Subject Code: UE19EC255
PRINCIPLES OF DIGITAL SIGNAL PROCESSING LABORATORY (0-0-2-0-1)

Marks Allotment

	Marks
Internal	**60**
RECORD	20
Assessment I- VIVA/ QUIZ	20
Assessment II - VIVA/ QUIZ	20
External	**40**
QUIZ	20
VIVA	20

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PRINCIPLES OF DIGITAL SIGNAL PROCESSING LABORATORY (0-0-2-0-1)

CYCLE I

LIST OF EXPERIMENTS USING MATLAB

1. Verification of Sampling theorem.
2. Program to solve difference equation and program to find the Impulse response of the system
3. Computation of N point DFT of a given sequence x(n) and to plot magnitude and phase spectrum and N-pt IDFT of the given X(k).
4. To find Linear convolution and Circular convolution of two given sequences.
5. To find Linear and circular convolution of two sequences using DFT and IDFT.
6. To find Autocorrelation and Cross correlation of given sequence / sequences.
7. Design and implementation of Analog Butterworth and Chebyshev filters to meet the given specifications.
8. Design and implementation of IIR, Butterworth and Chebyshev Filters to meet the given specifications.
9. Design and implementation of FIR filter to meet given specifications.

CYCLE II

LIST OF EXPERIMENTS USING DSP PROCESSOR (6748)

1. To find Impulse response of first order and second order system
2. Computation of N- Point DFT of a given sequence and IDFT
3. Linear convolution and Circular convolution of two given sequences.

Reference Books:

1. "Digital signal processing using MATLAB", Sanjeet Mitra, TMH, 2001

2. "Digital signal processing using MATLAB", J.G.Proakis & Ingle, MGH, 2000

3. "Digital signal processors", B.Venkataramani and Bhaskar, TMH, 2002

DSP USING MATLAB

MATLAB is a high-level language and interactive environment that enables you to perform computationally intensive tasks faster than with traditional programming languages such as C, C++ etc. The key features of MATLAB are as follows

- High-level language for technical computing
- Development environment for managing code, files, and data
- Interactive tools for iterative exploration, design, and problem solving
- Mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, and numerical integration
- 2-D and 3-D graphics functions for visualizing data
- Tools for building custom graphical user interfaces
- MATLAB (MATrix LABoratory) is a special purpose computer program optimized to perform engineering and scientific calculations.
- The MATLAB program implements the MATLAB language, and provides a very extensive library of predefined functions to make technical programming tasks easier and more efficient.
- The extremely wide variety of functions makes it much easier to solve technical problems in MATLAB than in other languages such as FORTRAN or C.
- The advantages of using MATLAB for technical programming are:
  - Ease of use
  - Platform independence
  - Predefined functions
  - Device-independent plotting
  - Graphical User Interface
  - MATLAB Compiler
- MATLAB is a huge program, with an incredibly rich variety of functions. There are more than 1000 functions in the basic MATLAB.
- The disadvantages of MATLAB are:
  - It is interpreted language, and therefore can execute more slowly than compiled languages.
  - Cost. (Student version of MATLAB is available for low cost with almost identical feature) full copy of MATLAB is 5 TO 10 times more expensive than a conventional C or FORTRAN compiler.
- The functional unit of data in any MATLAB program is the array. An array is a collection of data values organized into rows and columns.
- When MATLAB executes, it can display several types of windows that accept commands or display information. The three most important types of windows are command windows, where commands may be entered: figure windows, which display plots and graphs: and edit/debug windows which permit a user to create and modify MATLAB programs.
- The major tools within or accessible from the MATLAB desktop are:
  - The command window: a user can enter interactive commands at the command prompt (>>) in the command window and they will be executed on the spot. Instead of typing commands directly in the command window, a series of commands may be placed in to a single file and the entire file may be executed by typing its name in the command window. Such files are called script files. Script files are also called M-Files because they have file extension of ". M".
  - The command history window: the command history window displays a list of the commands that a user has entered in the command window.
  - The launch pad: it is a special tool that collects references to the documentation, demos, and related tools for MATLAB itself and for each toolkit that you own.
  - The edit/debug window: used to create new M-Files, or to modify existing ones. An edit/debug window is created automatically when you create a new M-File or open

an existing one. The edit/debug window is essentially a programming text editor, with the MATLAB languages features highlighted in different colors. Comments in an M-File appear in green, variables and numbers appear in black, character strings appear in red, and language keywords appear in blue.

- Figure windows: used to display MATLAB graphics. A figure can be two or three-dimensional plot of data, an image or a GUI.
- The MATLAB workspace: it is a collection of all the variables and arrays that can be used by MATLAB when a particular command, M-File, or function is executing. All commands executed in the command window share a common workspace, so they can all share variables. (Clear deletes all variables from the current workspace).
- The workspace browser: it provides a graphic display of the same information as *whos* command, and the display is dynamically updated whenever the contents of workspace change. The workspace browser also allows user to change the contents of any variables in the workspace. (A list of the variables and arrays in the current workspace can be generated with the *whos* command)

- Getting help: by selecting the? *Help* icon bar from the desktop tool bar, or by typing helpdesk or *helpwin* in the command window. The other way of obtaining help is by using *lookfor* command. Help command searches for an exact function name match, whereas the lookfor command searches the quick summary information in each function for a match. Lookfor is slower than help but it improves the chances of getting useful information.
- For new users of MATLAB, a few demonstrations may help to give you a feel for its capabilities. To run MATLAB's built in demonstrations, type demo in the command window, or select "*demos*" from the launch pad.
- The contents of the command window can be cleared at any time using the clc command, and the contents of the current figure window can be cleared at any time using the clf command. The variables in the workspace can be cleared with the clear command. It is a good idea to issue the clear command at the start of each new independent calculation.
- Another important command is the abort command. If an m-file appears to be running for too long, it might contain an infinite loop, and it will never terminate. In this case the user can regain the control by typing control-c (^c) in the command window. When MATLAB detects a ^c, it interrupts the running program and returns a command prompt.
- After diary command is typed, a copy of all input and most output typed in the command window is echoed in the diary file. The command diary off suspends input in to the diary file, and the command diary on resumes input again.
- MATLAB includes a special command (which) to help you to find out just which version of a file is being executed. and where it is located. The format of this command is which functionname, where functionname is the name of the function that you are trying to locate.

The path related function include:

* addpath	Add directory to MATLAB search path
* path	Display MATLAB search path
* path2rc	Add current directory to MATLAB search path
* rmpath	Remove directory from MATLAB search path

- The functional unit of data in any MATLAB program is the array. An array is a collection of data values organized into rows and columns, and known by a single name.
- MATLAB variable is a region of memory containing an array, which is known by a user-specified name. MATLAB variable names must begin with a letter, followed by any combination of letters, numbers, and the underscore(_) character. Only the first 31 characters are significant; if more than 31 are used, the remaining characters will be ignored. If two variables are declared with names that only differ in the 32nd character, MATLAB will treat them as same variable.
- Spaces cannot be used in MATLAB variable names, underscore letters can be substituted to create meaningful names.
- It is important to include a data dictionary in the header of any program that you write. A data dictionary lists the definition of each variable used in a program. The definition should include both a description of the contents of the item and the units in which it is measured.
- MATLAB language is case-sensitive. It is customary to use lower-case letters for ordinary variable names.
- The most common types of MATLAB variables are double and char.
- MATLAB is weakly typed language. Variables are not declared in a program before it is used.
- MATLAB variables are created automatically when they are initialized. There are three common ways to initialize variables in MATLAB:
  - Assign data to the variable in an assignment system.
  - Input data into the variable from the keyboard.
  - Read data from a file.
- The semicolon at the end of each assignment statement suppresses the automatic echoing of values that normally occurs whenever an expression is evaluated in an assignment statement.

How to invoke MATLAB?

1) Double Click on the MATLAB icon on the desktop .

2) You will find a Command window where in which you can type the commands and see the output. For example if you type PWD in the command window, it will print current working directory.

3)If you want to create a directory type mkdir *mydir* in the command window, It will create a directory called *pes.*

4) If you want delete a directory type rmdir *mydir* in the command window.

How to open a file in MATLAB?

5) Go to **File → New→ M-File** and click

Then type the program in the file and save the file with an extension of .**m.** While giving file name we should make sure that given file name should not be a command. It is better to the file name as myconvolution.m

How to run a MATLAB file?

*) Go to **Debug→run** and **click**

EXPERIMENT No. 1: Verification of Sampling theorem

Aim: To verify Sampling theorem for a signal of given frequency.

Theory: Sampling is a process of converting a continuous time signal (analog signal) x(t) into a discrete time signal x[n], which is represented as a sequence of numbers. (A/D converter)Converting back x[n] into analog (resulting in the process of reconstruction.) (D/A converter)
For the reconstructed signal to be exactly the same as x(t), sampling theorem is used to get x(n) from x(t). The sampling frequency fs determines the spacing between samples.
Aliasing - A high frequency signal is converted to a lower frequency, results due to under sampling. Though it is undesirable in ADCs, it finds practical applications in stroboscope and sampling oscilloscopes.

Algorithm:
1. Input the desired frequency f1,f2 and generate y (for which sampling theorem is to be verified).
2. Input the Sampling Frequency fs.
3. Generate oversampled, Nyquist & under sampled discrete time signals.
4. Plot the waveforms and hence prove sampling theorem.

```
%% Program
clc;  % clears the command window
clear all; %clears variables in workspace
close all;  %close all fig windows
t=0:0.001:0.2; %analog time axis

f1=input ('Enter the input frequency1  = ');
f2=input ('Enter the input frequency2  = ');

xa=cos(2*pi*f1*t)+cos(2*pi*f2*t);

fm=max(f1,f2);
% For Right sampling fs=2*fm
% For Over sampling fs>2*fm so let fs=fm
% For Under sampling fs<2*fm so let fs=4*fm
fs=2*fm;                        %fs = sampling freequency
ts=1/fs;

n=0:1:(0.2*fs);
xd=cos(2*pi*f1*(n*ts))+cos(2*pi*f2*(n*ts));
figure;
subplot(3,1,1);
plot(t,xa);
xlabel('t in s');
ylabel('amp');
title('Analog Signal and Discrete Signal');
hold on;
stem(n*ts,xd);
hold off;
legend('Continuous xa(t)','xd(n)');
%% Plot only Discrete signal
```

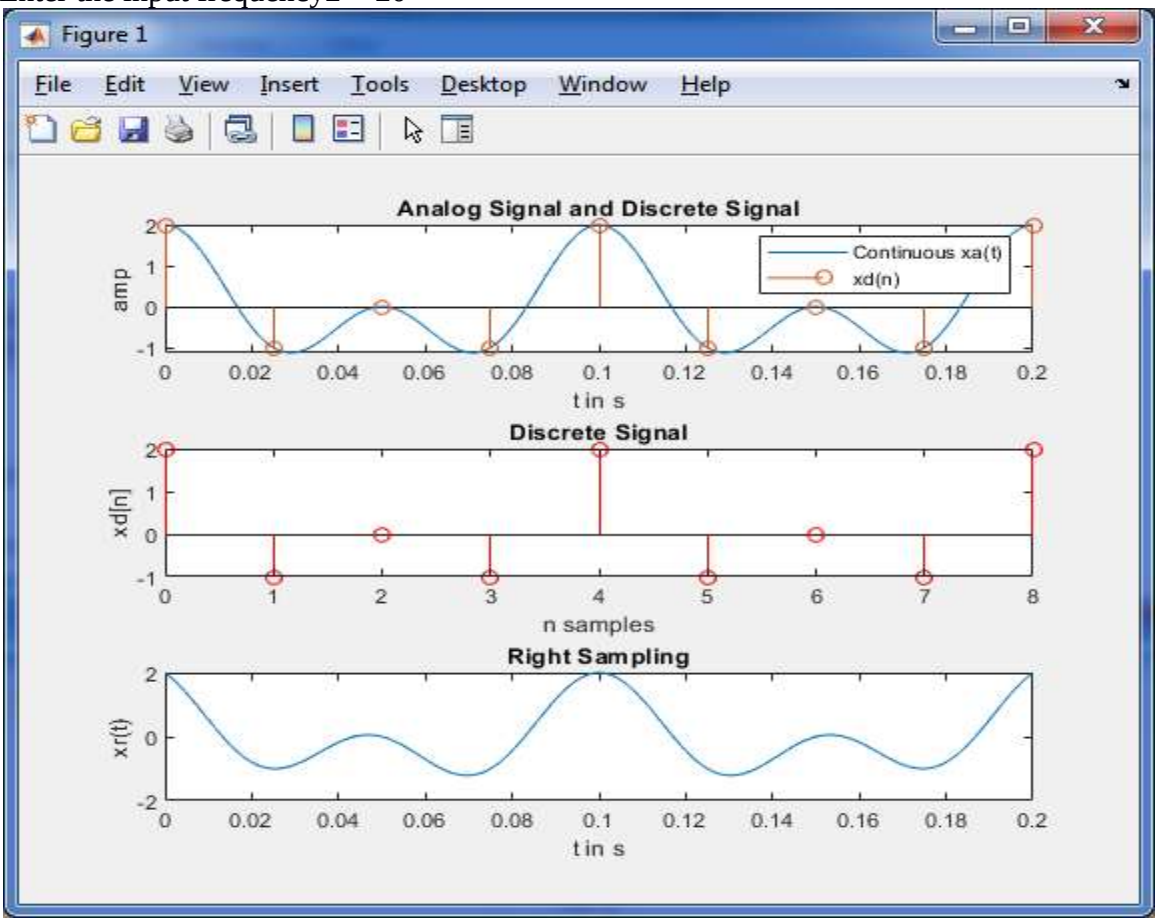
```
subplot(3,1,2);
stem(n,xd,'r');
xlabel('n samples');
ylabel('xd[n]');
title('Discrete Signal');
%% Reconstruction by using the formula:
% xr(t) = sum over n=0,...,N-1: x(nT)*sin(pi*(t-nT)/T)/(pi*(t-
nT)/T)
% Note that sin(pi*(t-nT)/T)/(pi*(t-nT)/T) = sinc((t-nT)/T)
% sinc(x) = sin(pi*x)/(pi*x) according to MATLAB
xr=xd*sinc((t-(n'*ts))/ts);
subplot(3,1,3);
plot(t,xr);
xlabel('t in s');
ylabel('xr(t)');
title('Right Sampling'); %or /Over Sampling/ Under Sampling
%%%%%%%%%%%%%%%%%%%%
```

OUTPUT:

Right Sampling:

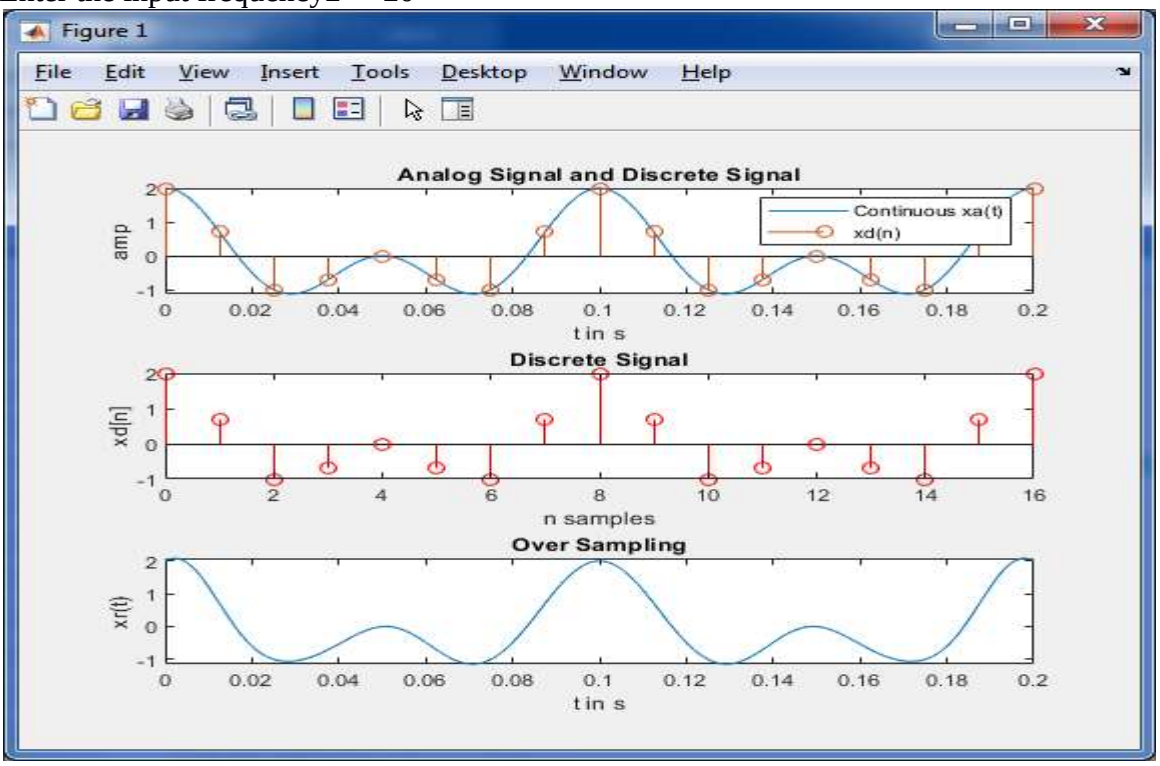
Enter the input frequency1 = 10

Enter the input frequency2 = 20



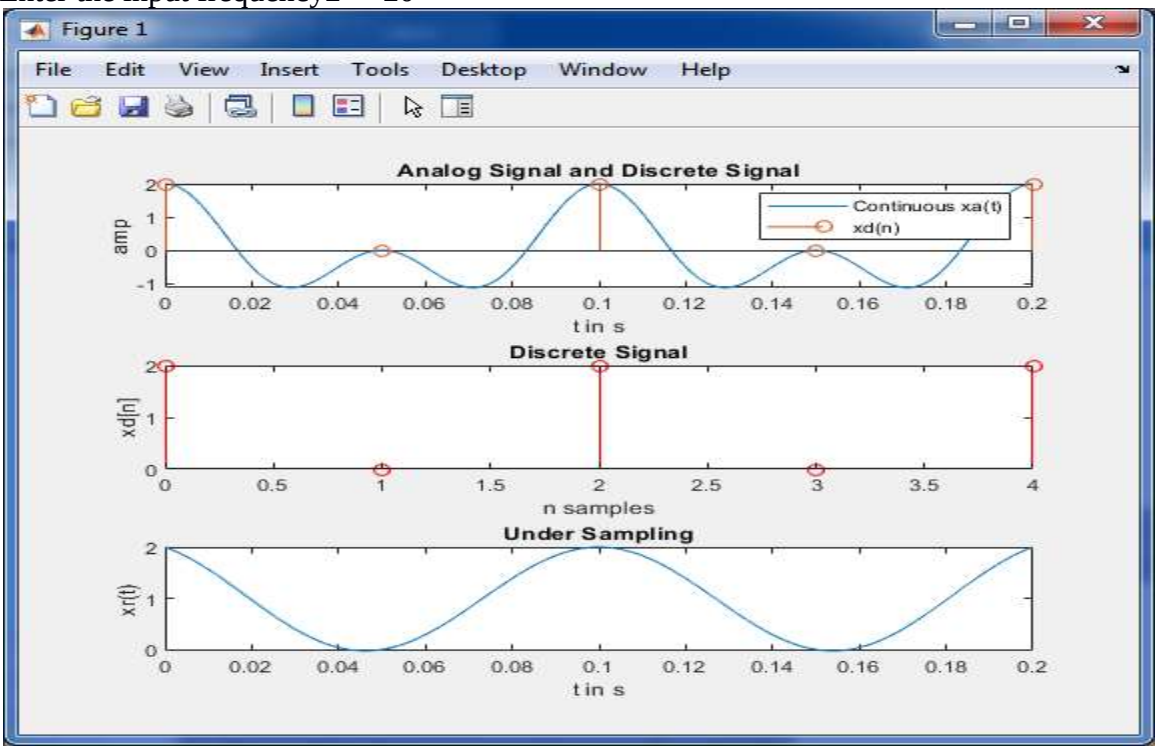
Over Sampling:

