

Scilab Manual for
Digital Signal Processing
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Experiment: 1

Verification of Sampling theorem.

Scilab code Solution 1.1 Verification of Sampling Theorem

```
1 //Caption: Verification of Sampling Theorem
2 //[1].Right Sampling [2]. Under Sampling [3]. Over
   Sampling
3 clc;
4 close;
5 clear;
6 fm=input('Enter the input signal frequency:');
7 k=input('Enter the number of Cycles of input signal:
   ');
8 A=input('Enter the amplitude of input signal:');
9 tm=0:1/(fm*fm):k/fm;
10 x=A*cos(2*%pi*fm*tm);
11 figure(1);
12 a = gca();
13 a.x_location = "origin";
14 a.y_location = "origin";
15 plot(tm,x);
16 title('ORIGINAL SIGNAL');
17 xlabel('Time');
```

```

18 ylabel('Amplitude');
19 xgrid(1)
20 //Sampling Rate(Nyquist Rate)=2*fm
21 fnyq=2*fm;
22 // UNDER SAMPLING
23 fs=(3/4)*fnyq;
24 n=0:1/fs:k/fm;
25 xn=A*cos(2*%pi*fm*n);
26 figure(2);
27 a = gca();
28 a.x_location = "origin";
29 a.y_location = "origin";
30 plot2d3('gnn',n,xn);
31 plot(n,xn,'r');
32 title('Under Sampling');
33 xlabel('Time');
34 ylabel('Amplitude');
35 legend('Sampled Signal', 'Reconstructed Signal');
36 xgrid(1)
37 //NYQUIST SAMPLING
38 fs=fnyq;
39 n=0:1/fs:k/fm;
40 xn=A*cos(2*%pi*fm*n);
41 figure(3);
42 a = gca();
43 a.x_location = "origin";
44 a.y_location = "origin";
45 plot2d3('gnn',n,xn);
46 plot(n,xn,'r');
47 title('Nyquist Sampling');
48 xlabel('Time');
49 ylabel('Amplitude');
50 legend('Sampled Signal', 'Reconstructed Signal');
51 xgrid(1)
52 //OVER SAMPLING
53 fs=fnyq*10;
54 n=0:1/fs:k/fm;
55 xn=A*cos(2*%pi*fm*n);

```

```
56 figure(4);
57 a = gca();
58 a.x_location = "origin";
59 a.y_location = "origin";
60 plot2d3('gmn',n,xn);
61 plot(n,xn,'r');
62 title('Over Sampling');
63 xlabel('Time');
64 ylabel('Amplitude');
65 legend('Sampled Signal', 'Reconstructed Signal');
66 xgrid(1)
67 //Result
68 //Enter the input signal frequency:100
69 //
70 //Enter the number of Cycles of input signal:2
71 //
72 //Enter the amplitude of input signal:2
```

