SEMESTER IV

17PHU413 DIGITAL SIGNAL PROCESSING PRACTICAL **L T P C**
- - 4 2

Any 8 Experiments

Scilab based simulations experiments based problems like

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence $u(n)$, (c) ramp sequence $r(n)$, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \le n \le 50$.

2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5
$$x(n) = rect\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \le n \le N \\ 0 & otherwise \end{cases}$$

3. An LTI system is specified by the difference equation
$$y(n) = 0.8y(n-1) + x(n)$$
(a) Determine $H(e^{jw})$
(b) Calculate and plot the steady state response $y_{ss}(n)$ to
$$x(n) = \cos(0.5\pi n)u(n)$$

4. Given a casual system
$$y(n) = 0.9y(n-1) + x(n)$$
(a) Find $H(z)$ and sketch its pole-zero plot
(b) Plot the frequency response $|H(e^{jw})|$ and $\angle H(e^{jw})$

5. Design a digital filter to eliminate the lower frequency sinusoid of $x(t) = \sin 7t + \sin 200t$. The sampling frequency is $f_s = 500\, Hz$. Plot its pole zero diagram, magnitude response, input and output of the filter.

6. Let $x(n)$ be a 4-point sequence:
$$x(n) = \underset{\uparrow}{\{1,1,1,1\}} = \begin{cases} 1 & 0 \le n \le 3 \\ 0 & otherwise \end{cases}$$
Compute the DTFT $X(e^{jw})$ and plot its magnitude
(a) Compute and plot the 4 point DFT of $x(n)$
(b) Compute and plot the 8 point DFT of $x(n)$ (by appending 4 zeros)
(c) Compute and plot the 16 point DFT of $x(n)$ (by appending 12 zeros)

7. Let $x(n)$ and $h(n)$ be the two 4-point sequences,
$$x(n) = \underset{\uparrow}{\{1,2,2,1\}}$$
$$h(n) = \underset{\uparrow}{\{1,-1,-1,1\}}$$
Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications:
passband edge $F_p = 2\ KHz$
stopband edge $F_s = 5\ KHz$
Passband attenuation $A_p = 2\ dB$
Stopband attenuation $A_s = 42\ dB$
Sampling frequency $F_s = 20\ KHz$

10. The frequency response of a linear phase digital differentiator is given by

$$H_d\left(e^{jw}\right) = jwe^{-j\tau w} \qquad |w| \leq \pi$$

Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response.

Reference Books:

- Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
- Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
- Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
- Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

1. Generate and plot the sample, step, ramp and exponential sequences

Aim : To generate and plot the following sequences :

a) Unit sample sequence
b) Unit step sequence
c) Ramp sequence
d) Real valued sequence

Program:-

```
clc
n1=0:5;
y1=[ones(1,4),zeros(1,2)];
y2=[ones(1,6)];
y3=exp(n1);
y4=n1;
subplot(2,2,1);
plot2d3 (n1,y1);
xlabel('time');
ylabel('amplitude');
title('Sample Discrete Signal');
subplot(2,2,2);
plot2d3 (n1,y2);
xlabel('time');
ylabel('amplitude');
title('Unit Step Discrete Signal');
subplot(2,2,3);
plot2d3(n1,y3);
xlabel('time');
ylabel('amplitude');
title('Exponential Signal');
subplot(2,2,4);
plot2d3(n1,y4);
xlabel('time');
ylabel('amplitude');
title('Unit Ramp Signal');
```

2. Program to compute the linear convolution using circular convolution for the two 4- point sequences

Aim: To write a program to compute the linear convolution using circular convolution for the two 4- point sequences

Program

```
// Caption: Performing Linear Convolution using circular Convolution

clear;
clc;
close;
h = [1,-1,-1, 1]; // Impulse Response of LTI System
x = [1, 2, 2, 1]; // Input Response of LTI System
N1 = length (x);
N2 = length (h);
N = N1+N2 -1
disp (N, ' Length o f Output Response y (n) ‘)
 // Padding z e r o s to Make Length o f ' h ' and ' x’
 // Equal to l e n g t h o f output r e s p o n s e ' y’
h1 = [h, zeros (1, N-N2)];
x1 = [x, zeros (1, N-N1)];
//Computing FFT
H = fft (h1, -1);
X = fft(x1, -1);
// Multiplication of 2 DFTs
Y = X.*H
// Linear Convolution Re s u l t
y = abs (fft (Y, 1))
disp (X, 'DFT o f i /p X (k) =‘)
disp (H, 'DFT of impulse sequence H (k) =‘)
disp (Y, 'DFT of Linear Filter o /p Y (k) =‘)
disp (y, ' Linear Convolution result y [n] = ‘)
```

3. Design a digital FIR differentiator and plot amplitude response using Hamming window

Aim: To design a digital FIR differentiator and plot amplitude response using Hamming window

