Scilab Textbook Companion for Digital Signal Processing by R. Babu[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 1

DISCRETE TIME SIGNALS AND LINEAR SYSTEMS

Scilab code Exa 1.1 Continuous Time Plot and Discrete Time Plot

```
1  //Example 1.1
2  //Sketch the continuous time signal x(t)=2*exp(-2t)
       and also its discrete time equivalent signal with
        a sampling period T = 0.2sec
3  clear;
4  clc ;
5  close ;
6  t=0:0.01:2;
7  x1=2*exp(-2*t);
8  subplot(1,2,1);
9  plot(t,x1);
10 xlabel('t');
11 ylabel('x(t)');
12 title('CONTINUOUS TIME PLOT');
13 n=0:0.2:2;
14 x2=2*exp(-2*n);
15 subplot(1,2,2);
```

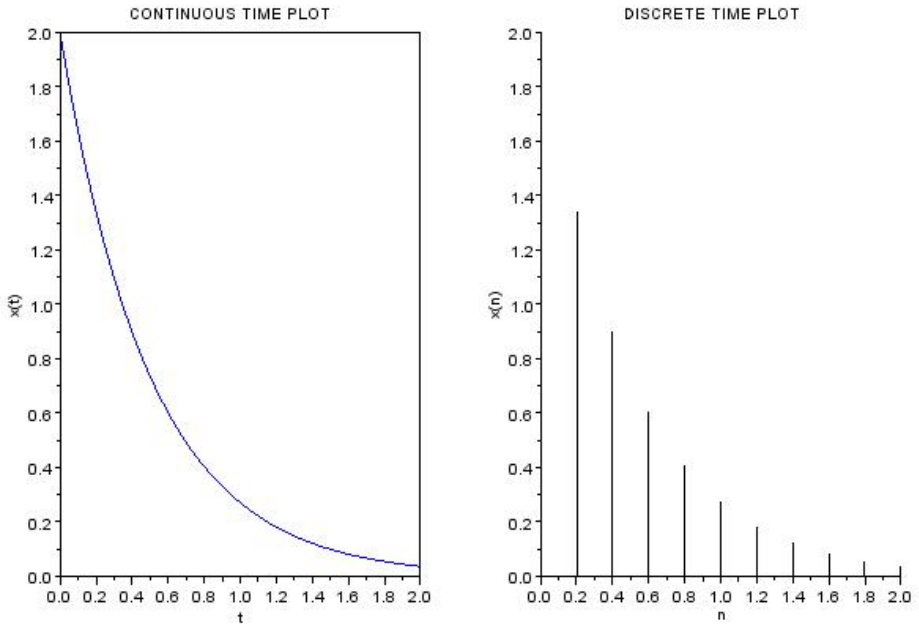

Figure 1.1: Continuous Time Plot and Discrete Time Plot

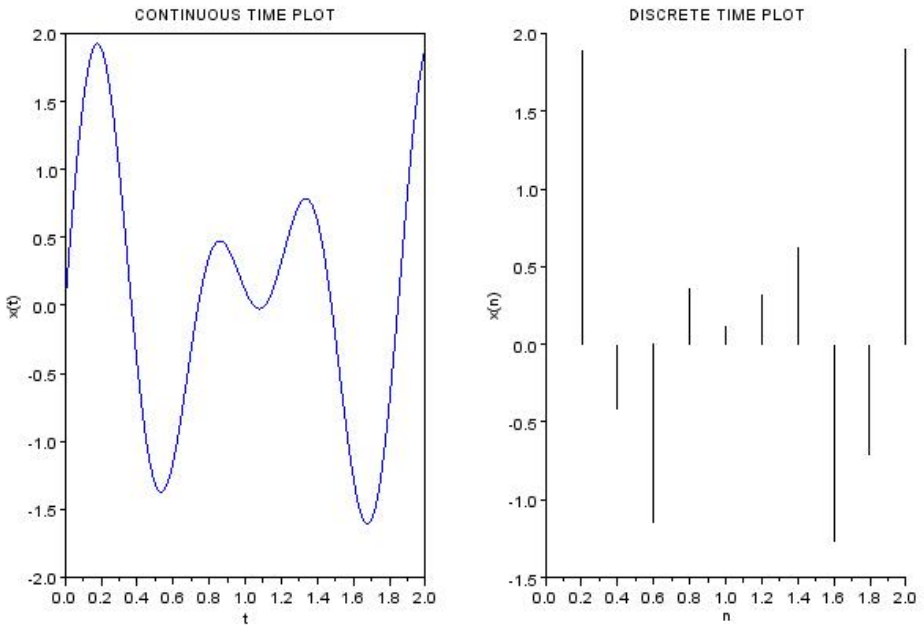

Figure 1.2: Continuous Time Plot and Discrete Time Plot

```
16 plot2d3(n,x2);
17 xlabel('n');
18 ylabel('x(n)');
19 title('DISCRETE TIME PLOT');
```

Scilab code Exa 1.2 Continuous Time Plot and Discrete Time Plot

```
1 //Example 1.2
2 //Sketch the continuous time signal x=sin(7*t)+sin
    (10*t) and also its discrete time equivalent
    signal with a sampling period T = 0.2sec
```

```
clear;
clc ;
close ;
t=0:0.01:2;
x1=sin(7*t)+sin(10*t);
subplot(1,2,1);
plot(t,x1);
xlabel('t');
ylabel('x(t)');
title('CONTINUOUS TIME PLOT');
n=0:0.2:2;
x2=sin(7*n)+sin(10*n);
subplot(1,2,2);
plot2d3(n,x2);
xlabel('n');
ylabel('x(n)');
title('DISCRETE TIME PLOT');
```

Scilab code Exa 1.3.a Evaluate the Summations

```
//Example 1.3 (a)
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//Calculate Following Summations
clear;
clc ;
close ;
syms n;
X= symsum (sin(2*n),n ,2, 2);
//Display the result in command window
disp (X,"The Value of summation comes out to be:");
```

Scilab code Exa 1.3.b Evaluate the Summations

```
1 //Example 1.3 (b)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Calculate Following Summations
4 clear;
5 clc ;
6 close ;
7 syms n;
8 X= symsum (%e^(2*n),n ,0, 0);
9 //Display the result in command window
10 disp (X,"The Value of summation comes out to be:");
```

Scilab code Exa 1.4.a Check for Energy or Power Signals

```
1 //Example 1.4 (a)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Find Energy and Power of Given Signals
4 clear;
5 clc ;
6 close ;
7 syms n N;
8 x=(1/3)^n;
9 E= symsum (x^2,n ,0, %inf);
10 //Display the result in command window
11 disp (E,"Energy:");
12 p=(1/(2*N+1))*symsum (x^2,n ,0, N);
13 P=limit(p,N,%inf);
14 disp (P,"Power:");
15 //The Energy is Finite and Power is 0. Therefore the
    given signal is an Energy Signal
```

Scilab code Exa 1.4.d Check for Energy or Power Signals

```
1 //Example 1.4 (d)
```

```
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Find Energy and Power of Given Signals
4 clear;
5 clc ;
6 close ;
7 syms n N;
8 x=%e^(2*n);
9 E= symsum (x^2,n ,0, %inf);
10 //Display the result in command window
11 disp (E,"Energy:");
12 p=(1/(2*N+1))*symsum (x^2,n ,0, N);
13 P=limit(p,N,%inf);
14 disp (P,"Power:");
15 //The Energy andPower is infinite. Therefore the
     given signal is an neither Energy Signal nor
     Power Signal
```

Scilab code Exa 1.5.a Determining Periodicity of Signal

```
1 //Example 1.5 (a)
2 //To Determine Whether Given Signal is Periodic or
     not
3 clear;
4 clc ;
5 close ;
6 t=0:0.01:2;
7 x1=exp(%i*6*%pi*t);
8 subplot(1,2,1);
9 plot(t,x1);
10 xlabel('t');
11 ylabel('x(t)');
12 title('CONTINUOUS TIME PLOT');
13 n=0:0.2:2;
```

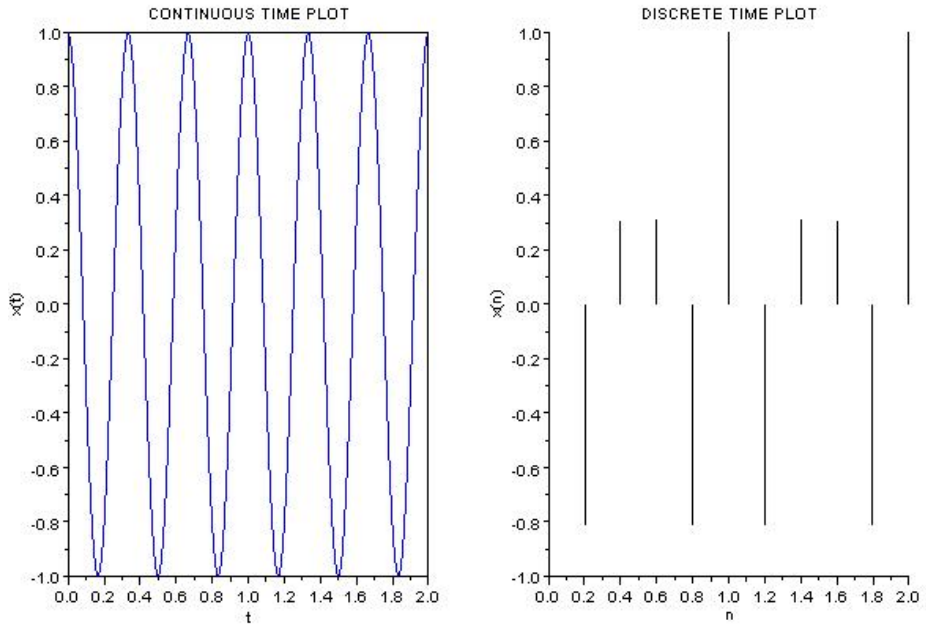

Figure 1.3: Determining Periodicity of Signal

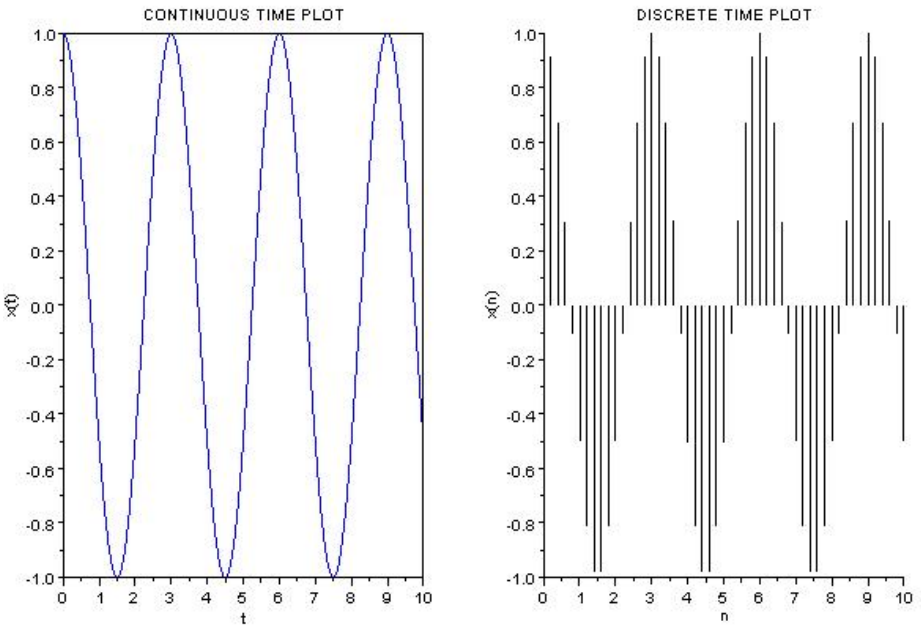

Figure 1.4: Determining Periodicity of Signal

```
14 x2=exp(%i*6*%pi*n);
15 subplot(1,2,2);
16 plot2d3(n,x2);
17 xlabel('n');
18 ylabel('x(n)');
19 title('DISCRETE TIME PLOT');
20 //Hence Given Signal is Periodic with N=1
```

Scilab code Exa 1.5.c Determining Periodicity of Signal

```
1 //Example 1.5 (c)
```

```
2 //To Determine Whether Given Signal is Periodic or
    not
3 clear;
4 clc ;
5 close ;
6 t=0:0.01:10;
7 x1=cos(2*%pi*t/3);
8 subplot(1,2,1);
9 plot(t,x1);
10 xlabel('t');
11 ylabel('x(t)');
12 title('CONTINUOUS TIME PLOT');
13 n=0:0.2:10;
14 x2=cos(2*%pi*n/3);
15 subplot(1,2,2);
16 plot2d3(n,x2);
17 xlabel('n');
18 ylabel('x(n)');
19 title('DISCRETE TIME PLOT');
20 //Hence Given Signal is Periodic with N=3
```

Scilab code Exa 1.5.d Determining Periodicity of Signal

```
1 //Example 1.5 (d)
2 //To Determine Whether Given Signal is Periodic or
    not
3 clear;
4 clc ;
5 close ;
6 t=0:0.01:50;
7 x1=cos(%pi*t/3)+cos(3*%pi*t/4);
8 subplot(1,2,1);
9 plot(t,x1);
```

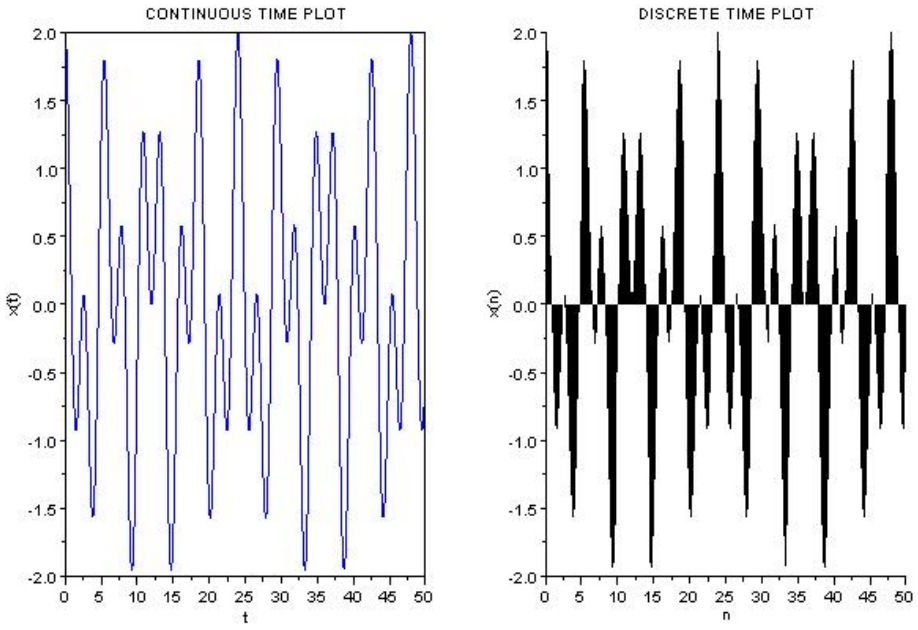

Figure 1.5: Determining Periodicity of Signal

```
10 xlabel('t');
11 ylabel('x(t)');
12 title('CONTINUOUS TIME PLOT');
13 n=0:0.2:50;
14 x2=cos(%pi*n/3)+cos(3*%pi*n/4);
15 subplot(1,2,2);
16 plot2d3(n,x2);
17 xlabel('n');
18 ylabel('x(n)');
19 title('DISCRETE TIME PLOT');
20 //Hence Given Signal is Periodic with N=24
```

Scilab code Exa 1.11 Stability of the System

```
1 //Example 1.11
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Testing Stability of Given System
4 clear;
5 clc ;
6 close ;
7 syms n;
8 x =(1/2)^n
9 X= symsum (x,n ,0, %inf );
10 //Display the result in command window
11 disp (X,"Summation is :");
12 disp('Hence Summation < infinity. Given System is
     Stable');
```

Scilab code Exa 1.12 Convolution Sum of Two Sequences

```
1 //Example 1.12
2 //Program to Compute convolution of given sequences
3 //x(n)=[3 2 1 2], h(n)=[1 2 1 2];
```

```
clear;
clc ;
close ;
x=[3 2 1 2];
h=[1 2 1 2];
y=convol(x,h);
disp(y);
```

Scilab code Exa 1.13 Convolution of Two Signals

```
//Example 1.13
//Program to Compute convolution of given sequences
//x(n)=[1 2 1 1], h(n)=[1 -1 1 -1];
clear;
clc ;
close ;
x=[1 2 1 1];
h=[1 -1 1 -1];
y=convol(x,h);
disp(round(y));
```

Scilab code Exa 1.18 Cross Correlation of Two Sequences

```
//Example 1.18
//Program to Compute Cross-correlation of given
   sequences
//x(n)=[1 2 1 1], h(n)=[1 1 2 1];
clear;
clc ;
close ;
x=[1 2 1 1];
h=[1 1 2 1];
h1=[1 2 1 1];
```

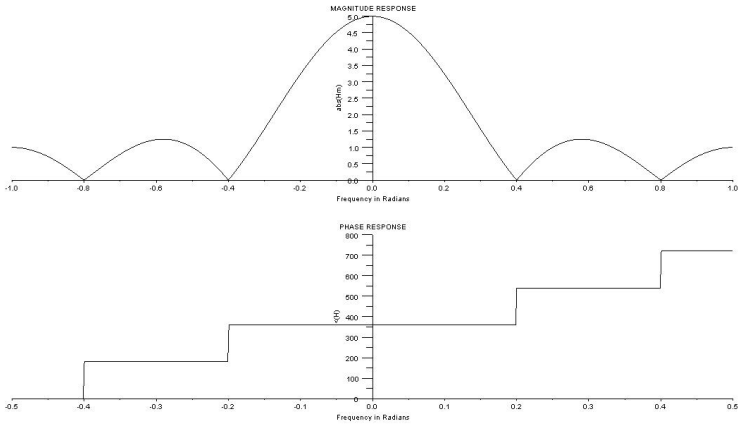

Figure 1.6: Plot Magnitude and Phase Response

```
10 y=convol(x,h1);
11 disp(round(y));
```

Scilab code Exa 1.19 Determination of Input Sequence

```
1  //Example 1.19
2  //To find input x(n)
3  //h(n)=[1 2 1], y(n)=[1 5 10 11 8 4 1]
4  clear;
5  clc ;
6  close ;
7  z=%z;
8  a=z^6+5*(z^(5))+10*(z^(4))+11*(z^(3))+8*(z^(2))+4*(z
       ^(1))+1;
9  b=z^6+2*z^(5)+1*z^(4);
10 x =ldiv(a,b,5);
11 disp (x,"x(n)=");
```

Scilab code Exa 1.32.a Plot Magnitude and Phase Response

```
1  //Example 1.32
2  //Program to Plot Magnitude and Phase Responce
3  clear;
4  clc ;
5  close ;
6  w=-%pi:0.01:%pi;
7  H=1+2*cos(w)+2*cos(2*w);
8  //caluculation of Phase and Magnitude of H
9  [phase_H,m]=phasemag(H);
10 Hm=abs(H);
11 a=gca();
12 subplot(2,1,1);
13 a.y_location="origin";
14 plot2d(w/%pi,Hm);
15 xlabel('Frequency in Radians')
16 ylabel('abs(Hm)');
17 title('MAGNITUDE RESPONSE');
18 subplot(2,1,2);
19 a=gca();
20 a.x_location="origin";
21 a.y_location="origin";
22 plot2d(w/(2*%pi),phase_H);
23 xlabel('Frequency in Radians');
24 ylabel('<(H)');
25 title('PHASE RESPONSE');
```

Scilab code Exa 1.37 Sketch Magnitude and Phase Response

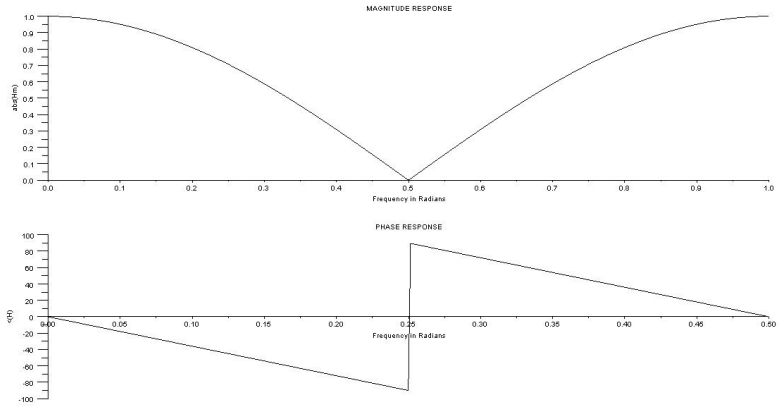

Figure 1.7: Sketch Magnitude and Phase Response

```
1  //Example 1.37
2  //Program to Plot Magnitude and Phase Responce
3  //y(n)=1/2[x(n)+x(n-2)]
4  clear;
5  clc ;
6  close ;
7  w=0:0.01:%pi;
8  H=(1+cos(2*w)-%i*sin(2*w))/2;
9  //caluculation of Phase and Magnitude of H
10 [phase_H,m]=phasemag(H);
11 Hm=abs(H);
12 a=gca();
13 subplot(2,1,1);
14 a.y_location="origin";
15 plot2d(w/%pi,Hm);
16 xlabel('Frequency in Radians')
17 ylabel('abs(Hm)');
18 title('MAGNITUDE RESPONSE');
19 subplot(2,1,2);
20 a=gca();
21 a.x_location="origin";
22 a.y_location="origin";
23 plot2d(w/(2*%pi),phase_H);
```

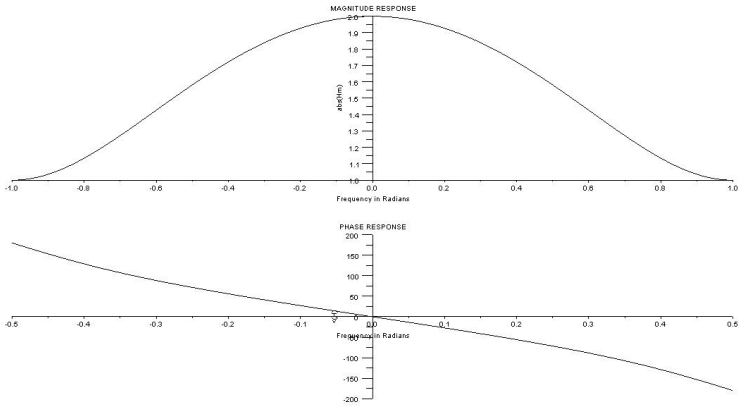

Figure 1.8: Plot Magnitude and Phase Response

```
24 xlabel('Frequency in Radians');
25 ylabel('<(H)');
26 title('PHASE RESPONSE');
```