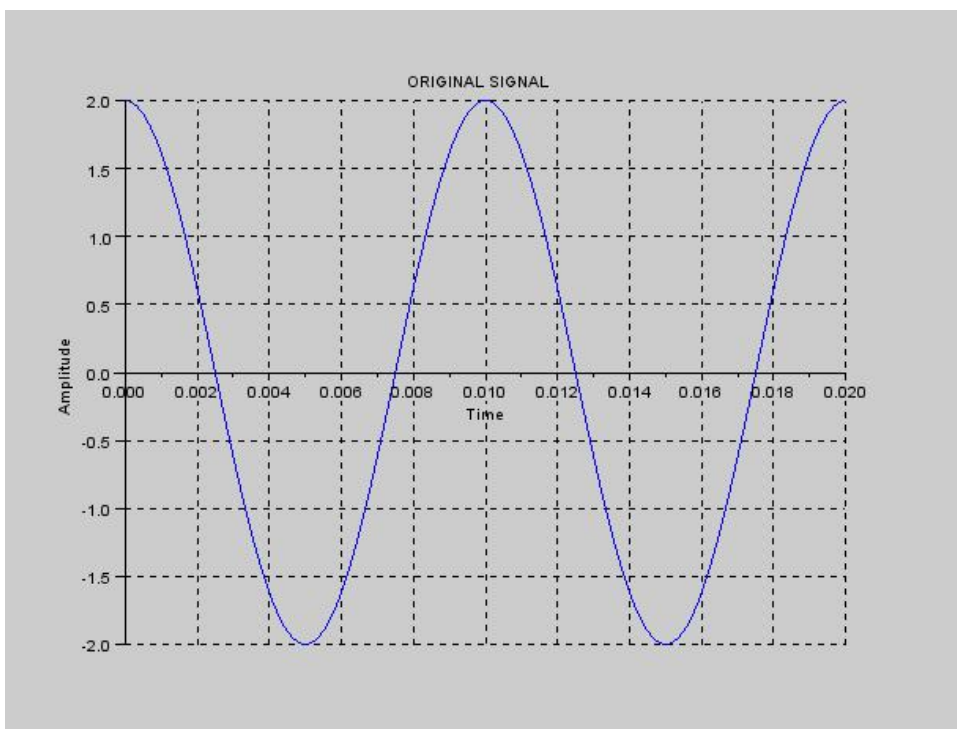


Figure 1.1: Verification of Sampling Theorem

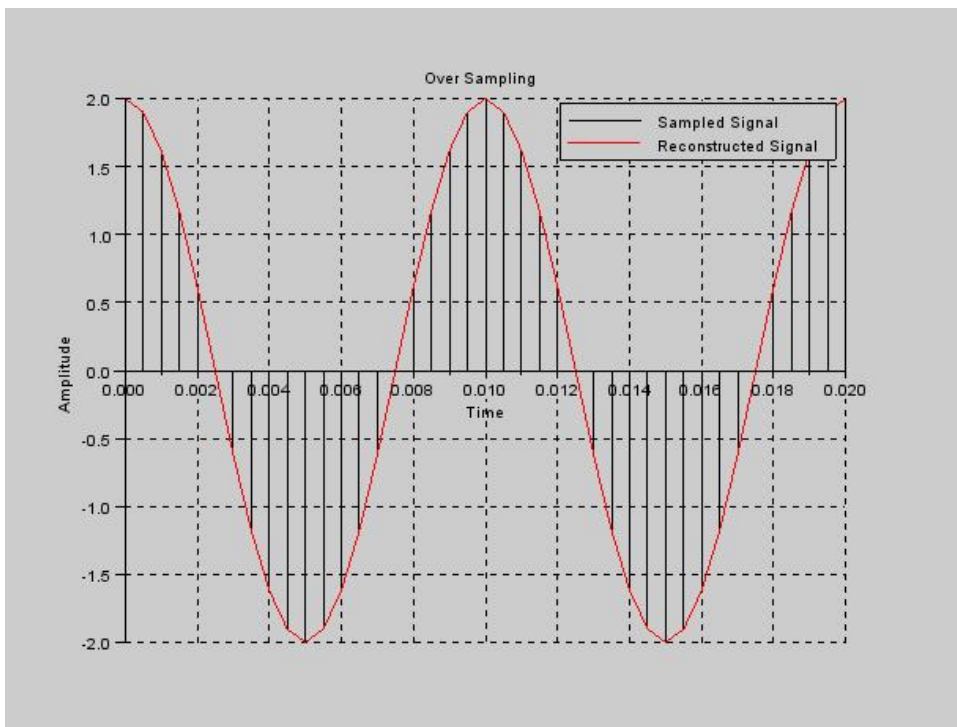


Figure 1.2: Verification of Sampling Theorem

Experiment: 2

Impulse response of a given system

Scilab code Solution 2.2 Program to find impulse response and Frequency Response of a system

```
1 //Caption: Program to find impulse response and
2 //Frequency Response of a system
3 //y[n] = a*y[n-1]+x[n]
4 //Assume y[n] = h[n], x[n]=delta[n]=unit impulse
   response
5 //a = 0.9
6 //h[n] = 0.9*h[n-1]+delta[n]
7 clc;
8 clear;
9 close;
10 a = 0.9; //constant a = 0.9 less than 1
11 h0 = 1;
12 h1 = a; //first two values of impulse response
13 h = [h0,h1,zeros(1,100)];
14 for i = 1:100
15     h(i+2) = ((a)^(i+1))*h(i+1); //impulse response
```

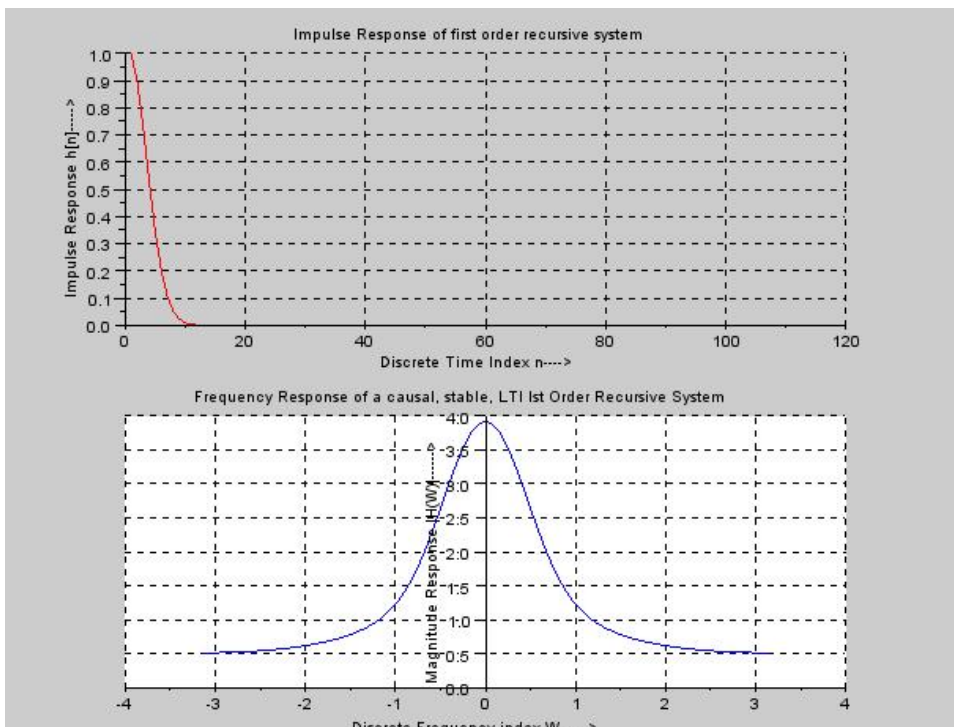


Figure 2.1: Program to find impulse response and Frequency Response of a system

```

16 end
17 [HW,W] = frmag(h,512); //frequency response
18 figure(1)
19 subplot(2,1,1)
20 a = gca();
21 a.x_location = 'origin';
22 a.y_location = 'origin';
23 plot([1:length(h)],h,'r');
24 xlabel('Discrete Time Index n——>');
25 ylabel('Impulse Response h[n]————>');
26 title('Impulse Response of first order recursive
        system');
27 xgrid(1)
28 subplot(2,1,2)
29 a = gca();
30 a.x_location = 'origin';
31 a.y_location = 'origin';
32 plot([mtlbfliplr(-2*pi*W),2*pi*W(2:$)],[
        mtlb_fliplr(abs(HW)),abs(HW(2:$))])
33 xlabel('Discrete Frequency index W————>')
34 ylabel('Magnitude Response |H(W)|————>')
35 title('Frequency Response of a causal, stable, LTI
        Ist Order Recursive System');
36 xgrid(1)

```

Experiment: 3

Linear Circular convolution of two given sequences

Scilab code Solution 3.1 Program to Compute the Convolution of Two Sequences

```
1 //Caption: Program to Compute the Convolution of Two
   Sequences
2 clc;
3 clear;
4 close;
5 x = input('Enter the input Sequence:=');
6 m = length(x);
7 lx = input('Enter the lower index of input sequence
   :=')
8 hx = lx+m-1;
9 n = lx:1:hx;
10 h = input('Enter impulse response sequence:=');
11 l = length(h);
12 lh = input('Enter the lower index of impulse
   response:=')
13 hh = lh+1-1;
```

