

Digital Signal Processing Lab

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Lab Report

Lab Work:-

Lab – 5

1).

```
% -> Write a program to calculate filter coefficients for high pass filter.
%
% -> Use these coefficients in the DTFT program and plot the frequency response
%
% -> Verify that you indeed get a low pass filter response

clc;
clear;

Fc = 0.25;

Fs = 20;
n = 1:1:Fs;

h_0 = 1 - 2*Fc;
h = -2*Fc*sin(2*pi*Fc.*n)./(2*pi*Fc.*n);

h = [fliplr(h) h_0 h];

f = 0:1:(length(h)-1);

y = DTFT(h,f);

disp(y(1:10));

figure;

subplot(2,1,1);
plot(h);
title('');

subplot(2,1,2);
plot(f/length(h),abs(y));
title('Filter Responce');
xlabel('Frequency');
ylabel('H(f)');
```

Columns 1 through 4

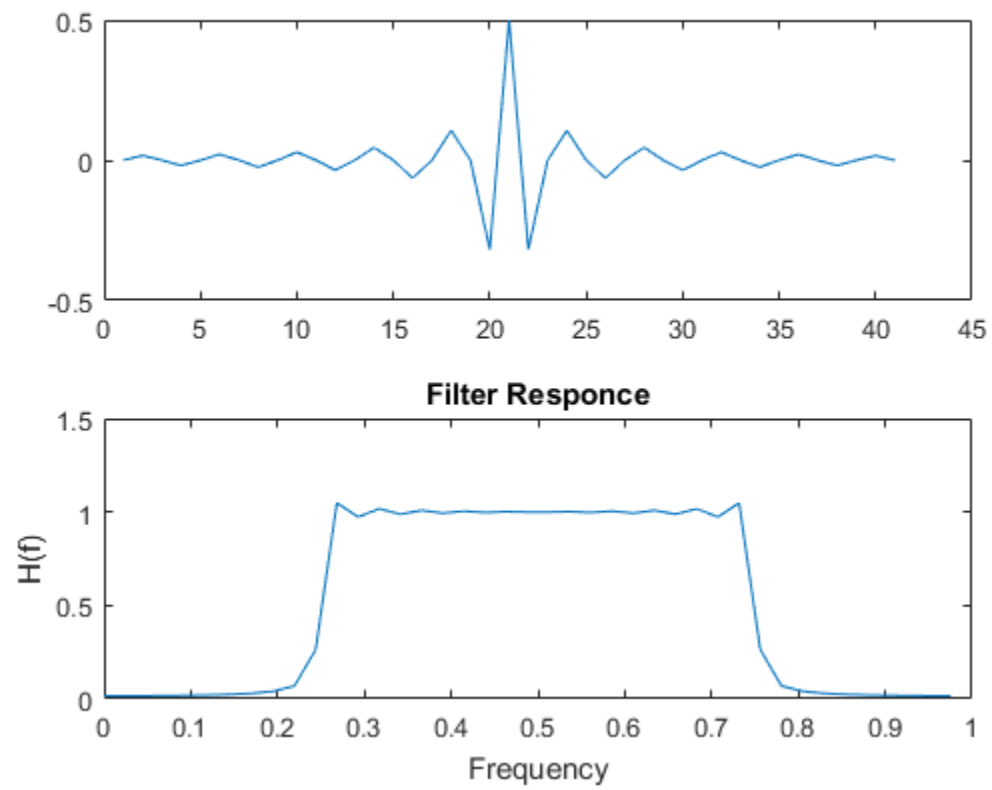
$0.0159 + 0.0000i$ $0.0160 + 0.0012i$ $0.0163 + 0.0025i$ $0.0169 + 0.0039i$

Columns 5 through 8

$0.0178 + 0.0056i$ $0.0192 + 0.0078i$ $0.0215 + 0.0107i$ $0.0255 + 0.0151i$

Columns 9 through 10

$0.0332 + 0.0234i$ $0.0536 + 0.0442i$



DTFT.M

```
% DTFT
function y = DTFT(x,f)

    N = length(x);
    y = zeros(1,N);

    for k = 1:1:length(f)
        for m = 1:1:N;

            y(1,k) = y(1,k) + (x(m)*exp(-1i*2*pi*(m-1)*(f(k)/N)));

        end
    end
end
```

