

Scilab Manual for
Digital Signal Processing
by Mr Kaustubh Shivaji Sagale
Electronics Engineering
S.S.V.P.S's B.S.D. C.O.E.¹

Solutions provided by
Mr R. Senthilkumar
Electrical Engineering
IRTT

July 16, 2024

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

Contents

List of Scilab Solutions	3
1 Basic operations on sequences of equal and unequal lengths.	4
2 Sampling of continuous time signal and aliasing effect.	11
3 Convolution of two sequence Impulse response.	13
4 Spectrum of signals using DFT.	16
5 Designing of FIR Filter.	19
6 Designing of IIR Filter.	21

List of Experiments

Solution 1.1	Program for addition of two sequences of unequal lengths	4
Solution 1.2	Program for multiplication of two sequences of unequal lengths	5
Solution 1.3	Program to Demonstrate the signal Folding	6
Solution 1.4	Program to demonstrate the Amplitude and Time Scaling of a signal	7
Solution 1.5	Program to demonstrate the shifting of the discrete time signal	8
Solution 1.6	Program to Generate Sine Waveform for one cycle	10
Solution 2.1	Program to demonstrate the Aliasing Effect	11
Solution 3.1	Program to Compute the Convolution of Two Sequences	13
Solution 4.1	Program to find the spectral information of discrete time signal	16
Solution 5.1	To Design an Low Pass FIR Filter	19
Solution 6.1	To Design Digital IIR Butterworth LPF	21

Experiment: 1

Basic operations on sequences of equal and unequal lengths.

Scilab code Solution 1.1 Program for addition of two sequences of unequal lengths

```
1 //Caption:Program for addition of two sequences of
   unequal lengths
2 clc;
3 clear;
4 close;
5 x = input('Enter Seq.= ');
6 y = input('Enter Seq.= ');
7 m = length(x);
8 n = length(y);
9 if m>n then
10     y = [y,zeros(1,m-n)];
11 elseif n>m
12     x = [x,zeros(1,n-m)];
13 end
14 z = x+y;
15 disp(z,'Addition result of two unequal length
   sequences:= ');
16 //Example
```

```

17 //Enter Seq.=[1,2,3]
18 //
19 //Enter Seq.=[1,1,1,1]
20 //
21 // Addition result of two unequal length sequences:=
22 //
23 //      2.      3.      4.      1.

```

Scilab code Solution 1.2 Program for multiplication of two sequences of unequal lengths

```

1 //Caption:Program for multiplication of two
  sequences of unequal lengths
2 clc;
3 clear;
4 close;
5 x = input('Enter Seq.= ');
6 y = input('Enter Seq.= ');
7 m = length(x);
8 n = length(y);
9 if m>n then
10     y = [y,zeros(1,m-n)];
11 elseif n>m
12     x = [x,zeros(1,n-m)];
13 end
14 z = x.*y;
15 disp(z, 'Multiplication result of two unequal length
  sequences:= ');
16 //Example
17 //Enter Seq.=[1,2,3]
18 //
19 //Enter Seq.=[1,1,1,1]
20 //
21 // Multiplication result of two unequal length
  sequences:=

```

```
22 //
23 //      1.      2.      3.      0.
```

Scilab code Solution 1.3 Program to Demonstrate the signal Folding

```
1 //Caption: Program to Demonstrate the signal Folding
2 clc;
3 clear;
4 x = input('Enter the input sequence:=');
5 m = length(x);
6 lx = input('Enter the starting point of original
      signal=');
7 hx = lx+m-1;
8 n = lx:1:hx;
9 subplot(2,1,1)
10 a = gca();
11 a.x_location = "origin";
12 a.y_location = "origin";
13 a.data_bounds = [-5,0;5,5];
14 plot2d3('gnn',n,x)
15 xlabel('n====>')
16 ylabel('Amplitude——>')
17 title('Original Sequence')
18 subplot(2,1,2)
19 a = gca();
20 a.x_location = "origin";
21 a.y_location = "origin";
22 a.data_bounds = [-5,0;5,5];
23 plot2d3(-n,x)
24 xlabel('n====>')
25 ylabel('Amplitude——>')
26 title('Folded Sequence')
```

