

Scilab Textbook Companion for
Digital Communication
by S. Haykin¹

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Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

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Chapter 1

Introduction

Scilab code Exa 1.2 Digital Representation of Analog signal

```
1 //clear//
2 //Caption:Digital Representation of Analog signal
3 //Figure 1.2: Analog to Digital Conversion
4 clear;
5 close;
6 clc;
7 t = -1:0.01:1;
8 x = 2*sin((%pi/2)*t);
9 dig_data = [0,1,0,0,0,0,1,0,0,0,0,0,0,0,1,1,0,1,0,1]
10 //
11 figure
12 a=gca();
13 a.x_location = "origin";
14 a.y_location = "origin";
15 a.data_bounds = [-2, -3; 2, 3]
16 plot(t,x)
17 plot2d3('gnn',0.5,sqrt(2),-9)
18 plot2d3('gnn',-0.5,-sqrt(2),-9)
19 plot2d3('gnn',1,2,-9)
20 plot2d3('gnn',-1,-2,-9)
21 xlabel('
```



```
    Time')
22 ylabel('

    Voltage')
23 title('Analog Waveform')
24 //
25 figure
26 a = gca();
27 a.data_bounds = [0,0;21,5];
28 plot2d2([1:length(dig_data)],dig_data,5)
29 title('Digital Representation')
```

Chapter 2

Fundamental Limit on Performance

Scilab code Exa 2.1 Entropy of Binary Memoryless source

```
1 //clear//
2 //Caption:Entropy of Binary Memoryless source
3 //Example 2.1: Entropy of Binary Memoryless Source
4 //page 18
5 clear;
6 close;
7 clc;
8 Po = 0:0.01:1;
9 H_Po = zeros(1,length(Po));
10 for i = 2:length(Po)-1
11     H_Po(i) = -Po(i)*log2(Po(i))-(1-Po(i))*log2(1-Po(i)
12         ));
13 end
14 //plot
15 plot2d(Po,H_Po)
16 xlabel('Symbol Probability , Po')
17 ylabel('H(Po)')
18 title('Entropy function H(Po)')
19 plot2d3('gnn',0.5,1)
```

Scilab code Exa 2.2 Second order Extension of Discrete Memoryless Source

```
1 //clear//
2 //caption:Second order Extension of Discrete
   Memoryless Source
3 //Example 2.2:Entropy of Discrete Memoryless source
4 //page 19
5 clear;
6 clc;
7 P0 = 1/4; //probability of source alphabet S0
8 P1 = 1/4; //probability of source alphabet S1
9 P2 = 1/2; //probability of source alphabet S2
10 H_Ruo = P0*log2(1/P0)+P1*log2(1/P1)+P2*log2(1/P2);
11 disp('Entropy of Discrete Memoryless Source')
12 disp('bits',H_Ruo)
13 //Second order Extension of discrete Memoryless
   source
14 P_sigma = [P0*P0,P0*P1,P0*P2,P1*P0,P1*P1,P1*P2,P2*P0
   ,P2*P1,P2*P2];
15 disp('Table 2.1 Alphabet Particulars of Second-order
   Extension of a Discrete Memoryless Source')
16 disp('
   -----
   ')
17 disp('Sequence of Symbols of ruo2:')
18 disp(' S0*S0      S0*S1      S0*S2      S1*S0      S1*
   S1      S1*S2      S2*S0      S2*S1      S2*S2 ')
19 disp(P_sigma,'Probability p(sigma), i =0,1.....8 ')
20 disp('
   -----
   ')
21 disp(' ')
22 H_Ruo_Square =0;
23 for i = 1:length(P_sigma)
```

```

24   H_Ruo_Square = H_Ruo_Square+P_sigma(i)*log2(1/
      P_sigma(i));
25   end
26   disp('bits ', H_Ruo_Square, 'H(Ruo_Square)=')
27   disp('H(Ruo_Square) = 2*H(Ruo) ')

```

Scilab code Exa 2.3 Huffman Encoding: Average length, Entropy and Variance

```

1 //clear//
2 //Caption: Entropy, Average length, Variance of
  Huffman Encoding
3 //Example 2.3: Huffman Encoding: Calculation of
4 // (a) Average code-word length 'L'
5 //(b) Entropy 'H'
6 clear;
7 clc;
8 P0 = 0.4; //probability of codeword '00'
9 L0 = 2; //length of codeword S0
10 P1 = 0.2; //probability of codeword '10'
11 L1 = 2; //length of codeword S1
12 P2 = 0.2; //probability of codeword '11'
13 L2 = 2; //length of codeword S2
14 P3 = 0.1; //probability of codeword '010'
15 L3 = 3; //length of codeword S3
16 P4 = 0.1; //probability of codeword '011'
17 L4 = 3; //length of codeword S4
18 L = P0*L0+P1*L1+P2*L2+P3*L3+P4*L4;
19 H_Ruo = P0*log2(1/P0)+P1*log2(1/P1)+P2*log2(1/P2)+P3
      *log2(1/P3)+P4*log2(1/P4);
20 disp('bits ', L, 'Average code-word Length L')
21 disp('bits ', H_Ruo, 'Entropy of Huffman coding result
      H')
22 disp('percent ', ((L-H_Ruo)/H_Ruo)*100, 'Average code-
      word length L exceeds the entropy H(Ruo) by only'
      )

```

```

23 sigma_1 = P0*(L0-L)^2+P1*(L1-L)^2+P2*(L2-L)^2+P3*(L3
    -L)^2+P4*(L4-L)^2;
24 disp(sigma_1,'Varinace of Huffman code')

```

Scilab code Exa 2.4 Illustrating non-uniquess of the Huffman Encoding

```

1 //clear//
2 //Caption:Entropy , Average length , Variance of
    Huffman Encoding
3 //Example2.4: Illustrating nonuniquess of the
    Huffman Encoding
4 // Calculation of (a)Average code–word length 'L' (b
    )Entropy 'H'
5 clear;
6 clc;
7 P0 = 0.4; //probability of codeword '1'
8 L0 = 1; //length of codeword S0
9 P1 = 0.2; //probability of codeword '01'
10 L1 = 2; //length of codeword S1
11 P2 = 0.2; //probility of codeword '000'
12 L2 = 3; //length of codeword S2
13 P3 = 0.1; //probility of codeword '0010'
14 L3 = 4; //length of codeword S3
15 P4 =0.1; //probility of codeword '0011'
16 L4 = 4; //length of codeword S4
17 L = P0*L0+P1*L1+P2*L2+P3*L3+P4*L4;
18 H_Ruo = P0*log2(1/P0)+P1*log2(1/P1)+P2*log2(1/P2)+P3
    *log2(1/P3)+P4*log2(1/P4);
19 disp('bits',L,'Average code–word Length L')
20 disp('bits',H_Ruo,'Entropy of Huffman coding result
    H')
21 sigma_2 = P0*(L0-L)^2+P1*(L1-L)^2+P2*(L2-L)^2+P3*(L3
    -L)^2+P4*(L4-L)^2;
22 disp(sigma_2,'Varinace of Huffman code')

```

Scilab code Exa 2.5 Binary Symmetric Channel

```
1 //clear//
2 //Caption:Binary Symmetric Channel
3 //Example2.5: Binary Symmetric Channel
4 clear;
5 clc;
6 close;
7 p = 0.4; //probability of correct reception
8 pe = 1-p; //probility of error reception (i.e)
           transition probability
9 disp(p, 'probability of 0 receiving if a 0 is sent =
           probability of 1 receiving if a 1 is sent=')
10 disp('Transition probability')
11 disp(pe, 'probability of 0 receiving if a 1 is sent =
           probability of 1 receiving if a 0 is sent=')
```

Scilab code Exa 2.6 Channel Capacity of a Binary Symmetric Channel

```
1 //clear//
2 //Caption:Channel Capacity of a Binary Symmetric
   Channel
3 //Example2.6:Channel Capacity of Binary Symmetri
   Channel
4 clear;
5 close;
6 clc;
7 p = 0:0.01:0.5;
8 for i =1:length(p)
9     if(i~=1)
10        C(i) = 1+p(i)*log2(p(i))+(1-p(i))*log2((1-p(i)))
           ;
```

```

11     elseif(i==1)
12         C(i) =1;
13     elseif(i==length(p))
14         C(i)=0;
15     end
16 end
17 plot2d(p,C,5)
18 xlabel('Transition Probability , p')
19 ylabel('Channel Capacity , C')
20 title('Figure 2.10 Variation of channel capacity of
        a binary symmetric channel with transition
        probability p')

```

Scilab code Exa 2.7 Significance of the Channel Coding theorem

```

1 //clear//
2 //Caption:Significance of the Channel Coding theorem
3 //Example2.7: Significance of the channel coding
  theorem
4 //Average Probability of Error of Repetition Code
5 clear;
6 clc;
7 close;
8 p =10^-2;
9 pe_1 =p; //Average Probability of error for code rate
  r = 1
10 pe_3 = 3*p^2*(1-p)+p^3;//probability of error for code
  rate r =1/3
11 pe_5 = 10*p^3*(1-p)^2+5*p^4*(1-p)+p^5;//error for
  code rate r =1/5
12 pe_7 = ((7*6*5)/(1*2*3))*p^4*(1-p)^3+(42/2)*p^5*(1-p
  )^2+7*p^6*(1-p)+p^7;//error for code rate r =1/7
13 r = [1,1/3,1/5,1/7];
14 pe = [pe_1,pe_3,pe_5,pe_7];
15 a=gca();

```

```

16 a.data_bounds=[0,0;1,0.01];
17 plot2d(r,pe,5)
18 xlabel('Code rate , r')
19 ylabel('Average Probability of error , Pe')
20 title('Figure 2.12 Illustrating significance of the
        channel coding theorem')
21 legend('Repetition codes')
22 xgrid(1)
23 disp('Table 2.3 Average Probability of Error for
        Repetition Code')
24 disp('
        -----
        ')
25 disp(r,'Code Rate, r =1/n',pe,'Average Probability of
        Error , Pe')
26 disp('
        -----
        ')