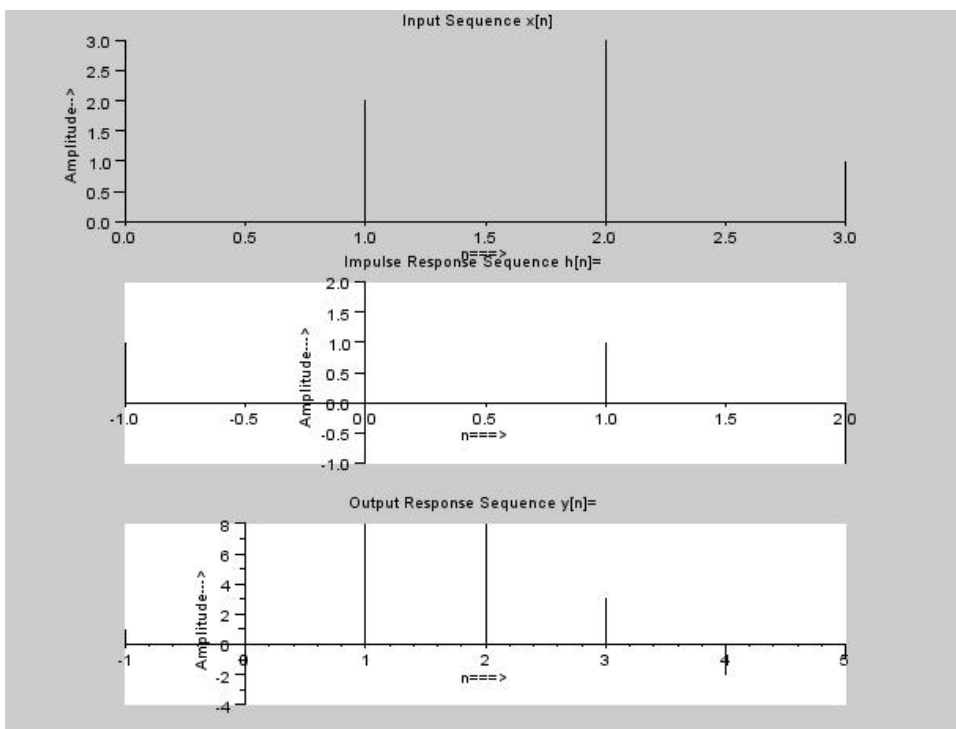


Figure 3.1: Program to Compute the Convolution of Two Sequences

```

14 g = lh:1:hh;
15 nx = lx+lh;
16 nh = nx+m+1-2;
17 y = convol(x,h)
18 r = nx:nh;
19 figure(1)
20 subplot(3,1,1)
21 a = gca();
22 a.x_location = "origin";
23 a.y_location = "origin";
24 plot2d3('gmn',n,x)
25 xlabel('n====>')
26 ylabel('Amplitude—>')
27 title('Input Sequence x[n]')
28 subplot(3,1,2)
29 a = gca();
30 a.x_location = "origin";
31 a.y_location = "origin";
32 plot2d3('gmn',g,h)
33 xlabel('n====>')
34 ylabel('Amplitude—>')
35 title('Impulse Response Sequence h[n]=')
36 subplot(3,1,3)
37 a = gca();
38 a.x_location = "origin";
39 a.y_location = "origin";
40 plot2d3('gmn',r,y)
41 xlabel('n====>')
42 ylabel('Amplitude—>')
43 title('Output Response Sequence y[n]=')
44 //Example
45 //Enter the input Sequence:=[1,2,3,1]
46 //
47 //Enter the lower index of input sequence:=0
48 //
49 //Enter impulse response sequence:=[1,2,1,-1]
50 //
51 //Enter the lower index of impulse response:=-1

```

```
52 //
53 //
54 //→y
55 // y =
56 //
57 // 1. 4. 8. 8. 3. - 2. - 1.
58 //
```

Experiment: 4

Autocorrelation of a given sequence and verification of its properties.

Scilab code Solution 4.1 Program to Compute the Autocorrelation of a Sequence And verification of Autocorrelation property

```
1 //Caption: Program to Compute the Autocorrelation of
  a Sequence
2 //And verification of Autocorrelation property
3 clc;
4 clear;
5 close;
6 x = input('Enter the input Sequence:=');
7 m = length(x);
8 lx = input('Enter the lower index of input sequence
  :=')
9 hx = lx+m-1;
10 n = lx:1:hx;
11 x_fold = x($:-1:1);
12 nx = lx+lx;
13 nh = nx+m+m-2;
14 r = nx:nh;
```

```

15 Rxx = convol(x,x_fold);
16 disp(Rxx,'Auto Correlation Rxx[n]:=')
17 //Property 1: Autocorrelation of a sequence has even
    symmetry
18 //Rxx[n] = Rxx[-n]
19 Rxx_flip = Rxx([$:-1:1]);
20 if Rxx_flip==Rxx then
21     disp('Property 1:Auto Correlation has Even
        Symmetry');
22     disp(Rxx_flip,'Auto Correlation time reversed
        Rxx[-n]:=');
23 end
24 //Property 2: Center value Rxx[0]= total power of
    the sequence
25 Tot_Px = sum(x.^2);
26 Mid = ceil(length(Rxx)/2);
27 if Tot_Px == Rxx(Mid) then
28     disp('Property 2:Rxx[0]=center value=max. value=
        Total power of i/p sequence');
29 end
30 subplot(2,1,1)
31 plot2d3('gnn',n,x)
32 xlabel('n====>')
33 ylabel('Amplitude—>')
34 title('Input Sequence x[n]')
35 subplot(2,1,2)
36 plot2d3('gnn',r,Rxx)
37 xlabel('n====>')
38 ylabel('Amplitude—>')
39 title('Auto correlation Sequence Rxx[n]')
40 //Example
41 //Enter the input Sequence:=[2,-1,3,4,1]
42 //
43 //Enter the lower index of input sequence:=-2
44 //
45 // Auto Correlation Rxx[n]:=
46 //
47 //      2.      7.      5.      11.      31.      11.      5.

```

```
7.      2.
48 //
49 // Property 1:Auto Correlation has Even Symmetry
50 //
51 // Auto Correlation time reversed Rxx[-n]:=
52 //
53 //      2.      7.      5.      11.      31.      11.      5.
54 //      7.      2.
55 // Property 2:Rxx[0]=center value=max. value=Total
power of i/p sequence
```

Experiment: 5

Cross correlation of given sequences and verification of its properties.

Scilab code Solution 5.1 Program to Compute the Crosscorrelation of a Sequence And verification of crosscorrelation property

```
1 //Caption: Program to Compute the Crosscorrelation
   of a Sequence
2 //And verification of crosscorrelation property
3 clc;
4 clear;
5 close;
6 x = input('Enter the First input Sequence:= ');
7 y = input('Enter the second input Sequence:= ');
8 mx = length(x);
9 my = length(y);
10 lx = input('Enter the lower index of first input
   sequence:= ');
11 ly = input('Enter the lower index of second input
   sequence:= ');
12 hx = lx+mx-1;
13 n = lx:1:hx;
```

```

14 x_fold = x($:-1:1);
15 y_fold = y($:-1:1);
16 nx = lx+ly;
17 ny = nx+mx+my-2;
18 r = nx:ny;
19 Rxy = convol(x,y_fold);
20 Ryx = convol(x_fold,y);
21 disp(Rxy,'Cross Correlation Rxy[n]:=')
22 count =1;
23 //Property 1: crosscorrelation of a sequence has
    Antisymmetry
24 //Rxy[n] = Ryx[-n]
25 Ryx_flip = Ryx([$:-1:1]);
26 for i = 1:length(Rxy)
27     if (ceil(Ryx_flip(i))==ceil(Rxy(i))) then
28         count = count+1;
29     end
30 end
31 if (count==length(Rxy)) then
32     disp('Property 1:Cross Correlation has
        AntiSymmetry: Rxy[n]=Ryx[-n]');
33 end
34 //Property 2:% Verification of Energy Property of
    Rxy
35 Ex = sum(x.^2);
36 Ey = sum(y.^2);
37 E = sqrt(Ex*Ey);
38 Mid = ceil(length(Rxy)/2);
39 if (E >= Rxy(Mid)) then
40     disp('Property 2:Energy Property of Cross
        Correlation verified')
41 end
42 subplot(2,1,1)
43 plot2d3('gnn',n,x)
44 xlabel('n====>')
45 ylabel('Amplitude—>')
46 title('Input Sequence x[n]')
47 subplot(2,1,2)

