Scilab Textbook Companion for Digital Communications by S. Sharma[1]

Created by
Guttula Eswararao
B.Tech
Electronics Engineering
RGUKT,NUZVID
College Teacher
Muni Rama Krishna
Cross-Checked by
Lavitha Pereira

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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

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.

Contents

List of Scilab Codes

Chapter 2

PROBABILITY RANDOM SIGNALS AND RANDOM PROCESS

Scilab code Exa 2.1.a Probability

```
1 //Caption: Probability
2 //Example 2.1.a
3 //page no 43
4 //Find the Probability
5 clc;
6 clear;
7 redballs=3;
8 whiteballs=4;
9 blackballs=5;
10 //P=ways of choosing a red ball/Total no. of ways
     choosing a ball
11 Pro=redballs/(redballs+whiteballs+blackballs);
12 disp("Probability Getting red ball is");
13 disp(Pro,"P(R)=");
```

Scilab code Exa 2.1.b Probability

```
1
2 //Caption: Probability
3 //Example 2_1b
4 //page no 43
5 //Find the probability Getting black ball
6 clc;
7 clear;
8 redballs=3;
9 whiteballs=4;
10 blackballs=5;
11 //Probability Getting black ball
12 prob=blackballs/(redballs+whiteballs+blackballs);
13 p=1-prob;
14 disp("Probability not getting black ball");
15 disp(p,"P(B~)=");
```

Scilab code Exa 2.1.c Probability

```
1 //Caption: Probability
2 //Example 2.1.c
3 //page no 43
4 //Find the probability
5 clc;
6 clear;
7 redballs=3;
8 whiteballs=4;
```

```
blackballs=5;
//Probability Getting black ball
pb=blackballs/(redballs+whiteballs+blackballs);
//Probability Getting white ball
pw=whiteballs/(redballs+whiteballs+blackballs);
//Probability Getting white ball or black ball
pwb=pb+pw//  black and white are mutuallly exclusive
    events
disp("Probability Getting white ball or black ball
   will be ")
disp(pwb,"P(B+W)=")
```

Scilab code Exa 2.2 Probability

```
//Caption: Probability
//Example 2.2
//page no 43
//find the probability of getting 5
clc;
clear;
total_possibleoutcomes=6*6;
probabilityofeachoutcome=1/total_possibleoutcomes;//
   probability of each outcome
noofways=4; //ways of getting 5
probability=noofways*probabilityofeachoutcome;//
   probability of getting 5
disp(probability,"Probability of getting 5 is");
```

Scilab code Exa 2.3 Probability

```
1 //Caption: Probability
2 //Example 2.3
3 //page no 43
4 //find the probability
5 clc;
6 clear;
7 total_cards=52;
8 ways_of_drawingtwocards=52*51/(2*1);//ways of
     drawing 2cards from a deck of 52cards
9 diamonds=13;
10 Hearts=13;
11 waysof_diamonds_Hearts=diamonds*Hearts;//ways of
     drawing a Diamond and a Heart
12 probability=waysof_diamonds_Hearts/
     ways_of_drawingtwocards;
13
14 disp(probability,"Probability that one card is
     Diamond and Othercard is Heart");
```

Scilab code Exa 2.4 Probability

```
1 //Caption: Probability
2 //Example 2.4
3 //page no 44
4 //find the probability
5 clc;
6 clear;
7 whiteballs=4;
8 blackballs=3;
9 pa1=whiteballs/(whiteballs+blackballs);//probability
     of first ball is white
10 pa2=(whiteballs-1)/(whiteballs+blackballs-1);//
     probability of second ball is white
```

```
11 pa3=(blackballs)/(whiteballs+blackballs-2);//
      probability of third ball is black
12 required_probability=pa1*pa2*pa3;
13 disp(required_probability,"probability of first two
      balls are white and third ball is black");
```

Scilab code Exa 2.5 Probability

```
1
2 //Caption: Probability
3 //Example 2.5
4 //page no 44
5 //find the probability
6 clc;
7 clear;
8 whiteballs=5;
9 redballs=3;
10 balckballs=2;
11 totalballs=whiteballs+redballs+balckballs;
12 pw=whiteballs/totalballs;//probability of
      gettingfirst ball is white
13 pr=redballs/(totalballs-1);//probability of getting
      second ball is red
14 pb=balckballs/(totalballs-2);//probability of
      getting third ball is black
15
16 possbilecases=6;
17 probabalityof_eachcase=pw*pr*pb;
18 totalprobability=6*probabalityof_eachcase;//required
       probability
19 disp(totalprobability,"Probability of balls will be
      in different colours");
```

Scilab code Exa 2.6 Probability

```
1 //Caption: Probability
2 //Example 2.6
3 //page no 45
4 //find the probability
5 clc;
6 clear;
7 //Probability of solving the problem
8 PA=3/4;
9 PB=2/3;
10 PC=1/4;
11 //Probability of not not able solving the problem
12 PNA=1-PA;
13 PNB=1-PB;
14 PNC=1-PC;
15 //probability that no one will solve the problem
16 probability_notsolve=PNA*PNB*PNC;
17 //probability that problem willbe solved
18 probability_solve=1-probability_notsolve;
19 disp(probability_solve,"probability that problem
   willbe solved");
```

Scilab code Exa 2.7 Probability

```
1 //Caption: Probability
2 //Example 2.7
3 //page no 45
```

```
4 //find the probability
5 clc;
6 clear;
7 whiteballs=3;
8 redballs=2;
9 totalballs=whiteballs+redballs;
10 pw1=whiteballs/totalballs;//probability of first
     ball is white
11 pr2=redballs/(totalballs-1)//conditional probability
     event second ball is red with first white
12 probability=pw1*pr2//probability of second ball is
     red with first ball is white
13 disp(probability,"probability of first ball is white
     and second ball is red");
```

Scilab code Exa 2.8 Probability

```
1 //Caption: Probability
2 //Example 2.8
3 //page no 45
4 //find the probability that recorded number is 2
5 clc;
6 clear;
7 head=1/2;//probability of getting head
8 tail=1-head;//probability of getting tail
9 head2= head*1/6;//probability of getting head with
     recorded number is 2
10 tail2=tail*1/36;//probability of getting tail with
     recorded number is 2
11
12 //probability of getting recorded number is 2
13 p=head2+tail2;
14 disp(p,"probability of getting recorded number is 2"
```

```
);
```

Scilab code Exa 2.9 Probability

```
1 //Caption: Probability
2 //Example 2.9
3 //page no 46
4 //find the probability
5 clc;
6 clear;
7 PA=1/8;
8 PB=1/12;
9 probability_makingerror=1/10001;
10 probability=(PA*PB)/((PA*PB)+((1-PA)*(1-PB)*
   probability_makingerror));
11 disp(probability,"Probability of program is correct"
   );
```

Scilab code Exa 2.12 Probability density function

```
1 //Caption: Probability density function
2 //Example 2.12
3 //Find  find the value of k
4 clc;
5 clear;
6 function y=FX1(x)              //for -infinte<x<=0
7          y=0
8 endfunction
9 function y=FX2(x)            //for 0<x<=10
```

```
10          y=k*x^2
11  endfunction
12  function y=FX3(x)           //for 10<x<infine
13          y=100*k
14  endfunction
15  k=poly(0,"k");
16                              //from the expression for
                                    CDF is given
17  y=100*k                     //for 10<x<infine
18  y==1;
19  k=1/100;                    //k=y/100
20  disp(k,"i) k = ");
21  //CDF function can be expressed
22  // FX(x)=P(X<=x)
23  P5=FX2(5);                  //x=5
24  disp(P5,"ii) P(X<=5) = ");
25                              //now differentiating with
                                    respect tox we ,have
26                              //PDF fX=0   for -infinte<
                                    x<=0,10<x<infine
27  x=poly(0,"x");
28  m=x^2/100;
29  df=derivat(m);             // for 0<x<=10
30  disp("  for 0<x<=10",df,"iii)PDF a) fX(x) =");
31  disp("  -infinte<x<=0,10<x<infine",0,"   b)fX(x) = "
    );
32
33  x1=5,x2=7;
34  function y=z(x),
35          y=x/50;
36  endfunction
37  P=intg(x1,x2,z);
38  disp(P,"iv) P(5<X<=7) =");
```

Scilab code Exa 2.13 Probability

```
1 //Caption: Probability
2 //Example 2.13
3 //page no 54
4 //find the probability
5 clc;
6 clear;
7 function y=f(x),
8     y=2*exp(-(2*x)),//Probability Density Function
9 endfunction
10
11 a=1;
12 b=3;
13 P=intg(a,b,f);//probability that random variable
     between 1 and 3
14 disp(P,"P(1<X<3)=");
```

