Scilab Textbook Companion for Modern Digital And Analog Communication System by B. P. Lathi[1]

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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.

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Chapter 2

INTRODUCTION TO SIGNALS

Scilab code Exa 2.1 `problem1`

```
clc;
//page no 17
//prob 2.1 b]

t0=-1;t1=1;
y=integrate('t^2','t',t0,t1);
disp(+'watt',y/2,'power of signal');
```

Scilab code Exa 2.3b `problem3b`

```
// page no.26
//exa no.2.3b
t=[-3:.0082:1];
m1=(0-1)/(-3-(-1));//slope for -3<t<-1
c1=(0-m1*(-3));//intercept for pt(-3,0)
u(t<=-1)=[(m1*t(t<=-1))+c1]'
```

```
m2=(1-0)/(-1-1);//slope for -1<t<1
c2=(0-m2*1)//intercept for pt(1,0)
u(t>-1)=[(m2*t(t>-1))+c2]';
subplot(221)
plot2d(t,u)//original signal
subplot(222)
plot2d(2*t,u)//expansion of signal
```

Scilab code Exa 2.4 `problem4`

```
clc;
//page27
//problem 2.4
t=(-5:-1);
subplot(221)
plot2d(t,(%e)^t/2);
xtitle(" Original signal "," Time ","g(t) ");
t=-t;
subplot(222)
plot2d(t,(%e)^-t/2);
xtitle(" Time inverted signal"," time ","g(-t) ");
```

Scilab code Exa 2.5 `problem5`

```
clc;
//Assuming SI units for all quantities
//page no 33
//exa 2.5a
//approximation of square signal to sine signal with minimum energy
t=[0:.1:2*%pi];
t0=0;t1=2*%pi;
```

```
y=integrate('(sin(t))^2','t',t0,t1);
disp(+'joule',y($),'energy of sine signal=');
//to calculate value of c
t2=0;t3=%pi;
g=integrate('sin(t)','t',t2,t3);
t4=%pi;t5=2*%pi;
h=integrate('-sin(t)','t',t4,t5);
disp((g($)+h($))/%pi,"value of c=");
```

Scilab code Exa 2.6a problem6a

```
clc;
//Assuming SI units for all quantities
//given signal is x(t)=1
//energy of signal x(t)
t0=0;t1=5;
x=1;
y=integrate('x^2','t',t0,t1);
disp(+'joule',y,'energy of signal x(t)=')
//to find correlation coefficient we have to
    calculate the energies of different given signals
//1st signal g1(t)=1
g1=1;
e1=integrate('g1^2','t',t0,t1);
disp(+'joule',e1,'energy of signal');
//correltion coefficient
c1=integrate('g1*x','t',t0,t1);
disp(+'joule',c1/sqrt(y*e1),'correlation coefficient
    =');
```

Scilab code Exa 2.6b problem6b

```
clc;
```

```
//Assuming SI units for all quantities
//given signal is x(t)=1
//energy of signal x(t)
t0=0;t1=5;
x=1;
y=integrate('x^2','t',t0,t1);
disp(+'joule',y,'energy of signal x(t)=');
//to find correlation coefficient we have to
    calculate the energies of different given signals
g2=.5;
e2=integrate('g2^2','t',t0,t1);
disp(+'joule',e2,'energy of signal');
//correltion coefficient
c2=integrate('g2*x','t',t0,t1);
disp(c2/sqrt(y*e2),'correlation coefficient=');
```

Scilab code Exa 2.6c `problem6c`

```
clc;
//Assuming SI units for all quantities
//given signal is x(t)=1
//energy of signal x(t)
t0=0;t1=5;
x=1;
y=integrate('x^2','t',t0,t1);
disp(+'joule',y,'energy of signal x(t)=');
//to find correlation coefficient we have to
    calculate the energies of different given signals
g3=-1;
e3=integrate('g3^2','t',t0,t1);
disp(+'joule',e3,'energy of signal');
//correltion coefficient
c3=integrate('g3*x','t',t0,t1);
disp(c3/sqrt(y*e3),'correlation coefficient=');
```

Scilab code Exa 2.6d `problem6d`

```
clc;
//Assuming SI units for all quantities
//given signal is x(t)=1
//energy of signal x(t)
t0=0;t1=5;
x=1;
y=integrate('x^2','t',t0,t1);
disp(+'joule',y,'energy of signal x(t)=');
//to find correlation coefficient we have to
    calculate the energies of different given signals
e4=integrate('((%e)^(-t/5))^2','t',t0,t1);
disp(+'joule',e4($),'energy of signal');
//correltion coefficient
c4=integrate('((%e)^(-t/5))*x','t',t0,t1);
disp(c4($)/sqrt(y*e4),'correlation coefficient=');
```

Scilab code Exa 2.6e `problem2e`

```
clc;
//Assuming  SI units for all quantities
//given signal is x(t)=1
//energy of signal x(t)
t0=0;t1=5;
x=1;
y=integrate('x^2','t',t0,t1);
disp(+'joule',y,'energy of signal x(t)=');
//to find correlation coefficient we have to
    calculate the energies of different given signals
e5=integrate('((%e)^(-t))^2','t',t0,t1);
disp(+'joule',e5,'energy of signal');
```

```
//correltion coefficient
c5=integrate('((%e)^(-t))*x','t',t0,t1);
disp(c5/sqrt(y*e5),'correlation coefficient=');
```

Scilab code Exa 2.6f `problem6f`

```
clc;
//Assuming SI units for all quantities
//given signal is x(t)=1
//energy of signal x(t)
t0=0;t1=5;
x=1;
y=integrate('x^2','t',t0,t1);
disp(+'joule',y,'energy of signal x(t)=');
//to find correlation coefficient we have to
   calculate the energies of different given signals
e6=integrate('(sin(2*%pi*t))^2','t',t0,t1);
disp(+'joule',e6,'energy of signal');
//correltion coefficient
c6=integrate('((sin(2*%pi*t))^2)*x','t',t0,t1);
disp(c6/sqrt(y*e6),'correlation coefficient=');
```

