

Scilab Textbook Companion for  
Analog Communication  
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June 3, 2016

<sup>1</sup>Funded by a grant from the National Mission on Education through ICT, <http://spoken-tutorial.org/NMEICT-Intro>. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website <http://scilab.in>

# Book Description

**Title:** Analog Communication

**Author:** V. Chandrasekar

**Publisher:** Oxford University Press

**Edition:** 1

**Year:** 2010

**ISBN:** 0198061854

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

# Signals An Introduction

Scilab code Exa 2.1.A Periodicity

```
1
2 clear;
3 clc;
4          //a) periodicity os 5sin(6t-pi/4)
5 t=0:0.001:1;
6 w=6;
7 theta=%pi/4;
8 T=2*%pi/w;
9 x=cos(t*w+theta);
10 y=cos((t+T)*w+theta);
11 if ceil(x)==ceil(y) then
12     disp(' a) cos(6t+pi/4) is periodic with T=2*pi/6
13         (sec) ')
14 else
15     disp('nonperiodic')
16 end
17
18
19          //b) periodicity of e^(j3t)
20
```

```

21     w=3;
22     t=0:0.001:1;
23     T=2*%pi/w;
24     x=exp(3*%i*t);
25     y=exp(3*%i*(t+T));
26     if ceil(x)==ceil(y) then
27         disp(' b) exp(j3t) is periodic with T=2*pi/3 (
                sec) ')
28
29     else
30         disp(' nonperiodic ')
31     end
32
33         //c) periodicity of cot(3t+theta)
34
35
36     t=0:0.001:1;
37     w=5;
38     T=%pi/w;
39
40     x=cotg(t*w+theta);
41     y=cotg((t+T)*w+theta);
42     if ceil(x)==ceil(y) then
43         disp(' c) cot(3t+Theta) is periodic with T=pi/5
                (sec) ')
44
45     else
46         disp(' nonperiodic ')
47     end

```

---

### Scilab code Exa 2.2.A Even and Odd Part of function

```

1  clc;
2  clear;
3  t = 0:1:10;

```

```

4
5 for i = 1:length(t)
6     x(i) = (t(i)^6) + 2*(t(i)^4)+ 3*(t(i)^2)+4 ;
7 end
8
9 for i = 1:length(t)
10    y(i) = ((-t(i))^6)+ 2*((-t(i))^4)+ 3*((-t(i))^2)+4
        ;
11 end
12
13 // checking if the function is even x(t)=x(-t)
14 if x==y then
15     disp("the function is even");
16 end
17 //odd part of the signal=0.5(x(t)-x(-t))
18
19 z=0.5*(x-y);
20 if z==0 then
21     disp("the odd part is 0")
22 end

```

---

### Scilab code Exa 2.2 Real and Imaginary part

```

1 clc;
2 clear;
3
4 /// ej(*2*pi*f*t+theta)
5
6 syms pi f0 t theta A
7 K=2*pi*f0*t+theta;
8
9 disp("the given signal is complex");
10 disp("e(j*theta) can be written as");
11 disp("cos(theta)+j*sin(theta)");
12

```

```

13 Re=A*cos(K);
14 Img=A*sin(K);
15 mag=sqrt(Re^2+Img^2);
16
17 disp(Re,"real part is ");
18 disp(Img,"the imaginary part ");
19 disp(mag,"Magnitude of signal is |A|=");
20 disp(K,"phase of the signal ");

```

---

### Scilab code Exa 2.3.A Power and Rms power of Signal

```

1 clear;
2 clc;
3
4 //x(t)=5u(t)....
5 amp=5; //amplitude is 5
6 t=0:0.01:1;
7 x0=0;
8 x1=0:0.1:10; // over a time interval of T
9 disp("the power of the signal (in watts) is");
10 X=(integrate('25','x',x0,10)/(2*10)); // power of
    the signal
11 disp(X);
12
13 rms=amp/sqrt(2);
14 disp(rms,"the rms value of power is (in watts)");

```

---

### Scilab code Exa 2.3 Energy of Signal

```

1 clc;
2 clear;
3
4 //x(t)=2 over an interval of (-2,2)

```

```

5
6 disp("the energy of the signal (in J)is");
7 Ex=(integrate('4','x',-2,2)); // energy content of
   the signal
8 disp(Ex);

```

---

### Scilab code Exa 2.5 Properties of Impulse Signal

```

1 clc;
2 clear;
3
4
5 //delta(t)
6
7   for j = 1:1000
8       if j==1
9           delta(j)=1;
10      else
11          delta(j)=0;
12      end
13  end
14
15 // a)
16 figure(1)
17 t=-1;
18 plot2d4(t,0);
19   for j=1:1:10
20       t=t+1;
21       z(j)=(cosd(j-1)*delta(j));
22       plot2d3(t,z(j));
23       disp(z(j));
24
25   end
26
27

```

```

28 //b)
29 figure(2)
30 t=1.5;
31 plot2d4(t,0);
32     for j=3:1:10
33         t=t+1;
34         z(j)=abs(cosd(2.5)*delta(2*j-5));
35         plot2d3(t,z(j));
36
37     end
38
39 //c)
40 syms t;
41
42 A=(-1)*exp(-1*t); //property 8
43 disp(diff(A,t));
44
45 disp("when t=3");
46
47 A=exp(-3);
48 disp(A);

```

---

### Scilab code Exa 2.10 Laplace Transform

```

1
2
3 //x(t) = del(t)
4 syms t s;
5
6 L =laplace('delta(t)',t,s)
7 disp(L)
8 // x(t) = u(t)
9
10 L1 =laplace('1',t,s);
11 disp(L1)

```

```
12 //x(t) = sin(w0*t)u(t)
13
14 L2 =laplace('sin(w0*t)',t,s);
15 disp(L2)
```

---

### Scilab code Exa 2.11 Z transform

```
1
2 clc;
3 clear;
4
5 // a) z-transform of unit impulse function
6 syms n z;
7 x=1;
8 X=symsum(x*(z^-n),n,0,0);
9 disp(X, 'X(z)=');
10
11 //b) z-transform of unit step function
12
13 y=ones(1);
14 Y=symsum(y*(z^-n),n,0,%inf);
15 disp(Y, 'Y(z)=');
```

---

# Chapter 3

## Amplitude Modulation

Scilab code Exa 3.1.A AM Sidebands

```
1  clc ;
2  clear ;
3  Fc=500; //carrier frequency in kHz
4  Fm=1; // message signal frequency in kHz
5  //a)
6
7  USB=Fc+Fm;
8  LSB=Fc-Fm;
9  disp(USB,"USBI(in kHz)=");
10 disp(LSB,"LSB(in kHz)=");
11
12 //b)
13
14 Bandwidth=USB-LSB;
15 disp(Bandwidth,"Bandwidth(in kHz)=")
16 //c)
17
18 Fm=1.5; //message signal frequency in kHz
19
```