Scilab code Solution 1.4 Program to demonstrate the Amplitude and Time Scaling of a signal

```
1 //Caption: Program to demonstrate the Amplitude &
   Time Scaling of a signal
2 clc;
3 clear;
4 x = input('Enter input Sequence:= ');
5 m = length(x);
6 lx = input('Enter starting point of original signal
   := ')
7 hx = lx+m-1;
8 n = lx:1:hx;
9 subplot(2,2,1)
10 a = gca();
11 a.x_location = "origin";
12 a.y_location = "origin";
13 a.data_bounds = [-10,0;10,10];
14 plot2d3('gnn',n,x)
15 xlabel('n====>')
16 ylabel('Amplitude——>')
17 title('original sequence')
18 //Amplitude Scaling
19 a = input('Amplitude Scaling Factor:= ')
20 y =a*x;
21 subplot(2,2,2)
22 a = gca();
23 a.x_location = "origin";
24 a.y_location = "origin";
25 a.data_bounds = [-10,0;10,10];
26 plot2d3('gnn',n,y)
27 xlabel('n====>')
28 ylabel('Amplitdue——>')
29 title('Amplitude Scaled Sequence')
30 //Time Scaling-Compression
31 C = input('Enter Compression factor-Time Scaling
   factor ')
32 n = lx/C:1/C:hx/C;
```



```

33 subplot(2,2,3)
34 a = gca();
35 a.x_location = "origin";
36 a.y_location = "origin";
37 a.data_bounds = [-10,0;10,10];
38 plot2d3('gnn',n,x)
39 xlabel('n====>')
40 ylabel('Amplitude——>')
41 title('Compressed Sequence')
42 //Time Scaling–Expansion
43 d = input('Enter Extension factor–Time Scaling
           factor ')
44 n = lx*d:d:hx*d;
45 subplot(2,2,4)
46 a = gca();
47 a.x_location = "origin";
48 a.y_location = "origin";
49 a.data_bounds = [-10,0;10,10];
50 plot2d3('gnn',n,x)
51 xlabel('n====>')
52 ylabel('Amplitude——>')
53 title('Extended Sequence')
54 //Example
55 //Enter input Sequence:=[1,2,3,4,5]
56 //
57 //Enter starting point of original signal:= 2
58 //
59 //Amplitude Scaling Factor:= 2
60 //
61 //Enter Compression factor–Time Scaling factor 2
62 //
63 //Enter Extension factor–Time Scaling factor 2

```

Scilab code Solution 1.5 Program to demonstrate the shifting of the discrete time signal

```

1 //Caption:Program to demonstrate the shifting of the
   discrete time signal
2 clc;
3 clear;
4 close;
5 x = input('Enter the input sequence:=')
6 m = length(x);
7 lx = input('Enter the starting point of original
   signal:=')
8 hx = lx+m-1;
9 n = lx:1:hx;
10 subplot(3,1,1)
11 a = gca();
12 a.x_location = "origin";
13 a.y_location = "origin";
14 a.data_bounds = [-10,0;10,10];
15 plot2d3('gnn',n,x);
16 xlabel('n====>')
17 ylabel('Amplitdue——>')
18 title('Original Sequence')
19 //
20 d = input('Enter the delay:=')
21 n = lx+d:1:hx+d;
22 subplot(3,1,2)
23 a = gca();
24 a.x_location = "origin";
25 a.y_location = "origin";
26 a.data_bounds = [-10,0;10,10];
27 plot2d3('gnn',n,x)
28 xlabel('n====>')
29 ylabel('Amplitude——>')
30 title('Delayed Sequence')
31 //
32 a = input('Enter the advance:=')
33 n = lx-a:1:hx-a;
34 subplot(3,1,3)
35 a = gca();
36 a.x_location = "origin";

```

```

37 a.y_location = "origin";
38 a.data_bounds = [-10,0;10,10];
39 plot2d3('gmn',n,x)
40 xlabel('n====>')
41 ylabel('Amplitude——>')
42 title('Advanced Sequence')
43 //Example
44 //Enter the input sequence:=[1,2,3,4,5]
45 //
46 //Enter the starting point of original signal:=0
47 //
48 //Enter the delay:=2
49 //
50 //Enter the advance:=3

```

Scilab code Solution 1.6 Program to Generate Sine Waveform for one cycle

```

1 //Caption: Program to Generate Sine Waveform for one
  cycle
2 clc;
3 clear;
4 close;
5 t = 0:0.01:1;
6 f = 1; //frequency = 1Hz (i.e) one cycle
7 y = sin(2*%pi*f*t);
8 plot(2*%pi*t,y)
9 xlabel('time——>')
10 ylabel('Amplitude——>')
11 title('Sinusoidal Waveform')
12 xgrid(1)

```

Experiment: 2

Sampling of continuous time signal and aliasing effect.