Scilab code Exa 2.14 Probability

```
1 //Caption: Probability
2 //Example 2.14
3 //page no 54
4 //find the probability
5 clc;
6 clear;
7 function y=f(x),
8     y=12*x^3-21*x^2+10*x,//Probability Density
        Function
9 endfunction
10 a=0;
11 b=1/2;
12 P=intg(a,b,f);
```

```
13 disp(P,"P(X<=1/2)=");
14 disp(1-P,"P(X>1/2)=");
```

Scilab code Exa 2.20 Joint probability

```
1  //Caption:  Joint probability
2  //Example 2.20
3  //Page no 60
4  //Find Determine the value of constant C
5  clc;
6  clear;
7  X=[0,0;2,2;2,0];
8  Y=[0,0;3,3;0,3];
9  function y=f(x,y),
10          y=2*x+y;
11 endfunction
12 P=int2d(X,Y,f);
13 C=poly(0,"C");
14 //we know that joint PDF
15 // double integration fXY(x,y)dxdy=1
16 //C*P==1;
17 C=1/P;
18 disp(C,"C = ")
```

Scilab code Exa 2.23 probability density function

```
1  //Caption:  probability density function
2  //Example 2.23
3  //page no
```

```
4  //verify the area under curve is unity,prove that
       the mean is zero
5  clc;
6  clear;
7  //continuous random variable X in the range(-3,3)
8  //PDF of fucntions
9  function y=fX1(x)
10          y=((3+x)^2)/16; //for -3<=x<=-1
11 endfunction
12 a1=-3;
13 a2=-1;
14
15 function y=fX2(x),        //for-1<=x<=1
16         y=(6-2*x^2)/16;
17 endfunction
18 b1=-1;
19 b2=1;
20
21 function y=fX3(x)
22          y=((3-x)^2)/16;    //for 1<=x<=3
23 endfunction
24 c1=1;
25 c2=3;
26 //area under pdf curve
27 //area = integral Fx(x)dx from -3 to 3
28 area =intg(a1,a2,fX1)+intg(b1,b2,fX2)+intg(c1,c2,fX3
       );
29 disp(area,"Area =");
30 disp("  Therefore area under PDF curve is  unity.");
31 function y=f1(x)
32          y=(x*(3+x)^2)/16;     //for -3<=x<=-1
33 endfunction
34 a1=-3;
35 a2=-1;
36
37 function y=f2(x),              //for-1<=x<=1
38         y=(x*(6-2*x^2))/16;
39 endfunction
```

```
40 b1=-1;
41 b2=1;
42 function y=f3(x)
43           y=(x*(3-x)^2)/16;      //for 1<=x<=3
44 endfunction
45 c1=1;
46 c2=3;
47 mx=intg(a1,a2,f1)+intg(b1,b2,f2)+intg(c1,c2,f3);//
      mean value
48 disp(mx,"Mean value =");
49 disp(" Therefore mean value is  zero.");
50 //Therefore area under PDF curve is  unity
51 //Hence Therefore mean value is  zero
```

Scilab code Exa 2.24 mean mean Square Standard deviation

```
1 //Caption:  mean ,mean Square Standard deviation
2 //Example 2.24
3 //page no
4 //Find mean,mean Square ,Standard deviation
5 clc;
6 clear;
7 function y=f(x)
8           y=x/(2*%pi); //for 0<=x<=2*%pi
9 endfunction
10
11 a=0;
12 b=2*%pi;
13 mx=intg(a,b,f);//mean value
14 disp(mx,"Mean value mx=");
15
16 function y=fX(x)
17           y=x^2/(2*%pi); //for 0<=x<=2*%pi
```

```
18 endfunction
19 a=0;
20 b=2*%pi;
21 //X^2=E(X^2)
22 X2=intg(a,b,fX);//mean square value
23 disp(X2,"Mean square value X^2 =");
24
25 sigma2=X2-mx^2;//variance
26 sigma=sqrt(sigma2);//Standard deviation
27 disp(sigma,"Standard deviation sigma=")
```

Scilab code Exa 2.31 Mean and Variance

```
1  //Caption: Mean,Variance
2  //Example 2.31
3  //page no 85
4  //find i)Mean
5  //      ii)Variance of given function
6  clc;
7  clear;
8
9  //Mean Value
10 function X=f(x),
11     z=3*(1-x)^2,//Marginal Probability Density
          Function
12     X=x*z
13 endfunction
14 a=0;
15 b=1;
16 EX=intg(a,b,f);//Mean value of X
17
18 function  Y=c(y)
19      z=3*(1-y)^2,//Marginal Probability Density
```

```
          Function
20        Y=y*z
21  endfunction
22
23  EY=intg(a,b,c);//Mean value of Y
24  disp(EX,"i)Mean of X  =")
25  disp(EY,"  Mean of Y  =")
26
27  //Variance
28  function X=g(x),
29      z=3*(1-x)^2,//Marginal Probability Density
           Function
30      X=x^2*z
31  endfunction
32  a=0;
33  b=1;
34  EX2=intg(a,b,g);
35
36  function  Y=h(y)
37        z=3*(1-y)^2,//Marginal Probability Density
           Function
38        Y=y^2*z
39  endfunction
40
41  EY2=intg(a,b,h);
42
43  vX2=EX2-(EX)^2;//Variance of X
44  vY2=EY2-(EY)^2;//Variance of Y
45
46  disp(vX2,"ii)Variance of X");
47
48  disp(vY2,"  Variance of Y");
```

Chapter 3

SAMPLING THEORY AND PULSE MODULATION

Scilab code Exa 3.1 Nquist Rate

```
1  //Caption: Nquist Rate
2  //Example 3.1
3  //page no 102
4  //find Nquist Rate
5  //given
6  clc;
7  clear;
8  w1=50*%pi;
9  w2=300*%pi;
10 w3=100*%pi;
11 //w=2*%pi*f
12 f1=w1/(2*%pi);
13 f2=w2/(2*%pi);
14 f3=w3/(2*%pi);
15 fm=f2;//fm = maximum frquency is present at the
       signal
16 disp(f2,"maximum frquency of the signal is");
17 disp(" Hz");
18 fs=2*fm;//Nyquist rate
```

```
19 disp("Nquist Rate of Signal is");
20 disp(" Hz",fs);
```

Scilab code Exa 3.2 Nquist Rate and time interval

```
1  //Caption: Nquist Rate,time interval
2  //Example 3.2
3  //page no 103
4  //Find Nquist Rate and Nquist time interval
5  //given
6  clc;
7  clear;
8  w1=5000*%pi;
9  w2=3000*%pi;
10 f1=w1/(2*%pi);
11 f2=w2/(2*%pi);
12 fm=f1;//fm = maximum frquency is present at the
       signal
13 disp(" Hz",f1,"i) maximum frquency of the signal is"
       );
14
15 fs=2*fm;//Nyquist rate
16 disp(" Hz",fs,"ii) Nquist Rate of the given Signal
       is");
17 Ts=1/(2*fm);//frequncy =1/time
18 disp("m Sec",Ts*10^3,"iii) Nquist Interval of the
       given signal is");
```

Scilab code Exa 3.3 Nquist Rate

```
////Caption Nquist Rate
//Example 3.3
//page no 104
//Find Nquist Rate
//given
clc;
clear;
f=100;
fs=2*f;//Nyquist rate
disp(" Hz",fs,"(i)To avoid aliasing Nquist Rate is ");
```

Scilab code Exa 3.4 Nquist Rate

```
//Caption: Nquist Rate
//Example 3.4
//page no 105
//Find Nquist Rate of Continous signal
//given
clc;
clear;

w1=50*%pi;
w2=300*%pi;
w3=100*%pi;
f1=w1/(2*%pi);
f2=w2/(2*%pi);
f3=w3/(2*%pi);
fmax=f2;//fmax = Highest frquency component of the message signal
disp("Highest frquency component of the message signal will be");
disp(fmax,"fmax=");
```

```
18 disp(" Hz");
19 fs=2*fmax;//Nyquist rate
20 disp("Nquist Rate of the given Signal is");
21 disp(" Hz",fs);
```