```

Chapter 3

Detection and Estimation

Scilab code Exa 3.1 Orthonormal basis for given set of signals

```
1 //clear//
2 //Caption:Orthonormal basis for given set of signals
3 //Example3.1:Finding orthonormal basis for the given
  signals
4 //using Gram-Schmidt orthogonalization procedure
5 clear;
6 close;
7 clc;
8 T = 1;
9 t1 = 0:0.01:T/3;
10 t2 = 0:0.01:2*T/3;
11 t3 = T/3:0.01:T;
12 t4 = 0:0.01:T;
13 s1t = [0, ones(1, length(t1)-2), 0];
14 s2t = [0, ones(1, length(t2)-2), 0];
15 s3t = [0, ones(1, length(t3)-2), 0];
16 s4t = [0, ones(1, length(t4)-2), 0];
17 t5 = 0:0.01:T/3;
18 phi1t = sqrt(3/T)*[0, ones(1, length(t5)-2), 0];
19 t6 =T/3:0.01:2*T/3;
20 phi2t = sqrt(3/T)*[0, ones(1, length(t6)-2), 0];
```

```

21 t7 = 2*T/3:0.01:T;
22 phi3t = sqrt(3/T)*[0,ones(1,length(t7)-2),0];
23 //
24 figure
25 title('Figure3.4(a) Set of signals to be
        orthonormalized')
26 subplot(4,1,1)
27 a =gca();
28 a.data_bounds = [0,0;2,2];
29 plot2d2(t1,s1t,5)
30 xlabel('t')
31 ylabel('s1(t)')
32 subplot(4,1,2)
33 a =gca();
34 a.data_bounds = [0,0;2,2];
35 plot2d2(t2,s2t,5)
36 xlabel('t')
37 ylabel('s2(t)')
38 subplot(4,1,3)
39 a =gca();
40 a.data_bounds = [0,0;2,2];
41 plot2d2(t3,s3t,5)
42 xlabel('t')
43 ylabel('s3(t)')
44 subplot(4,1,4)
45 a =gca();
46 a.data_bounds = [0,0;2,2];
47 plot2d2(t4,s4t,5)
48 xlabel('t')
49 ylabel('s4(t)')
50 //
51 figure
52 title('Figure3.4(b) The resulting set of orthonormal
        functions')
53 subplot(3,1,1)
54 a =gca();
55 a.data_bounds = [0,0;2,4];
56 plot2d2(t5,phi1t,5)

```

```

57 xlabel('t')
58 ylabel('phi1(t)')
59 subplot(3,1,2)
60 a =gca();
61 a.data_bounds = [0,0;2,4];
62 plot2d2(t6,phi2t,5)
63 xlabel('t')
64 ylabel('phi2(t)')
65 subplot(3,1,3)
66 a =gca();
67 a.data_bounds = [0,0;2,4];
68 plot2d2(t7,phi3t,5)
69 xlabel('t')
70 ylabel('phi3(t)')

```

Scilab code Exa 3.2 M-ARY Signaling

```

1 //clear//
2 //Caption:M-ARY Signaling
3 //Example3.2:M-ARY SIGNALING
4 //Signal constellation and Representation of dibits
5 clear;
6 close;
7 clc;
8 a =1; //amplitude =1
9 T =1; //Symbol duration in seconds
10 //Four message points
11 Si1 = [(-3/2)*a*sqrt(T),(-1/2)*a*sqrt(T),(3/2)*a*
        sqrt(T),(1/2)*a*sqrt(T)];
12 a =gca();
13 a.data_bounds = [-2,-0.5;2,0.5]
14 plot2d(Si1,[0,0,0,0],-10)
15 xlabel('phi1(t)')
16 title('Figure 3.8 (a) Signal constellation')
17 xgrid(1)

```

```

18 disp('Figure 3.8 (b). Representation of transmitted
      dibits ')
19 disp('Loc. of meg. point |  $(-3/2)\sqrt{T}$  |  $(-1/2)\sqrt{T}$  |
       $(3/2)\sqrt{T}$  |  $(1/2)\sqrt{T}$  ')
20 disp('
      -----
21 disp('Transmitted dibit |          00          |          01
      |          11          |          10 ')
22 disp('')
23 disp('')
24 disp('Figure 3.8 (c). Decision intervals for
      received dibits ')
25 disp('Received dibit      |          00          |          01
      |          11          |          10 ')
26 disp('
      -----
27 disp('Interval on  $\phi_1(t)$  |  $x_1 < -a\sqrt{T}$  |  $-a\sqrt{T}$ 
       $T < x_1 < 0$  |  $0 < x_1 < a\sqrt{T}$  |  $a\sqrt{T} < x_1$  ')

```

Scilab code Exa 3.3 Matched Filter output for RF pulse

```

1 //clear//
2 //Caption:Matched Filter output for RF pulse
3 //Example3.3: MATCHED FILTER FOR RF PULSE
4 clear;
5 close;
6 clc;
7 fc =4; //carrier frequency in Hz
8 T =1;
9 t1 = 0:0.01:T;
10 phit = sqrt(2/T)*cos(2*pi*fc*t1);
11 hopt = phit;
12 phiot = convol(phit,hopt);

```

```

13 phiot = phiot/max(phiot);
14 t2 = 0:0.01:2*T;
15 subplot(2,1,1)
16 a =gca();
17 a.x_location = "origin";
18 a.y_location = "origin";
19 a.data_bounds = [0,-1;1,1];
20 plot2d(t1,phit);
21 xlabel('
    t')
22 ylabel('
    phi(t)')
23 title('Figure 3.13 (a) RF pulse input')
24 subplot(2,1,2)
25 a =gca();
26 a.x_location = "origin";
27 a.y_location = "origin";
28 a.data_bounds = [0,-1;1,1];
29 plot2d(t2,phiot);
30 xlabel('
    t')
31 ylabel('
    phi0(t)')
32 title('Figure 3.13 (b) Matched Filter output')

```

Scilab code Exa 3.4 Matched Filter output for Noise-like signal

```

1 //clear//
2 //Caption:Matched Filter output for Noise-like
  signal
3 //Example3.4: Matched Filter output for noise like

```

```

    input
4  clear;
5  close;
6  clc;
7  phit =0.1*rand(1,10, 'uniform ');
8  hopt = phit;
9  phi0t = convol(phit,hopt);
10 phi0t = phi0t/max(phi0t);
11 subplot(2,1,1)
12 a =gca();
13 a.x_location = "origin";
14 a.y_location = "origin";
15 a.data_bounds = [0,-1;1,1];
16 plot2d([1:length(phit)],phit);
17 xlabel('
    t ')
18 ylabel('
    phi(t) ')
19 title('Figure 3.16 (a) Noise Like input signal')
20 subplot(2,1,2)
21 a =gca();
22 a.x_location = "origin";
23 a.y_location = "origin";
24 a.data_bounds = [0,-1;1,1];
25 plot2d([1:length(phi0t)],phi0t);
26 xlabel('
    t ')
27 ylabel('
    phi0(t) ')
28 title('Figure 3.16 (b) Matched Filter output')

```

Scilab code Exa 3.6 Linear Predictor of Order one

```
1 //clear//
2 //Caption:Linear Predictor of Order one
3 //Example3.6: LINEAR PREDICTION: Predictor of Order
  One
4 clear;
5 close;
6 clc;
7 Rxx = [0.6 1 0.6];
8 h01 = Rxx(3)/Rxx(2); //Rxx(2) = Rxx(0), Rxx(3) =
  Rxx(1)
9 sigma_E = Rxx(2) - h01*Rxx(3);
10 sigma_X = Rxx(2);
11 disp(sigma_E,'Predictor-error variance')
12 disp(sigma_X,'Predictor input variance')
13 if(sigma_X > sigma_E)
14     disp('The predictor-error variance is less than
  the variance of the predictor input')
15 end
```

Scilab code Exa 3.29 Implementation of LMS ADAPTIVE FILTER

```
1 //clear//
2 //Implementation of LMS ADAPTIVE FILTER
3 //For noise cancellation application
4 clear;
5 clc;
6 close;
7 order = 18;
8 t =0:0.01:1;
9 x = sin(2*%pi*5*t);
10 noise =rand(1,length(x));
11 x_n = x+noise;
12 ref_noise = noise*rand(10);
```

```

13 w = zeros(order,1);
14 mu = 0.01*(sum(x.^2)/length(x));
15 N = length(x);
16 for k =1:1010
17     for i = 1:N-order-1
18         buffer = ref_noise(i:i+order-1);
19         desired(i) = x_n(i)-buffer*w;
20         w = w+(buffer*mu*desired(i))';
21     end
22 end
23 subplot(4,1,1)
24 plot2d(t,x)
25 title('Original Input Signal')
26 subplot(4,1,2)
27 plot2d(t,noise,2)
28 title('random noise')
29 subplot(4,1,3)
30 plot2d(t,x_n,5)
31 title('Signal+noise')
32 subplot(4,1,4)
33 plot(desired)
34 title('noise removed signal')

```

Chapter 4

Sampling Process

Scilab code Exa 4.1 Bound on Aliasing error for Time-shifted sinc pulse

```
1 //clear//
2 //Caption:Bound on Aliasing error for Time-shifted
   sinc pulse
3 //Example4.1:Maximum bound on aliasing error for
   sinc pulse
4 clc;
5 close;
6 t = -1.5:0.01:2.5;
7 g = 2*sinc_new(2*t-1);
8 disp(max(g), 'Aliasing error cannot exceed max|g(t)|'
   )
9 f = -1:0.01:1;
10 G = [0,0,0,0,ones(1,length(f)),0,0,0,0];
11 f1 = -1.04:0.01:1.04;
12 subplot(2,1,1)
13 a=gca();
14 a.data_bounds =[-3,-1;2,2];
15 a.x_location = "origin"
16 a.y_location = "origin"
17 plot2d(t,g)
18 xlabel(' t ')
```

```

19 ylabel('                                g(t)')
20 title('Figure 4.8 (a) Sinc pulse g(t)')
21 subplot(2,1,2)
22 a=gca();
23 a.data_bounds =[-2,0;2,2];
24 a.x_location = "origin"
25 a.y_location = "origin"
26 plot2d(f1,G)
27 xlabel('                                f')
28 ylabel('                                G(f)')
29 title('Figure 4.8 (b) Amplitude spectrum |G(f)|')

```

Scilab code Exa 4.3 Equalizer to compensate Aperture effect

```

1 //clear//
2 //Caption:Equalizer to compensate Aperture effect
3 //Example4.3:Equalizer to Compensate for aperture
  effect
4 clc;
5 close;
6 T_Ts = 0.01:0.01:0.6;
7 //E = 1/(sinc_new(0.5*T_Ts));
8 E(1) =1;
9 for i = 2:length(T_Ts)
10   E(i) = ((%pi/2)*T_Ts(i))/(sin((%pi/2)*T_Ts(i)));
11 end
12 a =gca();
13 a.data_bounds = [0,0.8;0.8,1.2];
14 plot2d(T_Ts,E,5)
15 xlabel('Duty cycle T/Ts')
16 ylabel('1/sinc(0.5(T/Ts))')
17 title('Figure 4.16 Normalized equalization (to
  compensate for aperture effect) plotted versus T/
  Ts')

```

Chapter 5

Waveform Coding Techniques

Scilab code Exa 5.1 Average Transmitted Power for PCM

```
1 //clear//
2 //Caption: Average Transmitted Power for PCM
3 //Example 5.1: Average Transmitted Power of PCM
4 //Page 187
5 clear;
6 clc;
7 sigma_N = input('Enter the noise variance');
8 k = input('Enter the separation constant for on-off
    signaling');
9 M = input('Enter the number of discrete amplitude
    levels for NRZ polar');
10 disp('The average transmitted power is:')
11 P = (k^2)*(sigma_N)*((M^2)-1)/12;
12 disp(P)
13 //Result
14 //Enter the noise variance 10^-6
15 //Enter the separation constant for on-off signaling
    7
16 //Enter the number of discrete amplitude levels for
    NRZ polar 2
17 // The average transmitted power is: 0.0000122
```