Scilab code Solution 2.1 Program to demonstrate the Aliasing Effect

```
1 //Caption: Program to demonstrate the Aliasing
  Effect
2 clc;
3 clear;
4 close;
5 f = input('Enter the frequency of Continuous Time
  Signal:= ')
6 t = 0:0.00001:1/f;
7 xt = 3*sin(2*%pi*f*t);
8 subplot(2,2,1)
9 a = gca();
10 a.x_location = "origin";
11 a.y_location = "origin";
12 plot(t,xt)
13 title('Continuous Time Signal')
14 fs = input('Enter the Sampling frequency Fs='); // fs
  = 3000Hz
15 fd = f/fs;
16 n = 0:0.01:1/fd;
```

```

17 xn = 3*sin(2*pi*fd*n);
18 subplot(2,2,2)
19 a = gca();
20 a.x_location = "origin";
21 a.y_location = "origin";
22 plot2d3('ggn',n,xn)
23 title('Discrete Time Signal')
24 x1 = 3300;
25 x1n = 3*sin(2*pi*(x1/fs)*n);
26 subplot(2,2,3)
27 a = gca();
28 a.x_location = "origin";
29 a.y_location = "origin";
30 plot2d3('ggn',n,x1n)
31 title('Samples of 3300 Hz signal with fs = 3000 Hz')
32 x2 = 30300;
33 x2n = 3*sin(2*pi*(x2/fs)*n);
34 subplot(2,2,4)
35 a = gca();
36 a.x_location = "origin";
37 a.y_location = "origin";
38 plot2d3('ggn',n,x2n)
39 title('Samples of 30300 Hz signal with fs = 3000 Hz'
    )
40 //Example
41 //Enter the frequency of Continuous Time Signal:=
    1500
42 //
43 //Enter the Sampling frequency Fs= 3000

```

Experiment: 3

Convolution of two sequence Impulse response.

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+l-1;
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 subplot(3,1,1)
20 a = gca();
21 a.x_location = "origin";
22 a.y_location = "origin";
23 plot2d3('gnn',n,x)
24 xlabel('n====>')
25 ylabel('Amplitude—>')
26 title('Input Sequence x[n]')
27 subplot(3,1,2)
28 a = gca();
29 a.x_location = "origin";
30 a.y_location = "origin";
31 plot2d3('gnn',g,h)
32 xlabel('n====>')
33 ylabel('Amplitude—>')
34 title('Impulse Response Sequence h[n]=')
35 subplot(3,1,3)
36 a = gca();
37 a.x_location = "origin";
38 a.y_location = "origin";
39 plot2d3('gnn',r,y)
40 xlabel('n====>')
41 ylabel('Amplitude—>')
42 title('Output Response Sequence y[n]=')
43 //Example
44 //Enter the input Sequence:=[1,2,3,1]
45 //
46 //Enter the lower index of input sequence:=0
47 //
48 //Enter impulse response sequence:=[1,2,1,-1]
49 //
50 //Enter the lower index of impulse response:=-1
51 //
52 //
53 //—>y

```

54 // y =
55 //
56 // 1. 4. 8. 8. 3. - 2. - 1.
57 //

Experiment: 4

Spectrum of signals using DFT.

Scilab code Solution 4.1 Program to find the spectral information of discrete time signal

```
1 //Caption: Program to find the spectral information
   of discrete time signal
2 clc;
3 close;
4 clear;
5 xn = input('Enter the real input discrete sequence x
   [n]= ');
6 N = length(xn);
7 XK = zeros(1,N);
8 IXK = zeros(1,N);
9 //Code block to find the DFT of the Sequence
10 for K = 0:N-1
11     for n = 0:N-1
12         XK(K+1) = XK(K+1)+xn(n+1)*exp(-%i*2*%pi*K*n/
   N);
13     end
14 end
15 [phase,db] = phasemag(XK)
16 disp(XK,'Discrete Fourier Transform X(k)=')
17 disp(abs(XK),'Magnitude Spectral Samples=')
```

```

18 disp(phase, 'Phase Spectral Samples=')
19 n = 0:N-1;
20 K = 0:N-1;
21 subplot(2,2,1)
22 a = gca();
23 a.x_location = "origin";
24 a.y_location = "origin";
25 plot2d3('gmn',n,xn)
26 xlabel('Time Index n——>')
27 ylabel('Amplitude xn——>')
28 title('Discrete Input Sequence')
29 subplot(2,2,2)
30 a = gca();
31 a.x_location = "origin";
32 a.y_location = "origin";
33 plot2d3('gmn',K,abs(XK))
34 xlabel('Frequency Sample Index K——>')
35 ylabel('|X(K)|——>')
36 title('Magnitude Spectrum')
37 subplot(2,2,3)
38 a = gca();
39 a.x_location = "origin";
40 a.y_location = "origin";
41 plot2d3('gmn',K,phase)
42 xlabel('Frequency Sample Index K——>')
43 ylabel('<X(K) in radians——>')
44 title('Phase Spectrum')
45 //Code block to find the IDFT of the sequence
46 for n = 0:N-1
47     for K = 0:N-1
48         IXK(n+1) = IXK(n+1)+XK(K+1)*exp(%i*2*%pi*K*n
49             /N);
49     end
50 end
51 IXK = IXK/N;
52 ixn = real(IXK);
53 subplot(2,2,4)
54 a = gca();

```

