

Scilab Manual for
Digital Communication
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Contents

List of Scilab Solutions	3
1 Study and generate different Line Codes - 1 (Unipolar and Polar RZ and NRZ)	4
2 Study and generate different Line Codes - 2(Bipolar, Manchestre and Quaternary)	10
3 Study Carrier Modulation Techniques using BASK, BPSK and BFSK	17
4 Study and generate OQPSK waveforms	23
5 Study and generate NON OQPSK waveforms	27
6 Study and generate 8-QAM waveforms	30
7 Study and generate MSK waveforms (PSK Approach)	33
8 Study and generate MSK waveforms (FSK Approach)	36
9 To calculate all Codewords, error detection and correction capability of given LBC	40
10 To encode Cyclic code and calculate Syndrome for the given generator polynomial	45
11 To encode and decode Hamming code	51

List of Experiments

Solution 1.1	Study and generate different Line Codes 1 Unipolar NRZ	4
Solution 1.2	Study and generate different Line Codes 1 Polar NRZ	5
Solution 1.3	Study and generate different Line Codes 1 Unipolar RZ	7
Solution 1.4	Study and generate different Line Codes 1 Polar RZ	8
Solution 2.1	Study and generate different Line Codes 2 Bipolar NRZ	10
Solution 2.2	Study and generate different Line Codes 2 Bipolar RZ	12
Solution 2.3	Study and generate different Line Codes 2 Manchestre	13
Solution 2.4	Study and generate different Line Codes 2 Quaternary	15
Solution 3.1	Study Carrier Modulation Techniques using BASK	17
Solution 3.2	Study Carrier Modulation Techniques using BFSK	18
Solution 3.3	Study Carrier Modulation Techniques using BPSK	20
Solution 4.1	Study and generate offset QPSK waveforms	23
Solution 5.1	Study and generate Non offset QPSK waveforms .	27
Solution 6.1	Study and generate 8QAM waveforms	30
Solution 7.1	Study and generate MSK waveforms with PSK Approach	33
Solution 8.1	Study and generate MSK waveforms with FSK Approach	36
Solution 9.1	Linear Block Codes	40
Solution 10.1	Cyclic Codes	45
Solution 11.1	Hamming Codes	51

Experiment: 1

Study and generate different Line Codes - 1 (Unipolar and Polar RZ and NRZ)

Scilab code Solution 1.1 Study and generate different Line Codes 1 Unipolar NRZ

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate different Line
   Codes - 1(Unipolar NRZ)
5
6 clear;
7 close;
8 clc;
9 clf;
10 x=[1 0 1 0 0 1 1 0]//Data Stream
11
12 //NRZ
```

```

13 z=0; //Starting value on x axis
14 for i=1:length(x)
15
16     t=[z:1:z+1] //Set of x cordinates for current bit
           duration
17     subplot(2,1,1)
18     a=gca();
19     a.data_bounds=[0,-1.5:length(x),1.5]
20     a.grid=[1,-1]
21     title('Data')
22     plot(t,x(i)) //Plot current data bit
23
24     subplot(2,1,2)
25     a=gca();
26     a.data_bounds=[0,-1.5:length(x),1.5]
27     a.grid=[1,-1]
28     title('NRZ')
29     if(x(i)==0)
30         plot(t,0) //Plot 0 for current bit duration
31     else
32         plot(t,1) //Plot 1 for current bit duration
33     end
34
35     z=z+1 //Increament starting value on x axis by
           one bit period
36 end

```

Scilab code Solution 1.2 Study and generate different Line Codes 1 Polar NRZ

```

1 //Note: Details of scilab software version and OS
           version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
           SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and

```

```

        64 bit versions)
4 //Program Title: Study and generate different Line
  Codes – 1(Polar NRZ)
5
6 clear;
7 close;
8 clc;
9 x=[1 0 1 0 0 1 1 0]//Data Stream
10
11 //Polar NRZ
12 z=0;//Starting value on x axis
13 for i=1:length(x)
14     t=[z:1:z+1]//Set of x coordinates for current bit
        duration
15     subplot(2,1,1)
16     a=gca();
17     a.data_bounds=[0,-1.5:length(x),1.5]
18     a.grid=[1,-1]
19     title('Data')
20     plot(t,x(i))//Plot current data bit
21
22     subplot(2,1,2)
23     a=gca();
24     a.data_bounds=[0,-1.5:length(x),1.5]
25     a.grid=[1,-1]
26     title('Polar NRZ')
27     if(x(i)==0)
28         plot(t,-1)//Plot -1 for current bit
            duration
29     else
30         plot(t,1)//Plot 1 for current bit
            duration
31     end
32
33     z=z+1//Increment starting value on x axis by
        one bit period
34 end

```

Scilab code Solution 1.3 Study and generate different Line Codes 1 Unipolar RZ

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate different Line
   Codes – 1(Unipolar RZ)
5
6 clear;
7 close;
8 clc;
9 x=[1 0 1 0 0 1 1 0]//Data Stream
10
11 //RZ
12 z=0;//Starting value on x axis
13 for i=1:length(x)
14     t=[z:z+1]//Set of x coordinates for current bit
        duration
15         subplot(2,1,1)
16         a=gca();
17         a.data_bounds=[0,-1.5:length(x),1.5]
18         a.grid=[1,-1]
19         title('Data')
20         plot(t,x(i))//Plot current data bit
21
22     t=[z:0.5:z+0.5]//Set of x coordinates for first
        half bit duration
23         subplot(2,1,2)
24         a=gca();
25         a.data_bounds=[0,-1.5:length(x),1.5]
```

```

26         a.grid=[1,-1]
27         title('Polar RZ')
28         if(x(i)==0)
29             plot(t,0)//Plot 0 for first half bit
                duration
30         else
31             plot(t,1)//Plot 1 for first half bit
                duration
32         end
33         t=[z+0.5:0.5:z+1]//Set of x coordinates for
                second half bit duration
34         plot(t,0)//Plot 0 for second half bit duration
35
36         z=z+1;//Increment starting value on x axis by
                one bit period
37 end

```

Scilab code Solution 1.4 Study and generate different Line Codes 1 Polar RZ

```

1 //Note: Details of scilab software version and OS
        version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
        SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
        64 bit versions)
4 //Program Title: Study and generate different Line
        Codes – 1(Polar RZ)
5
6 clear;
7 close;
8 clc;
9 x=[1 0 1 0 0 1 1 0]//Data Stream
10
11 //Polar RZ