Scilab code Exa 1.38 Plot Magnitude and Phase Response

```
1  //Example 1.38
2  //Program to Plot Magnitude and Phase Responce
3  //0.5delta(n)+delta(n-1)+0.5delta(n-2)
4  clear;
5  clc ;
6  close ;
7  w=-%pi:0.01:%pi;
8  H=0.5+exp(-%i*w)+0.5*exp(-%i*w);
9  //caluculation of Phase and Magnitude of H
10 [phase_H,m]=phasemag(H);
11 Hm=abs(H);
12 a=gca();
13 subplot(2,1,1);
```

```
a.y_location="origin";
plot2d(w/%pi,Hm);
xlabel('Frequency in Radians')
ylabel('abs(Hm)');
title('MAGNITUDE RESPONSE');
subplot(2,1,2);
a=gca();
a.x_location="origin";
a.y_location="origin";
plot2d(w/(2*%pi),phase_H);
xlabel('Frequency in Radians');
ylabel('<(H)');
title('PHASE RESPONSE');
```

Scilab code Exa 1.45 Filter to Eliminate High Frequency Component

```
//Example 1.45
//
clear;
clc ;
close ;
t=0:0.01:10;
x=2*cos(5*t)+cos(300*t);
x1=2*cos(5*t);
b=[0.05 0.05];
a=[1 -0.9];
y=filter(b,a,x);
subplot(2,1,1);
plot(t,x);
xlabel('Time in Sec');
ylabel('Amplitude');
subplot(2,1,2);
plot(t,y);
```

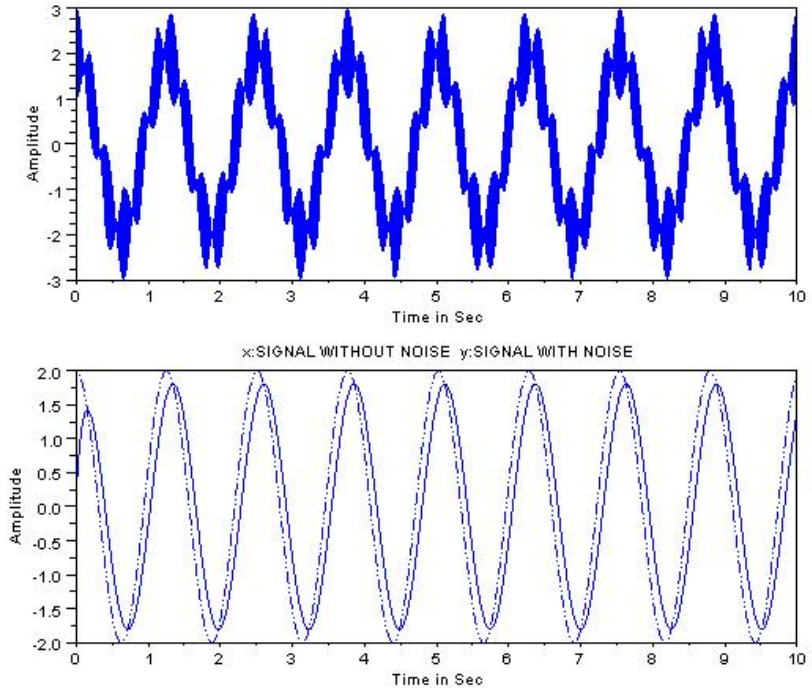

Figure 1.9: Filter to Eliminate High Frequency Component

```
18 subplot(2,1,2);
19 plot(t,x1,':');
20 title('x:SIGNAL WITHOUT NOISE  y:SIGNAL WITH NOISE')
      ;
21 xlabel('Time in Sec');
22 ylabel('Amplitude');
```

Scilab code Exa 1.57.a Discrete Convolution of Sequences

```
1 //Example 1.57 (a)
2 //Program to Compute discrete convolution of given
     sequences
3 //x(n)=[1 2 -1 1], h(n)=[1 0 1 1];
4 clear;
5 clc ;
6 close ;
7 x=[1 2 -1 1];
8 h=[1 0 1 1];
9 y=convol(x,h);
10 disp(round(y));
```

Scilab code Exa 1.61 Fourier Transform

```
1 //Example 1.61
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Fourier transform of (3)^n u(n)
4 clear;
5 clc ;
6 close ;
7 syms n;
8 x =(3) ^n;
9 X= symsum (x,n ,0, %inf )
10 //Display the result in command window
```

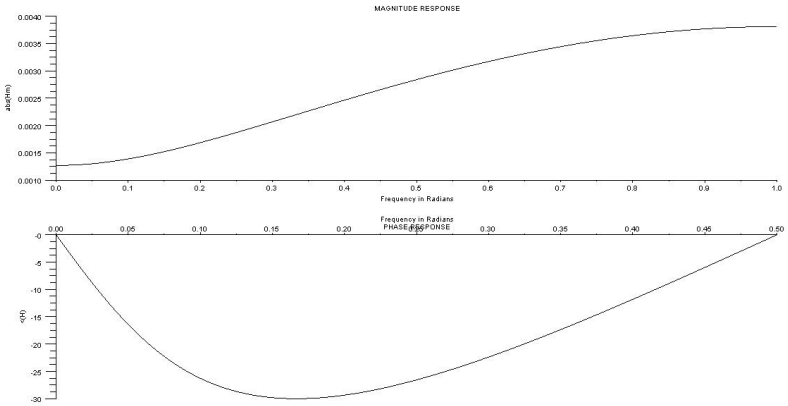

Figure 1.10: Frequency Response of LTI System

```
11 disp (X,"The Fourier Transform does not exit as x(n)
       is not absolutely summable and approaches
      infinity i.e.");
```

Scilab code Exa 1.62 Fourier Transform

```
1 //Example 1.62
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Fourier transform of (0.8)^|n| u(n)
4 clear;
5 clc ;
6 close ;
7 syms w n;
8 X= symsum ((0.8)^n*%e^(%i*w*n),n ,1, %inf )+symsum
     ((0.8)^n*%e^(-%i*w*n),n ,0, %inf )
9 //Display the result in command window
10 disp (X,"The Fourier Transform comes out to be:");
```

Scilab code Exa 1.64.a Frequency Response of LTI System

```
1 //Example 1.64 (a)
2 //Program to Calculate Plot Magnitude and Phase
     Responce
3 clear;
4 clc ;
5 close ;
6 w=0:0.01:%pi;
7 H=1/(1-0.5*%e^(-%i*w));
8 //caluculation of Phase and Magnitude of H
9 [phase_H,m]=phasemag(H);
10 Hm=abs(H);
11 a=gca();
12 subplot(2,1,1);
13 a.y_location="origin";
14 plot2d(w/%pi,Hm);
15 xlabel('Frequency in Radians')
16 ylabel('abs(Hm)');
17 title('MAGNITUDE RESPONSE');
18 subplot(2,1,2);
19 a=gca();
20 a.x_location="origin";
21 a.y_location="origin";
22 plot2d(w/(2*%pi),phase_H);
23 xlabel('Frequency in Radians');
24 ylabel('<(H)');
25 title('PHASE RESPONSE');
```

Scilab code Exa 1.64.c Frequency Response of LTI System

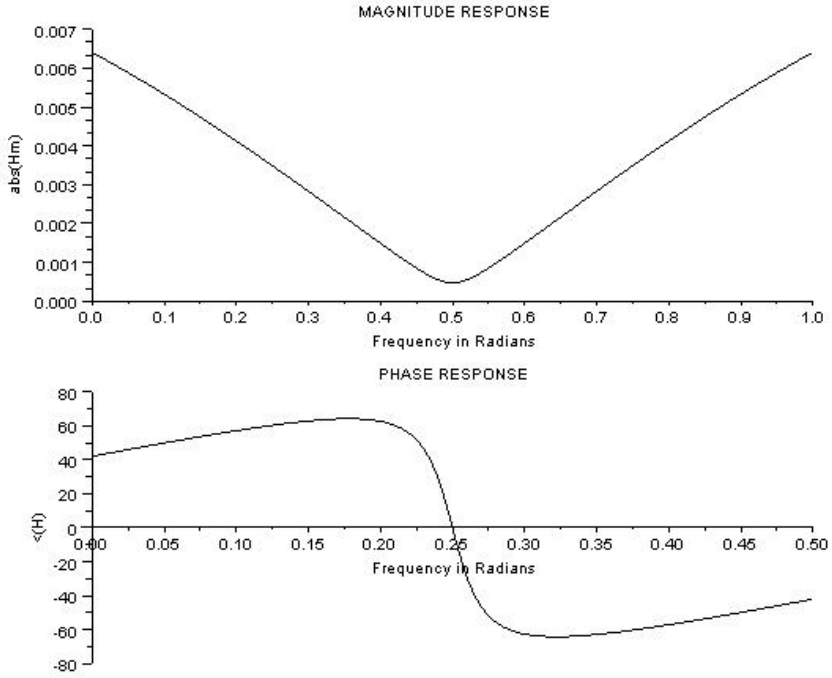

Figure 1.11: Frequency Response of LTI System

```
1  //Example 1.64 (c)
2  //Program to Calculate Plot Magnitude and Phase
       Responce
3  clear;
4  clc ;
5  close ;
6  w=0:0.01:%pi;
7  H=1/(1-0.9*%i*%e^(-%i*w));
8  //caluculation of Phase and Magnitude of H
9  [phase_H,m]=phasemag(H);
10 Hm=abs(H);
11 a=gca();
12 subplot(2,1,1);
13 a.y_location="origin";
14 plot2d(w/%pi,Hm);
15 xlabel('Frequency in Radians')
16 ylabel('abs(Hm)');
17 title('MAGNITUDE RESPONSE');
18 subplot(2,1,2);
19 a=gca();
20 a.x_location="origin";
21 a.y_location="origin";
22 plot2d(w/(2*%pi),phase_H);
23 xlabel('Frequency in Radians');
24 ylabel('<(H)');
25 title('PHASE RESPONSE');
```

Chapter 2

THE Z TRANSFORM

Scilab code Exa 2.1 z Transform and ROC of Causal Sequence

```
1  //Example 2.1
2  //Z- transform of [1 0 3 -1 2]
3  clear;
4  clc ;
5  close ;
6  function[za]=ztransfer(sequence,n)
7  z=poly(0,'z','r')
8  za=sequence*(1/z)^n'
9  endfunction
10 x1=[1 0 3 -1 2];
11 n=0:length(x1)-1;
12 zz=ztransfer(x1,n);
13 //Display the result in command window
14 disp (zz,"Z-transform of sequence is:");
15 disp('ROC is the entire plane except z = 0');
```

Scilab code Exa 2.2 z Transform and ROC of Anticausal Sequence

```
1  //Example 2.2
2  //Z- transform of [-3 -2 -1 0 1]
3  clear;
4  clc ;
5  close ;
6  function[za]=ztransfer(sequence,n)
7  z=poly(0,'z','r')
8  za=sequence*(1/z)^n'
9  endfunction
10 x1=[-3 -2 -1 0 1];
11 n=-(length(x1)-1):0;
12 zz=ztransfer(x1,n);
13 //Display the result in command window
14 disp (zz,"Z-transform of sequence is:");
15 disp('ROC is the entire plane except z = %inf');
```

Scilab code Exa 2.3 z Transform of the Sequence

```
1  //Example 2.3
2  //Z- transform of [2 -1 3 2 1 0 2 3 -1]
3  clear;
4  clc ;
5  close ;
6  function[za]=ztransfer(sequence,n)
7  z=poly(0,'z','r')
8  za=sequence*(1/z)^n'
9  endfunction
10 x1=[2 -1 3 2 1 0 2 3 -1];
11 n=-4:4;
12 zz=ztransfer(x1,n);
13 //Display the result in command window
14 disp (zz,"Z-transform of sequence is:");
15 disp('ROC is the entire plane except z = 0 and z =
     %inf');
```

Scilab code Exa 2.4 z Transform and ROC of the Signal

```
1 //Example 2.4
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z- transform of a^n u(n)
4 clear;
5 clc ;
6 close ;
7 syms a n z;
8 x =a^n
9 X= symsum (x*(z^(-n)),n ,0, %inf );
10 //Display the result in command window
11 disp (X,"Z-transform of a^n u(n) with is:");
12 disp('ROC is the Region mod(z) > a')
```

Scilab code Exa 2.5 z Transform and ROC of the Signal

```
1 //Example 2.5
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z- transform of -b^n u(-n-1)
4 clear;
5 clc ;
6 close ;
7 syms b n z;
8 x =b^n
9 X= symsum (x*(z^(-n)),n ,0, %inf );
10 //Display the result in command window
11 disp (X,"Z-transform of b^n u(n) with is:");
12 disp('ROC is the Region mod(z) < b')
```

Scilab code Exa 2.6 Stability of the System

```
1 //Example 2.6
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z- transform of 2^n u(n)
4 clear;
5 clc ;
6 close ;
7 syms n z;
8 x =(2) ^n
9 X= symsum (x*(z^(-n)),n ,0, %inf );
10 //Display the result in command window
11 disp (X,"Z-transform of 2^n u(n) is:");
12 disp('ROC is the Region mod(z) > 2');
```

Scilab code Exa 2.7 z Transform of the Signal

```
1 //Example 2.7
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z- transform of [3(3^n)-4(2)^n] u(n)
4 clear;
5 clc ;
6 close ;
7 syms n z;
8 x1 =(3) ^(n);
9 X1= symsum (3* x1 *(z^(-n)),n ,0, %inf );
10 x2 =(4) ^(n);
11 X2= symsum (4* x2 *(z^(-n)),n ,0, %inf );
12 X = (X1 -X2);
13 //Display the result in command window
14 disp (X,"Z-transform of [3(3^n)-4(2)^n] u(n)  is:");
```

Scilab code Exa 2.8.a z Transform of the Signal

```
1 //Example 2.8 (a)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z transform of cos(Wo*n)
4 clc;
5 syms Wo n z;
6 x1=exp(sqrt(-1)*Wo*n);
7 X1=symsum(x1*(z^-n),n,0,%inf);
8 x2=exp(-sqrt(-1)*Wo*n);
9 X2=symsum(x2*(z^-n),n,0,%inf);
10 X=(X1+X2)/2;
11 disp(X,'X(z)=');
```

Scilab code Exa 2.9 z Transform of the Sequence

```
1 //Example 2.9
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z- transform of (1/3)^n u(n-1)
4 clear;
5 clc ;
6 close ;
7 syms n z;
8 x =(1/3)^n;
9 X= (1/z)*symsum (x*(z^(-n)),n ,0, %inf );
10 //Display the result in command window
11 disp (X,"Z-transform of (1/3)^n u(n-1) is:");
```

Scilab code Exa 2.10 z Transform Computation

```
1 //Example 2.10
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z transform of r^n.cos(Wo*n)
4 clc;
5 syms r Wo n z;
```

```
x1=(r^n)*exp(sqrt(-1)*Wo*n);
X1=symsum(x1*(z^-n),n,0,%inf);
x2=(r^n)*exp(-sqrt(-1)*Wo*n);
X2=symsum(x2*(z^-n),n,0,%inf);
X=(X1+X2)/2;
disp(X,'X(z)=');
```

Scilab code Exa 2.11 z Transform of the Sequence

```
//Example 2.11
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//Z- transform of n.a^n u(n)
clear;
clc ;
close ;
syms a n z;
x =(a) ^n;
X= symsum (x*(z^(-n)),n ,0, %inf )
Y = diff (X,z);
//Display the result in command window
disp (Y,"Z-transform of n.a^n u(n)  is:");
```

Scilab code Exa 2.13.a z Transform of Discrete Time Signals

```
//Example 2.13 (a)
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//Z- transform of (-1/5)^n u(n)+5(1/2)^(-n)u(-n-1)
clear;
clc ;
close ;
syms n z;
x1 =(-1/5)^n ;
X1= symsum (x1 *(z^(-n)),n ,0, %inf );
```

```
10 x2 =(1/2)^(-n);
11 X2= symsum (5* x2 *(z^(-n)),n ,0, %inf );
12 X = (X1 -X2);
13 //Display the result in command window
14 disp (X,"Z-transform of [3(3^n)-4(2)^n] u(n)  is:");
15 disp('ROC is the Region 1/5 < mod(z) < 2');
```

Scilab code Exa 2.13.b z Transform of Discrete Time Signals

```
1 //Example 2.13 (b)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z transform
4 clc;
5 syms n z k;
6 x1=1;
7 X1=symsum(x1*z^(-n),n,0,0);
8 x2=1;
9 X2=symsum(x2*z^(-n),n,1,1);
10 x3=1;
11 X3=symsum(x3*z^(-n),n,2,2);
12 X=0.5*X1+X2-1/3*X3;
13 disp(X,'X(z)=');
```

Scilab code Exa 2.13.c z Transform of Discrete Time Signals

```
1 //Example 2.13 (c)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z- transform of u(n-2)
4 clear;
5 clc ;
6 close ;
7 syms n z;
8 x =1;
```

```
X= (1/(z^2))*symsum (x*(z^(-n)),n ,0, %inf );
//Display the result in command window
disp (X,"Z-transform of u(n-2) is:");
```

Scilab code Exa 2.13.d z Transform of Discrete Time Signals

```
//Example 2.13 (d)
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//Z- transform of (n+0.5)((1/3)^n)u(n)
clear;
clc ;
close ;
syms n z;
x1 =(1/3)^n;
X11= symsum (x1*(z^(-n)),n ,0, %inf )
X1 = diff (X11,z);
x2 =(1/3) ^(n);
X2= symsum (0.5* x2 *(z^(-n)),n ,0, %inf );
X = (X1+X2);
//Display the result in command window
disp (X,"Z-transform of (n+0.5)((1/3)^n)u(n)  is:");
```

Scilab code Exa 2.16 Impulse Response of the System

```
//Example 2.16
//To find input h(n)
//a=[1 2 -4 1], b=[1]
clear;
clc ;
close ;
z=%z;
a=z^3+2*(z^(2))-4*(z)+1;
b=z^3;
```

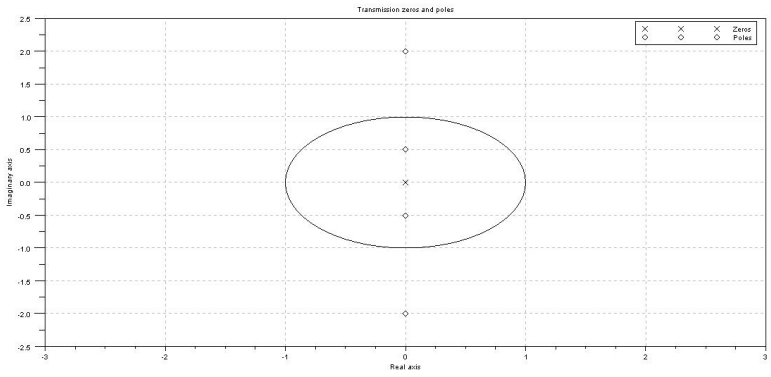

Figure 2.1: Pole Zero Plot of the Difference Equation

```
10 h =ldiv(a,b,4);
11 disp (h,"h(n)=");
```

Scilab code Exa 2.17 Pole Zero Plot of the Difference Equation

```
1 //Example 2.17
2 //To draw the pole-zero plot
3 clear;
4 clc ;
5 close ;
6 z=%z
7 H1Z=((z)*(z-1))/((z-0.25)*(z-0.5));
8 xset('window',1);
9 plzr(H1Z);
```

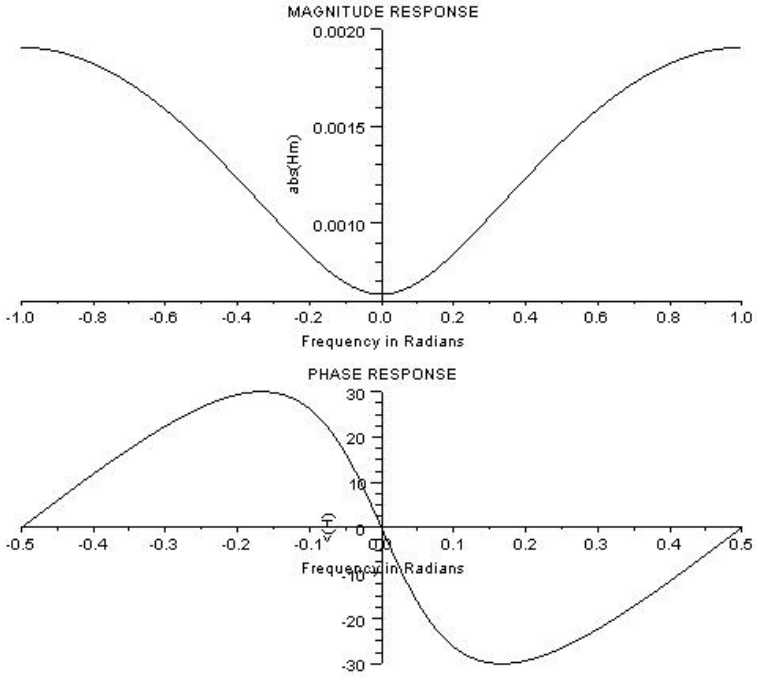

Figure 2.2: Frequency Response of the System

Scilab code Exa 2.19 Frequency Response of the System

```
1  //Example 2.19
2  //Program to Plot Magnitude and Phase Responce
3  clear;
4  clc ;
5  close ;
6  w=-%pi:0.01:%pi;
7  H=1/(1-0.5*(cos(w)-%i*sin(w)));
8  //caluculation of Phase and Magnitude of H
9  [phase_H,m]=phasemag(H);
10 Hm=abs(H);
11 a=gca();
12 subplot(2,1,1);
13 a.y_location="origin";
14 plot2d(w/%pi,Hm);
15 xlabel('Frequency in Radians');
16 ylabel('abs(Hm)');
17 title('MAGNITUDE RESPONSE');
18 subplot(2,1,2);
19 a=gca();
20 a.x_location="origin";
21 a.y_location="origin";
22 plot2d(w/(2*%pi),phase_H);
23 xlabel('Frequency in Radians');
24 ylabel('<(H)');
25 title('PHASE RESPONSE');
```

Scilab code Exa 2.20.a Inverse z Transform Computation

```
1  //Example 2.10 (a)
2  //To find input h(n)
3  //X(z)=(z+0.2)/((z+0.5)(z-1);
4  clear;
5  clc ;
```

```
close ;
z=%z;
a=(z+0.5)*(z-1);
b=z+0.2;
h =ldiv(b,a,4);
disp (h,"h(n)=");
```