Scilab code Exa 3.7 Amplitude

```
1 //caption: amplitude
2 //Example 3.7
3 //page no 123
4 //find amplitude distortion at highest frquency
5 //given
6 clc;
7 clear;
8
9 fs=9.5;  //samplig frequncy
10 fmax=1;   //maximum frequncy
11 t=0.2; //pulse width
12 c=3*10^8;
13 f=fmax;
14 H1=t*sinc(f*t); //aperture effect at highest
      frequency
15 disp(H1*100,"|H(1)|=");
16 disp("%");
```

Scilab code Exa 3.8 Transmission Bandwidth

```
1 //Caption: Transmission Bandwidth
2 //Example 3.8
```

```
3  //page no 131
4  //Calculate Transmission Bandwidth
5  //given
6  clc;
7  clear;
8
9  fm=3*10^3;
10 fs=8*10^3;// sampling frequncy
11 Ts=1/fs;
12 t=0.1*Ts;
13 BW=1/(2*t);//Bandwidth
14 disp("Transmission Bandwidth of PAM signal is  ");
15 disp("kHz",BW*10^-3,"BW>=");
```

Chapter 4

WAVEFORM CODING TECHNIQUES

Scilab code Exa 4.2.i code word length

```
1 //Caption:code word length
2 //Example 4.2.i
3 //page no 167
4 //find code word length
5 clc;
6 clear;
7 //Given data
8 bandwidth=4.2*10^6;
9 fm=bandwidth;
10 q=512// Quantization levels
11 //q=2^v
12 v=log10(512)/log10(2);
13 disp(v,"The code word legth is ");
14 disp("bits");
```

Scilab code Exa 4.2.ii Transmission Bandwidth

```
1 //Caption: Transmission Bandwidth
2 //Example 4.2.ii
3 //page no 167
4 //find The transmission Bandwidth
5 clc;
6 clear;
7 //Given data
8 bandwidth=4.2*10^6;
9 fm=bandwidth;
10 q=512// Quantization levels
11 v=9;
12 bw=v*fm;
13 disp(bw*10^-6,"The transmission Bandwidth is ");
14 disp("MHz");
```

Scilab code Exa 4.2.iii Final Bit rate

```
1 //Caption: Final Bit rate
2 //Example 4.2.iii
3 //page no 167
4 //find  Final Bit rate
5 clc;
6 clear;
7 //Given data
8 bandwidth=4.2*10^6;
9 fm=bandwidth;
10 q=512// Quantization levels
11 v=9;
12 fs=2*fm;
13 r=v*fs;//signaling rate
14 disp(r,"Final Bit rate ");
```

```
15 disp("bits/sec");
```

Scilab code Exa 4.2.iv Output signal to noise ratio

```
1 //Caption: Output signal to noise ratio
2 //Example 4.2.iv
3 //page no 167
4 //find Output signal to noise ratio
5 clc;
6 clear;
7 //Given data
8 bandwidth=4.2*10^6;
9 fm=bandwidth;
10 q=512// Quantization levels
11 v=9;
12 sn=4.8+6*v;//noise in dB
13 disp(sn,"Output signal to noise ratio is");
14 disp("dB");
```

Scilab code Exa 4.3.i bits per sample

```
1 //Caption :bits per sample
2 //Example 4.3.i
3 //page no 168
4 //find bits per sample
5 clc;
6 clear;
7 //Given data
8 fmax=4*10^3;
```

```
9  xmax=3.8;
10 snr=100;
11 P=30*10^-3;
12 v=(log10(((snr*xmax^2)/(3*P)))/(2*log10(2)));
13 disp(ceil(v),"Number of bits required per sample are
      ");
14 disp("bits");
```

Scilab code Exa 4.3.ii Transmission Bandwith

```
1  //Caption: Transmission Bandwith
2  //Example 4.3.ii
3  //page no 168
4  //Find  Transmission Bandwith
5  clc;
6  clear;
7  //Given data
8  fm=4*10^3;//Bandwidth of PCM
9  xmax=3.8;
10 snr=100;// Signal to Noise Ratio
11 outputs=30;
12 v=7;
13 bw=outputs*v*fm;
14 r=bw*2;
15 disp(bw/10^3,"Transmission Bandwith");
16 disp("kHz");
17 disp("bits/sec",r/1000,"Signaling rate")
```

Scilab code Exa 4.4 samplingrate bandwidth and bitrate

```
1 //Caption: samplingrate,number of bits,bitrate,
    bandwidth
2 //Example 4.4
3 //page no 169
4 //find sampling rate,number of bits,bit rate,
    bandwidht
5 clc;
6 clear;
7 //Given data
8 emax=0.001;
9 del=2*emax;;
10 fm=100;
11 xmax=10;
12
13 q=(2*xmax)/del;
14 fs=2*fm;
15 v=(log10(q))/log10(2);
16 v=ceil(v);
17 r=v*fs;
18 disp(fs,"i)sampling Frequncy");
19 disp("Hz.");
20 disp(v,"ii)no.of bits in PCM");
21 disp("bits.");
22 disp(r,"iii)sampling rate");
23 disp("bits per second.");
24 disp(r/2,"iv)Transmission Bandwidth");
25 disp("Hz.");
```

Scilab code Exa 4.5 Bandwidth and Sampling Rate

```
1 //Caption: Bandwidth,Sampling Rate
2 //Example 4.5
3 //page no 170
```

```
4 //Find  Bandwidth,Sampling Rate
5 clc;
6 clear;
7 //Given data
8 fm=3.4*10^3;
9 N=24;
10 r=1.5*10^6;
11 encoder=8;
12
13 BW=N*fm;
14 disp(BW/10^3,"Channel Bandwith is");
15 disp("kHz");
16
17 r1=r/N;
18 fs=r1/encoder;
19
20 disp(fs,"sampling frequency");
21 disp("Hz or samples per second.");
```

Scilab code Exa 4.6 Signal Bandwidth and Noise Ratio

```
1 //Caption: Signal Bandwidth,Noise Ratio
2 //Example 4.6
3 //page no 170
4 //Find Signal Bandwidth,Noise Ratio
5 clc;
6 clear;
7 //Given data
8 v=7;
9 r=50*10^6;
10 //fs=2*fm
11 fm=r/(2*v);
12 disp(fm*10^-6,"Maximum message Bandwidth is ");
```

```
13 disp("MHz");
14
15 snr=1.8+(6*v);
16 disp(snr,"signal to quantization niose ration");
17 disp("dB");
```

Scilab code Exa 4.7 Bitspersample and Transmissionrate

```
1 //Caption: bitspersample,Transmissionrate
2 //Example 4.7
3 //page no 171
4 //find i)bits per sample,ii)transmission rate
5 clc;
6 clear;
7 //Given data
8 fm=3*10^3;
9 q=16;
10
11 v=(log10(q))/log10(2);
12 disp(v,"bits in code word");
13 disp("bits");
14 fs=2*fm;
15 r=v*fs;
16 disp(r,"bit trasmission rate");
17 disp("bits per second")
```

Scilab code Exa 4.8 signal to noise ratio

```
1 //Caption:signal to noise ratio
```

```
2 //Example 4.8
3 //page no 171
4 //find signal to noise ratio
5 clc;
6 clear;
7 //Given data
8 fm=3.5*10^3;
9 r=50*10^3;
10 fs=2*fm;
11 rms=0.2;
12 xmax=2;
13 v=r/fs;//signaling rate r=v*fs
14 v=ceil(v);
15 P=(rms^2)/1;
16 SNR=((3*P*2^(2*v))/(xmax^2));
17 SN=10*log10(SNR);
18 disp(ceil(SN),"signal to niose ratio");
19 disp("dB");
```

Scilab code Exa 4.10 noise ratio and required bits

```
1 //Caption :noise ratio,required bits
2 //Example 4.10
3 //page no 173
4 //find i)noise ratio ii)bits
5 clc;
6 clear;
7 //Given data
8 Am=3;
9 v=10;
10 SNR=1.8+6*v;//noise ratio
11 disp(SNR,"Signal to Quantization noise ratio");
12 disp("dB.");
```

```
13 SN=40;
14 v=(SN-1.8)/6;
15
16 disp("bits required to get signal to niose ratio of
      40dB",ceil(v));
```

Scilab code Exa 4.11 Maximum frequency

```
1 //Caption :Maximum frequency
2 //Example 4.11
3 //page no 174
4 //find Maximum frequency
5 clc;
6 clear;
7 //Given data
8 v=7;
9 SNR=1.8+6*v;
10 r=56*10^3;
11 fs=r/v;//r=v*fs signaling rate
12 fm=fs/2;//Nquset rate
13 disp(fm/10^3,"Maximum frequency is");
14 disp("kHz");
```