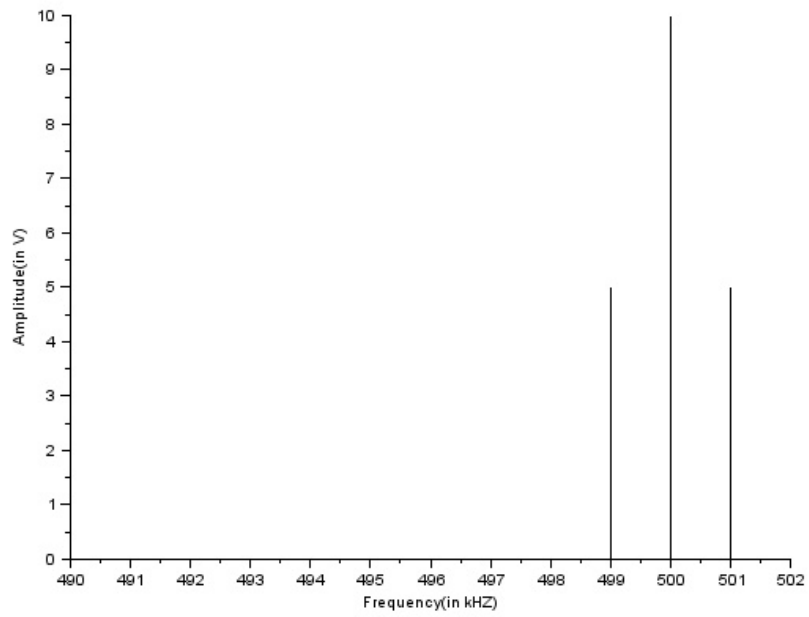


Figure 3.1: AM Sidebands

```

20 USB1=Fc+Fm;
21 LSB1=Fc-Fm;
22 disp(USB1,"USB(in kHz)=");
23 disp(LSB1,"LSB(in kHz)=");
24
25
26 //d)
27
28 Amplitude=[0 0 0 0 0 0 0 0 0 5 10 5 0]; //sample
    values as denoted in textbook
29 frequency=490:1:502;
30
31 plot2d3(frequency,Amplitude);
32 xlabel("Frequency(in kHz)");
33 ylabel("Amplitude(in V)");

```

---

### Scilab code Exa 3.1 amplitude modulation

```

1  clc;
2  clear;
3  Vm=3; // amplitude of message signal in V
4  Vc=5; //amplitude of carrier signal in V
5  m=Vm/Vc; //modulation index
6  disp("modulation index");
7  disp(m,"=");
8  disp("Upper Sideband Frequency(in MHz)");
9  Fm=4; //Frequency in KHz
10 Fc=5; //Frequency in MHz
11 disp(Fc+(Fm*10^(-3)),"=");
12 disp("Lower Sideband Frequency(in MHz)");
13 disp(Fc-(Fm*10^(-3)),"=");
14 disp("AMplitude of each Sideband(in V)");
15 disp(m*Vc/2,"=");

```

---

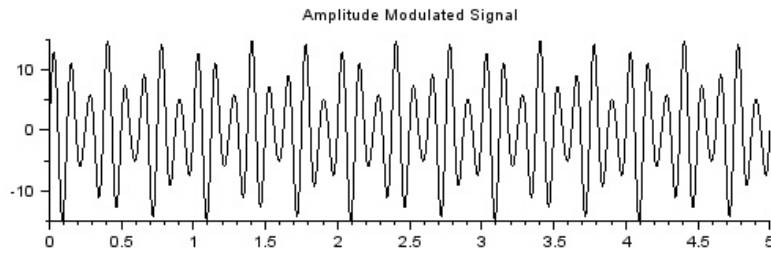


Figure 3.2: Amplitude Modulation

### Scilab code Exa 3.2.A Amplitude Modulation

```
1 clear;  
2 clc;  
3  
4  
5 Fm=3; //frequency of message signal  
6 Fc=8; //frequency of carrier signal  
7 Ea=5;  
8 Eb=10;
```

```

9  m=Ea/Eb; //modulation index
10
11  disp(m,"m=");
12  USf=Fc+Fm*10^(-3); //Upper Sideband frequency
13  LSf=Fc-Fm*10^(-3); //Lower sideband frequency
14  disp(USf,"USf(Mhz)=");
15  disp(LSf,"LSf(Mhz)=");
16  Amp=m*Eb/2; // amplitude of each sideband
17  disp(Amp,"amp(v)=");
18
19
20
21  function [x,Vm,Vc]=ampmod(Ea,Eb,m,Fc,Fm)
22      t=0:0.005:5;
23
24      Vm = Ea*sin(2*pi*Fm*t);
25      Vc = Eb*sin(2*pi*Fc*t);
26
27      x = ((Eb+Ea*sin(2*pi*Fm*t)).*(sin(2*pi*Fc*t)))
          ;
28
29      subplot(3,1,2);
30      plot2d(t,x);
31      title('Amplitude Modulated Signal');
32  endfunction
33
34  ampmod(Ea,Eb,m,Fc,Fm) //amplitude modulation

```

---

### Scilab code Exa 3.2 Total power of AM wave

```

1  clc;
2  clear;
3  Pc=300; // Power of the carrier in W
4  m=0.6 // modulation index
5  Pt=Pc*(1+(m^2)/2); //total power

```

```
6 disp("Total power in the modulated wave(in W) is");
7 disp(Pt);
```

---

### Scilab code Exa 3.3.A Efficiency of DSBFC

```
1 clc;
2 clear;
3 disp(" efficiency (n)=(useful power/total power)*100%"
      );
4 disp("          =total sideband power/(total sideband
      power+carrier power)*100%");
5
6 syms m Pc
7 N=[((m^2)*Pc/2)/(Pc*(1+(m^2)/2))];
8 disp(" *100% ",N);
9
10 disp("
      ");
11 m=0.7 //modulation index
12
13
14 n=[m^2/(m^2+2)]*100; //efficiency
15 disp(n,"the percentage of useful power is ");
```

---

### Scilab code Exa 3.3 Modulation index

```
1 clc;
2 clear;
3 Pt=11.5; //Total power in kW
4 Pc=10; // Carrier power in kW
5 //a)
6
```

```

7 m_square=2*((Pt/Pc)-1);
8 m=sqrt(m_square); //modulation index
9
10 //b)
11 m2=0.5;
12 mt=sqrt(m^2 +m2^2);
13 Pt=Pc*(1+mt^2/2); //total power in kW
14
15 disp(m,"modulation index is ");
16 disp(Pt,"Total carrier power(in kW) ");

```

---

#### Scilab code Exa 3.4.A DSBFC

```

1 clc;
2 clear;
3 Vc=8; // carrier signal voltage in V
4 m=1; //modulation index
5 R=8; //resistance in ohms
6 //a)
7
8 Pc=Vc^2/(2*R);
9 disp(Pc,"power of the carrier(in W) is");
10 Ps=m^2*Pc/4;
11 disp(Ps,"Power in each Side-Bands(in W)");
12
13 //b)
14 disp(2*Ps,"Total sideband Power(in W)");
15
16 //c)
17 disp(Pc+2*Ps,"Total Power of Modulated wave(in W)");
18
19 //d)
20 disp(2*Ps/(Pc+2*Ps)*100,"Efficiency Percentage");

```

---

### Scilab code Exa 3.4 Modulation index and power

```
1  clc;
2  clear;
3  m1=0.3;
4  m2=0.4;
5  m3=0.5;
6  m4=0.6; //modulation indices
7  Pc=150; //power of carrier in Watts
8
9  mt=sqrt(m1^2+m2^2+m3^2+m4^2); //total modulation
   index
10
11 Pt=Pc*(1+mt^2/2); //Total transmitted power in Watts
12
13 Ps=(mt^2)*Pc/4; //Sideband Power in Watts
14
15 disp(mt,"Total Modulation index");
16
17 disp(Pt,"Total Transmitted Power (in W)");
18
19 //change in answer as compared to book ,due to
   approximation error..
20 disp(Ps,"Sideband Power(in W)")
```

