Scilab Textbook Companion for Digital Signal Processing: A Computer Based Approach by S. K. Mitra[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.

Contents

List of Scilab Codes

Chapter 2

Discreet Time Signals and Systems

Scilab code Exa 2.1 Ensemble Averaging

```
//EXAMPLE 2.1
//Ensemble averaging
clear ;
clc ;
n = 1:50;
clf();
figure(0)
a=gca();
a.x_location="origin";
a.y_location="origin";
   for i =1:length(n)
       s(i)=2*n(i)*((0.9)^n(i));
       d(i)=(-0.1)^n(i);       //arbitrary noise
          signal.
   end

M=length(n);

 for i =1:M
```

```
    d(i)=(-0.1)^i;
    S=sum(d);
end
Eav=(s+S/M)';            //Ensemble average.
disp(Eav,'The output of Ensemble averaging is')
plot2d3(n,s)
plot(n,s,'r.')
xtitle('Ensemble averaging','n','Eav-s');
a.children.children.thickness=2;
a.children.children.foreground=2;
```

Scilab code Exa 2.2 Basic operations

```
//EXAMPLE 2.2 , BASIC OPERATIONS.
clear;
clc;
c=[3.2 41 36 -9.5 0];
disp(c,'c = ');
d=[1.7 -0.5 0 0.8 1];
disp(d,'d = ');
w1=c.*d;                    //Multiplication
disp(w1,'The product of two input vectors is =');
w2=c+d;                     //addition
disp(w2,'The addition of two input vectors is =');
w3=3.5*c;
disp(w3,'The scaling of first input vector is =');
```

Scilab code Exa 2.3 Unequal length sequence

```
//EXAMPLE 2.3, Basic ops on unequal length sequence
clear;
clc;
c=[3.2 41 36 -9.5 0];
```

```
disp(c,'c = ');
g=[-21 1.5 3];
disp(g,'g = ');
a=length(g);
b=length(c);
i=0;
    while(i<b-a)
        g(b-i)=0;
        i=i+1;
    end
w4=g.*c;
disp(w4,'The product of two sequences is =');
w5=c+g;
disp(w5,'The addition  of two sequences is =');
```

Scilab code Exa 2.5 Generating symmetric parts

```
//EXAMPLE 2.5,Conjugate-Antisymmetric & Conjugate-
    symmetric parts of Sequence
clc;
clear;
g=[0, 1+%i*4, -2+%i*3, 4-%i*2, -5-%i*6, -%i*2, 3];
disp(g,'g = ')
g1=conj(g);           //Conjugate of g;
disp(g1,conj(g));
a=length(g);
for i=1:a
    g2(1,i)=g1(a-i+1);
end

gcs=(g+g2)/2          //Conjugate-Symmetric part
disp(gcs,'The Conjugate symmetric part is =');
gcas=(g-g2)/2;        //Conjugate-Antisymmetric part
disp(gcas,'The Conjugate antisymmetric part is =');
```

Scilab code Exa 2.6 Energy Signal

```
//EXAMPLE 2.6, Energy Signal

clear ;
clc ;
n = -5:5;
for i =1:length ( n )
 if(n(i)>=1)
 h(i)=1/n(i);
 else
 h(i)=0;
 end
end

Sum=0;
N=1:10000;
  for i=1:length(N)
  h(i)=(1/N(i))^2;
  end

Energy = sum(h);

 if (Energy<%inf ) then
  disp ('Energy Signal') ;
  disp(Energy,'Energy of signal = ');
  else
  if  (Energy/length(N)<%inf ) then
  disp ('Power Signal') ;

  else
  disp ('Niether Energy nor Power Signal') ;
  end
 end
```

Scilab code Exa 2.7 Power Signal

```
//EXAMPLE 2.7,Example of Power signal
clear ;
clc ;

Sum=0;
N=1:10000;
    for i=1:length(N)
     h1= 3*((-1)^i);
     h=h1^2;
    end

Energy = sum(h);
  if  (Energy/(2*(length(N))+1)<%inf ) then
  disp ('Power Signal') ;
  disp(Energy/2,'Power Signal = ');
  else
  disp ('Not a Power Signal') ;
  end
```

Scilab code Exa 2.9 Square wave generation

```
//EXAMPLE 2.9, Generation of a Square wave sequence:
clc;
clear;
clf();
a=gca();
figure(0);
a.x_location="origin";
x=[0:1:80];
y1=sin(x*.05*%pi);
```

```
y2=sin(x*.15*%pi);
y3=sin(x*.25*%pi);
y4=y1+y2/3+y3/5;
plot2d3(x,y4,2)
plot(x,y4,'r.')
xtitle('Approximate Square wave','x','y4');
a.children.children.thickness=3;
```

Scilab code Exa 2.16 Linearity of accumulator

```
//EXAMPLE 2.16,
clear;
clc;
//Given input sequence = [3 4 5]
x=[0 3 4 5 0];
disp([3 4 5],'Input sequence = ')
//determining median filter
//first sequence
for k=2:4
    if  x(k)>x(k-1) & x(k+1)>x(k-1) & x(k+1)>x(k)
         y(k-1)=x(k);
     else
         x(k-1)>x(k+1) & x(k)>x(k+1) & x(k)>x(k-1)
         y(k-1)=x(k-1);
    end
end
disp(y','The Median Filter of the given input is =')
  ;
```

Scilab code Exa 2.20 Passive system

```
//EXAMPLE 2.20,Passive or lossless system.
clear;
```

```
clc;
a=input("any value of a less than or equal to one")
n=-10:1:10;
 x=n;
 y=a*n;
 S=0;
 for i=1:length(n)
     S=S+y^2;
 end

 if a<1 then
     disp('the system is passive')
 else

     a==1
     disp('the system is lossless')

 end
```

Scilab code Exa 2.22 Impulse response of Accumulator

```
//EXAMPLE 2.22,impulse response of accumulator

clear;
clc;
d=[1];
t=-1:.01:1;
h=0;
clf();
figure(0);
a=gca();
a.x_location="origin";

for i=1:length(t)
    if t(i)<0
```

```
      h=0;
    else
        h=d;
        plot2d3(i-101,h)
        plot(i-101,h,'.r')
        xtitle('Impulse Response of accumulator','t'
           ,'Y');
        a.children.children.thickness=1;
        a.children.children.foreground=2;
    end
end
disp(h,'The impulse response of Accumulator is =')
```

Scilab code Exa 2.26 Convolution

```
//EXAMPLE 2.26,convolution of x & h
x=[-2 0 1 -1 3];
disp(x,'x = ');
h=[1 2 0 -1];
disp(h,'h = ');
n=0:7;
y=convol(x,h);
disp(y,'The convolution of the two inputs is :')
```

Scilab code Exa 2.27 Convolution

```
//EXAMPLE 2.27, convolution of an exponential
   sequence
clear;
clc;
n=0:.5:5
c=0.5;
b=0.4;
```

```
clf();
figure(0);
a=gca();
a.x_location="origin";
x = c^n;
subplot(2,2,1);
plot2d3(n,x,2);
plot(n,x,'.r');
xtitle('','n','x');
h = b^n ;
subplot(2,2,2);
plot2d3(n,h,2)
plot(n,h,'.r')
xtitle('','n','h');
N=0:.5:10;
y = convol (x , h );
subplot(2,2,3);
plot2d3(N,y,2)
plot(N,y,'.r')
xtitle('convol(x,h)' ,'n','y');
disp(y,'Convolution of the two exponential sequences
    is =')
```

Scilab code Exa 2.28 Convolution

```
//EXAMPLE 2.28,graphical representation of
   convolution of x & h.
clear;
clc;
x=[-2 0 1 -1 3];
disp(x,'x');
h=[1 2 0 -1];
disp(h,'h');
n=0:7;
y=convol(x,h);
```

```
disp(y,'convolution = ');
clf();
figure(0);
a=gca();
a.x_location="origin";
a.y_location="origin";
plot2d3(n,y)
plot(n,y,'r.')
xtitle('convolution','n','Y');
a.children.children.thickness=2;
a.children.children.foreground=2;
```

Scilab code Exa 2.29 Convolution

```
//Example 2.29,Convolution using Tabular method.
clear;
clc;
x=[-2 0 1 -1 3];
h=[1 2 0 -1];
q=length(x);
w=length(h);
z=q+w-1;
y0=0;
for i=1:z;
    y(i)=0;
    for k=1:i;
        if k>q
            x(k)=0;
        else
            if (i-k+1)>w
                h(i-k+1)=0;
            else
             y(i)= y(i) + x(k)*h(i-k+1);
            end
        end
```

```
    end
end
disp(y','The Convolution of the two sequences is =')
```

Scilab code Exa 2.30 Convolution

```
//EXAMPLE 2.30
//Convolution of two sided sequences
clear;
clc;
g=[3 -2 4];//originating at n=-1
h=[4 2 -1];//originating at n=0
q=length(g);
w=length(h);
z=q+w-1;
y0=0;
for i=1:z;
    y(i)=0;
    for k=1:i;
        if k>q
            g(k)=0;
        else
            if (i-k+1)>w
                h(i-k+1)=0;
            else
             y(i)= y(i) + g(k)*h(i-k+1);
            end
        end
    end
end
n=-1:z-2;
disp(y,'The Convolution of the two sequences is =')
clf();
a=gca();
figure(0);
```

```
a.x_location="origin";
plot2d3(n,y,2);
plot(n,y,'r.');
xtitle('convolution','n','y');
```

