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

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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.

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List of Scilab Codes

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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;
```

```
9   blackballs=5;
10  //Probability  Getting  black  ball
11  pb=blackballs/(redballs+whiteballs+blackballs);
12  //Probability  Getting  white  ball
13  pw=whiteballs/(redballs+whiteballs+blackballs);
14  //Probability  Getting  white  ball  or  black  ball
15  pwb=pb+pw//  black  and  white  are  mutuallly  exclusive
        events
16  disp("Probability  Getting  white  ball  or  black  ball
        will  be  ")
17  disp(pwb,"P(B+W)=")
```

Scilab code Exa 2.2 `Probability`

```
1   //Caption:  Probability
2   //Example  2.2
3   //page  no  43
4   //find  the  probability  of  getting  5
5   clc;
6   clear;
7   total_possibleoutcomes=6*6;
8   probabilityofeachoutcome=1/total_possibleoutcomes;//
        probability  of  each  outcome
9   noofways=4;  //ways  of  getting  5
10  probability=noofways*probabilityofeachoutcome;//
        probability  of  getting  5
11  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);
```

17

```
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
```

```scilab
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
```

19

```
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

```scilab
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

```scilab
1  ////Caption Nquist Rate
2  //Example 3.3
3  //page no 104
4  //Find Nquist Rate
5  //given
6  clc;
7  clear;
8  f=100;
9  fs=2*f;//Nyquist rate
10 disp(" Hz",fs,"(i)To avoid aliasing Nquist Rate is "
     );
```

Scilab code Exa 3.4 Nquist Rate

```scilab
1  //Caption: Nquist Rate
2  //Example 3.4
3  //page no 105
4  //Find Nquist Rate of Continous signal
5  //given
6  clc;
7  clear;
8
9  w1=50*%pi;
10 w2=300*%pi;
11 w3=100*%pi;
12 f1=w1/(2*%pi);
13 f2=w2/(2*%pi);
14 f3=w3/(2*%pi);
15 fmax=f2;//fmax = Highest frquency component of the
     message signal
16 disp("Highest frquency component of the message
     signal will be");
17 disp(fmax,"fmax=");
```

25

```
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
```

```scilab
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`

```scilab
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`

```scilab
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`

```scilab
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

```scilab
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
```

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

Scilab code Exa 4.14 `Signaling rate`

```
 1 //Caption: signaling rate
 2 //Example 4.14
 3 //page no 187
 4 //Find   signaling rate
 5 clear;
 6 clc;
 7 fs1=8*10^3;
 8 del=31.25*10^-3;
 9 q=64;
10 v=log2(q);
11 r=v*fs1;//signaling rate
12 disp(r*10^-3,"i)Signaling rate of PCM is");
13 disp("kHz");
14
15 fm=3*10^3;
16 A=1;
17 fs2=(2*%pi*fm*A)/(del);
18 disp(fs2*10^-3,"ii)The signaling rate of DM is");;
19 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
```

```scilab
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

```scilab
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
```

```
 8  fmin =300;
 9  fmax =3300;
10  fs =8000;
11
12  q=10^((SNRO+10.1)/20);
13  q=ceil(q);
14  v=log2(q);
15  v=ceil(v);
16  disp(q,"Quantizing   levels  need  is");
17  disp(v,"minimum  number  of  bits  per  sample  is");
18
19
20  fPCM=(v*fs)/2;
21  disp(fPCM/1000,"minimum  required  bandwidth");
22  disp("kHz");
```

Scilab code Exa 4.24 Maximum Amplitude and SNR

```
 1  //Caption:  Maximum  Amplitude ,SNR
 2  //Example  4.24
 3  //page  no  199
 4  //determine  the   Maximum  Amplitude ,
 5  //
 6  clear;
 7  clc;
 8  del =250*10^-3;
 9  wm=2*%pi*1000;
10  fs =3*10^3;
11  Ts =1/fs
12
13  Amax=(del*3*fs*2)/(wm);//Amplitude
14  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;
```

