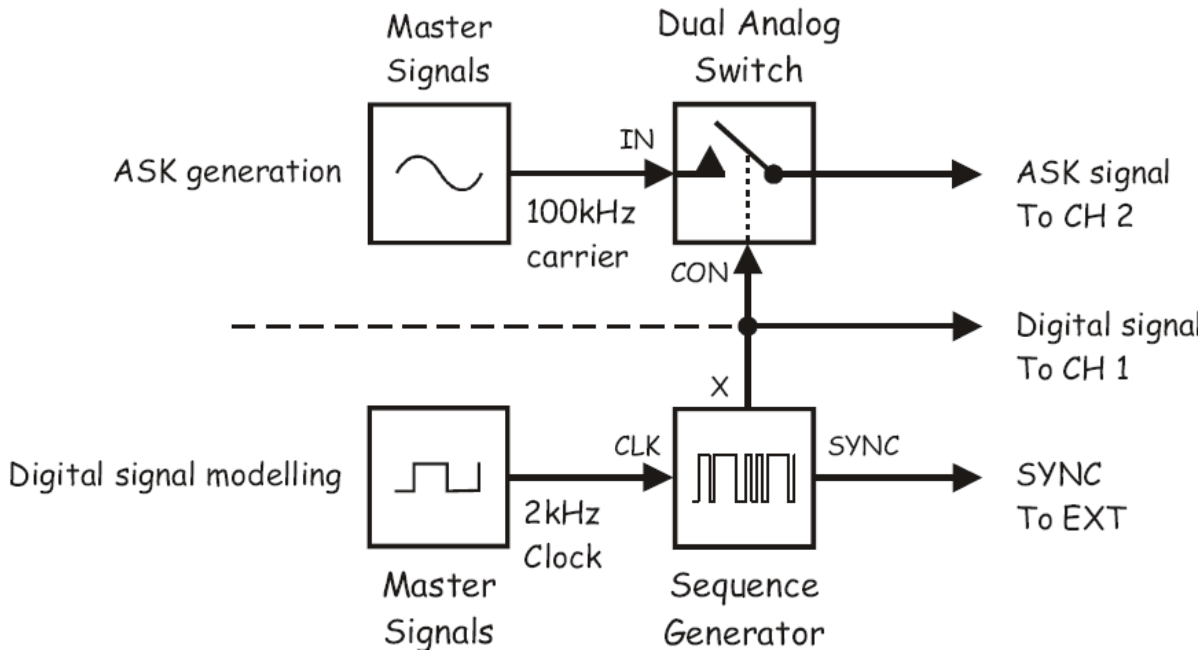


Figure 2

2. Set up the scope.
3. Adjust the following scope controls as indicated:
    - Vertical Attenuation control for channel 1 to 2V/div.
    - Input Coupling controls for both channels to DC.
    - Time base control to the 1ms/div position.
    - Trigger Source control to the EXT position.
4. Set the scope's module control to the DUAL position to observe the signal on the Dual Analog switch module's output as well as the digital data message.

Demodulating ASK signal using Product Detection

1. Locate the Tunable Low-pass filter module and turn its gain control fully clockwise.
2. Turn the tunable Low-pass Filter module's Cut-off Frequency Adjust control fully clockwise.
3. Modify the set-up as shown in the Figure3.

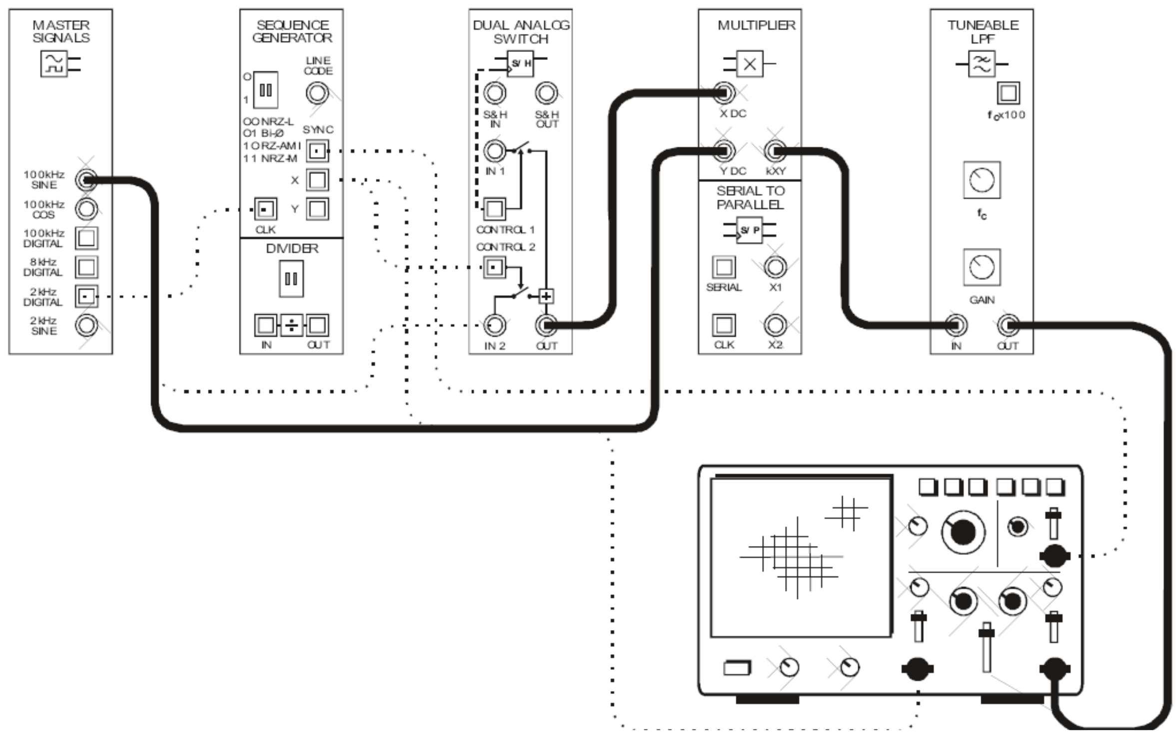


Figure 3

The ASK generation and demodulation parts of the set-up is represented in the Figure 4 The Multiplier and the Tunable Low-pass Filter modules are used to implement a product detector. The product detector's local carrier's is "stolen" from the modulator to ensure carrier synchronization between the modulator and demodulator.