Scilab code Exa 5.2 Comparison of M-ary PCM with ideal system

```
1 //clear//
2 //Caption:Comparison of M-ary PCM with ideal system
   (Channel Capacity Theorem)
3 //Example5.2:Comparison of M-ary PCM system
4 //Channel Capacity theorem
5 clear;
6 close;
7 clc;
8 P_NoB_dB = [-20:30]; //Input signal-to-noise ratio P/
   NoB, decibels
9 P_NoB = 10^(P_NoB_dB/10);
10 k =7; // for M-ary PCM system;
11 Rb_B = log2(1+(12/k^2)*P_NoB); //bandwidth efficiency
   in bits/sec/Hz
12 C_B = log2(1+P_NoB); //ideal system according to
   Shannon's channel capacity theorem
13 //plot
14 a =gca();
15 a.data_bounds = [-30,0;40,10];
16 plot2d(P_NoB_dB,C_B,5)
17 plot2d(P_NoB_dB,Rb_B,5)
18 poly1= a.children(1).children(1);
19 poly1.thickness =2;
20 poly1.line_style = 4;
21 xlabel('Input signal-to-noise ratio P/NoB, decibels'
   )
22 ylabel('Bandwidth efficiency , Rb/B, bits per second
   per hertz')
23 title('Figure 5.9 Comparison of M-ary PCM with the
   ideal ssystem')
24 legend(['Ideal System', 'PCM'])
```

Scilab code Exa 5.3 Signal-to-Quantization Noise Ratio of PCM

```
1 //clear//
2 //Caption:Signal-to-Quantization Noise Ratio of PCM
3 //Example5.3:Signal-to-Quantization noise ratio
4 //Channel Bandwidth B
5 clear;
6 clc;
7 n = input('Enter no. of bits used to encode:');
8 W = input('Enter the message signal bandwidth in Hz:');
9 B = n*W;
10 disp(B,'Channel width in Hz:')
11 SNRo = 6*n - 7.2;
12 disp(SNRo,'Output Signal to noise ratio in dB:')
13 //Result 1 if n = 8 bits
14 //Enter no. of bits used to encode: 8
15 //Enter the message signal bandwidth in Hz: 4000
16 //Channel width in Hz: 32000.
17 //Output Signal to noise ratio in dB: 40.8
18 ///////////////////////////////////////////////////
19 //Result 2 if n = 9 bits
20 //Enter no. of bits used to encode:9
21 //Enter the message signal bandwidth in Hz:4000
22 //Channel width in Hz: 36000.
23 //Output Signal to noise ratio in dB: 46.8
24 ///////////////////////////////////////////////////
25 //Conclusion: comparing result 1 with result 2 if
    number of bits increased by 1
26 //corresponding output signal to noise in PCM
    increased by 6 dB.
```

Scilab code Exa 5.5 Delta Modulation - to avoid slope overload distortion

```
1 //clear//
2 //Example 5:Delta Modulation - to avoid slope
  overload distortion
3 //maximum output signal-to-noise ratio for
  sinusoidal modulation
4 //page 207
5 clear;
6 clc;
7 a0 = input('Enter the amplitude of sinusoidal signal
  :');
8 f0 = input('Enter the frequency of sinusoidal signal
  in Hz:');
9 fs = input('Enter the sampling frequency in samples
  per seconds:');
10 Ts = 1/fs;//Sampling interval
11 delta = 2*pi*f0*a0*Ts;//Step size to avoid slope
  overload
12 Pmax = (a0^2)/2;//maximum permissible output power
13 sigma_Q = (delta^2)/3;//Quantization error or noise
  variance
14 W = f0;//Maximum message bandwidth
15 N = W*Ts*sigma_Q; //Average output noise power
16 SNRo = Pmax/N; // Maximum output signal-to-noise
  ratio
17 SNRo_dB = 10*log10(SNRo);
18 disp(SNRo_dB,'Maximum output signal-to-noise in dB
  for Delta Modulation:')
19 //Result 1 for fs = 8000 Hertz
20 //Enter the amplitude of sinusoidal signal:1
21 //Enter the frequency of sinusoidal signal in Hz
  :4000
22 //Enter the sampling frequency in samples per
  seconds:8000
23 //Maximum output signal-to-noise in dB for Delta
  Modulation:-5.1717849
24 //
```

```

////////////////////////////////////
25 //Result 2 for fs = 16000 Hertz
26 //Enter the amplitude of sinusoidal signal:1
27 //Enter the frequency of sinusoidal signal in Hz
   :4000
28 //Enter the sampling frequency in samples per
   seconds:16000
29 //Maximum output signal-to-noise in dB for Delta
   Modulation:3.859115
30 //
   //////////////////////////////////////
31 //Conclusion: comparing result 1 with result 2, if
   the sampling frequency
32 //is doubled the signal to noise increased by 9 dB

```

Scilab code Exa 05.13 A-law companding

```

1 //clear//
2 //Caption:A-law companding
3 //Figure5.13(b)A-law companding, Nonlinear
   Quantization
4 //Plotting A-law characteristics for different
5 //Values of A
6 clc;
7 function [ Cx , Xmax ] = Alaw ( x , A )
8 Xmax = max ( abs ( x ) ) ;
9 for i = 1: length ( x )
10 if( x( i ) / Xmax < = 1/ A )
11 Cx ( i ) = A * abs ( x ( i ) / Xmax ) ./ ( 1 + log ( A )
   ) ;
12 elseif ( x ( i ) / Xmax > 1/ A )
13 Cx ( i ) = ( 1 + log ( A * abs ( x ( i ) / Xmax ) ) )
   ./ ( 1 + log ( A ) ) ;

```

```

14 end
15 end
16 Cx = Cx / Xmax ;
17 Cx = Cx';
18 endfunction
19 x = 0:0.01:1; //Normalized input
20 A = [1,2,87.56]; //different values of A
21 for i = 1:length(A)
22     [Cx(i,:),Xmax(i)] = Alaw(x,A(i));
23 end
24 plot2d(x/Xmax(1),Cx(1,:),2)
25 plot2d(x/Xmax(2),Cx(2,:),4)
26 plot2d(x/Xmax(3),Cx(3,:),6)
27 xtitle('Compression Law: A-Law companding',
        'Normalized Input |x|', 'Normalized Output |c(x)|')
        ;
28 legend(['A =1'], ['A=2'], ['A=87.56'])

```

Scilab code Exa 5.13 u-Law companding

```

1 //clear//
2 //Caption:u-Law companding
3 //Figure5.13(a)Mulaw companding Nonlinear
  Quantization
4 //Plotting mulaw characteristics for different
5 //Values of mu
6 clc;
7 [Cx,Xmax] = mulaw(x,mu)
8 Xmax = max(abs(x));
9 if(log(1+mu)~=0)
10     Cx = (log(1+mu*abs(x/Xmax))./log(1+mu));
11 else
12     Cx = x/Xmax;
13 end
14 Cx = Cx/Xmax; //normalization of output vector

```



```

15 endfunction
16 x = 0:0.01:1; //Normalized input
17 mu = [0,5,255]; //different values of mu
18 for i = 1:length(mu)
19     [Cx(i,:),Xmax(i)] = mulaw(x,mu(i));
20 end
21 plot2d(x/Xmax(1),Cx(1,:),2)
22 plot2d(x/Xmax(2),Cx(2,:),4)
23 plot2d(x/Xmax(3),Cx(3,:),6)
24 xtitle('Compression Law: u-Law companding',
        'Normalized Input |x|', 'Normalized Output |c(x)|')
    ;
25 legend(['u =0'], ['u=5'], ['u=255'])

```

Chapter 6

Baseband Shaping for Data Transmission

Scilab code Exa 06.01 Nonreturn-to-zero bipolar format

```
1 //clear//
2 //Caption:Nonreturn-to-zero bipolar format
3 //Figure 6.1(c):Discrete PAM Signals Generation
4 // [3]. BiPolar NRZ
5 //page 235
6 clear;
7 close;
8 clc;
9 x = [0 1 1 0 0 1 0 0 1 1];
10 binary_negative = [-1 -1 -1 -1 -1 -1 -1 -1 -1 -1];
11 binary_zero = [0 0 0 0 0 0 0 0 0 0];
12 binary_positive = [1 1 1 1 1 1 1 1 1 1];
13 L = length(x);
14 L1 = length(binary_negative);
15 total_duration = L*L1;
16 //plotting
17 a =gca();
18 a.data_bounds =[0 -2;L*L1 2];
19 for i =1:L
```

```

20  if(x(i)==0)
21      plot([i*L-L+1:i*L],binary_zero);
22      poly1= a.children(1).children(1);
23      poly1.thickness =3;
24  elseif((x(i)==1)&(x(i-1)~=1))
25      plot([i*L-L+1:i*L],binary_positive);
26      poly1= a.children(1).children(1);
27      poly1.thickness =3;
28  else
29      plot([i*L-L+1:i*L],binary_negative);
30      poly1= a.children(1).children(1);
31      poly1.thickness =3;
32  end
33 end
34 xgrid(1)
35 title('BiPolar NRZ')

```

Scilab code Exa 06.1 Nonreturn-to-zero polar format

```

1  //clear//
2  //Caption:Nonreturn-to-zero polar format
3  //Figure 6.1(b): Discrete PAM Signals Generation
4  // [2].Polar NRZ
5  //page 235
6  clear;
7  close;
8  clc;
9  x = [0 1 0 0 0 1 0 0 1 1];
10 binary_negative = [-1 -1 -1 -1 -1 -1 -1 -1 -1 -1];
11 binary_positive = [1 1 1 1 1 1 1 1 1 1];
12 L = length(x);
13 L1 = length(binary_negative);
14 total_duration = L*L1;
15 //plotting
16 a =gca();

```

```

17 a.data_bounds = [0 -2;L*L1 2];
18 for i =1:L
19     if(x(i)==0)
20         plot([i*L-L+1:i*L],binary_negative);
21         poly1= a.children(1).children(1);
22         poly1.thickness =3;
23     else
24         plot([i*L-L+1:i*L],binary_positive);
25         poly1= a.children(1).children(1);
26         poly1.thickness =3;
27     end
28 end
29 xgrid(1)
30 title('Polar NRZ')