Chapter 3

ANALYSIS AND TRANSMISSION OF SIGNALS

Scilab code Exa 3.1 problem1

```
clc;
//page no 75
//prob 3.1
// given signal is x(t)= e^(-at) * u(t)
//unity function u(t)=1 for 0 to infinity
//therefore
x=1;
//here we consider 'infinity' value as 10 and the
   value of 'a' is 1
t= 0:1:10;
a=1;// a >0
z=((%e)^(-a*t) * x);
y=fft(z);
disp(y,'fourier transform of x(t)=');
```

Scilab code Exa 3.2 `problem2`

```
clc;
//page no 81
//prob 3.2
//given signal is x(t) = rect(t/T)
//rect(t/T) = 1 for |t| < T/2  and
//              = 0 for |t| > T/2
// therefore we have to find out fourier transform
   of x(t)= 1 for |t| < T/2 thus,
x=1;
T= 200; // consider
t= -T/2 : 1 : T/2;//range for fourer transform
y=fft(x);
disp(y,'fourier transform of x(t)=');
```

Scilab code Exa 3.3 `problem3`

```
clc;
//page no 82
//prob 3.3
// given signal is x(t)= unit impulse d(t)
//it is defined as d(t) = 1 for t=0
//therefore
x=1;
y=fft(x);
disp(y,'fourier transform of x(t)=');
```

Scilab code Exa 3.7 `problem7`

```
clc;
//page 84
// problem 3.7
```

```
t=-10:1:10;
y=sign(t);
g=fft(y);
disp(g,"fourier transform of signum funcion is");
```

Chapter 4

AMPLITUDE MODULATION

Scilab code Exa 4.5 `problem5`

```
clc;
//page 166
//problem 4.5
// we  have given 1)u=.5 and 2)u=.3
// efficiency n is calculated by using formula n= (u
   ^2) / (2+u^2) *100 %
//for u=0.5
u1=0.5;
n1= (u1^2) / (2+u1^2) *100 ;
disp(n1,'efficiency in % is');
// Hence only 11.1111% of total power is in
   sidebands.
//for u=0.3
u2=0.3;
n2= (u2^2) / (2+u2^2) *100;
disp(n2,'efficiency in % is');
// Hence only 4.3062% of the total power is the
   useful power (power in sidebands)
```

Chapter 5

ANGLE MODULATION

Scilab code Exa 5.1 problem1

```
clc;
//page 212
//problem 5.1
// The values of constsnts Kf and Kp are given as Kf
    = 2*pi*10^5 and Kp=10*pi, and carrier frequency
    fc=100MHz

// For FM :
//fi= fc + Kf*m(t)/2*pi
// Minimum value of m(t) = -1 and Maximum value of m
    (t)= +1
Kf= 2*%pi*10^5 ; Kp=10*%pi;
fc=100*10^6 ;// in Hz
Mmin = -1 ; Mmax=1;
fimin1= fc + Kf*Mmin/(2*%pi);
disp(+'MHz',fimin1/10^6,'Minimum frequency in MHz is
    ');
fimax1= fc + Kf*Mmax/(2*%pi);
disp(+'MHz',fimax1/10^6,'Maximum frequency in MHz is
    ');

```

```
//For PM :
// fi= fc + Kp*m(t)'/2*pi
// Minimum value of m(t)' = -20,000 and Maximum
   value of m(t)'= +20,000
Mmin1=-20000 ; Mmax1=20000;
fimin2= fc + Kp*Mmin1/(2*%pi);
disp(+'MHz',fimin2/10^6,'Minimum frequency in MHz is
   ');
fimax2= fc + Kp*Mmax1/(2*%pi);
disp(+'MHz',fimax2/10^6,'Maximum frequency in MHz is
   ');

// Since m(t) is increases and decreases linearly
   with time, the instantaneous frequency increases
   linearly from fimin to fimax
```

Scilab code Exa 5.2 problem2

```
clc;
//page 213
//problem 5.2
// The values of constsnts Kf and Kp are given as Kf
   = 2*pi*10^5 and Kp=pi/2, and carrier frequency fc
   =100MHz
// For FM :
// fi= fc + Kf*m(t)/2*pi
// Minimum value of m(t) = -1 and Maximum value of m
   (t)= +1
Kf= 2*%pi*10^5 ; Kp=%pi/2;
fc=100*10^6 ;// in Hz
Mmin = -1 ; Mmax=1;
fimin1= fc + Kf*Mmin/(2*%pi);
disp(+'MHz',fimin1/10^6,'Minimum frequency in MHz is
   ');
fimax1= fc + Kf*Mmax/(2*%pi);
```

```
disp(+'MHz',fimax1/10^6,'Maximum frequency in MHz is
    ');
// Since m(t) is increases and decreases linearly
   with time, the instantaneous frequency increases
   linearly from fimin to fimax
```

Scilab code Exa 5.3a problem3a

```
clc;
//page 222
//problem 5.3.a
// refer fig from page no. 212 Fig.5.4a
// The values of constsnts Kf and Kp are given as Kf
   = 2*pi*10^5 and Kp=5*pi .
// Here we are assuming the Bandwidth B of m(t) as
   the frequency of the third harmonic, i.e.
   3(10^4/2)Hz= 15kHz
B=15;// in kHz
// For FM:
//  Here peak amplitude of m(t) is mp=1
mp=1;
// df=kf*mp/2*pi
Kf= 2*%pi*10^5; Kp=5*%pi;
df= (Kf*mp)/(2*%pi);// in Hz
df=df/10^3;// in KHz
Bfm=2*(df+B);
disp(+'KHz',Bfm,'Bfm in kHz is');
// For PM:
//Here peak amplitude of m(t)' is mp=20000
mp=20000;
// df=kp*mp/2*pi
df= (Kp*mp)/(2*%pi);// in Hz
df=df/10^3;// in KHz
Bpm=2*(df+B);
disp(+'KHz',Bpm,'Bpm in kHz is');
```