---

### Scilab code Exa 3.5.A Amplitude Modulation

```
1  clc;
2  clear;
3  m1=0.3;
4  m2=0.4;
5  m3=0.5;
```

```

6 m4=0.6; //modulation indices
7 Pc=80; // Power in carrier signal
8
9 mt=sqrt(m1^2+m2^2+m3^2+m4^2);
10
11 //a)
12 disp(mt,"Total Coefficient of Modulation ");
13
14 //calculation error in book
15
16 //b)
17 Ps=(mt^2)*Pc/2;
18 disp(Ps,"Sideband powers(in W) ");
19
20 //c)
21 disp(Pc+2*Ps,"Total Transmitted Power(in W)");
22
23 //d)
24 disp((Ps/(Pc+2*Ps))*100,"Efficiency Percentage");

```

---

### Scilab code Exa 3.5 Peak Envelope Power and average power

```

1 clc;
2 clear;
3 fLSB1=395;
4 fLSB2=397.5; // Two LSB frequencies in kHz
5 E1=4;
6 E2=3; //peak voltages of modulating signal in V
7 R=60; //resistor in ohms
8
9 Et=sqrt(E1^2+E2^2);
10
11 Erms=Et*0.707;
12
13 PEP=((Et*0.707)^2)/R; //Peak Envelope Power in W

```



```

14
15 Avg_Power=PEP/2;
16
17 disp(PEP,"Peak Envelope Power(in W)");
18 disp(Avg_Power,"Average Power(in W)");

```

---

### Scilab code Exa 3.7.A Diagonal Clipping

```

1 clc;
2 clear;
3 Fc=10;//carrier Frequency in kHz
4 R=15;//Resistance in Kohms
5 C=660;//Capacitance in pF
6 a=1/R;
7 b=2*%pi*Fc*10^(3)*C*10^(-12);
8 Y=a+%i*b;
9 Z=1/abs(Y);
10 //after rounding off
11 Z=12.83//Impedence in Kohms
12 m=Z/(R);//modulation index
13 disp(m,"MAximum modulation index to avoid diagonal
    clipping is");

```

---

### Scilab code Exa 3.8.A Sideband Frequencies

```

1 clc;
2 clear;
3
4
5 syms Ec Fc Fm pi t
6
7 Wave=Ec*cos(2*pi*Fm*t)*cos(2*pi*Fc*t)+Ec*sin(2*pi*Fm
    *t)*sin(2*pi*Fc*t);

```

```
8  disp("when the wave is");
9  disp(Wave);
10
11 f_upper=Ec*cos(2*pi*(Fc+Fm)*t);
12 disp("We get the upper sideband as");
13 disp(f_upper);
14
15
16 f_lower=Ec*cos(2*pi*(Fc-Fm)*t);
17 disp("We get the lower sideband as");
18 disp(f_lower);
```

---

# Chapter 4

## Angle Modulation

Scilab code Exa 4.1.A Frequency Deviation

```
1
2 clc;
3 clear;
4 Freq_dev=6; //Frequency Deviation in kHz
5 Vm=3; //Modulating Voltage in V
6
7 Dev=Freq_dev*10^(3)/Vm;
8
9 // for Vm=6V
10
11 Vm=6;
12 Freq_dev_new=Dev*Vm;
13
14 disp(Freq_dev_new,"the new deviation( in Hz)");
```

---

Scilab code Exa 4.1 phase and frequency deviation

```
1 clc;
```

```

2  clear;
3
4  t=0:0.01:1;
5  Freq=2*%pi*10^(5)+3*2*%pi*100*cos(2*%pi*100*(t)); //
    Phase=2*%pi*10^(5)*t+3*sin(2*%pi*100*t);
6
7  t1=0.4; // time in ms
8  Ang_Freq=2*%pi*10^(5)+3*2*%pi*100*cos(2*%pi*100*(t1
    *10^(-3)));
9  Freq=Ang_Freq/(2*%pi);
10
11 //change in answer due to calculation error in book
12 disp(Freq,"Instantaneous Frequency(in Hz) at (t=0.4
    ms)N =");
13
14
15 Max_pha_Dev=3; //max(3 sin(2*%pi*100t))
16
17 disp(Max_pha_Dev,"Maximum Phase Deviation(in rad) =
    ");
18
19 Max_fre_Dev=6*%pi*100; //max(6*pi*100*cos(2*pi*100t))
20
21
22
23 disp(Max_fre_Dev/(2*%pi),"MAximum Frequency Deiation
    (in Hz)");

```

---

#### Scilab code Exa 4.2.A Power in FM system

```

1  clc;
2  clear;
3  Wc=8*10^(8); // Angular Frequency of Carrier Signal
4  fc=Wc/(2*%pi);
5

```

```

6 Wm=1300; //Angular Frequency of Message Signal
7 fm=Wm/(2*%pi);
8
9 B=3; //Modulation Index
10 R=12;
11 Vc_rms=15/sqrt(2);
12
13 Max_dev=B*fm;
14 Power=Vc_rms^(2)/R;
15
16 disp(Power,"Power Dissipated (in W) is");

```

---

#### Scilab code Exa 4.2 Peak Frequency Deviation

```

1 clc;
2 clear;
3 a=3; //amplitude in volts
4 Dev_sen=4; // deviation sensitivity in KHz/volts
5 fm=1.5; // frequency modulating signal in KHz
6
7 f=Dev_sen*10^(3)*3; //peak frequency deviation
8 B=f/(fm*10^3);
9
10 disp(f,"Peak Frequency Deviation( in Hz) ");
11 disp(B,"modulation index ");

```

---

#### Scilab code Exa 4.3.A BAndwidth of FM

```

1 clc;
2 clear;
3 fm=3; //Modulating Frequency in kHz
4 Max_Dev=18; //Maximum Deviation in kHz
5

```

```

6  B=Max_Dev/fm; //modulation index
7
8  J=12;//from Bessel Table, for B=6
9  Bw=fm*J*2*10^(3);
10
11  disp(Bw,"The Bandwidth (in Hz) is") ;

```

---

#### Scilab code Exa 4.3 Peak Phase Deviation

```

1  clc;
2  clear;
3  Dev_sen=3.5;// Deviation Sensitivity in rad/volt
4  a=2.5;// amplitude in volts
5
6  B=a*Dev_sen; //Peak Phase Deviation
7
8  disp(B,"Peak Phase Deviation( in rad)");

```

---

#### Scilab code Exa 4.4.A Peak Deviation in FM

```

1  clc;
2  clear;
3  Wm=18850;//Angular Frequency of message signal
4  fm=Wm/(2*%pi);
5  a=3;// amplitude of message signal
6
7  Dev_sen=6;//Deviation Sensitivity in kHz/V
8  Max_Freq_Dev=a*Dev_sen*10^(3);
9
10 B=Max_Freq_Dev/(fm);
11
12 disp(Max_Freq_Dev,"Maximum Frequency Deviation(in Hz
    )");