2).

```
% -> Write a program to calculate filter coefficients for band pass filter.
%
% -> Use these coefficients in the DTFT program and plot the frequency response
%
% -> Verify that you indeed get a low pass filter response

clc;
clear;

F1 = 0.25;
F2 = 0.40;

Fs = 20;
n = 1:1:Fs;

h_0 = 2*(F2 - F1);
h = 2*((F2*sin(2*pi*F2.*n)./(2*pi*F2.*n))-(F1*sin(2*pi*F1.*n)./(2*pi*F1.*n)));

h = [fliplr(h) h_0 h];

f = 0:1:(length(h)-1);

y = DTFT(h,f);

disp(y(1:10));

figure;

subplot(2,1,1);
plot(h);
title('');

subplot(2,1,2);
plot(f/length(h),abs(y));
title('Filter Responce');
```

```
xlabel('Frequency');
ylabel('H(f)');
```

Columns 1 through 4

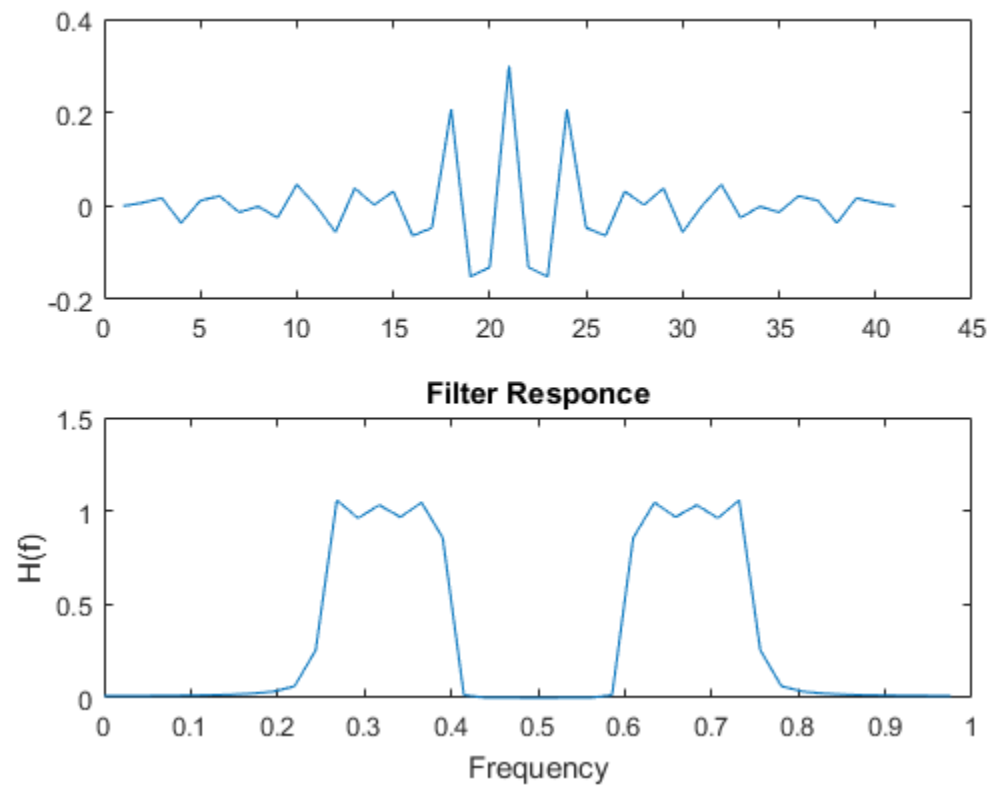
```
0.0107 + 0.0000i    0.0108 + 0.0008i    0.0111 + 0.0017i    0.0117 + 0.0027i
```

Columns 5 through 8

```
0.0125 + 0.0040i    0.0139 + 0.0056i    0.0162 + 0.0080i    0.0200 + 0.0119i
```

Columns 9 through 10

```
0.0276 + 0.0194i    0.0479 + 0.0395i
```



DTFT.M

```
% DTFT
function y = DTFT(x,f)

    N = length(x);
    y = zeros(1,N);

    for k = 1:1:length(f)
        for m = 1:1:N;

            y(1,k) = y(1,k) + (x(m)*exp(-1i*2*pi*(m-1)*(f(k)/N)));

        end
    end
end
```