Scilab code Exa 2.22 Inverse z Transform Computation

```
//Example 2.22
//To find input x(n)
//X(z)=1/(2*z^(-2)+2*z^(-1)+1);
clear;
clc ;
close ;
z=%z;
a=(2+2*z+z^2);
b=z^2;
h =ldiv(b,a,6);
disp (h,"First six values of h(n)=");
```

Scilab code Exa 2.23 Causal Sequence Determination

```
//Example 2.23
//To find input x(n)
//X(z)=1/(1-2z^(-1))(1-z^(-1))^2;
clear;
clc ;
close ;
z=%z;
a=(z-2)*(z-1)^2;
b=z^3;
h =ldiv(b,a,6);
```

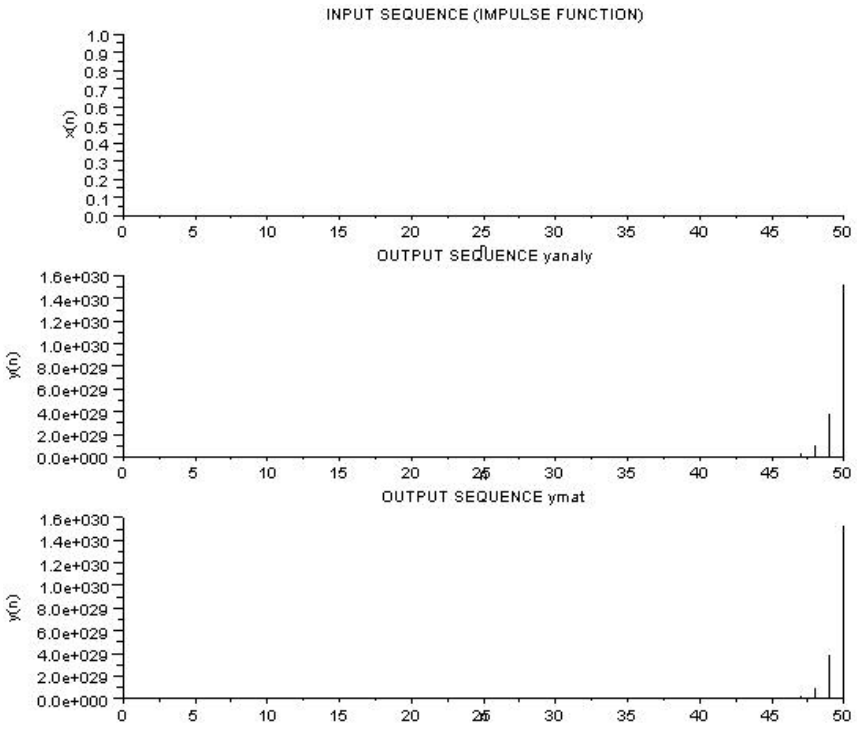

Figure 2.3: Impulse Response of the System

```
11 disp (h,"First six values of h(n)=");
```

Scilab code Exa 2.34 Impulse Response of the System

```
1 //Example 2.34
2 //To plot the impulse responce of the system
     analyically and using scilab
3 clear;
4 clc ;
5 close ;
6 n=0:1:50;
```

```
x=[1,zeros(1,50)];
b=[1 2];
a=[1 -3 -4];
yanaly=6/5*4.^n-1/5*(-1).^n;//Analytical Solution
ymat=filter(b,a,x);
subplot(3,1,1);
plot2d3(n,x);
xlabel('n');
ylabel('x(n)');
title('INPUT SEQUENCE (IMPULSE FUNCTION)');
subplot(3,1,2);
plot2d3(n,yanaly);
xlabel('n');
ylabel('y(n)');
title('OUTPUT SEQUENCE yanaly');
subplot(3,1,3);
plot2d3(n,ymat);
xlabel('n');
ylabel('y(n)');
title('OUTPUT SEQUENCE ymat');
//As the Analtical Plot matches the Scilab Plot
   hence it is the Responce of the system
```

Scilab code Exa 2.35.a Pole Zero Plot of the System

```
//Example 2.35 (a)
//To draw the pole-zero plot
clear;
clc ;
close ;
z=%z
H1Z=(z)/(z^2-z-1);
xset('window',1);
```

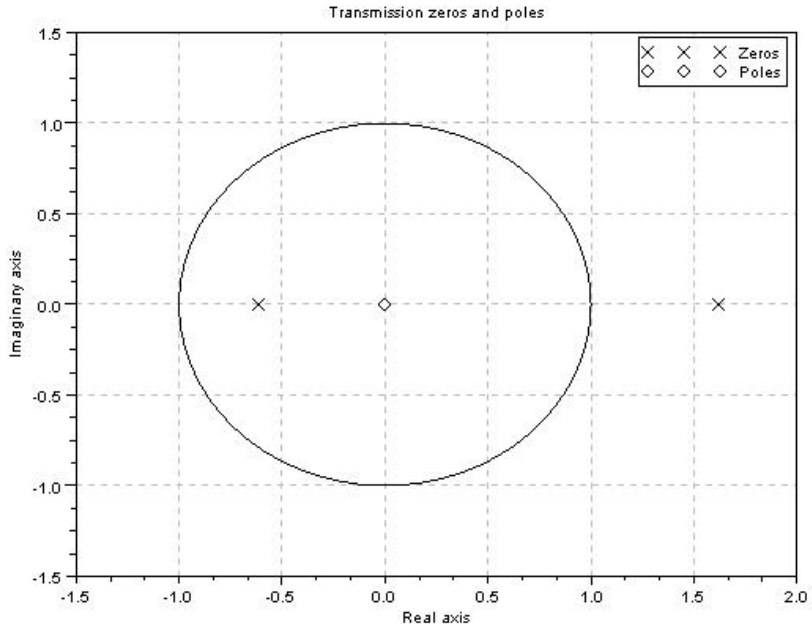

Figure 2.4: Pole Zero Plot of the System

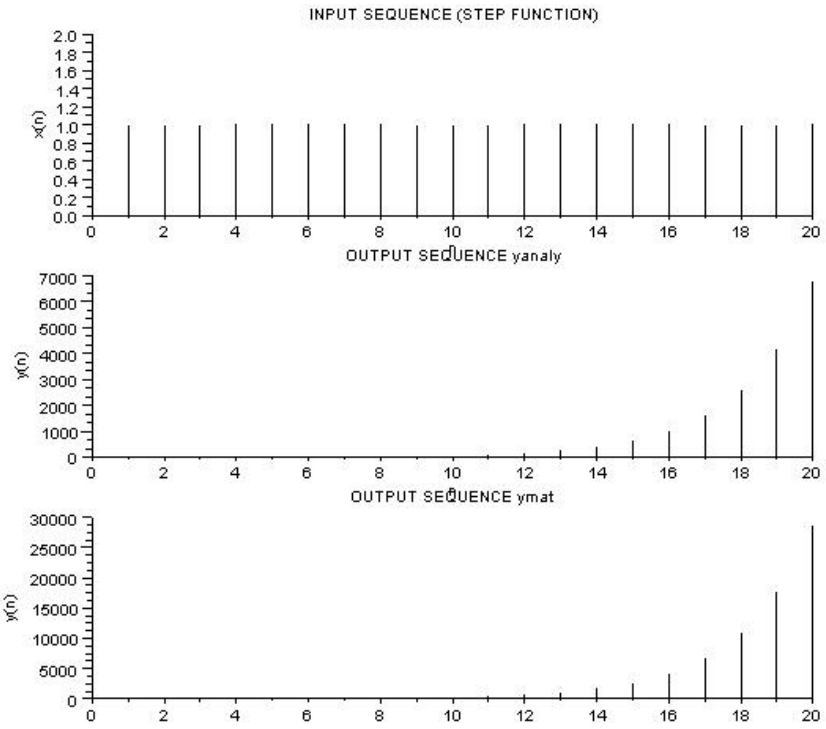

Figure 2.5: Unit Sample Response of the System

```
9 plzr(H1Z);
```

Scilab code Exa 2.35.b Unit Sample Response of the System

```
1 //Example 2.35 (b)
2 //To plot the responce of the system analyically and
      using scilab
3 clear;
4 clc ;
5 close ;
6 n=0:1:20;
```

```
x=ones(1,length(n));
b=[0 1];
a=[1 -1 -1];
yanaly=0.447*(1.618).^n-0.447*(-0.618).^n;//
   Analytical Solution
[ymat,zf]=filter(b, a, x);
subplot(3,1,1);
plot2d3(n,x);
xlabel('n');
ylabel('x(n)');
title('INPUT SEQUENCE (STEP FUNCTION)');
subplot(3,1,2);
plot2d3(n,yanaly);
xlabel('n');
ylabel('y(n)');
title('OUTPUT SEQUENCE yanaly');
subplot(3,1,3);
plot2d3(n,ymat,zf);
xlabel('n');
ylabel('y(n)');
title('OUTPUT SEQUENCE ymat');
//As the Analtical Plot matches the Scilab Plot
   hence it is the Responce of the system
```

Scilab code Exa 2.38 Determine Output Response

```
//Example 2.38
//To plot the responce of the system analyically and
    using scilab
clear;
clc ;
close ;
n=0:1:20;
```

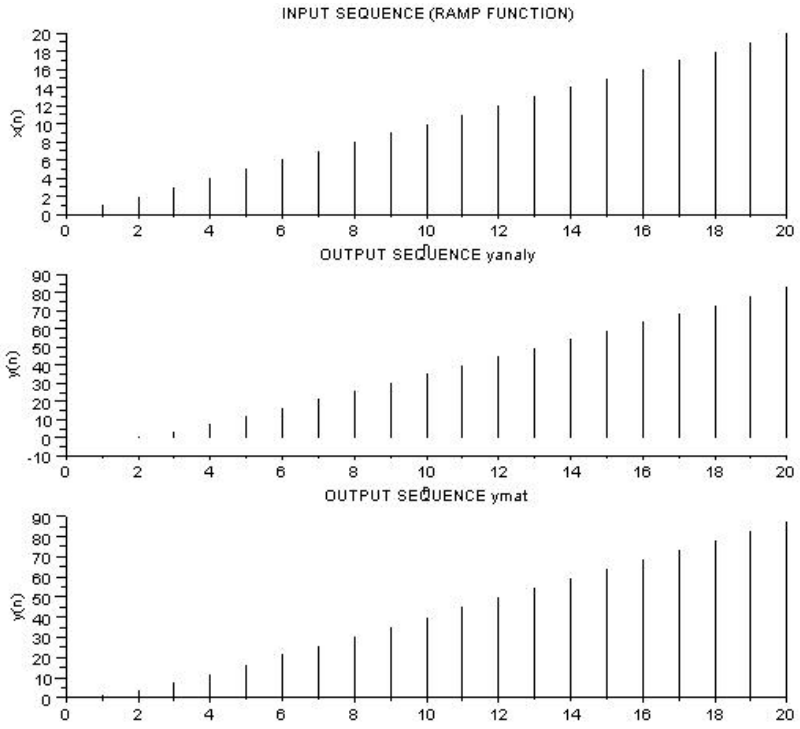

Figure 2.6: Determine Output Response

```
7  x=n;
8  b=[0 1 1];
9  a=[1 -0.7 0.12];
10 yanaly=38.89*(0.4).^n-26.53*(0.3).^n-12.36+4.76*n;//
       Analytical Solution
11 ymat=filter(b,a,x);
12 subplot(3,1,1);
13 plot2d3(n,x);
14 xlabel('n');
15 ylabel('x(n)');
16 title('INPUT SEQUENCE (RAMP FUNCTION)');
17 subplot(3,1,2);
18 plot2d3(n,yanaly);
19 xlabel('n');
20 ylabel('y(n)');
21 title('OUTPUT SEQUENCE yanaly');
22 subplot(3,1,3);
23 plot2d3(n,ymat);
24 xlabel('n');
25 ylabel('y(n)');
26 title('OUTPUT SEQUENCE ymat');
27 //As the Analtical Plot matches the Scilab Plot
       hence it is the Responce of the system
```

Scilab code Exa 2.40 Input Sequence Computation

```
1 //Example 2.40
2 //To find input x(n)
3 //h(n)=1 2 3 2, y(n)=[1 3 7 10 10 7 2]
4 clear;
5 clc ;
6 close ;
7 z=%z;
8 a=z^6+3*(z^(5))+7*(z^(4))+10*(z^(3))+10*(z^(2))+7*(z
      ^(1))+2;
```

```
b=z^6+2*z^(5)+3*z^(4)+2*z^(3);
x =ldiv(a,b,4);
disp (x,"x(n)=");
```

Scilab code Exa 2.41.a z Transform of the Signal

```
//Example 2.41 (a)
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//Z- transform of n.(-1)^n u(n)
clear;
clc ;
close ;
syms a n z;
x =(-1) ^n;
X= symsum (x*(z^(-n)),n ,0, %inf )
Y = diff (X,z);
//Display the result in command window
disp (Y,"Z-transform of n.(-1)^n u(n)  is:");
```

Scilab code Exa 2.41.b z Transform of the Signal

```
//Example 2.41 (b)
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//Z- transform of n^2 u(n)
clear;
clc ;
close ;
syms n z;
x =1;
X= symsum (x*(z^(-n)),n ,0, %inf )
Y = diff(diff (X,z),z);
//Display the result in command window
disp (Y,"Z-transform of n^2 u(n)  is:");
```

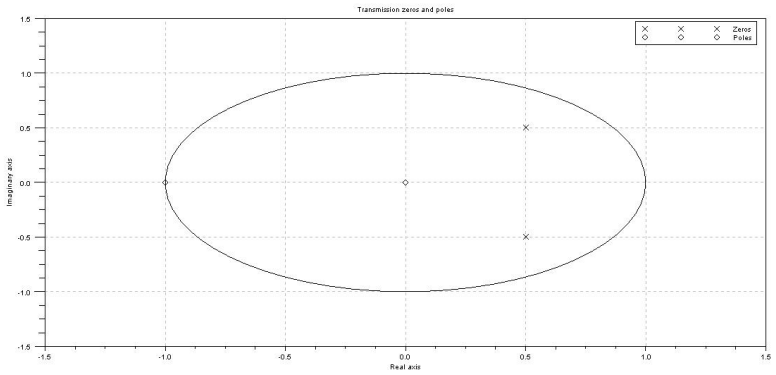

Figure 2.7: Pole Zero Pattern of the System

Scilab code Exa 2.41.c z Transform of the Signal

```
1  //Example 2.41 (c)
2  //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3  //Z transform of (-1)^n.cos(%pi/3*n)
4  clc;
5  syms n z;
6  Wo=%pi/3;
7  x1=exp(sqrt(-1)*Wo*n);
8  X1=(-1)^n*symsum(x1*(z^-n),n,0,%inf);
9  x2=exp(-sqrt(-1)*Wo*n);
10 X2=(-1)^n*symsum(x2*(z^-n),n,0,%inf);
11 X=(X1+X2)/2;
12 disp(X,'X(z)=');
```

Scilab code Exa 2.45 Pole Zero Pattern of the System

```
1 //Example 2.45
2 //To draw the pole-zero plot
3 clear;
4 clc ;
5 close ;
6 z=%z
7 H1Z=((z)*(z+1))/(z^2-z+0.5);
8 xset('window',1);
9 plzr(H1Z);
```

Scilab code Exa 2.53.a z Transform of the Sequence

```
1 //Example 2.53 (a)
2 //Z- transform of [3 1 2 5 7 0 1]
3 clear;
4 clc ;
5 close ;
6 function[za]=ztransfer(sequence,n)
7 z=poly(0,'z','r')
8 za=sequence*(1/z)^n'
9 endfunction
10 x1=[3 1 2 5 7 0 1];
11 n=-3:3;
12 zz=ztransfer(x1,n);
13 //Display the result in command window
14 disp (zz,"Z-transform of sequence is:");
```

Scilab code Exa 2.53.b z Transform of the Signal

```
1 //Example 2.53 (b)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
```

```
3 //Z transform of delta(n)
4 clc;
5 syms n z;
6 x=1;
7 X=symsum(x*z^(-n),n,0,0);
8 disp(X,'X(z)=');
```

Scilab code Exa 2.53.c z Transform of the Signal

```
1 //Example 2.53 (c)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z transform of delta(n)
4 clc;
5 syms n z k;
6 x=1;
7 X=symsum(x*z^(-n),n,k,k);
8 disp(X,'X(z)=');
```

Scilab code Exa 2.53.d z Transform of the Signal

```
1 //Example 2.53 (d)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Z transform of delta(n)
4 clc;
5 syms n z kc;
6 x=1;
7 X=symsum(x*z^(-n),n,-k,-k);
8 disp(X,'X(z)=');
```

Scilab code Exa 2.54 z Transform of Cosine Signal

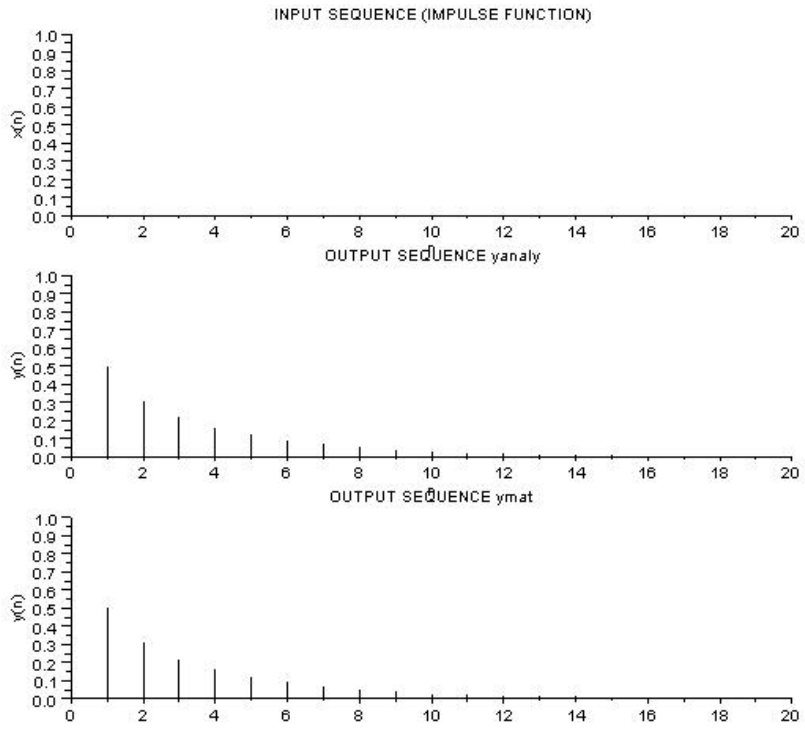

Figure 2.8: Impulse Response of the System

```
1  //Example 2.54
2  //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3  //Z transform of cos(Wo*n)
4  clc;
5  syms Wo n z;
6  x1=exp(sqrt(-1)*Wo*n);
7  X1=symsum(x1*(z^-n),n,0,%inf);
8  x2=exp(-sqrt(-1)*Wo*n);
9  X2=symsum(x2*(z^-n),n,0,%inf);
10 X=(X1+X2)/2;
11 disp(X,'X(z)=');
```

Scilab code Exa 2.58 Impulse Response of the System

```
1 //Example 2.58
2 //To plot the responce of the system analyically and
      using scilab
3 clear;
4 clc ;
5 close ;
6 n=0:1:20;
7 x=[1 zeros(1,20)];
8 b=[1 -0.5];
9 a=[1 -1 3/16];
10 yanaly=0.5*(0.75).^n+0.5*(0.25).^n;//Analytical
     Solution
11 ymat=filter(b,a,x);
12 subplot(3,1,1);
13 plot2d3(n,x);
14 xlabel('n');
15 ylabel('x(n)');
16 title('INPUT SEQUENCE (IMPULSE FUNCTION)');
17 subplot(3,1,2);
18 plot2d3(n,yanaly);
19 xlabel('n');
20 ylabel('y(n)');
21 title('OUTPUT SEQUENCE yanaly');
22 subplot(3,1,3);
23 plot2d3(n,ymat);
24 xlabel('n');
25 ylabel('y(n)');
26 title('OUTPUT SEQUENCE ymat');
27 //As the Analtical Plot matches the Scilab Plot
     hence it is the Responce of the system
```

Chapter 3

THE DISCRETE FOURIER TRANSFORM

Scilab code Exa 3.1 DFT and IDFT

```
1 //Example 3.1
2 //Program to Compute the DFT of a Sequence x[n
     ]=[1,1,0,0]
3 //and IDFT of a Sequence Y[k]=[1,0,1,0]
4 clear;
5 clc ;
6 close ;
7 x = [1,1,0,0];
8 //DFT Computation
9 X = fft (x , -1);
10 Y = [1,0,1,0];
11 //IDFT Computation
12 y = fft (Y , 1);
13 //Display sequence X[k] and y[n] in command window
14 disp(X,"X[k]=");
15 disp(y,"y[n]=");
```

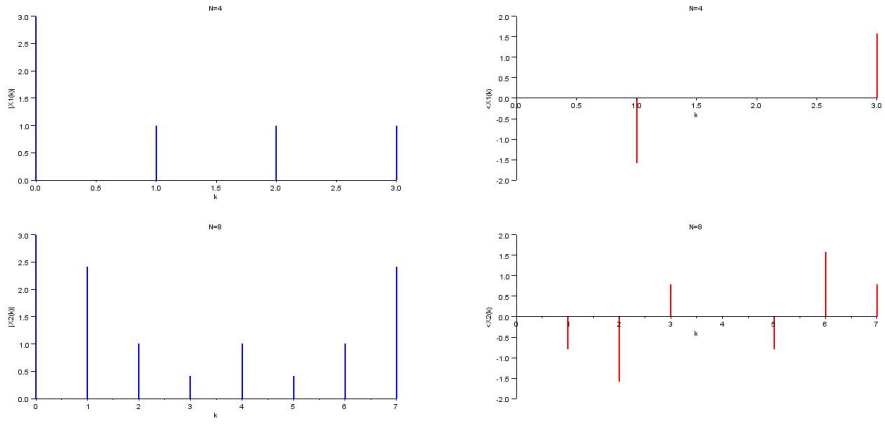

Figure 3.1: DFT of the Sequence

Scilab code Exa 3.2 DFT of the Sequence

```
1  //Example 3.2
2  //Program to Compute the DFT of a Sequence x[n]=1,
       0<=n<=2; and 0 otherwise
3  //for N=4 and N=8. Plot Magnitude and phase plots of
       each.
4  clear;
5  clc ;
6  close ;
7  //N=4
8  x1 = [1,1,1,0];
9  //DFT Computation
10 X1 = fft (x1 , -1);
11 //N=8
12 x2 = [1,1,1,0,0,0,0,0];
13 //DFT Computation
14 X2 = fft (x2 , -1);
15 //Display sequence X1[k] and X2[k] in command window
16 disp(X1,"X1[k]=");
```

```
17 disp(X2,"X2[k]=");
18 //Plots for N=4
19 n1=0:1:3;
20 subplot(2,2,1);
21 a = gca ();
22 a.y_location ="origin";
23 a.x_location ="origin";
24 plot2d3(n1,abs(X1),2);
25 poly1=a.children(1).children (1);
26 poly1.thickness=2;
27 xtitle('N=4','k','|X1(k)|');
28 subplot(2,2,2);
29 a = gca ();
30 a.y_location ="origin";
31 a.x_location ="origin";
32 plot2d3(n1,atan(imag(X1),real(X1)),5);
33 poly1=a.children(1).children (1);
34 poly1.thickness=2;
35 xtitle('N=4','k','<X1(k)');
36 //Plots for N=8
37 n2=0:1:7;
38 subplot(2,2,3);
39 a = gca ();
40 a.y_location ="origin";
41 a.x_location ="origin";
42 plot2d3(n2,abs(X2),2);
43 poly1=a.children(1).children (1);
44 poly1.thickness=2;
45 xtitle('N=8','k','|X2(k)|');
46 subplot(2,2,4);
47 a = gca ();
48 a.y_location ="origin";
49 a.x_location ="origin";
50 plot2d3(n2,atan(imag(X2),real(X2)),5);
51 poly1=a.children(1).children (1);
52 poly1.thickness=2;
53 xtitle('N=8','k','<X2(k)');
```