Scilab code Exa 2.31 Stabbility of causal system

```
//EXAMPLE 2.31, Stability for causal system.
//h[i]=impulse response of LTI system.
clear;
clc;
n= -5:0.001:5;
a=0.6;

for i=1:length(n)
    if (n(i)<0)
        h(i)=0;
    else
        h(i)=abs(a^n(i));

    end
end
S=sum(h);
if(S<%inf)
    disp('BIBO stable system');
else
    disp('BIBO unstable system');

end
```

Scilab code Exa 2.32 Stability of Anti causal system

```
//EXAMPLE2.32 Stability for anti-Causal system.
```

```
//h[i]=impulse response of LTI system.
clear;
clc;
n= -5:1/1000:5;
a=5;
for i=1:length(n)
    if (n(i)>-1)
        h(i)=0;
    else
        h(i)=a^n(i);
        S=sum(h);
    end
end

if(S<%inf)
    disp('BIBO stable system');
else
    disp('BIBO unstable system');

end
```

Scilab code Exa 2.33 Stability of a system

```
//EXAMPLE 2.33 ,stability of finite impulse response
    .
//h[i]=impulse response of LTI system.
clear;
clc;
n= -5:1/100:5;
a= input('value of a');
N1=input('lower limit');
N2=input('upper limit');
for i=1:length(a)
    if (n(i)<N1 & n(i)>N2)
        h(i)=0;
```

```
    else
        h(i)=a^n(i);
        S=sum(h);
    end
end

if(S<%inf)
    disp('BIBO stable system');        //as long as
       N1,N2!=%inf
else
    disp('BIBO unstable system');

end
```

Scilab code Exa 2.46 Cross coreation computation

```
//EXAMPLE 2.46, Cross corelation Computation.
// Given two finite length sequence.x[n],y[n]:
clear;
clc;
x=[1 3 -2 1 2 -1 4 4 2];
disp(x,'x');
y=[2 -1 4 1 -2 3];
disp(y,'y');
//Cross corelation rxy[n]:

rxy=convol(x,mtlb_fliplr(y));
disp(rxy,'The Cross-Corelation Operation of the
   Inputs is =')
```

Chapter 3

Discreet TIme Fourier Transform

Scilab code Exa 3.5 DTFT computation

```
//EXAMPLE 3.5
//DTFT of unit sample sequence
clc;
clear;
//a=0.5;
n=0:9;
x = [1,zeros(1,9)];
disp(x,'x[n] = ')

K = 4;
k = 0:4/1000:4;
W = k*2*%pi/K;
X = (x)*exp(%i*n'*W);
disp(X,'DTFT,x[n] --> ')
X_mag   = abs(X);
X_phase = phasemag(X);//no phase exists

figure(0);
plot2d3(mtlb_fliplr(W),X_mag);
```

```
xtitle('Magnitude plot','W ---->','X_mag ---->');
figure(1);
plot2d3(mtlb_fliplr(W),X_phase);
xtitle(' zero phase plot','W ---->','X_phase ---->');
```

Scilab code Exa 3.6 DTFT computation

```
//EXAMPLE 3.6
//Determine DTFT of sequence
//PROGRAM REQUIRES MAXIMA SCILAB TOOLBOX

clc;
clear;
//Symbolic calculation
Syms n w a ;
x1=(a^n)*exp(-%i*n*w);
X1=nusum(x1,n,0,%inf);
disp(X1,'DFT,X = ');

//Given:
a=0.5;
n=0:9;
//x[n]=a^n*u[n]
for i = 0:9
    x(i+1) = a^i;
end
//The DTFT of the sequence
K = 4;
k = 0:4/1000:4;
W = k*6*%pi/K;
X = (x')*exp(%i*n'*W);
X_mag   = abs(X);
[X_phase,db] = phasemag(X);

clf();
```

```
a=gca();
figure(0);
//Note %pi ~ 3.14
plot2d3(mtlb_fliplr(W),X_mag);
xtitle('Magnitude response','W --->','Amplitude --->
    ');
figure(1);
plot2d3(mtlb_fliplr(W),X_phase);
xtitle('Phase response','W --->','Phase in degrees
    --->');
```

Scilab code Exa 3.7 Plotting real and imaginary part

```
//EXAMPLE 3.12
//x[n]=((-1)^n)*(a^n)*u[n].....given a=0.5;

clc;
clear;

a=0.5;
n=0:9;
for i = 0:9
    x(i+1) = (a*exp(-%i*%pi))^i;
end

//The DTFT of the sequence
K = 4;
k = 0:4/1000:4;
W = k*6*%pi/K;
X = (x')*exp(%i*n'*W);
X_mag   = abs(X);
X_phase = phasemag(X);

//PLOTTING GRAPHS FOR THE INTERVAL OF 0 TO 6*%pi
clf();
```

```
a=gca();
figure(0);
plot2d3(mtlb_fliplr(W),X_mag);
xtitle('Magnitude response','W','Amplitude');
figure(1);
plot2d3(mtlb_fliplr(W),X_phase);
xtitle('Phase response','W','X_phase,degrees');
```

Scilab code Exa 3.10 DTFT of finite length exponential sequence

```
//EXAMPLE 3.10
// DTFT of a sequence
clc;
clear;
syms a n M w;
x=a^n;
X=nusum(x*(exp(-%i*w*n)),n,0,M-1)
disp(limit(X),'The DTFT of the given sequence, X = '
  )
```

Scilab code Exa 3.12 Plotting DTFT of exponential sequence

```
//EXAMPLE 3.12
//x[n]=((-1)^n)*(a^n)*u[n].....given a=0.5;

clc;
clear;

a=0.5;
n=0:9;
for i = 0:9
    x(i+1) = (a*exp(-%i*%pi))^i;
end
```

```

//The DTFT of the sequence
K = 4;
k = 0:4/1000:4;
W = k*6*%pi/K;
X = (x')*exp(%i*n'*W);
X_mag   = abs(X);
X_phase = phasemag(X);

//PLOTTING GRAPHS FOR THE INTERVAL OF 0 TO 6*%pi
clf();
a=gca();
figure(0);
plot2d3(mtlb_fliplr(W),X_mag);
xtitle('Magnitude response','W','Amplitude');
figure(1);
plot2d3(mtlb_fliplr(W),X_phase);
xtitle('Phase response','W','X_phase,degrees');
```

Scilab code Exa 3.13 DTFT computation

```
//EXAMPLE 3.13

clc;
clear;
a=0.5;
n=0:9;
for i = 0:9
    x(i+1) = a^i;
end
//The DTFT of the sequence
K  = 4;
k  = 0:4/1000:4;
W  = k*6*%pi/K;
X1 = (x')*exp(%i*n'*W);
```

```
X   = %i*diff(X1);
X   = [X,0] + X1;

X_mag    = abs(X);
[X_phase,db] = phasemag(X);

clf();
a=gca();
figure(0);
plot2d3(mtlb_fliplr(W),X_mag);
xtitle('Magnitude response','W','X_mag');
figure(1);
plot2d3(mtlb_fliplr(W),X_phase);
xtitle('Phase response','W','X_phase');
```

Scilab code Exa 3.14 Energy of signal

```
//EXAMPLE 3.14
//ENERGY OF LP DISCREET TIME SIGNAL
//PROGRAM REQUIRES MAXIMA SCILAB TOOLBOX
clc;
clear;
syms n wc w;
 wc = input("the value of wc ( less than %pi)= ");
n = -5:0.05:5;

for i =0:length (n)
    hlp(i+1) = (wc/%pi)*sinc((wc*i)/%pi);
    E(i+1)=(abs(hlp(i+1)))^2;
end

Energy = sum(E);
 if (Energy<%inf ) then
  disp ('The filter is Energy Signal') ;
  else
```

```
  if  (Energy/length(N)<%inf ) then
  disp ('Power Signal') ;
  else
  disp ('Niether Energy nor Power Signal') ;
  end
 end
disp(Energy,'the energy is = ');
```

Scilab code Exa 3.15 Energy of exponential sequence

```
//EXAMPLE 3.15
//ENERGY OF A SIGNAL x[n]=a^n*u[n]
clc;
clear;
a=0.5;
n=0:0.1:9.9;
//x[n]=a^n*u[n]
for i = 0:length(n)
    x(i+1) = a^i;
    E=(abs(x))^2;
end
Energy=sum(E);
disp(Energy,'Energy of the signal = ');
```

Chapter 4

Digital Processing of Continous TIme Systems

Scilab code Exa 4.5 Passband and Stopband ripple computation

```
//EXAMPLE 4.5
//determine ripple values in db;
clc
clear;
ap = 0.01//Peak passband ripple in dB
as = 70//min. stopband atteuation in dB
dp = 1-10^-(ap/20);
ds = 10^-(as/20);
disp( dp,'dp = ');
disp( ds,'ds = ');
```

Scilab code Exa 4.6 Order of Analog filter

```
//EXAMPLE 4.6
//Order of LP filter
clc;
```

```
clear;
ap = 1 //Peak passband ripple in dB
as = 40 //min. stopband atteuation in dB
wp = 1000 //Hz
ws = 5000 //Hz
k  = wp/ws;
disp(1/k,'1/k = ');
k1 = 1/(sqrt((10^(0.1* as)-1)/(10^(0.1*ap)-1)));
disp(1/k1,'1/k1 = ');
N=ceil(log10(sqrt((10^(0.1* as)-1)/(10^(0.1*ap)-1)))
   /log10(1/k));
disp(N,'order of the filter is :');
```