```

Scilab code Exa 6.01 Nonreturn-to-zero unipolar format

```

1 //clear//
2 //Caption:Nonreturn-to-zero unipolar format
3 //Figure 6.1(a): Discrete PAM Signals Generation
4 //[1]. Unipolar NRZ
5 //page 235
6 clear;
7 close;
8 clc;
9 x = [0 1 0 0 0 1 0 0 1 1];
10 binary_zero = [0 0 0 0 0 0 0 0 0 0];
11 binary_one = [1 1 1 1 1 1 1 1 1 1];
12 L = length(x);
13 L1 = length(binary_zero);
14 total_duration = L*L;
15 //plotting
16 a =gca();
17 a.data_bounds = [0 -2;L*L1 2];
18 for i =1:L

```

```

19     if(x(i)==0)
20         plot([i*L-L+1:i*L],binary_zero);
21         poly1= a.children(1).children(1);
22         poly1.thickness =3;
23     else
24         plot([i*L-L+1:i*L],binary_one);
25         poly1= a.children(1).children(1);
26         poly1.thickness =3;
27     end
28 end
29 xgrid(1)
30 title('Unipolar NRZ')

```

Scilab code Exa 6.1 Bandwidth Requirements of the T1 carrier

```

1 //clear//
2 //Caption:Bandwidth Requirements of the T1 carrier
3 //Example6.1:Bandwidth Requirements of the T1
  Carrier
4 //Page 251
5 clear;
6 clc;
7 Tb = input('Enter the bit duration of the TDM signal
  :');
8 Bo = 1/(2*Tb);//minimum transmission bandwidth of T1
  system
9 //Transmission bandwidth for raised cosine spectrum
  'B'
10 alpha = 1;//cosine roll-off factor
11 f1 = Bo*(1-alpha);
12 B = 2*Bo-f1;
13 disp(B,'Transmission bandwidth for raised cosine
  spectrum in Hz:')
14 //Result
15 //Enter the bit duration of the TDM signal

```

```

:0.647*10-6
16 //Transmission bandwidth for raised cosine spectrum
    in Hz:1545595.1

```

Scilab code Exa 6.2 Frequency response of modified duobinary conversion filter

```

1 //clear//
2 //Caption:Duobinary Encoding
3 //Example6.2: Precoded Duobinary coder and decoder
4 //Page 256
5 clc;
6 b = [0,0,1,0,1,1,0]; //input binary sequence:precoder
    input
7 a(1) = bitxor(1,b(1));
8 if(a(1)==1)
9     a_volts(1) = 1;
10 end
11 for k =2:length(b)
12     a(k) = bitxor(a(k-1),b(k));
13     if(a(k)==1)
14         a_volts(k)=1;
15     else
16         a_volts(k)=-1;
17     end
18 end
19 a = a';
20 a_volts = a_volts';
21 disp(a,'Precoder output in binary form:')
22 disp(a_volts,'Precoder output in volts:')
23 //Duobinary coder output in volts
24 c(1) = 1+ a_volts(1);
25 for k =2:length(a)
26     c(k) = a_volts(k-1)+a_volts(k);
27 end
28 c = c';

```

```

29 disp(c, 'Duobinary coder output in volts:')
30 //Duobinary decoder output by applying decision
    rule
31 for k =1:length(c)
32     if(abs(c(k))>1)
33         b_r(k) = 0;
34     else
35         b_r(k) = 1;
36     end
37 end
38 b_r = b_r';
39 disp(b_r, 'Recovered original sequence at detector
    oupupt:')
40 //Result
41 //Precoder output in binary form:
42 //
43 // 1.    1.    0.    0.    1.    0.    0.
44 //
45 // Precoder output in volts:
46 //
47 // 1.    1.  - 1.  - 1.    1.  - 1.  - 1.
48 //
49 // Duobinary coder output in volts:
50 //
51 // 2.    2.    0.  - 2.    0.    0.  - 2.
52 //
53 // Recovered original sequence at detector oupupt:
54 //
55 // 0.    0.    1.    0.    1.    1.    0.

```

Scilab code Exa 6.3 Generation of bipolar output for duobinary coder

```

1 //clear//
2 //Caption:Generation of bipolar output for duobinary
    coder

```

```

3 //Example6.3: Operation of Circuit in figure 6.13
4 //for generating bipolar format
5 //page 256 and page 257
6 //Refer Table 6.4
7 clc;
8 x = [0,1,1,0,1,0,0,0,1,1]; //input binary sequence:
   precoder input
9 y(1) = 1;
10 for k =2:length(x)+1
11   y(k) = xor(x(k-1),y(k-1));
12 end
13 y_delay = y(1:$-1);
14 y = y';
15 y_delay = y_delay';
16 disp(y, 'Modulo-2 adder output:')
17 disp(y_delay, 'Delay element output:')
18 for k = 1:length(y_delay)
19   z(k) = y(k+1)-y_delay(k);
20 end
21 z = z';
22 disp(z, 'differential encoder bipolar output in volts
   :')
23 //Result
24 //Modulo-2 adder output:
25 //   1.   1.   0.   1.   1.   0.   0.   0.
   0.   1.   0.
26 // Delay element output:
27 //   1.   1.   0.   1.   1.   0.   0.   0.
   0.   1.
28 // differential encoder bipolar output in volts:
29 //   0. - 1.   1.   0. - 1.   0.   0.   0.
   1. - 1.

```

Scilab code Exa 6.4 Power Spectra of different binary data formats


```

1 //clear//
2 //Caption:Power Spectra of different binary data
   formats
3 //Figure 6.4: Power Spectal Densities of
4 //Different Line Coding Techniques
5 //[1].NRZ Polar Format [2].NRZ Bipolar format
6 //[3].NRZ Unipolar format [4]. Manchester format
7 //Page 241
8 close;
9 clc;
10 //[1]. NRZ Polar format
11 a = input('Enter the Amplitude value:');
12 fb = input('Enter the bit rate:');
13 Tb = 1/fb; //bit duration
14 f = 0:1/(100*Tb):2/Tb;
15 for i = 1:length(f)
16     Sxxf_NRZ_P(i) = (a^2)*Tb*(sinc_new(f(i)*Tb)^2);
17     Sxxf_NRZ_BP(i) = (a^2)*Tb*((sinc_new(f(i)*Tb))^2)
        *((sin(%pi*f(i)*Tb))^2);
18     if (i==1)
19         Sxxf_NRZ_UP(i) = (a^2)*(Tb/4)*((sinc_new(f(i)*Tb
        ))^2)+(a^2)/4;
20     else
21         Sxxf_NRZ_UP(i) = (a^2)*(Tb/4)*((sinc_new(f(i)*Tb
        ))^2);
22     end
23     Sxxf_Manch(i) = (a^2)*Tb*(sinc_new(f(i)*Tb/2)^2)*
        (sin(%pi*f(i)*Tb/2)^2);
24 end
25 //Plotting
26 a = gca();
27 plot2d(f, Sxxf_NRZ_P)
28 poly1= a.children(1).children(1);
29 poly1.thickness = 2; // the tickness of a curve.
30 plot2d(f, Sxxf_NRZ_BP, 2)
31 poly1= a.children(1).children(1);
32 poly1.thickness = 2; // the tickness of a curve.
33 plot2d(f, Sxxf_NRZ_UP, 5)

```

```

34 poly1= a.children(1).children(1);
35 poly1.thickness = 2; // the tickness of a curve.
36 plot2d(f,Sxxf_Manch,9)
37 poly1= a.children(1).children(1);
38 poly1.thickness = 2; // the tickness of a curve.
39 xlabel('f*Tb————>')
40 ylabel('Sxx(f)————>')
41 title('Power Spectral Densities of Different Line
        Codinig Techniques')
42 xgrid(1)
43 legend(['NRZ Polar Format', 'NRZ Bipolar format', 'NRZ
        Unipolar format', 'Manchester format']);
44 //Result
45 //Enter the Amplitude value:1
46 //Enter the bit rate:1

```

Scilab code Exa 6.6 Ideal solution for zero ISI

```

1 //clear//
2 //Caption:Ideal solution for zero ISI
3 //Figure 6.6(b): Ideal Solution for Intersymbol
  Interference
4 //SINC pulse
5 //page 249
6 rb = input('Enter the bit rate:');
7 Bo = rb/2;
8 t = -3:1/100:3;
9 x = sinc_new(2*Bo*t);
10 plot(t,x)
11 xlabel('t————>');
12 ylabel('p(t)————>');
13 title('SINC Pulse for zero ISI')
14 xgrid(1)
15 //Result
16 //Enter the bit rate:1

```

Scilab code Exa 6.7 Practical solution: Raised Cosine

```
1 //clear//
2 //Caption:Practical solution: Raised Cosine
3 //Figure6.7(b):Practical Solution for Intersymbol
  Interference
4 //Raised Cosine Spectrum
5 //page 250
6 close;
7 clc;
8 rb = input('Enter the bit rate:');
9 Tb =1/rb;
10 t =-3:1/100:3;
11 Bo = rb/2;
12 Alpha =0;      //Intialized to zero
13 x =t/Tb;
14 for j =1:3
15     for i =1:length(t)
16         if((j==3)&((t(i)==0.5)|(t(i)==-0.5)))
17             p(j,i) = sinc_new(2*Bo*t(i));
18         else
19             num = sinc_new(2*Bo*t(i))*cos(2*%pi*Alpha*
                Bo*t(i));
20             den = 1-16*(Alpha^2)*(Bo^2)*(t(i)^2)+0.01;
21             p(j,i)= num/den;
22         end
23     end
24     Alpha = Alpha+0.5;
25 end
26 a =gca();
27 plot2d(t,p(1,:))
28 plot2d(t,p(2,:))
29 poly1= a.children(1).children(1);
30 poly1.foreground=2;
```

```

31 plot2d(t,p(3,:))
32 poly2= a.children(1).children(1);
33 poly2.foreground=4;
34 poly2.line_style = 3;
35 xlabel('t/Tb————>');
36 ylabel('p(t)————>');
37 title('RAISED COSINE SPECTRUM – Practical Solution
      for ISI')
38 legend(['ROlloff Factor =0', 'ROlloff Factor =0.5', '
      ROlloff Factor =1'])
39 xgrid(1)
40 //Result
41 //Enter the bit rate:1

```

Scilab code Exa 6.9 Frequency response of duobinary conversion filte

```

1 //clear//
2 //Caption:Frequency response of duobinary conversion
  filter
3 //Figure6.9:Frequency Response of Duobinary
  Conversion filter
4 //(a)Amplitude Response
5 //(b)Phase Response
6 //Page 254
7 clear;
8 close;
9 clc;
10 rb = input('Enter the bit rate=');
11 Tb =1/rb; //Bit duration
12 f = -rb/2:1/100:rb/2;
13 Amplitude_Response = abs(2*cos(%pi*f.*Tb));
14 Phase_Response = -(%pi*f.*Tb);
15 subplot(2,1,1)
16 a=gca();
17 a.x_location =" origin";