Scilab code Exa 3.3 8 Point DFT

```
1 //Example 3.3
2 //Program to Compute the 8-point DFT of the Sequence
      x[n]=[1,1,1,1,1,1,0,0]
3 clear;
4 clc ;
5 close ;
6 x = [1,1,1,1,1,1,0,0];
7 //DFT Computation
8 X = fft (x , -1);
9 //Display sequence X[k] in command window
10 disp(X,"X[k]=");
```

Scilab code Exa 3.4 IDFT of the given Sequence

```
1 //Example 3.4
2 //Program to Compute the IDFT of the Sequence X[k
     ]=[5,0,1-j,0,1,0,1+j,0]
3 clear;
4 clc ;
5 close ;
6 j=sqrt(-1);
7 X = [5,0,1-j,0,1,0,1+j,0]
8 //IDFT Computation
9 x = fft (X , 1);
10 //Display sequences x[n]in command window
11 disp(x,"x[n]=");
```

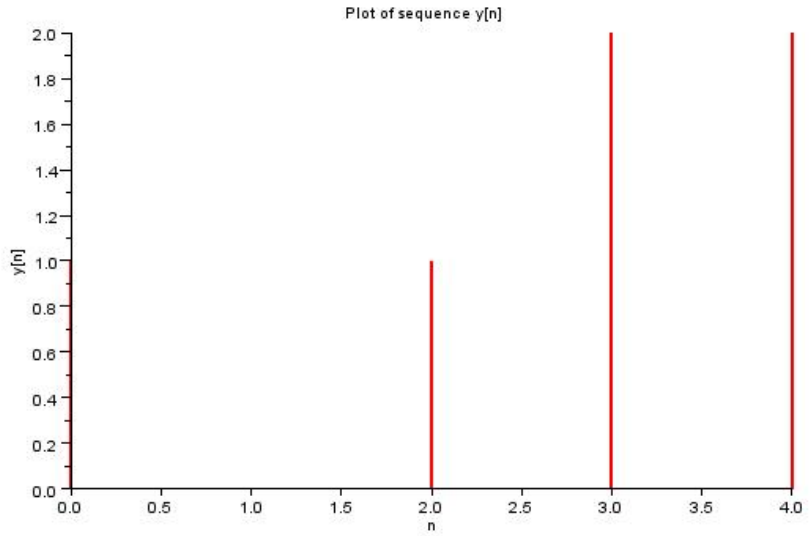

Figure 3.2: Plot the Sequence

Scilab code Exa 3.7 Plot the Sequence

```
1  //Example 3.7
2  //Program to Compute circular convolution of
       following sequences
3  //x[n]=[1,2,2,1,0]
4  //Y[k]=exp(-j*4*pi*k/5).X[k]
5  clear;
6  clc ;
7  close ;
8  x=[1,2,2,1,0];
9  X=fft(x,-1);
10 k=0:1:4;
11 j=sqrt(-1);
12 pi=22/7;
```

```
13 H=exp(-j*4*pi*k/5);
14 Y=H.*X;
15 //IDFT Computation
16 y=fft(Y,1);
17 //Display sequence y[n] in command window
18 disp(round(y),"y[n]=");
19 //Plots
20 n=0:1:4;
21 a = gca ();
22 a.y_location ="origin";
23 a.x_location ="origin";
24 plot2d3(n,round(y),5);
25 poly1=a.children(1).children (1);
26 poly1.thickness=2;
27 xtitle('Plot of sequence y[n]','n','y[n]');
```

Scilab code Exa 3.9 Remaining Samples

```
1 //Example 3.9
2 //Program to remaining samples of the sequence
3 //X(0)=12,X(1)=-1+j3 ,X(2)=3+j4 ,X(3)=1-j5 ,X(4)=-2+j2 ,
     X(5)=6+j3 ,X(6)=-2-j3 ,X(7)=10
4 clear;
5 clc ;
6 close ;
7 j=sqrt(-1);
8 z=1;
9 X(0+z)=12,X(1+z)=-1+j*3,X(2+z)=3+j*4,X(3+z)=1-j*5,X
     (4+z)=-2+j*2,X(5+z)=6+j*3,X(6+z)=-2-j*3,X(7+z)
     =10;
10 for a=9:1:14 do X(a)=conj(X(16-a)), end;
11 //Display the complete sequence X[k] in command
     window
12 disp(X,"X[k]=");
```

Scilab code Exa 3.11 DFT Computation

```
1 //Example 3.11
2 //Program to Compute the 8-point DFT of the
     following sequences
3 //x1[n]=[1,0,0,0,0,1,1,1]
4 //x2[n]=[0,0,1,1,1,1,0,0]
5 clear;
6 clc ;
7 close ;
8 x1=[1,0,0,0,0,1,1,1];
9 x2=[0,0,1,1,1,1,0,0];
10 //DFT Computation
11 X1 = fft (x1 , -1);
12 X2 = fft (x2 , -1);
13 //Display sequences X1[k] and X2[k] in command
     window
14 disp(X1,"X1[k]=");
15 disp(X2,"X2[k]=");
```

Scilab code Exa 3.13 Circular Convolution

```
1 //Example 3.13
2 //Program to Compute circular convolution of
     following sequences
3 //x1[n]=[1,-1,-2,3,-1]
4 //x2[n]=[1,2,3]
5 clear;
6 clc ;
7 close ;
8 x1=[1,-1,-2,3,-1];
9 x2=[1,2,3];
```

```
10 //Loop for zero padding the smaller sequence out of
     the two
11 n1=length(x1);
12 n2=length(x2);
13 n3=n2-n1;
14 if (n3>=0) then
15  x1=[x1,zeros(1,n3)];
16 else
17  x2=[x2,zeros(1,-n3)];
18 end
19 //DFT Computation
20 X1=fft(x1,-1);
21 X2=fft(x2,-1);
22 Y=X1.*X2;
23 //IDFT Computation
24 y=fft(Y,1);
25 //Display sequence y[n] in command window
26 disp(y,"y[n]=");
```

Scilab code Exa 3.14 Circular Convolution

```
1 //Example 3.14
2 //Program to Compute circular convolution of
     following sequences
3 //x1[n]=[1,2,2,1]
4 //x2[n]=[1,2,3,1]
5 clear;
6 clc ;
7 close ;
8 x1=[1,2,2,1];
9 x2=[1,2,3,1];
10 //DFT Computation
11 X1=fft(x1,-1);
12 X2=fft(x2,-1);
13 Y=X1.*X2;
```

```
14 //IDFT Computation
15 y=fft(Y,1);
16 //Display sequence y[n] in command window
17 disp(y,"y[n]=");
```

Scilab code Exa 3.15 Determine Sequence x3

```
1  //Example 3.15
2  //Program to Compute x3[n] where X3[k]=X1[k].X2[k]
3  //x1[n]=[1,2,3,4]
4  //x2[n]=[1,1,2,2]
5  clear;
6  clc ;
7  close ;
8  x1=[1,2,3,4];
9  x2=[1,1,2,2];
10 //DFT Computation
11 X1=fft(x1,-1);
12 X2=fft(x2,-1);
13 X3=X1.*X2;
14 //IDFT Computation
15 x3=fft(X3,1);
16 //Display sequence x3[n] in command window
17 disp(x3,"x3[n]=");
```

Scilab code Exa 3.16 Circular Convolution

```
1  //Example 3.16
2  //Program to Compute circular convolution of
      following sequences
3  //x1[n]=[1,1,2,1]
4  //x2[n]=[1,2,3,4]
5  clear;
```

```
clc ;
close ;
x1=[1,1,2,1];
x2=[1,2,3,4];
//DFT Computation
X1=fft(x1,-1);
X2=fft(x2,-1);
X3=X1.*X2;
//IDFT Computation
x3=fft(X3,1);
//Display sequence x3[n] in command window
disp(x3,"x3[n]=");
```

Scilab code Exa 3.17 Circular Convolution

```
//Example 3.17
//Program to Compute y[n] where Y[k]=X1[k].X2[k]
//x1[n]=[0,1,2,3,4]
//x2[n]=[0,1,0,0,0]
clear;
clc ;
close ;
x1=[0,1,2,3,4];
x2=[0,1,0,0,0];
//DFT Computation
X1=fft(x1,-1);
X2=fft(x2,-1);
Y=X1.*X2;
//IDFT Computation
y=round(fft(Y,1));
//Display sequence y[n] in command window
disp(y,"y[n]=");
```

Scilab code Exa 3.18 Output Response

```
1 //Example 3.18
2 //Program to Compute output responce of following
     sequences
3 //x[n]=[1,2,3,1]
4 //h[n]=[1,1,1]
5 //(1)Linear Convolution
6 //(2)Circular Convolution
7 //(3)Circular Convolution with zero padding
8 clear;
9 clc ;
10 close ;
11 x=[1,2,3,1];
12 h=[1,1,1];
13 //(1)Linear Convolution Computation
14 ylinear=convol (x,h);
15 //Display Linear Convoluted Sequence y[n] in command
     window
16 disp(ylinear,"ylinear[n]=");
17 //(2)Circular Convolution Computation
18 //Now zero padding in h[n] sequence to make length
     of x[n] and h[n] equal
19 h1=[h,zeros(1,1)];
20 //Now Performing Circular Convolution by DFT method
21 X=fft(x,-1);
22 H=fft(h1,-1);
23 Y=X.*H;
24 ycircular=fft(Y,1);
25 //Display Circular Convoluted Sequence y[n] in
     command window
26 disp(ycircular,"ycircular[n]=");
27 //(3)Circular Convolution Computation with zero
     Padding
28 x2=[x,zeros(1,2)];
29 h2=[h,zeros(1,3)];
30 //Now Performing Circular Convolution by DFT method
31 X2=fft(x2,-1);
```

```
32 H2=fft(h2,-1);
33 Y2=X2.*H2;
34 ycirculary=fft(Y2,1);
35 //Display Circular Convoluted Sequence with zero
      Padding y[n] in command window
36 disp(ycirculary,"ycirculary[n]=");
```

Scilab code Exa 3.20 Output Response

```
1 //Example 3.20
2 //Program to Compute Linear Convolution of following
      sequences
3 //x[n]=[3,-1,0,1,3,2,0,1,2,1]
4 //h[n]=[1,1,1]
5 clear;
6 clc ;
7 close ;
8 x=[3,-1,0,1,3,2,0,1,2,1];
9 h=[1,1,1];
10 // Linear Convolution Computation
11 y=convol (x,h);
12 //Display Sequence y[n] in command window
13 disp(y,"y[n]=");
```

Scilab code Exa 3.21 Linear Convolution

```
1 //Example 3.21
2 //Program to Compute Linear Convolution of following
      sequences
3 //x[n]=[1,2,-1,2,3,-2,-3,-1,1,1,2,-1]
4 //h[n]=[1,2]
5 clear;
6 clc ;
```

```
close ;
x=[1,2,-1,2,3,-2,-3,-1,1,1,2,-1];
h=[1,2];
// Linear Convolution Computation
y=convol (x,h);
//Display Sequence y[n] in command window
disp(y,"y[n]=");
```

Scilab code Exa 3.23.a N Point DFT Computation

```
//Example 3.23 (a)
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//N point DFT of delta(n)
clc;
syms n k N;
x=1;
X=symsum(x*exp(-%i*2*%pi*n*k/N),n,0,0);
disp(X,'X(k)=');
```

Scilab code Exa 3.23.b N Point DFT Computation

```
//Example 3.23 (b)
//MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
//N point DFT of delta(n-no)
clc;
syms n k N no;
x=1;
X=symsum(x*exp(-%i*2*%pi*n*k/N),n,-no,-no);
disp(X,'X(k)=');
```

Scilab code Exa 3.23.c N Point DFT Computation

```
1 //Example 3.23 (c)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //N point DFT of a^n
4 clc;
5 syms a n k N;
6 x=a^n;
7 X=symsum(x*exp(-%i*2*%pi*n*k/N),n,0,N-1);
8 disp(X,'X(k)=');
```

Scilab code Exa 3.23.d N Point DFT Computation

```
1 //Example 3.23 (d)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //N point DFT of x(n)=1, 0<=n<=N/2-1
4 clc;
5 syms n k N;
6 x=1;
7 X=symsum(x*exp(-%i*2*%pi*n*k/N),n,0,(N/2)-1);
8 disp(X,'X(k)=');
```

Scilab code Exa 3.23.e N Point DFT Computation

```
1 //Example 3.23 (e)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //N point DFT of x(n)=exp(%i*2*%pi*ko*n/N);
4 clc;
5 syms n k N ko;
6 x=exp(%i*2*%pi*ko*n/N);
7 X=symsum(x*exp(-%i*2*%pi*n*k/N),n,0,(N/2)-1);
8 disp(X,'X(k)=');
```

Scilab code Exa 3.23.f N Point DFT Computation

```
1 //Example 3.23 (f)
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //N point DFT of x(n)=1, for n=even and 0, for n=odd
4 clc;
5 syms n k N ;
6 x=1;//x(2n)=1,for all n
7 X=symsum(x*exp(-%i*4*%pi*n*k/N),n,0,N/2-1);
8 disp(X,'X(k)=');
```

Scilab code Exa 3.24 DFT of the Sequence

```
1 //Example 3.24
2 //Program to Compute the DFT of the Sequence x[n
     ]=(-1)^n, for N=4
3 clear;
4 clc ;
5 close ;
6 N=4;
7 n=0:1:N-1;
8 x=(-1)^n;
9 //DFT Computation
10 X = fft (x,-1);
11 //Display Sequence X[k] in command window
12 disp(X,"X[k]=");
```

Scilab code Exa 3.25 8 Point Circular Convolution

```
1  //Example 3.25
2  //Program to Compute the 8-point Circular
       Convolution of the Sequences
3  //x1[n]=[1,1,1,1,0,0,0,0]
4  //x2[n]=sin(3*pi*n/8)
5  clear;
6  clc ;
7  close ;
8  x1=[1,1,1,1,0,0,0,0];
9  n=0:1:7;
10 pi=22/7;
11 x2=sin(3*pi*n/8);
12 //DFT Computation
13 X1=fft (x1,-1);
14 X2=fft (x2,-1);
15 //Circular Convolution using DFT
16 Y=X1.*X2;
17 //IDFT Computation
18 y= fft (Y,1);
19 //Display sequence y[n] in command window
20 disp(y,"y[n]=");
```

Scilab code Exa 3.26 Linear Convolution using DFT

```
1  //Example 3.26
2  //Program to Compute the Linear Convolution of the
       following Sequences
3  //x[n]=[1,-1,1]
4  //h[n]=[2,2,1]
5  clear;
6  clc ;
7  close ;
8  x=[1,-1,1];
9  h=[2,2,1];
10 //Convolution Computation
```

```
11 y= convol(x,h);
12 //Display sequence y[n] in command window
13 disp(y,"y[n]=");
```

Scilab code Exa 3.27.a Circular Convolution Computation

```
1 //Example 3.27 (a)
2 //Program to Compute the Convolution of the
     following Sequences
3 //x1[n]=[1,1,1]
4 //x2[n]=[2,-1,2]
5 clear;
6 clc ;
7 close ;
8 x1=[1,1,1];
9 x2=[2,-1,2];
10 //Convolution Computation
11 X1=fft (x1,-1);
12 X2=fft (x2,-1);
13 Y=X1.*X2;
14 y=fft (Y,1);
15 //Display Sequence y[n] in command window
16 disp(y,"y[n]=");
```

Scilab code Exa 3.27.b Circular Convolution Computation

```
1 //Example 3.27 (b)
2 //Program to Compute the Convolution of the
     following Sequences
3 //x1[n]=[1,1,-1,-1,0]
4 //x2[n]=[1,0,-1,0,1]
5 clear;
6 clc ;
```

```
close ;
x1=[1,1,-1,-1,0];
x2=[1,0,-1,0,1];
//Convolution Computation
X1=fft (x1,-1);
X2=fft (x2,-1);
Y=X1.*X2;
y= fft (Y,1);
//Display Sequence y[n] in command window
disp(y,"y[n]=");
```

Scilab code Exa 3.30 Calculate value of N

```
//Example 3.30
//Program to Calculate N from given data
//fm=5000Hz
//df=50Hz
//t=0.5sec
clear;
clc ;
close ;
fm=5000 //Hz
df=50   //Hz
t=0.5   //sec
N1=2*fm/df;
N=2;
while N<=N1, N=N*2,end
//Displaying the value of N in command window
disp(N,"N=");
```

Scilab code Exa 3.32 Sketch Sequence

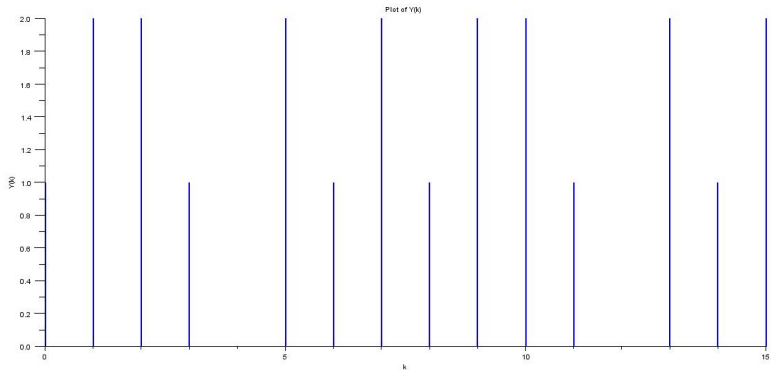

Figure 3.3: Sketch Sequence

```
1  //Example 3.32
2  //Program to plot the result of the given sequence
3  //X[k]=[1,2,2,1,0,2,1,2]
4  //y[n]=x[n/2] for n=even,0 for n=odd
5  clear;
6  clc ;
7  close ;
8  X=[1,2,2,1,0,2,1,2];
9  x = fft (X , 1);
10 y=[x(1),0,x(2),0,x(3),0,x(4),0,x(5),0,x(6),0,x(7),0,
       x(8),0];
11 Y = fft (y , -1);
12 //Display sequence Y[k] and in command window
13 disp(Y,"Y[k]=");
14 //Plotting the sequence Y[k]
15 k=0:1:15;
16 a = gca ();
17 a.y_location ="origin";
18 a.x_location ="origin";
19 plot2d3(k,Y,2);
20 poly1=a.children(1).children (1);
21 poly1.thickness=2;
22 xtitle('Plot of Y(k)','k','Y(k)');
```

Scilab code Exa 3.36 Determine IDFT

```
1 //Example 3.36
2 //Program to Compute the IDFT of the following
     Sequence
3 //X[k]=[12,-1.5+j2.598,-1.5+j0.866,0,-1.5-j0
     .866,-1.5-j2.598]
4 clear;
5 clc ;
6 close ;
7 j=sqrt(-1);
8 X=[12,-1.5+j*2.598,-1.5+j*0.866,0,-1.5-j*0.866,-1.5-
     j*2.598];
9 //IDFT Computation
10 x = fft (X , 1);
11 //Display Sequence x[n] in command window
12 disp(round(x),"x[n]=");
```

Chapter 4

THE FAST FOURIER TRANSFORM

Scilab code Exa 4.3 Shortest Sequence N Computation

```
1  //Example 4.3
2  //Program to calculate shortest sequence N such that
       algorithm B runs //faster than A
3  clear;
4  clc ;
5  close ;
6  i=0;
7  N=32; //Given
8  //Calculation of Twiddle factor exponents for each
       stage
9  while 1==1
10   i=i+1;
11   N=2^i;
12   A=N^2;
13   B=5*N*log2(N);
14   if A>B then break;
15     end;
16 end
17 disp(N,'SHORTEST SEQUENCE N =');
```

Scilab code Exa 4.4 Twiddle Factor Exponents Calculation

```
1 //Example 4.4
2 //Program to calculate Twiddle factor exponents for
     each stage
3 clear;
4 clc ;
5 close ;
6 N=32; //Given
7 //Calculation of Twiddle factor exponents for each
     stage
8 for m=1:5
9   disp(m,'Stage: m =');
10  disp(' k =');
11  for t=0:(2^(m-1)-1)
12    k=N*t/2^m;
13    disp(k);
14  end
15 end
```

Scilab code Exa 4.6 DFT using DIT Algorithm

```
1 //Example 4.6
2 //Program to find the DFT of a Sequence x[n
     ]=[1,2,3,4,4,3,2,1]
3 //using DIT Algorithm.
4 clear;
5 clc ;
6 close ;
7 x = [1,2,3,4,4,3,2,1];
8 //FFT Computation
```

```
9 X = fft (x , -1);
10 disp(X,'X(z) = ');
```

Scilab code Exa 4.8 DFT using DIF Algorithm

```
1 //Example 4.8
2 //Program to find the DFT of a Sequence x[n
    ]=[1,2,3,4,4,3,2,1]
3 //using DIF Algorithm.
4 clear;
5 clc ;
6 close ;
7 x = [1,2,3,4,4,3,2,1];
8 //FFT Computation
9 X = fft (x , -1);
10 disp(X,'X(z) = ');
```

Scilab code Exa 4.9 8 Point DFT of the Sequence

```
1 //Example 4.9
2 //Program to find the 8-point DFT of a Sequence x[n
    ]=1, 0<=n<=7
3 //using DIT,DIF Algorithm.
4 clear;
5 clc ;
6 close ;
7 x = [1,1,1,1,1,1,1,1];
8 //FFT Computation
9 X = fft (x , -1);
10 disp(X,'X(z) = ');
```