```

```

12 z=0; //Starting value on x axis
13 for i=1:length(x)
14     t=[z:z+1] //Set of x cordinates for current bit
        duration
15     subplot(2,1,1)
16     a=gca();
17     a.data_bounds=[0,-1.5:length(x),1.5]
18     a.grid=[1,-1]
19     title('Data')
20     plot(t,x(i)) //Plot current data bit
21
22     t=[z:0.5:z+0.5] //Set of x cordinates for first
        half bit duration
23     subplot(2,1,2)
24     a=gca();
25     a.data_bounds=[0,-1.5:length(x),1.5]
26     a.grid=[1,-1]
27     title('Polar RZ')
28     if(x(i)==0)
29         plot(t,-1) //Plot -1 for first half bit
            duration
30     else
31         plot(t,1) //Plot 1 for first half bit
            duration
32     end
33
34     t=[z+0.5:0.5:z+1] //Set of x cordinates for
        second half bit duration
35 plot(t,0) //Plot 0 for second half bit duration
36
37     z=z+1; //Increament starting value on x axis by
        one bit period
38 end

```

Experiment: 2

Study and generate different Line Codes - 2(Bipolar, Manchestre and Quaternary)

Scilab code Solution 2.1 Study and generate different Line Codes 2 Bipolar NRZ

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate different Line
   Codes – 2(Bipolar NRZ)
5
6 clear;
7 close;
8 clc;
9 x=[1 0 1 0 0 1 1 0]//Data stream
10
11 //Bipolar NRZ
12
```

```

13 z=0; //Starting point of plot on x-axis
14 ob=-1; //Initial o/p bit value
15
16 for i=1:1:length(x)
17
18     subplot(2,1,1) //Data Plot
19     a=gca();
20     a.data_bounds=[0,-1.5:length(x),1.5]
21     a.grid=[1,-1]
22     title('Data')
23
24     t=[z:1:z+1] //Plot range on x-axis (One bit
                period)
25     plot(t,x(i))
26
27     subplot(2,1,2) //Bipolar Bipolar NRZ
28     a=gca();
29     a.data_bounds=[0,-1.5:length(x),1.5]
30     a.grid=[1,-1]
31     title('Bipolar NRZ')
32
33     if(x(i)==0)
34         t=[z:1:z+1] //Plot range on x-axis (One
                bit period)
35         plot(t,0) //Plot zero
36     else
37         t=[z:1:z+1] //Plot range on x-axis (One
                bit period)
38         ob=-ob //Invert previous o/p bit value
39         plot(t,ob) // Plot o/p bit
40     end
41
42     z=z+1 //Move starting point of plot on x-axis by
                one bit period
43 end

```

Scilab code Solution 2.2 Study and generate different Line Codes 2 Bipolar RZ

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate different Line
   Codes – 2(Bipolar RZ)
5
6 clear;
7 close;
8 clc;
9 x=[1 0 1 0 0 1 1 0]//Data stream
10
11 //Bipolar RZ
12
13 z=0;//Starting point of plot on x-axis
14 ob=-1;//Initial o/p bit value
15
16 for i=1:length(x)
17
18     subplot(2,1,1)//Data Plot
19         a=gca();
20         a.data_bounds=[0,-1.5:length(x),1.5]
21         a.grid=[1,-1]
22         title('Data')
23
24         t=[z:1:z+1]//Plot range on x-axis (One bit
           period)
25         plot(t,x(i))
26
```

```

27 subplot(2,1,2)//Bipolar Bipolar RZ
28     a=gca();
29     a.data_bounds=[0,-1.5;length(x),1.5]
30     a.grid=[1,-1]
31     title('Bipolar RZ')
32
33     if(x(i)==0)
34         t=[z:1:z+1]//Plot range on x-axis (One
35             bit period)
36         plot(t,0)//Plot zero
37     else
38         t=[z:0.5:z+0.5]//Plot range on x-axis (
39             first half bit period)
40         ob=-ob//Invert previous o/p bit value
41         plot(t,ob)// Plot o/p bit
42         t=[z+0.5:0.5:z+1]//Plot range on x-axis
43             (second half bit period)
44         plot(t,0)
45     end
46
47     z=z+1//Move starting point of plot on x-axis by
48         one bit period
49 end

```

Scilab code Solution 2.3 Study and generate different Line Codes 2 Manchestre

```

1 //Note: Details of scilab software version and OS
2 //version used:
3 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
4 //SP3, 32 bit
5 //Scilab version: 5.4.1 (Tested on both 32 bit and
6 //64 bit versions)
7 //Program Title: Study and generate different Line
8 //Codes – 2(Manchestre)
9

```

```

6  clear;
7  close;
8  clc;
9  x=[1 0 1 0 0 1 1 0] //Data Stream
10
11 //Manchester
12 z=0; //Starting value on x axis
13 for i=1:length(x)
14     t=[z:1:z+1] //Plot range on x-axis (One bit
        period)
15     subplot(2,1,1)
16     a=gca();
17     a.data_bounds=[0,-1.5:length(x),1.5]
18     a.grid=[1,-1]
19     title('Data')
20     plot(t,x(i)) //Plot current data bit
21
22     t=[z:0.5:z+0.5] //Plot range on x-axis (first
        half bit period)
23     subplot(2,1,2)
24     a=gca();
25     a.data_bounds=[0,-1.5:length(x),1.5]
26     a.grid=[1,-1]
27     title('Manchester')
28     if(x(i)==0)
29         plot(t,1) //Plot 1 for first half bit
            duration
30         t=[z+0.5:0.5:z+1] //Plot range on x-axis
            (second half bit period)
31         plot(t,-1) //Plot -1 for second half bit
            duration
32     else
33         plot(t,-1) //Plot -1 for first half bit
            duration
34         t=[z+0.5:0.5:z+1] //Plot range on x-axis
            (second half bit period)
35         plot(t,1) //Plot 1 for second half bit
            duration

```

```

36         end
37         z=z+1; //Increment starting value on x axis by
           one bit period
38 end

```

Scilab code Solution 2.4 Study and generate different Line Codes 2 Quaternary

```

1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate different Line
   Codes – 2(Quaternary)
5
6 clear;
7 close;
8 clc;
9 x=[1 0 0 1 1 1 0 0] //Data Stream
10 //x=[0 0 0 1 1 0 1 1] //Data Stream
11 a=1;
12 //Polar NRZ
13 z=0; //Starting value on x axis
14 for i=1:2:length(x)
15     subplot(2,1,1)
16     g=gca();
17     g.data_bounds=[0,-1.5;length(x),1.5]
18     g.grid=[1,-1]
19     title('Data')
20     t=[z:1:z+1] //Plot range on x-axis (One bit
   period for current bit)
21     plot(t,x(i)) //Plot current bit
22     t=[z+1:1:z+2] //Plot range on x-axis (One bit