```

```
13 disp(B," Modulation Index");
```

---

#### Scilab code Exa 4.4 Frequency Modulation

```
1  clc;
2  clear;
3  a=3; //amplitude in Volts
4  Dev=4; // Deviation in kHz
5  fm=1; // modulating frequency in kHz
6
7  Dev_sen=Dev*10^(3)/a; //Deviation Sensitivity
8  B=Dev/fm; // Modulation Index
9
10 disp(Dev_sen," Deviation Sensitivity (in kHz/V)");
11 disp(B," Modulation Index");
12
13 //a)
14 a=5;
15 Dev_sen_1=a*Dev_sen;
16 B=Dev_sen_1/(fm*10^(3));
17
18 disp(Dev_sen_1," Deviation Sensitivity for 5V (in Hz)
19      ");
19 disp(B," Modulation index");
20
21
22 //b)
23 a=10;
24 fm=400;
25 Dev_sen_2=a*Dev_sen;
26 B=Dev_sen_2/fm;
27
28
29 disp(Dev_sen_2," Deviation Sensitivity for 10V (in Hz
30      )");
```

```
30 disp(B," Modulation index");
```

---

#### Scilab code Exa 4.5.A side frequencies and Aplitudes

```
1 clc;
2 clear;
3 disp("for B=2, The number of significant frequencies
      are 6");
4 disp("They are J1 ,J2 ,J3 ,J4 ,J5 and J6");
5 disp('Their amplitudes with carriers are ');
6 J0= 0.224*8;
7 J1= 0.577*8;
8 J2= 0.353*8;
9 J3= 0.129*8;
10 J4= 0.034*8;
11 J5= 0.007*8;
12 J6= 0.001*8;
13 disp(J6, J5, J4, J3, J2, J1, J0, "they are (in V)");
```

---

#### Scilab code Exa 4.5 CArson Bandwidth

```
1 clc;
2 clear;
3 fm=3; //Modulating Frequency in kHz
4 Max_dev=15; // Maximum Deviatin in kHz
5
6 B=Max_dev/fm;
7
8 J=8; // Bessel table ,the highest J coefficient
9 BW=J*fm*10^(3); //Bandwidth in kHz
10
11 BW1=2*(fm+Max_dev)*10^(3); // According to carson
    rule , BAndwidth
```



```

12
13 disp(BW,"Bandwidth required (in Hz)");
14 disp(BW1,"According to Carsons rule , Bandwidth(in Hz
    )");

```

---

#### Scilab code Exa 4.6.A Carson Bandwidth

```

1  clc;
2  clear;
3  Max_Freq_Dev=12; //Maximum Frequency Deviation in
    kHz
4  fm=6; //Modulating frquency in kHz
5
6  B=Max_Freq_Dev/fm; // Modulation index
7
8  J=6; //From Bessel Table , for B=2
9
10 Bw=2*J*6*10^(3);
11 BW_carson=2*(fm + Max_Freq_Dev)*10^(3);
12
13 disp(Bw," Minimum Bandwidth (in Hz) is");
14 disp(BW_carson," Approximate Minimum Bandwidth
    according to carson rule( in Hz) is");

```

---

#### Scilab code Exa 4.6 Average Power of signal

```

1  clc;
2  clear;
3  a=10; //Amplitude in V
4  Pt=a*(0.18^2 +2*(0.33^2
    +0.05^2+0.36^2+0.39^2+0.26^2+0.13^2+0.05^2+0.02^2+0.01^2)
    );
5

```

```

6 disp(" For B=5 from the Bessel table ,The Bessel
    Function is taken upto J9");
7 disp(Pt," Hence the average power of the modulated
    signal (in W) is");
8 disp("Hence, the average power of the modulated
    signal is equal to ");
9 disp("unmodulated carrier power");

```

---

#### Scilab code Exa 4.7.A Unmodulated Carrier Power

```

1 clc;
2 clear;
3 a=8; // amplitude in V
4 r=30; //resistance in ohms
5
6 Pc_unmodulated=a^2/(2*r);
7 Pt=1.792^2/(2*30)+2*(4.616)^2/(2*30)+2*(2.824^2)
    /(2*30)+2*(1.032)^2/(2*30)+2*(0.272)^2/(2*30)
    +2*(0.056)^2/(2*30)+2*(0.008)^2/(2*30);
8
9 // change in answer due to approximations in the
    book
10
11 disp(Pc_unmodulated,"Unmodulated Power Carrier(in W)
    =");
12 disp(Pt,"Total Power in modulated wave(in W)=");
13 disp("Power in the modulated wave is equal to");
14 disp("power in the unmodulated wave");
15 disp("Small error due to rounded off values in
    Bessel functions");

```

---

#### Scilab code Exa 4.7 Phase Modulation

```

1  clc;
2  clear;
3  syms t pi;
4
5  Pha_dev=3; //Phase_Deviation constant in rad/V
6
7  // Phase Modulation Function
8
9  Pha_function=Pha_dev*4*sin(2*pi*1.5*10^(3)*t);
10 Mod_wave=8*cos(2*pi*10^(4)*t) +Pha_function
11
12 disp( Pha_function,"the Phase Modulation Function =
    ");
13
14 disp(Mod_wave ,"The Modulated Wave Function = ");

```

---

#### Scilab code Exa 4.8.A Balanced Modulator

```

1  clc;
2  clear;
3
4  initial_Freq_Dev=5; //frequency in kHz
5  B_initial=0.5; //modulation index
6  fm_initial=10; // message signal frequency in kHz
7  fc_initial=800; //carrier frequency in kHz
8
9  disp("The outputs of the balanced modulator for
    these parameters");
10 disp("are same as the inputs");
11 disp("They remain unaltered");
12
13 //at the output of the multiplier
14
15 m=12; // multiplication factor
16

```

```

17 final_Freq_Dev=initial_Freq_Dev*m;
18 B_final=0.5*m;
19 fm_final=10; //modulating signal remains unaltered
20 fc_final=800*m;
21
22 disp("At the output of the Multiplier,");
23 disp(fc_final,"Fc(in kHz)=",fm_final,"Fm(in kHz)=",
      B_final,"B=");
24 disp(final_Freq_Dev," Frequency Deviation(in kHz)=")
      ;

```

---

#### Scilab code Exa 4.9.A Frequency Deviation

```

1  clc;
2  clear;
3  ft=100.2; //final carrier frequency in MHz
4  Freq_Dev_ft=60; // Frequency Deviation in KHz at
      power amplifier
5  fm=10; //modulating frequency in KHz
6  m=25; //multiplication factor
7
8  //a)
9  fc=ft/25;
10
11 //b)
12 Freq_Dev=Freq_Dev_ft/25;
13
14 //c)
15 B=Freq_Dev/fm;
16
17 //d)
18 Bt=B*m;
19
20 disp(fc,"a) MAster Oscillator Centre Frequency(in
      MHz) =");

```

```

21 disp(Freq_Dev, "b) Frequency Deviation at the output
    of modulator(in KHz)=");
22 disp(B,"c) Devaiton ratio at the output of modulator
    ");
23 disp(Bt,"d) deviation ratio at power amplifier");

```

---

#### Scilab code Exa 4.10.A Angle Modulation

```

1  clc;
2  clear;
3
4  //f(t)=5cos(Wc*t+3sin(2000*t)+5sin(2000*pi*t))
5
6  fm=2000*%pi/(2*%pi); //bandwidth is the highest
    frequency component
7
8  //a)
9
10 Freq_dev=(6000+10000*%pi)/(2*%pi);
11
12 //b)
13
14 B=Freq_dev/fm;
15
16 //c)
17 Phase_dev=8; //Highest value of [3 sin(2000t)+5sin
    (2000*pi*t)]
18
19 //d)
20 Bw= 2*(fm+Freq_dev);
21
22 disp(Freq_dev," a) Frequency Deviation(in Hz)=");
23 disp(B," b) Devaiton Ratio=");
24 disp(Phase_dev," c) Phase Deviation( in rad)=");
25 disp(Bw," d) Bandwidth( in Hz)=")