Scilab code Exa 5.3b problem3b

```
clc;
//page 222
//problem 5.3.b
// The values of constsnts Kf and Kp are given as Kf
    = 2*pi*10^5 and Kp=5*pi .
// Here we are assuming the Bandwidth B of m(t) as
    the frequency of the third harmonic , i.e.
    3(10^4/2)Hz= 15kHz
B=15;// in kHz
// For FM:
// Here peak amplitude of m(t) is doubled ,mp=2
mp=2;
// df=kf*mp/2*pi
Kf= 2*%pi*10^5; Kp=5*%pi;
df= (Kf*mp)/(2*%pi);// in Hz
df=df/10^3;// in KHz
Bfm=2*(df+B);
disp(+'KHz',Bfm,'Bfm in kHz is');
// For PM:
//Here peak amplitude of m(t)' is doubled mp=40000
mp=40000;
// df=kp*mp/2*pi
df= (Kp*mp)/(2*%pi);// in Hz
df=df/10^3;// in KHz
Bpm=2*(df+B);
disp(+'KHz',Bpm,'Bpm in kHz is');
// doubling the signal amplitude roughly doubles the
     bandwidth of both FM and PM waveform
```

Scilab code Exa 5.4 problem4

```
clc;
//page 224
//problem 5.4
// Repeat example 5.3 with m(t) expanded by a factor of 2 i.e. if the period of m(t) is 4*10^-4
// The values of constsnts Kf and Kp are given as Kf = 2*pi*10^5 and Kp=5*pi .
// we know that time expansion by a factor 2 reduces the signal spectrum width by a factor 2
// Therefore bandwidth is half the previous bandwidth
B=7.5; // im KHz
// For FM:
//  Time expansion does not affect the peak amplitude so that mp=1.
mp=1;
// df=kf*mp/2*pi
Kf= 2*%pi*10^5; Kp=5*%pi;
df= (Kf*mp)/(2*%pi);// in Hz
df=df/10^3;// in KHz
Bfm=2*(df+B);
disp(+'KHz',Bfm,'Bfm in kHz is');
// For PM:
//mp is halved i.e. mp=10000
mp=10000;
// df=kp*mp/2*pi
df= (Kp*mp)/(2*%pi);// in Hz
df=df/10^3;// in KHz
Bpm=2*(df+B);
disp(+'KHz',Bpm,'Bpm in kHz is');
// Time expansion of m(t) has very little effect on the FM bandwidth, but it halves the PM bandwidth
```

Scilab code Exa 5.5 `problem5`

```
clc;
//Assuming SI unit for all quantities
//page 225
//problem 5.5
// An angle modulated signal with carrier frequency
   wc = 2*pi*10^5 is described by the equation Qem=
   10cos(@(t)) where @(t)=wct+5sin3000t+10sin2000pi*
   t
B=2000*%pi/(2*%pi);//signal bandwidthis the highest
   frequency in m(t)
Ac=10;//carrier amplitude
P=Ac^2/2;// carrier power
disp(+'watt',P,'a) The carrier power is ');
// to find frequency derivative df, e find
   instantaneous freq. w as
// wi=d/dt(@(t))= wc+15000cos3000t+20000pi*cos2000pi
   *t;
// The carrier derivative is 15000cos3000t+20000pi*
   cos2000pi*t. The two sinusoids will add in phase
   at some point and the maximum value of the
   expression is dW=15000+20000pi
dW=15000+20000*%pi;
df=dW/(2*%pi);
disp(+'Hz',df,'b) The frequency deviation in Hz is '
   );
// The deviation ratio B1 is given as
B1=df/B;
disp(B1,'c) The deviation ratio is ');
//The phase deviation is the maximum value of the
   angle @(t) and is given b d@
d=5+10;
disp(+'rad',d,'d)The phase deviation in rad is');
Bem=2*(df+B);
disp(+'Hz',Bem,'e)Bandwidth is ');
```

Chapter 6

SAMPLING AND PULSE CODE MODULATION

Scilab code Exa 6.2 `problem2`

```
clc;
// page no 271
// prob no. 6.2
fm=input("Enter the band limited freq in hertz = ");
Rn=2*fm; // Nyquist sampling rate
Ra=Rn*(4/3);// actual Nyquist sampling rate
// here the maximum quantization error(E) is 0.5% of the peak amplitide mp. Hence, E=mp/L=0.5*mp/100*L
mp=1;//we assume peak amplitude is unity
L=(mp*100)/(0.5*mp);
for (i=0:10)
  j=2^i;
  if(j>=L)
    L1=j;
    break;
    end
end
n=log2(L1);// bits per sample
```

```
c=n*Ra;// total no of bits transmitted
// Beause we can transmit up to 2bits/per hertz of bandwidth,we require minimum transmission bandwidth Bt=c/2
Bt=c/2;
disp(+'Hz',Bt,"minimum transmission bandwidth in hertz = ");
s=input("enter the no of signal to be multiplexed = ");
Cm=s*c;//total no of bits of 's' signal
c1=Cm/2;// minimum transmission bandwidth
disp(+'Hz',c1,"minimum transmission bandwidth in hertz = ")
```