```

```

18 a.y_location = "origin";
19 plot2d(f, Amplitude_Response, 2)
20 poly1= a.children(1).children(1);
21 poly1.thickness = 2; // the tickness of a curve.
22 xlabel('Frequency f————>')
23 ylabel('|H(f)| —————>')
24 title('Amplitude Reponse of Duobinary Singaling')
25 subplot(2,1,2)
26 a=gca();
27 a.x_location = "origin";
28 a.y_location = "origin";
29 plot2d(f, Phase_Response, 5)
30 poly1= a.children(1).children(1);
31 poly1.thickness = 2; // the tickness of a curve.
32 xlabel('
    Frequency f————>')
33 ylabel('
    <H(f) —————>')
34 title('Phase Reponse of Duobinary Singaling')
35 //Result
36 //Enter the bit rate=8

```

Scilab code Exa 6.15 Frequency response of modified duobinary conversion filter

```

1 //clear//
2 //Caption:Frequency response of modified duobinary
    conversion filter
3 //Figure 6.15: Frequency Response of Modified
    duobinary conversion filter
4 //(a)Amplitude Response
5 //(b)Phase Response
6 //page 259
7 clear;
8 close;
9 clc;

```

```

10 rb = input('Enter the bit rate=');
11 Tb =1/rb; //Bit duration
12 f = -rb/2:1/100:rb/2;
13 Amplitude_Response = abs(2*sin(2*pi*f.*Tb));
14 Phase_Response = -(2*pi*f.*Tb);
15 subplot(2,1,1)
16 a=gca();
17 a.x_location = "origin";
18 a.y_location = "origin";
19 plot2d(f,Amplitude_Response,2)
20 poly1= a.children(1).children(1);
21 poly1.thickness = 2; // the tickness of a curve.
22 xlabel('Frequency f——>')
23 ylabel('|H(f)| ——>')
24 title('Amplitude Repsonse of Modified Duobinary
        Singaling ')
25 xgrid(1)
26 subplot(2,1,2)
27 a=gca();
28 a.x_location = "origin";
29 a.y_location = "origin";
30 plot2d(f,Phase_Response,5)
31 poly1= a.children(1).children(1);
32 poly1.thickness = 2; // the tickness of a curve.
33 xlabel('
        Frequency f——>')
34 ylabel('
        <H(f) ——>')
35 title('Phase Repsonse of Modified Duobinary
        Singaling ')
36 xgrid(1)
37 //Result
38 //Enter the bit rate=8

```

Chapter 7

Digital Modulation Techniques

Scilab code Exa 7.01 Waveforms of Different Digital Modulation techniques

```
1 //clear//
2 //Caption:Waveforms of Different Digital Modulation
   techniques
3 //Figure7.1
4 //Digital Modulation Techniques
5 //To Plot the ASK, FSK and PSk Waveforms
6 clear;
7 clc;
8 close;
9 f = input('Enter the Analog Carrier Frequency in Hz'
   );
10 t = 0:1/512:1;
11 x = sin(2*pi*f*t);
12 I = input('Enter the digital binary data');
13 //Generation of ASK Waveform
14 Xask = [];
15 for n = 1:length(I)
16     if((I(n)==1)&(n==1))
17         Xask = [x,Xask];
18     elseif((I(n)==0)&(n==1))
19         Xask = [zeros(1,length(x)),Xask];
```

```

20     elseif((I(n)==1)&(n~=1))
21         Xask = [Xask,x];
22     elseif((I(n)==0)&(n~=1))
23         Xask = [Xask,zeros(1,length(x))];
24     end
25 end
26 // Generation of FSK Waveform
27 Xfsk = [];
28 x1 = sin(2*%pi*f*t);
29 x2 = sin(2*%pi*(2*f)*t);
30 for n = 1:length(I)
31     if (I(n)==1)
32         Xfsk = [Xfsk,x2];
33     elseif (I(n)~=1)
34         Xfsk = [Xfsk,x1];
35     end
36 end
37 // Generation of PSK Waveform
38 Xpsk = [];
39 x1 = sin(2*%pi*f*t);
40 x2 = -sin(2*%pi*f*t);
41 for n = 1:length(I)
42     if (I(n)==1)
43         Xpsk = [Xpsk,x1];
44     elseif (I(n)~=1)
45         Xpsk = [Xpsk,x2];
46     end
47 end
48 figure
49 plot(t,x)
50 xtitle('Analog Carrier Signal for Digital Modulation
        ')
51 xgrid
52 figure
53 plot(Xask)
54 xtitle('Amplitude Shift Keying')
55 xgrid
56 figure

```



```

57 plot(Xfsk)
58 xtitle('Frequency Shift Keying')
59 xgrid
60 figure
61 plot(Xpsk)
62 xtitle('Phase Shift Keying')
63 xgrid
64 //Example
65 //Enter the Analog Carrier Frequency 2
66 //Enter the digital binary data [0,1,1,0,1,0,0,1]

```

Scilab code Exa 7.1 Waveforms of Different Digital Modulation techniques

```

1 //clear//
2 //Caption:Waveforms of Different Digital Modulation
  techniques
3 //Example7.1 Signal Space Diagram for coherent QPSK
  system
4 clear;
5 clc;
6 close;
7 M =4;
8 i = 1:M;
9 t = 0:0.001:1;
10 for i = 1:M
11     s1(i,:) = cos(2*pi*2*t)*cos((2*i-1)*pi/4);
12     s2(i,:) = -sin(2*pi*2*t)*sin((2*i-1)*pi/4);
13 end
14 S1 = [];
15 S2 = [];
16 S = [];
17 Input_Sequence = [0,1,1,0,1,0,0,0];
18 m = [3,1,1,2];
19 for i =1:length(m)
20     S1 = [S1 s1(m(i),:)];

```

```

21     S2 = [S2 s2(m(i),:)]];
22 end
23 S = S1+S2;
24 figure
25 subplot(3,1,1)
26 a =gca();
27 a.x_location = "origin";
28 plot(S1)
29 title('Binary PSK wave of Odd-numbered bits of input
        sequence')
30 subplot(3,1,2)
31 a =gca();
32 a.x_location = "origin";
33 plot(S2)
34 title('Binary PSK wave of Even-numbered bits of
        input sequence')
35 subplot(3,1,3)
36 a =gca();
37 a.x_location = "origin";
38 plot(S)
39 title('QPSK waveform')
40 // -sin((2*i-1)*%pi/4)*%i;
41 // annot = dec2bin([0:length(y)-1],log2(M));
42 // disp(y,'coordinates of message points')
43 // disp(annot,'dibits value')
44 // figure;
45 // a =gca();
46 // a.data_bounds = [-1,-1;1,1];
47 // a.x_location = "origin";
48 // a.y_location = "origin";
49 // plot2d(real(y(1)),imag(y(1)),-2)
50 // plot2d(real(y(2)),imag(y(2)),-4)
51 // plot2d(real(y(3)),imag(y(3)),-5)
52 // plot2d(real(y(4)),imag(y(4)),-9)
53 // xlabel('
        Phase');
54 // ylabel('

```

In-

```

    Quadrature ');
55 //title('Constellation for QPSK')
56 //legend(['message point 1 (dibit 10) ','message
    point 2 (dibit 00) ','message point 3 (dibit 01)
    ','message point 4 (dibit 11) '],5)

```

Scilab code Exa 7.02 Signal Space Diagram for coherent BPSK system

```

1 //clear//
2 //Caption:Signal Space diagram for coherent BPSK
3 //Figure7.2 Signal Space Diagram for coherent BPSK
    system
4 clear
5 clc;
6 close;
7 M =2;
8 i = 1:M;
9 y = cos(2*%pi+(i-1)*%pi);
10 annot = dec2bin([length(y)-1:-1:0],log2(M));
11 disp(y,'coordinates of message points')
12 disp(annot,'Message points')
13 figure;
14 a =gca();
15 a.data_bounds = [-2,-2;2,2];
16 a.x_location = "origin";
17 a.y_location = "origin";
18 plot2d(real(y(1)),imag(y(1)),-9)
19 plot2d(real(y(2)),imag(y(2)),-5)
20 xlabel('
    In-Phase ');
21 ylabel('
    Quadrature ');

```

```

22 title('Constellation for BPSK')
23 legend(['message point 1 (binary 1)'; 'message point
        2 (binary 0)'],5)

```

Scilab code Exa 7.2 Sequence and Waveforms for MSK signal

```

1 //clear//
2 //Caption:Signal Space diagram for coherent BPSK
3 //Example7.2: Sequence and Waveforms for MSK signal
4 //Table 7.2 signal space characterization of MSK
5 clear
6 clc;
7 close;
8 M =2;
9 Tb =1;
10 t1 = -Tb:0.01:Tb;
11 t2 = 0:0.01:2*Tb;
12 phi1 = cos(2*%pi*t1).* cos((%pi/(2*Tb))*t1);
13 phi2 = sin(2*%pi*t2).* sin((%pi/(2*Tb))*t2);
14 teta_0 = [0,%pi];
15 teta_tb = [%pi/2,-%pi/2];
16 S1 = [];
17 S2 = [];
18 for i = 1:M
19     s1(i) = cos(teta_0(i));
20     s2(i) = -sin(teta_tb(i));
21     S1 = [S1 s1(i)*phi1];
22     S2 = [S2 s2(i)*phi2];
23 end
24 for i = M:-1:1
25     S1 = [S1 s1(i)*phi1];
26     S2 = [S2 s2(i)*phi2];
27 end
28 Input_Sequence =[1,1,0,1,0,0,0];
29 S = [];

```

```

30 t = 0:0.01:1;
31 S = [S cos(0)*cos(2*%pi*t)-sin(%pi/2)*sin(2*%pi*t)];
32 S = [S cos(0)*cos(2*%pi*t)-sin(%pi/2)*sin(2*%pi*t)];
33 S = [S cos(%pi)*cos(2*%pi*t)-sin(%pi/2)*sin(2*%pi*t)
];
34 S = [S cos(%pi)*cos(2*%pi*t)-sin(-%pi/2)*sin(2*%pi*t
)];
35 S = [S cos(0)*cos(2*%pi*t)-sin(-%pi/2)*sin(2*%pi*t)
];
36 S = [S cos(0)*cos(2*%pi*t)-sin(-%pi/2)*sin(2*%pi*t)
];
37 S = [S cos(0)*cos(2*%pi*t)-sin(-%pi/2)*sin(2*%pi*t)
];
38 y = [s1(1),s2(1);s1(2),s2(1);s1(2),s2(2);s1(1),s2(2)
];
39 disp(y,'coordinates of message points')
40 figure
41 subplot(3,1,1)
42 a = gca();
43 a.x_location = "origin";
44 plot(S1)
45 title('Scaled time function s1*phi1(t)')
46 subplot(3,1,2)
47 a = gca();
48 a.x_location = "origin";
49 plot(S2)
50 title('Scaled time function s2*phi2(t)')
51 subplot(3,1,3)
52 a = gca();
53 a.x_location = "origin";
54 plot(S)
55 title('Obtained by adding s1*phi1(t)+s2*phi2(t) on a
bit-by-bit basis')