```

```

48 plot2d3('gnn',r,Rxy)
49 xlabel('n====>')
50 ylabel('Amplitude—>')
51 title('Cross correlation Sequence Rxy[n]')
52 //Example
53 //Enter the First input Sequence:=[1,2,1,1]
54 //Enter the second input Sequence:=[1,1,2,1]
55 //Enter the lower index of first input sequence:=0
56 //Enter the lower index of second input sequence:=0
57 //Cross Correlation Rxy[n]:=
58 //      1.      4.      6.      6.      5.      2.      1.
59 //Property 1:Cross Correlation has AntiSymmetry: Rxy
      [n]=Ryx[-n]
60 //
61 // Property 2:Energy Property of Cross Correlation
      verified

```

Experiment: 6

Solving a given difference equation.

Scilab code Solution 6.1 Solving Difference Equation Direct Form II Realization

```
1 //Caption: Solving Difference Equation
2 //Direct Form-II Realization
3 //Finding out the Output Response of the first order
4 //system(Filter)
5 clc;
6 clear;
7 close;
8 x =
    [1,1/2,1/4,1/8,1/16,1/32,1/64,1/128,1/256,1/512];
9 b = [3,-4/3]; //numerator polynomials
10 a = [1,-1/3]; //denominator polynomials
11 p = length(a)-1;
12 q = length(b)-1;
13 pq = max(p,q);
14 a = a(2:p+1);
15 w = zeros(1,pq);
16 for i = 1:length(x)
17     wnew = x(i)-sum(w(1:p).*a);
```

```
18     w = [wnew,w];
19     y(i) = sum(w(1:q+1).*b);
20 end
21 disp(y,'Output Response y[n]= ');
22 //Result
23 //Output Response y[n]=
24 //      3.
25 //      1.1666667
26 //      0.4722222
27 //      0.1990741
28 //      0.0871914
29 //      0.0394805
30 //      0.0183685
31 //      0.0087270
32 //      0.0042111
33 //      0.0020547
```

Experiment: 7

Computation of N point DFT of a given sequence and to plot magnitude and phase spectrum.

Scilab code Solution 7.1 Program to find the spectral information of discrete time signal Calculation of DFT and IDFT

```
1 //Caption: Program to find the spectral information
   of discrete time signal
2 //Calculation of DFT and IDFT
3 //Plotting Magnitude and Phase Spectrum
4 clc;
5 close;
6 clear;
7 xn = input('Enter the real input discrete sequence x
   [n]= ');
8 N = length(xn);
9 XK = zeros(1,N);
10 IXK = zeros(1,N);
11 //Code block to find the DFT of the Sequence
12 for K = 0:N-1
```

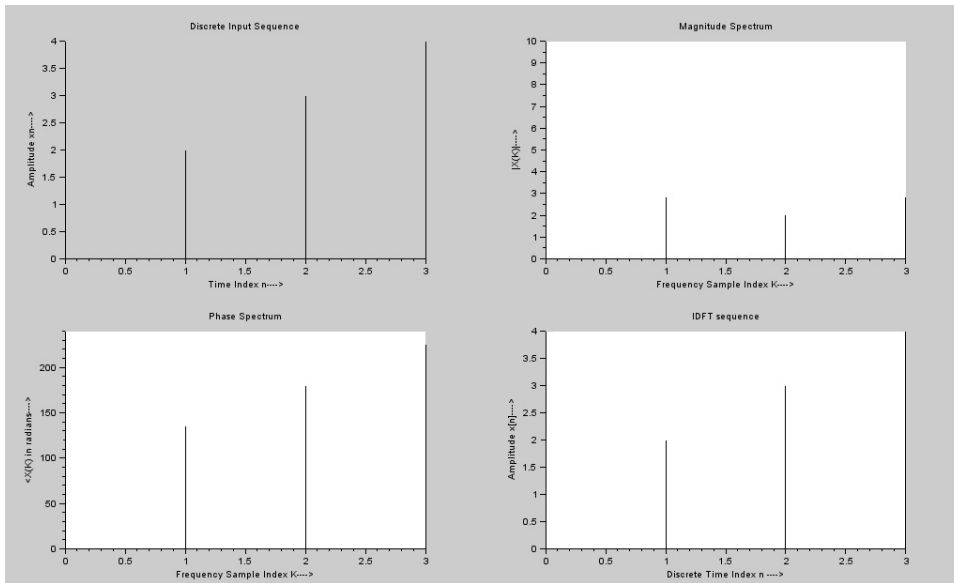


Figure 7.1: Program to find the spectral information of discrete time signal
Calculation of DFT and IDFT

```

13     for n = 0:N-1
14         XK(K+1) = XK(K+1)+xn(n+1)*exp(-%i*2*%pi*K*n/
           N);
15     end
16 end
17 [phase,db] = phasemag(XK)
18 disp(XK,'Discrete Fourier Transform X(k)=')
19 disp(abs(XK),'Magnitude Spectral Samples=')
20 disp(phase,'Phase Spectral Samples=')
21 n = 0:N-1;
22 K = 0:N-1;
23 figure(1)
24 subplot(2,2,1)
25 a = gca();
26 a.x_location = "origin";
27 a.y_location = "origin";
28 plot2d3('gnn',n,xn)
29 xlabel('Time Index n——>')

```

```

30 ylabel('Amplitude xn——>')
31 title('Discrete Input Sequence')
32 subplot(2,2,2)
33 a = gca();
34 a.x_location = "origin";
35 a.y_location = "origin";
36 plot2d3('ggn',K,abs(XK))
37 xlabel('Frequency Sample Index K——>')
38 ylabel('|X(K)|——>')
39 title('Magnitude Spectrum')
40 subplot(2,2,3)
41 a = gca();
42 a.x_location = "origin";
43 a.y_location = "origin";
44 plot2d3('ggn',K,phase)
45 xlabel('Frequency Sample Index K——>')
46 ylabel('<X(K) in radians——>')
47 title('Phase Spectrum')
48 //Code block to find the IDFT of the sequence
49 for n = 0:N-1
50     for K = 0:N-1
51         IXK(n+1) = IXK(n+1)+XK(K+1)*exp(%i*2*%pi*K*n
52             /N);
53     end
54 end
55 IXK = IXK/N;
56 ixn = real(IXK);
57 subplot(2,2,4)
58 a = gca();
59 a.x_location = "origin";
60 a.y_location = "origin";
61 plot2d3('ggn',[0:N-1],ixn)
62 xlabel('Discrete Time Index n ——>')
63 ylabel('Amplitude x[n]——>')
64 title('IDFT sequence')
65 //Example
66 //Enter the real input discrete sequence x[n