Scilab code Exa 4.10 4 Point DFT of the Sequence

```
1 //Example 4.10
2 //Program to Compute the 4-point DFT of a Sequence x
     [n]=[0,1,2,3]
3 //using DIT-DIF Algorithm.
4 clear;
5 clc ;
6 close ;
7 x = [0,1,2,3];
8 //FFT Computation
9 X = fft (x , -1);
10 disp(X,'X(z) = ');
```

Scilab code Exa 4.11 IDFT of the Sequence using DIT Algorithm

```
1 //Example 4.11
2 //Program to Compute the IDFT of a Sequence using
     DIT Algorithm.
3 //X[k] = [7,-0.707-j0.707,-j,0.707-j0.707,1,0.707+j0
     .707,j,-0.707+j0.707]
4 clear;
5 clc ;
6 close ;
7 j=sqrt(-1);
8 X = [7,-0.707-j*0.707,-j,0.707-j*0.707,1,0.707+j
     *0.707,j,-0.707+j*0.707];
9 //Inverse FFT Computation
10 x = fft (X , 1);
11 disp(x,'x(n) = ');
```

Scilab code Exa 4.12 8 Point DFT of the Sequence

```
1 //Example 4.12
2 //Program to Compute the 8-point DFT of a Sequence
3 //x[n]=[0.5,0.5,0.5,0.5,0,0,0,0] using radix-2 DIT
     Algorithm.
4 clear;
5 clc ;
6 close ;
7 x=[0.5,0.5,0.5,0.5,0,0,0,0];
8 //FFT Computation
9 X = fft (x , -1);
10 disp(X,'X(z) = ');
```

Scilab code Exa 4.13 8 Point DFT of the Sequence

```
1 //Example 4.13
2 //Program to Compute the 8-point DFT of a Sequence
3 //x[n]=[0.5,0.5,0.5,0.5,0,0,0,0] using radix-2 DIF
     Algorithm.
4 clear;
5 clc ;
6 close ;
7 x=[0.5,0.5,0.5,0.5,0,0,0,0];
8 //FFT Computation
9 X = fft (x , -1);
10 disp(X,'X(z) = ');
```

Scilab code Exa 4.14 DFT using DIT Algorithm

```
1 //Example 4.14
2 //Program to Compute the 4-point DFT of a Sequence x
     [n]=[1,-1,1,-1]
3 //using DIT Algorithm.
4 clear;
```

```
clc ;
close ;
x=[1,-1,1,-1];
//FFT Computation
X =fft (x , -1);
disp(X,'X(z) = ');
```

Scilab code Exa 4.15 DFT using DIF Algorithm

```
//Example 4.15
//Program to Compute the 4-point DFT of a Sequence x
   [n]=[1,0,0,1]
//using DIF Algorithm.
clear;
clc ;
close ;
x=[1,0,0,1];
//FFT Computation
X =fft (x , -1);
disp(X,'X(z) = ');
```

Scilab code Exa 4.16.a 8 Point DFT using DIT FFT

```
//Example 4.16 (a)
//Program to Evaluate and Compare the 8-point DFT of
    the given Sequence
//x1[n]=1, -3<=n<=3 using DIT-FFT Algorithm.
clear;
clc ;
close ;
x1=[1,1,1,1,0,1,1,1];
//FFT Computation
X1 = fft (x1 , -1);
```

```
10 disp(X1,'X1(k) = ');
```

Scilab code Exa 4.16.b 8 Point DFT using DIT FFT

```
1 //Example 4.16 (b)
2 //Program to Evaluate and Compare the 8-point DFT of
      the given Sequence
3 //x2[n]=1, 0<=n<=6 using DIT-FFT Algorithm.
4 clear;
5 clc ;
6 close ;
7 x2=[1,1,1,1,1,1,1,0];
8 //FFT Computation
9 X2 = fft (x2 , -1);
10 disp(X2,'X2(k) = ');
```

Scilab code Exa 4.17 IDFT using DIF Algorithm

```
1 //Example 4.17
2 //Program to find the IDFT of the Sequence using DIF
      Algorithm.
3 //X[k]= [4,1-j2.414,0,1-j0.414,0,1+j0.414,0,1+j2
     .414]
4 clear;
5 clc ;
6 close ;
7 j=sqrt(-1);
8 X= [4,1-j*2.414,0,1-j*0.414,0,1+j*0.414,0,1+j
     *2.414];
9 //Inverse FFT Computation
10 x = fft (X , 1);
11 disp(x,'x(n) = ');
```

Scilab code Exa 4.18 IDFT using DIT Algorithm

```
1 //Example 4.18
2 //Program to find the IDFT of the Sequence X[k]=
     [10,-2+j2,-2,-2-j2]
3 //using DIT Algorithm.
4 clear;
5 clc ;
6 close ;
7 j=sqrt(-1);
8 X = [10,-2+j*2,-2,-2-j*2];
9 //Inverse FFT Computation
10 x = fft (X , 1);
11 disp(x,'x(n) = ');
```

Scilab code Exa 4.19 FFT Computation of the Sequence

```
1 //Example 4.19
2 //Program to Compute the FFT of given Sequence x[n
     ]=[1,0,0,0,0,0,0,0].
3 clear;
4 clc ;
5 close ;
6 x = [1,0,0,0,0,0,0,0];
7 //FFT Computation
8 X = fft (x , -1);
9 disp(X,'X(z) = ');
```

Scilab code Exa 4.20 8 Point DFT by Radix 2 DIT FFT

```
1 //Example 4.20
2 //Program to Compute the 8-point DFT of given
     Sequence
3 //x[n]=[2,2,2,2,1,1,1,1] using DIT, radix-2,FFT
     Algorithm.
4 clear;
5 clc ;
6 close ;
7 x = [2,2,2,2,1,1,1,1];
8 //FFT Computation
9 X = fft (x , -1);
10 disp(X,'X(z) = ');
```

Scilab code Exa 4.21 DFT using DIT FFT Algorithm

```
1 //Example 4.21
2 //Program to Compute the DFT of given Sequence
3 //x[n]=[1,-1,-1,-1,1,1,1,-1] using DIT-FFT Algorithm
     .
4 clear;
5 clc ;
6 close ;
7 x = [1,-1,-1,-1,1,1,1,-1];
8 //FFT Computation
9 X = fft (x , -1);
10 disp(X,'X(z) = ');
```

Scilab code Exa 4.22 Compute X using DIT FFT

```
1 //Example 4.22
2 //Program to Compute the DFT of given Sequence
3 //x[n]=2^n and N=8 using DIT-FFT Algorithm.
4 clear;
```

```
clc ;
close ;
N=8;
n=0:1:N-1;
x =2^n;
//FFT Computation
X = fft (x , -1);
disp(X,'X(z) = ');
```

Scilab code Exa 4.23 DFT using DIF FFT Algorithm

```
//Example 4.23
//Program to Compute the DFT of given Sequence
//x[n]=cos(n*pi/2), and N=4 using DIF-FFT Algorithm.
clear;
clc ;
close ;
N=4;
pi=22/7;
n=0:1:N-1;
x =cos(n*pi/2);
//FFT Computation
X = fft (x , -1);
disp(X,'X(z) = ');
```

Scilab code Exa 4.24 8 Point DFT of the Sequence

```
//Example 4.24
//Program to Compute the 8-point DFT of given
   Sequence
//x[n]=[0,1,2,3,4,5,6,7] using DIF, radix-2,FFT
   Algorithm.
clear;
```

```
5  clc ;
6  close ;
7  x = [0,1,2,3,4,5,6,7];
8  //FFT Computation
9  X = fft (x , -1);
10 disp(X,'X(z) = ');
```

Chapter 5

INFINITE IMPULSE RESPONSE FILTERS

Scilab code Exa 5.1 Order of the Filter Determination

```
1 //Example 5.1
2 //To Find out the order of the filter
3 clear;
4 clc ;
5 close ;
6 ap=1;//db
7 as=30;//db
8 op=200;//rad/sec
9 os=600;//rad/sec
10 N=log(sqrt((10^(0.1*as)-1)/(10^(0.1*ap)-1)))/log(os/
   op);
11 disp(ceil(N),'Order of the filter , N =');
```

Scilab code Exa 5.2 Order of Low Pass Butterworth Filter

```
1 //Example 5.2
```

```
2 //To Find out the order of a Low Pass Butterworth
     Filter
3 clear;
4 clc ;
5 close ;
6 ap=3;//db
7 as=40;//db
8 fp=500;//Hz
9 fs=1000;//Hz
10 op=2*%pi*fp;
11 os=2*%pi*fs;
12 N=log(sqrt((10^(0.1*as)-1)/(10^(0.1*ap)-1)))/log(os/
     op);
13 disp(ceil(N),'Order of the filter , N =');
```

Scilab code Exa 5.4 Analog Butterworth Filter Design

```
1 //Example 5.4
2 //To Design an Analog Butterworth Filter
3 clear;
4 clc ;
5 close ;
6 ap=2;//db
7 as=10;//db
8 op=20;//rad/sec
9 os=30;//rad/sec
10 N=log(sqrt((10^(0.1*as)-1)/(10^(0.1*ap)-1)))/log(os/
     op);
11 disp(ceil(N),'Order of the filter , N =');
12 s=%s;
13 HS=1/((s^2+0.76537*s+1)*(s^2+1.8477*s+1));//Transfer
     Function for N=4
14 oc=op/(10^(0.1*ap)-1)^(1/(2*ceil(N)));
15 HS1=horner(HS,s/oc);
16 disp(HS1,'Normalized Transfer Function, H(s) =');
```

Scilab code Exa 5.5 Analog Butterworth Filter Design

```
1 //Example 5.5
2 //To Design an Analog Butterworth Filter
3 clear;
4 clc ;
5 close ;
6 op=0.2*%pi;
7 os=0.4*%pi;
8 e1=0.9;
9 l1=0.2;
10 epsilon=sqrt(1/(e1^2)-1);
11 lambda=sqrt(1/(l1^2)-1);
12 N=log(lambda/epsilon)/log(os/op);
13 disp(ceil(N),'Order of the filter , N =');
14 s=%s;
15 HS=1/((s^2+0.76537*s+1)*(s^2+1.8477*s+1));//Transfer
    Function for N=4
16 oc=op/epsilon^(1/ceil(N));
17 HS1=horner(HS,s/oc);
18 disp(HS1,'Normalized Transfer Function, H(s) =');
```

Scilab code Exa 5.6 Order of Chebyshev Filter

```
1 //Example 5.6
2 //To Find out the order of the Filter using
    Chebyshev Approximation
3 clear;
4 clc ;
5 close ;
6 ap=3;//db
```

```
7  as=16;//db
8  fp=1000;//Hz
9  fs=2000;//Hz
10 op=2*%pi*fp;
11 os=2*%pi*fs;
12 N=acosh(sqrt((10^(0.1*as)-1)/(10^(0.1*ap)-1)))/acosh
       (os/op);
13 disp(ceil(N),'Order of the filter, N =');
```

Scilab code Exa 5.7 Chebyshev Filter Design

```
1  //Example 5.7
2  //To Design an analog Chebyshev Filter with Given
       Specifications
3  clear;
4  clc ;
5  close ;
6  os=2;
7  op=1;
8  ap=3;//db
9  as=16;//db
10 e1=1/sqrt(2);
11 l1=0.1;
12 epsilon=sqrt(1/(e1^2)-1);
13 lambda=sqrt(1/(l1^2)-1);
14 N=acosh(lambda/epsilon)/acosh(os/op);
15 disp(ceil(N),'Order of the filter, N =');
```

Scilab code Exa 5.8 Order of Type 1 Low Pass Chebyshev Filter

```
1  //Example 5.8
2  //To Find out the order of the poles of the Type 1
       Lowpass Chebyshev Filter
```

```
3 clear;
4 clc ;
5 close ;
6 ap=1;//dB
7 as=40;//dB
8 op=1000*%pi;
9 os=2000*%pi;
10 N=acosh(sqrt((10^(0.1*as)-1)/(10^(0.1*ap)-1)))/acosh
    (os/op);
11 disp(ceil(N),'Order of the filter , N =');
```

Scilab code Exa 5.9 Chebyshev Filter Design

```
1 //Example 5.9
2 //To Design a Chebyshev Filter with Given
    Specifications
3 clear;
4 clc ;
5 close ;
6 ap=2.5;//db
7 as=30;//db
8 op=20;//rad/sec
9 os=50;//rad/sec
10 N=acosh(sqrt((10^(0.1*as)-1)/(10^(0.1*ap)-1)))/acosh
    (os/op);
11 disp(ceil(N),'Order of the filter , N =');
```

Scilab code Exa 5.10 HPF Filter Design with given Specifications

```
1 //Example 5.10
2 //To Design a H.P.F. with given specifications
3 clear;
4 clc ;
```

```
close ;
ap=3;//db
as=15;//db
op=500;//rad/sec
os=1000;//rad/sec
N=log(sqrt((10^(0.1*as)-1)/(10^(0.1*ap)-1)))/log(os/
   op);
disp(ceil(N),'Order of the filter, N =');
s=%s;
HS=1/((s+1)*(s^2+s+1));//Transfer Function for N=3
oc=1000//rad/sec
HS1=horner(HS,oc/s);
disp(HS1,'Normalized Transfer Function, H(s) =');
```

Scilab code Exa 5.11 Impulse Invariant Method Filter Design

```
//Example 5.11
//To Design the Filter using Impulse Invarient
   Method
clear;
clc ;
close ;
s=%s;
T=1;
HS=(2)/(s^2+3*s+2);
elts=pfss(HS);
disp(elts,'Factorized HS = ');
//The poles comes out to be at -2 and -1
p1=-2;
p2=-1;
z=%z;
HZ=(2/(1-%e^(p2*T)*z^(-1)))-(2/(1-%e^(p1*T)*z^(-1)))
disp(HZ,'HZ = ');
```

Scilab code Exa 5.12 Impulse Invariant Method Filter Design

```
1 //Example 5.12
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //To Design the Filter using Impulse Invarient
     Method
4 clear;
5 clc ;
6 close ;
7 s=%s;
8 HS=1/(s^2+sqrt(2)*s+1);
9 pp=ilaplace(HS);
10 syms n z;
11 t=1;
12 X= symsum (pp*(z^(-n)),n ,0, %inf );
13 disp(X,'Factorized HS = ');
```

Scilab code Exa 5.13 Impulse Invariant Method Filter Design

```
1 //Example 5.13
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //To Design the 3rd Order Butterworth Filter using
     Impulse Invarient Method
4 clear;
5 clc ;
6 close ;
7 s=%s;
8 HS=1/((s+1)*(s^2+s+1));
9 pp=ilaplace(HS);//Inverse Laplace
10 syms n z;
11 t=1;
12 X= symsum (pp*(z^(-n)),n ,0, %inf );//Z Transform
```

```
13 disp(X,'H(z)= ');
```

Scilab code Exa 5.15 Impulse Invariant Method Filter Design

```
1 //Example 5.15
2 //To Design the Filter using Impulse Invarient
     Method
3 clear;
4 clc ;
5 close ;
6 s=%s;
7 T=0.2;
8 HS=10/(s^2+7*s+10);
9 elts=pfss(HS);
10 disp(elts,'Factorized HS = ');
11 //The poles comes out to be at -5 and -2
12 p1=-5;
13 p2=-2;
14 z=%z;
15 HZ=T*((-3.33/(1-%e^(p1*T)*z^(-1)))+(3.33/(1-%e^(p2*T
     )*z^(-1))))
16 disp(HZ,'HZ = ');
```

Scilab code Exa 5.16 Bilinear Transformation Method Filter Design

```
1 //Example 5.16
2 //To Find out Bilinear Transformation of HS=2/((s+1)
     *(s+2))
3 clear;
4 clc ;
5 close ;
6 s=%s;
7 z=%z;
```

```
HS=2/((s+1)*(s+2));
T=1;
HZ=horner(HS,(2/T)*(z-1)/(z+1));
disp(HZ,'H(z) =');
```

Scilab code Exa 5.17 HPF Design using Bilinear Transform

```
//Example 5.17
//To Design an H.P.F. monotonic in passband using
   Bilinear Transform
clear;
clc ;
close ;
ap=3;//db
as=10;//db
fp=1000;//Hz
fs=350;//Hz
f=5000;
T=1/f;
wp=2*%pi*fp;
ws=2*%pi*fs;
op=2/T*tan(wp*T/2);
os=2/T*tan(ws*T/2);
N=log(sqrt((10^(0.1*as)-1)/(10^(0.1*ap)-1)))/log(op/
   os);
disp(ceil(N),'Order of the filter , N =');
s=%s;
HS=1/(s+1)//Transfer Function for N=1
oc=op//rad/sec
HS1=horner(HS,oc/s);
disp(HS1,'Normalized Transfer Function, H(s) =');
z=%z;
HZ=horner(HS,(2/T)*(z-1)/(z+1));
disp(HZ,'H(z) =');
```

Scilab code Exa 5.18 Bilinear Transformation Method Filter Design

```
1 //Example 5.18
2 //To Find out Bilinear Transformation of H(s)=(s
     ^2+4.525)/(s^2+0.692*s+0.504)
3 clear;
4 clc ;
5 close ;
6 s=%s;
7 z=%z;
8 HS=(s^2+4.525)/(s^2+0.692*s+0.504);
9 T=1;
10 HZ=horner(HS,(2/T)*(z-1)/(z+1));
11 disp(HZ,'H(z) =');
```

Scilab code Exa 5.19 Single Pole LPF into BPF Conversion

```
1 //Example 5.19
2 //To Convert a single Pole LPF into BPF
3 clear;
4 clc ;
5 close ;
6 s=%s;
7 z=%z;
8 HZ=(0.5*(1+z^(-1)))/(1-0.302*z^(-2));
9 T=1;
10 wu=3*%pi/4;
11 wl=%pi/4;
12 wp=%pi/6;
13 k=tan(wp/2)/tan((wu-wl)/2);
14 a=cos((wu+wl)/2)/cos((wu-wl)/2);
```

```
15 transf=-((((k-1)/(k+1))*(z^(-2)))-((2*a*k/(k+1))*(z
     ^(-1)))+1)/(z^(-2)-(2*a*k/(1+k)*z^(-1))+((k-1)/(k
     +1)));
16 HZ1=horner(HZ,transf);
17 disp(HZ1,'H(z) of B.P.F =');
```

Scilab code Exa 5.29 Pole Zero IIR Filter into Lattice Ladder Structure

```
1  //Example 5.29
2  //Program to convert given IIR pole-zero Filter into
       Lattice Ladder Structure.
3  clear;
4  clc ;
5  close ;
6  U=1;              //Zero Adjust
7  a(3+U,0+U)=1;
8  a(3+U,1+U)=13/24;
9  a(3+U,2+U)=5/8;
10 a(3+U,3+U)=1/3;
11 a(2+U,0+U)=1; //a(m,0)=1
12 a(2+U,3+U)=1/3;
13 m=3,k=1;
14 a(m-1+U,k+U)=(a(m+U,k+U)-a(m+U,m+U)*a(m+U,m-k+U))
     /(1-a(m+U,m+U)*a(m+U,m+U));
15 m=3,k=2;
16 a(m-1+U,k+U)=(a(m+U,k+U)-a(m+U,m+U)*a(m+U,m-k+U))
     /(1-a(m+U,m+U)*a(m+U,m+U));
17 m=2,k=1;
18 a(m-1+U,k+U)=(a(m+U,k+U)-a(m+U,m+U)*a(m+U,m-k+U))
     /(1-a(m+U,m+U)*a(m+U,m+U));
19 disp('LATTICE COEFFICIENTS');
20 disp(a(1+U,1+U),'k1');
21 disp(a(2+U,2+U),'k2');
22 disp(a(3+U,3+U),'k3');
23 b0=1;
```

```
24 b1=2;
25 b2=2;
26 b3=1;
27 c3=b3;
28 c2=b2-c3*a(3+U,1+U);
29 c1=b1-(c2*a(2+U,1+U)+c3*a(3+U,2+U));
30 c0=b0-(c1*a(1+U,1+U)+c2*a(2+U,2+U)+c3*a(3+U,3+U));
31 disp('LADDER COEFFICIENTS');
32 disp(c0,'c0 =');
33 disp(c1,'c1 =');
34 disp(c2,'c2 =');
35 disp(c3,'c3 =');
```

Chapter 6

FINITE IMPULSE RESPONSE FILTERS

Scilab code Exa 6.1 Group Delay and Phase Delay

```
1  //Example 6.1
2  //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3  //Program to Calculate Group Delay and Phase Delay
4  //y(n)=0.25x(n)+x(n-1)+0.25x(n-2)
5  clear;
6  clc ;
7  close ;
8  //w=poly(0,"w");
9  syms w;
10 theeta=-w;
11 gd= -diff (theeta,w); //Group Delay
12 pd=-theeta/w; //Phase Delay
13 disp(gd,'GROUP DELAY =');
14 disp(pd,'PHASE DELAY =');
```