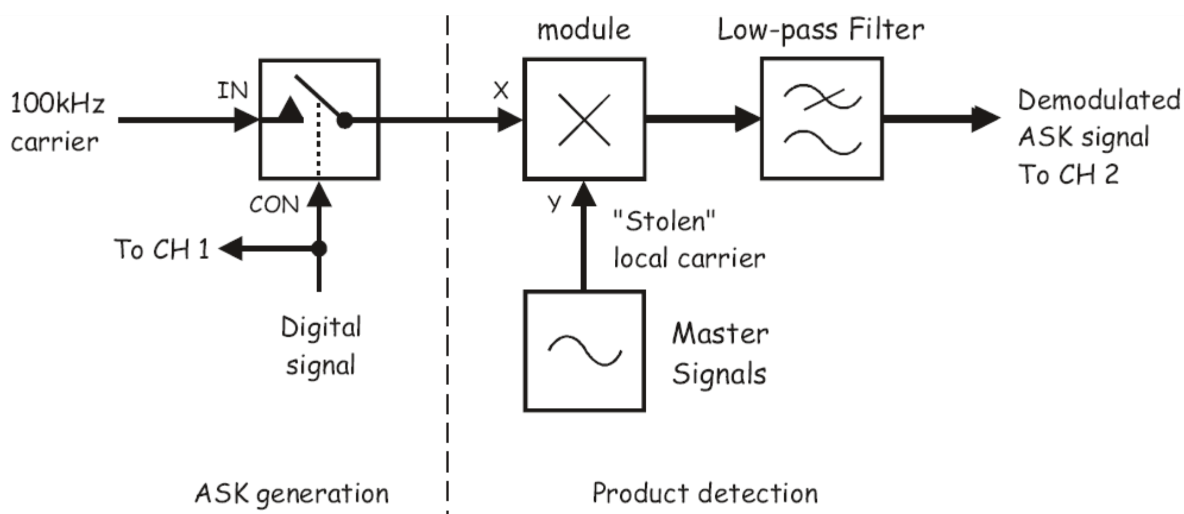


Figure 4

4. Compare the original and recovered digital signals.

Result

The ASK signal was demodulated through product detection technique using the Communication Trainer Kit.

Experiment No.8

FSK DEMODULATION USING ENVELOPE DETECTOR

Aim: To demodulate FSK signal through Envelope detection technique using the Communication Trainer Kit

Theory

Frequency shift keying (FSK) is the frequency modulation (FM) scheme with a digital data signal for the message instead of speech and/or music. As such, the advantage of FSK over ASK is the same as the advantage of FM over AM – noise immunity.

FM/FSK resists noise problem (though is not completely immune from it) because demodulation is designed to respond to the signal's frequency variations. That being the case, any variations in the signal's amplitude due to noise can be removed by a limiter.

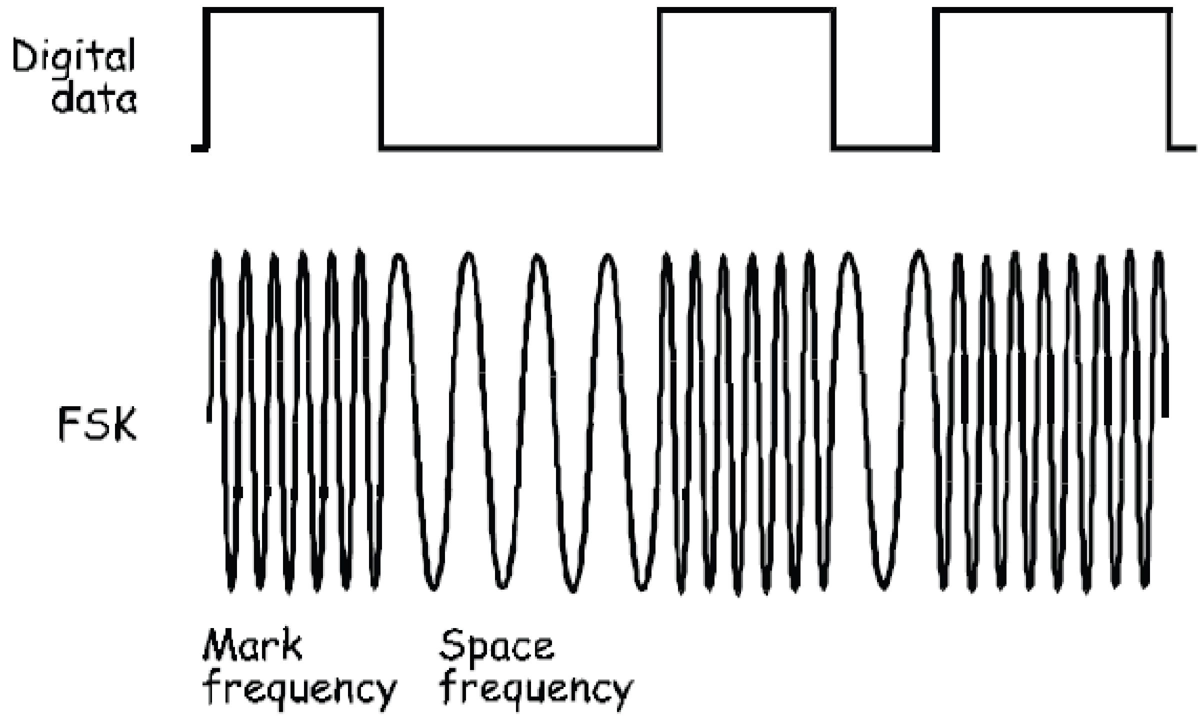


Figure 1

Notice that the FSK signal switches between two sine waves. The sine wave that corresponds with logic-0s in the digital data is called the space frequency. The sine wave that corresponds with logic-1s in the digital data is called mark frequency. In the above figure, the mark frequency is higher than the space frequency but this is not a necessary requirement of FSK – the relative frequency can be reversed.

Equipment Required

- Emona Telecoms-Trainer 101 (plus power-pack)
- Dual-channel 20MHZ oscilloscope
- Three Emona Telecoms-Trainer 101 oscilloscope leads
- Assorted Emona Telecoms-Trainer 101 patch leads

PROCEDURE:

Generating FSK signal

1. Set the scope's channel 1 Input Coupling control to the GND position.
2. Use the scope's Channel 1 Vertical Position control to move the trace so that it lines up with the horizontal line in the middle of the scope's screen.

3. Set the scope's Input coupling control for both channels to the DC position.

4. Connect the set-up shown in the below Figure 2.

   Note: Insert the black plugs of the oscilloscope leads into a ground(GND) socket.