Program:

```
//Program to Plot Magnitude Response o f ideal differentiator with specifications:
//N=8, w=pi
// using Hamming window
clear;
clc;
close;
N =8;
alpha =7/2;
U =1; // Zero Adjust
h_hamm = window (‘hm’, N);
for n =0+ U: 1:7+ U
hd (n) =-(sin (%pi *(n-U- alpha)))/ (%pi *(n-U- alpha)*(n-U-alpha));
h (n) =hd (n)* h_hamm (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 ideal differentiator using Hamming Window , N=8 ' );
xgrid (2)
```

4. Compute and plot 4 point, 8 point, 16 point DFT of x (n) for a given 4-point sequence

Aim: To Compute and plot 4 point, 8 point, 16 point DFT of x (n) for a given 4-point sequence

Given parameter:

x (n) = {1,1,1,1} = {1 for 0<n<3 ; 0 for otherwise

Program:

```
//a. Program to Compute the 4-point DFT of the Sequence
x [ n ]=[ 1 , 1 , 1 , 1 ]
clear ;
clc ;
close ;
x = [1 ,1 ,1 ,1 ];
//DFT Computation
X = fft (x , -1);
// Display sequence X[ k ] in command window
disp (X,"X[ k]=");
//b. Program to Compute the 8-point DFT of the Sequence
x [ n ]=[ 1 , 1 , 1 , 1 , 0 , 0 , 0 , 0 ]
clear ;
clc ;
close ;
x = [1 ,1 ,1 ,1 ,0 ,0 ,0 ,0];
//DFT Computation
X = fft (x , -1);
// Display sequence X[ k ] in command window
disp (X,"X[ k]=");
//c. Program to Compute the 16-point DFT of the Sequence
x [ n ]=[ 1 , 1 , 1 , 1 , 0 , 0 , 0 , 0, 0, 0, 0, 0, 0, 0, 0, 0 ]
clear ;
clc ;
close ;
x = ]=[ 1 , 1 , 1 , 1 , 0 , 0 , 0 , 0, 0, 0, 0, 0, 0, 0, 0, 0 ];
//DFT Computation
X = fft (x , -1);
// Display sequence X[ k ] in command window disp (X,"X[ k]=");
```

5. Using a rectangular window design a FIR low pass filter

Aim: To design a FIR low pass filter using a rectangular window
Given parameter:

Cut off frequency = 1000 Hz, sampling frequency = 5 KHz, length = 17

Program:

```
// To De s ign an Low Pas s FIR F i l t e r
// F i l t e r Length =5, Order = 4
//Window = Re c t angul a r Window
clc ;
clear ;
xdel ( winsid ());
fc = input (" Enter Analog cut off freq . i n Hz=") // 250
fs = input (" Enter Analog sampling freq . i n Hz=") // 2000
M = input (" Enter order of filter =") // 4
w = (2* %pi)*( fc/fs);
disp (w, ' Digital cut off frequency in radians . cycles /samples ' );
wc = w/ %pi ;
disp (wc , ' Normalized digital cut off frequency in cycles / samples ' );
[wft ,wfm ,fr ]= wfir ( ' l p ' ,M+1 ,[ wc /2 ,0] , ' r e ' ,[0 ,0]);
disp (wft , ' Impulse Response of LPF FIR Filter : h [ n]= ' );
// Plotting the Magnitude Response of LPF FIR Filter
subplot (2 ,1 ,1)
plot (2*fr , wfm )
xlabel ( ' Normalized Digital Frequency w' )
ylabel ( 'Magnitude jH(w) j= ' )
title ( 'Magnitude Response of FIR LPF ' )
xgrid (1)
subplot (2 ,1 ,2)
plot (fr*fs , wfm )
xlabel ( ' Analog Frequency in Hz f ' )
ylabel ( 'Magnitude jH(w) j= ' )
title ( 'Magnitude Response of FIR LPF ' )
xgrid (1)
```

6. Design Low Pass F i l t e r as pe r the g i v e n s p e c i f i c a t i o n and p l o t the Frequency Respons e .

Aim : To design low pass filter as per the given specification and plot frequency response.

Program

```
clc ;
close ;
clear ;
delta1 =0.1; // At ennuat ion
delta2 =0.1;
fl =400; // Low Cut of f Fr equency
fh =500; // High Cut f f Fr equency
fs =8000; // Sampling Fr equency
A= -20* log10 ( min ( delta1 : delta2 ));
w1 =2* %pi *fl/fs;
w2 =2* %pi *fh/fs;
temp =1+((A -8) /(2.285*((2*3.14* fh/fs) -(2*3.14* fl/fs))
));
N= ceil (( temp -1) /2);
n=-N:N;
h =((( w2+w1) /2) *( sinc ((( w2+w1) /2) *n))) /(3.14) ; // Re spons e
// p l o t ( n , h ) ;
[xm1 ,fr1 ]= frmag (h ,8000) ; // Fr equency Re spons e
figure ;
plot (fr1 , xm1 );
title ( ' Fr equency Re spons e ' , ' c o l o r ' , ' r ed ' , ' f o n t s i z e ' ,4);
xlabel (" Fr equency ( Normal i z ed ) " , " f o n t s i z e " , 2," c o l o r " , " blue ");
ylabel ("Magni tude " , " f o n t s i z e " , 2, " c o l o r " , " blue ");
```