Enter the input frequency1 = 10
Enter the input frequency2 = 20



Under Sampling:

Enter the input frequency1 = 10
Enter the input frequency2 = 20



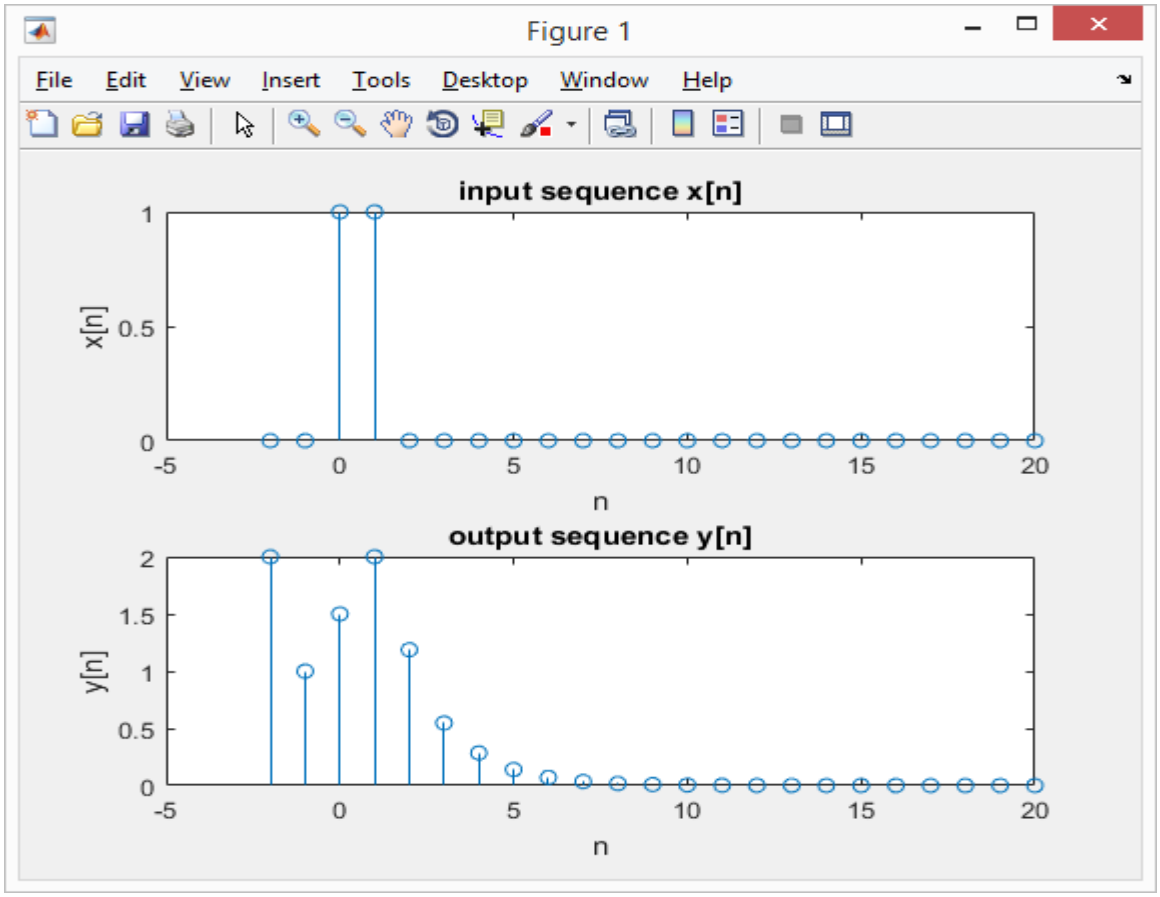
EXPERIMENT No.2 : Program to solve difference equation and program to find the Impulse response of the system

WITHOUT INBUILT FUNCTION

```
%y(n)-0.25y(n-1)-0.125y(n-2)=x(n)+0.5x(n-1)
%x(n)=u(n)-u(n-2)
%y(-1)=1 and y(-2)=2  (enter the values as [2 1])

clc; %clears the console window
clear all;%deletes the user defined variable in variable browser
close all;%close the figure window

%a=[1 -0.25 -0.125]
%b=[1 0.5]
b=input('Enter the coefficients of x: ');
a=input('Enter the coefficients of y: ');

M=length(b)-1;
N=length(a)-1;
IC=input('Enter the initial conditions for y: ');

n=[-N:20];%number of terms

%x[n]=u[n]-u[n-2]
x=[(n>=0)]-[(n>=2)];
subplot(211);
stem(n,x);

title('input sequence x[n]');
xlabel('n');
ylabel('x[n]');

y=[IC zeros(1,length(n)-N)];


for n=N+1:20   %loop runs length(n) times to find y(n)
      sumx=0;sumy=0;

      for k=0:M
            sumx=sumx+(b(k+1)*x(n-k));
      end
      for k=1:N
            sumy=sumy+(a(k+1)*y(n-k));
      end
      y(n)=sumx-sumy;
end

n=[-N:20];%number of terms

subplot(212);
stem(n,y);

title('output sequence y[n]');
xlabel('n');
ylabel('y[n]');
disp('y[n]=');
disp(y)
```

OUTPUT :

```
Enter the coefficients of x: [1 0.5]
Enter the coefficients of y: [1 -0.25 -0.125]
Enter the initial conditions for y: [2 1]
y[n]=
  Columns 1 through 13

    2.0000    1.0000    1.5000    2.0000    1.1875    0.5469    0.2852    0.1396    0.0706    0.0351
0.0176    0.0088    0.0044

  Columns 14 through 23

    0.0022    0.0011    0.0005    0.0003    0.0001    0.0001    0.0000         0         0         0
```



WITH INBUILT FUNCTION

```
%y(n)-0.25y(n-1)-0.125y(n-2)=x(n)+0.5x(n-1)
%x(n)=u(n)-u(n-2)
%y(-1)=1 and y(-2)=2 , (enter the values as [2 1])

clc; %clears the console window
clear all;%deletes the user defined variable in variable browser
close all;%close the figure window

%a=[1 -0.25 -0.125]
%b=[1 0.5]
```

```
b=input('Enter the coefficients of x: ');
a=input('Enter the coefficients of y: ');

M=length(b)-1;
N=length(a)-1;
IC=input('Enter the initial conditions for y: ');

%Initial conditions for transposed direct-form II filter
ic=filtic(b,a,flip(IC));
n=[0:20];%number of terms

%x[n]=u[n]-u[n-2]
x=[(n>=0)]-[(n>=2)];
y=filter(b, a, x, ic);

subplot(211);
stem(n,x);

title('input sequence x[n]');
xlabel('n');
ylabel('x[n]');

subplot(212);
stem(n,y);

title('output sequence y[n]');
xlabel('n');
ylabel('y[n]');
disp('y[n]=');
disp(y)
```

OUTPUT:

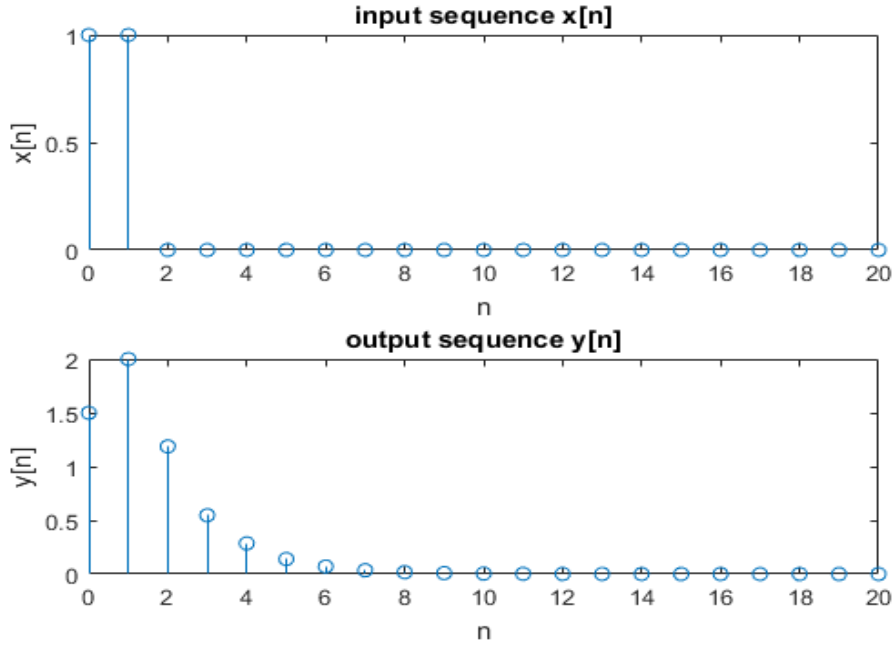
Enter the coefficients of x: [1 0.5]
Enter the coefficients of y: [1 -0.25 -0.125]
Enter the initial conditions for y: [2 1]

y[n]=
Columns 1 through 13

1.5000 2.0000 1.1875 0.5469 0.2852 0.1396 0.0706 0.0351 0.0176 0.0088 0.0044 0.0022 0.0011

Columns 14 through 21

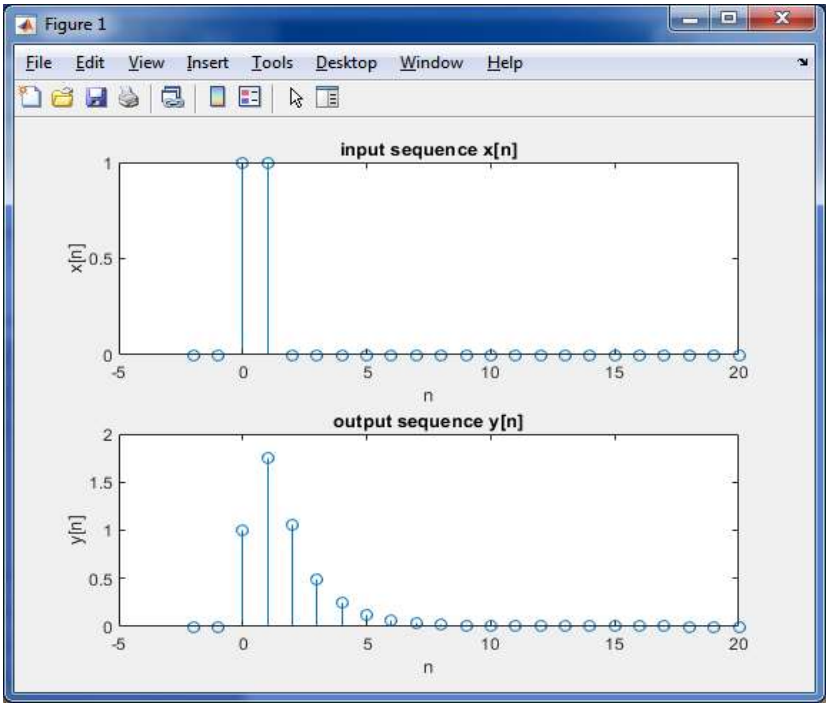
0.0005 0.0003 0.0001 0.0001 0.0000 0.0000 0.0000 0.0000



With zero initial conditions

Enter the coefficients of x: [1 0.5]
Enter the coefficients of y: [1 -0.25 -0.125]
Enter the initial conditions for y: [0 0]

y[n]	yinbuilt[n]
0	0
0	0
1.0000	1.0000
1.7500	1.7500
1.0625	1.0625
0.4844	0.4844
0.2539	0.2539
0.1240	0.1240
0.0627	0.0627
0.0312	0.0312
0.0156	0.0156
0.0078	0.0078
0.0039	0.0039
0.0020	0.0020
0.0010	0.0010
0.0005	0.0005
0.0002	0.0002
0.0001	0.0001
0.0001	0.0001



To find impulse response

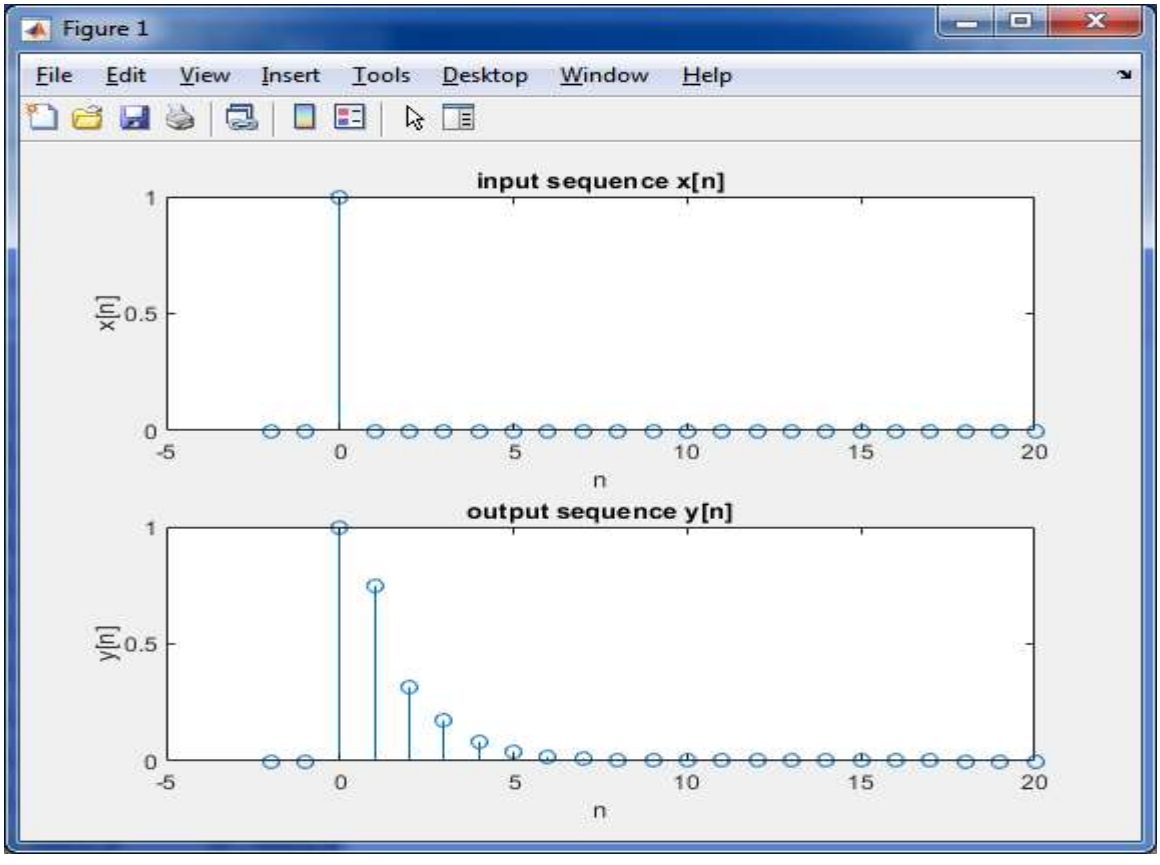
```
x=double([n==0]);
```

IC =[0 0];

Impulse Response Output:

Enter the coefficients of x: [1 0.5]
Enter the coefficients of y: [1 -0.25 -0.125]
Enter the initial conditions for y: [0 0]

y[n]	yinbuilt[n]
0	0
0	0
1.0000	1.0000
0.7500	0.7500
0.3125	0.3125
0.1719	0.1719
0.0820	0.0820
0.0420	0.0420
0.0208	0.0208
0.0104	0.0104
0.0052	0.0052
0.0026	0.0026
0.0013	0.0013
0.0007	0.0007
0.0003	0.0003
0.0002	0.0002
0.0001	0.0001



EXPERIMENT No. 3: (a) Computation of N point DFT of a given sequence x(n) and to plot magnitude and phase spectrum (b) Computation N-pt IDFT of the given X(k).