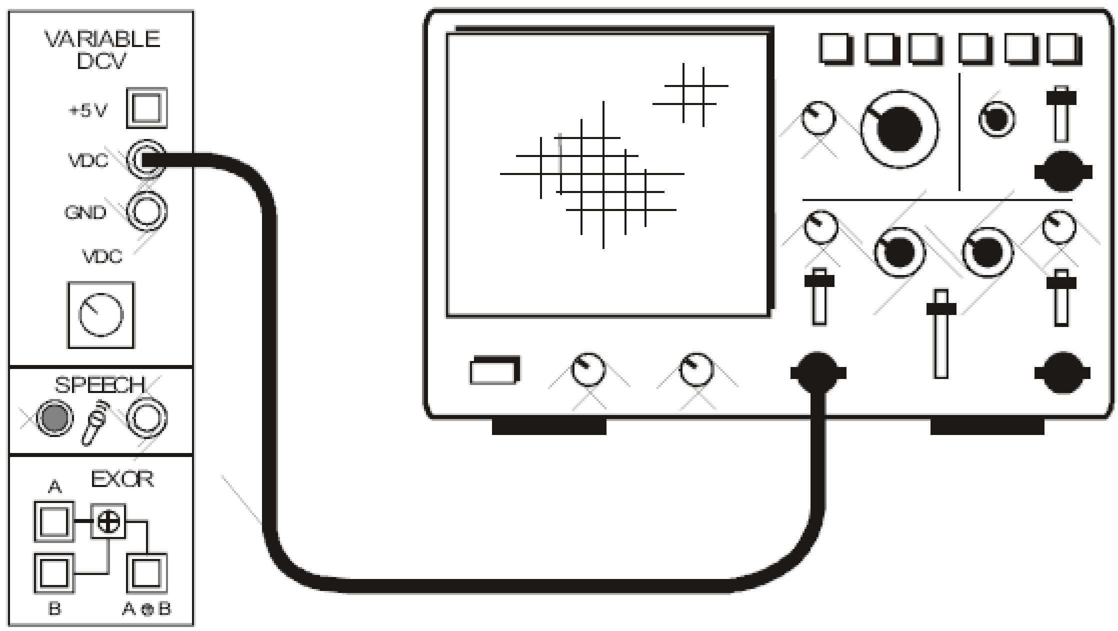


Figure 2

5. While watching the Variable DCV module's output on the scope, turn its VDC control until the DC level is 2V.

6. Locate the VCO module and turn its Gain control fully anti-clockwise.

7. Turn the VCO module's Frequency Adjust control fully anti-clockwise.

8. Set the VCO module's range control to the LO position.

9. Disconnect the scope from the Variable DCV module and connect the set-up shown in the below Figure 3.

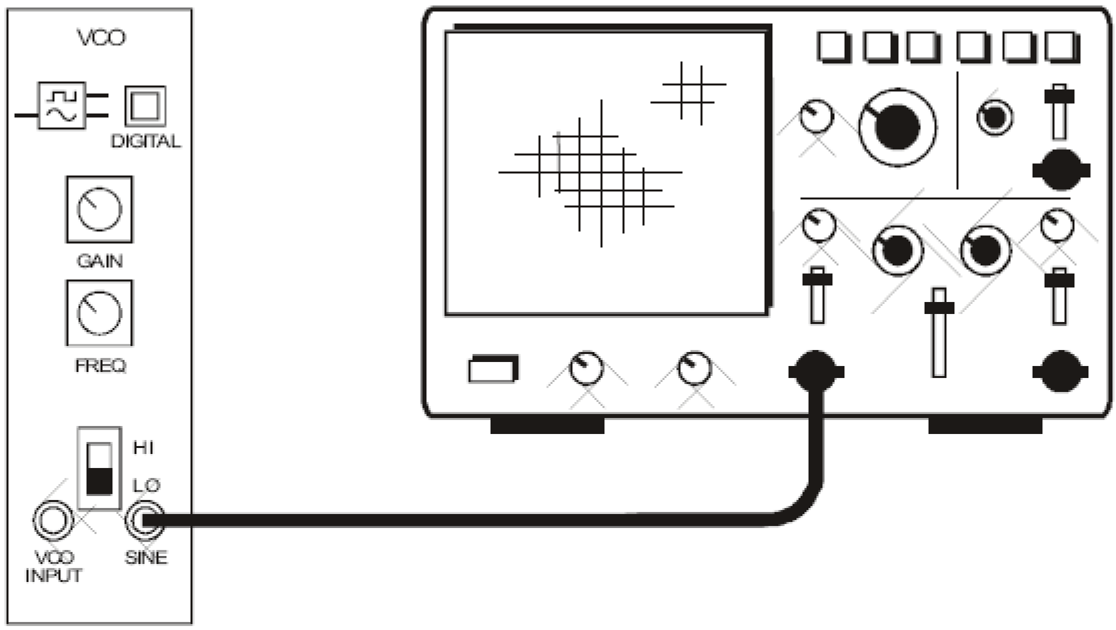


Figure 3

10. Adjust the VCO module's Frequency Adjust to obtain a 4 kHz sine wave.

    Note: Once done, do not change the VCO module's Frequency Adjust control unless otherwise instructed.