Scilab code Exa 4.13 Maximum Amplitude

```
1 //Caption: Maximum Amplitude
2 //Example 4.13
3 //page no 185
4 //Find  Maximum Amplitude
```

```
clear;
clc;
fm=3*10^3;
Nyquistrate=2*fm;//Nyquistrate
fs=5*Nyquistrate;//Samplingfrquency
Ts=1/fs;// Sampling Interval
del=0.25;//step size
fm1=2*10^3;
Am=del/(2*%pi*fm1*Ts);
disp("Volts",Am,"Maximum Amplitude ");
```

Scilab code Exa 4.14 Signaling rate

```
//Caption: signaling rate
//Example 4.14
//page no 187
//Find  signaling rate
clear;
clc;
fs1=8*10^3;
del=31.25*10^-3;
q=64;
v=log2(q);
r=v*fs1;//signaling rate
disp(r*10^-3,"i)Signaling rate of PCM is");
disp("kHz");

fm=3*10^3;
A=1;
fs2=(2*%pi*fm*A)/(del);
disp(fs2*10^-3,"ii)The signaling rate of DM is");;
disp("kHz");
```

Scilab code Exa 4.15 Signal to noise ratio

```
1 //Caption: Signal to noise ratio
2 //Example 4.15
3 //page no 188
4 //Find  signal to noise ratio
5 clear;
6 clc;
7 fs=64*10^3;
8 fm=2*10^3;
9 fM=4*10^3;
10 SNR=(3*fs^3)/(8*%pi^2*fm^2*fM);// Signal to noise
     ratio
11 SNRO=10*log10(SNR)
12 disp("dB",SNRO,"Output signal to noise ratio =");
```

Scilab code Exa 4.16 Signal to Quatization noise ratio

```
1 //Caption: Signal to Quatization noise ratio
2 //Example 4.16
3 //page no 188
4 //Find  signal to Quatization noise ratio
5 clear;
6 clc;
7
8 fs=8*10^3;
9 r=64*10^3;
10 N=8;//number of bits
```

```
11 SNR=(1.8+6*N);//signal to Quatization noise ratio
12 disp(SNR,"Signal to Quatization noise ratio of PCM
      system is")
13 disp("dB");
```

Scilab code Exa 4.17 sampling rate and quantizing level

```
1 //Caption: sampling rate,quantizing level
2 //Example 4.17
3 //page no 194
4 //Find  sampling rate,quantizing level
5 clear;
6 clc;
7 r=36000;
8 fm=3.2*10^3;
9 fs=2*fm;//Nquest rate
10
11 v=r/fs;  //r=v*fs signaling rate
12 v=floor(v);
13 q=2^v;
14 fs1=r/v;
15 disp(q,"quantizing level q=");
16 disp(fs1/1000,"sampling rate fs=");
17 disp("kHz");
18 disp(v,"Number of binary digits =")
```

Scilab code Exa 4.18 time duration of binary signal

```
1 //Caption: time duration of binary signal
```

```
2 //Example 4.18
3 //page no 196
4 //Find  time duration of 1bit  binary encoded signal
5 clear;
6 clc;
7 fs=input("Enter the Nyquist rate of Signal fs(Hz)=")
    ;
8 q=input("Enter the Quantization levels q =");
9
10 v=log2(q);//binary pulses transmitted per second
11 t=1/(v*fs);//Nyquist interval
12 disp("  sec",t," Time duration of binary signal  t="
    );
13 //output
14 //Enter the Nyquist rate fs(Hz)=3
15 //Enter the Quantization levels q =5
16
17  // time duration of 1bit binary signal
18
19  //   t=0.1435589  sec
```

Scilab code Exa 4.20 Quantizing noise ratio

```
1
2 //Caption: Quantizing noise ratio
3 //Example 4.20
4 //page no 196
5 //find signal to noise ratio
6 clc;
7 clear;
8
9 SNR=40;
10 SNRO=10^(SNR/10);
```

```
11 //SNR=3(q^2)/2, Signal to Quantization noise ratio
12 q=sqrt((2*SNRO)/3);
13 q=ceil(q);
14 v=log2(q);//q=2^v  Quantization levels
15 v=ceil(v);
16 snr=1.76+6.02*v;//output Signal to Quantization
      noise ratio
17 disp("dB",snr,"Output Signal to Quantization noise
      ratio")
```

Scilab code Exa 4.21.i Quantizing levels and bits per sample

```
1 //Caption:Quantizing  levels, bits per sample
2 //Example 4_21.i
3 //page no 197
4 //Find  Quantizing  levels,minimum number of bits
      per sample
5 clear;
6 clc;
7 SNRO=30;//dB
8 fmin=300;
9 fmax=3300;
10 fs=80000;
11 //SNRO=1.76+20log10(q)
12 q=10^((SNRO-1.76)/20);
13 q=ceil(q);
14 v=log2(q);
15 disp(q,"Quantizing  levels required is");
16 disp(ceil(v),"minimum number of bits per sample are"
      );
```

Scilab code Exa 4.21.ii Bandwidth

```
1 //Caption: Bandwidth
2 //Example 4.21.i
3 //page no 197
4 //Find  minimum required bandwidth
5 clear;
6 clc;
7 SNRO=30;//dB
8 fmin=300;
9 fmax=3300;
10 fs=8000;
11 v=5;
12 fPCM=(v*fs)/2;
13 disp(fPCM/1000,"minimum required bandwidth");
14 disp("kHz");
```

Scilab code Exa 4.21.iii Quantizing levels bits per sample and Bandwidth

```
1 //Caption: Quantizing levels,bits per sample,
    Bandwidth
2 //Example 4.21.iii
3 //page no 197
4 //Find  Quantizing  levels,minimum number of bits
    per sample and bandwidth
5 clear;
6 clc;
7 SNRO=30;//dB
```

```
fmin=300;
fmax=3300;
fs=8000;

q=10^((SNRO+10.1)/20);
q=ceil(q);
v=log2(q);
v=ceil(v);
disp(q,"Quantizing  levels need is");
disp(v,"minimum number of bits per sample is");


fPCM=(v*fs)/2;
disp(fPCM/1000,"minimum required bandwidth");
disp("kHz");
```

Scilab code Exa 4.24 Maximum Amplitude and SNR

```
//Caption: Maximum Amplitude,SNR
//Example 4.24
//page no 199
//determine the  Maximum Amplitude,
//
clear;
clc;
del=250*10^-3;
wm=2*%pi*1000;
fs=3*10^3;
Ts=1/fs

Amax=(del*3*fs*2)/(wm);//Amplitude
disp("V",Amax,"Maximum Amplitude,");
```

Scilab code Exa 4.26 Bits per sample

```
1 //Caption:Bits per sample
2 //Example 4.26
3 //page no 200
4 //Find number of bits per sample
5 clear;
6 clc;
7 SNR=20;//dB
8 averagepower=30*10^-3;
9 SNRO=10^(SNR/10);//dB
10 A=3.8;
11 //L=2^n
12 //SNRO=average signal power/Quatizing power
13 //del=(2*A)/L
14 L=sqrt((SNRO*A^2)/(3*averagepower));
15 n=log2(L);
16 n=ceil(n);
17 disp(n,"Bits required per sample");
```

Scilab code Exa 4.27.i Normalized power

```
1 //Caption:Normalized power
2 //Example 4.27.i
3 //page no 200
4 //Find  Normalized power for quantization noise
5 clear;
6 clc;
```

```
7  fm=3*10^3;
8  v=8;
9  VH=5;
10 VL=-5;
11 q=2^v;
12 del=(VH-VL)/q;
13 Nq=del^2/12;//quantization noise
14 disp("W",Nq,"Normalized power for quantization noise
   ")
```

Scilab code Exa 4.27.ii Bit transmission rate

```
1  //Caption: Bit transmission rate
2  //Example 4.27.ii
3  //page no 200
4  //Find bit transmission rate
5  clear;
6  clc;
7  fm=3*10^3;
8  v=8;
9  VH=5;
10 VL=-5;
11 q=2^v;
12
13 fs=2*fm; //Nyquist rate
14 r=8*fs;
15 disp("K bits/s",r/1000,"bit transmission rate");
```

Scilab code Exa 4.27.iii SNR

```
1  //Caption: SNR
2  //Example 4.27.i
3  //page no 200
4  //Find  Signal to quantization noise ratio
5  clear;
6  clc;
7  Nq=127.15*10^-6
8  Meansignal=2;
9  P=Meansignal/1;
10 SNR=P/Nq;
11 SNRq=10*log10(SNR);
12 disp("dB",SNRq,"Signal to quantization noise ratio")
     ;
```