(a) Computation of N point DFT of a given sequence x(n) and to plot magnitude and phase spectrum

```
%%Program to find dft
clc;
clear all;
close all;
%%input sequence
xn=input('enter the input sequence: ');
N=input('enter the number of points: ');
Xk=calcdft(xn,N);

disp('DFT X(K)= ');
disp(Xk);
%%magnitude of dft
magXk=abs(Xk);
%%phase of dft
phaseXk=angle(Xk);
k=0:N-1;
subplot(2,1,1);
stem(k,magXk);
title('fft sequence');
xlabel('frequency');
ylabel('magnitude');
subplot(2,1,2);
stem(k,phaseXk);
title('phase of fft sequence');
xlabel('frequency');
ylabel('phase');

function [Xk]=calcdft(xn, N)
L=length(xn);
if(N<L)
error('N must be >=L');
end
x1=[xn zeros(1,N-L)];
for k=0:1:N-1;
for n=0:1:N-1;
p=exp(-i*2*pi*n*k/N);
T(k+1,n+1)=p;
end
end
disp('Transformation Matrix for dft')
disp(T);
Xk=T*x1.';
end
```

OUTPUT :

enter the input sequence: [0 1 2 3]
enter the number of points: 8

x1 =

0 1 2 3 0 0 0 0

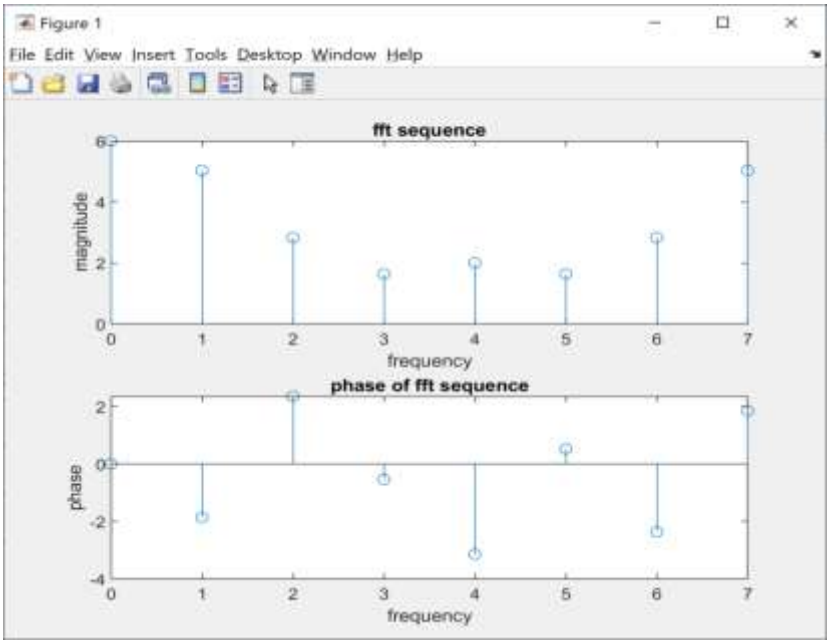
Transformation Matrix for dft
Columns 1 through 4

1.0000 + 0.0000i 1.0000 + 0.0000i 1.0000 + 0.0000i 1.0000 + 0.0000i
1.0000 + 0.0000i 0.7071 - 0.7071i 0.0000 - 1.0000i -0.7071 - 0.7071i
1.0000 + 0.0000i 0.0000 - 1.0000i -1.0000 - 0.0000i -0.0000 + 1.0000i
1.0000 + 0.0000i -0.7071 - 0.7071i -0.0000 + 1.0000i 0.7071 - 0.7071i
1.0000 + 0.0000i -1.0000 - 0.0000i 1.0000 + 0.0000i -1.0000 - 0.0000i
1.0000 + 0.0000i -0.7071 + 0.7071i 0.0000 - 1.0000i 0.7071 + 0.7071i
1.0000 + 0.0000i -0.0000 + 1.0000i -1.0000 - 0.0000i 0.0000 - 1.0000i
1.0000 + 0.0000i 0.7071 + 0.7071i -0.0000 + 1.0000i -0.7071 + 0.7071i

Columns 5 through 8

1.0000 + 0.0000i 1.0000 + 0.0000i 1.0000 + 0.0000i 1.0000 + 0.0000i
-1.0000 - 0.0000i -0.7071 + 0.7071i -0.0000 + 1.0000i 0.7071 + 0.7071i
1.0000 + 0.0000i 0.0000 - 1.0000i -1.0000 - 0.0000i -0.0000 + 1.0000i
-1.0000 - 0.0000i 0.7071 + 0.7071i 0.0000 - 1.0000i -0.7071 + 0.7071i
1.0000 + 0.0000i -1.0000 - 0.0000i 1.0000 + 0.0000i -1.0000 - 0.0000i
-1.0000 - 0.0000i 0.7071 - 0.7071i -0.0000 + 1.0000i -0.7071 - 0.7071i
1.0000 + 0.0000i -0.0000 + 1.0000i -1.0000 - 0.0000i -0.0000 - 1.0000i
-1.0000 - 0.0000i -0.7071 - 0.7071i -0.0000 - 1.0000i 0.7071 - 0.7071i

DFT X(K)=
6.0000 + 0.0000i
-1.4142 - 4.8284i
-2.0000 + 2.0000i
1.4142 - 0.8284i
-2.0000 - 0.0000i
1.4142 + 0.8284i
-2.0000 - 2.0000i
-1.4142 + 4.8284i



(b) Computation N-pt IDFT of the given X(k).

```
%%Program to find idft
clc;
clear all;
close all;

%%input sequence
Xk=input('enter the input sequence');
xn=calcidft(Xk);

N=length(xn);

disp('x(n)=');
disp(xn);
n=0:N-1;
stem(n,xn);
title('ifft sequence');
xlabel('time');
ylabel('amplitude');



%%Xk should be row vector
function [xn]=calcidft(Xk)
N=length(Xk);
for k=0:1:N-1;
for n=0:1:N-1;
p=exp(i*2*pi*n*k/N);
IT(k+1,n+1)=p;
end
end
disp('Transformation Matrix for idft')
disp(IT);
xn=(IT*(Xk.'))./N;
end
```

OUTPUT:

enter the input sequence[6.0000 + 0.0000i -1.4142 - 4.8284i -2.0000 + 2.0000i   1.4142 - 0.8284i - 2.0000 - 0.0000i   1.4142 + 0.8284i -2.0000 - 2.0000i -1.4142 + 4.8284i]
Transformation Matrix for idft
  Columns 1 through 4

  1.0000 + 0.0000i   1.0000 + 0.0000i   1.0000 + 0.0000i   1.0000 + 0.0000i
  1.0000 + 0.0000i   0.7071 + 0.7071i   0.0000 + 1.0000i -0.7071 + 0.7071i
  1.0000 + 0.0000i   0.0000 + 1.0000i -1.0000 + 0.0000i -0.0000 - 1.0000i
  1.0000 + 0.0000i -0.7071 + 0.7071i -0.0000 - 1.0000i   0.7071 + 0.7071i
  1.0000 + 0.0000i -1.0000 + 0.0000i   1.0000 - 0.0000i -1.0000 + 0.0000i
  1.0000 + 0.0000i -0.7071 - 0.7071i   0.0000 + 1.0000i   0.7071 - 0.7071i
  1.0000 + 0.0000i -0.0000 - 1.0000i -1.0000 + 0.0000i   0.0000 + 1.0000i
  1.0000 + 0.0000i   0.7071 - 0.7071i -0.0000 - 1.0000i -0.7071 - 0.7071i

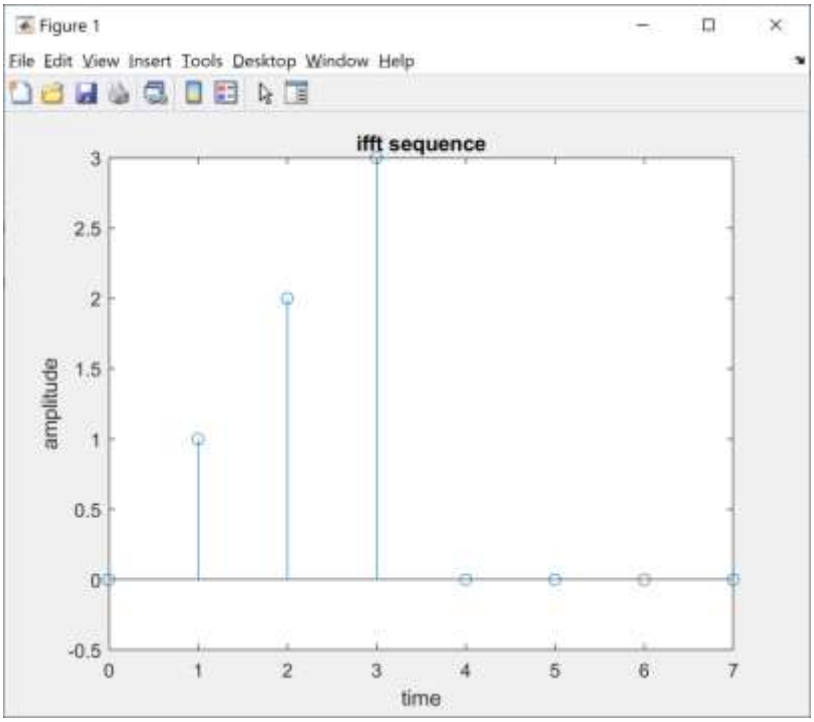
Columns 5 through 8

```
  1.0000 + 0.0000i   1.0000 + 0.0000i   1.0000 + 0.0000i   1.0000 + 0.0000i
 -1.0000 + 0.0000i  -0.7071 - 0.7071i  -0.0000 - 1.0000i   0.7071 - 0.7071i
  1.0000 - 0.0000i   0.0000 + 1.0000i  -1.0000 + 0.0000i  -0.0000 - 1.0000i
 -1.0000 + 0.0000i   0.7071 - 0.7071i   0.0000 + 1.0000i  -0.7071 - 0.7071i
  1.0000 - 0.0000i  -1.0000 + 0.0000i   1.0000 - 0.0000i  -1.0000 + 0.0000i
 -1.0000 + 0.0000i   0.7071 + 0.7071i  -0.0000 - 1.0000i  -0.7071 + 0.7071i
  1.0000 - 0.0000i  -0.0000 - 1.0000i  -1.0000 + 0.0000i  -0.0000 + 1.0000i
 -1.0000 + 0.0000i  -0.7071 + 0.7071i  -0.0000 + 1.0000i   0.7071 + 0.7071i
```

x(n)=

```
   0.0000 + 0.0000i
   1.0000 - 0.0000i
   2.0000 - 0.0000i
   3.0000 - 0.0000i
  -0.0000 + 0.0000i
   0.0000 + 0.0000i
  -0.0000 - 0.0000i
   0.0000 + 0.0000i
```

Warning: Using only the real component of complex data.
> In getRealData (line 52)
  In stem (line 40)
  In prog5b (line 15)
>>



EXPERIMENT No. 4: Linear convolution and circular convolution of two sequences.

```
%%This program gives the Linear convolution of two sequences.

%% Main Program
clc; %clears the console window
clear all;%deletes the user defined variable in variable browser
close all;%close the figure window

x=input('Enter the 1st sequence:');
nx=input('Enter the time index sequence:');
h=input('Enter the 2nd sequence:');
nh=input('Enter the time index sequence:');
[y,ny]=findconv(x,nx,h,nh);
figure;
subplot(3,1,1);
stem(nx,x);
xlabel('Time');
ylabel('Amplitude');
title('1st sequence');
subplot(3,1,2);
stem(nh,h);
xlabel('Time');
ylabel('Amplitude');
title('2nd sequence');
subplot(3,1,3);
stem(ny,y);
xlabel('Time');
ylabel('Amplitude');
title('Linear convolution');
disp(y);
disp(ny);
%%function
function [y,ny]=findconv(x,nx,h,nh)
nybegin=nx(1)+nh(1);
nyend=nx(length(nx))+nh(length(nh));
ny=nybegin:nyend;
%y=conv(x,h); %calling inbuilt function
 y=calcconv(x,h)
end

function [y]=calcconv(x,h)
l1=length(x);
l2=length(h);
N = l1+l2-1; %length of linear convolution
%-------------------------------------------------------------
%y=linear convolution of x[n] and h[n]
%note: in matlab index starts with 1 and not 0
for n=1:1:N
y(n)=0;
```

```
for k=1:1:l1
if(n-k+1>=1 & n-k+1<=l2) % to avoid negative index
y(n)=y(n)+x(k)*h(n-k+1);
end
end
end
end
```

OUTPUT:

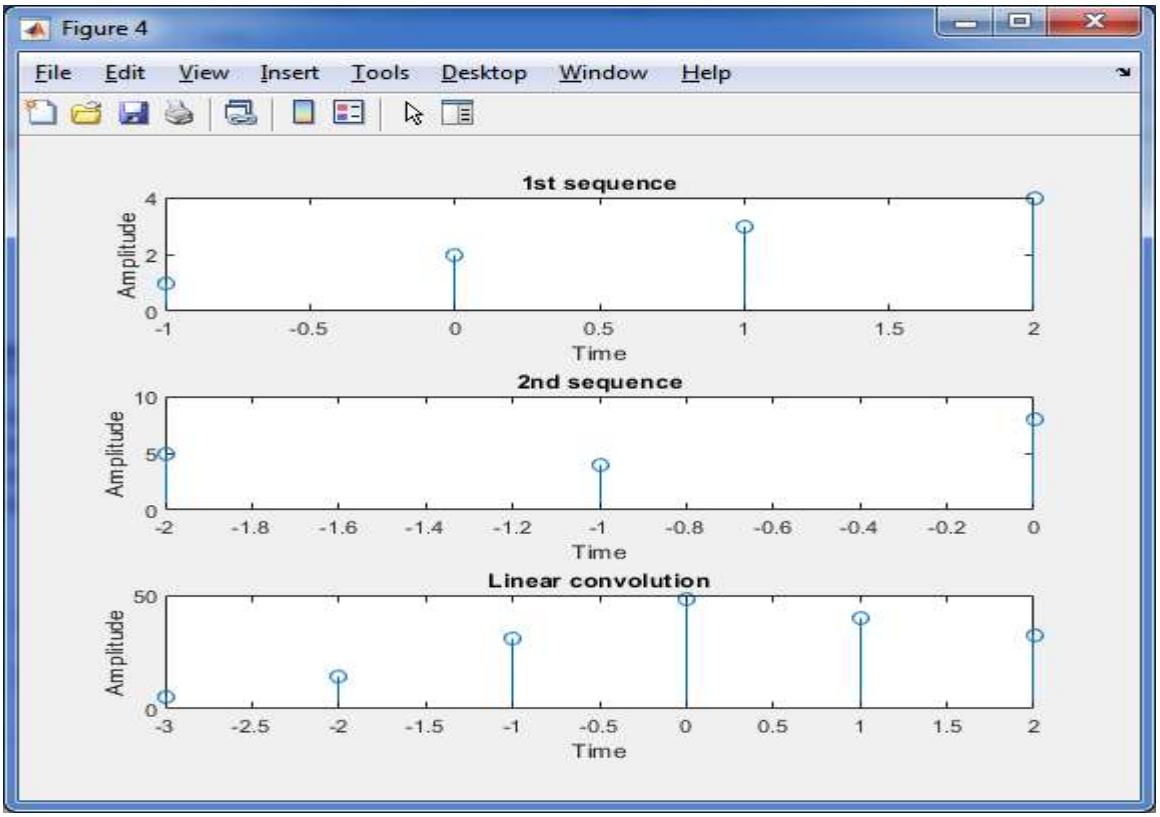
Enter the 1st sequence:[1 2 3 4]
Enter the time index sequence:[-1 0 1 2]
Enter the 2nd sequence:[5 4 8]
Enter the time index sequence:[-2 -1 0]

y =

5 14 31 48 40 32

5 14 31 48 40 32

-3 -2 -1 0 1 2

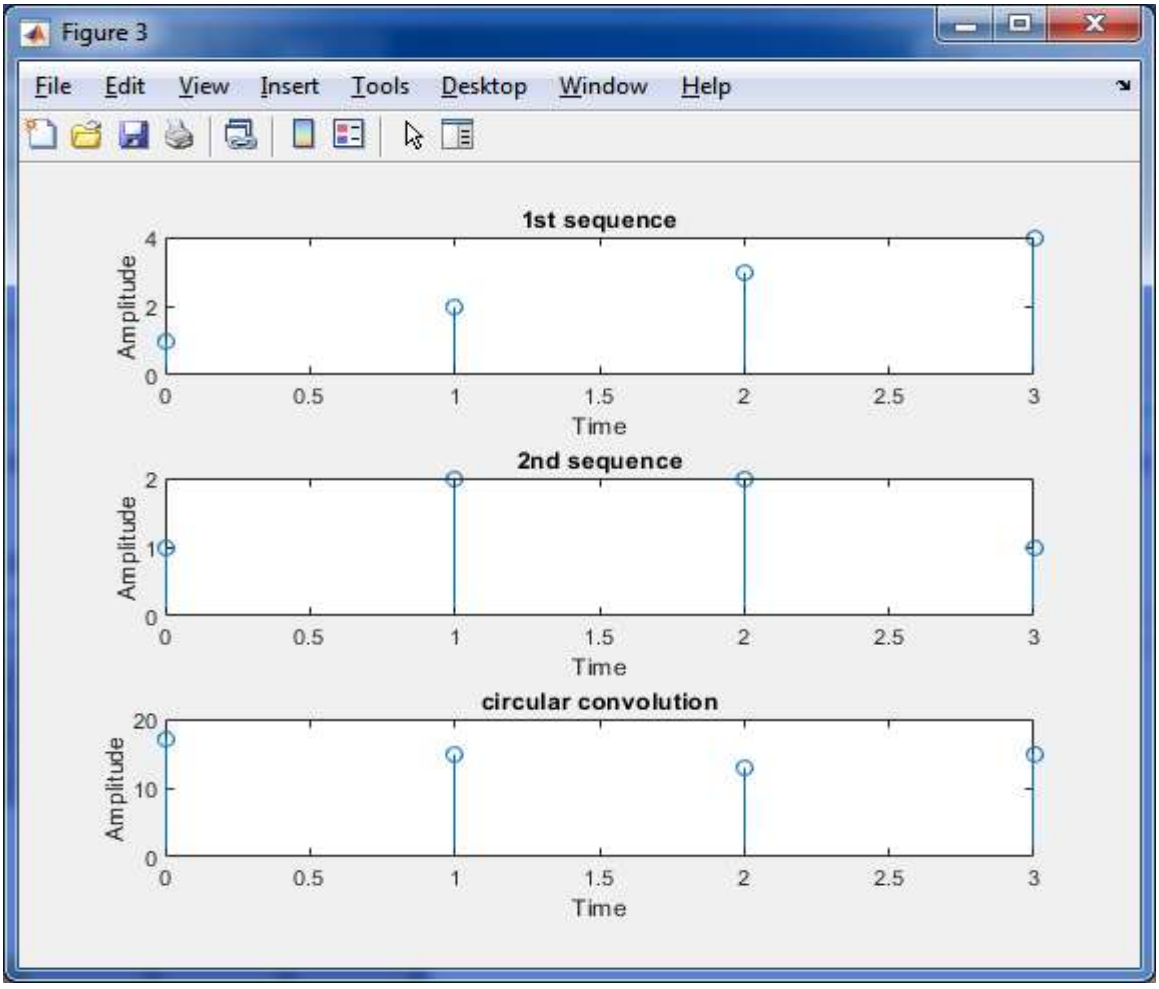



```
%%This program gives the Circular convolution of two sequences.
```

```
%Circular convolution without using inbuilt function
clc; %clears the console window
clear all;%deletes the user defined variable in variable browser
close all;%close the figure window
x= input('Enter x[n]: '); %read input x[n]
h= input('Enter h[n]: '); % read impulse response h[n]
N= input('Enter N: ');
l1=length(x);
l2=length(h);

x=[x zeros(1,(N-l1))]
h=[h zeros(1,(N-l2))]

%inbuilt function
%y=cconv(x,h,N);

%-----------------------------------------------------------------
%y=Circular convolution of x[n] and h[n]
%note: in matlab index starts with 1 and not 0
for n=1:1:N
y(n)=0;
for k=1:1:N

y(n)=y(n)+x(k)*h(mod((n-k),N)+1);
end
end
%end
%-----------------------------------------------------------------
disp('The circular convolution of two given sequence');

n=0:N-1;
figure;
subplot(3,1,1);
stem(n,x);
xlabel('Time');
ylabel('Amplitude');
title('1st sequence');
subplot(3,1,2);
stem(n,h);
xlabel('Time');
ylabel('Amplitude');
title('2nd sequence');
subplot(3,1,3);
stem(n,y);
xlabel('Time');
ylabel('Amplitude');
title('circular convolution');
disp(y);
disp(n);
```

