DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY KOTA

Digital Communication Lab File (ECP-303)
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Batch B1

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EXPERIMENT 06

Objective : To generate and demodulate quadrature phase shifted (QPSK) signals 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 $\pi/4$, $3\pi/4$, $5\pi/4$ and$7\pi/4$.

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

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

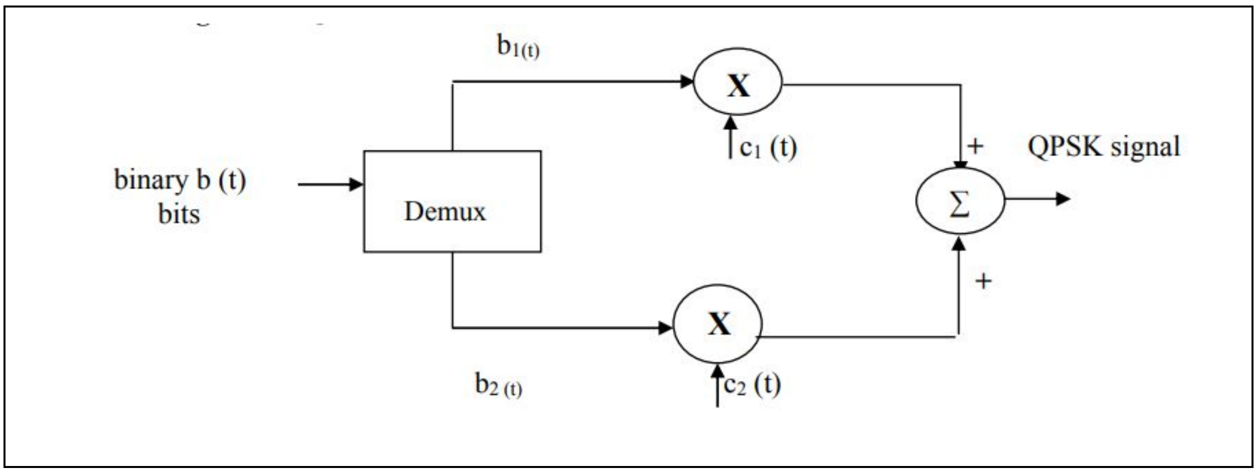
There are two orthonormal basis functions

$c_1(t) = \sqrt{2/T} \cos 2\pi f_c t$, $0 \le t \le T_b$
$c_2(t) = \sqrt{2/T} \sin 2\pi f_c t$, $0 \le t \le T_b$

There are four message points.

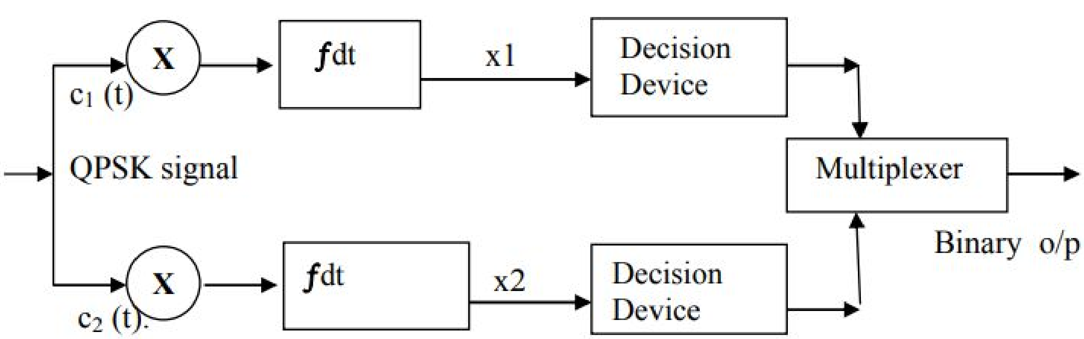
Input debits	Phase of QPSK signal	Co-ordinates of message signals	
		S1	S2
10	$\pi/4$	$\sqrt{E/2}$	$-\sqrt{E/2}$
00	$3\pi/4$	$-\sqrt{E/2}$	$-\sqrt{E/2}$
01	$5\pi/4$	$-\sqrt{E/2}$	$+\sqrt{E/2}$
11	$7\pi/4$	$+\sqrt{E/2}$	$+\sqrt{E/2}$

Block diagram of QPSK Transmitter



The I/p binary sequence b(t) is represented in polar form with symbols 1 & 0 represented as $+\sqrt{E/2}$ and $-\sqrt{E/2}$. This binary wave is demultiplexed into two separate binary waves consisting of odd & even numbered I/P bits denoted by b1 (t) & b2 (t). b1 (t) & b2(t) are used to modulate a pair of quadrature carriers. The result is two PSK waves .These two binary PSK waves are added to produce the desired QPSK signal.