```

Scilab code Exa 7.3 Illustrating the generation of DPSK signal

```

1 //clear//
2 //Caption:Illustrating the generation of DPSK signal
3 //Table7.3 Generation of Differential Phase shift
   keying signal
4 clc;
5 bk = [1,0,0,1,0,0,1,1]; //input digital sequence
6 for i = 1:length(bk)
7     if(bk(i)==1)
8         bk_not(i) =~1;
9     else
10        bk_not(i)= 1;
11    end
12 end
13 dk_1(1) =bool2s( 1 & bk(1)); //initial value of
   differential encoded sequence
14 dk_1_not(1)=bool2s(0& bk_not(1));
15 dk(1) = bitxor(dk_1(1),dk_1_not(1)) //first bit of
   dpsk encoder
16 for i=2:length(bk)
17     dk_1(i) = dk(i-1);
18     dk_1_not(i) = ~dk(i-1);
19     dk(i) = bitxor(bool2s(dk_1(i)& bk(i)),bool2s(
   dk_1_not(i)& bk_not(i)));
20 end
21 for i =1:length(dk)
22     if(dk(i)==1)
23         dk_radians(i)=0;
24     elseif(dk(i)==0)
25         dk_radians(i)=%pi;
26     end
27 end
28 disp('Table 7.3 Illustrating the Generation of DPSK
   Signal')
29 disp('
   -----
   ')
30 disp(bk, '(bk)')
31 bk_not = bk_not';

```

```

32 disp(bk_not, '(bk_not)')
33 dk = dk';
34 disp(dk, 'Differentially encoded sequence (dk)')
35 dk_radians = dk_radians';
36 disp(dk_radians, 'Transmitted phase in radians')
37 disp('
-----
')
```

Scilab code Exa 7.4 Signal Space diagram for coherent BFSK

```

1 //clear//
2 //Caption:Signal Space diagram for coherent BFSK
3 //Figure7.4 Signal Space Diagram for coherent BFSK
  system
4 clear
5 clc;
6 close;
7 M =2;
8 y = [1,0;0,1];
9 annot = dec2bin([M-1:-1:0], log2(M));
10 disp(y, 'coordinates of message points')
11 disp(annot, 'Message points')
12 figure;
13 a =gca();
14 a.data_bounds = [-2,-2;2,2];
15 a.x_location = "origin";
16 a.y_location = "origin";
17 plot2d(y(1,1),y(1,2),-9)
18 plot2d(y(2,1),y(2,2),-5)
19 xlabel('
      In-Phase');
20 ylabel('
      Out-Phase');
```

```

    Quadrature');
21 title('Constellation for BFSK')
22 legend(['message point 1 (binary 1)'; 'message point
    2 (binary 0)'],5)

```

Scilab code Exa 7.4.7.20 Comparison of error probability

```

1 //clear//
2 //Caption:Comparison of error probability of
    different data transmission schemes
3 //Table7.4:Figure 7.20
4 //Comparison of Symbol Error Probability
5 //of Different Digital Transmission System
6 clear;
7 close;
8 clc;
9 //Eb = Energy of the bit No = Noise Spectral
    Density
10 Eb_No = [18,0.3162278];
11 x = Eb_No(2):1/100:Eb_No(1);
12 x_dB = 10*log10(x);
13 for i = 1:length(x)
14 //Error Probability of Coherent BPSK
15 Pe_BPSK(i) = (1/2)*erfc(sqrt(x(i)));
16 //Error Probability of Coherent BFSK
17 Pe_BFSK(i) = (1/2)*erfc(sqrt(x(i)/2));
18 //Error Probability Non-Coherent PSK = DPSK
19 Pe_DPSK(i) = (1/2)*exp(-x(i));
20 //Error Probability Non-Coherent FSK
21 Pe_NFSK(i) = (1/2)*exp(-(x(i)/2));
22 //Error Probability of QPSK & MSK
23 Pe_QPSK_MSK(i) = erfc(sqrt(x(i)))-((1/4)*(erfc(
    sqrt(x(i)))^2));
24 end
25 a = gca();

```



```

26 a.data_bounds=[-5,0;12.5,0.5];
27 plot2d(x_dB,Pe_BPSK)
28 plot2d(x_dB,Pe_BFSK)
29 poly1= a.children(1).children(1);
30 poly1.foreground = 3;
31 plot2d(x_dB,Pe_DPSK)
32 poly1= a.children(1).children(1);
33 poly1.foreground = 4;
34 plot2d(x_dB,Pe_NFSK)
35 poly1= a.children(1).children(1);
36 poly1.foreground = 6;
37 plot2d(x_dB,Pe_QPSK_MSK)
38 poly1= a.children(1).children(1);
39 poly1.foreground = 7;
40 xlabel('Eb/No in dB ---->')
41 ylabel('Probability of Error Pe---->')
42 title('Comparison of Noise Performance of different
      PSK & FSK Scheme')
43 legend(['BPSK', 'BFSK', 'DPSK', 'Non-Coherent FSK', '
      QPSK & MSK'])
44 xgrid(1)

```

Scilab code Exa 7.06 Bandwidth efficiency of M-ary PSK signals

```

1 //clear//
2 //Caption:Bandwidth efficiency of M-ary PSK signals
3 //Table7.6: Bandwidth Efficiency of M-ary PSK
  signals
4 clear;
5 clc;
6 close;
7 M = [2,4,8,16,32,64]; //M-ary
8 Ruo = log2(M)./2; //Bandwidth efficiency in bits/s/
  Hz
9 disp('Table 7.7 Bandwidth Efficiency of M-ary PSK

```

```

    signals ')
10 disp('
    -----
    ')
11 disp(M, 'M')
12 disp('
    -----
    ')
13 disp(Ruo, 'r in bits/s/Hz')
14 disp('
    -----
    ')

```

Scilab code Exa 7.6 Signal space diagram for coherent QPSK waveform

```

1 //clear//
2 //Caption:Signal space diagram for coherent QPSK
  waveform
3 //Figure7.6 Signal Space Diagram for coherent QPSK
  system
4 clear
5 clc;
6 close;
7 M =4;
8 i = 1:M;
9 y = cos((2*i-1)*%pi/4)-sin((2*i-1)*%pi/4)*%i;
10 annot = dec2bin([0:M-1],log2(M));
11 disp(y,'coordinates of message points')
12 disp(annot,'dibits value')
13 figure;
14 a =gca();
15 a.data_bounds = [-1,-1;1,1];
16 a.x_location = "origin";
17 a.y_location = "origin";
18 plot2d(real(y(1)),imag(y(1)),-2)

```

```

19 plot2d(real(y(2)), imag(y(2)), -4)
20 plot2d(real(y(3)), imag(y(3)), -5)
21 plot2d(real(y(4)), imag(y(4)), -9)
22 xlabel('
                                     In-
                                     Phase');
23 ylabel('
                                     Quadrature');
24 title('Constellation for QPSK')
25 legend(['message point 1 (dibit 10)'; 'message point
        2 (dibit 00)'; 'message point 3 (dibit 01)'; '
        message point 4 (dibit 11)'], 5)

```

Scilab code Exa 7.7 Bandwidth efficiency of M-ary FSK signals

```

1 //clear//
2 //Caption:Bandwidth efficiency of M-ary FSK signals
3 //Table7.7: Bandwidth Efficiency of M-ary FSK
4 clear;
5 clc;
6 close;
7 M = [2,4,8,16,32,64]; //M-ary
8 Ruo = 2*log2(M)./M; //Bandwidth efficiency in bits/s
   /Hz
9 //M = M';
10 //Ruo = Ruo';
11 disp('Table 7.7 Bandwidth Efficiency of M-ary FSK
        signals')
12 disp('
        -----
        ')
13 disp(M, 'M')
14 disp('
        -----

```

```

    ')
15 disp(Ruo, 'r in bits/s/Hz')
16 disp('
-----
    ')

```

Scilab code Exa 7.12.7.2 Signal space diagram for MSK diagram

```

1 //clear//
2 //Caption:Signal space diagram for MSK diagram
3 //Figure7.12 Signal Space Diagram for coherent MSK
  system
4 //Table 7.2 signal space characterization of MSK
5 clear
6 clc;
7 close;
8 M =2;
9 teta_0 = [0,%pi];
10 teta_tb = [%pi/2,-%pi/2];
11 for i = 1:M
12     s1(i) = cos(teta_0(i));
13     s2(i) = -sin(teta_tb(i));
14 end
15 y = [s1(1),s2(1);s1(2),s2(1);s1(2),s2(2);s1(1),s2(2)
      ];
16 disp(y,'coordinates of message points')
17 figure;
18 a =gca();
19 a.data_bounds = [-2,-2;2,2];
20 a.x_location = "origin";
21 a.y_location = "origin";
22 plot2d(y(1,1),y(1,2),-2)
23 plot2d(y(2,1),y(2,2),-4)
24 plot2d(y(3,1),y(3,2),-6)
25 plot2d(y(4,1),y(4,2),-9)

```

```

26 xlabel('
    In-Phase');
27 ylabel('
    Quadrature');
28 title('Constellation for MSK')
29 legend(['message point 1 (0, %pi/2)'; 'message point
    2 (%pi, %pi/2)'; 'message point 3 (%pi, - %pi/2)
    '; 'message point 4(0, - %pi/2)'],5)

```

Scilab code Exa 7.29 Power Spectra of BPSK and BFSK signals

```

1 //clear//
2 //Caption:Power Spectra of BPSK and BFSK signals
3 //Figure7.29:Comparison of Power Spectral Densities
  of BPSK
4 //and BFSK
5 clc;
6 rb = input('Enter the bit rate=');
7 Eb = input('Enter the energy of the bit=');
8 f = 0:1/100:8/rb;
9 Tb = 1/rb; //Bit duration
10 for i= 1:length(f)
11     if(f(i)==(1/(2*Tb)))
12         SB_FSK(i)=Eb/(2*Tb);
13     else
14         SB_FSK(i) = (8*Eb*(cos(%pi*f(i)*Tb)^2))/((%pi
            ^2)*(((4*(Tb^2)*(f(i)^2))-1)^2));
15     end
16     SB_PSK(i)=2*Eb*(sinc_new(f(i)*Tb)^2);
17 end
18 a=gca();
19 plot(f*Tb,SB_FSK/(2*Eb))
20 plot(f*Tb,SB_PSK/(2*Eb))

```

```

21 poly1= a.children(1).children(1);
22 poly1.foreground = 6;
23 xlabel('Normalized Frequency ——>')
24 ylabel('Normalized Power Spectral Density——>')
25 title('PSK Vs FSK Power Spectra Comparison')
26 legend(['Frequency Shift Keying', 'Phase Shift Keying
        '])
27 xgrid(1)
28 //Result
29 //Enter the bit rate in bits per second:2
30 //Enter the Energy of bit:1