3).

```
% -> Write a program to calculate filter coefficients for band reject filter.
%
% -> Use these coefficients in the DTFT program and plot the frequency response
%
% -> Verify that you indeed get a low pass filter response

clc;
clear;

F1 = 0.25;
F2 = 0.40;

Fs = 20;
n = 1:1:Fs;

h_0 = 1 - 2*(F2 - F1);
h = -2*((F2*sin(2*pi*F2.*n)./(2*pi*F2.*n)) - (F1*sin(2*pi*F1.*n)./(2*pi*F1.*n)));

h = [fliplr(h) h_0 h];

f = 0:1:(length(h)-1);

y = DTFT(h,f);

disp(y(1:10));

figure;

subplot(2,1,1);
plot(h);
title('');

subplot(2,1,2);
plot(f/length(h),abs(y));
title('Filter Responce');
```

```
xlabel('Frequency');
ylabel('H(f)');
```

Columns 1 through 4

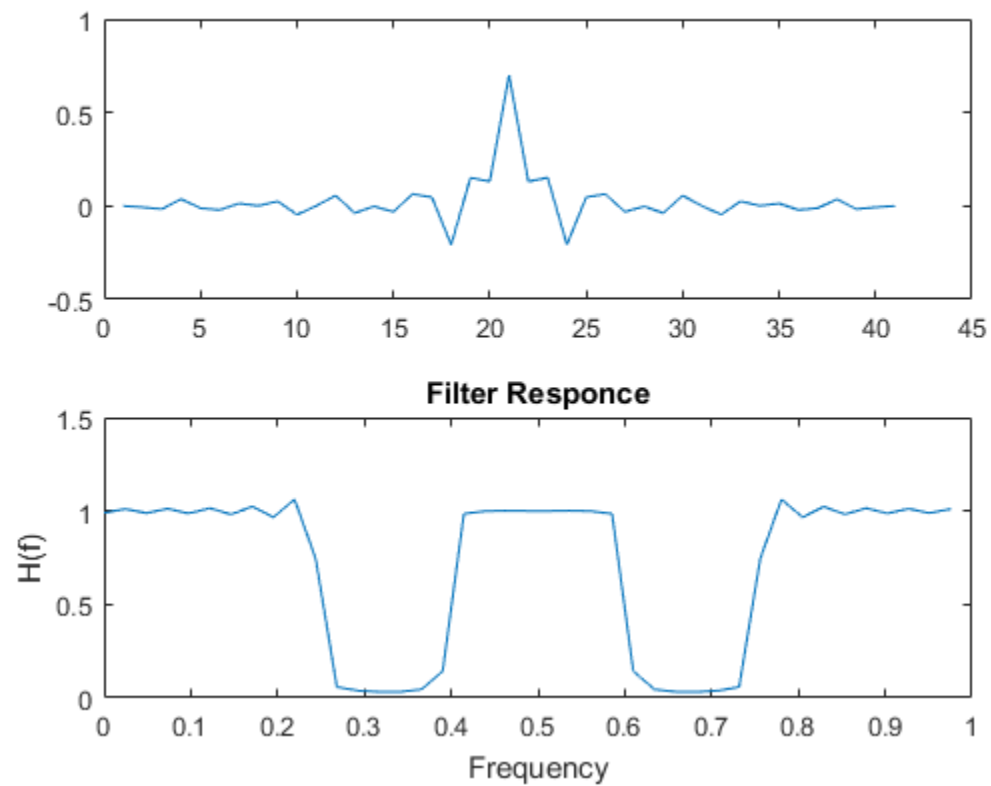
```
0.9893 + 0.0000i  -1.0079 - 0.0774i   0.9772 + 0.1509i  -0.9854 - 0.2306i
```

Columns 5 through 8

```
0.9408 + 0.2977i  -0.9414 - 0.3794i   0.8800 + 0.4357i  -0.8796 - 0.5229i
```

Columns 9 through 10

```
0.7903 + 0.5559i  -0.8194 - 0.6757i
```



DTFT.M

```
% DTFT

function y = DTFT(x,f)

    N = length(x);
    y = zeros(1,N);

    for k = 1:1:length(f)
        for m = 1:1:N;

            y(1,k) = y(1,k) + (x(m)*exp(-1i*2*pi*(m-1)*(f(k)/N)));

        end
    end

end
```