Scilab code Exa 6.3 `problem3`

```
clc;
//page no 273
// prob no 6.3
// from the expresion given on the page no 272; (So/No)=(a+6n) dB where a=10log[3/[ln(1+u)]^2]
//check the ollowing code for L=64 and L=256
L=input("enter the value of L = ");
B=input("enter the bandwidth of signal in hertz = ");
n=log2(L);
Bt=n*B;
u=100;//given
a=10*log10(3/[log(1+u)]^2);
SNR=(a+(6*n));
disp(SNR,"SNR ratio is = ");
// Here the SNR ratio for the two cases are found out. The difference between the two SNRs is 12dB which is the ratio of 16. Thus the SNR for L=256 is 16 times the SNR for L=64. The former requires
```

```
just about 33% more bandwidth compared to the
later.
```

Chapter 7

PRINCIPLES OF DIGITAL DATA TRANSMISSION

Scilab code Exa 7.1 `problem1`

```
clc;
// page no 314
// prob no 7.1
//The transmission bandwidth is given by the
   equation Bt=(1+r)Rb/2 and hence transmission rate
    is given by Rb=2Bt/(1+r);where r=roll-off factor
    and 0<=r<=1. Since 'r' can take value in between
    0 and 1,bandwidth varies from 2Bt to Bt.
Bt=32000;r=1;//assume values of Bt and r
Rb=(2*Bt)/(1+r);
disp(Rb,"transmission rate");//Rb=Bt for r=1
```

Scilab code Exa 7.3 `problem3`

```
clc;
//page no 326
```

```
//prob no 7.3
// problem fig. is ggiven on page no 324. Referring the fig. we are given the values of a0,a1,a-1,a-2
a=1;b=-0.3;c=0.1;d=-0.2;e=0.05;
//design a three-tap (N=1) equalizer by substituting these values into eq no 7.45 of the page no 325
A=[0;1;0];
B=[a d e;b a d;c b a];
c=inv(B)*A;// As, A=B*C Hence c is obtained as given
disp(c);// values of C-1,C0,C1 are obtained
```

Scilab code Exa 7.4 `problem4`

```
clc;
// page no 334
//PROB NO 7.4 a) Find detection error probability
//Given: Ap=1mV, 6n=192.3uV
// The formula for polar case is given by Ap/6n
Ap=1;sigma_n=192.3;
x=Ap/sigma_n;//here we have to find the value of P(e)=Q(x) from the table10.2 given on page no. 454
disp(x);
Q1=(0.9964)*10^(-7);
disp(Q1,"error probability = ");//this is nearly equal to zero

//PROB NO 7.4 b) Find detection error probability.
//In this case, only half the bits are transmitted by no pulse, there are, on the average, only half as many pulses in the on-off case(compared to the polar).
//To maintain the same power,we need to double the energy of each pulse in the on-off or the bipolar case(compared to the polar).
//Now, doubling the pulse energy is accomplished by
```

```
    multiplying the pulse by sqrt(2).
//Thus, for on-off Ap is sqrt(2) times the Ap in the
     polar case,that is, Ap=sqrt(2)*10^-3
x=Ap/2*sigma_n;//here we have to find the value of P
    (e)=Q(x) from the table10.2 given on page no. 454
disp(x);
Q2=(1.166)*10^-4;
disp(Q2,"error probability = ");
//for a given power , the Ap for both the on-off and
     the bipolar  cases are identical. Hence P(e)=1.5
     Q(x);
Q3=1.5*Q2;
disp(Q3,"error probability = ");
```

Chapter 8

EMERGING DIGITAL COMMUNICATIONS TECHNOLOGIES

Scilab code Exa 8.3 problem3

```
clc;
// page no. 367
//prob no. 8.3
//since both the plots can be out of synchronization
    by as much as 6 parts (bits)in 10^13 , we have
// timing error bits per second can be calculated as
  -
//error in synchronization is given as
e=6/(10^13);//timing eeor bits per transmitted bits
//bit rate is given as
r =1544000 ;// in bits/sec
//timing error bits per second ,Te is given as
Te=e*r;
S=1/Te;// seconds per timing error bits
H=S/3600;// hours per timing error bits
//since a synchronization error can occur whenever
   the network is out of synchronization by 1/5 bits
```

```
    , the time between resynchronizing is given as
T=H/5;
disp(+'Hr',T,"No. of hours for resynchronizing");
```

Chapter 10

Introduction to Theory of Probability

Scilab code Exa 10.1 `problem1`

```
//page no 437
//prob 10.1
// referred to fig 10.1 on the page no. 435
// the occurance of each outcome is essumed to be
   equal.
n=input("number of outcomes= ");
p=1/n;
disp(p,"probability of each outcome=");
```

Scilab code Exa 10.3 `problem3`

```
// page no 438
//problem no 10.3
clc;
m=input("enter the number of faces = ");// m = 6
n=input("enter the number of dice = ");// n = 2
```

```
l=m^n ;// j is total number of outcomes = 36
a=input("enter the number which is to be obtained as
    the sum of dice  = ") // a=7
c=0 ; // counter value for favorable outcome
for i=1:6
  for j=1:6
    if(i+j==a)
      c=c+1;
    else
      continue
   end
  end
end
p=c/l;
disp(p,"probability = ");
```

Scilab code Exa 10.4 `problem4`

```
// page no 438
//problem no 10.4
clc;
m=input("enter the number of faces = ");// m = 2
n=input("enter the number of tosses = ");// n = 4
l=m^n ;// j is total number of outcomes = 16
a=input(" enter exact no of heads = "); // to obtain
    exactly 'a' heads
p=gamma (n+1)/(gamma(n+1-a) * gamma (a+1));// to
   find combination
disp(p/l,"probability = ");
```