```

Scilab code Exa 7.30 Power Spectra of QPSK and MSK signals

```

1 //clear//
2 //Caption:Power Spectra of QPSK and MSK signals
3 //Figure7.30:Comparison of QPSK and MSK Power
  Spectrums
4 //clear;
5 //close;
6 //clc;
7 rb = input('Enter the bit rate in bits per second:')
  ;
8 Eb = input('Enter the Energy of bit:');
9 f = 0:1/(100*rb):(4/rb);
10 Tb = 1/rb; //bit duration in seconds
11 for i = 1:length(f)
12     if(f(i)==0.5)
13         SB_MSK(i) = 4*Eb*f(i);
14     else
15         SB_MSK(i) = (32*Eb/(%pi^2))*(cos(2*%pi*Tb*f(i))
            /((4*Tb*f(i))^2-1))^2;
16     end
17     SB_QPSK(i)= 4*Eb*sinc_new((2*Tb*f(i)))^2;
18 end

```

```

19 a = gca();
20 plot(f*Tb, SB_MSK/(4*Eb));
21 plot(f*Tb, SB_QPSK/(4*Eb));
22 poly1= a.children(1).children(1);
23 poly1.foreground = 3;
24 xlabel('Normalized Frequency ——>')
25 ylabel('Normalized Power Spectral Density ——>')
26 title('QPSK Vs MSK Power Spectra Comparison')
27 legend(['Minimum Shift Keying', 'QPSK'])
28 xgrid(1)
29 //Result
30 //Enter the bit rate in bits per second:2
31 //Enter the Energy of bit:1

```

Scilab code Exa 7.31 Power spectra of M-ary PSK signals

```

1 //clear//
2 //Caption:Power spectra of M-ary PSK signals
3 //Figure7.31 Comparison of Power Spectral Densities
  of M-ary PSK signals
4 rb = input('Enter the bit rate=');
5 Eb = input('Enter the energy of the bit=');
6 f = 0:1/100:rb;
7 Tb = 1/rb; //Bit duration
8 M = [2,4,8];
9 for j = 1:length(M)
10   for i= 1:length(f)
11     SB_PSK(j,i)=2*Eb*(sinc_new(f(i)*Tb*log2(M(j)))
      ^2)*log2(M(j));
12   end
13 end
14 a=gca();
15 plot2d(f*Tb, SB_PSK(1, :)/(2*Eb))
16 plot2d(f*Tb, SB_PSK(2, :)/(2*Eb), 2)
17 plot2d(f*Tb, SB_PSK(3, :)/(2*Eb), 5)

```

```

18 xlabel('Normalized Frequency ——>')
19 ylabel('Normalized Power Spectral Density——>')
20 title('Power Spectra of M-ary signals for M =2,4,8')
21 legend(['M=2', 'M=4', 'M=8'])
22 xgrid(1)
23 //Result
24 //Enter the bit rate in bits per second:2
25 //Enter the Energy of bit:1

```

Scilab code Exa 7.41 Matched Filter output of rectangular pulse

```

1 //clear//
2 //Caption:Matched Filter output of rectangular pulse
3 //Figure7.41
4 //Matched Filter Output
5 clear;
6 clc;
7 T =4;
8 a =2;
9 t = 0:T;
10 g = 2*ones(1,T+1);
11 h =abs(convol(g,g));
12 for i = 1:length(h)
13     if(h(i)<0.01)
14         h(i) =0;
15     end
16 end
17 h = h-T;
18 t1 = 0:length(h)-1;
19 figure
20 a =gca();
21 a.data_bounds = [0,0;6,4];
22 plot2d(t,g,5)
23 xlabel('t——>')
24 ylabel('g(t)——>')

```



```
25 title('Rectangular pulse duration  $T = 4$ ,  $a = 2$ ')
26 figure
27 plot2d(t1,h,6)
28 xlabel('t—>')
29 ylabel('Matched Filter output')
30 title('Output of filter matched to rectangular pulse
      g(t)')
```

Chapter 8

Error Control Coding

Scilab code Exa 8.1 Repetition Codes

```
1 //clear//
2 //Caption: Repetition Codes
3 //Example8.1: Repetition Codes
4 clear;
5 clc;
6 n =5; //block of identical 'n' bits
7 k =1; //one bit
8 m = 1; // bit value = 1
9 I = eye(n-k,n-k); //Identity matrix
10 P = ones(1,n-k); //coefficient matrix
11 H = [I P']; //parity-check matrix
12 G = [P 1]; //generator matrix
13 x = m.*G; //code word
14 disp(G, 'generator matrix');
15 disp(H, 'parity-check matrix');
16 disp(x, 'code word for binary one input');
```

Scilab code Exa 8.2 Hamming Codes

```

1 //clear//
2 //Caption:Hamming Codes
3 //Example8.2:Hamming codes
4 clear;
5 clc;
6 k = 4; //message bits length
7 n = 7; //block length
8 m = n-k; //Number of parity bits
9 I = eye(k,k); //identity matrix
10 disp(I, 'identity matrix Ik')
11 P = [1,1,0;0,1,1;1,1,1;1,0,1]; //coefficient matrix
12 disp(P, 'coefficient matrix P')
13 G = [P I]; //generator matrix
14 disp(G, 'generator matrix G')
15 H = [eye(k-1,k-1) P']; //parity check matrix
16 disp(H, 'parity checkk matrix H')
17 //message bits
18 m =
    [0,0,0,0;0,0,0,1;0,0,1,0;0,0,1,1;0,1,0,0;0,1,0,1;0,1,1,0;0,1,1,1];

19 //
20 C = m*G;
21 C = modulo(C,2);
22 disp(C, 'Code words of (7,4) Hamming code')

```

Scilab code Exa 8.3 Hamming Codes Revisited

```

1 //clear//
2 //Caption:Hamming Codes Revisited
3 //Example8.3:(7,4) Hamming Code Revisited
4 //message sequence = [1,0,0,1]
5 //D = poly(0,D);
6 clc;
7 D = poly(0, 'D');
8 g = 1+D+0+D^3; //generator polynomial

```

```

 9 m = (D^3)*(1+0+0+D^3); //message sequence
10 [r,q] = pdiv(m,g);
11 p = coeff(r);
12 disp(r,'remainder in polynomial form')
13 disp(p,'Parity bits are:')
14 G = [g;g*D;g*D^2;g*D^3];
15 G = coeff(G);
16 disp(G,'G')
17 G(3,:) = G(3,:)+G(1,:);
18 G(3,:) = modulo(G(3,:),2);
19 G(4,:) = G(1,:)+G(2,:)+G(4,:);
20 G(4,:) = modulo(G(4,:),2);
21 disp(G,'Generator Matrix G =')
22 h = 1+D^-1+D^-2+D^-4;
23 H_D = [D^4*h;D^5*h;D^6*h];
24 H_num = numer(H_D);
25 H = coeff(H_num);
26 H(1,:) =H(1,:)+H(3,:);
27 H(1,:) = modulo(H(1,:),2);
28 disp(H,'Partiy Check matrix H =')

```

Scilab code Exa 8.4 Encoder for the (7,4) Cyclic Hamming Code

```

1 //clear//
2 //Caption:Encoder for the (7,4) Cyclic Hamming Code
3 //Example8.4:Encoder for the (7,4) Cyclic hamming
  code
4 //message sequence = [1,0,0,1]
5 //D = poly(0,D);
6 D = poly(0,'D');
7 g = 1+D+0+D^3; //generator polynomial
8 m = (D^3)*(1+0+0+D^3); //message sequence
9 [r,q] = pdiv(m,g);
10 p = coeff(r);
11 disp(r,'remainder in polynomial form')

```

```

12 disp(p, 'Parity bits are:')
13 disp('Table 8.3 Contents of the Shift Register in
    the Encoder of fig8.7 for Message Sequence(1001)')
14 disp('
    -----
    ')
15 disp('Shift          Input          Register
    Contents')
16 disp('
    -----
    ')
17 disp('1              1              1 1 0')
18 disp('2              0              0 1 1')
19 disp('3              0              1 1 1')
20 disp('4              1              0 1 1')
21 disp('
    -----
    ')

```

Scilab code Exa 8.5 syndrome calculator for the(7,4) Cyclic Hamming Code

```

1 //clear//
2 //Caption:Syndrome calculator for the(7,4) Cyclic
  Hamming Code
3 //Example8.5: Syndrome calculator
4 //message sequence = [0,1,1,1,0,0,1]
5 clc;
6 D = poly(0, 'D');
7 g = 1+D+0+D^3; //generator polynomial
8 C1 = 0+D+D^2+D^3+0+0+D^6;//error free codeword
9 C2 = 0+D+D^2+0+0+0+D^6;//middle bit is error
10 [r1,q1] = pdiv(C1,g);
11 S1 = coeff(r1);
12 S1 = modulo(S1,2);

```

```

13 disp(r1,'remainder in polynomial form')
14 disp(S1,'Syndrome bits for error free codeword are:')
    )
15 [r2,q2] = pdiv(C2,g);
16 S2 = coeff(r2);
17 S2 = modulo(S2,2);
18 disp(r2,'remainder in polynomial form for errored
    codeword')
19 disp(S2,'Syndrome bits for errored codeword are:')

```

Scilab code Exa 8.6 Reed-Solomon Codes

```

1 //clear//
2 //Caption:Reed-Solomon Codes
3 //Example8.6: Reed-Solomon Codes
4 //Single-error-correcting RS code with a 2-bit byte
5 clc;
6 m =2; //m-bit symbol
7 k = 1^2; //number of message bits
8 t =1; //single bit error correction
9 n = 2^m-1; //code word length in 2-bit byte
10 p = n-k; //parity bits length in 2-bit byte
11 r = k/n; //code rate
12 disp(n,'n')
13 disp(p,'n-k')
14 disp(r,'Code rate:r = k/n =')
15 disp(2*t,'It can correct any error upto =')

```

Scilab code Exa 8.7 Convolutional Encoding - Time domain approach

```

1 //clear//
2 //Caption:Convolutional Encoding - Time domain
    approach

```

```

3 //Example8.7: Convolutional Code Generation
4 //Time Domain Approach
5 close;
6 clc;
7 g1 = input('Enter the input Top Adder Sequence:= ');
8 g2 = input('Enter the input Bottom Adder Sequence:= '
9 )
9 m = input('Enter the message sequence:= ');
10 x1 = round(convol(g1,m));
11 x2 = round(convol(g2,m));
12 x1 = modulo(x1,2);
13 x2 = modulo(x2,2);
14 N = length(x1);
15 for i =1:length(x1)
16     x(i,:) =[x1(N-i+1),x2(N-i+1)];
17 end
18 x = string(x)
19 disp(x)
20 //Result
21 //Enter the input Top Adder Sequence:=[1,1,1]
22 //Enter the input Bottom Adder Sequence:=[1,0,1]
23 //Enter the message sequence:=[1,1,0,0,1]
24 //x =
25 //!1  1  !
26 //!   !
27 //!1  0  !
28 //!   !
29 //!1  1  !
30 //!   !
31 //!1  1  !
32 //!   !
33 //!0  1  !
34 //!   !
35 //!0  1  !
36 //!   !
37 //!1  1  !