Scilab code Exa 4.28 SNR bitrate and no of bits recorded

```
1  //Caption: SNR,bitrate,no.of bits recorded
2  //Example 4.28
3  //page no 201
4  //Find  i)SNR  ii)output bit rate iii)no.of bits
     recorded
5  clear;
6  clc;
7  N=16;
8  v=16;
9  fs=44.1*10^3;
10 SNR=1.76+6*N;
11 disp("dB",SNR,"i)Out put signal noise ratio");
12 bitrate=2*v*fs;
13 outputbitrate=2*bitrate;//including addtional 100%
     over head
14 disp("Mbits/sec",outputbitrate*10^-6,"ii)output bit
     rate");
```

```
15 CD=outputbitrate*3600;
16 disp("gigabits",CD*10^-9,"iii)no.of bits recorded in
       CD");
```

Scilab code Exa 4.29 output SNR

```
1 //Caption: output SNR
2 //Example 4.29
3 //page no 202
4 //Find  output SNR
5 clear;
6 clc;
7 fm=1*10^3;
8 fs=32*10^3;
9 FM=4*10^3;// Bandwidth
10 SNR=(3*fs^3)/(8*%pi^2*fm^2*FM);//SNR
11 SNRO=10*log10(SNR);
12 disp("dB",SNRO,"Output signal to noise ratio");
```

Scilab code Exa 4.30.i step size

```
1 //Caption: step size
2 //Example 4.30 i
3 //page no 202
4 //Find  step size
5 clear;
6 clc;
7 fs=64000; //  samples/sec
8 Amax=1;
```

```
fm=3500;
//A=del/(2*%pi*fm*Ts)
del=(2*%pi*fm*Amax)/fs;
disp("mV",del*1000,"Step Size ");
```

Scilab code Exa 4.30.ii Noise power

```
//Caption: noise power
//Example 4.30 ii
//page no 202
//Find  Quantizatio noise power
clear;
clc;
fs=64000;
Amax=1;
fm=3500;
 del=343.6117*10^-3;//step size
 Nq=del^2/3;//Quantizatio noise power
 Nqd=Nq*(fm/fs);
disp("mW",Nqd*1000,"Quantizatio noise power ");
```

Scilab code Exa 4.30.iii Signal to Noise Ratio

```
//Caption: SNR
//Example 4.30 iii
//page no 202
//Find SNR
clear;
clc;
```

```
fs=64000;
Amax=1;
fm=3500;
Nqd=2.1522995*10^-3;
So=Amax^2/2;
SNR=So/Nqd;
SNRO=10*log10(SNR);
disp("dB",SNRO,"Output signal noise ratio");
```

Scilab code Exa 4.31 number of bits per sec

```
//Caption: no.of bits/sec
//Example 4.31
//page no 203
//Find  no.of bits/sec
//assuming signal is sampled at the rate 20% above
   Nyquist rate
clear;
clc;
fm=4.5*10^6;
q=1024;
fs=1.2*2*fm;//20% above Nyquist rate
v=log2(q);
r=v*fs;
disp("M bit/sec",r/10^6,"no.of bits/sec");
```

Scilab code Exa 4.32 step size noise power and SNR

```
//Caption: step size,noise power, SNR
```

```
2 //Example 4.32
3 //page no 203
4 //Find step size,noise power, SNR
5 //assume bandwidth of the singal is 4kHz
6 clear;
7 clc;
8 fs=32000;
9 A=2;
10 fm=4000;
11 BW=4000;
12 del=(2*%pi*fm*A)/fs;
13 disp("Volt",del,"i)step size");
14 Nq=del^2/3
15 disp("W",Nq,"ii)noise power");
16 SNR=(3*fs^3)/(8*%pi^2*fm^2*BW);
17 disp(SNR,"iii)SNR=");
```

Scilab code Exa 4.33 signaling rate and bandwidth

```
1 //Caption: signaling rate, bandwidth
2 //Example 4.33
3 //page no 204
4 //Find  signaling rate, bandwidth
5 //assuming signal is sampled at the rate 20% above
     Nyquist rate
6 clear;
7 clc;
8 fm=15*10^3;
9 fs=1.2*2*fm;
10 q=65536;
11 v=log2(q);
12 r=v*fs;
13 disp("i)signaling rate,")
```

```
14 disp("K bits/sec",r/1000,"r=");
15 BW=r/2;
16 disp("ii)bandwidth")
17 disp("kHz",BW/1000,"BW min=")
```

Scilab code Exa 4.34 Step size and Noise power

```
1 //Caption: step size,noise power
2 //Example 4.34
3 //page no 204
4 //Find  step size,noise power
5 clear;
6 clc;
7 fs=64*10^3;
8 fm=3500;
9 A=1;
10 del=(2*%pi*fm*A)/fs;//step size
11 disp("Volts",del,"i)step size");
12 Nq=(del^2/3)*(fm/fs);//Granular noise power
13 disp("W",Nq,"ii)Nq=");
```

Chapter 5

DIGITAL MULTIPLEXERS

Scilab code Exa 5.1 Sampling Rate

```
1 //Caption: Sampling Rate
2 //Example 5.1
3 //page no 220
4 //Find  Sampling Rate
5 clear;
6 clc;
7 f1=4*10^3;
8 f2=4.5*10^3;
9 fsmin=2*f2;
10 disp("kHz",fsmin/1000,"Sampling rate");
```

Scilab code Exa 5.2 Nyquest rate Signaling rate and bandwidth

```
1 //Caption: Nyquest rate,Signaling rate,bandwidth
2 //Example 5.2
3 //page no 220
4 //Find i)Nyquest rate,
```

```
5 //      iii)Signaling rate,
6 //      iv)bandwidth
7 clc;
8 clear;
9
10 f1=3000;
11 f4=1000;
12 f2=1000;
13 f3=1000;
14 //Nyquest rate
15 nq1=2*f1;
16 nq2=2*f2;
17 nq3=2*f3;
18 nq4=2*f4;
19 disp("kHz",nq1,"i)Nyquest rate of x1");
20 disp("kHz",nq2,"  Nyquest rate of x2");
21 disp("kHz",nq3,"  Nyquest rate of x3");
22 disp("kHz",nq4,"  Nyquest rate of x4");
23
24 r=nq1+nq2+nq3+nq4;
25 disp("Samples/sec",r,"iii)Signaling rate");
26 bw=r/2;
27 disp("Hz",bw,"iv)Minimum channel bandwidth");
```

Scilab code Exa 5.3 spacing distance

```
1 //Caption: spacing  distance
2 //Example 5.3
3 //page no 221
4 //Find The spacing between two successive pules
5 clc;
6 clear;
7 samplingrate=8000;
```

```
totalsignals=24+1;
t=1/samplingrate;
T=t/totalsignals;
T=T*10^6//time is now u sec
space=T-1;
disp("u sec",space,"The spacing between two
   successive pules");
```

Scilab code Exa 5.4 signaling rate and bandwidth

```
//Caption: signaling rate ,bandwidth
//Example 5.4
//page no 222
//Find signaling rate ,bandwidth
clc;
clear;
N=6;
fm=5000;
r=2*fm;//sampling rate
sr=N*r;//signalingrate
disp("K bits/sec",sr/1000,"Signaling rate");
BW=N*fm;//Bandwith
disp("kHz",BW/1000,"Bandwith to avoid the cross talk
    in TDM is");
```

Chapter 6

DIGTIAL BASEBAND TRANSMISSION

Scilab code Exa 6.25 roll of factor

```
1 //Caption: roll of factor
2 //Example 6.25
3 //page no 307
4 //Find The roll of factor alpha
5 clc;
6 clear;
7 datarate=0.1*10^6;
8 fB=75000; //bandwidth
9 Tb=1/datarate;
10 alpha=2*fB*Tb-1
11 disp(alpha,"factor alpha = ")
```

Scilab code Exa 6.26 Transmission bandwidth

```
1  //Caption: Transmission bandwidth
2  //Example 6.26
3  //page no 307
4  //Find The Transmission bandwidth
5  clc;
6  clear;
7  q=128;
8  alpha=0.2
9  n=log2(q);
10 fm=2000;
11 Nq=2*fm;
12 fs=1.25*Nq;
13 N=8;
14 total=N*fs;
15 bitrate=7*total;
16 fB=((1+alpha)*bitrate)/2;
17 disp("kHz",fB/1000,"Transmission Bandwidth");
```