4).

```
% Write the program to test FIR linear phase low pass filter with cut-off
% frequency c = using the following Window having filter length M=7 and 11.
% Use the above commands in your program:-
% -> Rectangular Window
% -> Barlett window
% -> Blackman Window
% -> Hamming Window
% -> Hanning window

clc;
clear;

Fc = 0.125; % Wc = 2*pi*Fc

Fs = 20;
M1 = 7;
M2 = 11;

% Rectangular Window

W1 = rectwin(M1+1); % Rectangular Window
W2 = rectwin(M2+1); % Rectangular Window
h_7 = fir1(M1,2*Fc,'low',W1); % M = 7
h_11 = fir1(M2,2*Fc,'low',W2); % M = 11

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;

subplot(4,1,1);
plot(h_7);
```

```

title('Rectangular Windowed Low Pass Filter, M = 7');

subplot(4,1,2);
plot(h_11);
title('Rectangular Windowed Low Pass Filter, M = 11');

subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Rectangular Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Rectangular Window, M = 11');

% Blackman Window

W1 = blackman(M1+1); % Blackman Window
W2 = blackman(M2+1); % Blackman Window
h_7 = fir1(M1,2*Fc,'low',W1); % M = 7
h_11 = fir1(M2,2*Fc,'low',W2); % M = 11

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;

subplot(4,1,1);
plot(h_7);
title('Blackman Windowed Low Pass Filter, M = 7');

subplot(4,1,2);
plot(h_11);
title('Blackman Windowed Low Pass Filter, M = 11');

subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Blackman Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Blackman Window, M = 11');

% Barlett Window

W1 = bartlett(M1+1); % Barlett Window
W2 = bartlett(M2+1); % Barlett Window
h_7 = fir1(M1,2*Fc,'low',W1); % M = 7
h_11 = fir1(M2,2*Fc,'low',W2); % M = 11

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;
plot(h_7);
title('Barlett Windowed Low Pass Filter, M = 7');

```



```

subplot(4,1,2);
plot(h_11);
title('Barlett Windowed Low Pass Filter, M = 11');

subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Barlett Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Barlett Window, M = 11');

% Hamming Window

W1 = hamming(M1+1); % Hamming Window
W2 = hamming(M2+1); % Hamming Window
h_7 = fir1(M1,2*Fc,'low',W1); % M = 7
h_11 = fir1(M2,2*Fc,'low',W2); % M = 11

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;

subplot(4,1,1);
plot(h_7);
title('Hamming Windowed Low Pass Filter, M = 7');

subplot(4,1,2);
plot(h_11);
title('Hamming Windowed Low Pass Filter, M = 11');

subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Hamming Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Hamming Window, M = 11');

% Hanning Window

W1 = hann(M1+1); % Hanning Window
W2 = hann(M2+1); % Hanning Window
h_7 = fir1(M1,2*Fc,'low',W1); % M = 7
h_11 = fir1(M2,2*Fc,'low',W2); % M = 11

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;

subplot(4,1,1);
plot(h_7);
title('Hanning Windowed Low Pass Filter, M = 7');