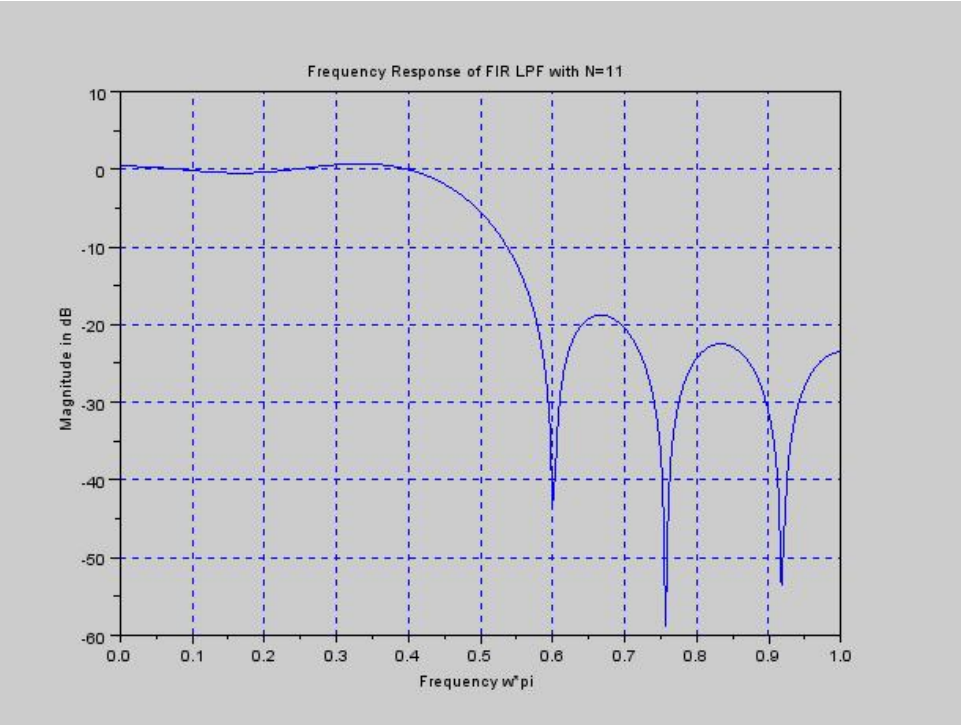

Figure 6.1: LPF Magnitude Response

Scilab code Exa 6.5 LPF Magnitude Response

```
1 //Example 6.5
2 //Program to Plot Magnitude Responce of ideal L.P.F.
      with wc=0.5*pi
3 //N=11
4 clear;
5 clc ;
6 close ;
7 N=11;
8 U=6;
9 for n=-5+U:1:5+U
10 if n==6
11 hd(n)=0.5;
12 else
13 hd(n)=(sin(%pi*(n-U)/2))/(%pi*(n-U));
14 end
15 end
16 [hzm ,fr ]= frmag (hd ,256) ;
17 hzm_dB = 20* log10 (hzm)./ max ( hzm );
18 figure;
19 plot (2*fr , hzm_dB );
20 a= gca ();
21 xlabel ('Frequency w*pi');
22 ylabel ('Magnitude in dB');
23 title ('Frequency Response of FIR LPF with N=11');
24 xgrid (2);
```

Scilab code Exa 6.6 HPF Magnitude Response

```
1 //Example 6.6
2 //Program to Plot Magnitude Responce of ideal H.P.F.
      with wc=0.25*pi
```

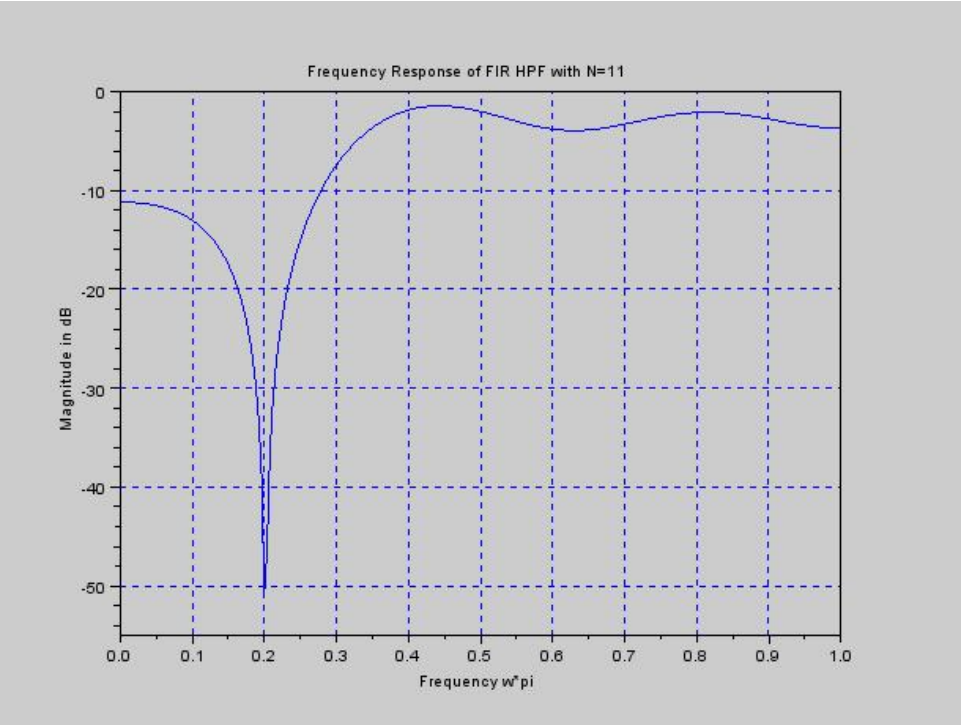

Figure 6.2: HPF Magnitude Response

```
3  //N=11
4  clear;
5  clc ;
6  close ;
7  N=11;
8  U=6;
9  for n=-5+U:1:5+U
10 if n==6
11 hd(n)=0.5;
12 else
13 hd(n)=(sin(%pi*(n-U))-sin(%pi*(n-U)/4))/(%pi*(n-U));
14 end
15 end
16 [hzm ,fr ]= frmag (hd ,256) ;
17 hzm_dB = 20* log10 (hzm)./ max ( hzm );
18 figure
19 plot (2*fr , hzm_dB )
20 a= gca ();
21 xlabel ('Frequency w*pi');
22 ylabel ('Magnitude in dB');
23 title ('Frequency Response of FIR HPF with N=11');
24 xgrid (2);
```

Scilab code Exa 6.7 BPF Magnitude Response

```
1  //Example 6.7
2  //Program to Plot Magnitude Responce of ideal B.P.F.
       with
3  //wc1=0.25*pi and wc2=0.75*pi
4  //N=11
5  clear;
6  clc ;
7  close ;
```

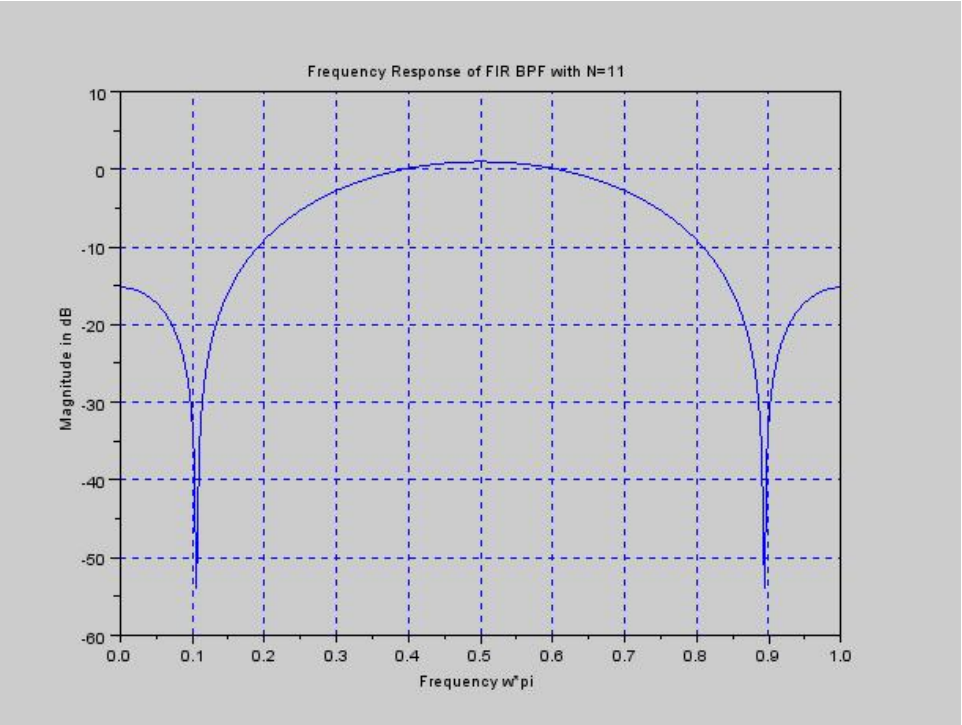

Figure 6.3: BPF Magnitude Response

```
N=11;
U=6;
for n=-5+U:1:5+U
if n==6
hd(n)=0.5;
else
hd(n)=(sin(%pi*3*(n-U)/4)-sin(%pi*(n-U)/4))/(%pi*(n-U));
end
end
[hzm ,fr ]= frmag (hd ,256) ;
hzm_dB = 20* log10 (hzm)./ max ( hzm );
figure
plot (2*fr , hzm_dB )
a= gca ();
xlabel ('Frequency w*pi');
ylabel ('Magnitude in dB');
title ('Frequency Response of FIR BPF with N=11');
xgrid (2);
```

Scilab code Exa 6.8 BRF Magnitude Response

```
//Example 6.8
//Program to Plot Magnitude Responce of ideal B.R.F. with
//wc1=0.33*pi and wc2=0.67*pi
//N=11
clear;
clc ;
close ;
N=11;
U=6;
for n=-5+U:1:5+U
```

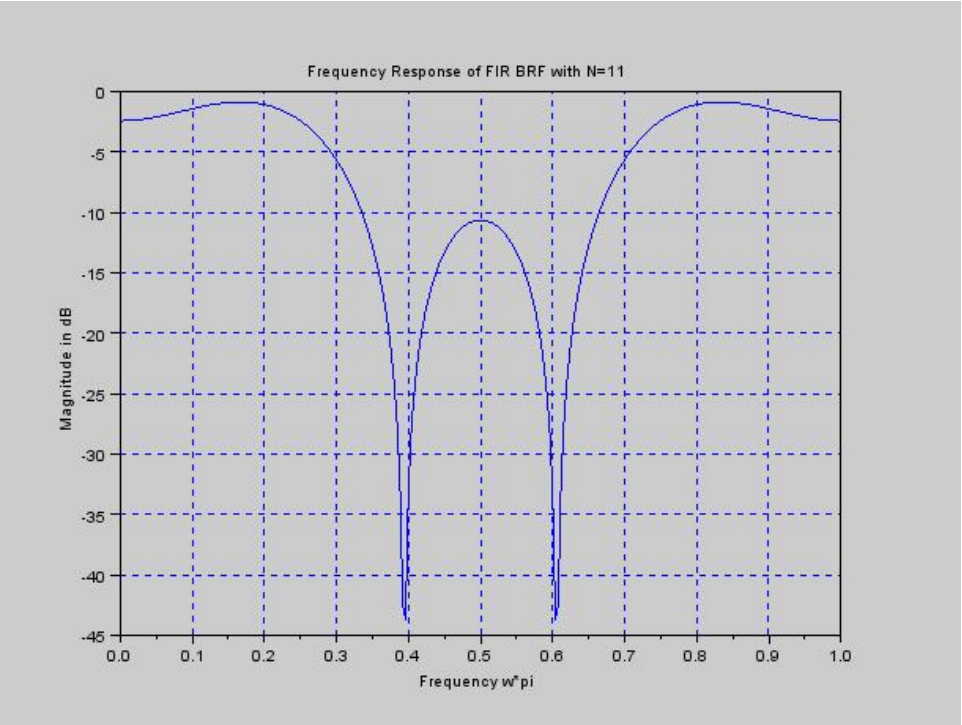

Figure 6.4: BRF Magnitude Response

```
11 if n==6
12 hd(n)=0.5;
13 else
14 hd(n)=(sin(%pi*(n-U))+sin(%pi*(n-U)/3)-sin(%pi*2*(n-
      U)/3))/(%pi*(n-U));
15 end
16 end
17 [hzm ,fr ]= frmag (hd ,256) ;
18 hzm_dB = 20* log10 (hzm)./ max ( hzm );
19 figure
20 plot (2*fr , hzm_dB )
21 a= gca ();
22 xlabel ('Frequency w*pi');
23 ylabel ('Magnitude in dB');
24 title ('Frequency Response of FIR BRF with N=11');
25 xgrid (2);
```

Scilab code Exa 6.9.a HPF Magnitude Response using Hanning Window

```
1 //Example 6.9a
2 //Program to Plot Magnitude Responce of ideal H.P.F.
3 //using Hanning Window
4 //wc1=0.25*pi
5 //N=11
6 clear;
7 clc ;
8 close ;
9 N=11;
10 U=6;
11 h_hann=window('hn',N);
12 for n=-5+U:1:5+U
13 if n==6
14 hd(n)=0.75;
```

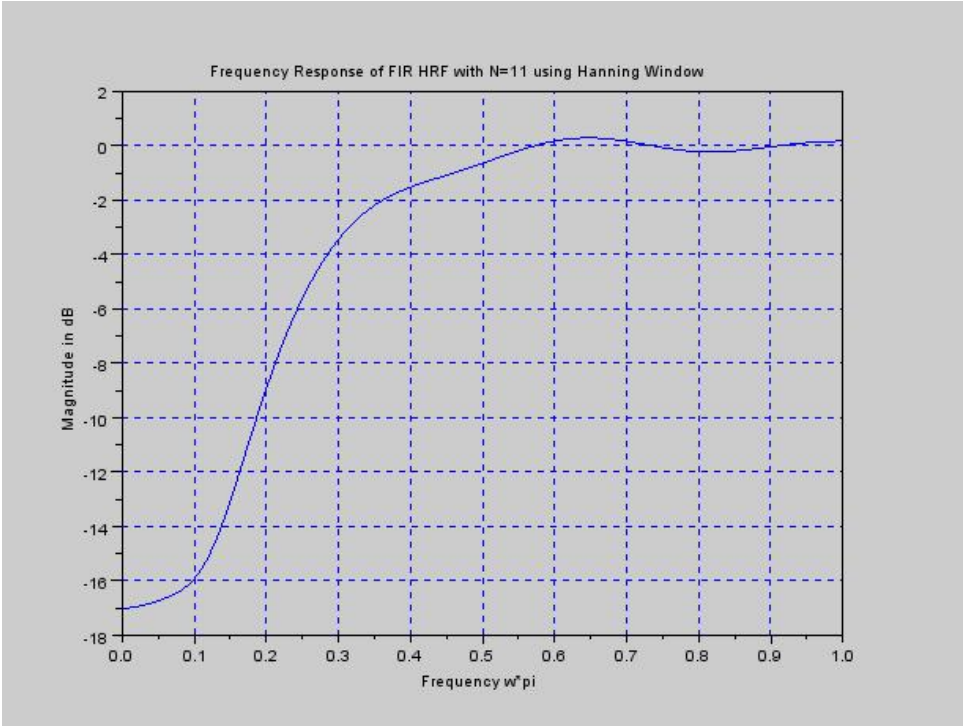

Figure 6.5: HPF Magnitude Response using Hanning Window

```
15 else
16 hd(n)=(sin(%pi*(n-U))-sin(%pi*(n-U)/4))/(%pi*(n-U));
17 end
18 h(n)=h_hann(n)*hd(n);
19 end
20 [hzm ,fr ]= frmag (h ,256) ;
21 hzm_dB = 20* log10 (hzm)./ max ( hzm );
22 figure
23 plot (2*fr , hzm_dB )
24 a= gca ();
25 xlabel ('Frequency w*pi');
26 ylabel ('Magnitude in dB');
27 title ('Frequency Response of FIR HRF with N=11
      using Hanning Window');
28 xgrid (2);
```

Scilab code Exa 6.9.b HPF Magnitude Response using Hamming Window

```
1 //Example 6.9b
2 //Program to Plot Magnitude Responce of ideal H.P.F.
3 //using Hamming Window
4 //wc1=0.25*pi
5 //N=11
6 clear;
7 clc ;
8 close ;
9 N=11;
10 U=6;
11 h_hamm=window('hm',N);
12 for n=-5+U:1:5+U
13 if n==6
14 hd(n)=0.75;
```

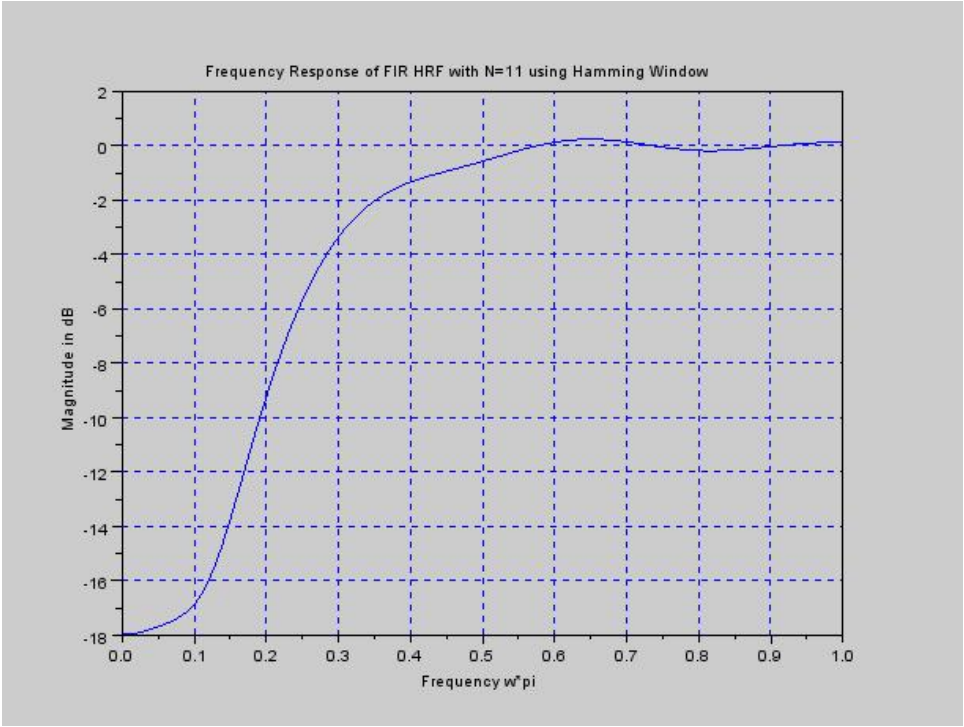

Figure 6.6: HPF Magnitude Response using Hamming Window

```
15 else
16 hd(n)=(sin(%pi*(n-U))-sin(%pi*(n-U)/4))/(%pi*(n-U));
17 end
18 h(n)=h_hamm(n)*hd(n);
19 end
20 [hzm ,fr ]= frmag (h ,256) ;
21 hzm_dB = 20* log10 (hzm)./ max ( hzm );
22 figure
23 plot (2*fr , hzm_dB )
24 a= gca ();
25 xlabel ('Frequency w*pi');
26 ylabel ('Magnitude in dB');
27 title ('Frequency Response of FIR HRF with N=11
      using Hamming Window');
28 xgrid (2);
```

Scilab code Exa 6.10 Hanning Window Filter Design

```
1 //Example 6.10
2 //Program to Plot Magnitude Responce of given L.P.F.
      with specifications:
3 //N=7,w=pi/4
4 //Using Hanning Window
5 clear;
6 clc ;
7 close ;
8 N=7;
9 alpha=3;
10 U=1;
11 h_hann=window('hn',N);
12 for n=0+U:1:6+U
13 if n==4
14 hd(n)=0.25;
```

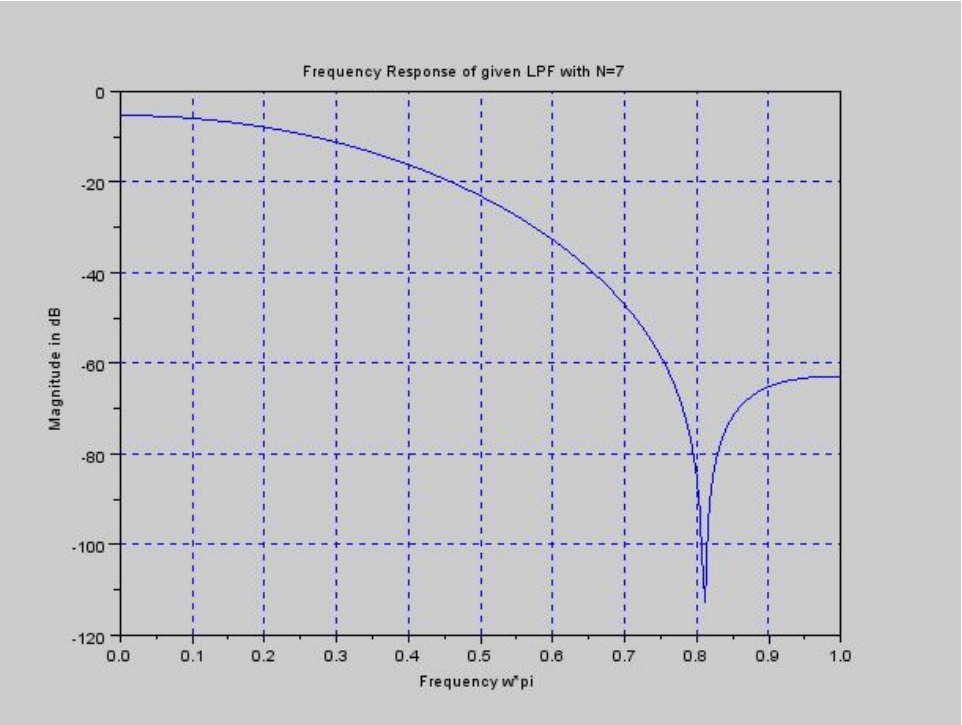

Figure 6.7: Hanning Window Filter Design

```
15 else
16 hd(n)=(sin(%pi*(n-U-alpha)/4))/(%pi*(n-U-alpha));
17 end
18 h(n)=hd(n)*h_hann(n);
19 end
20 [hzm ,fr ]= frmag (h ,256) ;
21 hzm_dB = 20* log10 (hzm)./ max ( hzm );
22 figure
23 plot (2*fr , hzm_dB )
24 a= gca ();
25 xlabel ('Frequency w*pi');
26 ylabel ('Magnitude in dB');
27 title ('Frequency Response of given LPF with N=7');
28 xgrid (2);
```

Scilab code Exa 6.11 LPF Filter Design using Kaiser Window

```
1 //Example 6.11
2 //Program to Plot Magnitude Responce of given L.P.F.
      with specifications:
3 //wp=20rad/sec, ws=30rad/sec, wsf=100rad/sec
4 //as=44.0dB, ap=0.1dB
5 //Using Kaiser Window
6 clear;
7 clc ;
8 close ;
9 wsf=100//rad/sec
10 ws=30;//rad/sec
11 wp=20;//rad/sec
12 as=44.0//dB
13 ap=0.1//dB
14 B=ws-wp;
15 wc=0.5*(ws+wp);
```