11. Connect the set-up as shown in the Figure 4.

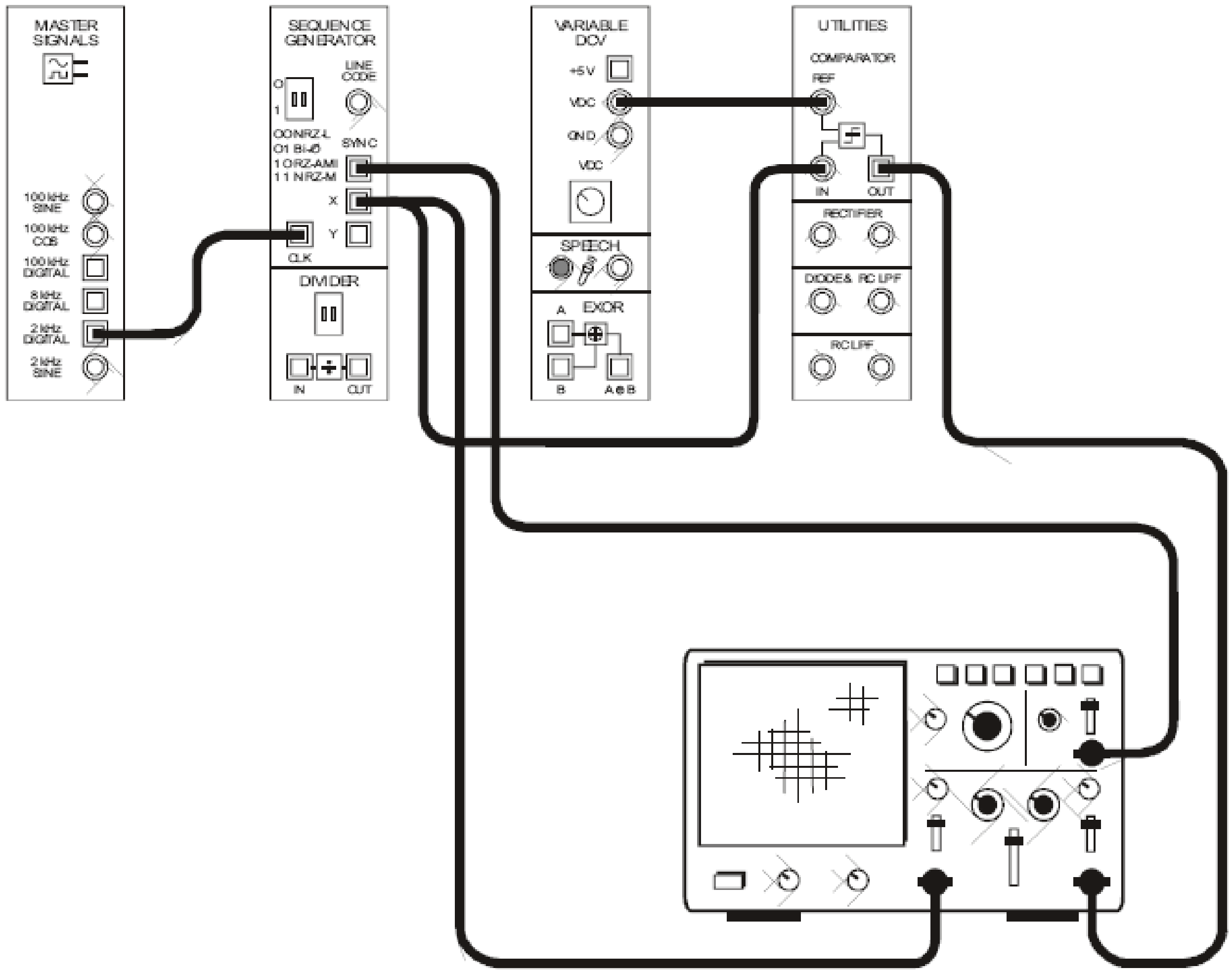


Figure 4

This set-up can be represented by the block diagram shown in Figure 5. The sequence Generator module is used to module a digital data signal and its SYNC output is used to trigger the scope to provide a stable display. The Comparator on the Utilities module, together with a DC voltage from the Variable DCV module, is used to invert the digital data signal.

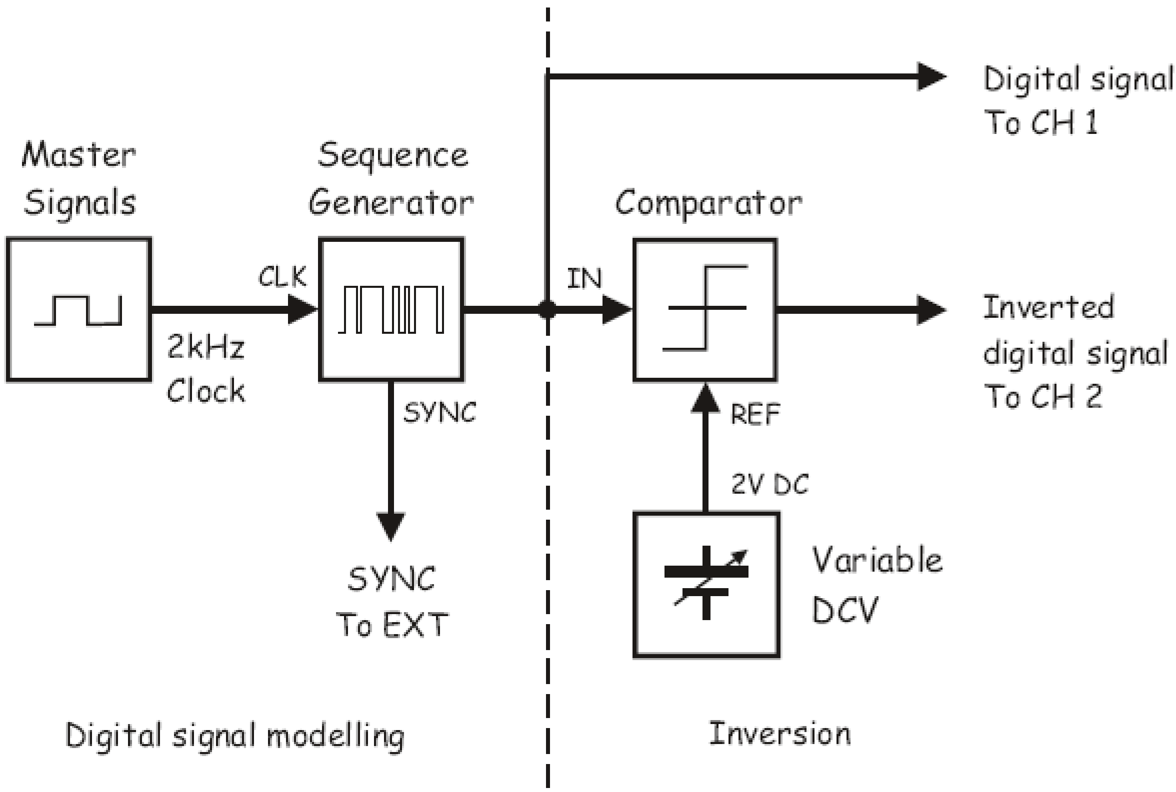


Figure 5

12. Set the scope's Mode control to the DUAL position to view the digital data signal and the comparators output.

13. Adjust the following scope controls as indicated:

    - Vertical Attenuation for both channels to 2V/div.
    - Time base to 1ms/div.
    - Trigger Source to EXT.

14. Compare the signals.

Demodulating FSK signal using Envelope Detection

As FSK is really just FM (with a digital message instead of speech and/or music), it can be recovered using any of the FM demodulation schemes. However, because the FSK signal switches back and forth between just two frequencies, we can use a method of demodulating it that cannot be used to demodulate speech-encoded FM signals.