```



# Chapter 5

## Pulse Modulation

Scilab code Exa 1.A Sample and Hold

```
1 clear;
2 clc;
3 //(" current through the capacitor is  $i=C(dv/dt)$ ");
4
5 t=15; //acquisition time in us
6 i=5; //current in mA
7 v=5; //maximum voltage across capacitor in V
8
9
10 // to satisfy current requirement
11 disp("to satisfy current requirement");
12 C_current_req=i*t/v;
13 disp(C_current_req,"C(nF)=");
14
15 //to satisfy accuracy requirement
16 disp("to satisfy accuracy requirement");
17
18 C_accuracy_req=t/(6.9*15)*1000; // to convert into "
    nanoFarad"
19
20 disp(C_accuracy_req,"C(nF)=");
```

```
21
22 disp("to satisfy both requirements ,smaller of the
      two can b taken");
```

---

### Scilab code Exa 5.1 Sampling

```
1 clear;
2 clc;
3 disp("for 8-KHz sampling ,the frequencies present are
      ... (in KHz)");
4
5 Fs=8; //sampling frequency
6 Fst=3.5 //single tone frequency
7
8 disp(Fst);
9 disp(-Fst);
10 disp(Fs-Fst);
11 disp(-(2*Fs+Fst) , (2*Fs+Fst) , -(Fs+Fst) , (Fs+Fst) , (Fs-
      Fst));
12 disp(" ... etc ... ");
13
14 disp("in this case , if the LPF is designed with cut-
      off frequency(8/2= 4-KHz)");
15 disp("then the maximum passable frequency is 3.5-KHz
      ");
16 disp("for 5-KHz sampling ,the frequencies present are
      ... (in KHz)");
17
18 Fs=5; //new sampling frequency
19 disp(Fst);
20 disp(-Fst);
21 disp(Fs-Fst);
22 disp(-(2*Fs+Fst) , (2*Fs+Fst) , -(Fs+Fst) , (Fs+Fst) , (Fs-
      Fst));
23 disp(" ... etc ... ");
```



```
24
25 disp("in this case , if the LPF is designed with cut-
      off frequency (5/2=2.5-KHz)");
26 disp("then the original signal cant be passed");
27 disp("therefore , the signal cant be reconstructed");
```

---

#### Scilab code Exa 5.2.A Aliasing Frequency

```
1  clc;
2  clear;
3  F_audio=5; //Audio input Frequency in kHz
4
5  F_sampling=2*F_audio;
6
7  disp(F_sampling,"The Minimum Sampling Frequency (in
      kHz)");
8
9  disp("When the audio Frequency of 6 Khz enters the
      Sample and Hold circuit");
10 disp("it will overlap the audio spectrum , and the
      alaising frequency is 4 kHz");
```

---

#### Scilab code Exa 5.2 Sampling Rate

```
1  clc;
2  clear;
3
4  //x(t)=2sin(4000*pi*t)+3sin(5000*pi*t)+4sin(8000*pi*
      t)
5
6  fh=8000/2;
7  fl=4000/2;
8
```

```

 9 disp(fh,"a) Highest Frequency component(in Hz)");
10 disp(fl,"Lowest Frequency component(in Hz)");
11
12 fs=2*fh;
13 disp(fs," Minimum Sampling frequency(in Hz)");
14
15 Bw=fh-fl;
16 disp(Bw," b)Bandwidth(in Hz) is");
17
18 n=fh/Bw;
19 disp(n,"integer factor");
20
21 Fs_new=2*fh/n;
22 disp(Fs_new,"Required Sampling frequency in this
    case(in Hz) is");

```

---

#### Scilab code Exa 5.3.A PCM system

```

1  clc;
2  clear;
3  fm=5; // maximum analog frequency in kHz
4  Min_dyna_range=35;
5  Vr=3; //Voltage in the receiver in V
6
7  //a)
8  F_sampling=2*fm;
9
10 //b)
11 n=Min_dyna_range/6;
12 k=(Vr-(-Vr)+1); // inclusive of sign bit
13
14 //c)
15 Resolution=Vr/(2^(7));
16
17 //d)

```

```

18 Max_quant_Error=Resolution/2
19
20 disp(F_sampling,"a)Minimum Sampling Rate(in kHz) =")
    ;
21 disp(n,"b) Minimum dynamic Range is");
22 disp(" But Closest whole number is 6. Henc,6 bits
    must be used for amplitude" );
23 disp("But the amplitude range is from -3 to +3 V,
    hence a sign bit also  ");
24 disp( k,"becomes necessary .. Therefore ,the total
    number of bits");
25 disp(Resolution,"c) Resolution(in V) =");
26 disp(Max_quant_Error," d)MAXimum Quantization Error
    (in V) ");

```

---

#### Scilab code Exa 5.4.A Bandwidth of PCM system

```

1  clc;
2  clear;
3  n=16; // Number of telephone lines
4  m=256; //Quantization levels
5  q=8; // since 2^(q)=256
6
7  fs=10; //Sampling frequency in kHz
8
9  Bw=[(16*9)+1]*10*10^(3);
10
11 disp(Bw,"Bandwidth (in Hz ) is");

```

---

# Chapter 6

## Noise

Scilab code Exa 6.A Thermal Noise Power

```
1  clc;
2  clear;
3  T=290; //Temperature in K
4  B=15; //Bandwidth in KHz
5  k=1.38*10^(-23); //Boltzman constant
6  R=60; //resistance in ohms
7
8  N=k*T*B*10^(3); //Therman Noise Power in watts
9  N_dBm=10*log10(N/0.001); //in dBm
10
11 Vrms=sqrt(4*R*k*T*B*10^(3));
12
13 disp("thermal noise power (in watts) is");
14 disp(N);
15 disp("thermal noise power (in dBm) is");
16 disp(N_dBm);
17 disp("RMS noise vantage (in Volts) is");
18 disp(Vrms);
```

---

### Scilab code Exa 6.1 Thermal Noise

```
1 clear;
2 clc;
3 T=290; // temperature in kelvin
4 k=1.38*10^(-23); // Boltzman constant
5 B=1; // bandwidth in MHz
6
7 P=k*T*B*10^(6); // thermal noise power
8 disp("the thermal noise power (in watts) is ");
9 disp(P);
```

---

### Scilab code Exa 6.2.A SNR and Noise Figure

```
1 clc;
2 clear;
3
4 Inp_sig_pow=1.5*10^(-9); //Input Signal Power in
   Watts
5 Inp_noi_pow=1.5*10^(-18); //Input Noise Power in
   Watts
6 Pow_gain=10^(6);
7 int_noi=4*10^(-12); //internal noise in watts
8
9 //a)
10 Inp_SNR=10*log10(Inp_sig_pow/Inp_noi_pow); // input
   SNR in dB
11
12 //b)
13 Nout=Pow_gain*Inp_noi_pow+int_noi //output output
   noise power
14
15 Pout=Pow_gain*Inp_sig_pow //output signal power
16
17 SNR=Pout/Nout; // Signal to Noise ratio
```

```

18 SNRout=10*log10(SNR); // Output SNR in dB
19
20 //c)
21 F=10^(9)/(273*10^(6)); //Noise factor
22 NF=10*log10(F); // Noise figure in dB
23
24 disp("Input SNR (in dB) is");
25 disp(Inp_SNR);
26 disp("Output SNR ( in dB) is");
27 disp(SNRout);
28 disp("Noise factor");
29 disp(F);
30 disp("Noise Figure(in dB)");
31 disp(NF);