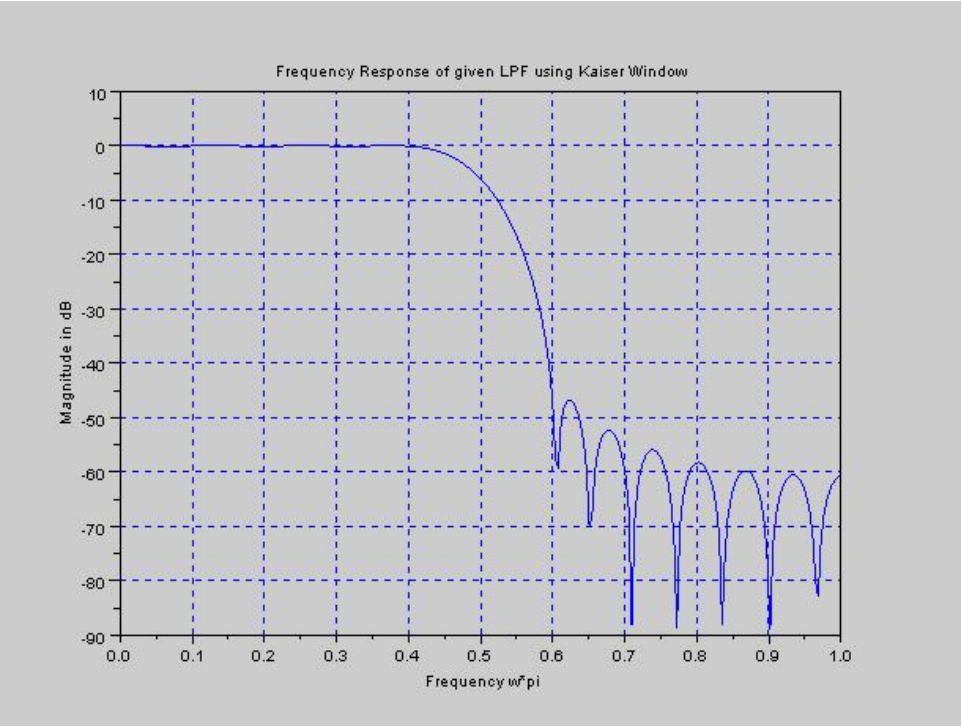

Figure 6.8: LPF Filter Design using Kaiser Window

```
16 wc1=wc*2*%pi/wsf;
17 delta1=10^(-0.05*as);
18 delta2=(10^(0.05*as)-1)/(10^(0.05*as)+1);
19 delta=min(delta1,delta2);
20 alphas=-20*log10(delta);
21 alpha=0.5842*(alphas-21)^0.4+0.07886*(alphas-21)
22 D=(alphas-7.95)/14.36;
23 N1=wsf*D/B+1;
24 N=ceil(N1);
25 U=ceil(N/2);
26 win_l=window('kr',N,alpha);
27 for n=-floor(N/2)+U:1:floor(N/2)+U
28 if n==ceil(N/2);
29 hd(n)=0.5;
30 else
31 hd(n)=(sin(%pi*(n-U)/2))/(%pi*(n-U));
32 end
33 h(n)=hd(n)*win_l(n);
34 end
35 [hzm ,fr ]= frmag (h ,256) ;
36 hzm_dB = 20* log10 (hzm)./ max ( hzm );
37 figure
38 plot (2*fr , hzm_dB )
39 a= gca ();
40 xlabel ('Frequency w*pi');
41 ylabel ('Magnitude in dB');
42 title ('Frequency Response of given LPF using Kaiser
      Window');
43 xgrid (2);
44 disp(h,"Filter Coefficients,h(n)=");
```

Scilab code Exa 6.12 BPF Filter Design using Kaiser Window

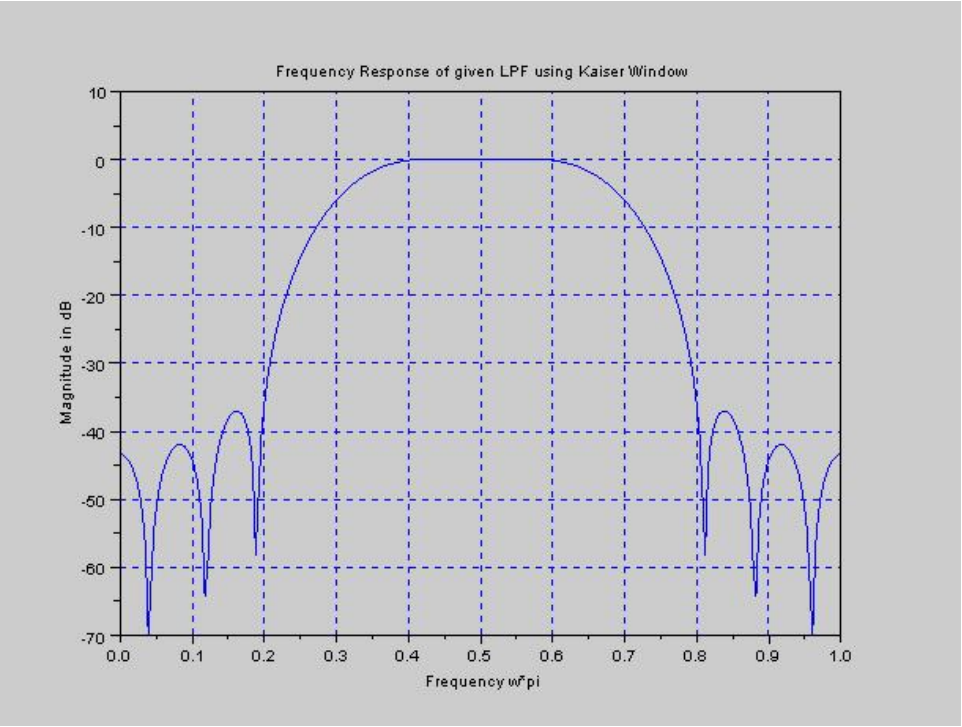

Figure 6.9: BPF Filter Design using Kaiser Window

```
1  //Example 6.12
2  //Program to Plot Magnitude Responce of given B.P.F.
       with specifications:
3  //wp1=40pi rad/sec, wp2=60pi rad/sec
4  //ws1=20pi rad/sec, ws2=80pi rad/sec
5  //as=30dB, ap=0.5dB
6  //F=100 Hz
7  //Using Kaiser Window
8  clear;
9  clc ;
10 close ;
11 wsf=200*%pi;//rad/sec
12 ws1=20*%pi;//rad/sec
13 ws2=80*%pi;//rad/sec
14 wp1=40*%pi;//rad/sec
15 wp2=60*%pi;//rad/sec
16 as=30//dB
17 ap=0.5//dB
18 B=min(wp1-ws1,ws2-wp2);
19 wc1=wp1-B/2;
20 wc2=wp2+B/2;
21 wc1=wc1*2*%pi/wsf;
22 wc2=wc2*2*%pi/wsf;
23 delta1=10^(-0.05*as);
24 delta2=(10^(0.05*as)-1)/(10^(0.05*as)+1);
25 delta=min(delta1,delta2);
26 alphas=-20*log10(delta);
27 alpha=0.5842*(alphas-21)^0.4+0.07886*(alphas-21)
28 D=(alphas-7.95)/14.36;
29 N1=wsf*D/B+1;
30 N=ceil(N1);
31 U=ceil(N/2);
32 win_l=window('kr',N,alpha);
33 for n=-floor(N/2)+U:1:floor(N/2)+U
34 if n==ceil(N/2);
35 hd(n)=0.4;
36 else
37 hd(n)=(sin(0.7*%pi*(n-U))-sin(0.3*%pi*(n-U)))/(%pi*(
```

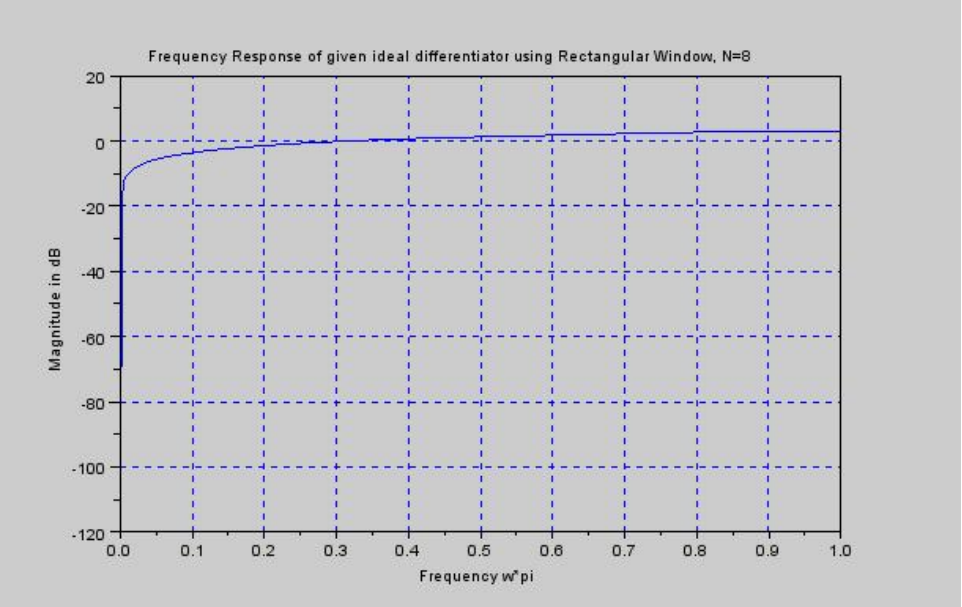

Figure 6.10: Digital Differentiator using Rectangular Window

```
   n-U));
end
h(n)=hd(n)*win_l(n);
end
[hzm ,fr ]= frmag (h ,256) ;
hzm_dB = 20* log10 (hzm)./ max ( hzm );
figure
plot (2*fr , hzm_dB )
a= gca ();
xlabel ('Frequency w*pi');
ylabel ('Magnitude in dB');
title ('Frequency Response of given LPF using Kaiser
    Window');
xgrid (2);
disp(h,"Filter Coefficients ,h(n)=");
```

Scilab code Exa 6.13.a Digital Differentiator using Rectangular Window

```
1  //Example 6.13a
2  //Program to Plot Magnitude Responce of ideal
       differentiator with specifications:
3  //N=8,w=pi
4  //using Rectangular window
5  clear;
6  clc ;
7  close ;
8  N=8;
9  alpha=7/2;
10 U=1;
11 h_Rect=window('re',N);
12 for n=0+U:1:7+U
13 hd(n)=-(sin(%pi*(n-U-alpha)))/(%pi*(n-U-alpha)*(n-U-
       alpha));
14 h(n)=hd(n)*h_Rect(n);
15 end
16 [hzm ,fr ]= frmag (h ,256) ;
17 hzm_dB = 20* log10 (hzm)./ max ( hzm );
18 figure
19 plot (2*fr , hzm_dB )
20 a= gca ();
21 xlabel ('Frequency w*pi');
22 ylabel ('Magnitude in dB');
23 title ('Frequency Response of given ideal
       differentiator using Rectangular Window, N=8');
24 xgrid (2)
```

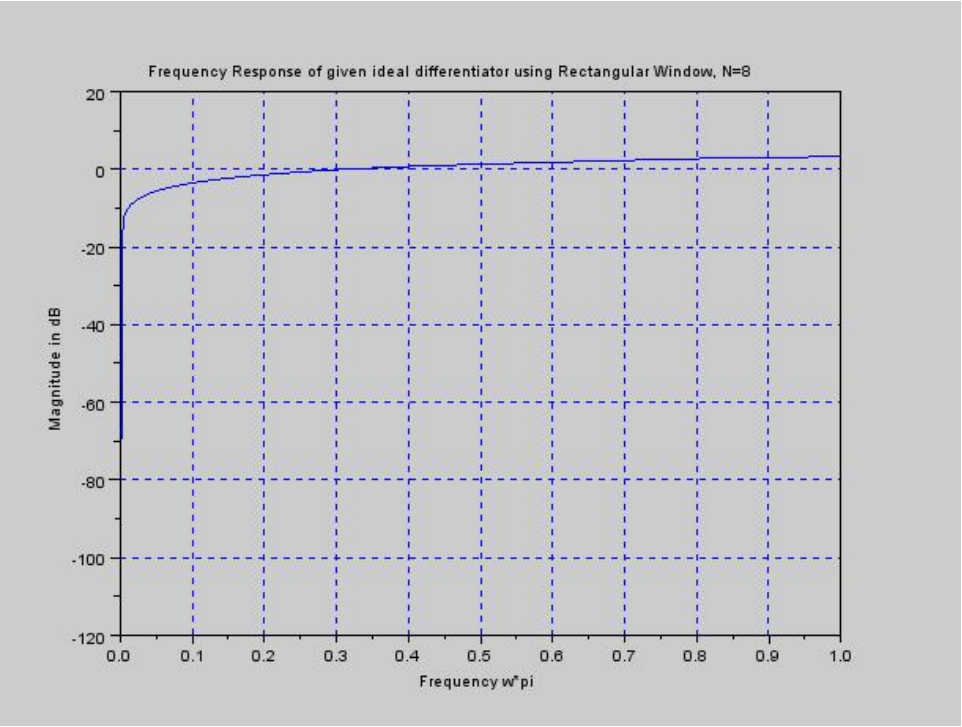

Figure 6.11: Digital Differentiator using Hamming Window

Scilab code Exa 6.13.b Digital Differentiator using Hamming Window

```
1 //Example 6.13b
2 //Program to Plot Magnitude Responce of ideal
     differentiator with specifications:
3 //N=8,w=pi
4 //using Hamming window
5 clear;
6 clc ;
7 close ;
8 N=8;
9 alpha=7/2;
10 U=1;        //Zero Adjust
11 h_hamm=window('hm',N);
12 for n=0+U:1:7+U
13 hd(n)=-(sin(%pi*(n-U-alpha)))/(%pi*(n-U-alpha)*(n-U-
     alpha));
14 h(n)=hd(n)*h_hamm(n);
15 end
16 [hzm ,fr ]= frmag (h ,256) ;
17 hzm_dB = 20* log10 (hzm)./ max ( hzm );
18 figure
19 plot (2*fr , hzm_dB )
20 a= gca ();
21 xlabel ('Frequency w*pi');
22 ylabel ('Magnitude in dB');
23 title ('Frequency Response of given ideal
     differentiator using Hamming Window, N=8');
24 xgrid (2)
```

Scilab code Exa 6.14.a Hilbert Transformer using Rectangular Window

```
1 //Example 6.14a
```

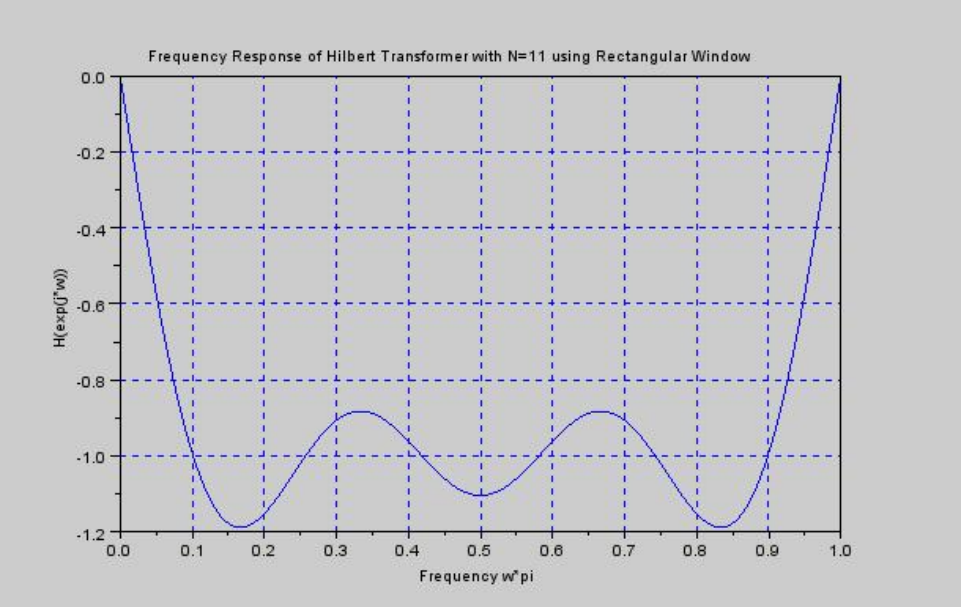

Figure 6.12: Hilbert Transformer using Rectangular Window

```
2  //Program to Plot Magnitude Responce of ideal
     Hilbert Transformer
3  //using Rectangular Window
4  //N=11
5  clear;
6  clc ;
7  close ;
8  N=11;
9  U=6;
10 h_Rect=window('re',N);
11 for n=-5+U:1:5+U
12 if n==6
13 hd(n)=0;
14 else
15 hd(n)=(1-cos(%pi*(n-U)))/(%pi*(n-U));
16 end
17 h(n)=hd(n)*h_Rect(n);
18 end
19 [hzm ,fr]= frmag (h,256) ;
```

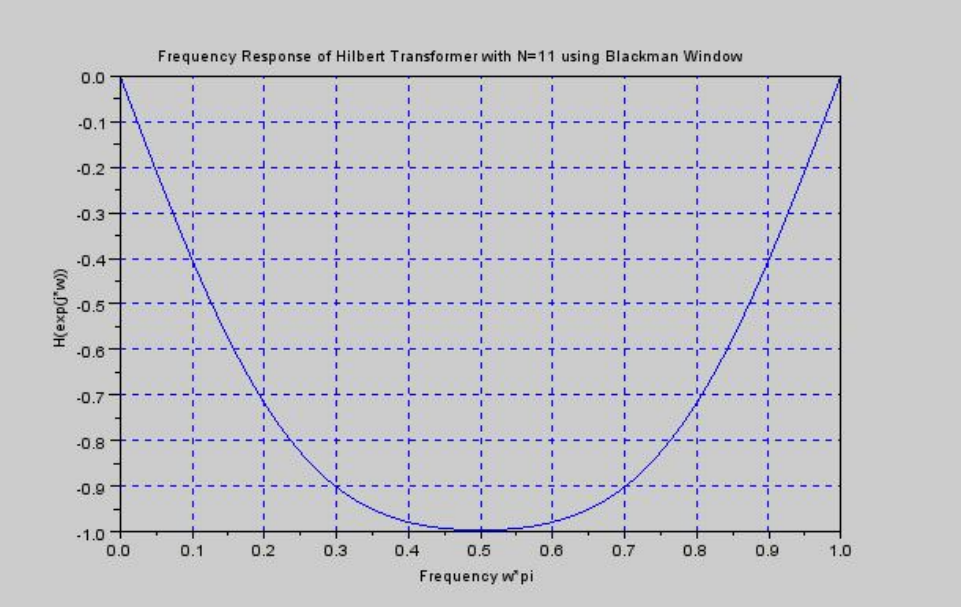

Figure 6.13: Hilbert Transformer using Blackman Window

```
20 figure
21 plot (2*fr ,-hzm);
22 a = gca ();
23 xlabel ('Frequency w*pi');
24 ylabel ('H(exp(j*w))');
25 title ('Frequency Response of Hilbert Transformer
      with N=11 using Rectangular Window');
26 xgrid (2);
```

Scilab code Exa 6.14.b Hilbert Transformer using Blackman Window

```
1 //Example 6.14b
2 //Program to Plot Magnitude Responce of ideal
     Hilbert Transformer
```

```
3 //using Blackman Window
4 //N=11
5 clear;
6 clc ;
7 close ;
8 N=11;
9 U=6;
10 for n=-5+U:1:5+U
11 h_balckmann(n) = 0.42+0.5*cos(2*%pi*(n-U)/(N-1))
     +0.08*cos(4*%pi*(n-U)/(N-1));
12 if n==6
13 hd(n)=0;
14 else
15 hd(n)=(1-cos(%pi*(n-U)))/(%pi*(n-U));
16 end
17 h(n)=hd(n)*h_balckmann(n);
18 end
19 [hzm ,fr]= frmag (h,256) ;
20 figure
21 plot (2*fr ,-hzm);
22 a = gca ();
23 xlabel ('Frequency w*pi');
24 ylabel ('H(exp(j*w))');
25 title ('Frequency Response of Hilbert Transformer
     with N=11 using Blackman Window');
26 xgrid (2);
```

Scilab code Exa 6.15 Filter Coefficients obtained by Sampling

```
1 //Example 6.15
2 //Program to determine filter coefficients obtained
     by sampling:
3 //N=7,w=pi/2
4 clear;
5 clc ;
```

```
close ;
N=7;
U=1;        //Zero Adjust
for n=0+U:1:N-1+U
h(n)=(1+2*cos(2*%pi*(n-U-3)/7))/N
end
disp(h,"Filter Coefficients ,h(n)=")
```

Scilab code Exa 6.16 Coefficients of Linear phase FIR Filter

```
//Example 6.16
//Program to determine filter coefficients obtained
   by sampling:
//N=15
clear;
clc ;
close ;
N=15;
U=1;        //Zero Adjust
for n=0:1:N-1
h(n+U)=(1+2*cos(2*%pi*(7-n)/N)+2*cos(4*%pi*(7-n)/N)
   +2*cos(6*%pi*(7-n)/N))/N;
end
disp(h,"Filter Coefficients ,h(n)=");
```

Scilab code Exa 6.17 BPF Filter Design using Sampling Method

```
//Example 6.17
//Program to design bandpass filter with following
   specifications:
//N=7, fc1=1000Hz, fc2=3000Hz, F=8000Hz
clear;
clc ;
```

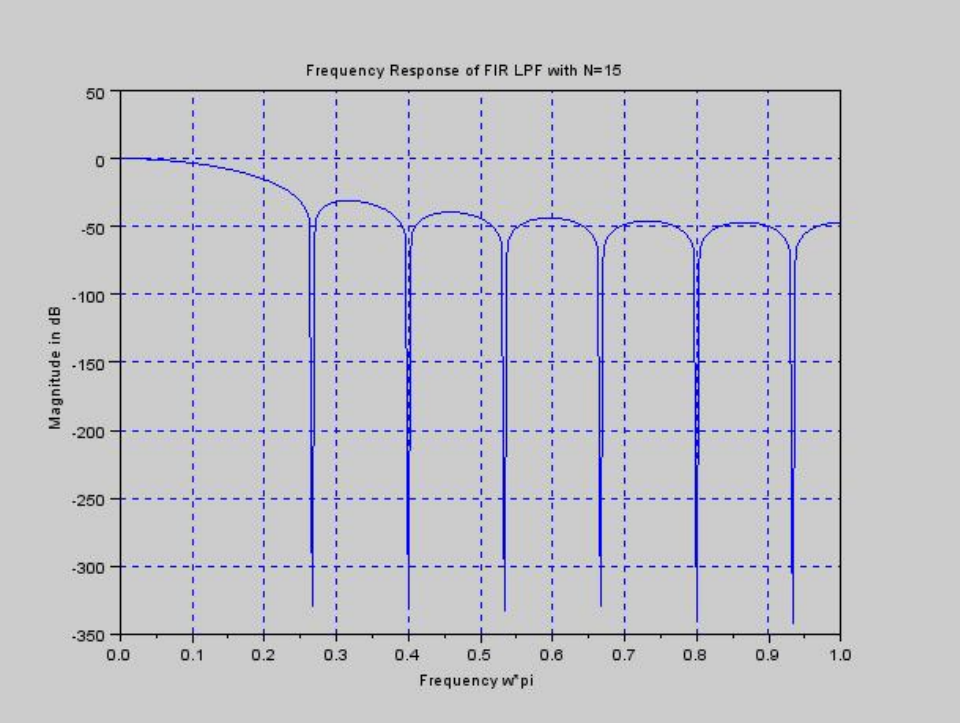

Figure 6.14: Frequency Sampling Method FIR LPF Filter

```
close ;
N=7;
U=1;          //Zero Adjust
for n=0:1:N-1
h(n+U)=2*(cos(2*%pi*(3-n)/N)+cos(4*%pi*(3-n)/N))/N;
end
disp(h,"Filter Coefficients ,h(n)=");
```