```

```

                period for next bit)
23         plot(t,x(i+1))//Plot next bit
24
25
26     subplot(2,1,2)
27     g=gca();
28     g.data_bounds=[0,-2;length(x),2]
29     g.grid=[1,-1]
30     title('2B1Q (Quaternary)')
31     t=[z:2:z+2]//Plot range on x-axis (two bit
                periods for current and next bit)
32     if((x(i)==0)&(x(i+1)==0))//Check current and
                next bit combination
33         plot(t,-3/2*a)//if 00 then plot -3/2*a
34     elseif((x(i)==0)&(x(i+1)==1))//Check current
                and next bit combination
35         plot(t,-1/2*a)//if 01 then plot -1/2*a
36     elseif((x(i)==1)&(x(i+1)==0))//Check current
                and next bit combination
37         plot(t,1/2*a)//if 10 then plot 1/2*a
38     elseif((x(i)==1)&(x(i+1)==1))//Check current
                and next bit combination
39         plot(t,3/2*a)//if 11 then plot 3/2*a
40     end
41     z=z+2//Increment starting value on x axis by
                two bits period
42 end

```

Experiment: 3

Study Carrier Modulation Techniques using BASK, BPSK and BFSK

Scilab code Solution 3.1 Study Carrier Modulation Techniques using BASK

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study Carrier Modulation Techniques
   using BASK
5
6 clear;
7 clc;
8 close;
9 t = 0:0.01:1; // One symbol period
10 f=2; // Carrier cycles per symbol period
11 I=[0,0,1,1,0,1,0,1]; //data stream
12
13 //Generation of ASK Waveform
```

```

14
15 z=0;
16 for n=1:length(I)
17     subplot(3,1,1) //Carrier Plot
18         a=gca();
19         a.data_bounds=[0,-1.5:length(I),1.5]; //set
           the boundary values for the x-y
           coordinates.
20         a.x_location="bottom";
21         a.grid=[1,-1];
22         title('Carrier')
23         plot((t+z),sin(2*%pi*f*t));
24
25     subplot(3,1,2) //Data Plot
26         a=gca();
27         a.data_bounds=[0,-1.5:length(I),1.5]; //set
           the boundary values for the x-y
           coordinates.
28         a.x_location="bottom";
29         a.grid=[1,-1];
30         title('Data')
31         plot((t+z),I(n));
32
33     subplot(3,1,3) //ASK Waveform Plot
34         a=gca();
35         a.data_bounds=[0,-1.5:length(I),1.5]; //set
           the boundary values for the x-y
           coordinates.
36         a.x_location="bottom";
37         a.grid=[1,-1];
38         title('ASK Waveform')
39         plot((t+z),(sin(2*%pi*f*t))*(I(n)));
40     z=z+1;
41 end

```

Scilab code Solution 3.2 Study Carrier Modulation Techniques using BFSK

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study Carrier Modulation Techniques
   using BFSK
5
6 clear;
7 clc;
8 close;
9 t = 0:0.01:1; // One symbol period
10 f1=2; // Carrier cycles per symbol period
11 f2=4; // Carrier cycles per symbol period
12 I=[0,0,1,1,0,1,0,1]; //data stream
13
14 //Generation of FSK Waveform
15
16 z=0;
17 for n=1:length(I)
18     subplot(4,1,1) //Carrier 1 Plot
19         a=gca();
20         a.data_bounds=[0,-1.5:length(I),1.5]; //set
           the boundary values for the x-y
           coordinates.
21         a.x_location="bottom";
22         a.grid=[1,-1];
23         title('Carrier 1')
24         plot((t+z),sin(2*%pi*f1*t));
25
26     subplot(4,1,2) //Carrier 2 Plot
27         a=gca();
28         a.data_bounds=[0,-1.5:length(I),1.5]; //set
           the boundary values for the x-y
           coordinates.
```

```

29         a.x_location="bottom";
30         a.grid=[1,-1];
31         title('Carrier 2')
32             plot((t+z),sin(2*pi*f2*t));
33
34 subplot(4,1,3) //Data Plot
35     a=gca();
36     a.data_bounds=[0,-1.5,length(I),1.5]; //set
        the boundary values for the x-y
        coordinates.
37     a.x_location="bottom";
38     a.grid=[1,-1];
39     title('Data')
40         plot((t+z),I(n));
41
42 subplot(4,1,4) //FSK Waveform Plot
43     a=gca();
44     a.data_bounds=[0,-1.5,length(I),1.5]; //set
        the boundary values for the x-y
        coordinates.
45     a.x_location="bottom";
46     a.grid=[1,-1];
47     title('FSK Waveform')
48         if (I(n)==0)
49             plot((t+z),sin(2*pi*f1*t));
50         elseif (I(n)==1)
51             plot((t+z),sin(2*pi*f2*t));
52         end
53     z=z+1;
54 end

```

Scilab code Solution 3.3 Study Carrier Modulation Techniques using BPSK

```

1 //Note: Details of scilab software version and OS
    version used:

```

```

2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study Carrier Modulation Techniques
   using BPSK
5
6 clear;
7 clc;
8 close;
9 t = 0:0.01:1; // One symbol period
10 f=2; // Carrier cycles per symbol period
11 I=[0,0,1,1,0,1,0,1]; //data stream
12
13 //Generation of PSK Waveform
14
15 z=0;
16 for n=1:length(I)
17     subplot(3,1,1) //Carrier Plot
18         a=gca();
19         a.data_bounds=[0,-1.5:length(I),1.5]; //set
           the boundary values for the x-y
           coordinates.
20         a.x_location="bottom";
21         a.grid=[1,-1];
22         title('Carrier')
23         plot((t+z),sin(2*%pi*f*t));
24
25     subplot(3,1,2) //Data Plot
26         a=gca();
27         a.data_bounds=[0,-1.5:length(I),1.5]; //set
           the boundary values for the x-y
           coordinates.
28         a.x_location="bottom";
29         a.grid=[1,-1];
30         title('Data')
31         plot((t+z),I(n));
32

```

```
33     subplot(3,1,3) //PSK Waveform Plot
34         a=gca();
35         a.data_bounds=[0,-1.5;length(I),1.5]; //set
           the boundary values for the x-y
           coordinates.
36         a.x_location="bottom";
37         a.grid=[1,-1];
38         title('PSK Waveform ')
39             if (I(n)==1)
40                 plot((t+z),sin(2*%pi*f*t));
41             elseif (I(n)==0)
42                 plot((t+z),sin((2*%pi*f*t)+%pi));
43             end
44         z=z+1;
45 end
```