OUTPUT :

```
Enter x[n]: [1 2 3 4]
Enter h[n]: [1 2 2 1]
Enter N: 4

x =

    1    2    3    4


h =

    1    2    2    1

The circular convolution of two given sequence
   17   15   13   15

    0    1    2    3
```



EXPERIMENT No. 5: To find Linear and circular convolution of two sequences using DFT and IDFT.

a) Linear convolution of two sequences using DFT and IDFT.

```
%% Program to find linear convolution using dft and idft
clear all;
close all;
clc;
x=input('Enter the 1st Sequence: ');
h=input('Enter the 2nd Sequence: ');
N=length(x)+length(h)-1;
X=fft(x,N);
H=fft(h,N);
Y=X.*H;
y=calcidft(Y);
figure;
subplot(3,1,1);
stem(0:length(x)-1,x);
xlabel('Time');
ylabel('Amplitude');
title('1st seq');
subplot(3,1,2);
stem(0:length(h)-1, h);
xlabel('Time');
ylabel('Amplitude');
title('2nd seq');
subplot(3,1,3);
stem(0:N-1,real(y));
xlabel('Time');
ylabel('Amplitude');
title('Linear convolution');
disp('Linear convolution');
disp(real(y));
```

OUTPUT:

Enter the 1st Sequence: [1 2 3 4]

Enter the 2nd Sequence: [3 2 4]

Linear convolution

3.0000

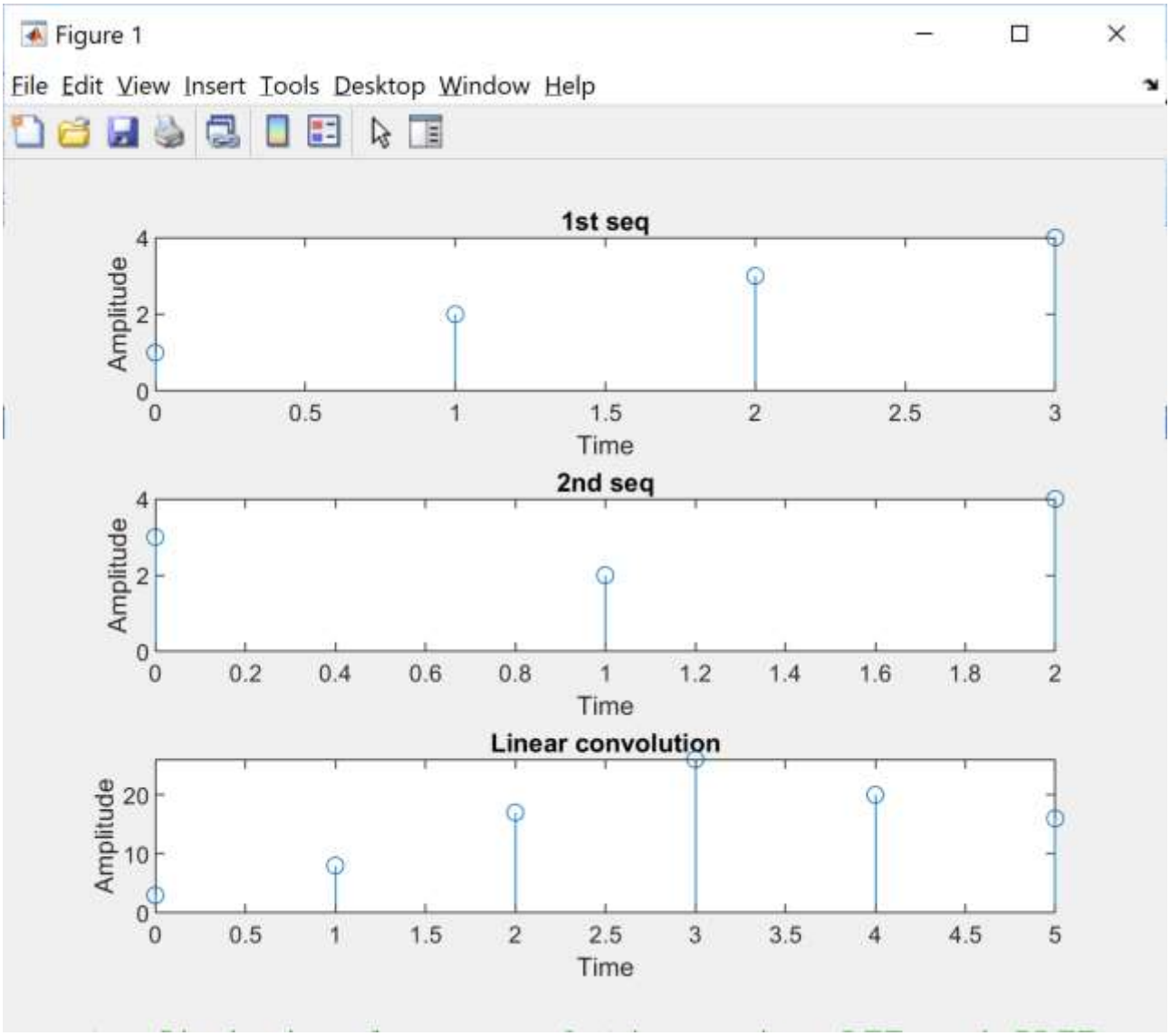
8.0000

17.0000

26.0000

20.0000

16.0000



b) Circular convolution of two given sequences using DFT and IDFT.

```
%% Program to find circular convolution using DFT and IDFT
clear all;
close all;
clc;
x=input('Enter the 1st Sequence: ');
h=input('Enter the 2nd Sequence: ');
N=max(length(x), length(h));
X=calcdft(x,N);
H=calcdft(h,N);
Y=X.*H;
y=ifft(Y,N);
figure;
subplot(3,1,1);
```

```
stem(0:length(x)-1,x);
xlabel('Time');
ylabel('Amplitude');
title('1st seq');
subplot(3,1,2);
stem(0:length(h)-1, h);
xlabel('Time');
ylabel('Amplitude');
title('2nd seq');
subplot(3,1,3);
stem(0:N-1,real(y));
xlabel('Time');
ylabel('Amplitude');
title('circular convolution');
disp('circular convolution');
disp(real(y));
```

OUTPUT:

Enter the 1st Sequence: [1 2 3 4]

Enter the 2nd Sequence: [1 2 2 1]

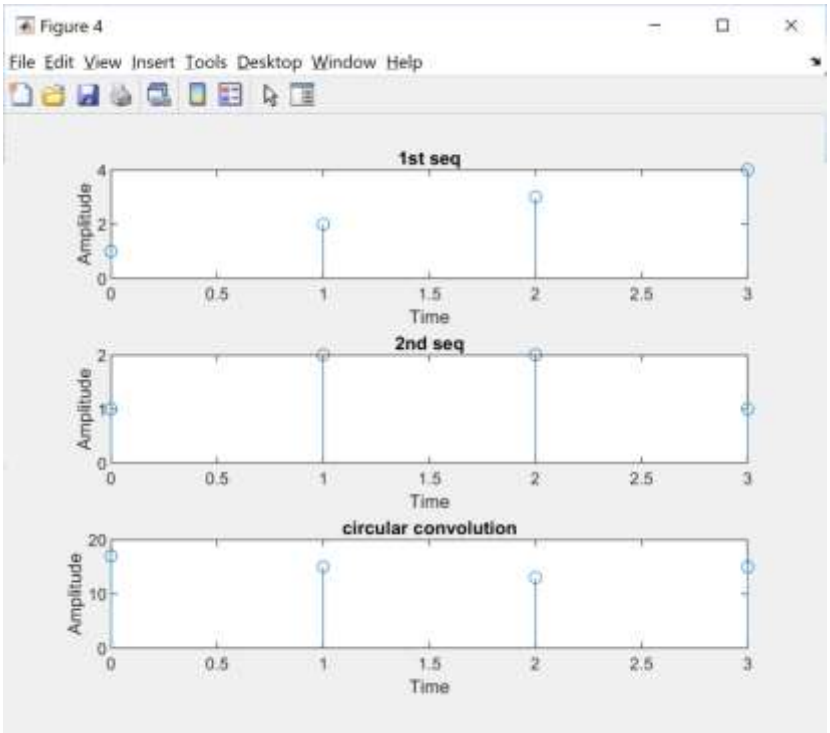
Circular convolution

17

15

13

15



EXPERIMENT No.6.(a) Autocorrelation of a given sequence and verification of its properties. (b)Cross correlation of given sequences and verification of its properties.

Verification of properties

- $r_{xx}[l] = r^*_{xx}[-l]$
- $r_{xx}[0] = Ex$
- $|r_{xx}[l]| \leq r_{xx}[0]$
- $r_{xy}[l] = r^*_{xy}[-l]$
- $|rxy[l]| \leq sqrt(ExEy)$

(a) Autocorrelation of a given sequence and verification of its properties

```
clc; %clears the console window
clear all;%deletes the user defined variable in variable browser
close all;%close the figure window

%% Main Program
x=input('enter the sequence x= ');
nx=input('enter the index for sequence nx= ');
[rxx,nrxx]=findconv(x,nx,flip(x),-flip(nx));
%using inbuilt function
%[rxx,nrxx]= xcorr(x);
E=sum(x.^2);
disp('energy');
disp(E);
disp(rxx);
disp(nrxx);
if(rxx(ceil(length(rxx)/2))==max(rxx))
disp('Rxx(0) is the maximum value; proved');
else
disp('Rxx(0) is the maximum value; not proved');
end;
if (rxx(ceil(length(rxx)/2))==E)
disp('Rxx(0)gives energy; proved');
else
disp('Rxx(0)gives energy; not proved');
end
if (rxx==flip(rxx))
disp('symmetric property satisfied');
else
disp('symmetric property not satisfied');
end
subplot(2,1,1);
stem(nx,x);
xlabel('n');
ylabel('x[n]');
```

```
subplot(2,1,2);
stem(nrxx,rxx);
xlabel('l');
ylabel('r[l]');
title('auto correlation');
%%function
function [y,ny]=findconv(x,nx,h,nh)
nyb=nx(1)+nh(1);
nye=nx(length(nx))+nh(length(nh));
ny=nyb:nye;
y=conv(x,h);
end
```

OUTPUT:

enter the sequence x= [1 1 1 1 1 1 1 1 1 1]
enter the index for sequence nx= [1:10]
energy

10

Columns 1 through 15

1 2 3 4 5 6 7 8 9 10 9 8 7 6 5

Columns 16 through 19

4 3 2 1

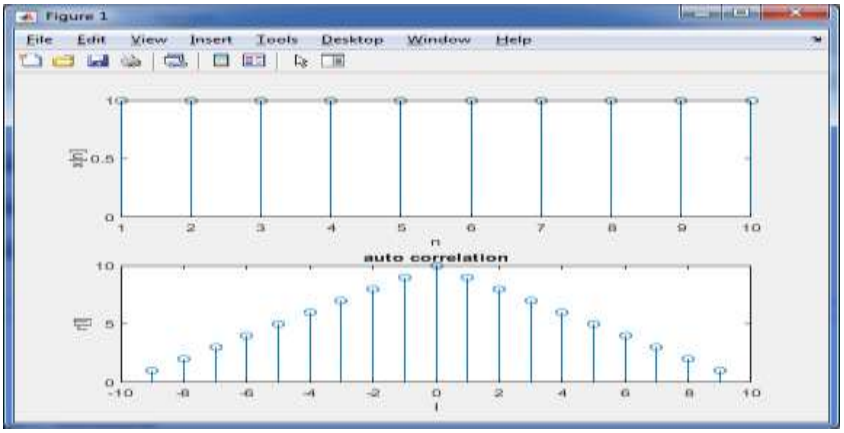
Columns 1 through 15

-9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5

Columns 16 through 19

6 7 8 9

Rxx(0) is the maximum value; proved
Rxx(0)gives energy; proved
symmetric property satisfied



(b)Cross correlation of given sequences and verification of its properties.

```
clc; %clears the console window
clear all;%deletes the user defined variable in variable browser
close all;%close the figure window

%% Main Program

x=input('Enter the 1st seq:');
nx=input('Enter the time index seq:');
y=input('Enter the 2nd seq:');
ny=input('Enter the time index seq:');
[rxy,nrxy]=findconv(x,nx,flip(y),-flip(ny));
[ryx,nryx]=findconv(y,ny,flip(x),-flip(nx));

disp('rxy=');
disp(rxy);
disp(nrxy);
disp('ryx=');
disp(ryx);
disp(nryx);

if (rxy==flip(ryx))
disp('Rxy(lag)=Ryx(-lag) satisfied');
else
disp('Rxy(lag)=Ryx(-lag) not satisfied');
end
figure;
subplot(3,1,1);
stem(nx,x);
xlabel('Time');
ylabel('Amplitude');
title('1st seq');
subplot(3,1,2);
stem(ny,y);
xlabel('Time');
ylabel('Amplitude');
title('2nd seq');
subplot(3,1,3);
stem(ny,y);
disp(y);
disp(ny);
xlabel('Time');
ylabel('Amplitude');
title('cross correlation convolution');

%%function
function [y,ny]=findconv(x,nx,h,nh)
nyb=nx(1)+nh(1);
nye=nx(length(nx))+nh(length(nh));
ny=nyb:nye;
```

```
y=conv(x,h);
end
```

OUTPUT:

Enter the 1st seq:[2 1 0 0]
Enter the time index seq:[0:3]
Enter the 2nd seq:[1 0 0 3]
Enter the time index seq:[0:3]
rxy=

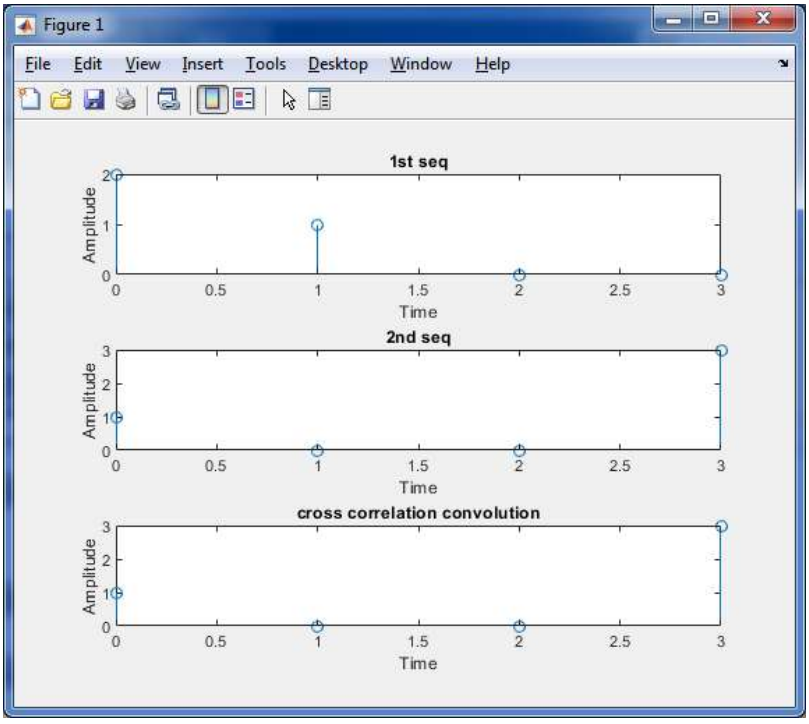
```
    6     3     0     2     1     0     0

   -3    -2    -1     0     1     2     3
```

ryx=

```
    0     0     1     2     0     3     6

   -3    -2    -1     0     1     2     3
```

Rxy(lag)=Ryx(-lag) satisfied

```
    1     0     0     3

    0     1     2     3
```



EXPERIMENT No. 7: Design and implementation of Analog Butterworth and Chebyshev Filters to meet the given specifications.

i. Design an analog low pass Butterworth filter for the following specifications.
   a. Pass band ripple=-3dB
   b. Stop band ripple=-40dB
   c. Pass band frequency=1000Hz
   d. Stop band frequency=2000Hz

   Show all the design steps plot and verify the same using MATLAB.

```
clc;
clear all;
close all;

ap=-3;%%db
as=-40;%%db
fp=1000;%%Hz
fs=2000;%%Hz


% ap=input('Enter the pass band ripple (in dB)');
% as=input('Enter the stop band ripple (in dB)');
% fp=input('Enter the pass band frequency (in Hz)');
% fs=input('Enter the stop band frequency (in Hz)');

op=2*pi*fp; %%angular freq in rad/sec
os=2*pi*fs; %%angular freq in rad/sec
A=log10((10^(-ap/10)-1)/(10^(-as/10)-1 ));
B=2*log10(op/os);
N= A/B;
N=ceil(N);
disp('Orderofthefilter,N=');
disp(N);

%oc=op/((10^(-ap/10)-1)^(1/(2*N))); %or
oc=os/((10^(-as/10)-1)^(1/(2*N)));

disp('Cutoff freq,oc=');
disp(oc);
% %using inbuilt function
% [N,oc]=buttord(op,os,-ap,-as,'s');
[b,a]=butter(N,oc,'s');

fr=0:100:4000;
wr=2*pi*fr;

[H,w]=freqs(b,a,wr);
f=w/(2*pi);
H_mag=20*log10(abs(H));
figure;
plot(f,H_mag);
```

```
grid on;
xlabel('Frequency in Hz');
ylabel('Magnitude in dB');
title('Magnitude Response');

Transferfunc=tf(b,a)
```