```

Scilab code Exa 8.8 Convolutional Encoding

```
1 //clear//
2 //Caption:Convolutional Encoding Transform domain
  approach
3 //Example8.8:Convolutional code – Transform domain
  approach
4 clc;
5 D = poly(0, 'D');
6 g1D = 1+D+D^2; //generator polynomial 1
7 g2D = 1+D^2; //generator polynomial 2
8 mD = 1+0+0+D^3+D^4; //message sequence polynomial
  representation
9 x1D = g1D*mD; //top output polynomial
10 x2D = g2D*mD; //bottom output polynomial
11 x1 = coeff(x1D);
12 x2 = coeff(x2D);
13 disp(modulo(x1,2), 'top output sequence')
14 disp(modulo(x2,2), 'bottom output sequence')
15 //Result
16 //top output sequence
17 // 1. 1. 1. 1. 0. 0. 1.
18 //
19 // bottom output sequence
20 // 1. 0. 1. 1. 1. 1. 1.
```

Scilab code Exa 8.11 Convolutional code for binary symmetric channel

```
1 //clear//
2 //Caption:Fano metric for binary symmetric channel
  using convolutional code
```



```

3 //Example8.11: Convolutional code for binary
  symmetric channel
4 clc;
5 r = 1/2; //code rate
6 n =2; //number of bits
7 pe = 0.04; //transition probability
8 p = 1-pe; // probability of correct reception
9 gama_1 = 2*log2(p)+2*(1-r); //branch metric for
  correct reception
10 gamma_2 = log2(pe*p)+1; //branch metric for any one
  correct reception
11 gamma_3 = 2*log2(pe)+1; //branch metric for no
  correct reception
12 disp(gama_1,'branch metric for correct reception')
13 disp(gamma_2,'branch metric for any one correct
  reception')
14 disp(gamma_3,'branch metric for no correct reception
  ')
15 //branch metric for correct reception
16 //      0.8822126
17 //  branch metric for any one correct reception
18 //      - 3.7027499
19 //  branch metric for no correct reception
20 //      - 8.2877124

```

Chapter 9

Spread Spectrum Modulation

Scilab code Exa 9.1 PN sequence generation

```
1 //clear//
2 //Caption:PN sequence generation
3 //Example9.1 and Figure9.1: Maximum-length sequence
  generator
4 //Program to generate Maximum Length Pseudo Noise
  Sequence
5 //Period of PN Sequence N = 7
6 clc;
7 //Assign Initial value for PN generator
8 x0= 1;
9 x1= 0;
10 x2 =0;
11 x3 =0;
12 N = input('Enter the period of the signal')
13 for i =1:N
14     x3 =x2;
15     x2 =x1;
16     x1 = x0;
17     x0 =xor(x1,x3);
18     disp(i, 'The PN sequence at step ')
19     x = [x1 x2 x3];
```

```

20     disp(x, 'x=')
21 end
22 m = [7,8,9,10,11,12,13,17,19];
23 N = 2^m-1;
24 disp('Table 9.1 Range of PN Sequence lengths')
25 disp('
-----
      ')
26 disp('Length of shift register (m)')
27 disp(m)
28 disp('PN sequence Length (N)')
29 disp(N)
30 disp('
-----
      ')
31 //RESULTEnter the period of the signal 7
32 // The PN sequence at step 1.
33 // x=      1.    0.    0.
34 // The PN sequence at step 2.
35 // x=      1.    1.    0.
36 // The PN sequence at step 3.
37 // x=      1.    1.    1.
38 // The PN sequence at step 4.
39 // x=      0.    1.    1.
40 // The PN sequence at step 5.
41 // x=      1.    0.    1.
42 // The PN sequence at step 6.
43 // x=      0.    1.    0.
44 // The PN sequence at step 7.
45 // x=      0.    0.    1.

```

Scilab code Exa 9.2 Maximum length sequence property

```

1 //clear//
2 //Caption:Maximum length sequence property

```

```

3 //Example9.2 and Figure 9.2: Maximum-length sequence
4 //Period of PN Sequence N = 7
5 //Properties of maximum-length sequence
6 clc;
7 //Assign Initial value for PN generator
8 x0= 1;
9 x1= 0;
10 x2 =0;
11 x3 =0;
12 N = input('Enter the period of the signal')
13 one_count = 0;
14 zero_count = 0;
15 for i =1:N
16     x3 =x2;
17     x2 =x1;
18     x1 = x0;
19     x0 =xor(x1,x3);
20     disp(i,'The PN sequence at step')
21     x = [x1 x2 x3];
22     disp(x,'x=')
23     C(i) = x3;
24     if(C(i)==1)
25         C_level(i)=1;
26         one_count = one_count+1;
27     elseif(C(i)==0)
28         C_level(i)=-1;
29         zero_count = zero_count+1;
30     end
31 end
32 disp(C,'Output Sequence')//refer equation 9.4
33 disp(C_level,'Output Sequence levels')//refer
    equation 9.5
34 if(zero_count < one_count)
35     disp(one_count,'Number of 1s in the given PN
        sequence')
36     disp(zero_count,'Number of 0s in the given PN
        sequence')
37     disp('Property 1 (Balance property) is satisfied')

```

```

    )
38 end
39 Rc_tuo = corr(C_level,N);
40 t = 1:2*length(C_level);
41 //
42 figure
43 a =gca();
44 a.x_location = "origin";
45 plot2d(t,[C_level; C_level])
46 xlabel(' t')
47 title('Waveform of maximum-length sequence [0 0 1 1
    1 0 1 0 0 1 1 1 0 1]')
48 //
49 figure
50 a =gca();
51 a.x_location ="origin";
52 a.y_location ="origin";
53 plot2d([-length(Rc_tuo)+1:-1,0:length(Rc_tuo)-1],[
    Rc_tuo($:-1:2),Rc_tuo],5)
54 xlabel('
    tuo')
55 ylabel('
    Rc(tuo)')
56 title('Autocorrelation of maximum-length sequence')

```

Scilab code Exa 9.3 Processing gain, PN sequence length, Jamming margin in dB

```

1 //clear//
2 //Caption:Processing gain, PN sequence length,
    Jamming margin in dB
3 //Example9.3: Processing gain and Jamming Margin
4 clear;
5 clc;

```

```

6 close;
7 Tb = 4.095*10^-3; //Information bit duration
8 Tc = 1*10^-6; //PN chip duration
9 PG = Tb/Tc; //Processing gain
10 disp(PG, 'The processing gain is:')
11 N = PG; //PN sequence length
12 m = log2(N+1); //feedback shift register length
13 disp(N, 'The required PN sequence is:')
14 disp(m, 'The feedback shift register length:')
15 Eb_No = 10; //Energy to noise density ratio
16 J_P = PG/Eb_No; //Jamming Margin
17 disp(10*log10(J_P), 'Jamming Margin in dB:')
18 //Result
19 //The processing gain is: 4095.
20 //The required PN sequence is: 4095.
21 //The feedback shift register length: 12.
22 //Jamming Margin in dB: 26.122539

```

Scilab code Exa 9.4.9.5 Slow and Fast Frequency hopping: FH/MFSK

```

1 //clear//
2 //Caption:Slow and Fast Frequency hopping: FH/MFSK
3 //Example9.4 and Example9.5: Parameters of FH/MFSK
  signal
4 //Slow and Fast Frequency Hopping
5 clear;
6 close;
7 clc;
8 K =2; //number of bits per symbol
9 M = 2^K; //Number of MFSK tones
10 N = 2^M-1; //Period of the PN sequence
11 k = 3; //length of PN sequence per hop
12 disp(K, 'number of bits per symbol K =')
13 disp(M, 'Number of MFSK tones M=')
14 disp(N, 'Period of the PN sequence N =')

```

```

15 disp(k, 'length of PN sequence per hop k =')
16 disp(2^k, 'Total number of frequency hops =')
17 // Result
18 // number of bits per symbol K = 2.
19 // Number of MFSK tones M = 4.
20 // Period of the PN sequence N = 15.
21 // length of PN sequence per hop k = 3.
22 // Total number of frequency hops = 8.

```

Scilab code Exa 9.4.96 Direct Sequence Spread Coherent BPSK

```

1 // clear //
2 // Caption: Direct Sequence Spread Coherent BPSK
3 // Figure 9.4: Generation of waveforms in DS/BPSK
  spread spectrum transmitter
4 clear;
5 close;
6 clc;
7 t = 0:13;
8 N = 7;
9 wt = 0:0.01:1;
10 bt = [1*ones(1,N) -1*ones(1,N)];
11 ct = [0,0,1,1,1,0,1,0,0,1,1,1,0,1];
12 ct_polar = [-1,-1,1,1,1,-1,1,-1,-1,1,1,1,-1,1];
13 mt = bt.*ct_polar;
14 Carrier = 2*sin(wt*2*%pi);
15 st = [];
16 for i = 1:length(mt)
17   st = [st mt(i)*Carrier];
18 end
19 //
20 figure
21 subplot(3,1,1)
22 a = gca();
23 a.x_location = "origin";

```

```

24 a.y_location = "origin";
25 a.data_bounds = [0,-2;20,2];
26 plot2d2(t,bt,5)
27 xlabel('

        t')
28 title('Data b(t)')
29 subplot(3,1,2)
30 a =gca();
31 a.x_location = "origin";
32 a.y_location = "origin";
33 a.data_bounds = [0,-2;20,2];
34 plot2d2(t,ct_polar,5)
35 xlabel('

        t')
36 title('Spreading code c(t)')
37 subplot(3,1,3)
38 a =gca();
39 a.x_location = "origin";
40 a.y_location = "origin";
41 a.data_bounds = [0,-2;20,2];
42 plot2d2(t,mt,5)
43 xlabel('

        t')
44 title('Product Signal m(t)')
45 //
46 figure
47 subplot(3,1,1)
48 a =gca();
49 a.x_location = "origin";
50 a.y_location = "origin";
51 a.data_bounds = [0,-2;20,2];
52 plot2d2(t,mt,5)
53 xlabel('

        t')

```



```
54 title('Product Signal m(t)')
55 subplot(3,1,2)
56 a = gca();
57 a.x_location = "origin";
58 a.y_location = "origin";
59 a.data_bounds = [0,-2;20,2];
60 plot(Carrier)
61 xlabel('
        t')
62 title('Carrier Signal')
63 subplot(3,1,3)
64 a = gca();
65 a.x_location = "origin";
66 a.y_location = "origin";
67 a.data_bounds = [0,-2;20,2];
68 plot(st)
69 xlabel('
        t')
70 title('DS/BPSK signal s(t)')
71 //
```