Scilab code Exa 10.5 `problem5`

```
// page no 440
```

```
//problem no 10.5
clc;
a=52; // total no of cards in a deck
b=input ("enter the no of cards to be drawn = ");
pA1= b/a;// probability of getting first red ace =
   pA1
//the cards are drawn in succession without
   replacement , therefore the probability that the 2
   nd card will be the red ace = pA2
pA2=1/(a-1);
disp(p= pA1*pA2,"total probability = ");
```

Scilab code Exa 10.6 `problem6`

```
// page no 441
// prob no 10.6
// This problem is based on Bernoulli Trials formula
    which is P( k successes in n trials ) = n!*p^k
   *(1-p)^(n-k)/k!*(n-k)!22
// hence the probability of finding 2 digits wrong
   in a sequence of 8 digits is
clc;
k= input ("no. of successes =");
p= input ("probability of success =");
n=input (" no. of trials =");
A=gamma (n+1)* (p^k)*((1-p)^(n-k))/(gamma(k)*gamma(n
   +1-k));
disp(A,"probability =");
```

Scilab code Exa 10.9 `problem9`

```
// page no 446
//problem no 10.9
```

```
clc;
m=input("enter the number of faces = ");
n=input("enter the number of dice = ");
l=m^n ;// j is total number of outcomes
a=input("enter the number which is to be obtained as
    the sum of dice  = ") // a is varied from 2 to
   12
c=0 ; // counter value for favorable outcome
for i=1:6
  for j=1:6
    if(i+j==a)
      c=c+1;
    else
      continue
   end
  end
end
p=c/l;
disp(p,"probability = ");
```

Scilab code Exa 10.10 `problem10`

```
// page no 447
//prob no 10.10
clc;
Pe= input ("enter error probability = ");
Q= input("enter the probability of transmitting 1 =
   ");//Hence probability of transmitting zero is 1-
   Q = P
P=1-Q;
Px(1)=Q;
Px0=P;
// If x and y are transmitted digit and received
   digit then for BSC P(y=0/x=1) = P(y=1/x=0) = Pe ,
    P(y=0/x=10) = P(y=1/x=1) = 1-Pe
```

```
// to find the probability of receiving 1 is Py(1) =
    Px(0)*P(y=1/x=0) + Px(1)*P(y=1/x=1)
Py(1)= ((1-Q)* Pe) + (Q *(1-Pe));
disp(Py(1),"Py(1)");
Py0=((1-Q)*(1-Pe)) + (Q*Pe)
disp(Py0,"Py0");
```

Scilab code Exa 10.11 problem11

```
//page no 448
//prob 10.11
clc;
Px0=.4 , Px1=.6 ,PE0=10^-6 , PE1=10^-4 ;// given
PE=(Px0*PE0) + (Px1*PE1)// formula for probability
    of error
disp(PE,"probability of error = ");
```

Scilab code Exa 10.20 problem20

```
//page no 472
//prob no 10.20
//Gaussian PDF: Q(x)= %e^((-x^2)/2)/ (x*sqrt(2*%pi))
clc;
x=input("input for the function Q = ");
Q(x)= (%e^-((x^2)/2))/ (x*sqrt(2*%pi));
P=1-(2*Q(x));
disp(P);// P gives the width or spread of Gaussian
    PDF
```

Scilab code Exa 10.21 problem21

```
// page no 479
//prob no 10.21
// formula for estimate error E is E = mk^ − mk = a1
    ∗ mk−1 +a2∗ mk−2 −mk
//given: various values of correlation (mk∗mk)'= (m
    ^2)',(mk∗mk−1)'= .825∗ (m^2)',(mk∗mk−2)'= .562∗(m
    ^2)',(mk∗mk−3)'= .825∗(m^2)' , R02=.562(m^2)', a1
    =1.1314, a2= −0.3714
// mean square error is given by I=(E^2)'=[1−((.825∗
    a1)+(.562∗a2))]∗(m^2)'= .2753∗(m^2)'
clc;
m=1;
I=.2753*(m^2)';
S=10*log ((m^2)'/I);
disp(+'dB',S,"SNR improvement = ");
```

Chapter 11

RANDOM PROCESSES

Scilab code Exa 11.2 Example 2 of chapter 11

```
//page 500
//example 11.2 (assuming SI units)
//given signal is Sx=(N/2)*rect(w/4(%pi)B)
clc;
N=1;B=1;
T=input("enter the value of T");
Rx=(N*B)*(sinc(2*(%pi)*B*T));
disp(+'Watt',Rx,"mean square value of the signal is"
    );
```

Scilab code Exa 11.3 Example 3 of chapter 11

```
//page 501
// example 11.3(Assuming SI units)
// autocorrelation function of given signal is A^2/2
    * cos(wct)
clc;
A=2;
```

```
wct=input("enter the value of wct");
Rx=((A^2)/2)* cos(wct);
disp(+'Watt',Rx,"mean square value of the process is ");
```

Scilab code Exa 11.7 Example 7 of chapter 11

```
//page 506
//example 11.7
clc;
P1=input("enter prob of symbol 1");
P2=input("enter prob of symbol -1");
ak=(1)*P1+(-1)*P2;
disp(ak,"mean is");
Ro=(1^2)*P1+((-1)^2)*P2;
disp(Ro,"mean square is");
```

Scilab code Exa 11.8a Example 8a of chapter 11

```
//page 507
// example 11.8a
clc;
P1=input("enter prob of symbol 1");
P0=input("enter prob of symbol 0");
ak=(1)*P1+(0)*P2;
disp(ak,"mean is");
Ro=(1^2)*P1+((0)^2)*P2;
disp(Ro,"mean square is");
```

Scilab code Exa 11.8b Example 8b of chapter 11

```
//page 508
// example 11.8b
// bipolar signalling
clc;
P0=input("enter prob of symbol 0");
P1=input("enter prob of symbol 1");
P2=input("enter prob of symbol -1");
ak=(0)*P0+(1)*P1+(-1)*P2;
disp(ak,"mean is");
Ro=(0^2)*P0+(1^2)*P1+((-1)^2)*P2;
disp(Ro,"mean square is");
```

