

Scilab Manual for
Digital Communication
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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 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     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
15         period)
16         subplot(2,1,1)
17         a=gca();
18         a.data_bounds=[0,-1.5:length(x),1.5]
19         a.grid=[1,-1]
20         title('Data')
21         plot(t,x(i)) //Plot current data bit
22     t=[z:0.5:z+0.5] //Plot range on x-axis (first
23         half bit period)
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('Manchester')
29         if(x(i)==0)
30             plot(t,1) //Plot 1 for first half bit
31                 duration
32             t=[z+0.5:0.5:z+1] //Plot range on x-axis
33                 (second half bit period)
34             plot(t,-1) //Plot -1 for second half bit
35                 duration
36         else
37             plot(t,-1) //Plot -1 for first half bit
38                 duration
39             t=[z+0.5:0.5:z+1] //Plot range on x-axis
40                 (second half bit period)
41             plot(t,1) //Plot 1 for second half bit
42                 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     z=z+3; //Move starting point of plot on x-axis by 3
77         bits (1 symbol) period
78 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 possibile 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
95     //(Transpose is used to convert
96     colomn to row as syndrome is
97     in row format)
98
99     while ((d(1)<>S(1))|(d(2)<>S(2))|(d(3)<>S(3)
100     )) do //Check element wise inequality
101     for any element (OR condition)
102     ErrPos=ErrPos+1 //Increament erroneous
103     bit position (Point to next colomn)
104     d=[H(:,ErrPos)]' //Transpose of next
      coloumn of H matrix
105
106 end
107
108 disp(ErrPos, 'Erroneous Bit Position')
109
110 //Error correction
111 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

```