Scilab code Exa 6.18.a Frequency Sampling Method FIR LPF Filter

```
//Example 6.18a
```

```
2 //Program to design L.P.F. filter with following
     specifications:
3 //N=15, wc=pi/4
4 clear;
5 clc ;
6 close ;
7 N=15;
8 U=1;
9 for n=0+U:1:N-1+U
10 h(n)=(1+cos(2*%pi*(7-n)/N))/N;
11 end
12 [hzm ,fr ]= frmag (h ,256) ;
13 hzm_dB = 20* log10 (hzm)./ max ( hzm );
14 figure;
15 plot (2*fr , hzm_dB );
16 a= gca ();
17 xlabel ('Frequency w*pi');
18 ylabel ('Magnitude in dB');
19 title ('Frequency Response of FIR LPF with N=15');
20 xgrid (2)
```

Scilab code Exa 6.18.b Frequency Sampling Method FIR LPF Filter

```
1 //Example 6.18b
2 //Program to design L.P.F. filter with following
     specifications:
3 //N=15, wc=pi/4
4 clear;
5 clc ;
6 close ;
7 N=15;
8 U=1;
9 for n=0+U:1:N-1+U
```

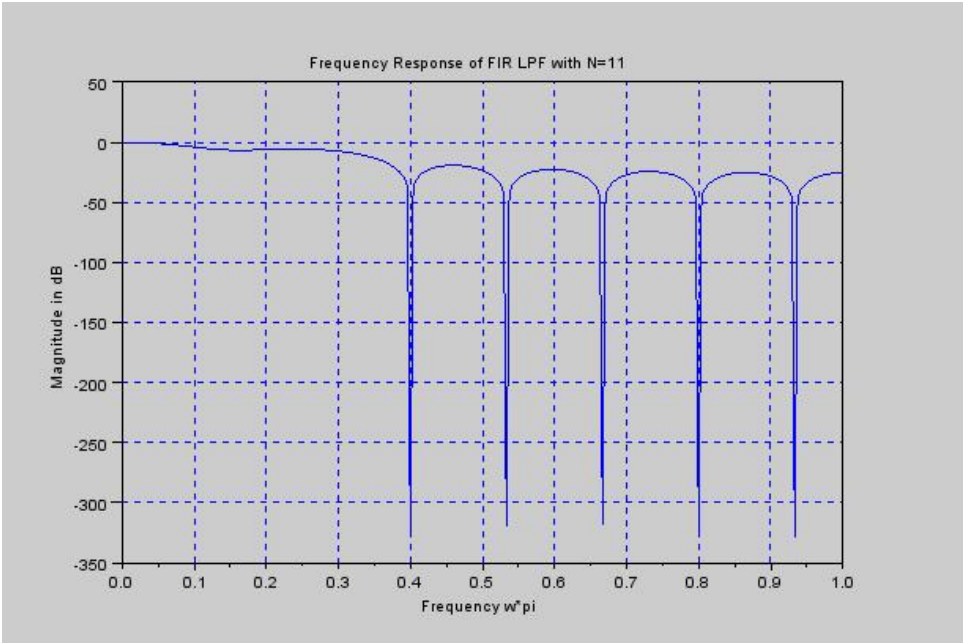

Figure 6.15: Frequency Sampling Method FIR LPF Filter

```
10 h(n)=(1+cos(2*%pi*(7-n)/N)+cos(4*%pi*(7-n)/N))/N;
11 end
12 [hzm ,fr ]= frmag (h ,256) ;
13 hzm_dB = 20* log10 (hzm)./ max ( hzm );
14 figure;
15 plot (2*fr , hzm_dB );
16 a= gca ();
17 xlabel ('Frequency w*pi');
18 ylabel ('Magnitude in dB');
19 title ('Frequency Response of FIR LPF with N=11');
20 xgrid (2)
```

Scilab code Exa 6.19 Filter Coefficients Determination

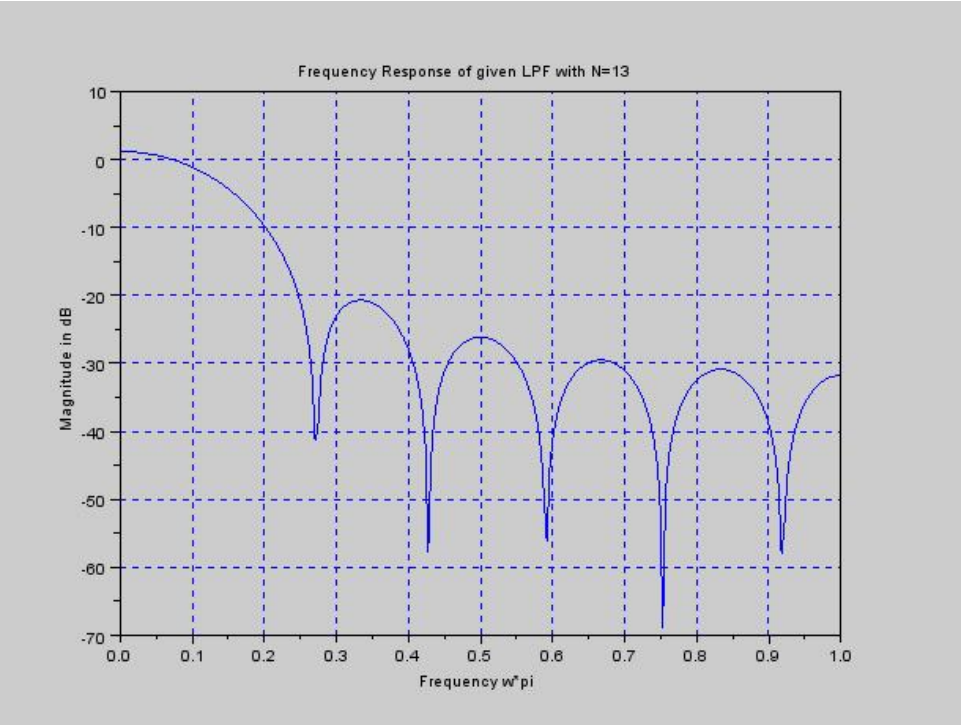

Figure 6.16: Filter Coefficients Determination

```
1  //Example 6.19
2  //Program to Plot Magnitude Responce of given L.P.F.
       with specifications:
3  //N=13,w=pi/6
4  clear;
5  clc ;
6  close ;
7  alpha=6;
8  U=1;
9  for n=0+U:1:12+U
10 if n==7
11 hd(n)=0.167;
12 else
13 hd(n)=(sin(%pi*(n-U-alpha)/6))/(%pi*(n-U-alpha));
14 end
15 end
16 [hzm ,fr ]= frmag (hd ,256) ;
17 hzm_dB = 20* log10 (hzm)./ max ( hzm );
18 figure
19 plot (2*fr , hzm_dB )
20 a= gca ();
21 xlabel ('Frequency w*pi');
22 ylabel ('Magnitude in dB');
23 title ('Frequency Response of given LPF with N=13');
24 xgrid (2)
25 disp(hd,"Filter Coefficients ,h(n)=");
```

Scilab code Exa 6.20 Filter Coefficients using Hamming Window

```
1  //Example 6.20
2  //Program to Plot Magnitude Responce of given L.P.F.
       with specifications:
3  //N=13,w=pi/6
```

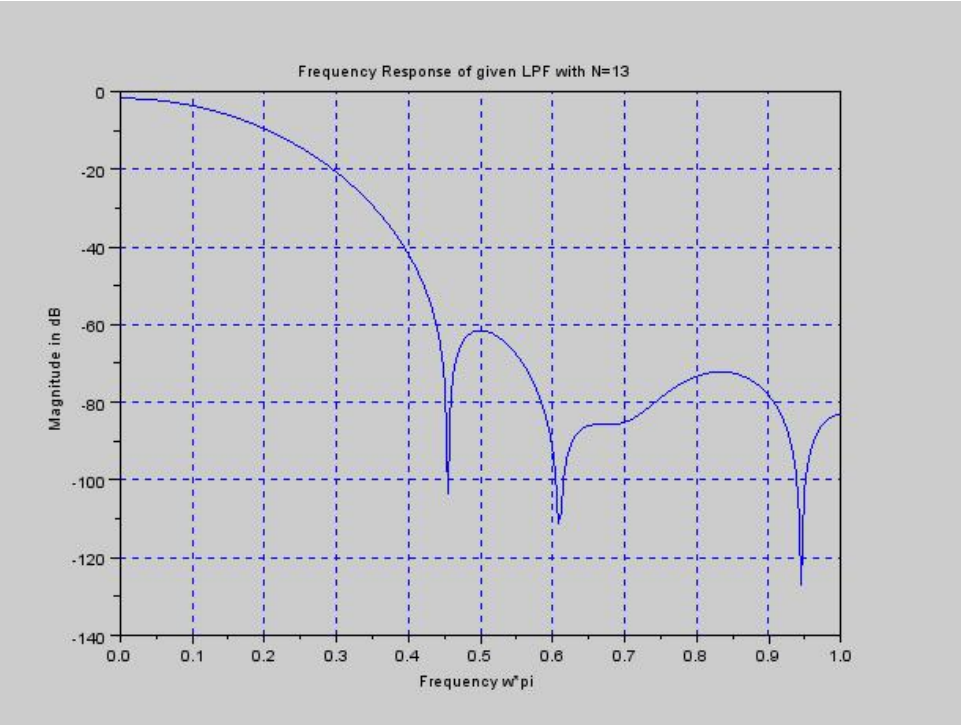

Figure 6.17: Filter Coefficients using Hamming Window

```
4  //Using Hamming Window
5  clear;
6  clc ;
7  close ;
8  N=13;
9  alpha=6;
10 U=1;
11 h_hamm=window('hm',N);
12 for n=0+U:1:12+U
13 if n==7
14 hd(n)=0.167;
15 else
16 hd(n)=(sin(%pi*(n-U-alpha)/6))/(%pi*(n-U-alpha));
17 end
18 h(n)=hd(n)*h_hamm(n);
19 end
20 [hzm ,fr ]= frmag (h ,256) ;
21 hzm_dB = 20* log10 (hzm)./ max ( hzm );
22 figure
23 plot (2*fr , hzm_dB )
24 a= gca ();
25 xlabel ('Frequency w*pi');
26 ylabel ('Magnitude in dB');
27 title ('Frequency Response of given LPF with N=13');
28 xgrid (2)
29 disp(h,"Filter Coefficients,h(n)=");
30 disp(h,"Filter Coefficients,h(n)=");
```

Scilab code Exa 6.21 LPF Filter using Rectangular Window

```
1  //Example 6.21
2  //Program to Plot Magnitude Responce of given L.P.F.
       with specifications:
```

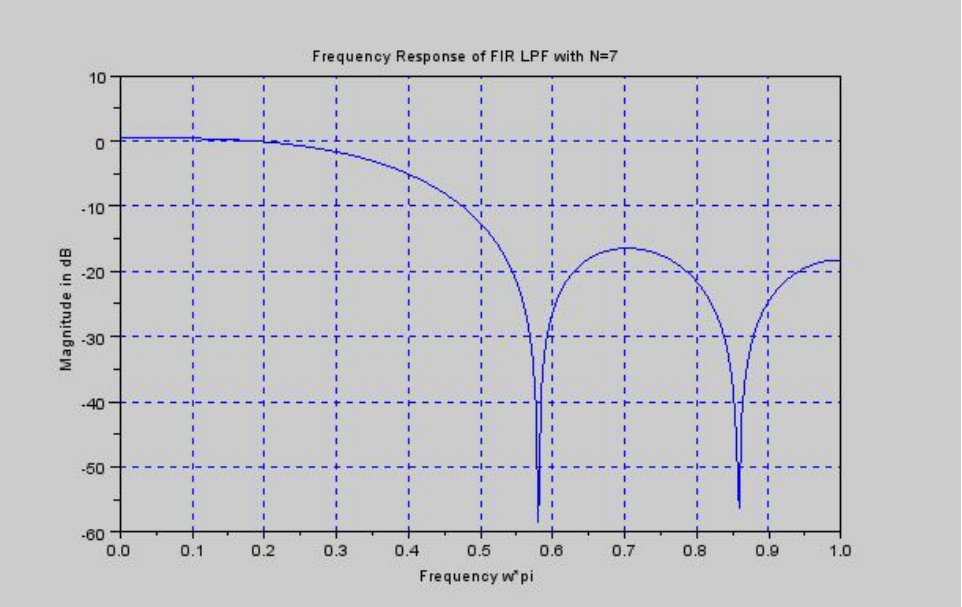

Figure 6.18: LPF Filter using Rectangular Window

```
3  //N=7, fc =1000Hz, F=5000Hz
4  clear;
5  clc ;
6  close ;
7  N=7;
8  U=4;
9  h_Rect=window('re',N);
10 for n=-3+U:1:3+U
11 if n==4
12 hd(n)=0.4;
13 else
14 hd(n)=(sin(2*%pi*(n-U)/5))/(%pi*(n-U));
15 end
16 h(n)=hd(n)*h_Rect(n);
17 end
18 [hzm ,fr ]= frmag (h ,256) ;
19 hzm_dB = 20* log10 (hzm)./ max ( hzm );
20 figure
21 plot (2*fr , hzm_dB )
```

```
a= gca ();
xlabel ('Frequency w*pi');
ylabel ('Magnitude in dB');
title ('Frequency Response of FIR LPF with N=7');
xgrid (2)
disp(h,"Filter Coefficients,h(n)=");
```

Scilab code Exa 6.28 Filter Coefficients for Direct Form Structure

```
//Example 6.28
//Program to calculate FIR Filter coefficients for
   the direct form structure
//k1=1/2 , k2=1/3 , k3=1/4
clear;
clc ;
close ;
U=1;
k1=1/2;
k2=1/3;
k3=1/4;
a(3+U,0+U)=1;
a(1+U,1+U)=k1;
a(2+U,2+U)=k2;
a(3+U,3+U)=k3;
m=2,k=1;
a(m+U,k+U)=a(m-1+U,k+U)+a(m+U,m+U)*a(m-1+U,m-k+U);
m=3,k=1;
a(m+U,k+U)=a(m-1+U,k+U)+a(m+U,m+U)*a(m-1+U,m-k+U);
m=3,k=2;
a(m+U,k+U)=a(m-1+U,k+U)+a(m+U,m+U)*a(m-1+U,m-k+U);
disp(a(3+U,0+U),'a(3,0)');
disp(a(3+U,1+U),'a(3,1)');
disp(a(3+U,2+U),'a(3,2)');
disp(a(3+U,3+U),'a(3,3)');
```

Scilab code Exa 6.29 Lattice Filter Coefficients Determination

```
1  //Example 6.29
2  //Program to calculate given FIR Filter's Lattice
       form coefficients.
3  clear;
4  clc ;
5  close ;
6  U=1;              //Zero Adjust
7  a(3+U,0+U)=1;
8  a(3+U,1+U)=2/5;
9  a(3+U,2+U)=3/4;
10 a(3+U,3+U)=1/3;
11 a(2+U,0+U)=1; //a(m,0)=1
12 a(2+U,3+U)=1/3;
13 m=3,k=1;
14 a(m-1+U,k+U)=(a(m+U,k+U)-a(m+U,m+U)*a(m+U,m-k+U))
       /(1-a(m+U,m+U)*a(m+U,m+U));
15 m=3,k=2;
16 a(m-1+U,k+U)=(a(m+U,k+U)-a(m+U,m+U)*a(m+U,m-k+U))
       /(1-a(m+U,m+U)*a(m+U,m+U));
17 m=2,k=1;
18 a(m-1+U,k+U)=(a(m+U,k+U)-a(m+U,m+U)*a(m+U,m-k+U))
       /(1-a(m+U,m+U)*a(m+U,m+U));
19 disp(a(1+U,1+U),'k1');
20 disp(a(2+U,2+U),'k2');
21 disp(a(3+U,3+U),'k3');
```

Chapter 7

FINITE WORD LENGTH EFFECTS IN DIGITAL FILTERS

Scilab code Exa 7.2 Subtraction Computation

```
1  //Example 7.2
2  //To Compute Subtraction
3  //(a) 0.25 from 0.5
4  clear;
5  clc ;
6  close ;
7  a=0.5;
8  b=0.25;
9  c=a-b;
10 disp(c,'=',b,'-',a,'PART 1');
11 //(a) 0.5 from 0.25
12 d=b-a;
13 disp(d,'=',a,'-',b,'PART 2');
```

Scilab code Exa 7.14 Variance of Output due to AD Conversion Process

```
1 //Example 7.14
2 //To Compare the Varience of Output due to A/D
     Conversion process
3 //y(n)=0.8y(n-1)+x(n)
4 clear;
5 clc ;
6 close ;
7 n=8;  //Bits
8 r=100;  //Range
9 Q=2*r/(2^n);  //Quantization Step Size
10 Ve=(Q^2)/12;
11 Vo=Ve*(1/(1-0.8^2));
12 disp(Q,'QUANTIZATION STEP SIZE =');
13 disp(Ve,'VARIANCE OF ERROR SIGNAL =');
14 disp(Vo,'VARIANCE OF OUTPUT =');
```

Chapter 8

MULTIRATE SIGNAL PROCESSING

Scilab code Exa 8.9 Two Component Decomposition

```
1 //Example 8.9
2 //MAXIMA SCILAB TOOLBOX REQUIRED FOR THIS PROGRAM
3 //Develop a two component decomposition for the
     transfer function
4 //and determine P0(z) and P1(z)
5 clear;
6 clc ;
7 close ;
8 syms z a n;
9 HZ=(z)/(z-a);
10 hn=a^n;//Inverse Z Transform of HZ
11 h2n=a^(2*n);
12 P0=symsum(h2n*z^(-n),n,0,%inf);
13 h2n1=a^(2*n+1);
14 P1=symsum(h2n1*z^(-n),n,0,%inf);
15 disp(P0,'P0(Z) = ');
16 disp(P1,'P1(Z) = ');
```

Scilab code Exa 8.10 Two Band Polyphase Decomposition

```
1 //Example 8.10
2 //Develop a two band polyphase decomposition for the
      transfer function
3 //H(z)=z^2+z+2/z^2+0.8z+0.6
4 clear;
5 clc ;
6 close ;
7 z=%z;
8 HZ=(z^2+z+2)/(z^2+0.8*z+0.6);
9 HZa=horner(HZ,-z);
10 P0=0.5*(HZ+HZa);
11 P1=0.5*(HZ-HZa);
12 disp(P1/z,'+',P0,'H(z) =')
```

Chapter 9

STATISTICAL DIGITAL SIGNAL PROCESSING

Scilab code Exa 9.7.a Frequency Resolution Determination

```
1 //Example 9.7 (a)
2 //Program To Determine Frequency Resolution of
     Bartlett ,
3 //Welch(50% Overlap) and Blackmann-Tukey Methods
4 clear;
5 clc;
6 close;
7 //Data
8 Q=10;//Quality Factor
9 N=1000;//Samples
10 //FREQUENCY RESOLUTION CALCULATION
11 K=Q;
12 rb=0.89*(2*%pi*K/N);
13 rw=1.28*(2*%pi*9*Q)/(16*N);
14 rbt=0.64*(2*%pi*2*Q)/(3*N);
15 //Display the result in command window
16 disp(rb,"Resolution of Bartlett Method");
17 disp(rw,"Resolution of Welch(50% overlap) Method");
18 disp(rbt,"Resolution of Blackmann-Tukey Method");
```

Scilab code Exa 9.7.b Record Length Determination

```
1 //Example 9.7 (b)
2 //Program To Determine Record Length of Bartlett,
3 //Welch(50% Overlap) and Blackmann-Tukey Methods
4 clear;
5 clc;
6 close;
7 //Data
8 Q=10;//Quality Factor
9 N=1000;//Samples
10 //RECORD LENGTH CALCULATION
11 lb=N/Q;
12 lw=16*N/(9*Q);
13 lbt=3*N/(2*Q);
14 //Display the result in command window
15 disp(lb,"Record Length of Bartlett Method");
16 disp(lw,"Record Length of Welch(50% overlap) Method"
   );
17 disp(lbt,"Record Length of Blackmann-Tukey Method");
```

Scilab code Exa 9.8.a Smallest Record Length Computation

```
1 //Example 9.8 (a)
2 //Program To Determine Smallest Record Length of
     Bartlett Method
3 clear;
4 clc;
5 close;
6 //Data
7 fr=0.01;//Frequency Resolution
```

```
8  N=2400; //Samples
9  //RECORD LENGTH CALCULATION
10 lb=0.89/fr;
11 //Display the result in command window
12 disp(lb,"Record Length of Bartlett Method");
```

Scilab code Exa 9.8.b Quality Factor Computation

```
1  //Example 9.8 (b)
2  //Program To Determine Quality Factor of Bartlett
      Method
3  clear;
4  clc;
5  close;
6  //Data
7  fr=0.01;//Frequency Resolution
8  N=2400; //Samples
9  lb=0.89/fr;
10 //QUALITY FACTOR CALCULATION
11 Q=N/lb;
12 //Display the result in command window
13 disp(Q,"Quality Factor of Bartlett Method");
```

Chapter 11

DIGITAL SIGNAL PROCESSORS

Scilab code Exa 11.3 Program for Integer Multiplication

```
1 //Program 11.3
2 //Program To Calculate the value of the function
3 //Y=A*B
4 clear;
5 clc;
6 close;
7 //Input Data
8 A=input('Enter Integer Number A =');
9 B=input('Enter Integer Number B =');
10 //Multiplication Computation
11 Y=A*B;
12 //Display the result in command window
13 disp(Y,"Y = A*B = ");
```

Scilab code Exa 11.5 Function Value Calculation

```
1  //Program 11.5
2  //Program To Calculate the value of the function
3  //Y=A*X1+B*X2+C*X3
4  clear;
5  clc;
6  close;
7  //Data
8  A=1;
9  B=2;
10 C=3;
11 X1=4;
12 X2=5;
13 X3=6;
14 //Compute the function
15 Y=A*X1+B*X2+C*X3;
16 //Display the result in command window
17 disp(Y,"Y = A*X1+B*X2+C*X3 = ");
```