Scilab code Exa 4.7 Order of Analog Chebyshev Filter

```
//EXAMPLE 4.7
//Determine the order of Analog Chebyshev LP filter.
clc;
clear;
ap = 1 //dB
as = 40 //dB
wp = 1000 //Hz
ws = 5000 //Hz
k  = wp/ws;
disp(1/k,'1/k = ');
k1 = 1/(sqrt(((10^(0.1* as))-1)/((10^(0.1*ap))-1)));
disp(1/k1,'1/k1 = ');
N = acosh(1/k1)/acosh(1/k);
disp(N,'N = ');
disp('Since order of the filter is always an integer
   , ');
disp(ceil(N),'Order of the filter is, N = ');
```

Scilab code Exa 4.8 Order of Analog Lowpass Elliptic Filter

```
//EXAMPLE 4.8
//Determine the order of Analog Elliptic LP filter.
clc;
clear;
ap = 1 //dB
as = 40 //dB
Fp = 1000 //Hz
Fs = 5000 //Hz
wp = Fp*2*%pi;
ws = Fs*2*%pi;


k1 = 1/(sqrt((10^(0.1* as)-1)/(10^(0.1*ap)-1)));
disp(1/k1,'1/k1 = ');
k  = wp/ws;
k2 = sqrt(1 - (k*k));
disp(k2,"k2 = ");
po = (1 - sqrt(k2))/(2*(1 + sqrt(k2)));
disp(po,'po = ');
p  = po +2*po^5 + 15*po^9 + 150*po^13;
disp(p,'p = ');
N = (2*log10(4/k1))/log10(1/p);
disp(N,'N = ');
disp('Since order of the filter is always an integer
    , ');
disp(ceil(N),'Order of the filter is, N = ');
```

Scilab code Exa 4.16 Design of Analof Butterworth HP Filter

```
//EXAMPLE 4.16
//Design analog butterworth High pass filter
clc;
clear;
```

```
wp=4000;
ws=1000;
ap=0.1;
as=40;

Ap=1; // assumption
As=(2*%pi*wp)*Ap/(2*%pi*ws);

N=ceil(log10(sqrt((10^(0.1* as)-1)/(10^(0.1*ap)-1)))
    /log10(As/Ap));
disp(N,'order of the filter is :');

Ac = As/((10^(0.1*as)-1)^(1/(N*2)));
disp(Ac,'cutoff frequency = ')

//[hs,pole,zero,gain]=analpf(N,'butt',Ac);

s=%s;
hs=1/((s + 1)*(s^2 + 0.61803*s + 1)*(s^2 + 1.61803*s
     + 1));
Hs=horner(hs,s/Ac);
H1 = numer(Hs)/0.0976514;
H2 = denom(Hs)/0.0976514;
disp(H1/H2,'the low pass transfer function is ,HLP(s)
     = ');
Hs=horner(hs,Ac/s);
H1 = numer(Hs);
H2 = denom(Hs);
disp(H1/H2,'the High pass transfer function is ,HHP(s
    ) = ');
```

Chapter 5

Finite Length Discreet Transform

Scilab code Exa 5.1 DFT computation

```
//EXAMPLE 5.1
//DETERMINE DFT OF GIVEN SEQUENCE
clc;
clear;
N = input("length of sequence = ");
x = [1,zeros(1,N-1)];
disp(x,'The sequence is,x = ');
X = dft(x,0);
disp(X,'DFT of the sequence is X = ');
m = input("value of some intemediate (mth) point = ");
y = [zeros(1,m-1),1,zeros(1,N-m)];
Y = dft(y,0);
disp(Y,'DFT of the sequence is Y = ');
```

Scilab code Exa 5.2 DFT of sinusoidal sequence

```
//EXAMPLE 5.2
//DFT of sinusoidal sequence
clc;
clear;

N = input("   input value of N   ");
r = input("   input r value   ") ;
n = 0:N-1;
x = cos(2*%pi*r*n/N)
X = dft(x,-1)
//X exisits only at n={r,N-r} where X = N/2
clf();
a=gca();
a.x_location = "origin";
a.y_location = 'origin';
plot2d3(n,X,2);
a.thickness=1;
plot(n,X,'r.');

xtitle('DFT','K -->','X[K] -->');
X = disp(X,'DFT of x--> ');
```

Scilab code Exa 5.3 DFT computation

```
//EXAMPLE 5.3
//DETERMINE DFT OF GIVEN SEQUENCE

clc;
clear;
N = input("length of sequence,N  =  ");
M = input("M point DFT = ");
if M > N
    x = [ones(1,N),zeros(1,M-N)];
    disp(x,'the sequence is :');
    for n=0:M-1
```

```
        for k=0:M-1
            W(n+1,k+1) = exp(-(%i*2*%pi*k/M)*n);
        end
    end
    X = W*x';
    disp(X,'DFT is , X = ');
else
    disp('invalid computation');
end


n=0:M-1;
clf();
figure(0)
a = gca();
plot2d3(n,x,2) //  plotting the sequence
plot(n,x,'r.');
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 2.5;
xtitle('original sequence','n','x[n]');

figure(1)
a = gca();
plot2d3(n,abs(X),2)  //  plotting absolute value of DFT of sequence
plot(n,abs(X),'r.');
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 2.5;
xtitle('magnitude plot','M','Absolute value');
```

Scilab code Exa 5.4 IDFT Computation

```
//EXAMPLE 5.4
//DETERMINE IDFT OF GIVEN SEQUENCE
clc;
clear;
K = input("   value of K   ");
disp('input M > K');
M = input("   value of M   ");
k1 = 0:K-1;
V1 = k1./K;//DFT
k=0:M-1;

N = length(V1);
V = [V1,zeros(1,M-N)];
v = dft(V,1);//IDFT

clf();
subplot(1,2,1)

a = gca();
plot2d3(k,real(v),2);
plot(k,real(v),'r.');
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 2;
xtitle('real part','N','v');

subplot(1,2,2)
a = gca();
plot2d3(k,imag(v),2)
plot(k,imag(v),'r.');
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 2;
xtitle('imaginary part','N','v');
v = disp(v);
```

Scilab code Exa 5.5 DFT computation

```
//EXAMPLE 5.5
//DFT computation
clc;
clear;

N = 16 ;
r = 3 ;
n = 0:N-1;
x = cos(2*%pi*r*n/N)
X = fft(x,-1)//DFT of the sequence
clf();
a = gca();
plot2d3(n,X,2);
plot(n,X,'r.')
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 3;
xtitle('DFT','k','X');
X = disp(real(X),'  X = ');
```

Scilab code Exa 5.7 Cicular convolution computation

```
//EXAMPLE 5.7
//Circular convolution
clear;
clc;
g = [1 2 0 1];
disp(g,'g[n] = ');
h = [2 2 1 1];
```

```
disp(h,'h[n] = ');
G = fft(g,-1);
H = fft(h,-1);
Y = G.*H;
yc = fft(Y,1);
n1 = 0:length(yc)-1;
yl = convol(g,h);
n2 = 0:length(yl)-1;

clf();
subplot(2,1,1)
a = gca();
plot2d3(n1,yc,2);
plot(n1,yc,'r.');
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 3;
xtitle('circular convolution','n','yc');

subplot(2,1,2)
a = gca();
plot2d3(n2,yl,2);
plot(n2,yl,'r.');
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 3;
xtitle('linear convolution','n','yl');

disp(real(yc)," circular convolution,yc = ");
disp(yl," linear convolution,yl = ");
```

Scilab code Exa 5.8 Cicular convolution computation

```
//EXAMPLE 5.8
//Cicular convolution
clc;
clear;
g = [1 2 0 1];
disp(g,'g[n] = ');
h = [2 2 1 1];
disp(h,'h[n] = ');
G = fft(g,-1);
H = fft(h,-1);
Y = G.*H;
yc = fft(Y,1);//IDFT of Y
disp(yc,"circular convolution,yc = ")
n=0:3;
clf();
figure(0);
a = gca();
plot2d3(n,yc,2);
plot(n,yc,'r.');
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 3;
xtitle('Circular convolution','n','yc');
```

Scilab code Exa 5.10 Generating symmetric parts

```
//EXAMPLE 5_10
//conjugate symmetric & anti-symmetric parts of
   complex sequence
clear;
clc;
un=[1+%i*4,-2+%i*3,4-%i*2,-5-%i*6];
disp(un,'u[n] = ');
u1=conj(un);
```

```
disp(u1,'u*[n] = ');
//modulo-4 circularly time reversed version:
disp(pmodulo(0,4),'u[<-0>4] = ');
disp(pmodulo(-1,4),'u[<-1>4] = ');
disp(pmodulo(-2,4),'u[<-2>4] = ');
disp(pmodulo(-3,4),'u[<-3>4] = ');
un1=[u1(pmodulo(-0,4)+1),u1(pmodulo(-1,4)+1),u1(pmodulo(-2,4)+1),u1(pmodulo(-3,4)+1)];
disp(un1,'u*[<-n>4] = ');
disp(0.5*(un+un1),'ucs[n] = ');
disp(0.5*(un-un1),'uca[n] = ');
```