QPSK Receiver :



QPSK receiver consists of a pair of correlators with common I/P & supplied with locally generated signal c1 (t) & c2 (t). The correlator output, x1, & x2 are each compared with a threshold of zero volts.If x1 > 0, decision is made in favour of symbol '1' for upper channel and if x1 > 0, decision is made in favour of symbol 0. Parallely if x2 >0, decision is made in favour of symbol 1 for lower channel & if x2 <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 decisions 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

MATLAB CODE :

```
% 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
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 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
```
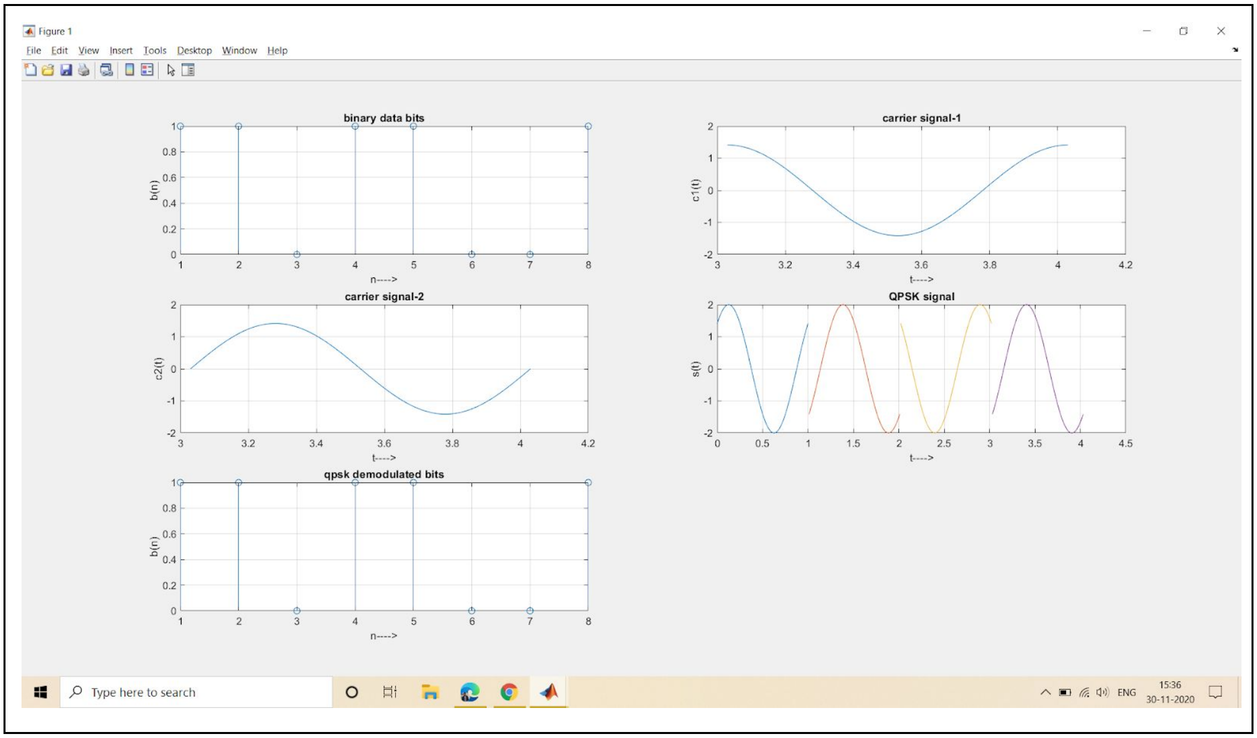

```
hold off
%Plot the binary data bits and carrier signal
subplot(3,2,1);stem(m);
title('binary data bits');xlabel('n---->');ylabel('b(n)');grid on;
subplot(3,2,2);plot(t,c1);
title('carrier signal-1');xlabel('t---->');ylabel('c1(t)');grid on;
subplot(3,2,3);plot(t,c2);
title('carrier signal-2');xlabel('t---->');ylabel('c2(t)');grid 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;
```

O/P Waveforms :



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