OUTPUT:

Orderofthefilter,N= 7
Cutoff freq,oc= 6.5088e+03

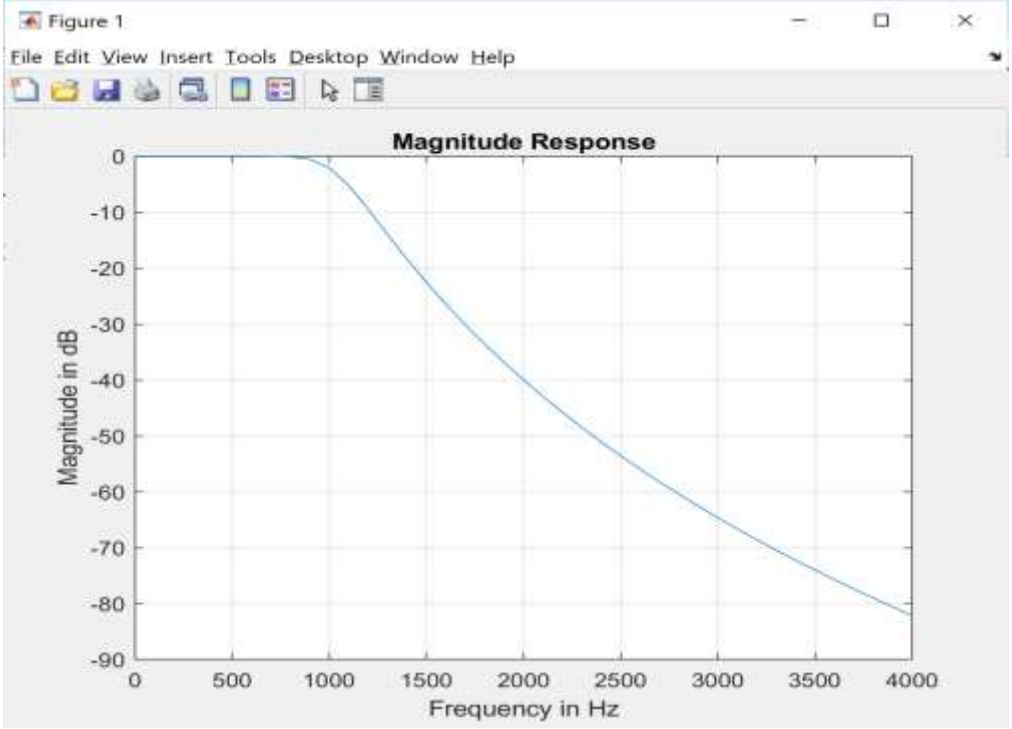
Transferfunc =

4.949e26

---

s^7 + 2.925e04 s^6 + 4.278e08 s^5 + 4.024e12 s^4 + 2.619e16 s^3 + 1.18e20 s^2

+ 3.417e23 s + 4.949e26



ii. Design an analog low pass Chebyshev type 1 filter for the following specifications.

a. Pass band ripple=-3dB
b. Stop band ripple=-40dB
c. Pass band frequency=1000Hz
d. Stop band frequency=2000Hz

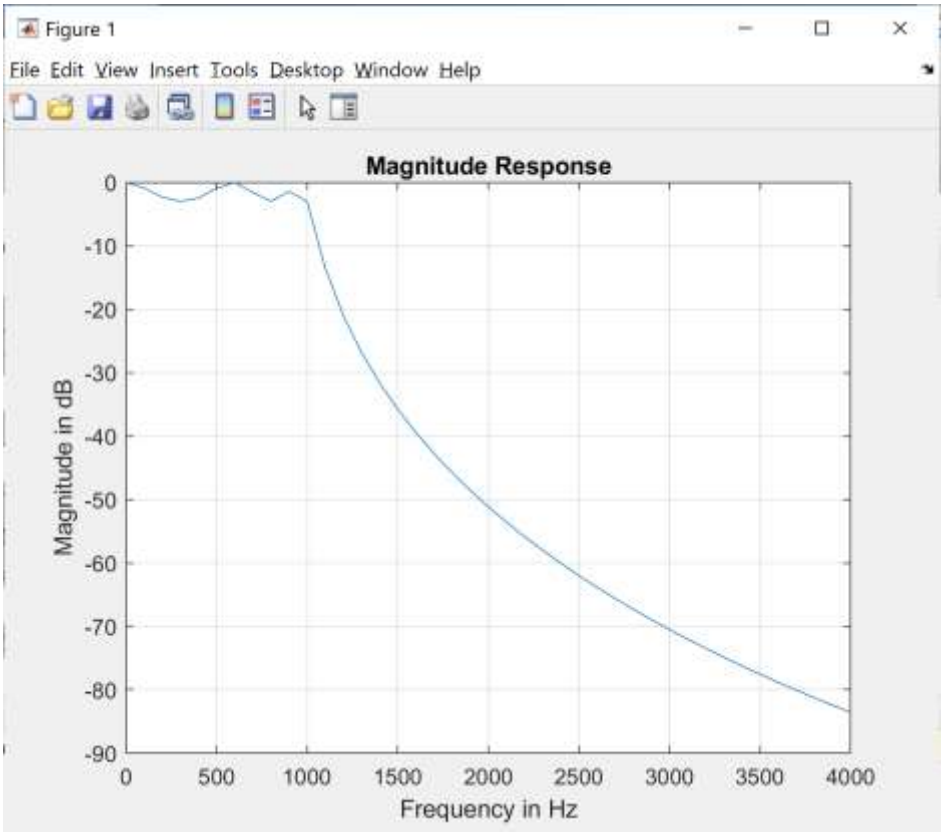
Show all the design steps plot and verify the same using MATLAB.

```
clc;
clear all;
close all;

ap=-3;%%db
as=-40;%%db
fp=1000;%%Hz
fs=2000;%%Hz


% ap=input('Enter the pass band ripple (in dB)');
% as=input('Enter the stop band ripple (in dB)');
% fp=input('Enter the pass band frequency (in Hz)');
% fs=input('Enter the stop band frequency (in Hz)');

op=2*pi*fp; %%angular freq in rad/sec
os=2*pi*fs; %%angular freq in rad/sec

omegar=os/op; %%omegar in rad/sec

epsilon=sqrt(10^(-ap/10)-1);

A=sqrt(10^(-as/10));

g=sqrt((A^2-1)/(epsilon^2));

N=log10(g+sqrt(g^2-1))/log10(omegar+sqrt(omegar^2-1))%%or
%%N=acosh(g)/acosh(omegar);

N=ceil(N);
disp('Orderofthefilter,N=');
disp(N);


%using inbuilt function
% [N,oc]=cheb1ord(op,os,-ap,-as,'s');
[b,a]=cheby1(N,-ap,op,'s');

fr=0:100:4000;
wr=2*pi*fr;

[H,w]=freqs(b,a,wr);
f=w/(2*pi);
H_mag=20*log10(abs(H));
figure;
plot(f,H_mag);
grid on;
xlabel('Frequency in Hz');
ylabel('Magnitude in dB');
title('Magnitude Response');
```

```
Transferfunc=tf(b,a)
```

OUTPUT:

```
N =

    4.0249

Orderofthefilter,N=
     5


Transferfunc =

                          6.135e17
  ------------------------------------------------------------------------
  s^5 + 3610 s^4 + 5.586e07 s^3 + 1.362e11 s^2 + 6.358e14 s + 6.135e17
```



EXPERIMENT No. 8: Design and implementation of IIR, Butterworth and Chebyshev Filters to meet the given specifications.

i. Design a low pass Butterworth filter (using bilinear transformation) for the following specifications.
   a. Pass band ripple=3.01dB
   b. Stop band ripple=15dB
   c. Pass band frequency=500Hz
   d. Stop band frequency=750Hz
   e. Sampling frequency=2kHz

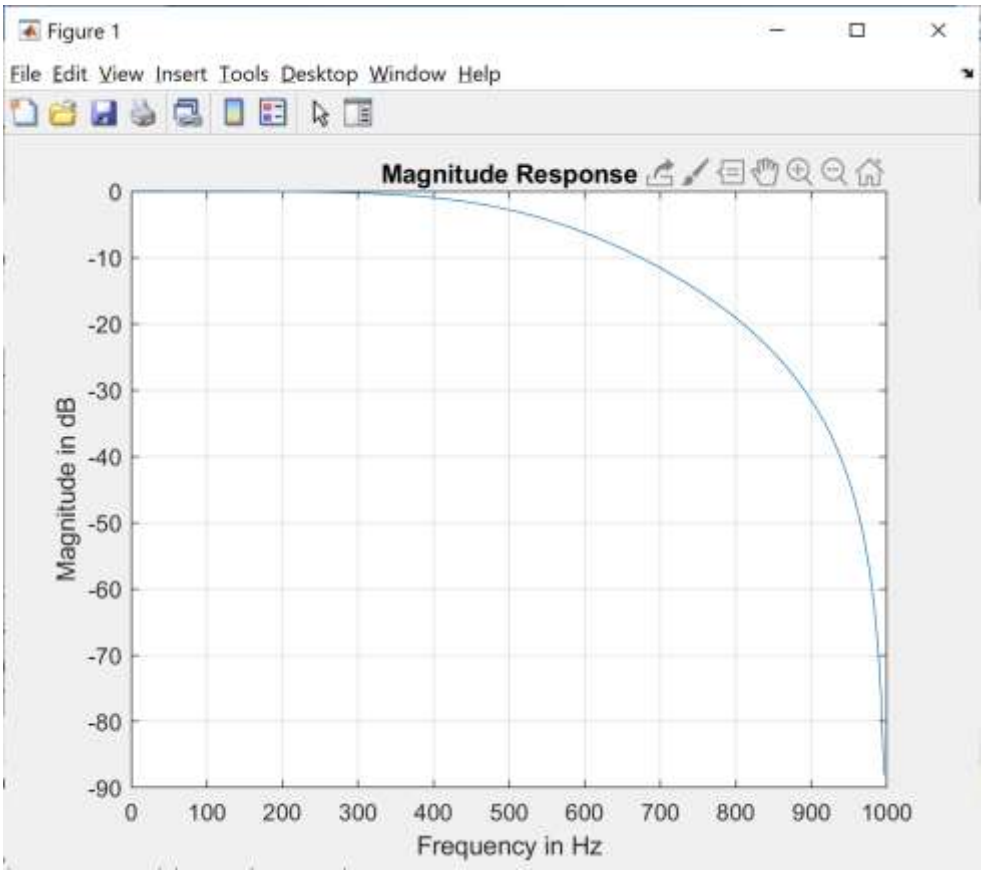
   Show all the design steps plot and verify the same using MATLAB.

```
clc;
clear all;
close all;
rp=input('Enter the pass band ripple (in dB)');
rs=input('Enter the stop band ripple (in dB)');
fs=input('Enter the sampling frequency (in Hz)');
fp=input('Enter the pass band frequency (in Hz)');
fst=input('Enter the stop band frequency (in Hz)');
fn=fs/2;%normalized sampling frequency
fpn=fp/fn;%normalized pass band frequency
fstn=fst/fn;%normalized stop band frequency

[N,wc]=buttord(fpn,fstn,rp,rs);
[b,a]=butter(N,wc);
[H,f]=freqz(b,a,256,fs);

Transferfunc=tf(b,a,(1/fs))
H_mag=20*log10(abs(H));
figure;
plot(f,H_mag);
grid on;
xlabel('Frequency in Hz');
ylabel('Magnitude in dB');
title('Magnitude Response');
```

OUTPUT:

```
Enter the pass band ripple (in dB)3
Enter the stop band ripple (in dB)15
Enter the sampling frequency (in Hz)2000
Enter the pass band frequency (in Hz)500
Enter the stop band frequency (in Hz)750

Transferfunc =

  0.3005 z^2 + 0.6011 z + 0.3005
  ------------------------------
    z^2 + 0.03039 z + 0.1717
```

Sample time: 0.0005 seconds
Discrete-time transfer function.



ii. Design a low pass Chebyshev filter type-1 (using bilinear transformation) for the following specifications.

a. Pass band ripple=3dB
b. Stop band ripple=20dB
c. Pass band frequency=1200Hz
d. Stop band frequency=1800Hz
e. Sampling frequency=8kHz

Show all the design steps. Plot and verify the same using MATLAB.

```
clc;
clear all;
close all;
rp=input('Enter the pass band ripple (in dB)');
rs=input('Enter the stop band ripple (in dB)');
fs=input('Enter the sampling frequency (in Hz)');
fp=input('Enter the pass band frequency (in Hz)');
fst=input('Enter the stop band frequency (in Hz)');
fn=fs/2;%normalized sampling frequency
```

```
fpn=fp/fn;%normalized pass band frequency
fstn=fst/fn;%normalized stop band frequency
[N,wc]=cheb1ord(fpn,fstn,rp,rs);
[b,a]=cheby1(N,rp,wc);

Transferfunc=tf(b,a,(1/fs))

[H,f]=freqz(b,a,256,fs);
H_mag=20*log10(abs(H));
figure;
plot(f,H_mag);
grid on;
xlabel('Frequency in Hz');
ylabel('Magnitude in dB');
title('Magnitude Response');
```

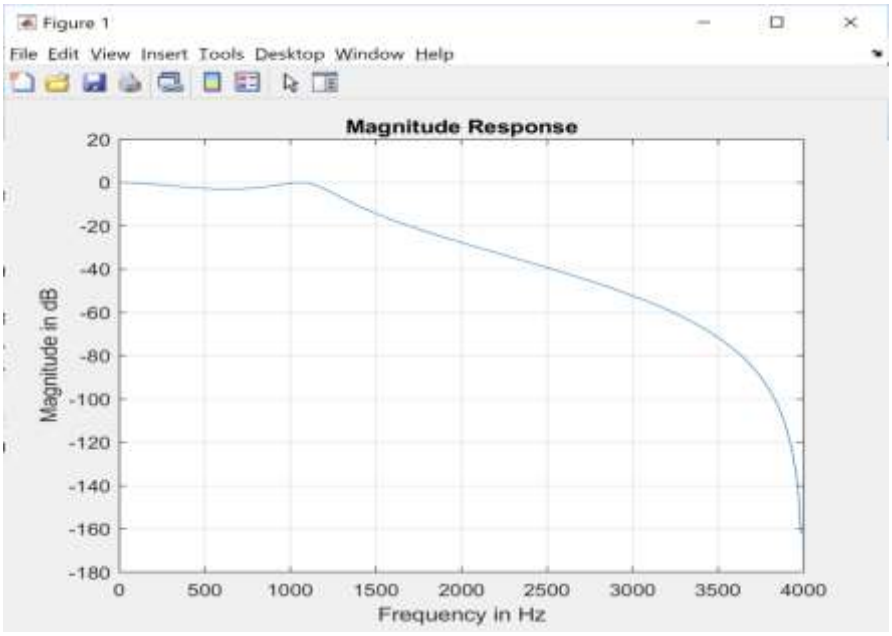
OUTPUT:

Enter the pass band ripple (in dB)3
Enter the stop band ripple (in dB)20
Enter the sampling frequency (in Hz)8000
Enter the pass band frequency (in Hz)1200
Enter the stop band frequency (in Hz)1800

Transferfunc =

$$\frac{0.021 z^3 + 0.063 z^2 + 0.063 z + 0.021}{z^3 - 1.878 z^2 + 1.618 z - 0.5724}$$

Sample time: 0.000125 seconds, Discrete-time transfer function.



EXPERIMENT No.9 .Design and implementation of FIR filter to meet given specifications.

A: FIR Filter design using windows

```
%%Designing Low Pass filter with pass band edge frequency=1500hz
minimum stop band attenuation is 50dB Transition bandwidth is
0.5khz sampling frequency is 8khz
clear all;
close all;

clc;
fs=8000; %%sampling frequency
fp=1500; %%pass band edge frequency
fst=2000;%%stop band edge frequency
wp=(2*pi*fp)/fs;
ws=(2*pi*fst)/fs;
twn=(ws-wp)/pi;%%normalize transition width choose hamming window
To find
wc=wp+twn*pi/2;
%%LENGTH(TAPS) of filter (i.e M).The filter order is always equal
to the number of taps minus 1
N=ceil(8/twn);
%%To design type I FIR filter , taps=odd or order=even
if(mod(N,2)==0)
N=N+1;
end
alpha=(N-1)/2;
er=0.001;
for n=0:1:N-1
hd(:,n+1)=(sin(wc*(n-alpha+er)))./(pi*(n-alpha+er));
end
%disp(hd)

figure;
whm=hamming(N);%%hamming window
disp('Hammind window coeff');
disp(whm);
stem(whm);
title('Hamming window');

hn=hd.*whm';

[H,f]=freqz(hn,1,1000,fs);
H_mag=20*log10(abs(H));

figure;
plot(f,H_mag);
xlabel('Normalized frequency');
ylabel('Magnitude');
```

```
disp('FIR Filter coeff hn');
disp(hn);
```

OUTPUT:

```
FIR Filter coeff hn
  Columns 1 through 8

   -0.0000   -0.0008   -0.0004    0.0009    0.0009   -0.0009   -
0.0018    0.0005

  Columns 9 through 16

    0.0028    0.0007   -0.0038   -0.0027    0.0041    0.0057   -
0.0031   -0.0091

  Columns 17 through 24

    0.0000    0.0122    0.0055   -0.0137   -0.0134    0.0122
0.0234   -0.0058

  Columns 25 through 32

   -0.0344   -0.0079    0.0452    0.0334   -0.0544   -0.0864
0.0606    0.3117

  Columns 33 through 40

    0.4375    0.3113    0.0601   -0.0865   -0.0542    0.0335
0.0452   -0.0080

  Columns 41 through 48

   -0.0344   -0.0057    0.0234    0.0121   -0.0134   -0.0137
0.0055    0.0122

  Columns 49 through 56

   -0.0000   -0.0091   -0.0030    0.0057    0.0041   -0.0027   -
0.0038    0.0007

  Columns 57 through 64

    0.0028    0.0005   -0.0018   -0.0009    0.0009    0.0009   -
0.0004   -0.0008

  Column 65

    0.0000
```