```

```

    ]=[1,2,3,4]
67 //
68 // Discrete Fourier Transform X(k)=
69 //
70 //      10. - 2. + 2.i - 2. - 9.797D-16i - 2. - 2.i
71 //
72 // Magnitude Spectral Samples=
73 //
74 //      10.      2.8284271      2.      2.8284271
75 //
76 // Phase Spectral Samples=
77 //
78 //      0.      135.      180.      225.
79 //

```

Experiment: 8

Linear convolution of two sequences using DFT and IDFT.

Scilab code Solution 8.1 Linear Convolution using Circular Convolution
DFT IDFT method

```
1 //Caption: Linear Convolution using Circular
   Convolution
2 //DFT-IDFT method
3 clc;
4 clear;
5 close;
6 x = input('Enter the input discrete sequence:=')
7 h = input('Enter the impulse discrete sequence:=')
8 N1 = length(x);
9 N2 = length(h);
10 N = N1+N2-1; //Linear Convolution result length
11 h = [h, zeros(1, N-N2)];
12 x = [x, zeros(1, N-N1)];
13 //Computing DFT-IDFT
```

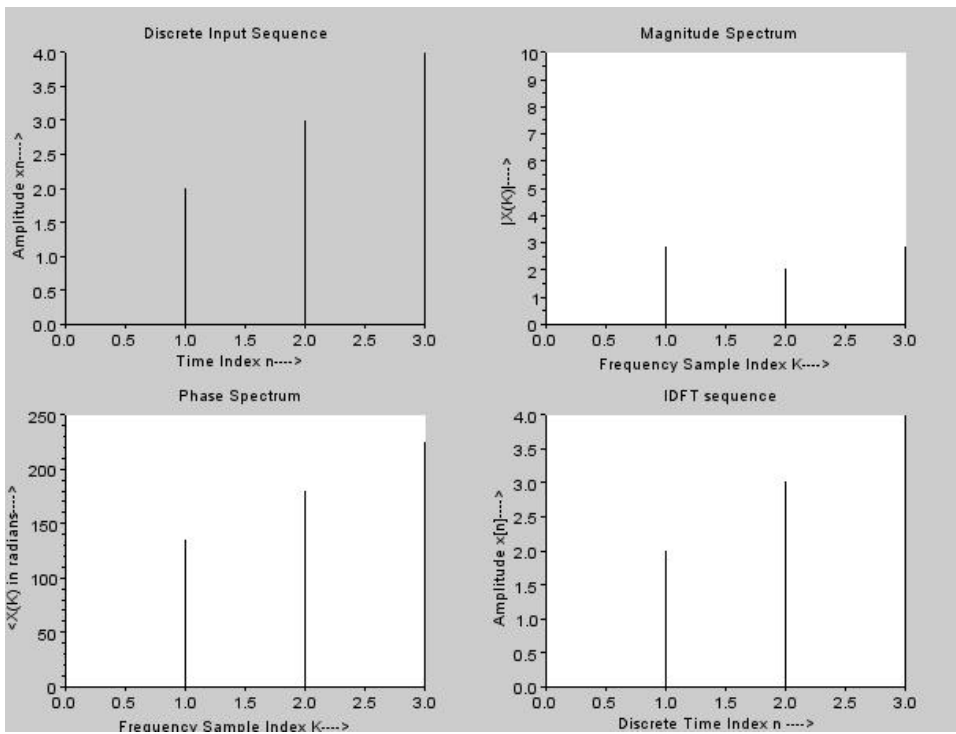


Figure 8.1: Linear Convolution using Circular Convolution DFT IDFT method

```

14 XK = dft(x,-1); //N point DFT of i/p sequence
15 HK = dft(h,-1); //N point DFT of impulse sequence
16 //Multiplication of 2 DFT's
17 YK = XK.*HK;
18 //Linear Convolution result
19 yn = dft(YK,1); //IDFT of Y(K)(o/p sequence)
20 disp(real(yn), 'Linear Convolution result y[n]:= ')
21 //Example
22 //Enter the input discrete sequence:= [1,2,3]
23 //Enter the impulse discrete sequence:=[1,2,2,1]
24 //Linear Convolution result y[n]:=
25 //
26 //      1.
27 //      4.
28 //      9.
29 //     11.
30 //      8.
31 //      3.

```

Experiment: 9

Circular convolution of two given sequences using DFT and IDFT

Scilab code Solution 9.1 Circular Convolution using DFT IDFT method

```
1 //Caption: Circular Convolution using DFT-IDFT
   method
2 clc;
3 clear;
4 close;
5 L = 4; // Length of the sequence
6 N = 4; //N-point DFT
7 x1 = input('Enter the first discrete sequence:x1[n]=
   ');
8 x2 = input('Enter the second discrete sequence:x2[n
   ]= ');
9 //Computing DFT
10 X1K = dft(x1,-1);
11 X2K = dft(x2,-1);
12 //Multiplication of 2 DFT's
13 X3K = X1K.*X2K;
14 x3 = dft(X3K,1); //IDFT of X3(K)
```

```
15 x3 = real(x3);
16 disp(x3, 'Circular Convolution result:x3[n]= ');
17 //Example
18 //Enter the first discrete sequence:x1[n]= [2,1,2,1]
19 //Enter the second discrete sequence:x2[n]=
    [1,2,3,4]
20 //
21 // Circular Convolution result:x3[n]=
22 //
23 //      14.
24 //      16.
25 //      14.
26 //      16.
```

Experiment: 10

Design and implementation of FIR filter to meet given specifications.