```

---

#### Scilab code Exa 6.2 Noise voltage

```

1 clc;
2 clear;
3 T=290; // temperature in kelvin
4 R=60; //resistance in ohms
5 k=1.38*10^(-23);
6
7 Esquare=4*R*T*k;
8 E=sqrt(Esquare); //noise voltage
9
10 disp("the noise voltage( in volts) is")
11 disp(E);

```

---

#### Scilab code Exa 6.3.A Noise Voltage

```

1 clc;
2 clear;

```

```

3 q=1.6*10(-19); // electron charge
4 Ieq=5; //equivalent shot noise current in uA
5 Bn=8; //bandwidth in MHz
6 Rn=200;
7 Rs=100; //resistance in ohms
8 k=1.38*10(-23); // boltzman constant
9 T=290; //temperature in K
10 Vs=10 // RMS signal source volatage in uV
11
12 In=sqrt(2*Ieq*q*Bn);
13
14 Vni=Rs*In; //shot noise voltage
15
16 Vns=sqrt(4*Rs*k*T*Bn*10(6)); //thermal noise volatge
    from source
17
18 //change in answer due to calculation error in book
19 Vne=sqrt(4*Rn*k*T*Bn*10(6)); //noise voltage by
    equivalent noise resistance
20
21 Vn=sqrt(Vni2+Vns2+Vne2); // total noise voltage
22
23 SNR=20*log10(Vs*10(-6)/Vn);
24
25 disp("shot noise voltage(in V) is ");
26 disp(Vni);
27 disp("thermal noise voltage from source(in V) is");
28 disp(Vns);
29 disp("noise voltage by equivalent noise resistance(
    in V) is");
30 disp(Vne);
31 disp("total noise voltage at the input(in V) is");
32 disp(Vn);
33 disp("SNR (in dB) is");
34 disp(SNR);

```

---

### Scilab code Exa 6.3 Thermal Noise Voltage

```
1 clear;
2 clc;
3 B=150; // bandwidth in KHz
4 R1=30;
5 R2=60; // both resistors R1 and R2 in K-ohms
6 k=1.38*10^(-23); // boltzman constant
7 T=290; //temperature in Kelvin
8
9 Esquare=4*R1*10^(3)*k*B*10^(3)*T;
10 E=sqrt(Esquare);
11
12 disp("series combination Rseries(in K-ohms)=");
13 disp(R1+R2);
14 Eseries=E*sqrt(3);
15 disp("the thermal noise voltage (in volts) is");
16 disp(Eseries);
17
18 disp("series combination Rseries(in K-ohms)=");
19 disp(R1*R2/(R1+R2));
20 Eparallel=E*sqrt(2/3);
21 disp("the thermal noise voltage (in volts) is");
22 disp(Eparallel);
```

---

### Scilab code Exa 6.4.A Output SNR

```
1 clc;
2 clear;
3 S=4; //number of stages
4 SNR_input=55; //input Signal to Noise ratio in dB
5
```



```
6 SNR_output=SNR_input-10*log10(S);
7
8 disp("Output SNR( in dB) is");
9 disp(SNR_output);
```

---

#### Scilab code Exa 6.4 Shot Noise

```
1 clc;
2 clear;
3
4 Idc=2; //direct current in mA
5 q=1.6*10^(-19); // electron charge
6 B=3; //bandwidth in MHz
7
8 Isquare=2*Idc*10^(-3)*q*B*10^6;
9 I=sqrt(Isquare); //shot noise component
10
11 disp("the shot noise component(in amperes) is");
12 disp(I);
```

---

#### Scilab code Exa 6.5.A Output SNR

```
1 clc;
2 clear;
3 F=5; //noise figure in dB
4 SNR_input=55; //Input Signal to noise ratio in dB
5 SNR_output=SNR_input-F;
6 disp("Output SNR (in dB) is");
7 disp(SNR_output);
```

---

### Scilab code Exa 6.5 Output SNR

```
1  clc ;
2  clear ;
3  Np1=60; // Noise-Power ratio of first system in dB
4  Np2=40; // Noise-Power ratio of second system in dB
5  Np3=30; // Noise-Power ratio of third system in dB
6  Np4=50; // Noise-Power ratio of fourth system in dB
7
8  P1=10(-6); //power ratio of first system
9  P2=10(-4); //power ratio of second system
10 P3=10(-3); //power ratio of third system
11 P4=10(-5); //power ratio of fourth system
12
13 SNR=(P1+P2+P3+P4); // Overall Signal to Noise ratio
14 disp("SNR ratio is");
15 disp(SNR);
16
17 N_final=30; //since SNR is 10(-3)
18
19 disp("overall SNR (in dB) is");
20 disp(N_final);
21
22 disp("the overall SNR is equal to that of the worst
      system")
```

---

### Scilab code Exa 6.6.A Noise Figure

```
1  clc ;
2  clear ;
3  F=16; // Power ratio in dB
4  k=1.38*10(-23) ; // boltzman constant
5  T=290; //temperature in K
6  B=5; //Bandwidth in MHz
7
```

```

8 P=(F-1)*k*T*B*10^(6);
9 disp(" Amplifier Inout noise power (in watts) is");
10 disp(P);

```

---

#### Scilab code Exa 6.6 Output SNR

```

1 clc;
2 clear;
3 N_figure=8 ;//Noise figure in dB
4 SNR_in=45; //Signal to Noise ratio in dB
5
6 SNR_out=SNR_in-N_figure //output Signal to Noise
   ratio
7
8 disp("the Output SNR(in dB) is ");
9 disp(SNR_out);

```

---

#### Scilab code Exa 6.7.A Overall noise figure

```

1 clc;
2 clear;
3 Nf1=7; //Noise figure of first stage in dB
4 F1=5.01; //first power ratio
5 Nf2=25; //Noise figure of second stage in dB
6 F2=316.22; //second power ratio
7 pG=15; //power gain in dB
8 G1=31.62; //power ratio
9
10 F=F1+(F2-1)/G1;
11
12 disp("overall noise factor");
13 disp(F);
14 disp("Overall noise factor in dB")

```

```
15 disp(10*log10(F));
```

---

#### Scilab code Exa 6.8.A Noise Temperature

```
1 clc;
2 clear;
3 Nf=15; //noise figure in dB
4 F=31.62; //power ratio
5 T=290; //Temperature in K
6 T_em=(F-1)*T
7
8 G1=10^(6); //power ratio
9 N_t=80; //Noise temperature in K
10 T_e=N_t+T_em/G1;
11
12 disp("Noise temperature of receiver (in K)");
13 disp(T_em);
14
15 // change in answer....the calculation in the book
    is wrong
16
17 disp("Overall Noise temperature of receiving system(
    in K) is");
18 disp(T_e);
```