Scilab code Exa 5.11 Cicular convolution computation

```
//EXAMPLE 5.11
//Circular convolution using DFT
clc;
clear;
g = [1 2 0 1];
disp(g,'g[n] = ');
h = [2 2 1 1];
disp(h,'h[n] = ');
M=4;
for n=0:M-1
        for k=0:M-1
            W(n+1,k+1) = exp(-(%i*2*%pi*k/M)*n);
        end
    end
    G = W*g';
    H = W*h';
disp(G,'DFT is , G = ');
disp(H,'DFT is , H = ');

Y=G.*H;
y=(1/4)*conj(W)*(Y);
```

```
disp(real(y),'Circular convolution = ');
```

Scilab code Exa 5.12 Linear Convolution using DFT

```
//EXAMPLE 5.12
//Linear convolution using Circular convolution
clc;
clear;
g = [1 2 0 1];
disp(g,'g[n] = ');
h = [2 2 1 1];
disp(h,'h[n] = ');

//linea convolution length = 4+4-1 = 7
//appending the two signals with zeros
g = [g,zeros(1,3)]
h = [h,zeros(1,3)]
G = fft(g,-1);
H = fft(h,-1);
Y = G.*H;      //element wise multiplication
y = fft(Y,1);//IDFT

//Plotting linear convolution
n=0:6;
figure(0);
clf();
a = gca();
a.x_location = 'origin';
a.y_location = 'origin';
plot2d3(n,y,2);
plot(n,y,'r.');
poly1 = a . children (1) . children (1) ;
poly1.thickness = 2;
xtitle('Linear convolution','n','y');
disp(y," linear convolution ,y = ");
```

Scilab code Exa 5.14 DFT computationusing single DFT

```
//EXAMPLE 5.14
//DFT of two real sequences using one DFT
clear;
clc;
g = [1 2 0 1];
disp(g,'g[n] = ');
h = [2 2 1 1];
disp(h,'h[n] = ');
x = g + %i.*h;
disp(x,'x[n] = ');
X = fft(x,-1);
disp(X,'The DFT, X[k] = ');
X1 = conj(X);
disp(X1,'X*[k] = ');

for i=0:3;
    a(i+1)=pmodulo(-i,4);
    X2(i+1)=X1(a(i+1)+1);
end

X3 = conj(X2');
disp(X3,'X*[<4-k>4] = ');
disp(0.5*(X + X3),'G[k] = ');
disp((X - X3)/(2*%i),'H[k] = ');
```

Scilab code Exa 5.15 DFT computationusing single DFT of shorter length

```
//EXAMPLE 5.15
//DFT computation using DFT of shorter length
    sequences
```

```
clc;
clear;
v = [1 2 2 2 0 1 1 1];
disp(v,'Length-8 real sequence v[n] = ')
for i=1:4
    g(i)=v(2*i-1);
    h(i)=v(2*i);
end
G = fft(g,-1);
H = fft(h,-1);
M=length(v);
//for n=0:M-1
        for k=0:M-1
            W(1,k+1) = exp(-(%i*2*%pi*k/M)*1);
        end
//end
G=[G(1) G(2) G(3) G(4) G(1) G(2) G(3) G(4)] ;
H=[H(1) H(2) H(3) H(4) H(1) H(2) H(3) H(4)] ;
V=G + W.*H;
disp(V,'DFt,V[k] = ');

//for k = 0:3
```

```
//      V1(k+1) = G(k+1) + (exp(-2*%pi*%i*k/8))*H(k+1)
    ;
//end

//for k = 4:7
//      V2(k) = G(k-3) + (exp(-2*%pi*%i*k/8))*H(k-3);
//end
//disp([V1,zeros(1,3)]+V2)
```

Chapter 6

z Transform

Scilab code Exa 6.1 z Transform of causal exponential sequence

```
//EXAMPLE 6.1
//Z-Transform of causal sequence
clc;
clear;
syms n a z;
x = a^n;
X = nusum(x*(1/z)^n,n,0,%inf);
limit(X);
disp(' X = ',X);
disp(' ROC = |z|>|a| ')
```

Scilab code Exa 6.2 z transform of anticausal sequence

```

clc;
clear;
syms n a z;
x = a^n;
```

```
X = nusum(-x*(1/z)^n,n,-%inf,-1);
limit(X);
disp(' X = ',X);
disp(' ROC = |z|<|a| ')
```

Scilab code Exa 6.3 z Transform

```
//EXAMPLE 6.3
//Z-Transform
clc;
clear;
syms n a z M N;
x = a^n;
X = nusum(x*(1/z)^n,n,M,N-1);
limit(X);
disp(X,' X = ');
```

Scilab code Exa 6.4 z Transform

```
//EXAMPLE 6.4
//Z-Transform
clc;
clear;
syms n z;
x = (-0.6)^n;
X = nusum(x*((1/z)^n),n,0,%inf);
limit(X);
disp(X,' X = ');
```

Scilab code Exa 6.5 Z transform of causal sequence

```
//EXAMPLE 6.9
//Z-Transform of causal sequence
clc;
clear;
//z=%z;
syms n a z M N;
x = a^n;
X = nusum(x*(1/z)^n,n,-M,N);
limit(X);
disp(X,' X = ');
```

Scilab code Exa 6.9 z Transform

```
//EXAMPLE 6.9
//Determination of ROC
clc;
clear;
z=%z;
a=2*z^4+16*z^3+44*z^2+56*z+32;
b=3*z^4+3*z^3-15*z^2+18*z-12;
[h1,g1]=factors(a);
[h2,g2]=factors(b);
disp(h1,'h1 = ');
disp(h2,'h2 = ');
c=a/b;
disp(c,'function is = ');
plzr(c);
```

Scilab code Exa 6.10 Rational form of z Transform from its zero and pole locations

```
//EXAMPLE 6.10
//Z-transform from pole-zero locations
```

```
clc;
clear;
z=%z;
//using the pole & zero locations provided
num=(z-0.21)*(z-3.14)*(z-(-0.3+%i*0.5))*(z-(-0.3-%i
    *0.5));
den=(z+0.45)*(z-0.67)*(z-(0.81+%i*0.72))*(z-(0.81-%i
    *0.72));
k=2.2;
Gz=(num/den);
disp(k*Gz,'Gz = ');
```

Scilab code Exa 6.11 Inverse z Transform

```
//EXAMPLE 6.11
//Inverse Z-transform
clc;
clear;
syms n z1;
z  = %z;
num = z;      //given |z|>1;
den = (z-1)^2;


//Power series expansion
x=ldiv(num,den,20);
disp(x,'x = ');
disp('x = n*u[n]');
```

Scilab code Exa 6.12 Inverse z Transform

```
//EXAMPLE 6.12
//Inverse Z-transform
```

```
clear;
clc;
z=%z;
num = 0.5*z;
den = z^2 -z + 0.25;
func = num/den;
v = factors(den);
disp(v,'factors are = ');
h1=ldiv(num,den,10);
disp(h1,'h  = ');
//using the property of z-trasnform
disp('observing v(1) & v(2) we conclude        h=n
    *(0.5)^n ')
```

Scilab code Exa 6.13 Proper fraction of Rational z Transform

```
//EXAMPLE 6.13
//Determining proper fraction
clc;
clear;
z=%z;
num = 2*z^3 + 0.8*z^2 + 0.5*z +0.3;
den = (z^3 + 0.8*z^2 + 0.2*z);
func = num/den;
disp(func,'the polynomial function is H = ')

  if degree(num)>=degree(den)
           disp('An  improper fraction');
      else disp('A proper fraction');
  end

disp('decomposing the fraction we get .....');

H1=func-(-3.5*z + 1.5)/z;
disp(H1,'H1 = ');
```

```
disp('H1 is a Proper fraction')
```

Scilab code Exa 6.14 Inverse z Transform by partial fraction expansion

```
//EXAMPLE 6.14
//Inverse Z-transform
clear;
clc;
z = %z;
num=z*(z+2);
den=(z-0.2)*(z+0.6);
H=num/den;
elts=factors(den);
disp(elts);
//solving Partial Fractions, we get:
Hz = 2.75/(1-(0.2)/z) - 1.75/(1+(0.6)/z);
disp(Hz);
//disp(h = 2.75*(0.2^n) - 1.75*(0.6^n)*u(n));
h1= ldiv(2.75*z,(z-(0.2)),10)
disp(h1/2.75,'h1 = ');
h1= ldiv(1.75*z,(z+(0.6)),10)
disp(h1/1.75,'h2 = ');
disp('the inverse z-transform is :')
disp('h = 2.75*(0.2^n)*u(n) - 1.75*(-0.6^n)*u(n)')
```

Scilab code Exa 6.15 residue computation using coefficient matching approach

```
//EXAMPLE 6.15
//solving for coefficients;
clear;
clc;
z = %z;
```

```
num=z*(z+2);
den=(z-0.2)*(z+0.6);
H=num/den;
disp('the factors are :');
elts=factors(den);
disp(elts);
//coeff are:
disp('The coefficients are p1,p2:');
p1 = horner((z+2)/(z+0.6),0.2);
disp(p1,'p1 = ') ;
p2 = horner((z+2)/(z-0.2),-0.6);
disp(p2,'p2 = ') ;
```