1. Locate the Tunable Low-pass Filter module and turn its Cut-off Frequency Adjust control fully clockwise.

2. Turn the Tunable Low-pass Filter module's Gain control fully clockwise.

3. Modify the setup as shown in the Figure 6

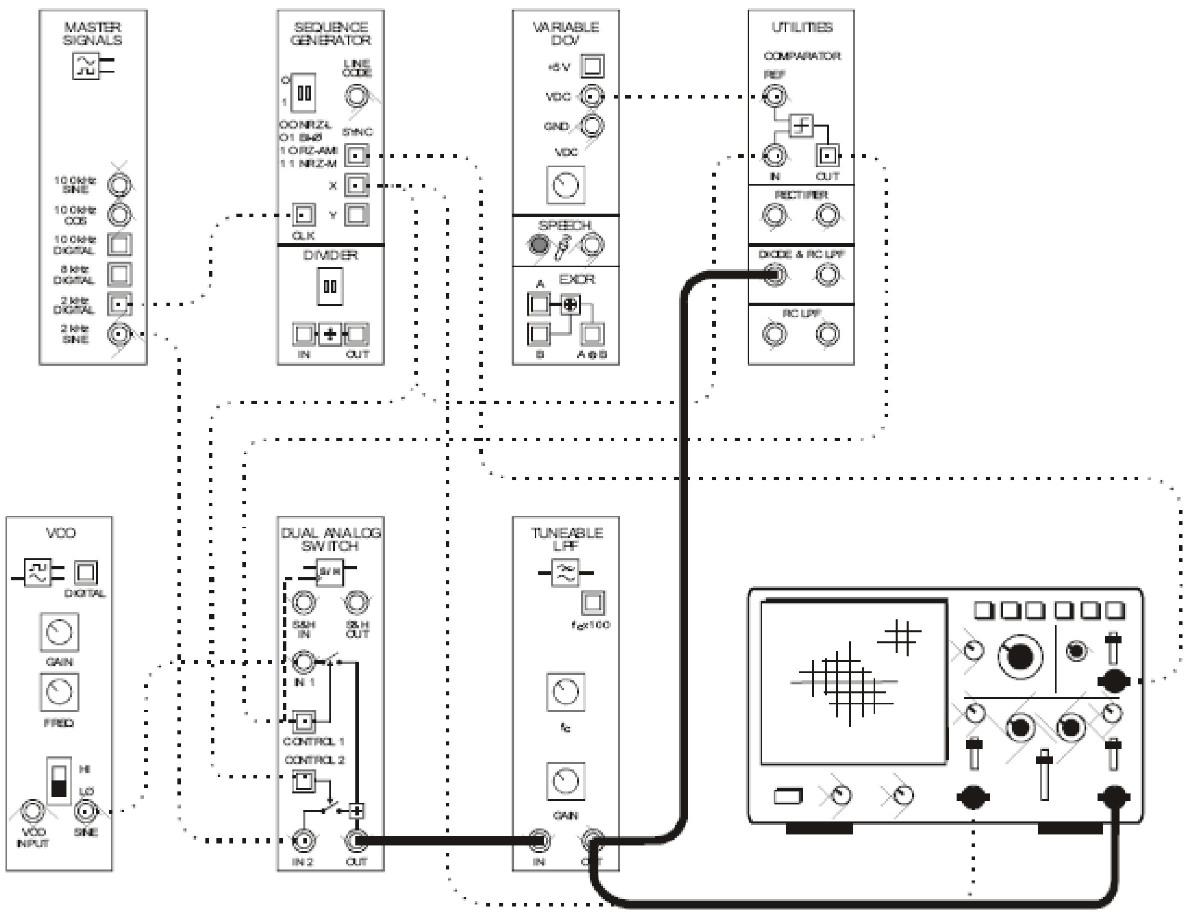


Figure 6

The Tunable Low-pass Filter module is used to pick out the lower frequency of the FSK signal's "two" sine waves and the DIODE and RC LPF on the Utilities module form the envelope detector to complete the FSK signal's demodulation. The set up shown in figure 6 is represented by the block diagram shown in figure 7

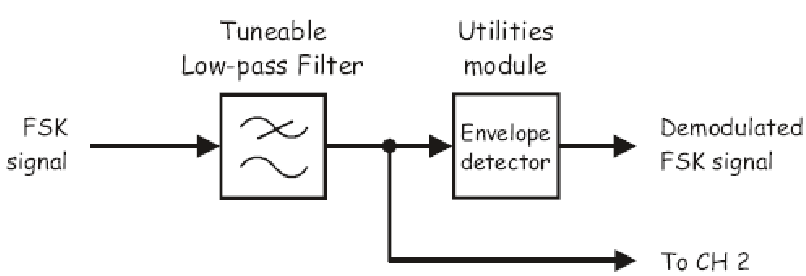


Figure 7

4. Slowly reduce the Tunable Low-pass Filter module's cut-off frequency until the FSK signal's higher frequency component has been removed (or at least minimized) while keeping as much of the lower frequency component as possible.

5. Compare the digital data signal and the filter's output.

6. Change the Scopes Channel 2 connection as shown in the figure 8

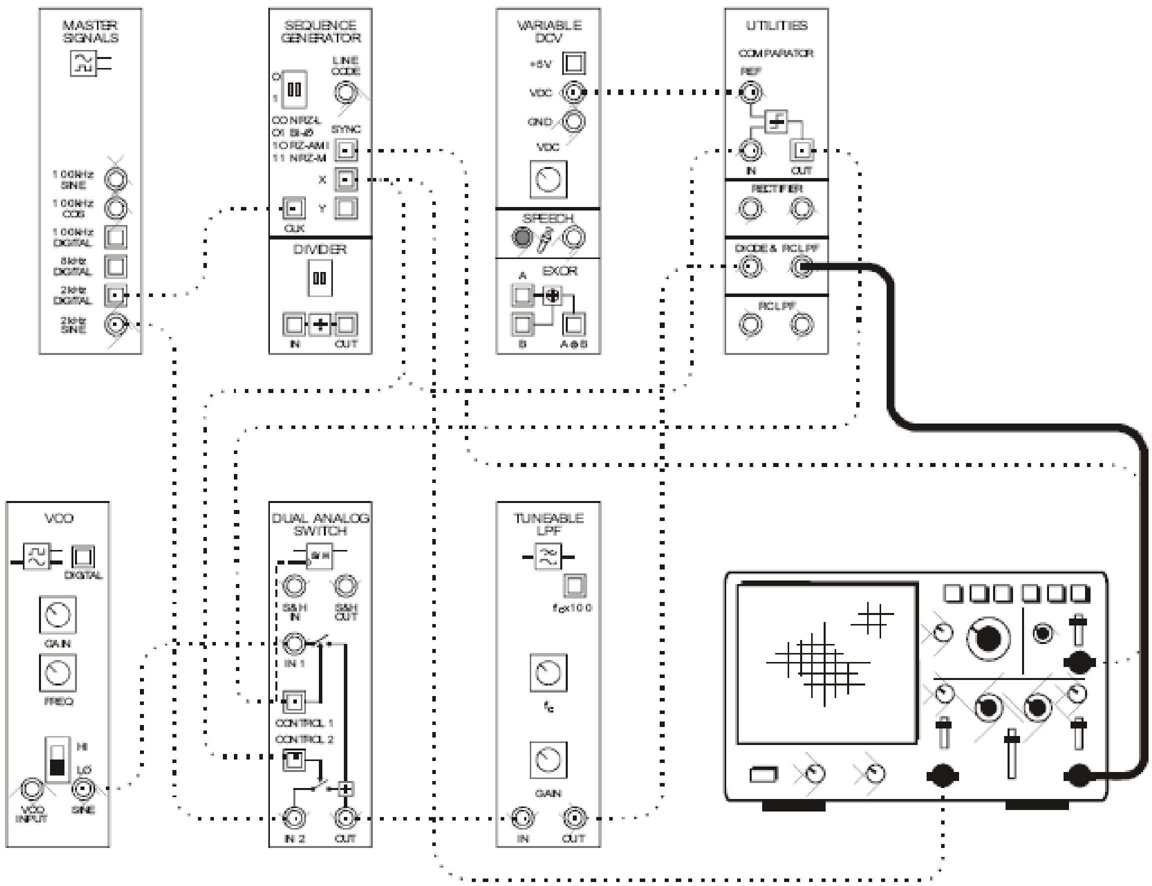


Figure 8

7. Compare the original digital data signal with the recovered digital data signal

Result

The FSK signal was demodulated through envelope detection technique using the Communication Trainer Kit.

Experiment No.9

NOISE GENERATION USING PN SEQUENCE

Aim: To generate Band limited noise using PN Sequence through the Communication Trainer Kit

Theory

The theoretical proposition of “white noise” is impossible in practice. To explain, an infinite number of sine waves (with or without equal power density) would require an infinite amount of power. Long PN sequences are rich in harmonics. Moreover, although the spectrums of PN sequences have lobes of changing amplitude, small portions of its spectrum are relatively flat. That being the case, it’s possible to isolate a small portion of a PN sequence’s spectrum using a filter to model band-limited White noise

Procedure

1. Locate the VCO module and turn its Gain control fully anti-clockwise.
2. Turn the VCO module’s Frequency Adjust control fully clockwise.
3. Set the VCO module’s Range control to the HI position.
4. Connect the set-up as shown in the figure1.