---

#### Scilab code Exa 6.9.A Noise Temperature

```
1 clc;
2 clear;
3 ENR=31.62; //10^(1.5);
4 Y=6.30; //10^(0.8)
5 T=290; //temperature in K
6 T_h=T*(ENR+1);
```

```
7
8 T_e=(T_h-Y*(T))/(Y-1);
9 disp("Equivalent Noise Temperature (in K) is");
10 disp(T_e);
```

---

# Chapter 7

## Introduction to Digital Communication

Scilab code Exa 7.1.A Baud Rate and Bandwidth

```
1 clc;  
2 clear;  
3 bin_signal=20; //binary signal in kbps  
4 N=1; //since ASK  
5  
6 Bw=bin_signal*10^(3);  
7 Baud=bin_signal*10^(3);  
8  
9 disp(Bw," Bandwidth (in Hz)=");  
10 disp(Baud," Baud rate=");
```

---

Scilab code Exa 7.1 Baud Rate

```
1 clc;  
2 clear;  
3 N=1; // since ASK
```

```

4 Bin_Sig=15; //Binary signal in kbps
5
6 BW=Bin_Sig*10^(3)/N;
7 Baud=Bin_Sig*10^(3)/N;
8 disp(BW,"Bw=");
9 disp(Baud,"Baud=");

```

---

### Scilab code Exa 7.2.A Bandwidth and Baud Rate

```

1 clc;
2 clear;
3 mark_f=59; //MArk Frequency in Hz
4 space_f=61; //space frequency in Hz
5 input_rate=5; //input rate in kbps
6
7 Peak_Frq_Dev=abs((mark_f-space_f)/2);
8 Bw=2*(Peak_Frq_Dev+input_rate)*10^(3);
9 baud=input_rate*10^(3);
10
11 disp(Peak_Frq_Dev,"Peak Frequency Deviation (in KHz)
    =");
12 disp(Bw,"Minimum BW (in Hz)=");
13 disp(baud,"Baud=");

```

---

### Scilab code Exa 7.2 Baud Rate and Bandwidth

```

1 clc;
2 clear;
3 mark_f=60; //Mark Frequency in KHz
4 space_f=63; //Space Frequency in KHz
5 input_bit_rate=3; // input bit rate
6
7 Peak_Frq_Dev=abs((mark_f-space_f)/2);

```

```

8 B=2*(Peak_Frq_Dev+input_bit_rate);
9 Baud=input_bit_rate*10^(3);
10
11 disp(Peak_Frq_Dev,"Peak Frequency Deviation(in KHz)=
    ");
12 disp(B,"Minimum Bandwidth(in KHz)=");
13 disp(Baud,"Baud rate=");

```

---

### Scilab code Exa 7.3.A Bandwidth and Baud Rate

```

1 clc;
2 clear;
3 N=3; // since 8-PSK
4 bit_rate=36; // in kbps
5
6 Bw=bit_rate*10^(3)/N;
7 baud=bit_rate*10^(3)/N;
8 n=bit_rate*10^(3)/Bw;
9
10 disp(Bw," Minimum Bandwidth(in Hz)=");
11 disp(baud,"Baud rate=");
12 disp(n,"Bandwidth efficiency(in bits per second per
    cycle of bandwidth)=");

```

---

### Scilab code Exa 7.3 Baud Rate and Bandwidth

```

1 clc;
2 clear;
3 bit_rate=36; // information bit rate in Kbps
4 m=3; // since 8-PSK
5
6 Baud=bit_rate*10^(3)/m;
7 Bw=36*10^(3)/m;

```



```

8 n=36000/12000;
9
10 disp(Baud,"Baud=");
11 disp(Bw,"BW=");
12 disp(n,"Bandwidth efficiency(in bits/cycle)=");

```

---

#### Scilab code Exa 7.4.A Nyquist Bandwidth

```

1 clc;
2 clear;
3
4 Input_bit=5; //Input bit rate in Mbps
5
6 //bit rate in I,Q,C channels is one-third of input
  bit rate
7
8 fbI=Input_bit/3;//bit rate in I channel
9 fbC=Input_bit/3;//bit rate in C channel
10 fbQ=Input_bit/3;////bit rate in I channel
11
12 Baud=fbI;//Baud in Mbps
13
14 fa=fbC/2;
15
16 //Output from Modulator is
17 // 0.5 cos(2*pi*49.17MHz) - 0.5 cos(2*pi*50.83MHz)
18
19 Nyquist=50.83-49.17;
20
21 disp(Nyquist,"Minimum Nyquist Bandwidth(in MHz)=");

```

---

# Chapter 8

## Information theory

Scilab code Exa 8.1.A Information Rate

```
1  clc;
2  clear;
3  p1=1/8;
4  p2=1/8;
5  p3=5/8;
6  p4=1/8; //Quantization Levels
7  //B is the Bandwidth of the signal
8
9  H=p1*log2(1/p1)+p2*log2(1/p2)+p3*log2(1/p3)+p4*log2
    (1/p4);
10
11 disp(H,"The average Information (in bits/message)=")
    ;
12 disp("The Information Rate R=rH =2*B(1.55) =3.1B
    bits/s");
```

---

Scilab code Exa 8.2.A ShannonFano and Huffman coding

```

1  clc;
2  clear;
3  m1=0.2;
4  m2=0.3;
5  m3=0.2;
6  m4=0.15;
7  m5=0.15; // probability of 5 source messages
8
9  H=m1*log2(1/m1)+m2*log2(1/m2)+m3*log2(1/m3)+m4*log2
    (1/m4)+m5*log2(1/m5); //Average information in
    bits
10
11 //a) Shannon-fano coding
12                                //coding
13 // m1  0.2  0 0           00
14 // m2  0.3  0 1           01
15 // m3  0.2  1 0           10
16 // m4  0.15 1 1 0        110
17 // m5  0.15 1 1 1        111
18
19 L=(0.2*2)+(0.3*2)+(0.2*2)+(2*0.15*3) //Average code
    word length(in bits)=probability *coding length
20
21 n=H/L;
22
23 disp(n*100,"Coding efficiency for Shannon Fano
    coding is");
24
25 //b) Huffman coding
26
27 // m1 0.2      01
28 // m2 0.3      00
29 // m3 0.2      11
30 // m4 0.15     010
31 // m5 0.15     110
32
33 L=(0.2*2)+(0.3*2)+(0.2*2)+(2*0.15*3) //Average code
    word length(in bits)=probability *coding length

```

```

34
35 n=H/L;
36
37 disp(n*100,"Coding efficiency for Huffman coding is"
    );
38
39 //change in answer due to rounded off value in text-
    book

```

---

### Scilab code Exa 8.3.A Gaussian Channel

```

1  clc;
2  clear;
3
4  PSD=10^(-9); //noise PSD in W/Hz
5  Bw=4000; //Wandwidth in Hz
6
7  //a)
8  E=0.1 //Energy in Joules
9  C=Bw*log2(1+E/(2*PSD*Bw));
10 disp(C,"a) Capacity of the gaussian channel(in bits/
    s) when E is 0.1J=");
11
12 //b)
13 E=0.001 //Energy in Joules
14 C=Bw*log2(1+E/(2*PSD*Bw));
15 disp(C,"b) Capacity of the gaussian channel(in bits/
    s) when E is 0.001J=");
16
17 //c)
18 Bw=10000;
19 C=Bw*log2(1+E/(2*PSD*Bw));
20 disp(C,"d) Capacity of the gaussian channel(in bits/
    s) when Bw is 10Khz=");
21

```

```
22 disp("100 times fall in Energy when the BW is
    increased by 2.5 times");
```