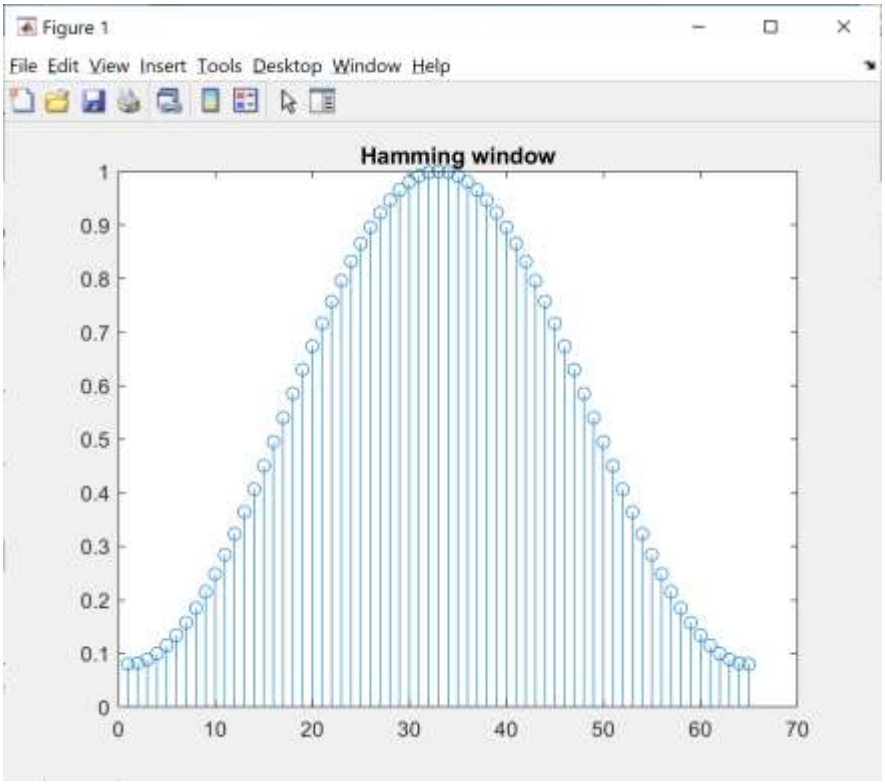


Figure 1
File Edit View Insert Tools Desktop Window Help
Hamming window
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70

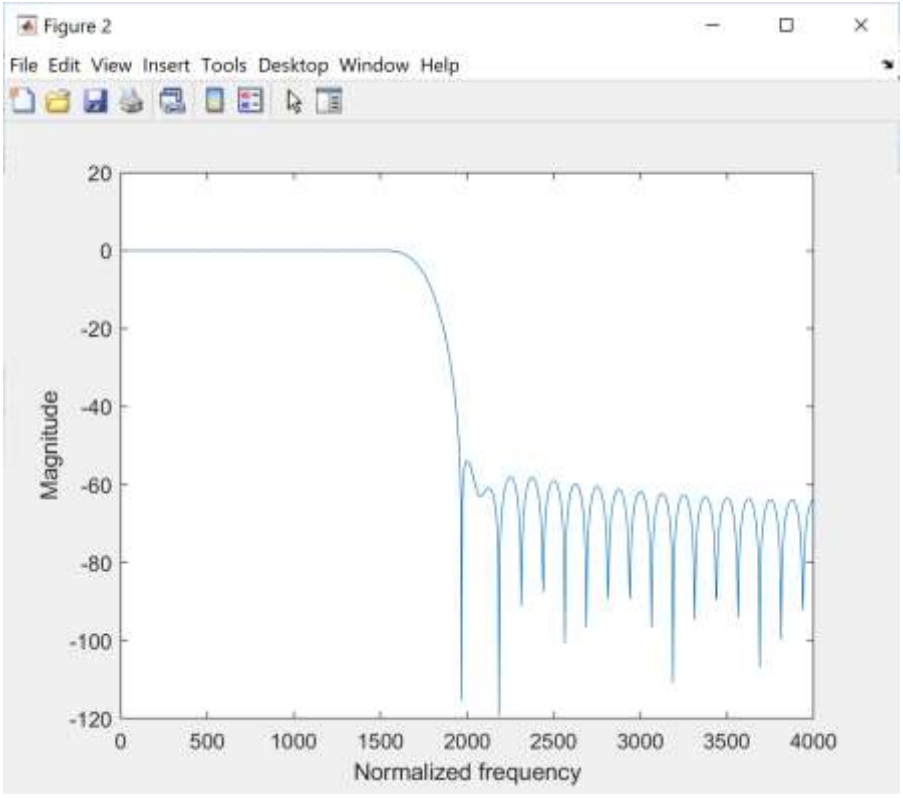


Figure 2
File Edit View Insert Tools Desktop Window Help
20
0
-20
-40
-60
-80
-100
-120
Magnitude
0
500
1000
1500
2000
2500
3000
3500
4000
Normalized frequency

B. Frequency sampling technique.

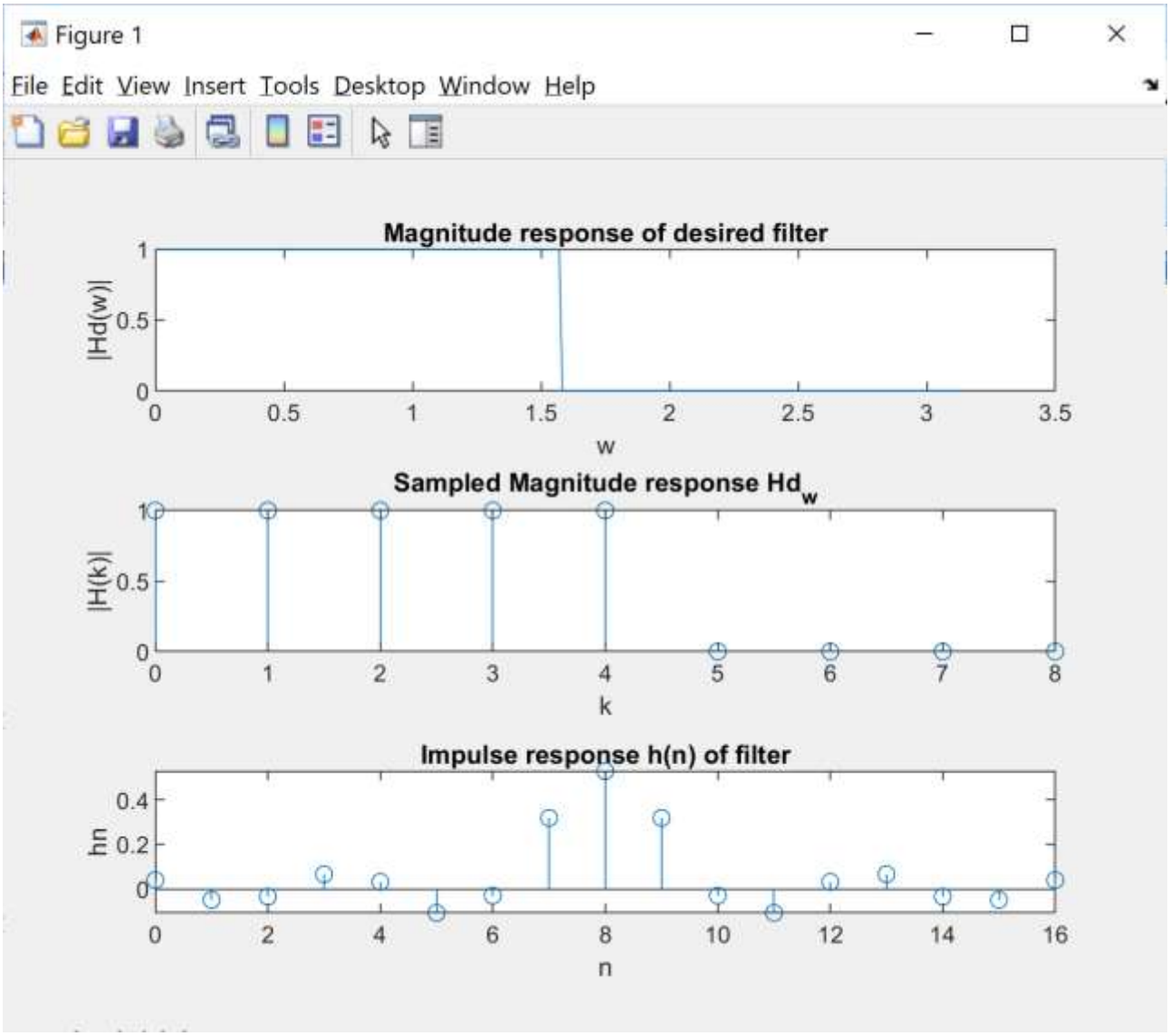
```
%%Design a linear phase FIR low pass filter using
%%frequency sampling method. Let M=17(order)
%%and cutoff frequency is wc=pi/2 rad/sample
%%Desired frequency response
%%Hd(w)= exp(-%j*w(M-1)/2) for 0<=w<=pi/2
%%     = 0                 for pi/2<=w<=pi

%%from Hd(w) we get H(k) by sampling w=(2*pi*k)/M
%% H(k)= Hd(w)| at w=(2*pi*k)/M
%% h(n)=1/M <summ k=0 to M-1>[H(k)e^j2pikn/M]  0<=n<=M-1
%%h(n) must be real
%% h(n)=1/M(H(0)+ 2 <summ n=1 to p> Re[H(k)e^j2pikn/M])
%%p=(M-1)/2 if N is odd
%% =M/2 -1 if N is even

clc;
clear all;
close all;

wc=pi/2; %%cutt of freq in rad/sample

M=17; %%take odd order

%%Desired frequency response
w=0:(pi/256):pi;
Hd_w =([w<=pi/2]).* exp(-i*w*(M-1)/2);
figure;
subplot(3,1,1);
plot(w,abs(Hd_w));
title('Magnitude response of desired filter');
xlabel('w');
ylabel('|Hd(w)|');


%%(2*pi*kc)/M <= pi/2
%% kc <= (pi/2)*(M/(2*pi))
%% kc<= M/4 = 17/4, but k can take only integer=4

kc = floor(wc*(M/(2*pi)));

k=0:(M-1)/2;

%%frequency sampling Hd_w to get Hk
Hk = ([k<=kc]).* exp(-i*(2*pi*k/M)*((M-1)/2))

subplot(3,1,2);
stem(k,abs(Hk));
title('Sampled Magnitude response Hd_w');
```

```
xlabel('k');
ylabel('|H(k)|');

%% Taking idft of H(k) to find h(n)

for n=0:(M-1)
       sumHk=0;
    for k=1:(M-1)/2
        sumHk = sumHk+real(Hk(k+1)*exp(i*2*pi*k*n/M));
    end

    hn(n+1)=(1/M)*(Hk(1)+2*sumHk);
end



n=0:(M-1);
subplot(3,1,3);
stem(n,hn);
title('Impulse response h(n) of filter')
xlabel('n');
ylabel('hn');


[H,f]=freqz(hn,1,1000);
H_mag=20*log10(abs(H));

figure;
plot(f,H_mag);
xlabel('Normalized frequency');
ylabel('Magnitude');

disp('FIR Filter coeff hn');
disp(hn);
```

OUTPUT:

```
Hk =

  Columns 1 through 4

   1.0000 + 0.0000i  -0.9830 - 0.1837i   0.9325 + 0.3612i  -0.8502
- 0.5264i

  Columns 5 through 8

   0.7390 + 0.6737i   0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000
+ 0.0000i
```

```
  Column 9

   0.0000 + 0.0000i

FIR Filter coeff hn
  Columns 1 through 8

    0.0398   -0.0488   -0.0346    0.0660    0.0315   -0.1075   -
0.0299    0.3188

  Columns 9 through 16

    0.5294    0.3188   -0.0299   -0.1075    0.0315    0.0660   -
0.0346   -0.0488

  Column 17

    0.0398
```



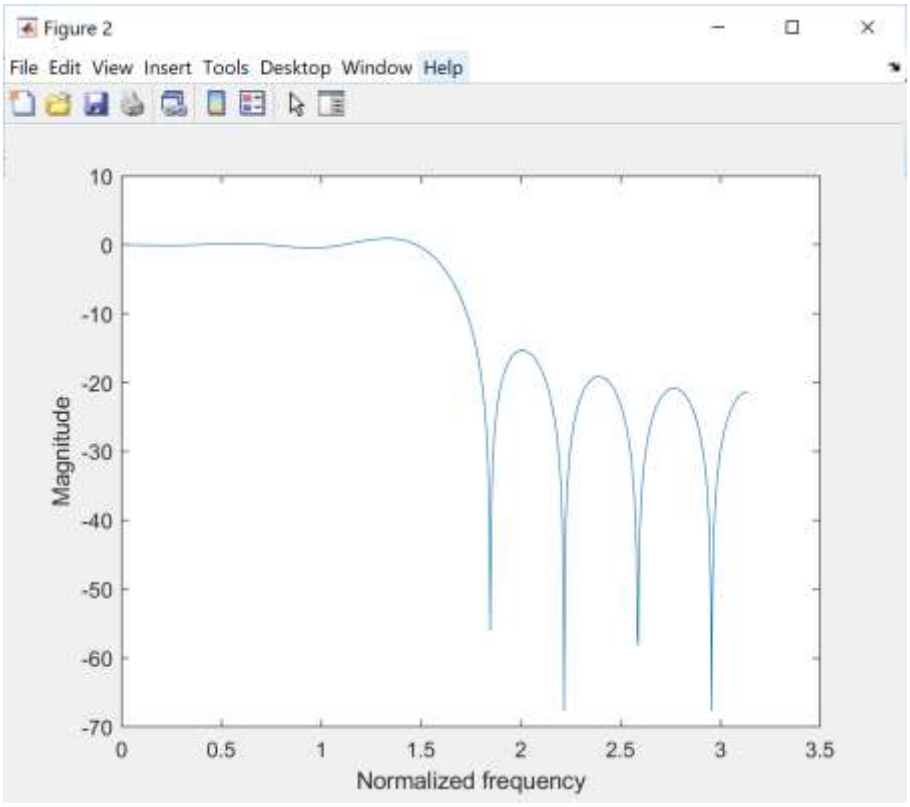
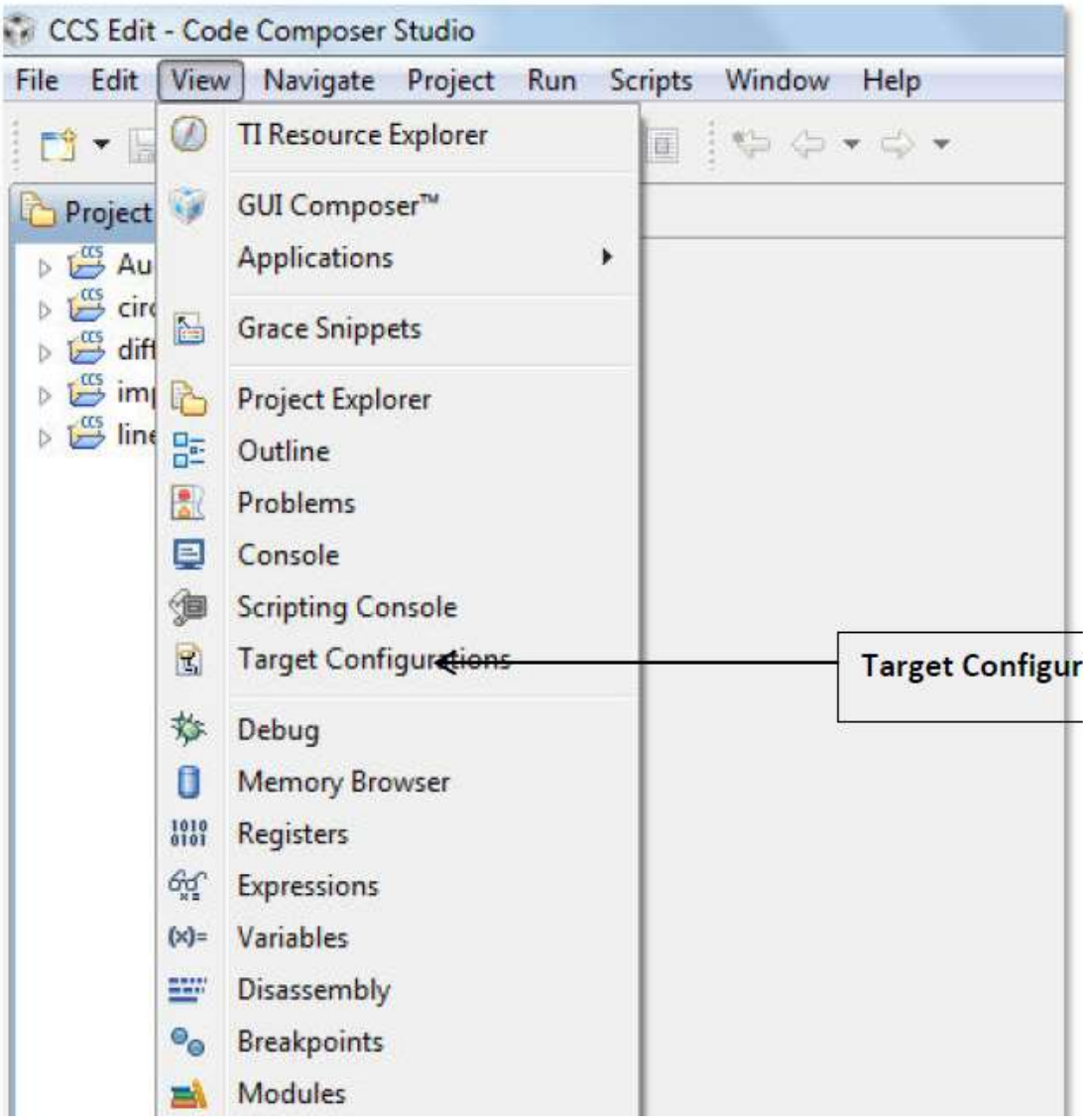


Figure 2
File Edit View Insert Tools Desktop Window Help
10
0
-10
-20
-30
-40
-50
-60
-70
Magnitude
0
0.5
1
1.5
2
2.5
3
3.5
Normalized frequency

CYCLE II LIST OF EXPERIMENTS USING DSP PROCESSOR

PROCEDURE TO EXECUTE CYCLE 2 PROGRAMS
PROCEDURE TO USE Code Composer Studio
It is assumed that the user has LAUNCHED THE CODE COMPOSER STUDIO according to the procedure mentioned above. Once the project explorer window appears, the user has to set the configurations for the target device (LCDK C6748).
Setting Target Configuration:

Go to View->Target Configurations



On the Right Hand Side of your project window, you can notice a target configuration space. Click on the new target configuration file as shown in the screen shot.