Scilab code Solution 10.1 To Design an Low Pass FIR Filter

```
1 //Caption: To Design an Low Pass FIR Filter
2 clc;
3 clear;
4 close;
5 wp= input('Enter the pass band edge (rad)= ');
6 ws= input('Enter the stop band edge (rad)= ');
7 ks= input('Enter the stop band attenuation (dB)= ');
8 //If 43<Ks<54 choose hamming window.
9 //To select N,order of filter.
10 N= (2*%pi*4)./(ws-wp); // k=4 for Hamming window.
11 N= ceil(N); //To round-off N to the next integer.
12 wc=(wp+(ws-wp)/2)./%pi
13 // To obtain FIR filter Impulse Response 'wft'
14 //And FIR Filter Frequency response 'wfm'
15 [wft,wfm,fr]=wfirm('lp',N+1,[wc/2,0],'hm',[0,0]);
```

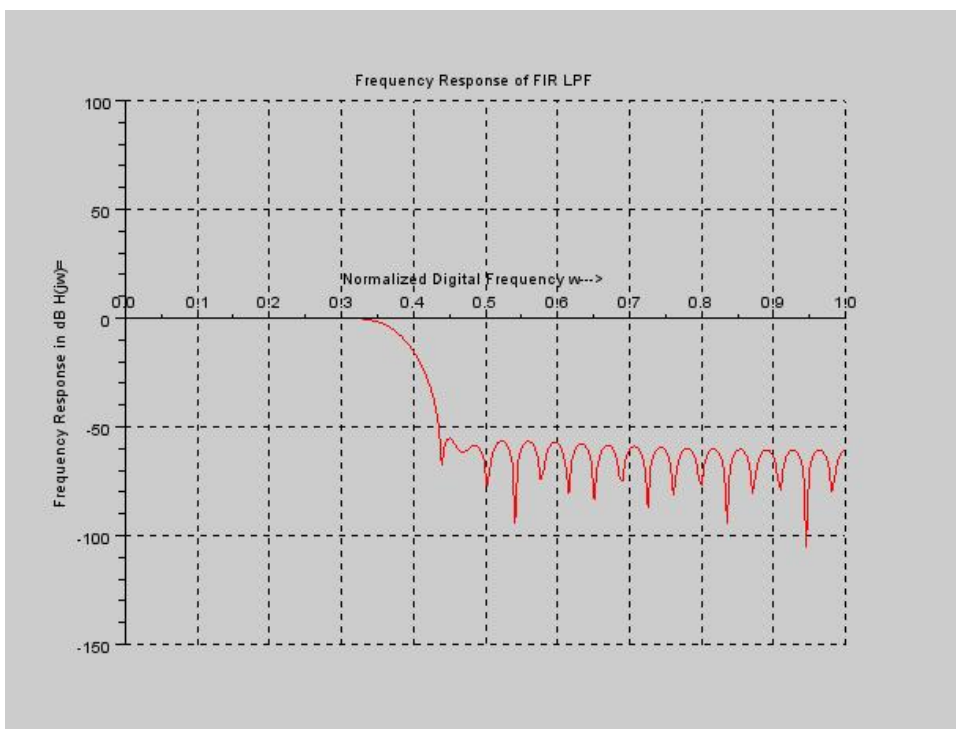


Figure 10.1: To Design an Low Pass FIR Filter

```

16 figure(1)
17 a = gca();
18 a.x_location = "origin";
19 a.y_location = "origin";
20 a.data_bounds = [0,-150;1,50];
21 plot(2*fr,20*log10(wfm),'r')
22 xlabel('Normalized Digital Frequency  $\omega \rightarrow$ ')
23 ylabel('Frequency Response in dB  $H(j\omega)=$ ')
24 title('Frequency Response of FIR LPF')
25 xgrid(1)
26 //Result
27 //Enter the pass band edge (rad)= 0.3*%pi
28 //Enter the stop band edge (rad)= 0.45*%pi
29 //Enter the stop band attenuation (dB)= 50
30 //N = 54.
31 //—>wc
32 // wc = 0.375
33 //—>disp(wft,'Impulse Response of FIR LPF=')
34 // Impulse Response of FIR LPF=
35 // column 1 to 7
36 // 0.0003609 - 0.0007195 - 0.0010869 1.575D
// -18 0.0016485 0.0015927 - 0.0010883
37 // column 8 to 14
38 // - 0.0035703 - 0.0017009 0.0038764
0.0061896 - 5.965D-18 - 0.0090208 - 0.0082516
39 // column 15 to 21
40 // 0.0053105 0.0164428 0.0074408 -
0.0162551 - 0.0251602 1.191D-17 0.0359480
41 // column 22 to 28
42 // 0.0334760 - 0.0225187 - 0.0756838 -
0.0394776 0.1111441 0.2931653 0.375
43 // column 29 to 35
44 // 0.2931653 0.1111441 - 0.0394776 -
0.0756838 - 0.0225187 0.0334760 0.0359480
45 // column 36 to 42
46 // 1.191D-17 - 0.0251602 - 0.0162551
0.0074408 0.0164428 0.0053105 - 0.0082516
47 // column 43 to 49

```

```
48 // - 0.0090208 - 5.965D-18 0.0061896
      0.0038764 - 0.0017009 - 0.0035703 - 0.0010883
      column 50 to 55
49 // 0.0015927 0.0016485 1.575D-18 -
      0.0010869 - 0.0007195 0.0003609
```

Experiment: 11

Design and implementation of IIR filter to meet given specifications.

Scilab code Solution 11.1 To obtain Digital IIR Butterworth low pass filter Frequency response

```
1 //Caption: To obtain Digital IIR Butterworth low
   pass filter
2 //Frequency response
3 clc;
4 clear;
5 close;
6 fp= input('Enter the pass band edge (Hz) = ');
7 fs= input('Enter the stop band edge (Hz) = ');
8 kp= input('Enter the pass band attenuation (dB) = ')
   ;
9 ks= input('Enter the stop band attenuation (dB) = ')
   ;
10 Fs= input('Enter the sampling rate samples/sec = ')
     ;
```