Chapter 8

DIGITAL MODULATION TECHNIQUES

Scilab code Exa 8.1 probability of error

```
1
2 //Caption: probability of  error
3 //Example 8.1
4 //page no 374
5 //Find probability of bit error
6 //AWGN is added to signal
7 clc;
8 clear;
9 N0=2*10^-15;
10 Ps1=1/2;
11 Ps2=1/2;
12 A=0.2*10^-3;
13 T=2*10^-6;
14
15 Eb=(A/sqrt(2))^2*T*Ps1+Ps2*0^2;//Eb=bit energy
16 z=sqrt(Eb/N0);//Probability
17 disp(z,"z = ");
18 //Pe=(8)*10^(-4)//probability of  error from the
     table
```

```
19 Pe=1/2*erfc(z/sqrt(2));
20 disp("probability of bit error when P(s1)=P(s2)=1/2
     ");
21 disp(Pe,"P(e)=");
```

Scilab code Exa 8.2 peak Amplitude

```
1 //Caption: peak Amplitude
2 //Example 8.2
3 //page no 374
4 //Find peak Transmission pulseAmplitude
5 clc;
6 clear;
7 N0=1.338*10^-5;
8 Pe=2.055*10^-5;
9 T=100*10^-6;
10 //Pe=erfc(sqrt(Eb/(2*N0)));
11 Eb=(2*2.9^2*N0);
12 A=sqrt((Eb*2)/T);
13 disp("Volts",A,"Transmission pulse Amplitude");
```

Scilab code Exa 8.4 probability of error

```
1 //Caption: probability of error
2 //Example 8.4
3 //page no 377
4 //Find probability of error
5 clc;
6 clear;
```

```
A=1*10^-3;
Tb=0.2*10^-3;
fb=1/Tb;
fc=5*fb;
N0=2*10^-11;// power sepctral density

Eb=(A^2*Tb)/2;//Eb=bit energy


z=sqrt(Eb/N0);
Pe=erfc(z)'//bit error probability
disp("Error probability of PSK is ")
disp(Pe,"P(e) =");
```

Scilab code Exa 8.5 probability bit error

```
//Caption: probability bit error
//Example 8.5
//page no 378
//Find bit error probability
clc;
clear;
A=10*10^-3;
T=10^-6;
N0=10^-11;// power sepctral density

Eb=(A^2*T)/2//Eb=bit energy

z=sqrt(Eb/N0);//Probability of ASK
Pe=erfc(z)'//bit error probability
disp("bit error probability ")
disp(Pe,"Pe =")
```

Scilab code Exa 8.7 Amplitude

```
1 //Caption: amplitude
2 //Example 8.7
3 //page no 379
4 //Find carrier amplitude
5 clc;
6 clear;
7 Pe=10^-4;//probability of error of PSK
8 N0=2*10^-10;
9 //from table error function
10 //Pe=erffc(z)
11 z=2.6
12 r=10^6;
13 T=1/r;
14  //z=sqrt(Eb/N0)
15 Eb=N0*z^2;       // Eb=bit energy
16 A=sqrt((Eb*2)/T); //Eb=A^2*T/2
17 disp("mV",A*1000,"Carrier Amplitude");
```

Scilab code Exa 8.8 Carrier power and Bandwidth

```
1
2 //Caption: Carrier power
3 //Example 8.8
4 //page no 382
5 //Find Carrier power,Bandwidth
6 clc;
```

```
clear;
Pe=10^-4;//probability of error of FSK
r=1*10^6//tranasmitted rate
N0=1*10^-7;//psd at input of the receiver
//from table error function
//Pe=erffc(z)
z=3.71
T=1/r;
 //z=sqrt(Eb/N0)
//Eb=N0*z^2;       // Eb=bit energy
Ac=sqrt((z^2*2*N0)/T);

AP=(Ac/sqrt(2))^2;//average carrier power
disp("watts",AP,"Average carrier power  =");
BW=1/T;
disp("MHz",BW*10^-6,"Channel Bandwidth  =");
```

Scilab code Exa 8.10 probability of error

```
//Caption: probability of error
//Example 8.10
//page no 382
//Find probability of error of FSK
clc;
clear;
rb=300;//bit rate
T=1/rb;
A2N0=8000;
//Pe=1/2*exp(-Eb/2N0);
//Eb=A^2*T/2
Pe=1/2*exp(-((A2N0*T)/4));//Probability of error non
    coherent FSK
disp(Pe,"Probability of error is ");
```

Scilab code Exa 8.11 probability of symbol error

```
1 //Caption: probability of symbol error
2 //Example 8.11
3 //page no 383
4 //Find probability of symbol error
5 //assuming coherent detection
6 clc;
7 clear;
8 rb=2.5*10^6//binary data rate
9 N0=2*10^-20;//power spectral density of noise FSK
     system
10 A=1*10^-6;//amplitude of received signal
11 T=1/rb;
12 Eb=(A^2*T)/2;// Eb=bit energy
13 z=sqrt(Eb/(2*N0))
14 Pe=1/2*erfc(z);//probability of symbol error
15 disp(Pe,"probability of symbol error");//
```

Chapter 9

INFORMATION THEORY

Scilab code Exa 9.1 Information Content

```
1 //Caption: Information Content
2 //Example 9.1
3 //page no 394
4 //Find Information Content of Each Symbol
5 clc;
6 clear;
7 px1=1/2;
8 px2=1/4;
9 px3=1/8;
10 px4=1/8;
11 //information content of each symbol
12 Ix1=log2(1/px1);
13 Ix2=log2(1/px2);
14 Ix3=log2(1/px3);
15 Ix4=log2(1/px4);
16 printf("Information Content \n\n \tI(x1) = %d bit \
   n",Ix1);
17 printf(" \tI(x2) = %d bits\n",Ix2);
18 printf(" \tI(x3) = %d bits\n",Ix3);
19 printf(" \tI(x4) = %d bits\n",Ix4);
```

Scilab code Exa 9.2 Information

```
1 //Caption: Information
2 //Example 9.2
3 //page no 394
4 //Find amount of Information
5 clc;
6 clear;
7 pxi=1/4;
8 Ixi=(log10(1/pxi))/log10(2);
9 printf(" \n The amount of Information \n \n\t I(Xi)
    = %.2d bits",Ixi)
```

Scilab code Exa 9.3 Amount of Information

```
1 //Caption: Amount of Information
2 //Example 9.3
3 //page no 395
4 //Find Amount og Information
5 clc;
6 clear;
7 px1=1/2;
8 px2=1/2;
9 Ix1=log2(1/px1);//entropy
10 Ix2=log2(1/px2);
11
12 printf(" \n The amount of Information \n \n\t I(X1)
    = %.2d bit\n",Ix1);
```

```
13 printf(" \n The amount of Information \n \n\t I(X2)
     = %.2d bit",Ix2);
```

Scilab code Exa 9.4 Amount of Information

```
1  //Caption: Amount of Information
2  //Example 9.4
3  //page no 395
4  //Find Amount of Information
5  clc;
6  clear;
7  px1=1/4;
8  px2=3/4;
9  Ix1=log2(1/px1);
10 Ix2=log2(1/px2);
11
12 printf(" \n The amount of Information \n \n\t I(X1)
     = %.2d bits\n",Ix1);
13 printf(" \n \t I(X2) = %.3f bits",Ix2);
```

Scilab code Exa 9.9 Entropy

```
1  //Caption: Entropy
2  //Example 9.9
3  //page no 398
4  //Find Entropy,Amount of information
5  clc;
6  clear;
7  px1=0.4;
```

```
px2=0.3;
px3=0.2;
px4=0.1;
HX=-px1*log2(px1)-px2*log2(px2)-px3*log2(px3)-px4*
   log2(px4);
printf(" \n  Entropy \n \n\t  i) H(X) = %.2f bits/
   symbol,\n",HX);
Px1x2x1x3=px1*px2*px1*px3;
Ix1x2x1x3=-log2(Px1x2x1x3);

printf(" \n  Amount of information \n \n\t ii) I(
   x1x2x1x3) = %.2f bits/symbol,\n",Ix1x2x1x3);
Px4x3x3x2=px4*px3*px3*px2;
Ix4x3x3x2=-log2(Px4x3x3x2);

printf(" \n \t \n \t I(x4x3x3x2) = %.2f bits/symbol
   .\n",Ix4x3x3x2);
```