---

### Scilab code Exa 8.5.A Throughput efficiency

```
1  clc;
2  clear;
3  k=973;
4  n=1023;
5  Pa=0.99;
6  Tw=10*10^(-6);
7  Tl=40*10^(-6);
8  N=4;
9
10 N_sw=(k/n)*(Pa/(1+Tl/Tw)); // efficiency of stop and
    wait algorithm
11 N_sgpull=(k/n)*(1/(1+N*(1-Pa)/Pa)); // efficiency of
    go-back-N algorithm
12 Nsr=(k/n)*Pa; // efficiency of selective repeat
    algorithm
13
14 disp(N_sw,"N s&w");
15 disp(N_sgpull,"Nsgpull");
16 disp(Nsr,"Nsr");
```

---

### Scilab code Exa 8.6.A Rate of source

```
1  clc;
2  clear;
3  p1=1/2;
4  p2=1/4;
5  p3=1/8;
6  p4=1/16;
```

```

7 p5=1/16; // probabilities
8
9 H=p1*log2(1/p1)+p2*log2(1/p2)+p3*log2(1/p3)+p4*log2
  (1/p4)+p5*log2(1/p5);
10 Bw=4000; //Bandwidth in Hz
11 R=2*H*Bw ;
12
13 disp(R,"Rate of the source ( in bits/s) is");

```

---

**Scilab code Exa 8.7.A** entropy of equiprobable source

```

1 clc;
2 clear;
3
4 // probability of all the events are same
5 syms N;
6
7 H_X=N*[(-1/N)*log(1/N)]; //H(X)=(-1/N)log(1/N)+(-1/N
  )log(1/N)+....N times
8
9 disp(H_X,"H(X)=");

```

---

**Scilab code Exa 8.8.A** Self Information

```

1 clc;
2 clear;
3 P0=2/3; //P(X=0)
4 P1=2/3; //P(Y=0)
5 H_x=0.919;
6 H_y=0.919;
7 H_b=0.919; //Hb(2/3)
8

```

```
9 //since X,Y pair is uniformly distributed on three
   values
10 H_xy=log2(3); // H(X,Y)
11
12 H_xdivy=H_xy-H_y; //H(X/Y)=H(X,Y)-H(Y)
13 I_xdivy=H_x-H_xdivy; //I(X,Y)=H(X)-H(X/Y)
14
15 disp(I_xdivy," I(X,Y)=");
```

---

#### Scilab code Exa 8.10.A SNR

```
1 clc;
2 clear;
3 W=3000;
4 SNR_db=39; // 10log (SNR_ratio)=SRN_db
5 SNR_ratio=7943; // 10^(3.9)
6
7 C=W*log2(1+SNR_ratio);
8
9 disp(C," Capacity (in bits/s) =");
```

---

# Chapter 9

## Introduction to Probability Random variable and Random processes

Scilab code Exa 9.1.A Multiplication Theoram

```
1  clc;
2  clear;
3
4  P_white=5/8; //P(ball is white)
5
6  //white ball is removed,the remaining balls are four
   white and three green
7
8  P_green=3/7; //P(ball is green)
9
10 P_tot=P_white*P_green;
11
12 disp(P_tot," Desired Probability using
   multiplication theoram=")
```

---



### Scilab code Exa 9.1 Conditional Probability

```
1 clear;
2 clc;
3 // f2 be the event that " a two occurs"
4
5
6 tot=6; //total number of possible outcomes
7 f_2=1; // number of desired outcomes
8 M=3; // number of even outcomes
9
10 ///// a)
11
12 P_A=f_2/tot; //P(A)
13
14 ///// b)
15 P_M=M/tot; //P(M)
16
17 /////// c)
18 P_AintersectionM=P_A/P_M; //P(A intersection M)
19
20 disp(P_A," a) P(A)= ");
21 disp(P_M," b) P(M)=");
22 disp(P_AintersectionM=P_A/P_M," c) P(A intersection M
    )=");
```

---

### Scilab code Exa 9.2.A Theoram of Total Probability

```
1 clc;
2 clear;
3 P_box1=0.25; //P(box1)
4 P_box2=0.25; //P(box2)
5 P_box3=0.25; //P(box3)
6 P_box4=0.25; //P(box4)
7
```

```

8 Pdef_1=0.05; //P(defective/box1)
9 Pdef_2=0.3; //P(defective/box2)
10 Pdef_3=0.10; //P(defective/box3)
11 Pdef_4=0.20; //P(defective/box4)
12
13
14 Pcomp_def=(P_box1*Pdef_1)+(P_box2*Pdef_2)+(P_box3*
    Pdef_3)+(P_box4*Pdef_4); //Theoram of total
    probability
15
16 disp(Pcomp_def," P(component is defective)=");

```

---

#### Scilab code Exa 9.2 Conditional Probability

```

1 clc;
2 clear;
3
4 white_ball=3;
5 red_ball=2;
6 total=white_ball+red_ball;
7 P_W=white_ball/total;
8
9 P_SRFW=1/2; //Prob. of second red given first white
10
11 P_FWSR=P_W *P_SRFW// prob. of first white and
    second red
12
13 disp(P_FWSR," P(First Ball is White and second is
    red)=");

```

---

#### Scilab code Exa 9.3.A Error Probability

```

1 clc;

```

```

2 clear;
3
4 P_1=0.3; //P( 1 is transmitted)
5 Pe_1=10^(-3); //P(detecting an error when 1 is
   transmitted)
6 P_0=0.7; //P( 0 is transmitted)
7 Pe_0=10^(-7); //P(detecting an error when 0 is
   transmitted)
8
9 error_prob=P_1*Pe_1+P_0*Pe_0;
10
11 disp(error_prob,"Error Probabillity of the channel")
   ;

```

---

### Scilab code Exa 9.3 Bayes Theoram

```

1 clc;
2 clear;
3 P_box1=0.25; //P(box1)
4 P_box2=0.25; //P(box2)
5 P_box3=0.25; //P(box3)
6 P_box4=0.25; //P(box4)
7
8 Pdef_1=0.05; //P(defective/box1)
9 Pdef_2=0.4; //P(defective/box2)
10 Pdef_3=0.10; //P(defective/box3)
11 Pdef_4=0.10; //P(defective/box4)
12
13 //a)
14
15 Pcomp_def=(P_box1*Pdef_1)+(P_box2*Pdef_2)+(P_box3*
   Pdef_3)+(P_box4*Pdef_4); //Theoram of total
   probability
16
17 //b)

```

```

18 Pbox2_def=(P_box2*Pdef_2)/((P_box1*Pdef_1)+(P_box2*
    Pdef_2)+(P_box3*Pdef_3)+(P_box4*Pdef_4)); //Bayes
    theorem
19
20 disp(Pcomp_def," a) P(component is defective)=");
21
22 disp(Pbox2_def," b) P(box2 | defective)=");

```

---

#### Scilab code Exa 9.4.A Density Function

```

1  clc;
2  clear;
3  //Y is a Gaussian Random Variable
4
5  syms y;
6
7  x=5;
8  m=-3*(x)+5; //mean
9  disp(m,"mean");
10
11 var=4*7; //variance
12 disp(var,"variance");
13
14 Y=exp(-{(y+10)^2}/56)/sqrt(56*%pi);
15
16 disp("Y is an N{-10,28} random variable");
17 disp(Y,"density function f(y)= ");

```

---