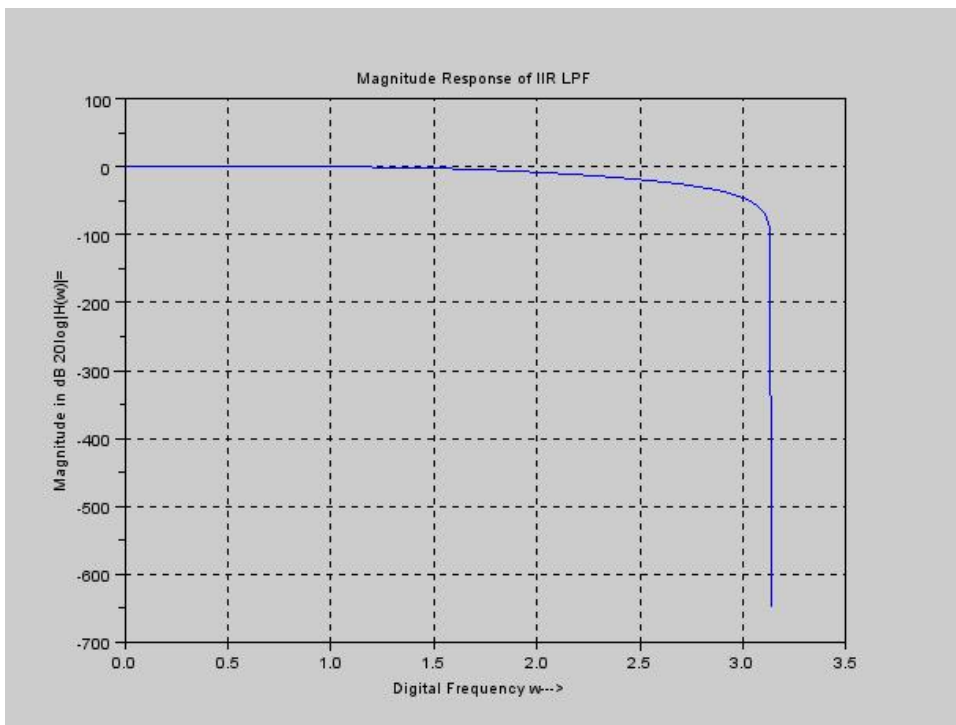


Figure 11.1: To obtain Digital IIR Butterworth low pass filter Frequency response

```

11 d1 = 10^(kp/20);
12 d2 = 10^(ks/20);
13 d = sqrt((1/(d2^2))-1);
14 E = sqrt((1/(d1^2))-1);
15 //Digital filter specifications(rad/samples)
16 wp=2*pi*fp*1/Fs;
17 ws=2*pi*fs*1/Fs;
18 disp(wp,'Digital Pass band edge freq in rad/samples
      wp=')
19 disp(ws,'Digital Stop band edge freq in rad/samples
      ws=')
20 //Pre warping
21 op=2*Fs*tan(wp/2);
22 os=2*Fs*tan(ws/2);
23 disp(op,'Analog Pass Band Edge Freq. in rad/sec op='
      )
24 disp(os,'Analog Stop band Edge Freq. in rad/sec os='
      )
25 N = log10(d/E)/log10(os/op);
26 oc = op/((E^2)^(1/(2*N)));
27 N = ceil(N);//rounded to nearest integer
28 disp(N,'IIR Filter order N =');
29 disp(oc,'Cutoff Frequency in rad/seconds OC = ')
30 [pols,gn] = zpbutt(N,oc);
31 disp(gn,'Gain of Analog IIR Butterworth LPF Gain =')
32 disp(pols,'Poles of Analog IIR Butterworth LPF Poles
      =')
33 HS = poly(gn,'s','coeff')/real(poly(pols,'s'));
34 disp(HS,'Transfer function of Analog IIR
      Butterworth LPF H(S)=')
35 z = poly(0,'z')
36 Hz = horner(HS,(2*Fs*(z-1)/(z+1)))
37 num = coeff(Hz(2))
38 den = coeff(Hz(3))
39 Hz(2)= Hz(2)./den(3);
40 Hz(3) = Hz(3)./den(3);
41 disp(Hz,'Transfer function of Digital IIR
      Butterworth LPF H(Z)=')

```

```

42 [Hw,w] = frmag(Hz,256);
43 figure(1)
44 plot(2*w*pi,20*log10(abs(Hw)));
45 xlabel('Digital Frequency w—>')
46 ylabel('Magnitude in dB 20log |H(w)|=')
47 title('Magnitude Response of IIR LPF')
48 xgrid(1)
49 //Result
50 //Enter the pass band edge (Hz) = 1500
51 //
52 //Enter the stop band edge (Hz) = 2000
53 //
54 //Enter the pass band attenuation (dB) = -1
55 //
56 //Enter the stop band attenuation (dB) = -3
57 //
58 //Enter the sampling rate samples/sec = 8000
59 //
60 // Digital Pass band edge freq in rad/samples wp=
61 //
62 // 1.1780972
63 //
64 // Digital Stop band edge freq in rad/samples ws=
65 //
66 // 1.5707963
67 //
68 // Analog Pass Band Edge Freq. in rad/sec op=
69 //
70 // 10690.858
71 //
72 // Analog Stop band Edge Freq. in rad/sec os=
73 //
74 // 16000.
75 //
76 // IIR Filter order N =
77 //
78 // 2.
79 //

```

```

80 // Cutoff Frequency in rad/seconds OC =
81 //
82 //     16022.769
83 //
84 // Gain of Analog IIR Butterworth LPF Gain =
85 //
86 //     2.567D+08
87 //
88 // Poles of Analog IIR Butterworth LPF Poles =
89 //
90 //     - 11329.809 + 11329.809 i     - 11329.809 -
91 //     11329.809 i
92 // Transfer function of Analog IIR Butterworth LPF
93 // H(S)=
94 //
95 //     2.567D+08
96 //     -----
97 //           2
98 //     2.567D+08 + 22659.618 s + s
99 // Transfer function of Digital IIR Butterworth LPF
100 // H(Z)=
101 //
102 //           2
103 //     0.2933099 + 0.5866197 z + 0.2933099 z
104 //     -----
105 //           2
106 //     0.1715734 + 0.0016661 z + z

```

Scilab code Solution 11.2 To obtain Digital IIR Chebyshev low pass filter Frequency response