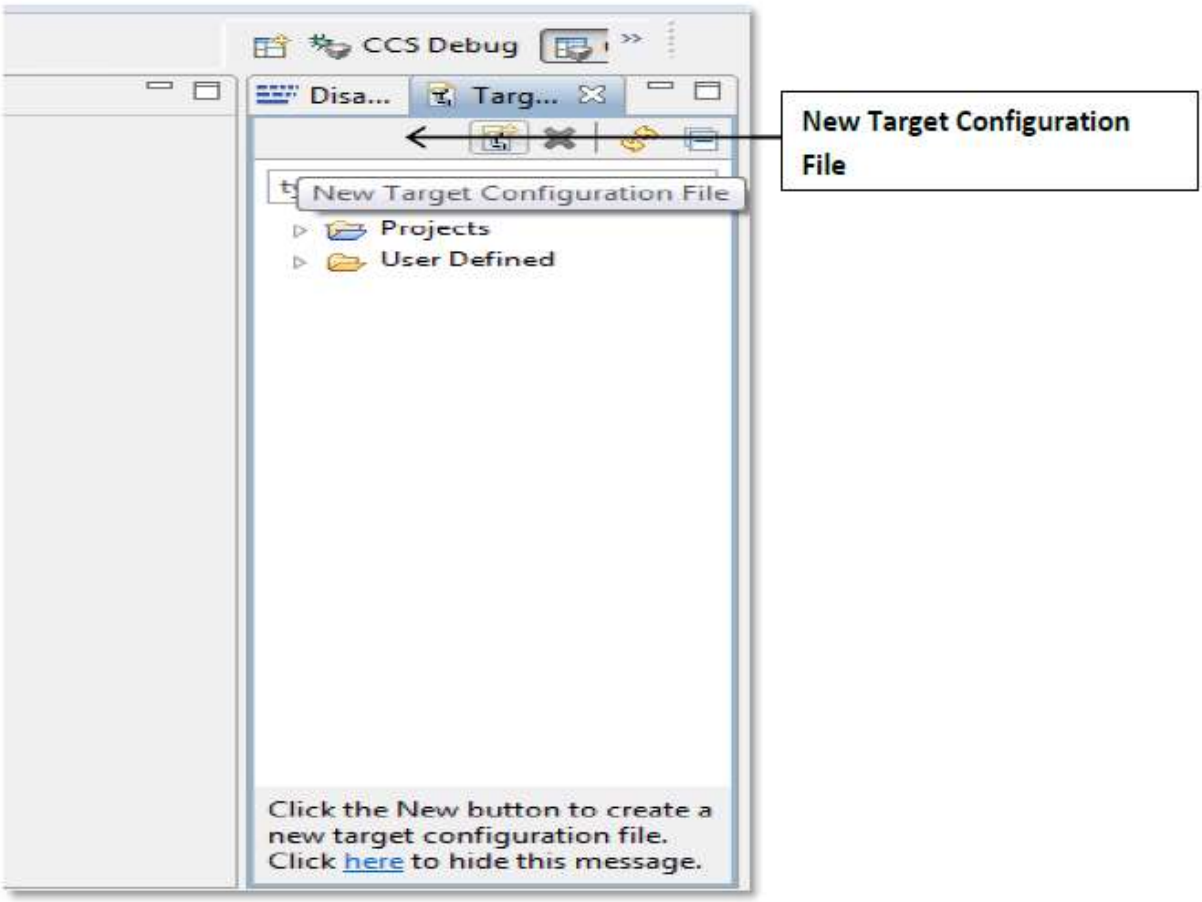
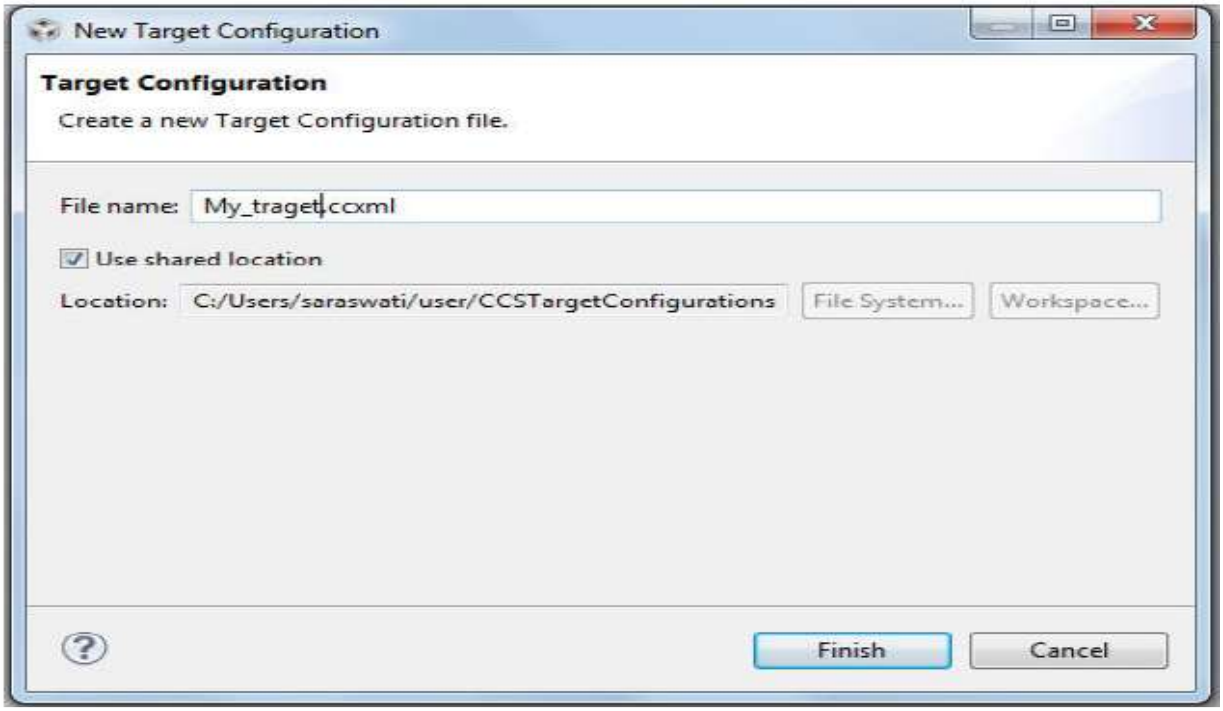


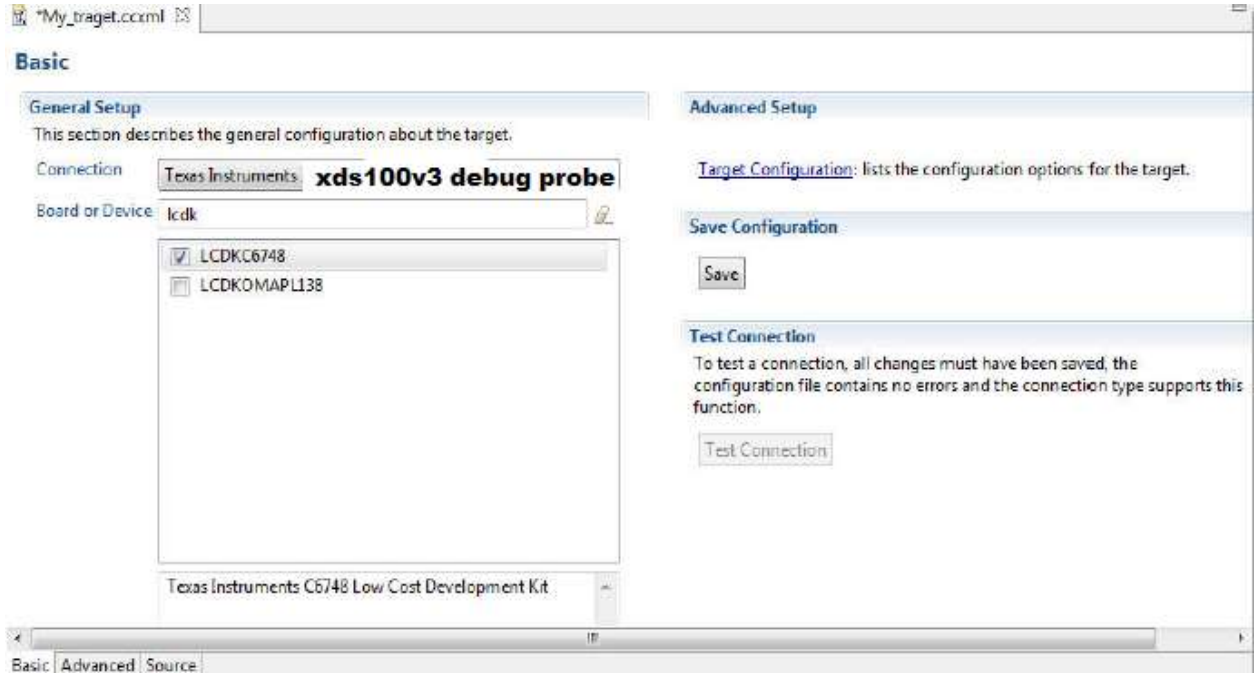
Fig: Target Configuration Space

- Give a suitable name to your target device(Here its named as My_target.ccxml)

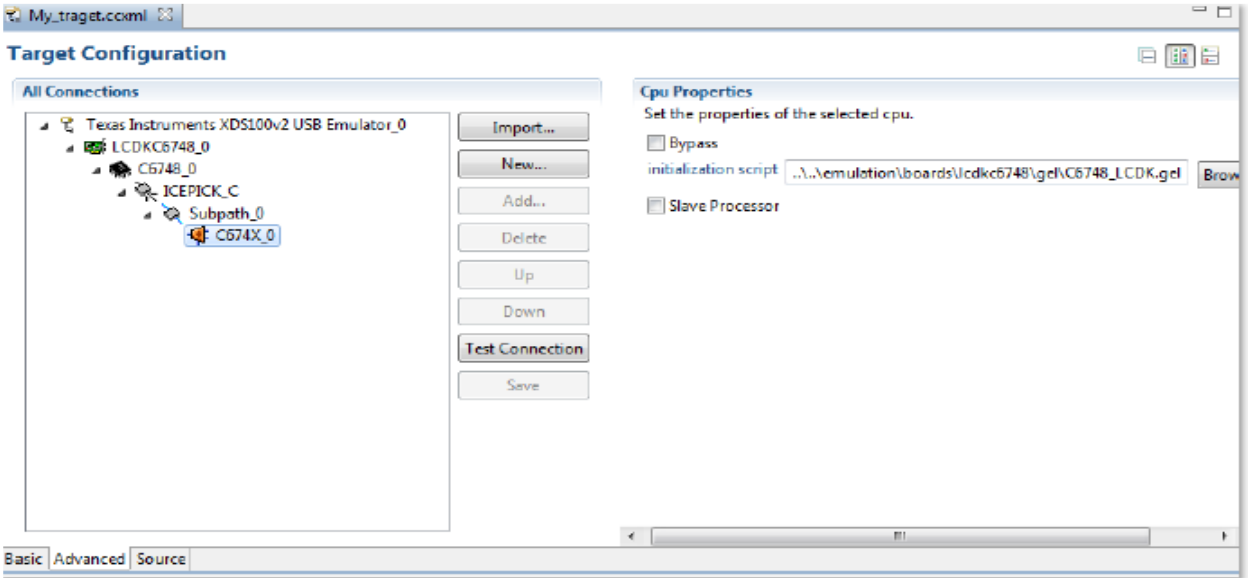


Click on Finish.

The Connection should be “Texas Instruments XDS100V3 Debug Probe”. The Board or Device should be LCDKC6748.



- Click on Save and then Test Connection. If your connection is OK, then a message as “JTAGDR integrity test succeeded” will appear.
- Click on the “Advanced” tab and then Click on C674x_0, verify the GEL file path.



Without the proper GEL file, hardware will not be connected to CCSv5.
Close “Target Configuration” window and Right Click on My_target and select SET AS DEFAULT and then LAUNCH SELECTED CONFIGURATION.

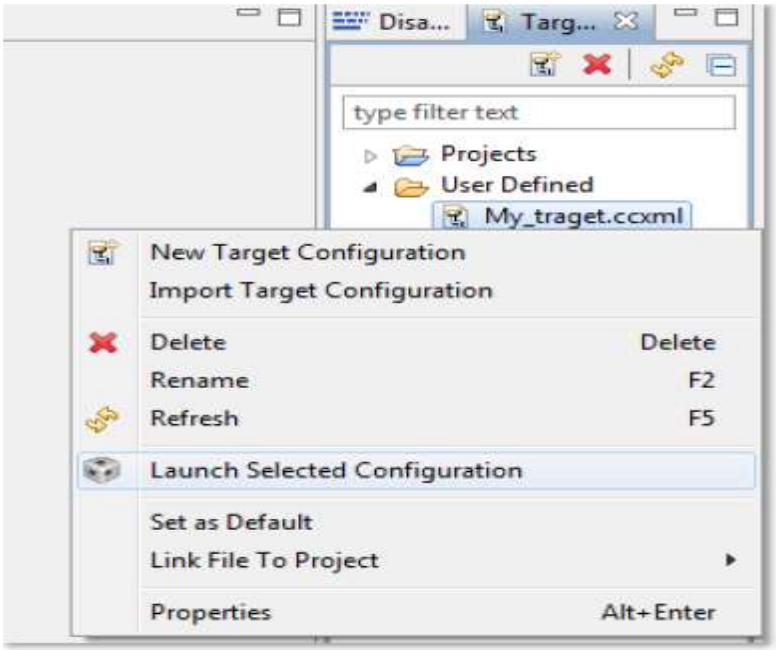


Fig: Launching Target Configuration

- Debug window will be launched.

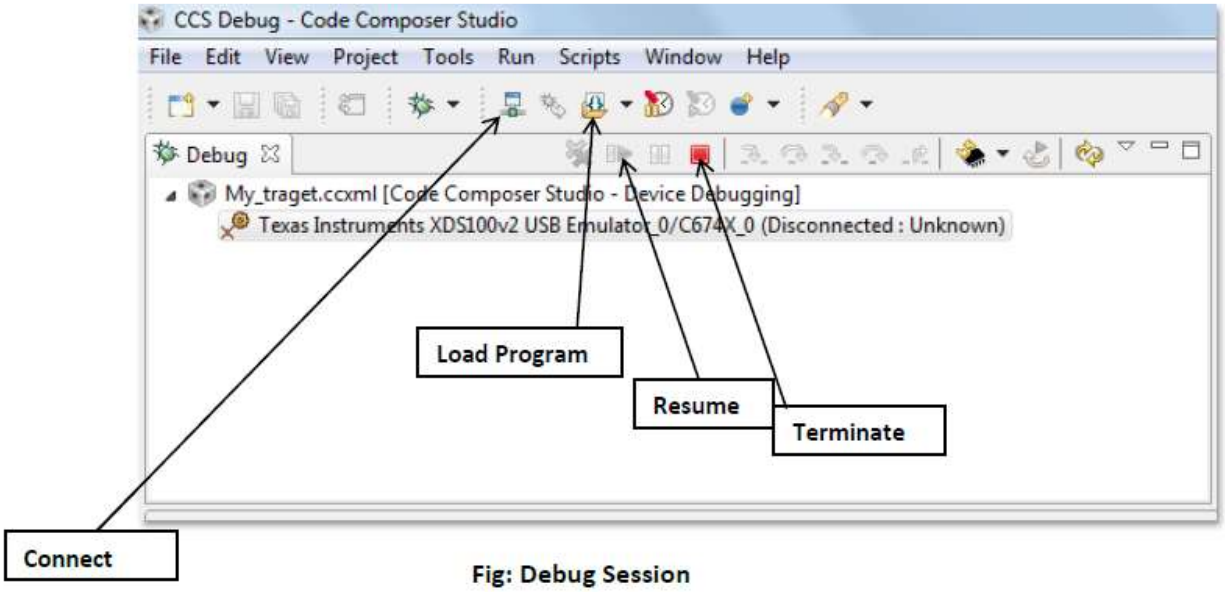
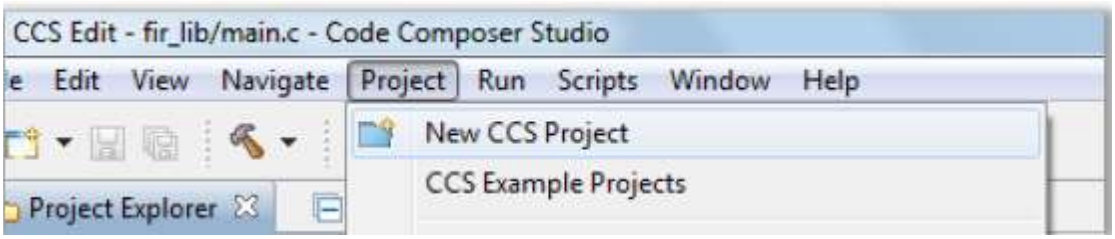


Fig: Debug Session

CREATE A NEW CCS PROJECT

Let's see how we can link these libraries to be used for our examples.
We are going to link the dsplib and implement an FIR filter, this is a non real time example.

- **Create a new CCS project**. Name it as **fir_lib**



Make the changes as follows. Please note that the connection field can be "Texas Instruments XDS100v3 Debug Probe" if you are using one.