Experiment: 4

Study and generate OQPSK waveforms

Scilab code Solution 4.1 Study and generate offset QPSK waveforms

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate Offset QPSK (
   OQPSK) waveforms
5
6 clear;
7 clc;
8 close;
9 T=2; // One symbol period
10 t = 0:0.01:T/2; //Sampling Matrix for half symbol
   period
11 f=1; // Carrier frequency (cycles per bit period)
12 //I=[0 0 1 1 0 0 1 1]; //data stream
13 I=[0 0 0 1 1 0 1 1]; //data stream giving dibit
   equivalent to 0,1,2,3
```

```

14 //I=[1 1 0 0 0 1 1 1]; //data stream
15
16 //Polar NRZ Converter
17 I_PNRZ = [] //empty matrix for Polar NRZ data
18     for n = 1:length(I)
19         if I(n)== 0 then
20             I_PNRZ = [I_PNRZ , -1]
21         else
22             I_PNRZ = [I_PNRZ , 1]
23         end
24     end
25
26 I_Carrier = sqrt(2/T)*cos(2*%pi*f*t); //In phase
    carrier
27 Q_Carrier = sqrt(2/T)*sin(2*%pi*f*t); //Quadrature
    phase carrier
28
29 //Generation of OQPSK Waveform
30 z=0;//Starting point of plot on x-axis
31     subplot(3,1,1) //I-PSK Plot
32         a=gca();
33         a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
34         a.x_location="origin";
35         a.grid=[1,1];
36         title('I-Data and I-PSK')
37         plot((t+z),I_Carrier*I_PNRZ(1));//
            I_Carrier * First bit (I Balance
            Modulator)
38         plot((t+z),I_PNRZ(1),'r');//First bit
            Data for reference
39 //xpause(2000000);//Delay for observation
40 z=z+1;//Move starting point of plot on x-axis by 1
    bit (half symbol) period
41 for n=2:1:length(I_PNRZ)
42     if modulo(n,2)==0 then//Check for odd-even bit
43         I_Bit=I_PNRZ(n-1)//set I bit as previous bit
44         Q_Bit=I_PNRZ(n)//set Q bit as current bit
45     else

```

```

46         I_Bit=I_PNRZ(n)//set I bit as current bit
47         Q_Bit=I_PNRZ(n-1)//set Q bit as previous bit
48     end
49
50     subplot(3,1,1) //I-PSK Plot
51         a=gca();
52         a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
53         a.x_location="origin";
54         a.grid=[1,1];
55         title('I-Data and I-PSK')
56         plot((t+z),I_Carrier*I_Bit);//I-Carrier
57         * Even bit (I Balance Modulator)
58         plot((t+z),I_Bit,'r');//I Data for
59         reference
60
61     subplot(3,1,2) //Q-PSK Plot
62         a=gca();
63         a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
64         a.x_location="origin";
65         a.grid=[1,1];
66         title('Q-Data and Q-PSK')
67         plot((t+z),Q_Carrier*Q_Bit);//Q-Carrier
68         * Odd bit (Q Balance Modulator)
69         plot((t+z),Q_Bit,'r');//Q Data for
70         reference
71
72     subplot(3,1,3) //QPSK Plot
73         a=gca();
74         a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
75         a.x_location="Origin";
76         a.grid=[1,1];
77         title('OQPSK and I-Carrier')
78         plot((t+z),(I_Carrier*I_Bit)+(Q_Carrier*
79         Q_Bit));//I-PSK + Q-PSK (Adder)
80         plot((t+z),I_Carrier,'r');//I Carrier
81         for reference
82
83     z=z+1;//Move starting point of plot on x-axis by 1
84     bit (half symbol) period

```

```
77 //xpause(2000000);//Delay for observation
78 end
```

Experiment: 5

Study and generate NON OQPSK waveforms

Scilab code Solution 5.1 Study and generate Non offset QPSK waveforms

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate Non-Offset QPSK
   waveforms
5
6 clear;
7 clc;
8 close;
9 T=2; //One Symbol period
10 t = 0:0.01:T; // Sampling Matrix for one symbol
   period
11 f=1; // Carrier frequency (cycles per bit period)
12 I=[0 0 0 1 1 0 1 1]; //data stream giving dibit
   equivalent to 0,1,2,3
13 //I=[0 1 1 0 1 0 0 0]; //data stream Simon Hykin Ex
```

6.1

```
14
15 //Polar NRZ Converter
16 I_PNRZ = [] //empty matrix for Polar NRZ data
17     for n = 1:length(I)
18         if I(n)== 0 then
19             I_PNRZ = [I_PNRZ , -1]
20         else
21             I_PNRZ = [I_PNRZ , 1]
22         end
23     end
24
25 I_Carrier = sqrt(2/T)*cos(2*%pi*f*t); // In phase
    carrier
26 Q_Carrier = sqrt(2/T)*sin(2*%pi*f*t); // Quadrature
    phase carrier
27
28 //Generation of QPSK Waveform
29
30 z=0;//Starting point of plot on x-axis
31 for n=1:2:length(I_PNRZ)
32     I_Bit=I_PNRZ(n)
33     Q_Bit=I_PNRZ(n+1)
34     subplot(3,1,1) //I-PSK Plot
35         a=gca();
36         a.data_bounds=[0,-1.5:length(I_PNRZ),1.5];
37         a.x_location="origin";
38         a.grid=[1,1];
39         title('I-Data and I-PSK')
40         plot((t+z),I_Carrier*I_Bit);//I_Carrier
            * Even bit (I Balance Modulator)
41         plot((t+z),I_Bit,'r');//I Data for
            reference
42
43     subplot(3,1,2) //Q-PSK Plot
44         a=gca();
45         a.data_bounds=[0,-1.5:length(I_PNRZ),1.5];
46         a.x_location="origin";
```

```

47     a.grid=[1,1];
48     title('Q-Data and Q-PSK')
49     plot((t+z),Q_Carrier*Q_Bit); // Q-Carrier
        * Odd bit (Q Balance Modulator)
50     plot((t+z),Q_Bit,'r'); //Q Data for
        reference
51
52     subplot(3,1,3) //QPSK Plot
53     a=gca();
54     a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
55     a.x_location="origin";
56     a.grid=[1,1];
57     title('QPSK and I-Carrier')
58     plot((t+z),(I_Carrier*I_Bit)+(Q_Carrier*
        Q_Bit)); //I-PSK + Q-PSK (Adder)
59     plot((t+z),I_Carrier,'r'); //I Carrier
        for reference
60 z=z+2; //Move starting point of plot on x-axis by 2
        bits (1 symbol) period
61 end