```

55 a.x_location = "origin";
56 a.y_location = "origin";
57 plot2d3('gnn',[0:N-1],ixn)
58 xlabel('Discrete Time Index n ——>')
59 ylabel('Amplitude x[n]——>')
60 title('IDFT sequence')
61 //Example
62 //
63 //Enter the real input discrete sequence x[n
    ]=[1,2,3,4]
64 //
65 // Discrete Fourier Transform X(k)=
66 //
67 //      10.   - 2. + 2.i   - 2. - 9.797D-16i   - 2. - 2.i
68 //
69 // Magnitude Spectral Samples=
70 //
71 //      10.      2.8284271      2.      2.8284271
72 //
73 // Phase Spectral Samples=
74 //
75 //      0.      135.      180.      225.
76 //

```

Experiment: 5

Designing of FIR Filter.

Scilab code Solution 5.1 To Design an Low Pass FIR Filter

```
1 //Caption: To Design an Low Pass FIR Filter
2 //Filter Length =5, Order = 4
3 //Window = Rectangular Window
4 //Ana
5 clc;
6 clear;
7 xdel(winsid());
8 fc = input("Enter Analog cutoff freq. in Hz=")
9 fs = input("Enter Analog sampling freq. in Hz=")
10 M = input("Enter order of filter =")
11 w = (2*%pi)*(fc/fs);
12 disp(w, 'Digital cutoff frequency in radians.cycles/
    samples');
13 wc = w/%pi;
14 disp(wc, 'Normalized digital cutoff frequency in
    cycles/samples');
15 [wft,wfm,fr]=wfir('lp',M+1,[wc/2,0], 're',[0,0]);
16 disp(wft, 'Impulse Response of LPF FIR Filter:h[n]=')
    ;
17 //Plotting the Magnitude Response of LPF FIR Filter
18 subplot(2,1,1)
```

```

19 plot(2*fr,wfm)
20 xlabel('Normalized Digital Frequency  $w \longrightarrow$ ')
21 ylabel('Magnitude  $|H(w)|=$ ')
22 title('Magnitude Response of FIR LPF')
23 xgrid(1)
24 subplot(2,1,2)
25 plot(fr*fs,wfm)
26 xlabel('Analog Frequency in Hz  $f \longrightarrow$ ')
27 ylabel('Magnitude  $|H(w)|=$ ')
28 title('Magnitude Response of FIR LPF')
29 xgrid(1)
30 //Example
31 //Enter Analog cutoff freq. in Hz= 250
32 //
33 //Enter Analog sampling freq. in Hz= 2000
34 //
35 //Enter order of filter = 4
36 //
37 // Digital cutoff frequency in radians.cycles/
    samples
38 //
39 //      0.7853982
40 //
41 // Normalized digital cutoff frequency in cycles/
    samples
42 //
43 //      0.25
44 //
45 // Impulse Response of LPF FIR Filter:h[n]=
46 //
47 //      0.1591549      0.2250791      0.25      0.2250791
    0.1591549

```

Experiment: 6

Designing of IIR Filter.

Scilab code Solution 6.1 To Design Digital IIR Butterworth LPF

```
1 //Caption: To Design Digital IIR Butterworth LPF
2 //Analog cutoff freq = 1000 Hz, Sampling Freq =
   10000 samples/sec
3 //Order of IIR filter N = 2
4 clc;
5 clear;
6 xdel(winsid());
7 fc = input('Enter cutoff freq in Hz fc =')
8 fs = input('Enter sampling freq in Hz fs =')
9 N = input('Enter order of Butterworth filterN =')
10 Fp = 2*fc/fs; //Pass band edge frequency in cycles/
   samples
11 [Hz]=iir(N, 'lp', 'butt', [Fp/2,0],[0,0]) //digital IIR
   Butterworth Filter
12 [Hw,w] = frmag(Hz,256);
13 subplot(2,1,1)
14 plot(2*w,abs(Hw));
15 xlabel('Normalized Digital Frequency w—>')
16 ylabel('Magnitude |H(w)|=')
17 title('Magnitude Response of IIR LPF')
18 xgrid(1)
```

```

19 subplot(2,1,2)
20 plot(2*w*fs,abs(Hw));
21 xlabel('Analog Frequency in Hz f ——>')
22 ylabel('Magnitude |H(w)|=')
23 title('Magnitude Response of IIR LPF')
24 xgrid(1)
25 //Example
26 //
27 //Enter cutoff freq in Hz fc =1000
28 //
29 //Enter sampling freq in Hz fs =10000
30 //
31 //Enter order of Butterworth filterN = 2
32 // ——>Hz
33 // Hz =
34 //
35 //
36 //      0.0674553 + 0.1349105z + 0.0674553z2
37 //      —————
38 //                                2
39 //      0.4128016 - 1.1429805z + z

```