Scilab code Exa 6.16 Inverse z Transform by power series expansion

```
//EXAMPLE 6.16
//Partial fraction expansion

clc;
clear;
z=%z;
num = z^3;
den = 18*z^3 + 3*z^2 - 4*z - 1;
elts=factors(den);
disp(elts,'the factors are :') ;
func = num/den;
//the partial fraction gives:
p1 = horner((1/(1+0.3333333/z)^2),0.5);
disp(p1,'p1 = ');
p2 = horner(1/((1-0.5/z)),-0.3333333);
disp(p2,'p2 = ');
p3 = horner(0.6/((1-0.5/z)),-0.3333333);
disp(p3,'p3 = ');
disp('partial fraction gives : ');
disp(p1*z/elts(1),'h1 = ');
```

```
disp(p3*z/elts(3),'h2 = ');
disp(p2*z^2/(elts(2)*elts(2)),'h3 = ');
```

Scilab code Exa 6.17 Coefficients of rational form

```
//EXAMPLE 6.16
//Coefficients of Rational form

clc;
clear;
z=%z;
num = 18*z^3;
den = 18*z^3 + 3*z^2 - 4*z - 1;
disp(coeff(num)/18,'the Numerator polynomial
   coefficients are:');
disp(coeff(den)/18,'the denominator polynomial
   coefficients are:');
```

Scilab code Exa 6.18 Inverse z Transform using long division

```
//EXAMPLE 6.18
//Inverse Z-transform using power series expansion
clc;
clear;
z=%z;
Xnum=z;
Xden=(z-1)^2;
xn=ldiv(Xnum,Xden,15);
disp(xn,'The function is = ');
disp(' Thus, xn = n*u(n)');
```

Scilab code Exa 6.19 Inverse z Transform using long division

```
//EXAMPLE 6.19
//Inverse Z−transform using Long division method
clc;
clear;
z=%z;
Hnum=z^2 + 2*z;
Hden=z^2 + 0.4*z -0.12;
hn=ldiv(Hnum,Hden,20);
disp(hn,'The function is , hn = ');
```

Scilab code Exa 6.20 Inverse z Transform

```
//EXAMPLE 6.20
//Inverse Z−transform using power series expansion
clc;
clear;
z=%z;
Hnum=z^2 + 2*z;
Hden=z^2 + 0.4*z -0.12;
hn=ldiv(Hnum,Hden,20);
disp(hn,'The impulse response is , hn = ');
```

Scilab code Exa 6.22 z Transform

```
    //Example 6.22
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//Z transform of r n.cos(wo n)
clc ;
clear;
syms r wo n z ;
x1 =(r^n)*exp(%i*wo*n) ;
```

```
X1 = nusum(x1*(z^-n),n,0,%inf);
x2 =(r^n)*exp(-%i*wo*n) ;
X2 = nusum(x2*(z^-n),n,0,%inf) ;
X =(X1+X2)/2 ;
disp(X,'X(z)=') ;
disp('ROC : |z|>r');
```

Scilab code Exa 6.23 z Transform

```
//Example 6.23
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//Z transform of w(n)  =((-0.5)^(n-2) +(0.2)^(n-1))*
   u(n)

syms n z ;
w1 = 4*(-0.5)^n
W1 = nusum(w1,n,0,%inf);
disp(W1,'ROC = |z|> 0.5  ,W1 = ');
w2 = 5*(0.2)^n
W2 = nusum(w2,n,0,%inf);
disp(W2,' ROC = |z|> 0.2  , W2 = ');
disp(W1+W2,'The Z-Transform is = ');
disp('ROC = |z|>0.5');
```

Scilab code Exa 6.24 sum of sequences of non overlapping ROC

```
//Example 6.24
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//Z transform of v(n)  =(a)^(n)*u(n) - (b)^(n)*u(-n
   -1)
clc;
clear;
disp('assuming  |b| > a');
```

```
syms a n;
x1 = a^n;
X1 = nusum(x1,n,0,%inf);
x1 = b^n;
X1 = nusum(x2,n,-%inf,-1);
Vz = X1 + X2;
disp(Vz,'The Z-transform is = ');
disp('ROC = |a|<|z|<|b|');
```

Scilab code Exa 6.25 z Transform

```
//Example 6.25
//Z transform of Vz , d0*v[n] + d1*v[n-1] = p0*d[n]
    + p1*d[n-1];
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS EXAMPLE
clc;
clear;
syms p0 p1 d0 d1;
z= %z;
disp('given that v[n] --> V(z).Using Time shifting
    property,we get : ')
disp(' d0*Vz + d1*Vz*(1/z) = p0 + p1*(1/z) ');
disp('Rearranging the terms ...');
Vz = (p0 + p1/z)/(d0 + d1/z);
disp(Vz,'Z-transform is Vz =');
```

Scilab code Exa 6.26 z Transform

```
    // Example 6.26
//MAXIMA SCILAB TOOLBOX
//Z transform of (n+1)*a^n*u(n)

clear ;
```

```
clc ;
syms a n z ;
x1 =(a)^n ;
X1 = symsum(x1*(z^(-n)),n,0,%inf);
X2 = -z*(diff (X,z,1)) ;
X = X1 + X2;
disp (X , 'Z transform of(n+1)*a^n*u(n) is X = ');
```

Scilab code Exa 6.27 Inverse z Transform

```
// Example 6.27
//inverse Z-transform of z^3/(z-0.5)*(z+1/3)^2;

clear ;
clc ;
z=%z;
Gnum = z^3;
Gden = (z-0.5)*(z+1/3)^2;
G = Gnum/Gden;
g1=ldiv(Gnum,Gden,10);
elts=factors(Gden);

//the partial fraction gives:
p1 = horner((1/(1+0.3333333/z)^2),0.5);
disp(p1,'p1 = ');
p2 = horner(1/((1-0.5/z)),-0.3333333);
disp(p2,'p2 = ');
p3 = horner(0.6/((1-0.5/z)),-0.3333333);
disp(p3,'p3 = ')
disp('partial fraction gives : ');
disp(p1*z/elts(1),'h1 = ');
disp(p3*z/elts(3),'h2 = ');
disp(p2*z^2/(elts(2)*elts(2)),'h3 = ');
disp('gn = 0.36*(0.5)^n + 0.24*(-1/3)^n + 0.4*(n+1)
    *(-1/3)^n')
```

```
disp(g1,'the first 10 samples of g[n] = ');
```

Scilab code Exa 6.28 Enlargement of ROC by pole zero cancellation

```
// Example 6.28
//Enlargement of ROC by pole-zero cancellation
clc;
clear;
z=%z;
Gz = (2 + 1.2*(1/z))/(1 - 0.2*(1/z))
disp(Gz,'Gz = ');
disp('ROC = |z|>0.2');
Hz = 3/(1 + 0.6*(1/z));
disp(Hz,'Hz = ');
disp('ROC = |z|>0.6');
Xz = Gz*Hz;
disp(Xz,'Xz = ');
disp('ROC = |z|>0.2');
```

Scilab code Exa 6.30 Convolution

```
//EXAMPLE 6.30
//PROGRAM REQUIRES MAXIMA SCILAB TOOLBOX
//USE Z-TRANSFORM TO EVALUATE CONVOLUTION OF TWO
    SEQUENCES:
clc;
clear;
syms n z;
x = [-2  0 1 -1 3];
h = [1 2 0 -1 0];

for n=0:4
    X(n+1) = x(n+1)*z^(-n);
```

```
    H(n+1) = h(n+1)*z^(-n);
end
disp(X','X = ');
disp(H','H = ');

for i=1:5
    U(i)=0;
    for j=1:5
        U(i)=U(i)+X(i)*H(j);
    end
end
Y=0;
for i=1:5;
    Y = Y + U(i);
end
disp(Y,'Y = ');

disp('y = [-2 -4 1 3 1 5 1 -3]')
```

Scilab code Exa 6.31 Convolution

```
//EXAMPLE 6.31
//PROGRAM REQUIRES MAXIMA SCILAB TOOLBOX
//USE Z-TRANSFORM TO EVALUATE CONVOLUTION OF TWO
   SEQUENCES:
clc;
clear;
syms n z;
x = [3 -2 4];
h = [4 2 -1];

for n=-1:1
    X(n+2) = x(n+2)*(z^-n);
end
disp(X','X = ');
```

```

for n=0:2
    H(n+1) = h(n+1)*(z^-n);
end
disp(H','H = ');


for i=1:3
    U(i)=0;
    for j=1:3
        U(i)=U(i)+X(i)*H(j);
    end
end
Y=0;
for i=1:3;
    Y = Y + U(i);
end
disp(Y,'Y = ');

disp('y = [12 -2 9 10 -4]');
```

Scilab code Exa 6.33 Transfer Function of Moving Average Filter

```
//EXAMPLE 6.33
//Transfer function of moving average filter
clear;
clc;
syms n z M;
x=z^(-n);
H1=nusum(x,n,0,M-1);
H=H1/M;
disp(H,'Transfer function , Hz = ');
```

Scilab code Exa 6.34 Transfer function determination

```
//EXAMPLE 6.34
//y[n]=x[n-1] - 1.2*x[n-2] + x[n-3] + 1.3*y[n-1]
    -1.04*y[n-2] + 0.222*y[n-3]
//Transfer function determination

clc;
clear;
z=%z;
disp('Given the difference equation taking
    ztransform on both sides :')
Yz = z^2 -1.2*z +1;
Xz = z^3 -1.3*z^2 + 1.04*z -0.222;
Hz = Yz/Xz;
disp(Hz,'The transfer function is = ')
elts = factors(Xz);
disp(elts,'factors of Xz are = ')
plzr(Hz);
```