```

Experiment: 6

Study and generate 8-QAM waveforms

Scilab code Solution 6.1 Study and generate 8QAM waveforms

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate 8-QAM waveforms
5
6 clear;
7 clc;
8 close;
9 T=3; //One Symbol period
10 t = 0:0.01:T; // Sampling Matrix for one symbol
   period
11 f=1/T; // Carrier frequency (cycles per bit period)
12 I=[0 0 0 0 0 1 0 1 0 0 1 1 1 0 0 1 0 1 1 1 0 1 1 1];
   //data stream giving tribits equivalent to
   0,1,2,3,4,5,6,7
13
```

```

14 //Polar NRZ Converter
15 I_PNRZ = [] //empty matrix for Polar NRZ data
16     for n = 1:length(I)
17         if I(n)== 0 then
18             I_PNRZ = [I_PNRZ , -1]
19         else
20             I_PNRZ = [I_PNRZ , 1]
21         end
22     end
23
24 I_Carrier = sqrt(2/T)*cos(2*%pi*f*t); // In phase
    carrier
25 Q_Carrier = sqrt(2/T)*sin(2*%pi*f*t); // Quadrature
    phase carrier
26
27 //Generation of 8-QAM Waveform
28
29 z=0; //Starting point of plot on x-axis
30 for n=1:3:length(I_PNRZ)
31     Q_Bit=I_PNRZ(n) //Set Q Bit Value
32     I_Bit=I_PNRZ(n+1) //Set I Bit Value
33     C_Bit=I_PNRZ(n+2) //Set C Bit Value
34     if C_Bit==-1 then //Set PAM, Product of C
        with I or Q
35         QC=0.5*Q_Bit //Set half amplitude
36         IC=0.5*I_Bit //Set half amplitude
37     else
38         QC=Q_Bit //Set full amplitude
39         IC=I_Bit //Set full amplitude
40     end
41
42     subplot(3,1,1) //QC Plot
43     a=gca();
44     a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
45     a.x_location="origin";
46     a.grid=[1,1];
47     title('Q-PAM')
48     plot((t+z),Q_Carrier*QC); //Q_Carrier * Q

```

```

49         -PAM (Q Balance Modulator)
50         plot((t+z),QC,'r'); //Q-PAM Output
51 subplot(3,1,2) //IC Plot
52     a=gca();
53     a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
54     a.x_location="origin";
55     a.grid=[1,1];
56     title('I-PAM')
57     plot((t+z),I_Carrier*IC); //I_Carrier * I
58         -PAM (I Balance Modulator)
59     plot((t+z),IC,'r'); //I-PAM Output
60 subplot(3,1,3) //8-QAM Plot
61     a=gca();
62     a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
63     a.x_location="origin";
64     a.grid=[1,1];
65     title('8-QAM')
66     plot((t+z),(I_Carrier*IC)+(Q_Carrier*QC)
67         ); //I-PAM + Q-PAM (Adder)
68     plot((t+z),I_Carrier,'r'); //I Carrier
69         for reference
70     plot(((t/3)+z),Q_Bit,'c'); //Q Bit for
71         reference
72     plot(((t/3)+1+z),I_Bit,'b'); //I Bit for
73         reference
74     plot(((t/3)+2+z),C_Bit,'m'); //C Bit for
75         reference
76
77 z=z+3; //Move starting point of plot on x-axis by 3
78     bits (1 symbol) period
79 end

```

Experiment: 7

Study and generate MSK waveforms (PSK Approach)

Scilab code Solution 7.1 Study and generate MSK waveforms with PSK Approach

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate MSK waveforms (
   PSK Approach)
5
6 clear;
7 clc;
8 close;
9 h=1/2;
10 T=1; // One symbol period
11 t = 0:0.01:T; // One symbol period vector
12 f=1; // Carrier cycles per symbol period "t"
13 //I=[0 1 0 1 0 1 0 1]; //data stream in binary to
   test worst case
```

```

14 I=[0 0 0 1 1 0 1 1]; //data stream giving dibits
    equivalent to 0,1,2,3
15
16 //PNRZ Converter , converts data to PNRZ (Bi-Polar
    Signal)
17     I_PNRZ = [] //empty matrix for PNRZ data
18     for n = 1:length(I)
19         if I(n)== 0 then
20             I_PNRZ = [I_PNRZ , -1]
21         else
22             I_PNRZ = [I_PNRZ , 1]
23         end
24     end
25
26 //Generation of MSK Waveform using PSK approach
27
28 theta=0; //Initial phase in radians
29
30 z=0; //Starting point of plot on x-axis
31
32 for n=1:1:length(I_PNRZ)
33     subplot(3,1,1) //Data Plot
34     a=gca();
35     a.data_bounds=[0,-1.5:length(I_PNRZ),1.5];
        //set the boundary values for the x-y
        coordinates.
36     a.x_location="origin";
37     a.grid=[1,-1];
38     title('Data')
39     plot((t+z), I_PNRZ(n));
40
41     subplot(3,1,2) //MSK Plot
42     a=gca();
43     a.data_bounds=[0,-1.5:length(I_PNRZ),1.5];
        //set the boundary values for the x-y
        coordinates.
44     a.x_location="origin";
45     a.grid=[1,-1];

```

```

46     title('MSK')
47     theta_change = theta + ((I_PNRZ(n))*((
        %pi*h*t)/T)); //Phase variation over a
        bit period
48     plot((t+z),sqrt(2/T)*cos(2*%pi*f*t +
        theta_change)); // MSK Plot
49     plot((t+z),sqrt(2/T)*cos(2*%pi*f*t), 'r')
        ; // Carrier for reference
50
51     subplot(3,1,3) // Plot for MSK Phase variation
        wrt Carrier
52     a=gca();
53     a.x_location="bottom";
54     a.grid=[1,1];
55     title('MSK Phase variation wrt Carrier')
56     theta_degrees = theta_change*(180/%pi); //
        converts radians to degrees
57     plot((t+z),theta_degrees); // plote phase
        variation for a bit period
58
59     theta=theta_change(length(theta_change)); //Stores
        last value of phase to theta
60     z=z+1; //Move starting point of plot on x-axis by 1
        bit period
61     //xpause(2000000); //Delay for observation
62     end

```

Experiment: 8

Study and generate MSK waveforms (FSK Approach)

Scilab code Solution 8.1 Study and generate MSK waveforms with FSK Approach

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Study and generate MSK waveforms (
   FSK Approach)
5
6 clear;
7 clc;
8 close;
9 h=1/2;
10 T=1; // One symbol period
11 t = 0:0.01:T; // One symbol period vector
12 f=1; // Carrier cycles per symbol period "t"
13 //I=[0 1 0 1 0 1 0 1]; //data stream in binary to
   test worst case
```