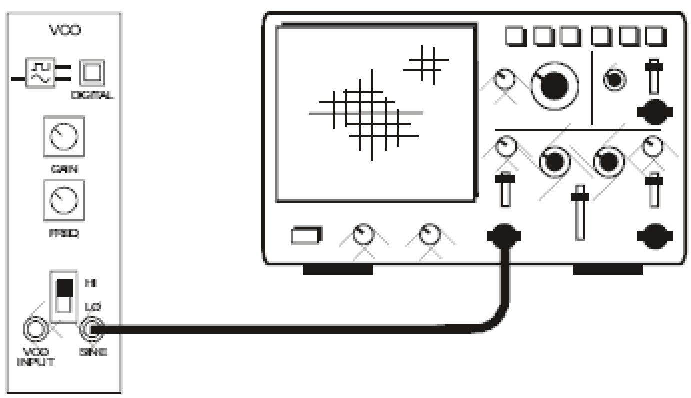


Figure 1

5. Set up the scope per the instructions in the Appendix.
   Note: Ensure that the scope’s Trigger Source control is set to the CH1 (or INT) position.
6. Adjust the scope’s Time base to view two just one cycle of the VCO module’s output.
7. Adjust the VCO module’s Frequency Adjust control to obtain a 150 kHz sine wave.
8. Locate the Tunable Low-pass Filter module and set its Gain control to about the middle of its travel.
9. Turn the Tunable Low-pass Filter module’s Cut-off Frequency Adjust control fully clockwise.
   Note: This sets the Tunable Low-pass Filter module’s cut-off frequency to 15 kHz.

10. Connect the set-up as shown in the figure 2.

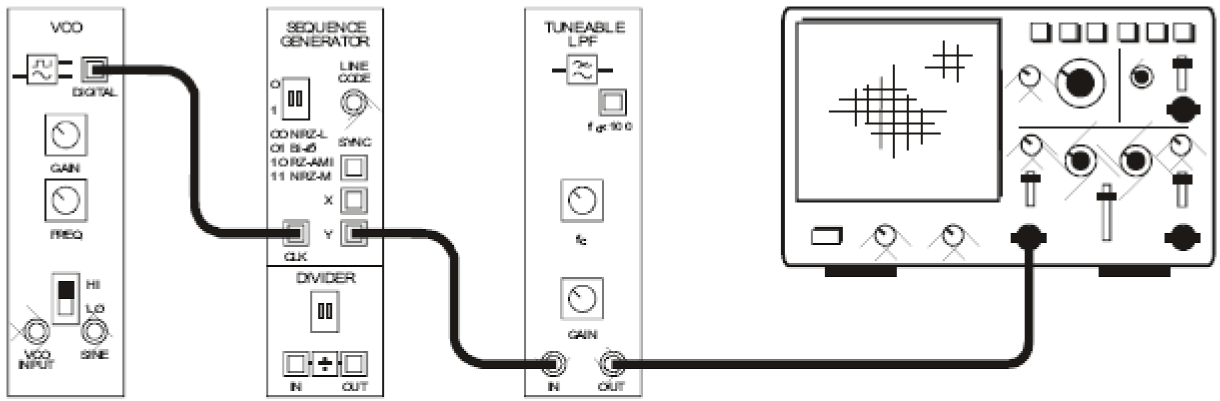


Figure 2

The above set-up can now be represented by the block diagram shown in figure 3. The spectral composition of the Sequence Generator module's Y output includes 255 sine waves per lobe. A quick calculation shows that, with a 150 kHz bit-clock, the sine waves are separated by 588Hz (150 kHz /255 = 588.2 Hz).

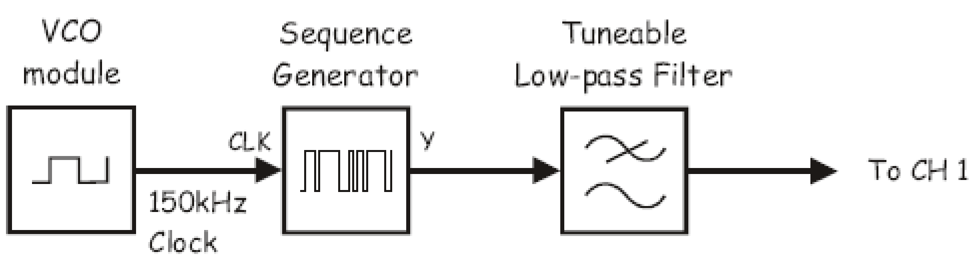


Figure 3

11. Set the scope's Time base control to the 1ms/div position.
12. Observe the signal on the Tunable Low-pass Filter module's output.
    Note: You may need to adjust the scope's Trigger Level control to obtain a stable display.

The signal on the Tunable Low-pass Filter module's output isn't "White" noise because it is bandwidth limited. Nor is the signal truly "noise". This can be demonstrated using the scope. True noise is non-repetitive. However, the signal on the Tunable Low-pass Filter modules output repeats itself every 1.7ms. [This figure is calculated using the bit-clock's period (1÷150,000 Hz) and multiplying it by the PN sequence's number of bits(255).]. The repetitive nature of the “noise” you have modeled can be observed using the scope.

13. Look closely at the signal – You should see it repeat itself about 5 times across the display.
14. Measure the “noise” signal’s period.

Result

The band limited noise was generated from the PN sequence using the Communication Trainer Kit.

Experiment No.10

TIME DIVISION MULTIPLEXING

Aim: To model a TDM system using the Communication Trainer Kit

Theory

Time division multiplexing is method of sharing the channel that is particularly suited to digital communications. TDM involves giving multiple users exclusive access to the entire channel (or to a carrier frequency if TDM is used in conjunction with FDM) Importantly , provided the duration of access is extremely short (much less than a second) and the rate of the access is fast, the users appear to have simultaneous and continuous access to the channel(or carrier).

TDM (or TDMA for time division multiple access) has been used extensively in telecommunications with PCM digital data. PCM samples analog signals converting them to proportional binary numbers. The binary numbers are then transmitted serially in frames usually containing an additional bit (or bits) for frame synchronization by the PCM decoder. The PCM encoder's clock and the frame-size determine the sample rate.

Suppose the PCM decoder only reads and decodes the contents of every alternate frame in the serial data. The effect of this is the same as halving the sample rate. So, the maximum message frequency would also be halved. The benefit of reading only every second frame however is, the unread frames are free to be filled with the PCM data for a second message having a maximum frequency equal to the first. Of course, for TDM to work with PCM signals, the PCM decoder must be designed to read the alternate frames as separate sets of data.

Equipment

- Emona Telecoms-Trainer 101 (plus power-pack)
- Dual-channel 20MHZ oscilloscope
- Two Emona Telecoms-Trainer 101 oscilloscope leads
- Assorted Emona Telecoms-Trainer 101 patch leads
- One set of headphones(stereo)

Procedure

1. Set up a single channel PCM communication System
2. Activate the PCM Encoder and Decoder Modules.
3. Transmit two signals to model a TDM system

- **Setting up the PCM encoding – decoding scheme**

    1. Locate the VCO module and turn its Gain control fully anti-clockwise.
    2. Turn the VCO module's Frequency Adjust control fully anti-clockwise.
    3. Set the VCO module's Range control to the LO position.