Chapter 7

LTI Discreet Time systems in the Transform Domain

Scilab code Exa 7.1 Bounded real function

```
//EXAMPLE 7.1
//PROGRAM REQUIRES MAXIMA SCILAB TOOLBOX

clc;
clear;
syms K a z w;

hzden = (1-a*(z^-1)); //0<|a|<1;
Hz = K/hzden;
disp('|H(e^(jw))|^2 = K^2/((1+a)^2 - 2*cos(w)') ;
// considering a>0
disp('(at w = %pi),K^2/(1+a)^2 < |H|^2  < K^2/(1-a)^2,(at w = 0)');
//considering a<0
disp(' (at w = 0),K^2/(1+a)^2 < |H|^2  < K^2/(1-a)^2,(at w = %pi)');
disp('if K = +/-(1-a), observe....');
disp('|H(e^(jw))|  <= 1      Hence a Bounded real function.');
```

```
//w=0:%pi;
//[a,b]=freq(hznum,hzden,w);
disp(abs(Hz))
```

Scilab code Exa 7.2 Transfer function determination

```
//EXAMPLE 7.2
//|H(e^(jw))|^2 = 4*((1.09 + 0.6*cosw)*(1.16-0.8*
    cosw))/((1.04-0.2*cosw)*(1.25+cosw))
//REPLACING cosw = (z + z(^-1))/2
clc;
clear;
z=%z;
H1=4*((1.09 + (0.3)*(z+1/z))*(1.16 - (0.4)*(z+1/z)))
    ;
H2=((1.04 - (0.2)*(z+1/z))*(1.25 + (0.5)*(z+1/z)));
H=H1/H2;
disp(H,'The transfer function is, H = ')
elts1=factors(numer(H));
disp(elts1,'The factors of numerator are :');
elts2=factors(denom(H));
disp(elts2,'The factors of denominator are :');
disp('The Four posible stable transfer function with
     same square magnitude function are :');
h1=2*((1+(0.3)/z)*(1- (0.4)/z))/((1-(0.2)/z)
    *(1+(0.5)/z));
disp(h1,'stable transfer function,h1 = ');
h2=2*((1+(0.3)/z)*((0.4)- (1)/z))/((1-(0.2)/z)
    *(1+(0.5)/z));
disp(h2,'stable transfer function,h2s = ');
h3=2*(((0.3)+1/z)*((1)- (0.4)/z))/((1-(0.2)/z)
    *(1+(0.5)/z));
disp(h3,'stable transfer function,h3 = ');
h4=2*(((0.3)+1/z)*((0.4)- (1)/z))/((1-(0.2)/z)
    *(1+(0.5)/z));
```

```
disp(h4,'stable transfer function,h4 = ');
```

Scilab code Exa 7.6 FIR Transfer function

```
//EXAMPLE 7.6
//FIR Trasnfer functions with different Phase.
clc;
clear;
z  = %z;
W  = 0:(1/400):1;
z  = exp(%i*2*%pi*W);
for i=1:401
    H1z(i)= -1+ 2/z(i) - 3/(z(i)^2) + 6/(z(i)^3)
        -3/(z(i)^4) +2/(z(i)^5) -1/z(i)^(6);
end
H1z_phase = phasemag(H1z);

clf();
figure(0);
plot2d(W/(2*%pi),H1z_phase,1);
xtitle('phase response','W/(2*%pi)','H2z_phase in
   degrees');

for i=1:401
    H2z(i)= +1 - 2/z(i) + 3/(z(i)^2) - 6/(z(i)^3) +
        3/(z(i)^4) - 2/(z(i)^5) + 1/z(i)^(6);
end
H2z_phase = phasemag(H2z);

plot2d(W/(2*%pi),H2z_phase,2);
xtitle('phase response','W/(2*%pi)','H2z_phase in
   degrees');
```

Chapter 8

Digital Filter Structures

Scilab code Exa 8.1 Analysis of Cascaded lattice digital filter structure

```
//EXAMPLE 8.1
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS EXAMPLE
//Digital filter structure
clear;
clc;
syms W1 W2 W3 X Y a d B y E z;
//Equations obtained are as follows:
W1 = X - a*W3/z;
W2 = W1 - d*W2/z;
W3 = W2/z + E*W2;
Y  = B*W1 +y*W3/z;
//Solving the above equations:
Hz=(B + (B*d+y*E)/z + y/(z^2))/(1 + (d+a*E)/z + a/(z
   ^2))
disp(Hz,'Hz = ');
```

Scilab code Exa 8.6 Factorization of FIR Transfer Function

```
//Example 8.6
//Factorization of FIR Transfer Function
clear;
clc;
z=%z;
Hz=50.4+28.02/z+13.89/z^2+7.42/z^3+6.09/z^4+3/z^5+1/
    z^6;
disp(factors(numer(Hz)),'The Factors of the FIR
    Transfer Function are = ');
```

Scilab code Exa 8.7 Factorization of IIR Transfer Function

```
//Example 8.7
//Factorization of IIR Transfer Function
clear;
clc;
z=%z;
//Numerator of the transfer function
Numz=6+17.1/z+33.05/z^2+24.72/z^3+19.908/z^4-5.292/z
    ^5+18.144/z^6;
//Denominator of the transfer function
Denz=1+2.2/z+2.56/z^2+1.372/z^3+0.118/z^4-0.332/z
    ^5-0.168/z^6;
Fn=factors(numer(Numz));
disp(Fn,'Factors of the numerator of the Transfer
    Function = ');
Fd=factors(numer(Denz));
disp(Fd,'Factors of the denominator of the Transfer
    Function = ');
```

Scilab code Exa 8.10 Cascaded lattice realization of IIR digital Transfer Function

```
//Example 8.10
//Cascaded lattice realization of IIR Transfer
   Function
clear;
clc;
z=%z;
P3z= -0.2 + 0.18/z + 0.4/(z^2) + 1/(z^3);
D3z=  1 + 0.4/z + 0.18/(z^2) - 0.2/(z^3);
A3z=P3z/D3z;
p1=coeff(numer(P3z));
p=mtlb_fliplr(p1);
disp(mtlb_fliplr(p),'The coefficients ofnumerator
   are = ');
d1=coeff(numer(D3z-1));
d=mtlb_fliplr(d1)
disp((d),'The coefficients ofnumerator are = ');
d1_1dash=(d(1)-d(3)*d(2))/(1-d(3)*d(3));
disp(d1_1dash,"d1_1dash = ");
d2_1dash=(d(2)-d(3)*d(1))/(1-d(3)*d(3));
disp(d2_1dash,"d2_1dash  ");
d1_2dash=(d1_1dash)/(1+d2_1dash);
disp(d1_2dash,"d1_2dash = ");
A1z=(d1_2dash + 1/z)/(1 + d1_2dash/z);
disp(A1z,'A1z = ');
A2z=(d2_1dash + d1_1dash*1/z + 1/z^2)/(1 + d1_1dash/
   z - d2_1dash/z^2);
disp(A2z,'A2z = ');
```

Scilab code Exa 8.12 Gray Markel method of realization

```
//Example 8.12
//Gray Markel method of Realisation
clear;
clc;
z=%z;
```

```
P3z= 0 + 0.44/z + 0.362/(z^2) +0.02/(z^3);
D3z= 0.4/z + 0.18/(z^2) - .2/(z^3);
Hz=P3z/D3z;
p1=coeff(numer(P3z));
p=mtlb_fliplr(p1)
disp(mtlb_fliplr(p),'The coefficients ofnumerator
    are = ');
d1=coeff(numer(D3z));
d=mtlb_fliplr(d1)
disp(mtlb_fliplr(d),'The coefficients ofnumerator
    are = ');
d1_1dash=(d(1)-d(3)*d(2))/(1-d(3)*d(3));
disp(d1_1dash,"d1_1dash = ");
d2_1dash=(d(2)-d(3)*d(1))/(1-d(3)*d(3));
disp(d2_1dash,"d2_1dash  ");
d1_2dash=(d1_1dash)/(1+d2_1dash);
disp(d1_2dash,"d1_2dash = ");
a1=p(3);
disp(p(3),'a1 = ');
a2=p(2)-a1*d(1);
disp(p(2)-a1*d(1),'a2 = ');
a3=p(1)-a1*d(2)-a2*d1_1dash;
disp(p(1)-a1*d(2)-a2*d1_1dash,'a3 = ');
disp(0-a1*d(3)-a3*d1_2dash-a2*d2_1dash,'a4 = ');
```

Scilab code Exa 8.18 Cascaded lattice realization

```
//Example 8.18
//Cascaded lattice realization of Power-symmetric
    FIR Transfer Function
clear;
clc;
z=%z;

H5z=(1 + 0.3/z + 0.2/z^2 - 0.376/z^3 - 0.06/z^4 +
```

```
    0.2/z^5);
disp(H5z,'FIR filter = ');
G5=horner(H5z,-1/z);
G5z=G5/z^5;
disp(G5z,'FIR filter = ');
k5=0.2;
H3z=(1/(1+k5^2))*(H5z - k5*G5z);
disp(H3z,'Synthesis eqn,H3z = ');
G3z=(1/(1+k5^2))*(k5*H5z + G5z);
disp(G3z,'Synthesis eqn,G3z = ');
k=coeff(numer(G3z));
disp(k(4),'k3 = ');
disp(k(2),'k1 = ');
```