Chapter 12

BEHAVIOUR OF ANALOG SYSTEMS IN THE PRESENCE OF NOISE

Scilab code Exa 12.1 `problem1`

```
// page no 536
// Example 12.1
// Let the received signal be km(t)cos(wct) ,
   demodulator input is [km(t)+nc(t)]cos(wct)+[ns(t)
   sin(wct)]. When this is multiplied by 2coswct and
    low pass filtered the output is s0(t)+n0(t)=km(t
   )+nc(t).
// Hence So=k^2*m^2' , No=nc^2'. But the power of
   the received signal km(t)cos(wct)= 1uW. Hence k
   ^2*m^2'/2=10^-6
clc;
So=2*10^-6;
// to compute nc: (nc^2)'=(n^2)'=x
t0=496000; t1=504000 ;
a=10^6 * %pi;
y=integrate ('1/((t^2)+(a^2))','t',t0,t1);
// to compute output SNR
```

```
SNR=So/y;
val=(10*(log (SNR)));
disp(+'dB',val,"output SNR = ");
```

Scilab code Exa 12.2 find gamma threshold

```
//page 540
//problem 12.2
//as En=sqrt(nc^2+ns^2),where both nc and ns are
   gaussian with variance 6n^2,according to the
   following eqn P(En>=A)=integrate(En/6n^2)*e^(-En
   ^2/2*6n^2)dEn;
// the value of this integral is the probability of
   which is 0.01
//hence e^(-A^2/2*6n^2)=0.01
//let g=A^2/(2*6n^2);
clc;
g=-(log(0.01)/log(%e));
// the variance 6n^2 of the bandpass noise of PSD N
   /2 and the bandwidth 2B is 2NB.Hence at the onset
    of the threshold
// therefore A^2/(2*6n^2)=A^2/(4NB)=g
//for tone modulation
//Si=A^2+m'^2/2;
//Si=3*A^2/4;
gma_th=3*(g);// gma_th=Si/NB=3*A^2/(4NB);
disp(gma_th,'gamma threshold');
```

Scilab code Exa 12.3 find output SNR

```
//page 547
//problem 12.3
// for a gaussian m(t),mp will be assumed as 36m
```

```
clc;
Sg=3;//assumed
Mbar=(Sg^2);
MP=((3*Sg)^2);
B=0.2;//ASSUMED
gma=0.4;//assumed
SNR=3*B^2*(Mbar/MP)*gma;
disp(SNR,'SIGNAL TO NOISE RATIO IS');
```

Scilab code Exa 12.4 prove the given expression

```
//page 550
//problem 12.4
clc;
t0=-5;t1=5;
y=integrate('t^2','t',t0,t1);
f=integrate('1','t',t0,t1);
Bm=y/f;
disp(Bm,'value of Bm is');
```

Scilab code Exa 12.5 prove the given expression

```
//page 550
//problem 12.5
// Sm(w)=k*e^(-w2/26^2) this is given
// let us the assume the value of constant 6^2/4(pi
   ^2) =3
// thus the variance can be calculated as
clc;
f0=0;f1=15;
y=integrate('(f^2)*(%e^(-(f^2)/6))','f',f0,f1);
g=integrate('%e^(-(f^2)/6)','f',f0,f1);
v=y/g;
```

```
disp(v,'Bm2');
```

Scilab code Exa 12.6 show that PM is superior to FM by factor of 3

```
//page 552
//prob 12.6
//for the same transmission bandwidth variance of PM and FM systems is same
//hence the ratio of SNR of PM to FM is B^2/(3Bm'^2)
//assuming 6=1
clc;
B=3/(2*%pi);//because W=2*%pi*B
//variance is Bm2
f0=0;f1=15;
y=integrate('(f^2)*(%e^(-(f^2)*2*(%pi^2)))','f',f0,f1);
g=integrate('%e^(-(f^2)*2*(%pi^2))','f',f0,f1);
Bm2=y/g;
l=(B^2)/(3*(Bm2));
disp(l,'factor of superiority of PM over FM');
```

Scilab code Exa 12.7 problem7

```
// page no 555
// Example 12.7
clc;
B=4; SNR=20.5; // given
r=20*(B+1);//as B=4
//output SNR is given as So/No=3*B^2*r*(m^2'/mp^2)
m=4;// m=mp/6m is given
SNRt=3*(B^2)*r*(1/m)^2;
disp(SNRt,"threshold SNR = ");
// to calculate output SNR in dB
```

```
SNRdB=20*log(SNR);
disp(+'dB',SNRdB,"Threshold SNR in dB = ");
if 20.5< SNRdB
  disp("system is in threshold")
else
  disp('system is not in threshold");
  end
```

Scilab code Exa 12.8 determine output SNR

```
//page 561
//prob 12.8
//for a gausssian signal ,mp=infinity(00),but we may
   assume 36 loading ,thus mp=3*6,
clc;
Sgm=3;
m2=(Sgm^2);
mp2=((3*Sgm)^2);
y=(m2)/(mp2);
// to calculate SNR,we have SNR=3(2^n)*((m^2)/(mp^2)
   )
n=8;//given
l=3*(2^(2*n))*y;//by formula
disp(l,'SNR is equal to');
disp(+'dB',(10*(log10(l))),'SNR in dB');
```

Scilab code Exa 12.10 find output SNR

```
//page 567
//prob 12.10
// to calculate |m|
clc;
m0=0;m1=50;
```

```
m=integrate('(m*(%e^-((m^2)/2)))','m',m0,m1);//
    assuming 6m=1
disp((sqrt(2/%pi)*m),'value of |m|');
```