Scilab code Exa 9.12 rate of information

```
//Caption: rate of information
//Example 9.12
//page no 401
//Find Average rate of information
clc;
clear;
m=16;
pxi=1/16;
elements=2*10^6;
n=32
HX=0;
for(i=1:16)
   HX=HX+(-(pxi*log2(pxi)));
```

```
14 end
15
16 r=elements*n;
17 R=r*HX
18 printf("Average rate of information\n \n \t R = %d
     Mbs",R/10^6);
```

Scilab code Exa 9.13 information rate

```
1  //Caption: information rate
2  //Example 9.13
3  //page no 401
4  //Find information rate the telegraphic source
5  clc;
6  clear;
7  pdash=1/3;
8  pdot=2/3;
9  tdot=0.2;
10 tdash=0.6;
11 tspace=0.2;
12 HX=-pdash*log2(pdash)-pdot*log2(pdot);
13 Ts=pdot*tdot+pdash*tdash+tspace;
14 r=1/Ts;
15 R=r*HX;
16 printf("Average rate of information\n \n \t R = %.2f
     b/s",R);
```

Scilab code Exa 9.14 Information rate

```
1  //Caption: information rate
2  //Example 9.14
3  //page no 402
4  //Find information rate of the source
5  clc;
6  clear;
7  f=input("Enter the frequncy f=");
8  px1=1/8;
9  px2=1/8;
10 px3=3/8;
11 px4=3/8;
12
13 HX=px1*log2(1/px1)+px2*log2(1/px2)+px3*log2(1/px3)+
      px4*log2(1/px4);//entropy of the source
14 R=2*f*HX;//r=2*f;
15 printf("information rate \n\n \t R= %.1f  bits/sec
      ",R);//f=signal bandwidth
```

Scilab code Exa 9.15 Information rate

```
1  //Caption: information rate
2  //Example 9.15
3  //page no 403
4  //Find information rate of the source
5  //all symbols are equally likely
6  clc;
7  clear;
8  px1=1/2;
9  px2=1/2;
10 px3=1/2;
11 px4=1/2;
12 f=input("Enter the frequncy of system fm(in Hz) =");
13 HX=px1*log2(1/px1)+px2*log2(1/px2)+px3*log2(1/px3)+
```

```
    px4*log2(1/px4);
14
15
16 printf("\n Entropy H(X) =%d bits/symbol\n ",HX);
17 R=2*f*HX;
18 printf("\n information rate =%d bits/sec",R);
```

Scilab code Exa 9.16 Entropy and information rate

```
1  //Caption: entropy ,information rate
2  //Example 9.16
3  //page no 404
4  //Find  source entropy ,information rate
5  clc;
6  clear;
7  //probability symbols
8  px1=1/2;
9  px2=1/4;
10 px3=1/8;
11 px4=1/16;
12 px5=1/16;
13 Tb=10^-3;
14 HX=px1*log2(1/px1)+px2*log2(1/px2)+px3*log2(1/px3)+
       px4*log2(1/px4)+px5*log2(1/px5);
15 printf("i) source entropy\n\n  \tH(X) = %.2f bits/
       symbol\n",HX);//source entropy
16 r=1/Tb;
17 R=r*HX;//information rate
18 printf("\n\n ii)information rate \n\n \t R = %d bits
       /sec",R);
```

Scilab code Exa 9.17 Entropy and information rate

```
1
2 //Caption: entropy and information rate
3 //Example 9.17
4 //page no 404
5 //determine entropy ,information rate
6 //assume if there are 16 outcomes per second
7 clc;
8 clear;
9 px1=1/2;
10 px2=1/4;
11 px3=1/8;
12 px4=1/16;
13 px5=1/16;
14 r=16
15 HX=px1*log2(1/px1)+px2*log2(1/px2)+px3*log2(1/px3)+
    px4*log2(1/px4)+px5*log2(1/px5);
16
17 printf("i) Entropy\n\n \tH(X) = %.2f bits/symbol\n"
    ,HX);//source entropy
18
19 R=r*HX;
20 printf("\n\n ii)information rate \n\n \t R = %d bits
    /sec",R);
```

Scilab code Exa 9.18 Entropy and information rate

```
1
2 //Caption: entropy ,information rate
3 //Example 9.18
4 //page no 405
5 //determine entropy ,information rate
6 clc;
7 clear;
8 px1=1/4;
9 px2=1/5;
10 px3=1/5;
11 px4=1/10;
12 px5=1/10;
13 px6=1/20;
14 px7=1/20;
15 px8=1/20;
16 f=10*10^3;
17 fs=10*2*10^3;
18 HX=px1*log2(1/px1)+px2*log2(1/px2)+px3*log2(1/px3)+
     px4*log2(1/px4)+px5*log2(1/px5)+px6*log2(1/px6)+
     px7*log2(1/px7)+px8*log2(1/px8);//entropy
19 disp("bits/message",HX,"H(X) = ");
20 r=fs;
21 R=r*HX;//information rate
22 disp("bits/sec",R,"R = ");
```

Scilab code Exa 9.19 Channel Matrix and joint probability

```
1 //Caption: Channel Matrix,joint probability
2 //Example 9.19
3 //page no 408
4 //Find Channel Matrix,joint probability
5
6 clc;
```

```
clear;
px1=0.5;
px2=0.5;
py1x1=0.9;
py2x1=0.1;
py1x2=0.2;
py2x2=0.8;
PYX=[py1x1 py2x1; py1x2 py2x2];
PX=[px1 px2];

disp(PYX,"    i)Channel Matrix   [P(Y/X)]=");
PY=PX*PYX;
printf("\n\   ii) P(y1)=%.2f and P(y2)=%.2f \n",PY(1)
   ,PY(2));

PXd=[px1 0;0 px2];
PXY=PXd*PYX;
printf("\n iii)P(x1y2)=%.2f and P(x2y1)=%.2f",PXY(3)
   ,PXY(2));
```

Scilab code Exa 9.21 probabilities channel matrix

```
//Caption: probabilities channel matrix
//Example 9.21
//Find probabilities channel matrix

clc;
clear;
p=0.2;
PX=[0.5 0.5];
PXY=[1-p p 0;0 p 1-p];
//P(Y)=[P(X)]*[P(Y|X)]
PY=PX*PXY
```

```
12 disp(PY,"[P(Y)]");
13 disp(PY(1),"P(y1)=");
14 disp(PY(2),"P(y2)=");
15 disp(PY(3),"P(y3)=");
```

Scilab code Exa 9.35 Capacity of Channel

```
1 //Caption: Capacity of Channel
2 //Example 9.35
3 //page no 426
4 //Find Capacity of Channel
5 //Channel is aproximated by the AWGN Channel
6 clear;
7 clc;
8 B=4000;
9 S=0.1*10^-3;
10 n=2*10^-12;
11 N=n*B;
12 C=B*log2(1+(S/N));//Capacity of Channel
13 printf("\n Capacity of Channel \n\n\t C=%.3f(10^3) b
   /s",C/1000);
```

Scilab code Exa 9.36.i information rate

```
1 //Caption: information rate
2 //Example 9.36 i
3 //page no 427
4 //Find information rate
```

```
5 //assume that  succeissive samples are statistically
      independent
6 clear;
7 clc;
8 fm=4000;
9 fs=2*fm;
10 n=1.25;
11 r=fs*n;
12 pxi=1/256;
13 HX=-log2(pxi);
14 R=r*HX;
15 printf("Information Rate \n\n \t R= %d kb/s",R/1000)
```

Scilab code Exa 9.36.ii Channel Capacity

```
1 //Caption: Channel Capacity
2 //Example 9.36 ii
3 //page no 427
4 //Find Capacity of Channel
5 //assume that  succeissive samples are statistically
      independent
6 clear;
7 clc;
8 B=10*10^3;
9 SN=20;
10 SNR=10^(SN/10)
11 C=B*log2(1+(SNR));
12 disp("kb/s",C/1000,"C =")
```

Scilab code Exa 9.36.iii SNR

```
1 //Caption: SNR
2 //Example 9.36 iii
3 //page no 427
4 //Find SNR
5 //assume that  succeissive samples are statistically
      independent
6 clear;
7 clc;
8 C=8*10^4;
9 B=10^4;
10 SN=2^(C/B)-1;
11 SNR=10*log10(SN);//SNR
12 disp("dB",SNR,"SNR =");//required SNR is greater
     that 24.064
```