```

14 I=[0 0 0 1 1 0 1 1]; //data stream giving dibits
    equivalent to 0,1,2,3
15
16 //PNRZ Converter , converts data to PNRZ (Bi-Polar
    Signal)
17     I_PNRZ = [] //empty matrix for PNRZ data
18         for n = 1:length(I)
19             if I(n)== 0 then
20                 I_PNRZ = [I_PNRZ , -1]
21             else
22                 I_PNRZ = [I_PNRZ , 1]
23             end
24         end
25
26 //Generation of MSK Waveform using FSK approach
27
28 bitchange=0;//Initial bit state (before first bit of
    sequence)
29 theta=0;//Initial phase state in radians (before
    first bit of sequence)
30 theta_degrees=[0,0];//Initial phase state in degrees
    (first element = start value , second element =
    last value)
31
32 z=0;//Starting point of plot on x-axis
33 for n=1:1:length(I_PNRZ)
34     subplot(3,1,1) //Data Plot
35         a=gca();
36         a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
            //set the boundary values for the x-y
            coordinates.
37         a.x_location="origin";
38         a.grid=[1,-1];
39         title('Data')
40         plot((t+z),I_PNRZ(n));
41
42     subplot(3,1,2) //MSK Plot
43         a=gca();

```

```

44     a.data_bounds=[0,-1.5;length(I_PNRZ),1.5];
        //set the boundary values for the x-y
        coordinates.
45     a.x_location="origin";
46     a.grid=[1,-1];
47     title('MSK')
48     fm = f + (I_PNRZ(n)*(h/(2*T))); //Generating
        two frequencies corresponding to
49                                     //binary 0 (-1
                                        in PNRZ)and
                                        binary 1 (1
                                        in PNRZ)
50                                     //(0 → fc - h
                                        /2T)
51                                     //(1 → fc + h
                                        /2T)
52     plot((t+z),sqrt(2/T)*cos(2*%pi*fm*t +
        theta)); // MSK Plot
53     plot((t+z),sqrt(2/T)*cos(2*%pi*f*t),'r')
        ; // Carrier for reference
54
55 subplot(3,1,3) // Plot for MSK Phase variation
    wrt Carrier
56     a=gca();
57     a.x_location="bottom";
58     a.grid=[1,1];
59     title('MSK Phase variation wrt Carrier')
60     bitchange=bitchange+I_PNRZ(n); //Bit State
        value (cumulative)
61     theta = bitchange*(%pi*h)/T; //Phase state
        at the end of bit period, in radians
62     theta_degrees(2)=theta*180/%pi; //Phase state
        at the end of bit period, in degrees
63     plot([z n],theta_degrees); // plote phase
        variation for a bit period
64
65 theta_degrees(1)=theta_degrees(2); //Copy end phase
    value to start phase value for next cycle

```

```
66 z=z+1; //Move starting point of plot on x-axis by 1
    bit period
67 //xpause(2000000); //Delay for observation
68 end
```

Experiment: 9

To calculate all Codewords,
error detection and correction
capability of given LBC

Scilab code Solution 9.1 Linear Block Codes

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Linear Block Codes (7,4)
5
6 clc;
7 clear;
8
9 k = 4; //Information message length
10 n = 7; //Coded word length
11
12 P = [1 1 0;0 1 1 ;1 1 1;1 0 1]//Parity Matrix
13 disp(P, 'Parity Matrix P')
14
```

```

15 G = [P eye(k,k)]//Generator Matrix to create code
    word in P1P2P3D1D2D3D4 format
16 disp(G, 'Generator Matrix G')
17
18 H=[eye(n-k,n-k);P]'//Parity Check Matrix
19 disp(H, 'Parity Check Matrix H')
20
21 //All_M = All 16 possibilities for Information
    Message Matrix
22 All_M = [0 0 0 0;0 0 0 1;0 0 1 0;0 0 1 1;
23 0 1 0 0;0 1 0 1;0 1 1 0;0 1 1 1;
24 1 0 0 0;1 0 0 1;1 0 1 0;1 0 1 1;
25 1 1 0 0;1 1 0 1;1 1 1 0;1 1 1 1]
26
27 //Calculate all 16 posible codewords
28 CodedMat=All_M*G;
29 CodedMat = modulo(CodedMat,2);//Convert generated
    code into binary
30 disp(CodedMat, 'Codewords Matrix')
31
32 //Calculate Hamming Distances
33 HamDist=sum(CodedMat, 'c')//Sum over the rows of
    CodedMat(column of values)
34 disp(HamDist, 'Hamming Distances');
35
36 //Find Minimum non-zero Hamming Distance
37 [row,col]=find(HamDist==0);//find elements that are
    zero
38 HamDist(row,:)=[];//Remove all rows that are zero (
    replace by null)
39 MinHamDist=min(HamDist)//Find Minimum non-zero
    Hamming Distance
40 disp(MinHamDist, 'Minimum Non-Zero Hamming Distance')
41
42 //Calculate Error Detection Capability
43 ErrDetCap=MinHamDist-1;
44 disp(ErrDetCap, 'Error Detection Capability');
45

```

```

46 //Calculate Error Correction Capability
47 ErrCorCap=(MinHamDist-1)/2;
48 disp(ErrCorCap,'Error Correction Capability');
49
50 //Generate random message
51 RandMessage=modulo(round(16*rand()),16)+1//Get
    random number between 1 to 16
52
53 M=All_M(RandMessage,:)//Select a random row from
    Message Matrix All_M as Information Message
54 disp(M,'Information Message M')
55
56 C = CodedMat(RandMessage,:)//Select a random row
    from Coded Matrix CodedMat as Coded Message
57 disp(C,'Coded Message C')
58
59 //Transmit random message
60 R=C//Create recieved code word
61
62 //Generate error at random bit position
63
64 ErrPos=modulo(round(8*rand()),8)//Get random number
    between 0 to 7
65
66 if ErrPos==0 then
67     //Do nothing, as '0' means no error
68 else
69     if R(ErrPos)==0 then
70         R(ErrPos)=1//Invert bit at Erroneous Bit
            Position
71     else
72         R(ErrPos)=0//Invert bit at Erroneous Bit
            Position
73     end
74 end
75
76 disp(R,'Recieved Code word R')
77