44

```
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;
```

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

Scilab code Exa 4.30.ii `Noise power`

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

Scilab code Exa 4.30.iii `Signal to Noise Ratio`

```
 1 //Caption: SNR
 2 //Example 4.30 iii
 3 //page no 202
 4 //Find SNR
 5 clear;
 6 clc;
```

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

Scilab code Exa 4.31 number of bits per sec

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

Scilab code Exa 4.32 step size noise power and SNR

```
 1  //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 b i t s / s e c" , r /1000 , "r=") ;
15  BW= r /2;
16  disp ("i i ) 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  f s =64*10^3;
8  fm =3500;
9  A=1;
10 del =(2*%pi * fm *A)/ f s ; // step  size
11 disp ( "Volts" , del , "i ) step  size") ;
12 Nq=( del ^2/3) *(fm/ f s ) ; // Granular  noise  power
13 disp ("W" ,Nq , "i i )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,
```

```scilab
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 ," i i i ) Signaling rate" ) ;
26 bw=r /2;
27 disp ( "Hz" ,bw ," iv )Minimum channel bandwidth" ) ;
```

Scilab code Exa 5.3 spacing distance

```scilab
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;
```

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

Scilab code Exa 5.4 signaling rate and bandwidth

```
1  // Caption:  signaling  rate  , bandwidth
2  // Example  5.4
3  // page  no  222
4  // Find  signaling  rate  , bandwidth
5  clc ;
6  clear ;
7  N=6;
8  fm =5000;
9  r=2*fm ;// sampling  rate
10  sr=N*r ;// signalingrate
11  disp("K bits/sec ", sr /1000 ,"Signaling  rate ");
12  BW=N*fm ;// Bandwith
13  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`

```scilab
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 ( " p r o b a b i l i t y  of  bit  e r r o r  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 ;
```

```
 7  A=1*10^-3;
 8  Tb=0.2*10^-3;
 9  fb=1/Tb;
10  fc=5*fb;
11  N0=2*10^-11;// power sepctral density
12
13  Eb=(A^2*Tb)/2;//Eb=bit energy
14
15
16  z=sqrt(Eb/N0);
17  Pe=erfc(z)'// bit error probability
18  disp("Error probability of PSK is ")
19  disp(Pe,"P(e) =");
```

Scilab code Exa 8.5 probability bit error

```
 1  //Caption: probability bit error
 2  //Example 8.5
 3  //page no 378
 4  //Find bit error probability
 5  clc;
 6  clear;
 7  A=10*10^-3;
 8  T=10^-6;
 9  N0=10^-11;// power sepctral density
10
11  Eb=(A^2*T)/2//Eb=bit energy
12
13  z=sqrt(Eb/N0);//Probability of ASK
14  Pe=erfc(z)'// bit error probability
15  disp("bit error probability ")
16  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;
```

```
7  clear;
8  Pe=10^-4;//probability of error of FSK
9  r=1*10^6//tranasmitted rate
10 N0=1*10^-7;//psd at input of the receiver
11 //from table error function
12 //Pe=erffc(z)
13 z=3.71
14 T=1/r;
15  //z=sqrt(Eb/N0)
16 //Eb=N0*z^2;        // Eb=bit energy
17 Ac=sqrt((z^2*2*N0)/T);
18
19 AP=(Ac/sqrt(2))^2;//average carrier power
20 disp("watts",AP,"Average carrier power =");
21 BW=1/T;
22 disp("MHz",BW*10^-6,"Channel Bandwidth =");
```

Scilab code Exa 8.10 probability of error

```
1  //Caption: probability of error
2  //Example 8.10
3  //page no 382
4  //Find probability of error of FSK
5  clc;
6  clear;
7  rb=300;//bit rate
8  T=1/rb;
9  A2N0=8000;
10 //Pe=1/2*exp(-Eb/2N0);
11 //Eb=A^2*T/2
12 Pe=1/2*exp(-((A2N0*T)/4));//Probability of error non
        coherent FSK
13 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 )
       = %.2 d 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 )
       = %.2 d 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;
```