4. Connect the set-up shown in figure 1.

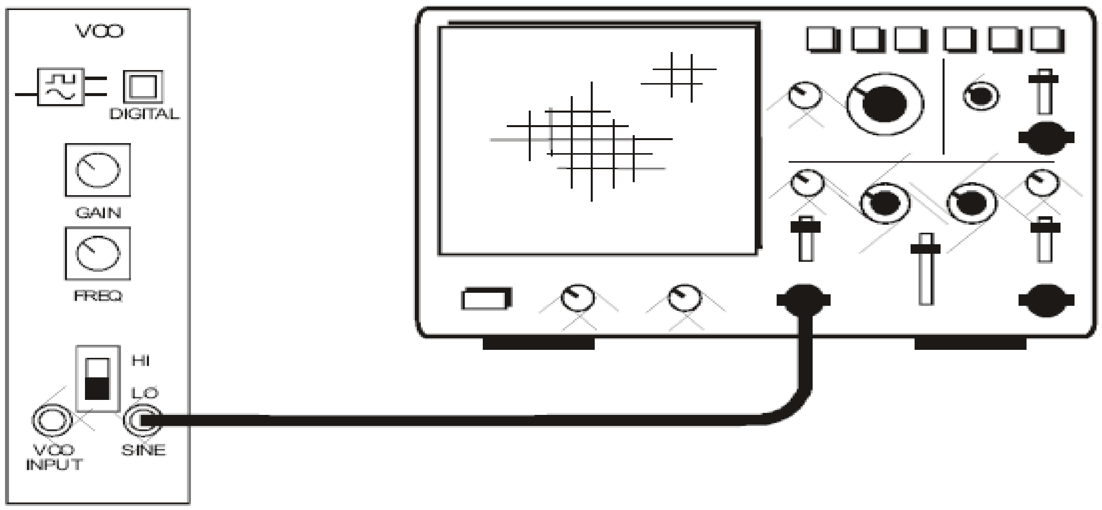


Figure 1

5. Set the scope's Time base control to the 50μs/div position.
6. Adjust the VCO module's Frequency Adjust control to obtain a 3kHz sine wave.
7. Locate the Tunable Low-pass filter module and set its Gain to about the middle of its travel.
8. Adjust the Tunable Low-pass Filter module's Cut-off Frequency control for the highest cut-off frequency.
9. Set the PCM Encoder module's Mode switch to the PCM position.
10. Connect the set-up shown in figure 2.

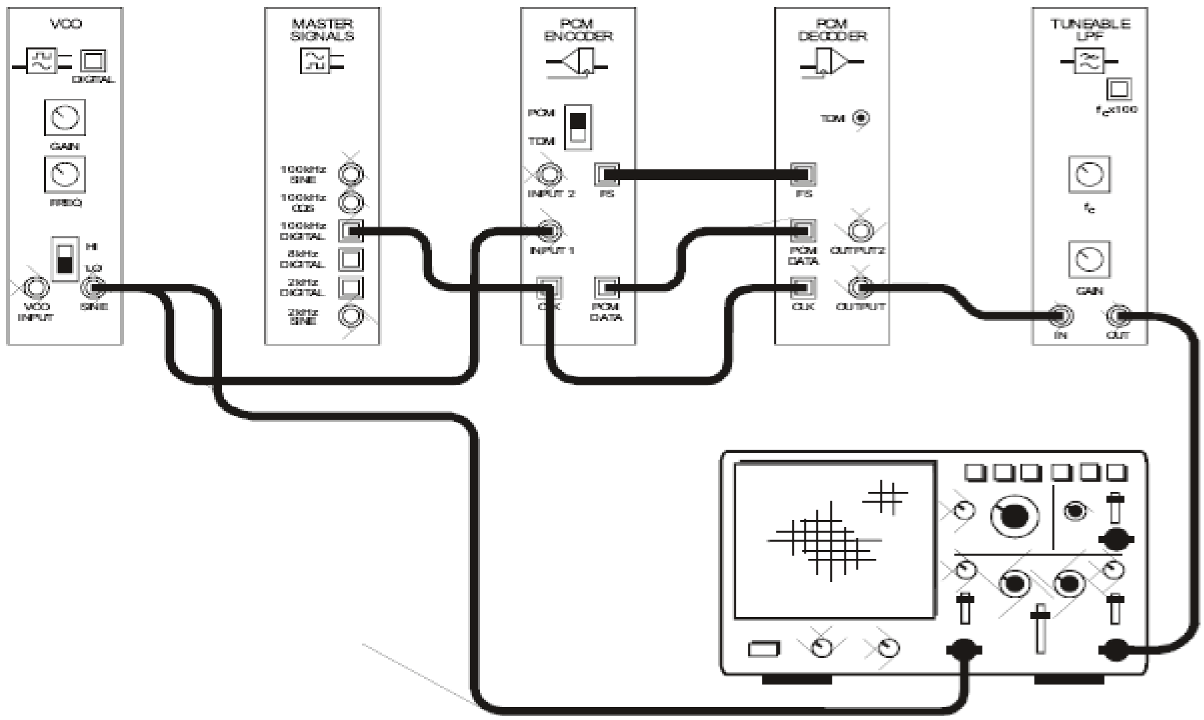


Figure 2

This set-up can be represented by the block diagram shown in Figure 3. The VCO module is used to produce a 3kHz sinewave message signal for the PCM Encoder module. The PCM Encoder module converts the message signal to a sampled version of the original signal. The tunable Low-pass Filter module is a reconstruction filter (also known as an anti-alias filter).to recover the message on the decoder's output.