Chapter 9

IIR digital filter design

Scilab code Exa 9.1 Computating ripple values

```
//EXAMPLE 9.1
//pass band & stop band ripple
clc;
clear;
ap=0.1;//peak passband ripple in dB
as=35;//min. stopband attenuation in dB

//calculation of peak ripple values
dp=1-10^-(ap/20);
disp(dp,'dp = ');
ds=10^-(as/20);
disp(ds,'ds = ');
```

Scilab code Exa 9.2 conversion of bandedged frequencies to Normalized digital frequencies

```
//EXAMPLE 9.2
//analog passband & stopband frequencies(in KHz) :
```

```
clc;
clear;
ap=7;
as=3;
//Sampling frequency (in KHz):
FT=25;
//digital frequencies:
wp=2*%pi*ap/FT;
disp(wp,'wp = ');
ws=2*%pi*as/FT;
disp(ws,'ws = ');
```

Scilab code Exa 9.3 Design of HP Digital Filter

```
//Example 9.3
//Design of HP IIR filter
clc;
clear;
Fp=700//Hz
Fs=500//Hz
ap=1//dB
as=32//dB
FT=2000//Hz
//normalized angular edge frequencies in rad/sec
wp=2*%pi*Fp/FT;
ws=2*%pi*Fs/FT;
//prewarp the digital edge frequencies
Ap1=tan(wp/2);
As1=tan(ws/2);

Ap=1;//assuming
As=(2*%pi*Ap1)*Ap/(2*%pi*As1);
disp(As,'As = ')
//Order 'N' of the filter
k  = Ap/As;
```

```
disp(1/k,'1/k = ');
k1 = 1/(sqrt(((10^(0.1* as))-1)/((10^(0.1*ap))-1)));
disp(1/k1,'1/k1 = ');
N = ceil(acosh(1/k1)/acosh(1/k));
disp(N,'N = ');
disp(N,'Order of the filter is, N = ');

e=sqrt(10^(0.1*ap)-1);
u=1/e + sqrt(1+(1/(e*e)));
a=Ap*(u^(1/N) - u^(-1/N))/2;
b=Ap*(u^(1/N) + u^(-1/N))/2;

for i=1:N
    phi(i)= %pi/2 + (2*i -1)*(%pi)/(2*N);
    p(i)=a*cos(phi(i)) + %i*b*sin(phi(i));
end
s=%s;
z=%z;
H1=1;
//Numerator of H(s)
for i=1:N
    H1=H1*(s + p(i))
end
//Denominator of H(s)
H2=horner(H1,0);
//Transfer function
H=H2/H1;
disp(H,'H = ')
//Bilnear Transformaation, s=((z-1/(z+1));
Hz=horner(H,(z-1)/(z+1));
disp(Hz,'The digital HP filter is Hz = ');
```

Scilab code Exa 9.6 Changing passband edge frequencies to LP IIR digital frequencies

```
//EXAMPLE 9.6
//LP TO LP Transformation

clc;
clear;
z=%z;
w=0:0.001*%pi:%pi;
Glz=(0.0662272*(1+1/z)^3)/((1-0.2593284/z)
   *(1-0.6762858/z+0.3917468/(z^2)))
wc=0.25*%pi;//Oringinal passband edge
Wc=0.35*%pi;//Required passband edge
l=sin((wc-Wc)/2)/sin((wc+Wc)/2)
disp(l,'lambda = ');
Gdz=horner(Glz,((1-l/z)/(1/z-l)));
disp(Gdz,'The transfer function is Gdz = ');
```

Scilab code Exa 9.7 Design of HP IIR Digital Filter from LP Digital Filter

```
//EXAMPLE 9.7
//LP TO HP Transformation

clc;
clear;
z=%z;
Glz=(0.0662272*(1+1/z)^3)/((1-0.2593284/z)
   *(1-0.6762858/z+0.3917468/(z^2)));
wc=0.25*%pi;//Oringinal passband edge
Wc=0.55*%pi;//Required passband edge
l=-cos((wc+Wc)/2)/cos((wc-Wc)/2);
disp(l,'lambda = ');

w=0:0.001:1;
Ghz=horner(Glz,-((z + l)/(1 +l*z)));//LP TO HP
   Transformation formula
den=factors(denom(Ghz));
```

```
disp(Ghz,'The transfer function is Gdz = ');
disp(den,'the facors of the denominator are = ');
```

Scilab code Exa 9.12 Minimum order of Type 2 Chebyshev HP IIR digital filter

```
//EXAMPLE 9.12
//Minimum order of type-2 Chebyshev highpass digital
    filter
clc;
clear;
ap = 1 //dB
as = 40 //dB
Fp = 1000 //Hz
Fs = 600 //Hz
Wp = Fp*2*%pi;
Ws = Fs*2*%pi;

F = 4000//Hz
T=1/F;

Ap=(2/T)*(tan(Wp*T/2))
As=(2/T)*(tan(Ws*T/2))


k  = Ap/As;
disp(1/k,'1/k = ');
k1 = 1/(sqrt(((10^(0.1* as))-1)/((10^(0.1*ap))-1)));
disp(1/k1,'1/k1 = ');
N = acosh(1/k1)/acosh(k);//order of the filter
disp(N,'N = ');
disp('Since order of the filter is always an integer
    , ');
disp(ceil(N),'Order of the filter is , N = ');
```

Chapter 10

FIR digital filter design

Scilab code Exa 10.1 Kaiser formula

```
//Example 10.01
//Order estimation using Kaiser's formula
clear;
clc;
Fp=1800;//Passband edge freq. in Hz
Fs=2000;//stopband edge freq. in Hz
ap=0.1;//peak passband ripple in dB
as=35;//min. stopband attenuation in dB
FT=12000;//Sampling freq. in Hz

//calculation of peak ripple values
dp=1-10^-(ap/20);
disp(dp,'dp = ');
ds=10^-(as/20);
disp(ds,'ds = ');

//Order of the FIR filter
N=(-(20*log10(sqrt(ds*dp))) - 13)/((14.6)*(Fs-Fp)/FT
    );
disp(ceil(N),'Order of the filter is N = ')
```

Scilab code Exa 10.2 Bellenger formula

```
//Example 10.01
// Order estimation using Bellanger's formula
clear;
clc;
Fp=1800;//Passband edge freq. in Hz
Fs=2000;//stopband edge freq. in Hz
ap=0.1;//peak passband ripple in dB
as=35;//min. stopband attenuation in dB
FT=12000;//Sampling freq. in Hz

//calculation of peak ripple values
dp=1-10^-(ap/20);
disp(dp,'dp = ');
ds=10^-(as/20);
disp(ds,'ds = ');

//Order of the FIR filter
N=((-2*log10(10*ds*dp)) /((3)*(Fs-Fp)/FT)) -1 ;
disp(ceil(N),'Order of the filter is N = ')
```

Scilab code Exa 10.3 Hermann formula

```
//Example 10.03
//Order estimation using Hermann's formula
clear;
clc;
Fp=1800;//Passband edge freq. in Hz
Fs=2000;//stopband edge freq. in Hz
ap=0.1;//peak passband ripple in dB
as=35;//min. stopband attenuation in dB
```

```
FT=12000;//Sampling freq. in Hz

//calculation of peak ripple values
dp=1-10^-(ap/20);
disp(dp,'dp = ');
ds=10^-(as/20);
disp(ds,'ds = ');

a1=0.005309;
a2=0.07114;
a3=-0.4761;
a4=0.00266;
a5=0.5941;
a6=0.4278;
D_infi=((a1*(log10(dp)^2) + a2*log10(dp) + a3)*log10
    (ds))-(a4*(log10(dp))^2 + a5*(log10(dp)) + a6);
disp(D_infi,'D_infi = ');
b1=11.01217;
b2=0.51244;
F=b1 + b2*((log10(dp))-(log10(ds)));
disp(F,'F = ');

//Order of the FIR filter
N=(D_infi- F*((Fs-Fp)/FT)^2)/((Fs-Fp)/FT);
disp(ceil(N),'Order of the filter is N = ')
```

Scilab code Exa 10.4 Order Estimation

```
//Example 10.04
//Kaiser's formula for bandpass filter
clear;
clc;
Fp1=300;//Passband edge freq. in Hz
Fs1=350;//stopband edge freq. in Hz
Fp2=1000;//Passband edge freq. in Hz
```

```
Fs2=1100;//stopband edge freq. in Hz

dp=0.004;//passband ripple in dB
ds=0.01;//stopband ripple in dB
FT=10000;//Sampling freq. in Hz

//Since (Fp1-Fs1)<(Fs2-Fp2),bandwith used is (Fp1-
   Fs1)

//Order of the FIR filter
N=(-(20*log10(sqrt(ds*dp)) - 13)/((14.6)*(Fs1-Fp1)/
   FT);
disp(ceil(N),'Order of the filter is N = ')
```