Scilab code Exa 12.11 find output SNR

```
//page 569
//prob 12.11
a=1400*%pi;//given
clc;
c=1;//assumed
w0=0;w1=8000*%pi;
S=integrate('1/((w^2)+(a^2))','w',w0,w1);
So=S/%pi;
disp(So,'transmitted power');//assuming G=1,hence St
    =So
//assuming N=1
No=4000;//because No=N*B
SNR=So/No;
disp(SNR,'SNR without pre-emphasis and de-emphasis')
    ;
S=integrate('1/(sqrt((w^2)+(a^2)))','w',w0,w1);
disp(S,'S is');
SNRo=(10^-8)*4*(%pi^2)/(2*(S^2));
disp(SNRo,'SNR at the output is');
disp((SNRo/SNR),'Improvement factor in SNR with pre-
    emphasis and de-emphasis');
```

Chapter 13

BEHAVIOUR OF DIGITAL COMMUNICATION SYSTEMS IN THE PRESENCE OF NOISE

Scilab code Exa 13.1 problem1

```
// page no 620
// prob no 13.1
//Determinaion of the transmission bandwidth and the
    signal power required at the receiver input for
    i)Binary ii)16-ary ASK iii)16-ary PSK
//given Rb=2.08*10^6,Pb<=10^-6

//i)for BINARY we have to consider Pb=Pe=10^-6=Q(
    sqrt(2Eb/N)). This yields Eb/N=11.35.
//SIgnal power is given by Si=Eb*Rb=11.35*N*Rb
clc;
N=2*10^-8;//for binary. Channel noise PSD=10^-8
Rb=2.08*10^6;
Si1=11.35*N*Rb;
disp(+'Watts',Si1,"signal power required at the
```

```
    receiver = ");
Bt1=Rb;// Bandwidth for baseband pulses
disp(+'Hertz',Bt1," Bandwidth is = ");

//ii)for 16-ary ASK we have to consider Pb=10^-6=Pem
    /log2(16)
// therefore Pem is given as Pem=Pb*log2(16)
Pb=10^-6;
Pem=Pb*log2(16);
//'Pem' is also given as Pem=2(M-1/M)*Q*sqrt(6Eb*
    log2(16)/(N(M^2-1)))
M=16;// for 16-array ASk
// By using above formula for 'Pem' , we can
    calculate the value of Eb,which is come out to be
     equal to 0.499*10^-5;
Eb=0.499*10^-5;// if the M-ary pulse rate is RM =Rb
    /4 then
RM =Rb/4;
Si2=Eb*(log2(M))*RM;
disp(+'Watts',Si2,"signal power required at the
    receiver= ");
Bt2=RM;//transmission bandwith
disp(+'Hertz',Bt2,"Bandwidth is = ");

//iii) for 16-array PSK we have to consider Pem=4*Pb
    . This is approximately equal to 2*Q(sqrt(2*pi^2*
    Eb*log2(16))/256*N). This yields
Eb= 137.8*10^-8;
Si3=Eb*log2(16)*RM;
disp(+'Watts',Si3,"signal power required at the
    receiver = ");
Bt3=RM;//normally
//But for PSK, as it is a modulated signal the
    required bandwidth is 2Bt3.
Bpsk=2*(Bt3);
disp(+'hertz',Bpsk,"Bandwidth is = ");
```

Chapter 14

OPTIMUM SIGNAL DETECTION

Scilab code Exa 14.1 Represent the given signal

```
//page 631
//prob 14.1
// the co-ordinates of the vectors are
// s1(1,-0.5),s2=(-0.5,1),s3=(0,-1),s4=(0.5,1)
x4=0:0.1:0.5;
y4=2*x4;

plot2d(x4,y4,style=1);// black line
x1=0:0.1:1;
y1=-0.5*x1;
plot(x1,y1,style=3);//blue line
```

Scilab code Exa 14.2 Example 2 of chapter 14

```
clc;
//page no. 650
```

```
// problem no. 14.2
// the two symbols to be transmitted are m1 and m2, the probabilities of which are not equal
// To design the optimum receiver we need to decide the threshold say d
// N be the given noise  PSD,E the energy of the signal , assume N =1, E=1.5
Pm1=input("probability of symbol m1=");
Pm2=input("probability of symbol m2=");
//d is calculated as follows
N=1;
E=1.5;
d=(N/(4*sqrt(E)))*log(Pm2/Pm1);
disp(d,"the threshold is=");
```

Scilab code Exa 14.7 Example 7 of chapter 14

```
//page no 665
// example 14.7
// we know k1P(m1)=k2P(m2) , where k1 and k2 are the distances of the signals s1 and s2 resp.,hence k1+k2=d
clc;
Pm1=input("probability of symbol m1=");
Pm2=input("probability of symbol m2=");
//assume d=1
d=1;
E1=(((Pm1)*((d^2)/2))+((Pm2)*((d^2)/2)));
disp(+'units',E1,"mean energy of the first signal");
E2=Pm1*Pm2*(d^2);
disp(+'units',E2,"mean energy of the second signal");
if(E1==E2)
    disp("signals are equiprobable");
    end
```