```

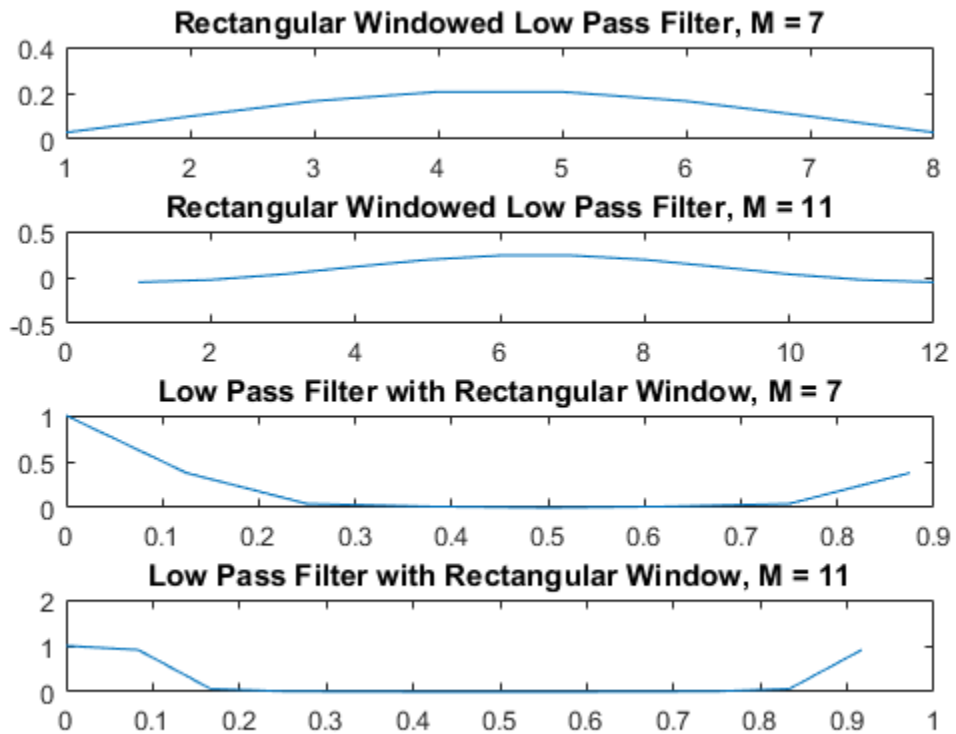
```

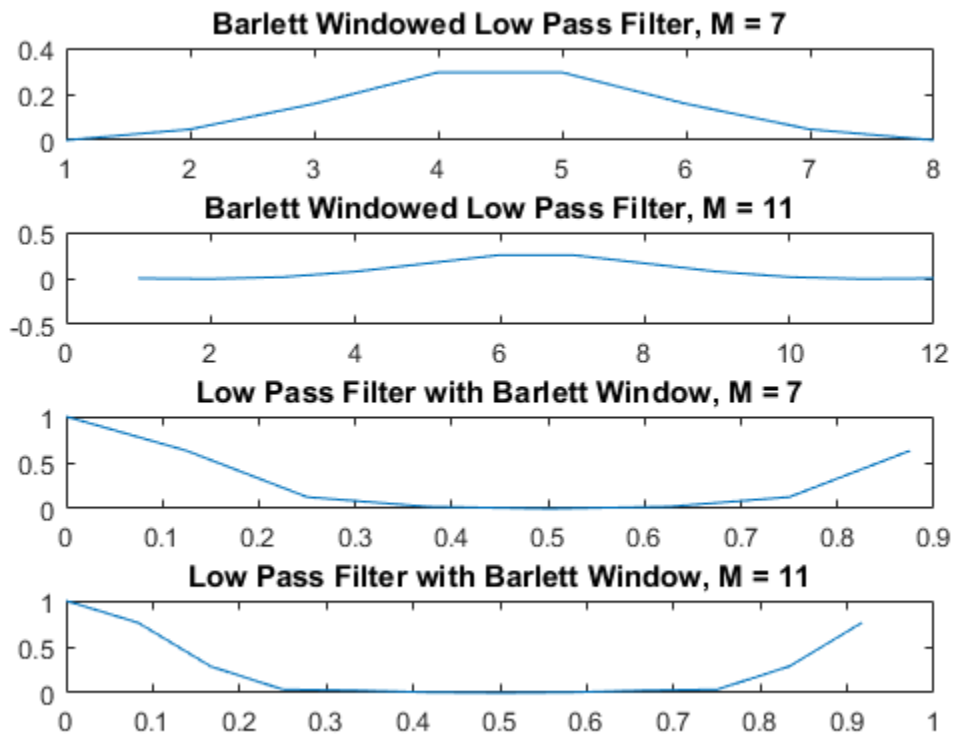
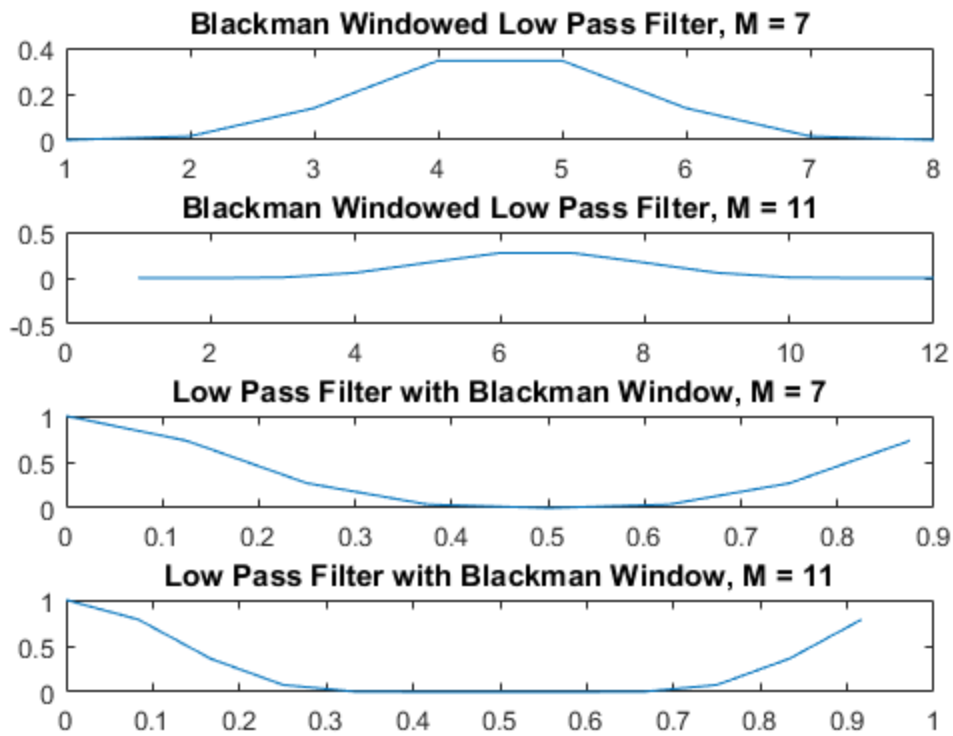