```

```

78 //Error Correction
79
80 S=R*H' //Find Syndrome Matrix
81 S = modulo(S,2); //Convert Syndrome Matrix into
    binary
82 disp(S, 'Syndrome Matrix R*H(transpose)')
83
84 if S==[0 0 0] then //[0 0 0] indicates no error
85     disp(R, 'Recieved Code without error')
86     disp(R(4:7), 'Recieved Information Message') //
        Extract and display Message from code word
87 else
88     //Find erroneous bit position
89     //Here we find colomn within H matrix with
        pattern simmlar to Syndrome Matrix
90     //The position number of that colomn is
        equivalent to erroneous bit position
91
92     ErrPos=1 //Initiallize erroneous bit position
93     d=[H(:,ErrPos)]' //Transpose of first coloumn of
        H matrix
94
        //(Transpose is used to convert
        colomn to row as syndrome is
        in row format)
95
96     while ((d(1)<>S(1))|(d(2)<>S(2))|(d(3)<>S(3)
97         )) do //Check element wise inequality
            for any element (OR condition)
98             ErrPos=ErrPos+1 //Increament erroneous
                bit position (Point to next colomn)
99             d=[H(:,ErrPos)]' //Transpose of next
                coloumn of H matrix
100
101         end
102
103         disp(ErrPos, 'Erroneous Bit Position')
104
105     //Error correction
106     if R(ErrPos)==0 then

```

```
105         R(ErrPos)=1//Invert bit at Erroneous
           Bit Position
106         disp(R,'Recieved Code with error
           corrected')
107         disp(R(4:7),'Recieved Information
           Message')//Extract and display
           Message from code word
108     else
109         R(ErrPos)=0//Invert bit at Erroneous Bit
           Position
110         disp(R,'Recieved Code with error
           corrected')
111         disp(R(4:7),'Recieved Information
           Message')//Extract and display
           Message from code word
112     end
113 end
```

Experiment: 10

To encode Cyclic code and calculate Syndrome for the given generator polynomial

Scilab code Solution 10.1 Cyclic Codes

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Cyclic Codes (7,4)
5
6 clc;
7 clear;
8 k = 4; //Information Message Length
9 n = 7; //Codeword Length
10
11 //Generator Polynomial
12 x=poly(0, 'x');
13 GenPoly=1+x+x^3;
14 disp(GenPoly, 'The Generator Polynomial');
```

```

15
16 //Generating Random Message
17
18 //All_M = All 16 possibilities for Information
    Message Matrix
19 All_M = [0 0 0 0;0 0 0 1;0 0 1 0;0 0 1 1;
20 0 1 0 0;0 1 0 1;0 1 1 0;0 1 1 1;
21 1 0 0 0;1 0 0 1;1 0 1 0;1 0 1 1;
22 1 1 0 0;1 1 0 1;1 1 1 0;1 1 1 1]
23
24 RandMessage=modulo(round(16*rand()),16)+1//Get
    random number between 1 to 16
25
26 M=All_M(RandMessage,:)//Select a random row from
    Message Matrix All_M as Information Message
27 disp(M,'Information Message M')
28
29 //Message Polynomial
30 MesPoly=(M(1)*1) + (M(2)*(x^1)) + (M(3)*(x^2)) + (M
    (4)*(x^3));
31 disp(MesPoly,'Message Polynomial u(x)');
32
33 //Encoding


---


34
35 //Generating Codeword Polynomial
36 p=(x^(n-k))*(MesPoly);//Step 1 – multiply MesPoly by
    x^(n-k), [x^(n-k)*u(x)]
37 [RemPoly,q]=pdiv(p,GenPoly);//Step 2 – divide above
    product by GenPoly, g(x)(Polynomial Division)
38 RemPoly=modulo(RemPoly,2);//Convert Remainder
    Polynomial to binary to get parity check
    polynomial, b(x)
39 disp(RemPoly,'Remainder Polynomial b(x)');
40 CodePoly=RemPoly+(MesPoly*(x^(n-k)));//Step 3 – add
    (x^(n-k)*u(x)) and b(x) to get Codeword
    Polynomial

```

```

41 disp(CodePoly, 'Codeword Polynomial c(x)');
42
43 //Finding Coefficients of Codeword Polynomial
44 CodePolyCoeff=coeff(CodePoly);
45     //Removal of - signs from Coefficients of
         Codeword Polynomial
46     for i=1:length(CodePolyCoeff)
47         if (CodePolyCoeff(i)==-1) then
48             CodePolyCoeff(i)=1;
49         end
50     end
51 disp(CodePolyCoeff, 'Coefficients of Codeword
         Polynomial');
52
53 //Generating 7 bit Codeword from Coefficients of
         Codeword Polynomial
54 C=CodePolyCoeff;
55 if length(C)<7 then
56     C(1,7)=0; //Assigning a value outside array
         dimension will automatically
57         //pad additional zeros to resize the
         array / vector
58 end
59 disp(C, 'Generated Codeword');
60
61 //Transmission

```

```

62 R=C//Create recieved code word
63
64     //Generate error at random bit position
65     ErrPos=modulo(round(8*rand()),8) //Get random
         number between 0 to 7
66     //ErrPos=0 //for testing
67     if ErrPos==0 then
68         //Do nothing, as '0' means no error
69     else
70         if R(ErrPos)==0 then

```

```

71             R(ErrPos)=1//Invert bit at Erroneous Bit
                Position
72         else
73             R(ErrPos)=0//Invert bit at Erroneous Bit
                Position
74         end
75     end
76
77 //Reception and Decoding

```

```

78
79 disp(R, 'Recieved Code word R')
80
81 //Received Polynomial
82 RecPoly=(R(1)*1) + (R(2)*(x^1)) + (R(3)*(x^2)) + (R
    (4)*(x^3)) + (R(5)*(x^4)) + (R(6)*(x^5)) + (R(7)
    *(x^6));
83 disp(RecPoly, 'Received Polynomial u(x)');
84
85 //Syndrome Polynomial
86 [SynPoly, q]=pdiv(RecPoly, GenPoly);
87 SynPoly=modulo(SynPoly, 2)
88 disp(SynPoly, 'Syndrome Polynomial')
89
90 //Finding Coefficients of Syndrome Polynomial
91 SynPolyCoeff=coeff(SynPoly);
92     //Removal of - signs from Coefficients of
        Syndrome Polynomial
93     for i=1:length(SynPolyCoeff)
94         if (SynPolyCoeff(i)==-1) then
95             SynPolyCoeff(i)=1;
96         end
97     end
98 disp(SynPolyCoeff, 'Coefficients of Syndrome
    Polynomial');
99
100 //Generating 3 bit Syndrome from Coefficients of

```