```
8  px2 =0.3;
9  px3 =0.2;
10 px4 =0.1;
11 HX=-px1*log2(px1)-px2*log2(px2)-px3*log2(px3)-px4*
      log2(px4);
12 printf(" \n  Entropy \n \n\t  i) H(X) = %.2f bits/
      symbol,\n",HX);
13 Px1x2x1x3=px1*px2*px1*px3;
14 Ix1x2x1x3=-log2(Px1x2x1x3);
15
16 printf(" \n  Amount of information \n \n\t ii) I(
      x1x2x1x3) = %.2f bits/symbol,\n",Ix1x2x1x3);
17 Px4x3x3x2=px4*px3*px3*px2;
18 Ix4x3x3x2=-log2(Px4x3x3x2);
19
20 printf(" \n \t \n \t I(x4x3x3x2) = %.2f bits/symbol
      .\n",Ix4x3x3x2);
```

Scilab code Exa 9.12 rate of information

```
1  //Caption: rate of information
2  //Example 9.12
3  //page no 401
4  //Find Average rate of information
5  clc;
6  clear;
7  m=16;
8  pxi=1/16;
9  elements=2*10^6;
10 n=32
11 HX=0;
12 for(i=1:16)
13     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=  %.1 f   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);
```

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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

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```
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 ;
```

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```
 7  clear ;
 8  px1 =0.5;
 9  px2 =0.5;
10  py1x1 =0.9;
11  py2x1 =0.1;
12  py1x2 =0.2;
13  py2x2 =0.8;
14  PYX =[ py1x1 py2x1 ; py1x2 py2x2 ];
15  PX =[ px1 px2 ];
16
17  disp ( PYX ,"    i ) Channel  Matrix   [P(Y/X)]=" ) ;
18  PY = PX * PYX ;
19  printf ( " \n\   ii )  P ( y1 )=%.2 f  and  P ( y2 )=%.2 f  \n" , PY (1)
        , PY (2) ) ;
20
21  PXd =[ px1 0;0 px2 ];
22  PXY = PXd * PYX ;
23  printf ( " \n  iii )P ( x1y2 )=%.2 f  and  P ( x2y1 )=%.2 f " , PXY (3)
        , PXY (2) ) ;
```

Scilab code Exa 9.21 `probabilities channel matrix`

```
 1  // Caption :  probabilities  channel  matrix
 2  // Example  9.21
 3  // Find  probabilities  channel  matrix
 4
 5  clc ;
 6  clear ;
 7  p =0.2;
 8  PX =[0.5 0.5];
 9  PXY =[1 -p p 0;0 p 1 -p ];
10  //P(Y)=[P(X) ]*[P(Y|X) ]
11  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
```

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```
 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;
```

```
 7  clc ;
 8
 9  P1 =1/2;
10  P2 =1/4;
11  P3 =1/8
12  P4 =1/16;
13  P5 =1/32;
14  P6 =1/32;
15   r =16;// message  rate
16  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
17  printf (" \n  \t  i) Entropy  of  system  \n\n  \t   H=%.4 f
       bits / message \n",H);
18  R=H*r;  //R=Entropy*message  rate
19  printf (" \n  \t  ii) Information  rate \n  \n\t  R = %d  bits
       / sec ",R);
```

Scilab code Exa 9.51 `Entropy`

```
 1  // Caption :   Entropy
 2  // Example  9.51
 3  // Pge  no  443
 4  // Calculate  H(X)  ,H(Y)
 5  clear ;
 6  clc ;
 7
 8  px1 =0.3;
 9  px2 =0.4;
10  px3 =0.3;
11
12  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`

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```scilab
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  =  %.2 f  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;
```

```
 7  m3 =1;
 8  m2 =0;
 9  m1 =1;
10  m0 =0;
11  //M=Message  Matrix
12  //G=Generator  Matrix
13  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];
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  required  code  word ");
```