Chapter 15

INTRODUCTION TO INFORMATION THEORY

Scilab code Exa 15.1 `problem1`

```
//page no 687
// prob no 15.1
// Here we have given six messages. For 4-ary Huffman code, we need to add one dummy variable to satisfy the required condition of r+k(r-1) messages.
//probabilities are given as p(1)=0.3; p(2)=0.25; p(3)=0.15; p(4)=0.12; p(5)=0.1; p(6)=0.08; p(7)=0.

//The length L of this code is calculated as
clc;

  n=input("enter the length of probability vector p, n= ");
p=[.3 .25 .15 .12 .1 .08 0];// enter probabilities in descending order
l=[1 1 1 2 2 2 2];// code length of individual message according to order
L=0;
```

```
for i=1:n
  L=L+(p(i)*l(i));
end
disp(+'4−ary digits',L,"Length = ");

// Entropy of source is calculated as
H=0;
for i=1:n-1//since the value of log(1/0) for the
   last entry is infinite which when multiply by 0
   gives result as 0
  H=H+(p(i)*log(1/p(i)));
end
H1=H/log(4)
disp(+'4−ary units',H1,"Entropy of source is, H = ")
   ;

// Efficiency of code is given as
N=H1/L;
disp(N,"Efficiency of code, N = ");
```

Scilab code Exa 15.2 `problem2`

```
// Page no 688
// Example no. 15.2
// N=1
//Here we have given two messages with probabilities
    m1=0.8 and m2=0.2 . Therefore, Huffman code for
   the source is simply 0 and 1.

//The length L of this code is calculated as
clear;
clc;
close;
N=1;
p=[.8 .2];//enter probabilities in descending order
```

```
n=length(p)
l=[1 1];//code length of individual message
   according to order
L=0;
for i=1:n
  L=L+(p(i)*l(i));
end
disp(L,"Length = ");

// Entropy of source is calculated as
H=0;
for i=1:n
  H=H+(p(i)*log2(1/p(i)));
end
disp(+'bit',H,"Entropy of source is, H = ");

// Efficiency of code is given as
N1=H/L;
disp(N1,"Efficiency of code, N = ");

//for N=2
//There are four (2^N) combinations and their
   probabilities obtained by multiplying individuals
    probability.
//The length L of this code is calculated as
N=2;
p=[0.64 0.16 0.16 0.04];//enter probabilities in
   descending order
n=length(p);
l=[1 2 3 3];//code length of individual message
   according to order
L1=0;
for i=1:n
  L1=L1+(p(i)*l(i));
end
L=L1/N;// word length per message
disp(L,"Length = ");

```

```
// Efficiency of code is given as
N2=H/L;
disp(N2,"Efficiency of code, N = ");


//for N=3
//There are eight (2^N)combinations and their
   probabilities obtained by multiplying individuals
    probability
//The length L of this code is calculated as
N=3;
p=[.512 .128 .128 .128 .032 .032 .032 .008];//enter
   probabilities in descending order
n=length(p);
l=[1 3 3 3 5 5 5 5];//code length of individual
   message according to order
L1=0;
for i=1:n
  L1=L1+(p(i)*l(i));
end
L=L1/N;// word length per message
disp(L,"Length = ");

// Efficiency of code is given as
N3=H/L;
disp(N3,"Efficiency of code, N = ");
```

Scilab code Exa 15.4 problem4

```
// page no 702
// prob no 15.4
clc;
x0=(-1);x1=1;//given
y0=(-2);y1=2;//given
G=2;//gain of amplifier
```

```
//the probbilities are given as P(x)=1/2 for |x|<1 & P(y)=1/4 for |y<2| otherwise P(x)=P(y)=0.
//P(x<1 & -x<1)=1/2;
//P(y<2 & -y<2)=1/4;
// hence entropies are given as
g1=(1/2)*log2(2);
g2=(1/4)*log2(4);
X=integrate('g1*1','x',x0,x1);
Y=integrate('g2*1','y',y0,y1);
disp(+'bit',X,"entropy = ");
disp(+'bits',Y,"entropy = ");
//Here the entropy of random variable 'y' is twice that of the 'x'.This results may come as a surprise,since a knowledge of 'x' uniquely determines 'y' and vice versa , since y=2x.Hence , the average uncertainty of x and y should be identical.
// The reference entropy R1 for x is -log dx ,and The reference entropy R2 for y is -log dy (in the limit as dx,dy->0 ).
// R1= lim (dx->0) -log dx
//R2= lim (dy->0) -log dy
//and R1-R2 = lim(dx,dy->0) log(dx/dy) = log (dy/dx) = log2 2 =1 bit
//Therefore,the reference entropy of x is higher than the reference entropy for y. Hence we conclude that
disp(" if x and y have equal absolute entropies, their relative (differential) entropies must differ by 1 bit ");
```

Chapter 16

ERROR CORRECTING CODES

Scilab code Exa 16.1 Linear block codes

```
//page no 732
// example no 16.1.
//here generator matrix is given
clc;
G=[1 0 0 1 0 1;0 1 0 0 1 1;0 0 1 1 1 0];
d1=[1 1 1];
d2=[1 1 0];
d3=[1 0 1];
d4=[1 0 0];
d5=[0 1 1];
d6=[0 1 0];
d7=[0 0 1];
d8=[0 0 0];
    c1=d1*G;
    for i=1:6
    if c1(i)==2 then
        c1(i)=0;
    end
end
```

```
c2=d2*G;
    for i=1:6
    if c2(i)==2 then
        c2(i)=0;
    end
end
c3=d3*G;
    for i=1:6
    if c3(i)==2 then
        c3(i)=0;
    end
   end
c4=d4*G;
    for i=1:6
    if c4(i)==2 then
        c4(i)=0;
    end
end
c5=d5*G;
    for i=1:6
    if c5(i)==2 then
        c5(i)=0;
    end
end
c6=d6*G;
    for i=1:6
    if c6(i)==2 then
c6(i)=0;
    end
end
c7=d7*G;
    for i=1:6
    if c7(i)==2 then
        c7(i)=0;
    end
end
c8=d8*G;
    for i=1:6
```

```
    if c8(i)==2 then
        c8(i)=0;
    end
end
disp("code words are given as")
disp(c1);
disp(c2);

disp(c3)
disp(c4)
disp(c5);
disp(c6);

disp(c7);

disp(c8);
```