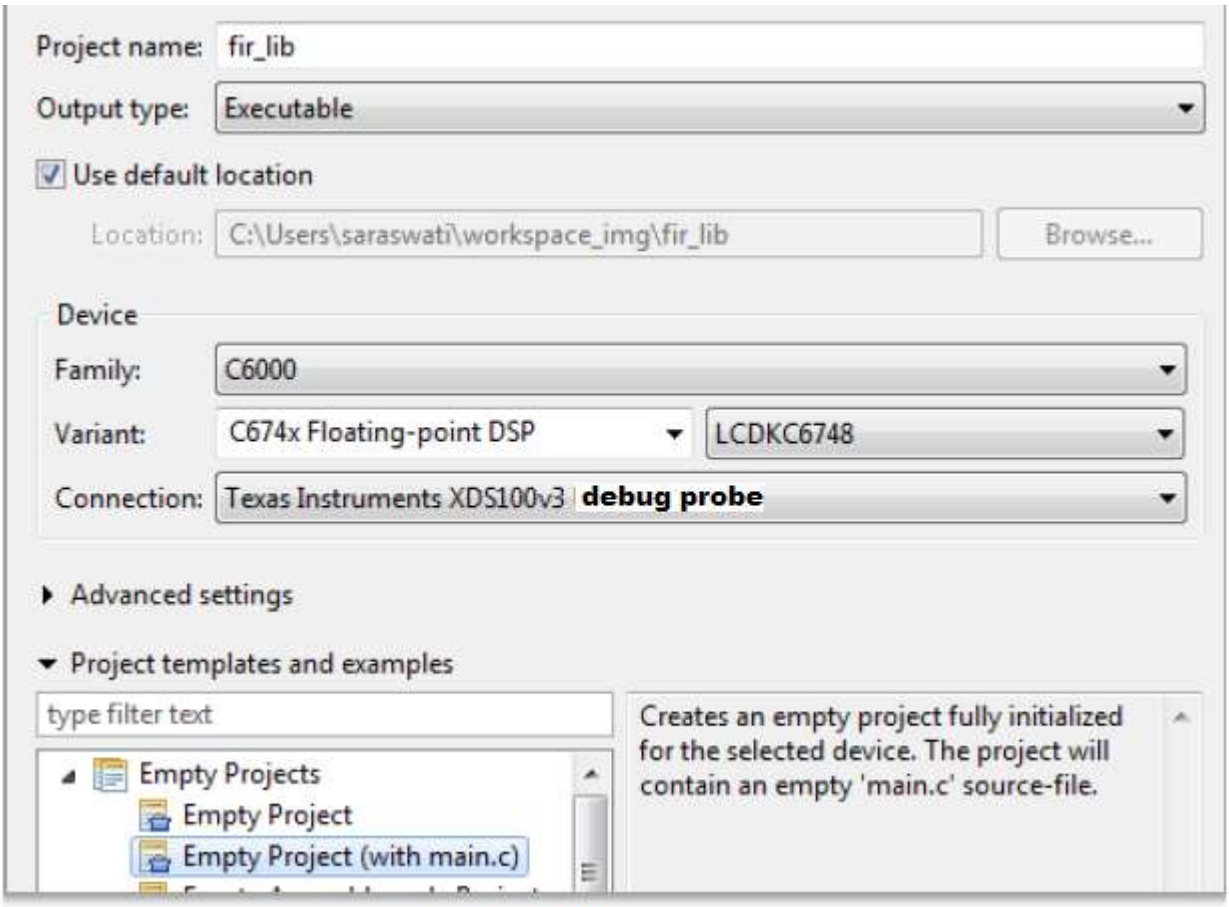


Fig: Project Creation

- Click on FINISH.

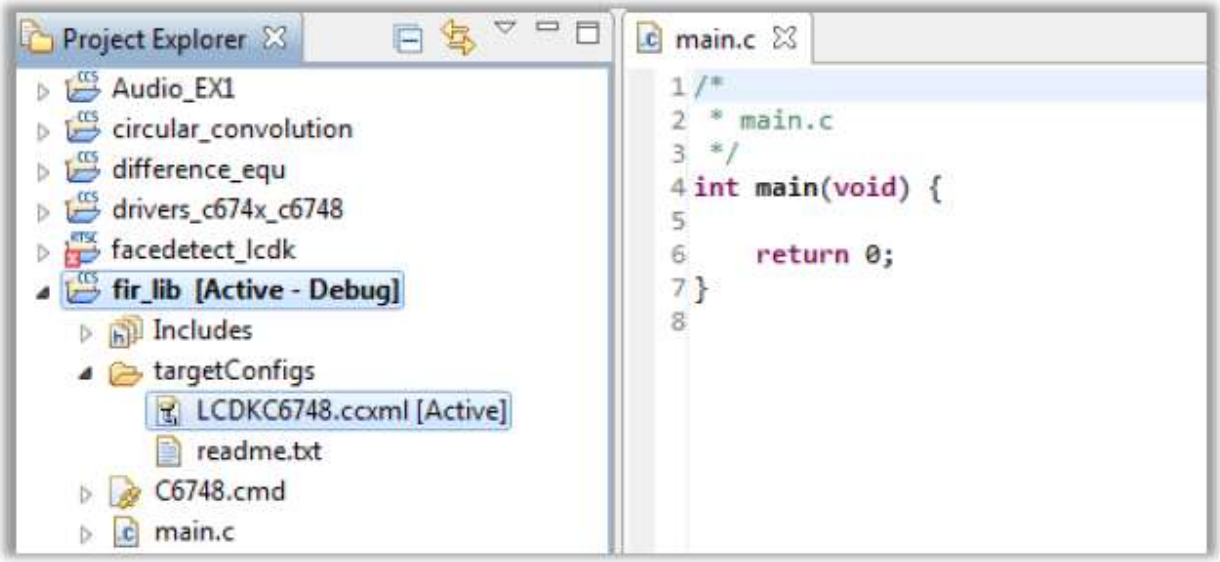


Fig: Project Explorer

1. Go to view-> target configurations
2. New target configuration: File name- test1.ccxml -> finish
3. Connection type- TIXDS100V3 Debug Probe
4. Board/Device – LCDK 6748

5. Save
6. Test connection-> wait for message “JTAG INTEGRITY SCAN TEST SUCCEEDED”
7. Right click on configuration file and set the configuration file as “default” and “launch selected configuration”.
8. To open new project: (In Edit mode) Go to Project-> New CCS project
    a. Target-LCDK 6748
    b. Connection type- TIXDS100V3
    c. Name the project- eg: test123
    d. Output type: EXCE
    e. Output format- Legacycoff
    f. Linker command- c6748.cmd
    g. Runtime- rts6740.lib
    h. Finish
9. Type code in main.c
10. Build, Debug (Debug mode) and Run the code

Experiment No. 1:-Impulse response

```
#include<stdio.h>
float x[5]={1,0,0,0,0};
float y[5]={0,0,0,0,0};
void main()
{
int i,j;
printf("\nTo calculate impulse response\n");
for(i=0;i<5;i++)
{
if(i==0)
y[i]=x[i]*0.1311;
if(i==1)
y[i]=x[i]*0.1311+0.2622*x[i-1]+0.7488*y[i-1];
if(i>=2)
y[i]=x[i]*0.1311+0.2622*x[i-1]+0.7488*y[i-1]-0.2722*y[i-
2];
}
for(j=0;j<5;j++)
printf("\n %f",y[j]);
}
```

Experiment No. 2:- N point DFT and IDFT

N point DFT USING DSP KIT

```
#include <stdio.h>
#include <math.h>
float x[4]={0,1,2,3}; //input only real sequence
float Yreal[4],Yimag[4];
//for 4 point DFT to store real & imaginary
float theta;
int n,k,N=4,xlen=4;
void main()
{
for(k=0;k<N;k++)
{
Yreal[k]=0;
Yimag[k]=0; //initialize real & imag parts
for(n=0;n<xlen;n++)
{
theta = -2*3.141592*k*n/N;
//careful about minus sign
Yreal[k]=Yreal[k]+x[n]*cos(theta);
Yimag[k]=Yimag[k]+x[n]*sin(theta);
}
printf("%0.2f+j%0.2f \n", Yreal[k], Yimag[k]);
}
}//end of main
```

IDFT USING DSP KIT

```
#include<stdio.h>
#include<math.h>
float x[4],XReal[4],XImag[4],theta;
int k,n,N;
void main()
{
printf("\t\tInverse Discrete Fourier Transform(IDFT)\n");
printf("\nEnter the length of the DFT N = ");
scanf("%d",&N);
// length of the DFT
printf("\nEnter the real amd imaginary parts of X(k) as
follows\n"
"X(k) = Re{X(k)} Im{X(k)}\n");
for(k = 0; k < N; k++)
{
printf("X(%1.0f) = ",k);
// enter values of DFT
scanf("%f %f",&XReal[k],&XImag[k]);
}
// next part of the program computes inverse DFT
```

```
for(n = 0; n < N; n++)
{
x[n] = 0;
for(k = 0; k < N; k++)
// this loop computes one value of x(n)
{
theta=(2*3.141592*k*n)/N;
x[n] = x[n] + XReal[k]*cos(theta)
- XImag[k]*sin(theta);
}
x[n] = x[n]/N;
}
// Next part of program displays x(n) on the screen
printf("\nThe sequence x(n) is as follows...");
for(n = 0; n < N; n++)
// displaying x(n) on the screen
printf("\nx(%1.0f) = %0.2f",n,x[n]);
}
```

Experiment No. 3:- Linear convolution and Circular convolution

Linear convolution

```
#include<stdio.h>
int x[20]={0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0};
int h[20]={0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0};
int y[20]={0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0};
int l1,l2,N;
int i,n,k;
void main()
{
printf("Enter length of x: ");
scanf("%d",&l1);
printf("Enter x[20]:\n ");
for(i=0;i<l1;i++)
scanf("%d",&x[i]);
printf("Enter length of h: ");
scanf("%d",&l2);
printf("Enter h[20]:\n ");
for(i=0;i<l2;i++)
scanf("%d",&h[i]);
N=l1+l2-1;
```

```
for(n=0;n<N;n++)
{
y[n]=0;
for(k=0;k<l1;k++)
{
if(n-k>=0 && n-k<l2)
y[n]=y[n]+x[k]*h[n-k];
}
}
printf("Convolution result y[n]= \n");
for(n=0;n<N;n++)
printf("%d\n",y[n]);

}
```

Circular convolution

```
#include<stdio.h>
int x[20]={0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0};
int h[20]={0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0};
int y[20]={0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0};
int m,N,sum;
int i,n,k;


void main()
{
printf("Enter N: ");
scanf("%d",&N);
printf("Enter x[20]:\n ");
for(i=0;i<N;i++)
scanf("%d",&x[i]);
printf("Enter h[20]:\n ");
for(i=0;i<N;i++)
scanf("%d",&h[i]);
// Next nested for loop calculates circular convolution
printf("\nThe circular of convolution is...");
for(m = 0; m < N; m++)
{
```

```
sum = 0.0;
for(k = 0; k < N; k++) //computation of one value in circular
{//convolution
if((m-k)>= 0)
n = m-k;
//modulo index
else
n = m-k+N;
sum += x[k] * h[n];
}
y[m] = sum;
printf("\ny[%d] = %d",m,y[m]);
}
// displaying the value on screen
}
```

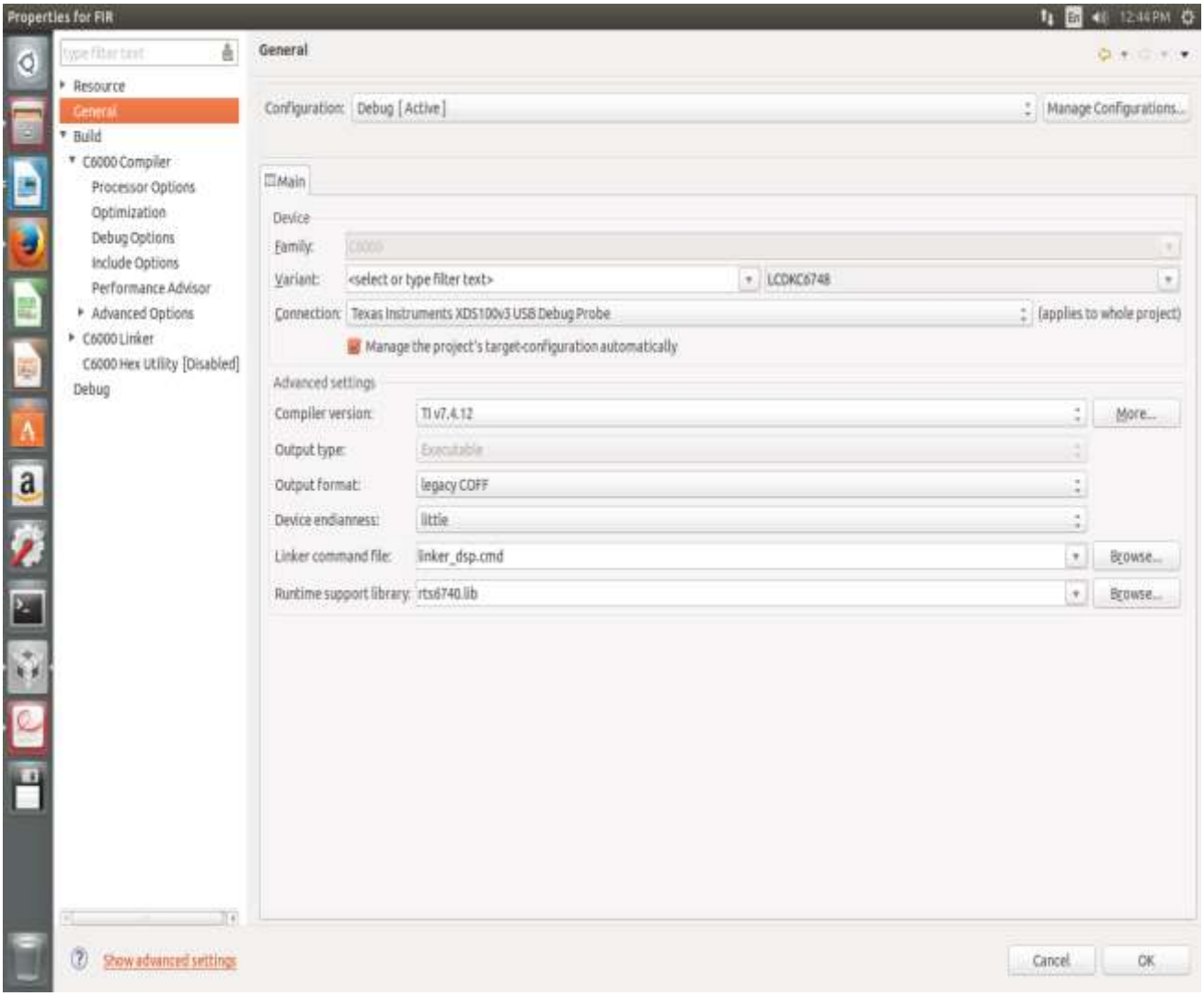
DEMO -Experiment:-FIR LPF for 1khz cut off frequency

Procedure to execute real time program:

1)Right click on project name and click on “add files”,
Go to “File system-mnt folder-lcdk6748-manual-dsplab-supportfiles”,
in this select L138_LCDK_aic3106_init.c,
L138_LCDK_aic3106_init.h,linker_dsp.cmd,vectors_intr.asm
and click “ok”

2) Two linker files are opened (linker_dsp.cmd & 6478.cmd) so delete old linker file with the extension .cmd (eg: 6478.cmd)

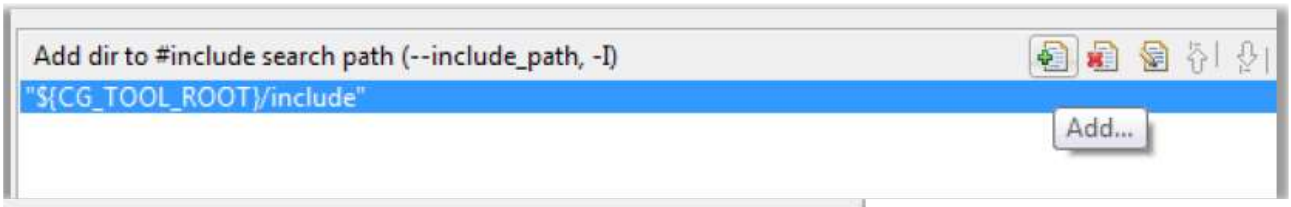
3) Right click on project name and click on “Properties”
check the settings.

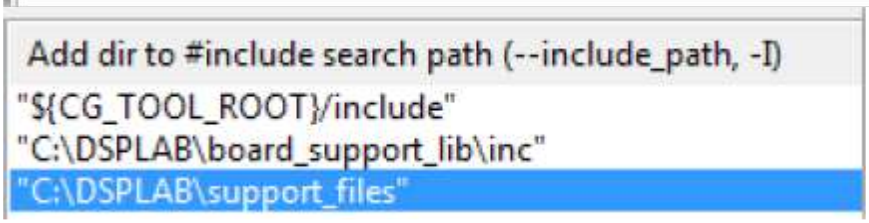


In project Properties go to C6000 Compiler→Include Options, Add include search path

 Browse for location-

- /board_support_lib/inc, click on OK
- /support_files, click on OK



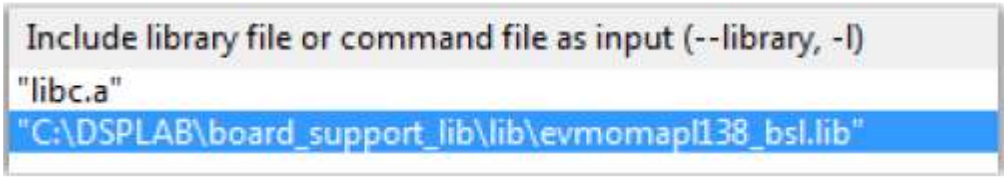


5) To add “Board support library file”

Right click on project name, select properties, click on “C6000 linker”, select “file search path”

in “include library file window” click on add + file

Browse /mnt/LCDK_6748/MANUAL/DSPLAB/board_support_lib/lib/evmomapl138_bsl/evmomapl138_bsl.lib and click ok



6) Reset the LCDK board, Select your project, build it, and debug it. Load and Run the program.

Connect the input signal of 500 Hz (less than 1volt amplitude) from signal generator to line in port.

Connect line out port to CRO to observe the o/p

You can also pass an audio input and hear the output signal through the speakers.

```
#include "L138_LCDK_aic3106_init.h"
#define N 31

float filcoeff[] = {0.000000,-0.001591,-0.002423,0.000000,0.005728,
                    0.011139,0.010502,-0.000000,-0.018003,-0.033416,-0.031505,0.000000,
0.063010,0.144802,0.220534,0.262448,0.220534,0.144802,0.063010,0.000000,
                    -0.031505,-0.033416,-0.018003,-0.000000,0.010502,0.011139,0.005728,
                    0.000000,-0.002423,-0.001591,0.000000
};
//FILTER CO-EFFICIENTS
static short in_buffer[100];
unsigned long int FIRFILTER(float * h, signed int x)
{
        int i=0;

        signed long output=0;

        in_buffer[0]=x;

        for(i=30;i>0;i--)
                in_buffer[i]=in_buffer[i-1];

        for(i=0;i<32;i++)
                output=output+h[i]*in_buffer[i];
        return(output);

}

interrupt void interrupt4(void)
{
uint32_t insample,outsample;
// interrupt service routine
insample = input_sample();
// read samples from ADC

outsample=(unsigned long int)FIRFILTER(&filcoeff[0],insample);
output_sample(outsample);
// write samples to DAC
return;
}
int main(void)
{
L138_initialise_intr(FS_8000_HZ,ADC_GAIN_0DB,DAC_ATTEN_0DB,LCDK_LINE_INPUT);
while(1);
}
```