Scilab code Exa 9.36.iv Bandwidth

```
1 //Caption: Bandwidth
2 //Example 9.36 ii
3 //page no 427
4 //Find Required bandwidth
5 //assume that  succeissive samples are statistically
      independent
6 clear;
7 clc;
8 SN=20;
9 SNR=10^(SN/10);
10 C=8*10^4;
11 B=C/(log2(1+SNR));//Bandwidth
12 disp("kHz",B/1000,"Bandwidth  B = ");
```

Scilab code Exa 9.37 efficiency and redundancy

```
1 //Caption:  efficiency ,redundancy
2 //Example 9.37
3 //page no 430
4 //Find code efficiency ,redundancy
5 clear;
6 clc;
7 px1=0.9;
8 px2=0.1;
9 n1=1;
10 n2=1;
11 L=px1*n1+px2*n2;// code leght
12 HX=px1*log2(1/px1)+px2*log2(1/px2);
13 n=(HX/L);// code efficiency
14
15 printf("\n\tcode efficiency = %.2f ",n*100);
16 disp("              %");
17
18 r=(1-n);//code reduncy
19 printf("\n\n\tcode redundancy = %.2f ",r*100);
20 disp("              %");
```

Scilab code Exa 9.38 Efficiency and redundancy

```
1 //Caption:  efficiency ,redundancy
2 //Example 9.38
3 //page no 431
```

```
4 //Find code efficiency ,redundancy
5 clear;
6 clc;
7 pa1=0.81;
8 pa2=0.09;
9 pa3=0.09;
10 pa4=0.01;
11 n1=1;
12 n2=2;
13 n3=3;
14 n4=3;
15
16 L=pa1*n1+pa2*n2+pa3*n3+pa4*n4;
17
18 HX2=pa1*log2(1/pa1)+pa2*log2(1/pa2)+pa3*log2(1/pa3)+
     pa4*log2(1/pa4);
19 n=HX2/L;
20
21 printf("\n\tcode efficiency =%.2f  ",n*100);
22 disp("              %");
23
24 r=(1-n);//code reduncy
25 printf("\n\n\tcode redundancy =%.1f ",r*100);
26 disp("              %");
```

Scilab code Exa 9.44 Efficiency

```
1 //Caption: efficiency
2 //Example 9.44
3 //page no 436
4 //Find  efficiency of the code
5 clear;
6 clc;
```

```
7
8  px1=1/2;
9  px2=1/4;
10 px3=1/8;
11 px4=1/8;
12 n1=1
13 n2=2;
14 n3=3;
15 n4=3;
16
17 //information content of each symbol
18 Ix1=-log2(px1);
19 Ix2=-log2(px2);
20 Ix3=-log2(px3);
21 Ix4=-log2(px4);
22
23 HX=px1*log2(1/px1)+px2*log2(1/px2)+px3*log2(1/px3)+
      px4*log2(1/px4);
24 L=px1*n1+px2*n2+px3*n3+px4*n4;
25
26 n=HX/L;
27
28 printf("\n\tcode efficiency = %.2f  ",n*100);
29 disp("              %");
```

Scilab code Exa 9.50 Entropy and information rate

```
1 //Caption:  entropy ,information rate
2 //Example 9.50
3 //Pge no 441
4 //Find entropy ,information rate
5 //If there are 16 outcomes per second
6 clear;
```

```
clc;

P1=1/2;
P2=1/4;
P3=1/8
P4=1/16;
P5=1/32;
P6=1/32;
 r=16;//message rate
H=P1*log2(1/P1)+P2*log2(1/P2)+P3*log2(1/P3)+P4*log2
   (1/P4)+P5*log2(1/P5)+P6*log2(1/P6);  //Entropy of
    system
printf("\n \t i)Entropy of system \n\n \t  H=%.4f
   bits/message\n",H);
R=H*r; //R=Entropy*message rate
printf("\n \t ii)Information rate\n \n\t R = %d bits
   /sec",R);
```

Scilab code Exa 9.51 Entropy

```
//Caption:  Entropy
//Example 9.51
//Pge no 443
//Calculate H(X) ,H(Y)
clear;
clc;

px1=0.3;
px2=0.4;
px3=0.3;

HX=px1*log2(1/px1)+px2*log2(1/px2)+px3*log2(1/px3);
   //Entropy of X
```

```
13 printf("\n \t i)Entropy of X \n\n \t  H(X)=%.3f bits
   /symbol\n",HX);
14
15 PYX=[0.8 0.2 0;0 1 0;0 0.3 0.7]
16 PX=[px1 px2 px3]
17 PXY=PX*PYX;
18 py1=PXY(1,1);
19 py2=PXY(1,2);
20 py3=PXY(1,3);
21
22 HY=py1*log2(1/py1)+py2*log2(1/py2)+py3*log2(1/py3);
   //Entropy of Y
23 printf("\n \t ii)Entropy of Y \n\n \t  H(Y)=%.2f
   bits/symbol\n",HY);
```

Scilab code Exa 9.52 Entropy

```
1 //Caption:  Entropy
2 //Example 9.52
3 //Pge no 442
4 //Find entropy of source ,entropy of second order
   extension
5
6 clear;
7 clc;
8
9 P1=0.7;
10 P2=0.15;
11 P3=0.15;
12
13 HX=P1*log2(1/P1)+P2*log2(1/P2)+P3*log2(1/P3)//
   Entropy of source
14 printf("\n \t i)Entropy of system \n\n \t  H(X)=%.4f
```

```
    bits/symbol\n",HX);
15 //H(X^n)=n*H(X)
16 n=2;//for second order
17 HX2=n*HX;
18 printf("\n \t ii)Entropy of second order system
      extension of source can be");
19 printf(" \n\n \t  H(X^2)=%.4f bits/symbol\n",HX);
```

Scilab code Exa 9.54 Entropy

```
1 //Caption:  Entropy
2 //Example 9.54
3 //Pge no 443
4 //Find entropy of source
5 clear;
6 clc;
7 S0=1/3;
8 S1=1/6;
9 S2=1/4;
10 S3=1/4
11
12 HX=S0*log2(1/S0)+S1*log2(1/S1)+S2*log2(1/S2)+S3*log2
     (1/S3);// EntroSy of source
13
14 printf("\n \t i)Entropy of system \n\n \t  H(X)=%.4f
    bits/symbol\n",HX);
```

Scilab code Exa 9.56 Information capacity

```
1  //Caption:  Information capacity
2  //Example 9.56
3  //page no 444
4  //Find Information capacity of telephone
5  clear;
6  clc;
7  B=3.4*10^3;
8  SNR=30
9  SN=10^(SNR/10);
10 C=B*log2(1+SN)//Information capacity
11 printf("Information capacity of telephone is \n\n \
     tC = %.2f kbps",C/1000);
```

Chapter 10

ERROR CONTROL CODING

Scilab code Exa 10.4 errors and corrected errors

```
1 //Caption:  errors,corrected errors
2 //Example 10.4
3 //page no 464
4 //Find  detected errors,corrected errors
5 clear;
6 clc;
7 dmin=5
8  // (s+1)<= dmin number errors can be detected(s)
9  s=dmin-1;
10 printf(" i)Number of detected errors \n\n \t s <= %d
       ",s );
11 //(2t+1)<=dmin number errors can be corrected(t)
12 t=(dmin-1)/2;
13
14 printf("\n\n ii) Number of corrected errors\n\n \t
    t<= %d ",t );
```

Scilab code Exa 10.17 code vectors

```
1 //Caption: code vectors
2 //Example 10.17
3 //page no 498
4 //Determine all possible code vectors
5 clc;
6 clear;
7 m3=1;
8 m2=0;
9 m1=1;
10 m0=0;
11 //M=Message Matrix
12 //G=Generator Matrix
13 G=[1 0 1 1 0 0 0;0 1 0 1 1 0 0;0 0 1 0 1 1 0;0 0 0 1
       0 1 1];
14 M=[m3 m2 m1 m0;];
15 X=M*G;
16 for i=1:7;
17     if X(i)>1
18         X(i)=0
19      end
20  end
21 disp(X,"The code vectors are ");
```

Scilab code Exa 10.19 code word

```
1 //Caption: code word
2 //Example 10.19
3 //page no 501
4 //Determine  code word
5 clc;
6 clear;
```

```
m3=1;
m2=0;
m1=1;
m0=0;
//M=Message Matrix
//G=Generator Matrix
G=[1 0 0 0 1 0 1;0 1 0 0 1 1 1;0 0 1 0 1 1 0;0 0 0 1
    0 1 1];
M=[m3 m2 m1 m0;];
X=M*G;
for i=1:7;
    if X(i)>1
        X(i)=0
     end
 end
disp(X,"The required code word ");
```