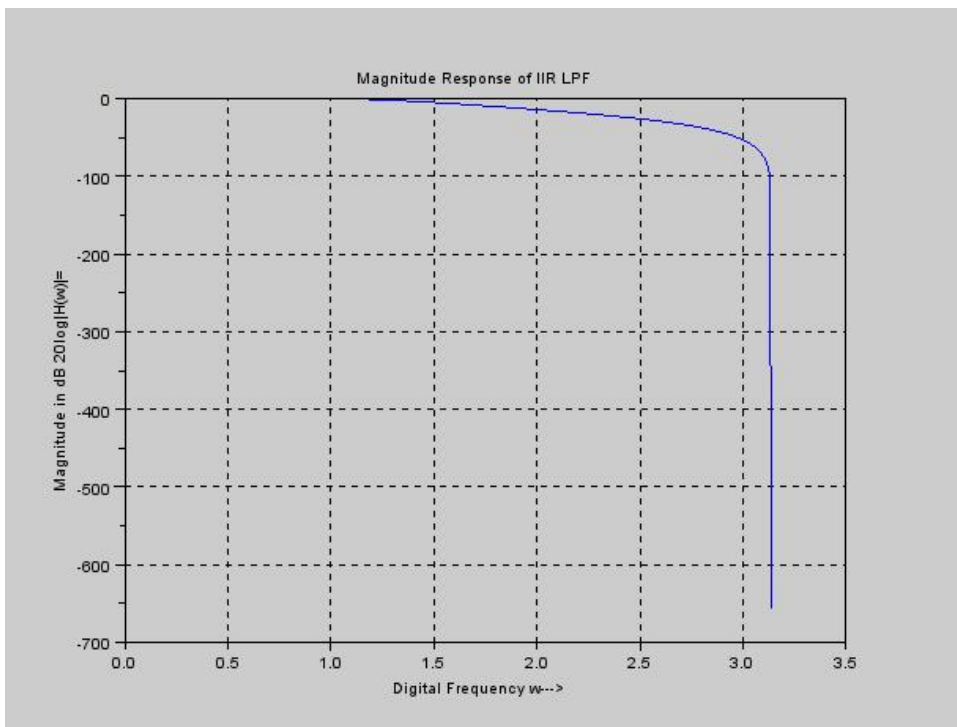


Figure 11.2: To obtain Digital IIR Chebyshev low pass filter Frequency response

```

1 //Caption: To obtain Digital IIR Chebyshev low pass
  filter
2 //Frequency response
3 clc;
4 clear;
5 close;
6 fp= input('Enter the pass band edge (Hz) = ');
7 fs= input('Enter the stop band edge (Hz) = ');
8 kp= input('Enter the pass band attenuation (dB) = ');
  ;
9 ks= input('Enter the stop band attenuation (dB) = ');
  ;
10 Fs= input('Enter the sampling rate samples/sec = ');
  ;
11 d1 = 10^(kp/20);
12 d2 = 10^(ks/20);
13 d = sqrt((1/(d2^2))-1);
14 E = sqrt((1/(d1^2))-1);
15 //Digital filter specifications(rad/samples)
16 wp=2*%pi*fp*1/Fs;
17 ws=2*%pi*fs*1/Fs;
18 disp(wp,'Digital Pass band edge freq in rad/samples
  wp=')
19 disp(ws,'Digital Stop band edge freq in rad/samples
  ws=')
20 //Pre warping
21 op=2*Fs*tan(wp/2);
22 os=2*Fs*tan(ws/2);
23 disp(op,'Analog Pass Band Edge Freq. in rad/sec op='
  )
24 disp(os,'Analog Stop band Edge Freq. in rad/sec os='
  )
25 N = acosh(d/E)/acosh(os/op);
26 oc = op/((E^2)^(1/(2*N)));
27 N = ceil(N);//rounded to nearest integer
28 disp(N,'IIR Filter order N =');
29 disp(oc,'Cutoff Frequency in rad/seconds OC = ')
30 [pols,gn] = zpchl(N,E,op);

```

```

31 disp(gn, 'Gain of Analog IIR Chebyshev Type-I LPF
    Gain =')
32 disp(pols, 'Poles of Analog IIR Chebyshev Type-I LPF
    Poles =')
33 HS = poly(gn, 's', 'coeff')/real(poly(pols, 's'));
34 disp(HS, 'Transfer function of Analog IIR Chebyshev
    Type-I LPF H(S)=')
35 z = poly(0, 'z')
36 Hz = horner(HS, (2*Fs*(z-1)/(z+1)))
37 num = coeff(Hz(2))
38 den = coeff(Hz(3))
39 Hz(2) = Hz(2) ./ den(3);
40 Hz(3) = Hz(3) ./ den(3);
41 disp(Hz, 'Transfer function of Digital IIR Chebyshev
    LPF H(Z)=')
42 [Hw, w] = frmag(Hz, 256);
43 figure(1)
44 plot(2*w*pi, 20*log10(abs(Hw)));
45 xlabel('Digital Frequency w-->')
46 ylabel('Magnitude in dB 20log |H(w)|=')
47 title('Magnitude Response of IIR LPF')
48 xgrid(1)
49 //Result
50 //Enter the pass band edge (Hz) = 1500
51 //
52 //Enter the stop band edge (Hz) = 2000
53 //
54 //Enter the pass band attenuation (dB) = -1
55 //
56 //Enter the stop band attenuation (dB) = -3
57 //
58 //Enter the sampling rate samples/sec = 8000
59 //
60 // Digital Pass band edge freq in rad/samples wp=
61 //
62 // 1.1780972
63 //
64 // Digital Stop band edge freq in rad/samples ws=

```

```

65 //
66 //      1.5707963
67 //
68 // Analog Pass Band Edge Freq. in rad/sec op=
69 //
70 //      10690.858
71 //
72 // Analog Stop band Edge Freq. in rad/sec os=
73 //
74 //      16000.
75 //
76 // IIR Filter order N =
77 //
78 //      2.
79 //
80 // Cutoff Frequency in rad/seconds OC =
81 //
82 //      17642.912
83 //
84 // Gain of Analog IIR Chebyshev Type-I LPF Gain =
85 //
86 //      1.123D+08
87 //
88 // Poles of Analog IIR Chebyshev Type-I LPF Poles =
89 //
90 //      - 5867.861 + 9569.6927i   - 5867.861 - 9569.6927i
91 //
92 // Transfer function of Analog IIR Chebyshev Type-I
93 // LPF H(S)=
94 //
95 //      1.123D+08
96 //      _____
97 //                                 2
98 //      1.260D+08 + 11735.722s + s
99 // Transfer function of Digital IIR Chebyshev LPF H(
100 // Z)=

```


Experiment: 12

Circular convolution of two given sequences

Scilab code Solution 12.1 Program to perform circular convolution of two sequences

```
1 //Caption: Program to perform circular convolution
  of two sequences
2 clc;
3 clear;
4 close;
5 x1 = input('Enter the first discrete sequence:=')
6 x2 = input('Enter the second discrete sequence:=')
7 m = length(x1); //length of first sequence
8 n = length(x2); //length of second sequence
9 //To make length of x1 and x2 are equal
10 if(m>n)
11     for i = n+1:m
12         x2(i)=0;
13     end
14 elseif(n>m)
15     for i = m+1:n
16         x1(i)=0;
17     end
```

```

18 end
19 N = length(x1);
20 x3 = zeros(1,N); //circular convolution result
    initialized to zero
21 a(1) = x2(1);
22 for j = 2:N
23     a(j) = x2(N-j+2);
24 end
25 for i = 1:N
26     x3(1) = x3(1)+x1(i)*a(i);
27 end
28 X(1,:) = a;
29 //Calculation of circular convolution
30 for k =2:N
31     for j = 2:N
32         x2(j) = a(j-1);
33     end
34 x2(1) = a(N);
35 X(k,:) = x2;
36     for i = 1:N
37         a(i) = x2(i);
38         x3(k) = x3(k)+x1(i)*a(i);
39     end
40 end
41 disp(x3,'Circular Convolution Result x3[n]=')
42 //Example
43 //Enter the first discrete sequence:= [2,1,2,1]
44 //Enter the second discrete sequence:= [1,2,3,4]
45 //Circular Convolution Result x3[n]=
46 //     14.     16.     14.     16.
47 //

```