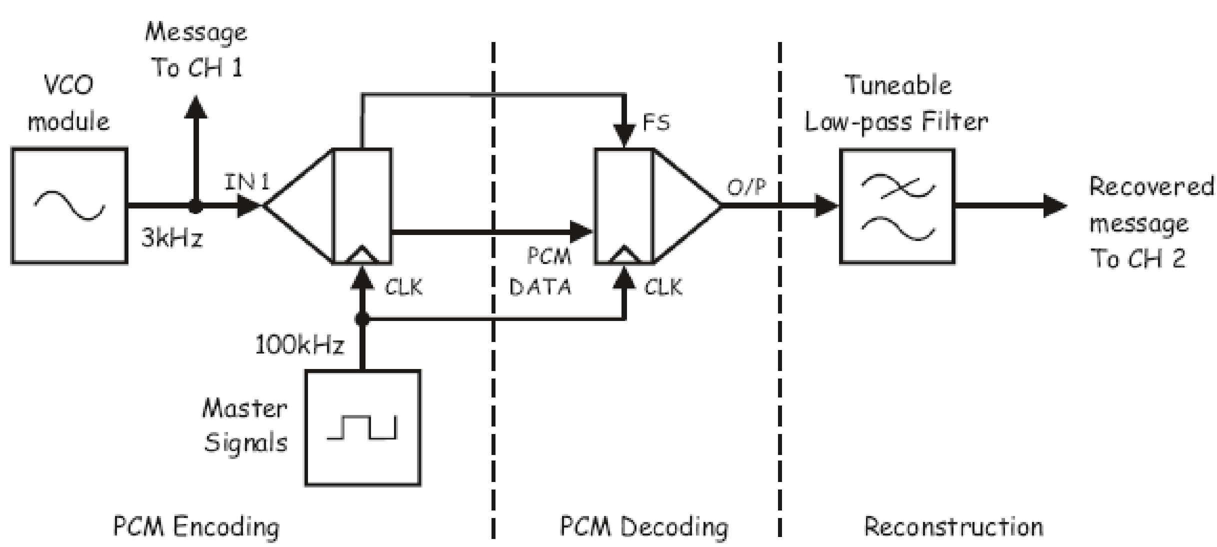


Figure 3

11. Set the scope's Mode control to the DUAL position to view the signal on the reconstruction filters output (that is, the Tunable Low-pass Filter module's output) as well as the message.

Time Division Multiplexing

12. Set the PCM Encoder module's Mode switch to the TDM position.

13. Return the reconstruction filters cut-off frequency to maximum.

14. Set the VCO modules output frequency to 2kHz.

15. Slowly reduce the reconstruction filters cut-off frequency until you obtain an undistorted copy of the message.

16. Set the VCO module's output frequency to 1kHz.

17. Modify the setup as shown in figure 4

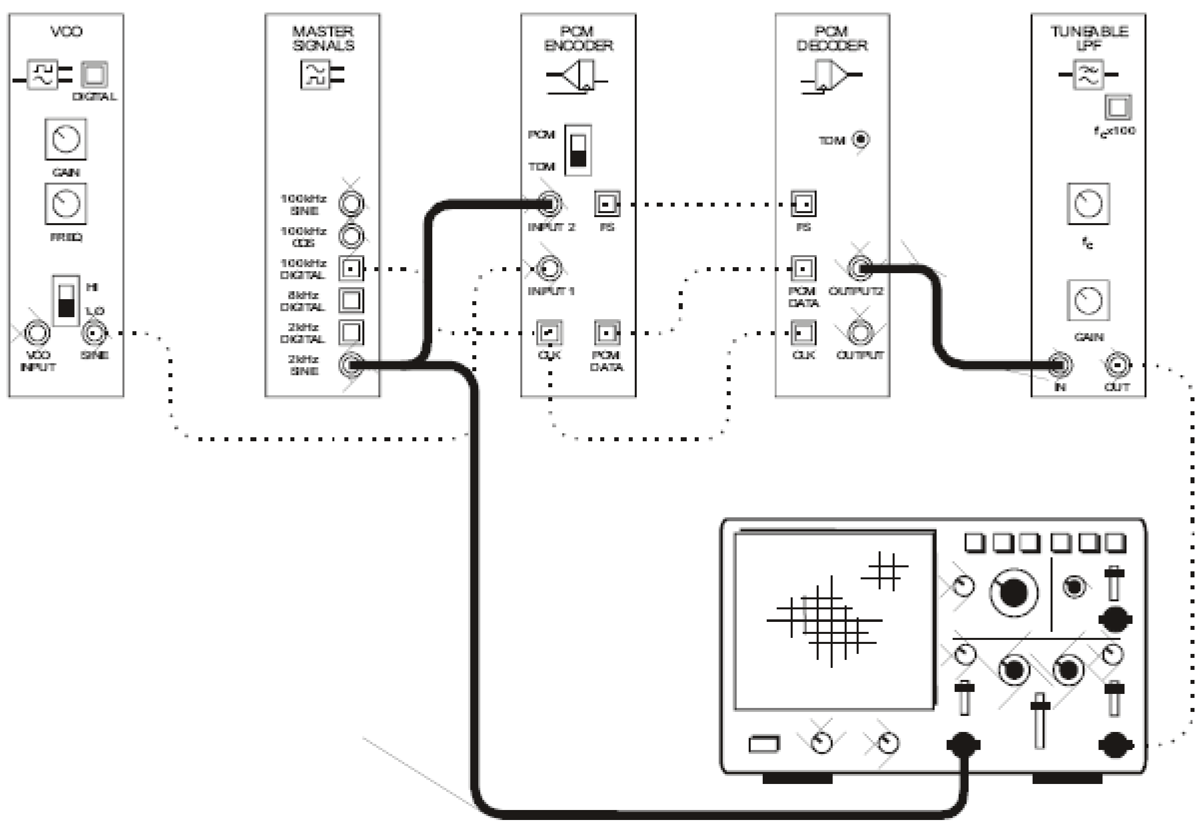


Figure 4

The above set up can be represented by the block diagram shown in Figure 5

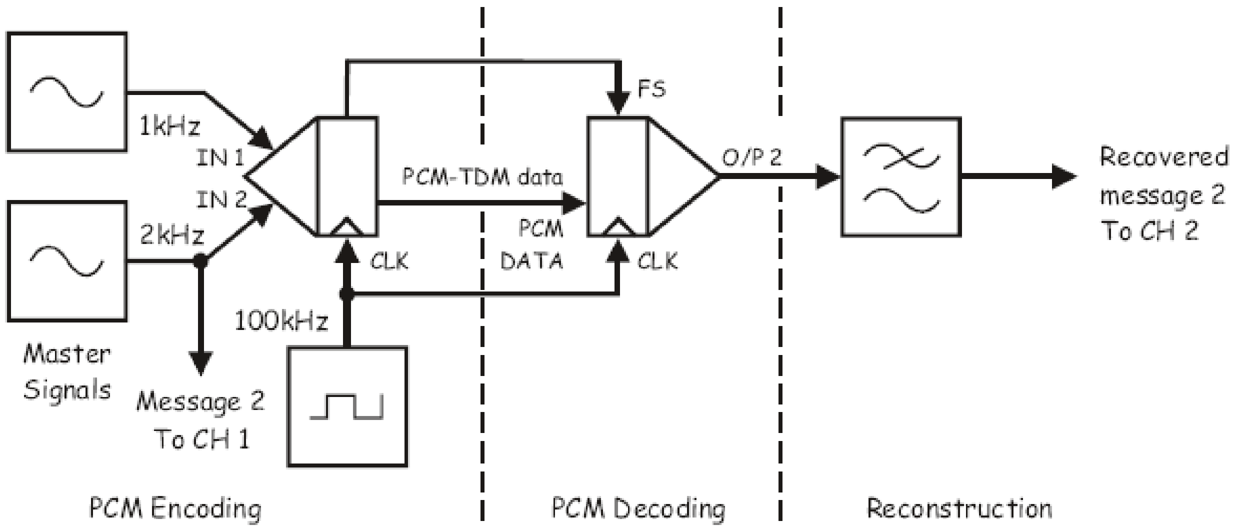


Figure 5

18. Compare the original message-2 with the reconstructed version of message-2. They should be the same.

Result

The Time Division Multiplexing System was studied from the Communication Trainer Kit