Scilab code Exa 10.6 Filter length estimation for window based design

```
//EXAMPLE 10.6
//FIlter length  for window -based design
clear;
clc;
wp=0.3*%pi;//rad/sec
ws=0.5*%pi;//rad/sec
as=40;//dB

wc=(wp+ws)/2;//cutoff frequency
Bw=ws-wp;
disp(Bw,'Normalized transition bandwidth is = ')
//Hann window
M1=3.11*%pi/Bw;
disp(M1,'Value of M = ')
//Hamming window
M2=3.32*%pi/Bw;
disp(M2,'Value of M = ')
//Blackman window
M3=5.56*%pi/Bw;
```

```
disp(M3,'Value of M = ')
```

Scilab code Exa 10.7 Order Estimation

```
//EXAMPLE 10.6
//Order estimation using Dolph-Cebyshev window
clear;
clc;
wp=0.3*%pi;//rad/sec
ws=0.5*%pi;//rad/sec
as=40;//dB

wc=(wp+ws)/2;//cutoff frequency
Bw=ws-wp;
disp(Bw,'Normalized transition bandwidth is = ')

//Order of the filter
N = ((2.056*as) - 16.4)/(2.285*Bw);
disp(ceil(N),'Order of the filter ,N =  ')
```

Scilab code Exa 10.8 Kaiser window

```
//EXAMPLE 10.8
//Design of LP FIR filter using Kaiser window
clear;
clc;
wp=0.3*%pi;//rad/sec
ws=0.5*%pi;//rad/sec
as=40;//dB
wc=(wp+ws)/2;//cutoff frequency
Bw=ws-wp;
disp(Bw,'Normalized transition bandwidth is = ')

```

```
ds=10^(-as/20);
B = (0.5842*(as-21)^0.4) + 0.07886*(as-21);

N = ceil((as - 8)/(2.285*Bw));
disp(N,'Order of the filter ,N =  ');
M=(N-1)*0.5;
disp(M,'M = ');
w=window('kr',N,6);//Kaiser window
i=-M:1:M;

    hn=(wc/%pi)*sinc(wc*i'/(%pi));
    h=hn*w;

clf();
n=0:0.001:1;
[H,fr]=frmag(w,1001);

plot2d(2*fr,log10(H./max(H)),style=color('blue'))
set(gca(),'grid',[1 1]*color('gray'))
a = gca () ;
xlabel ( 'w/%pi' ) ;
ylabel ('Magnitude in dB') ;
title ( 'Gain Response of Kaiser Window' );
```

Chapter 11

DSP Algorithm implementation

Scilab code Exa 11.3 Reconstruction of Transfer function from Impulse response coeeficients

```
//example 11.3
//Reconstruction of Transfer function from Impulse
   response coeff.
clear;
clc;
z=%z;
numz=2+6/z+3/(z^2);
denz=(1+1/z+2/z^2);
disp(numz/denz,'Hz = ');
d=coeff(numer(denz));
disp(d,'coefficients of the denominator are = ')
h1=ldiv(numer(numz),numer(denz),5);
disp(h1','The first five coeffcients are of H(z) = '
   );
for i=1:3
    for j=1:3
        if i>=j
            h(i,j)=h1(i-j+1)
        else
            h(i,j)=0;
```

```
            end
        end
end
disp(h,'h = ');
disp((h'*d')','coefficients of the numerator are = '
    );
```

Scilab code Exa 11.11 Cascaded lattice Filter structure

```
//Example 11.11
//Simulation of IIR cascaded lattice filter
    structure
clear;
clc;
z=%z;
P3z= 0 + 0.44/z + 0.362/(z^2) +0.02/(z^3);
D3z= 1 + 0.4/z + 0.18/(z^2) - 0.2/(z^3);
Hz=P3z/D3z;
p1=coeff(numer(P3z));
p=mtlb_fliplr(p1)
disp(mtlb_fliplr(p),'The coefficients ofnumerator
    are = ');
d1=coeff(numer(D3z-1));
d=mtlb_fliplr(d1)
disp(mtlb_fliplr(d),'The coefficients ofnumerator
    are = ');
d1_1dash=(d(1)-d(3)*d(2))/(1-d(3)*d(3));
disp(d1_1dash,"d1_1dash = ");
d2_1dash=(d(2)-d(3)*d(1))/(1-d(3)*d(3));
disp(d2_1dash,"d2_1dash  ");
d1_2dash=(d1_1dash)/(1+d2_1dash);
disp(d1_2dash,"d1_2dash = ");
a1=p(3);
disp(p(3),'a1 = ');
a2=p(2)-a1*d(1);
```

```
disp(p(2)-a1*d(1),'a2 = ');
a3=p(1)-a1*d(2)-a2*d1_1dash;
disp(p(1)-a1*d(2)-a2*d1_1dash,'a3 = ');
disp(0-a1*d(3)-a3*d1_2dash-a2*d2_1dash,'a4 = ');
```

Chapter 12

Analysis of Finite Wordlength Effects

Scilab code Exa 12.3 Signal to Quantisation Noise Ratio

```
//Example 12.3
//Signal−to−quantization Noise ratio
clear;
clc;
b=[7 9 11 13 15];//Given values of b
K=[4 6 8];//Given values of K
for i=1:5
    for j=1:3
        SNR(j,i)=6.02*b(i)+16.81-20*log10(K(j));
    end
end
disp(SNR,'SNR,A/D = ');
```

Chapter 13

Multirate DIgital Signal Processing Findamentals

Scilab code Exa 13.1 Up sampling operation

```
//Example 13.1
//Upsampling Operation
clear;
clc;
clf();
a=gca();
figure(0);
n=[0:0.1:4.9];
a.x_location="origin";
x=sin(%pi*n);
plot2d3(n,x,2);
xtitle('The sine wave','n','sin(x)');
plot(n,x,'r.');
//Up sampling
//Up sampling value - user input
figure(1);
L=input(" The up sampling value  ");

a.x_location="origin";
```

```
x1=sin(%pi*n/L);
plot2d3(n,x1,5);
plot(n,x1,'r.');
xtitle('The sine wave','n','sin(x/L)');
```

Scilab code Exa 13.2 Down sampling operation

```
//Example 13.2
//Downsampling Operation
clear;
clc;
clf();
a=gca();
figure(0);
n=[0:0.1:4.9];
a.x_location="origin";
x=sin(%pi*n);
plot2d3(n,x,2);
xtitle('The sine wave','n','sin(x)');
plot(n,x,'r.');
//Down sampling
//Down sampling - user input
figure(1);
M=input(" The down sampling factor  ");
a.x_location="origin";
x1=sin(%pi*n*M);
plot2d3(n,x1,1);
plot(n,x1,'r.');
xtitle('The sine wave','n','sin(x*M)');
```

Scilab code Exa 13.6 Decimator Computation complexity

```
//Example 13.6
```

```
//Decimator computational complexity
clear;
clc;
//no. of multiplications/sec =Rm
FT = input("Sampling Frequency");
N  = input("The order of the FIR Hz");
Rm1 = N*FT;
disp(Rm1,'Rm,FIR = ');
//M = factor of Down sampler
M = input("The Down Sampling factor ");
disp(Rm1/M,'Rm,FIR-DEC = ');
K  = input("The order of the IIR Hz");
Rm2 = (2*K + 1)*FT;
disp(Rm2,'Rm,IIR = ');
disp( (K*FT + ((K+1)*FT/M)),'Rm,IIR-DEC = ');
```

Chapter 14

Applications of Digital Signal Processing

Scilab code Exa 14.1 Effect of DFT length

```
//Example 14.1
//EFFECT OF DFT LENGTH ON SPECTRAL ANALYSIS
clear;
clc;
N=16;
n=0:N-1;
f1=0.22;
f2=0.34;

R = input("R point DFT(R E [16,128]) = ");          // Input f1 = 64
if R >= N
    x=0.5*(sin(2*%pi*f1*n')) + sin(sin(2*%pi*f2*n'));
    x=[x',zeros(1,R-length(n))];
    disp(x,'the sequence is :');
    for n=0:R-1
        for k=0:R-1
            W(n+1,k+1) = exp(-(%i*2*%pi*k/R)*n);
```

```
        end
    end
    X = W*x';
    disp(X,'DFT is , X = ')
else
    disp('invalid computation');
end
m=0:R-1;
clf();
figure(0)
a = gca();
plot2d3(m,abs(X),2) //  plotting DFT of sequence
plot(m,abs(X),'r.')
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 2.5;
xtitle('original sequence','n','x[n]');
```

Scilab code Exa 14.2 Effect of DFT length

```
//Example 14.2
//EFFECT OF DFT LENGTH ON SPECTRAL ANALYSIS
clear;
clc;
N=16;
n=0:N-1;
f1=input("Enter f1 value between 0.28 to 0.31 = "); //Input f1 = 64
f2=0.34;

R = 128//
//DFT of the sequence x[n]
    x=0.5*(sin(2*%pi*f1*n')) + sin((2*%pi*f2*n'));
    x=[x',zeros(1,R-length(n))];
```

```
    disp(x,'the sequence is :');
    for n=0:R-1
        for k=0:R-1
            W(n+1,k+1) = exp(-(%i*2*%pi*k/R)*n);
        end
    end
    X = W*x';
    disp(X,'DFT is , X = ')
//plotting DFT of sequence
m=0:R-1;
clf();
figure(0)
a = gca();
plot2d3(m,abs(X),2)
plot(m,abs(X),'r.')
a.x_location = 'origin';
a.y_location = 'origin';
poly1 = a . children (1) . children (1) ;
poly1.thickness = 2.5;
xtitle('original sequence','n','x[n]');
```