```

Syndrome Polynomial
101 if length(SynPolyCoeff)<3 then
102     SynPolyCoeff(1,3)=0; //Assigning a value outside
        arrey dimension will automatically
103         //pad additional zeros to resize the
            arrey / vector
104 end
105 disp(SynPolyCoeff, 'Syndrome');
106
107
108
109     //Create H (Parity check matrix) as error
        lookup table
110     P = [1 1 0;0 1 1 ;1 1 1;1 0 1] //Parity
        Matrix
111     H=[eye(n-k,n-k);P]' //Parity Check Matrix
112     //disp(H, 'Parity Check Matrix H') //for
        testing
113
114 if SynPolyCoeff==[0 0 0] then //[0 0 0] indicates
        no error
115     disp(R, 'Recieved Code without error')
116     disp(R(4:7), 'Recieved Information Message') //
        Extract and display Message from code word
117 else
118     //Find erroneous bit position
119     //Here we find colomn within H matrix with
        pattern simmlar to Syndrome Matrix
120     //The position number of that colomn is
        equivalent to erroneous bit position
121
122     ErrPos=1 //Initiallize erroneous bit position
123     d=[H(:,ErrPos)]' //Transpose of first coloumn of
        H matrix
124         //(Transpose is used to convert
            colomn to row as syndrome is
            in row format)
125

```

```

126     while ((d(1)<>SynPolyCoeff(1))|(d(2)<>
        SynPolyCoeff(2))|(d(3)<>SynPolyCoeff(3)))
        do //Check element wise inequallity for
          any element (OR condition)
127         ErrPos=ErrPos+1//Increament erroneous
            bit position (Point to next colomn)
128         d=[H(:,ErrPos)]'//Transpose of next
            coloumn of H matrix
129     end
130
131     disp(ErrPos,'Erroneous Bit Position')
132
133     //Error correction
134     if R(ErrPos)==0 then
135         R(ErrPos)=1//Invert bit at Erroneous Bit
            Position
136     else
137         R(ErrPos)=0//Invert bit at Erroneous Bit
            Position
138     end
139     disp(R,'Recieved Code with error corrected')
140     disp(R(4:7),'Recieved Information Message')
        //Extract and display Message from code
        word
141 end
142 disp(M,'Information Message M that was sent...')

```

Experiment: 11

To encode and decode Hamming code

Scilab code Solution 11.1 Hamming Codes

```
1 //Note: Details of scilab software version and OS
   version used:
2 //Tested on OS: Windows 7 SP1, 64 bit and Windows XP
   SP3, 32 bit
3 //Scilab version: 5.4.1 (Tested on both 32 bit and
   64 bit versions)
4 //Program Title: Hamming Codes (7,4)
5
6 clc;
7 clear;
8
9 k = 4; //Information message matrix length
10 n = 7; //Coded word length
11
12 P = [1 1 0;0 1 1 ;1 1 1;1 0 1]//Parity Matrix
13 disp(P, 'Parity Matrix P')
14
15 G = [P eye(k,k)]//Generator Matrix to create code
   word in P1P2P3D1D2D3D4 format
```

```

16 G(:,[3 4])=G(:,[4 3])//Swap colomn 3 and 4 of G to
    create code word in P1P2D1P3D2D3D4 format
17 disp(G, 'Generator Matrix G')
18
19 H=[eye(n-k,n-k);P]'//Parity Check Matrix
20 H(:,[3 4])=H(:,[4 3])//Swap colomn 3 and 4 of H to
    satisfy GH'=0
21 disp(H, 'Parity Check Matrix H')
22
23 //disp(modulo(G*H',2),'GH')//Check if the condition
    GH'=0 satisfy (for testing)
24
25 //M = [1 1 0 1]//Information Message Matrix for
    testing
26
27 //Generate random message
28 //All_M = All 16 possibilities for Information
    Message Matrix
29 All_M = [0 0 0 0;0 0 0 1;0 0 1 0;0 0 1 1;
30 0 1 0 0;0 1 0 1;0 1 1 0;0 1 1 1;
31 1 0 0 0;1 0 0 1;1 0 1 0;1 0 1 1;
32 1 1 0 0;1 1 0 1;1 1 1 0;1 1 1 1]
33 RandMessage=modulo(round(16*rand()),16)+1//Get
    random number between 1 to 16
34 M=All_M(RandMessage,:)//Select a random row from 1
    to 16 as Information Message
35
36 disp(M, 'Information Message M')
37
38 C = M*G;//Generate code word
39 C = modulo(C,2);//Convert generated code into binary
40 disp(C, 'Code word of (7,4) Hamming code M*G')
41
42 R=C//Create recieved code word
43
44 //Generate error at random bit position
45
46 ErrPos=modulo(round(8*rand()),8)//Get random number

```

```

        between 0 to 7
47
48 if ErrPos==0 then
49     //Do nothing , as '0' means no error
50 else
51     if R(ErrPos)==0 then
52         R(ErrPos)=1//Invert bit at Erroneous Bit
                    Position
53     else
54         R(ErrPos)=0//Invert bit at Erroneous Bit
                    Position
55     end
56 end
57
58 disp(R, 'Recieved Code word R')
59
60 //Error Correction
61
62 S=R*H' //Find Syndrome Matrix
63 S = modulo(S,2); //Convert Syndrome Matrix into
        binary
64 disp(S, 'Syndrome Matrix R*H(transpose)')
65
66 if S==[0 0 0] then //[0 0 0] indicates no error
67     disp(R, 'Recieved Code without error')
68     disp([R(3) R(5:7)], 'Recieved Information Message
        ')//Extract and display Message from code
        word
69 else
70     //Find erroneous bit position
71     //Here we find colomn within H matrix with
        pattern simmlar to Syndrome Matrix
72     //The position number of that colomn is
        equivalent to erroneous bit position
73
74     ErrPos=1//Initiallize erroneous bit position
75     d=[H(:,ErrPos)]' //Transpose of first coloumn of
        H matrix

```

```

76             //(Transpose is used to convert
              column to row as syndrome is
              in row format)
77
78     while ((d(1)<>S(1))|(d(2)<>S(2))|(d(3)<>S(3)
79           )) do //Check element wise inequality
              for any element (OR condition)
80         ErrPos=ErrPos+1//Increament erroneous
              bit position (Point to next colomn)
81         d=[H(:,ErrPos)]'//Transpose of next
              coloumn of H matrix
82
83     end
84
85     disp(ErrPos,'Erroneous Bit Position')
86
87     //Error correction
88     if R(ErrPos)==0 then
89         R(ErrPos)=1//Invert bit at Erroneous
              Bit Position
90         disp(R,'Recieved Code with error
              corrected')
91         disp([R(3) R(5:7)],'Recieved
              Information Message')//Extract
              and display Message from code
              word
92     else
93         R(ErrPos)=0//Invert bit at Erroneous Bit
              Position
94         disp(R,'Recieved Code with error
              corrected')
95         disp([R(3) R(5:7)],'Recieved Information
              Message')//Extract and display
              Message from code word
96     end
97 end

```