subplot(4,1,2);
plot(h_11);
title('Hanning Windowed Low Pass Filter, M = 11');

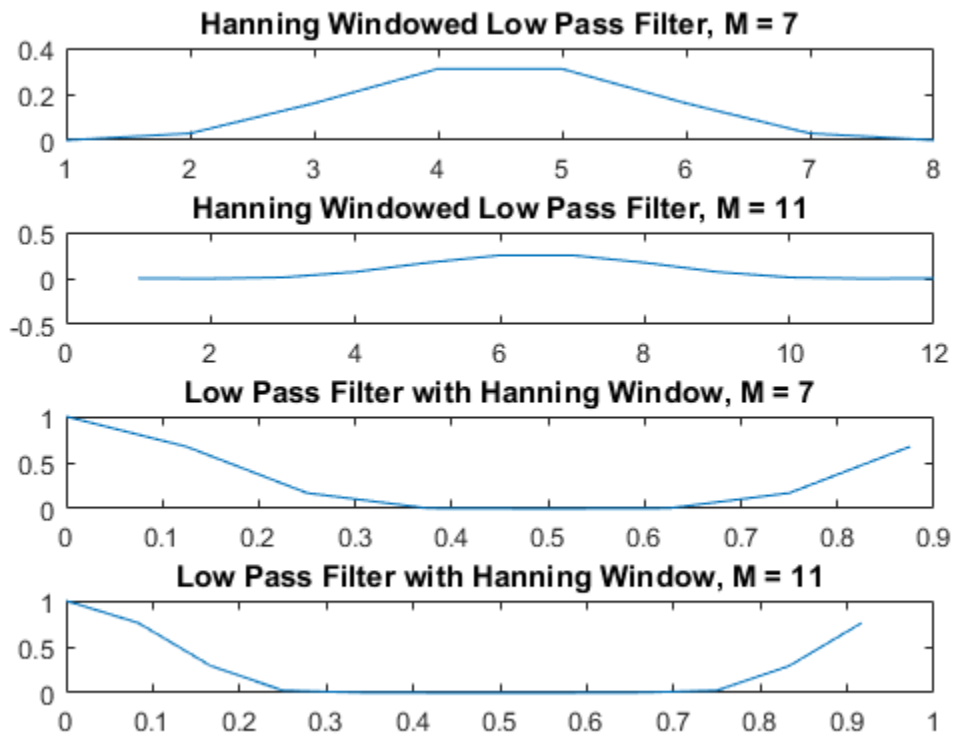
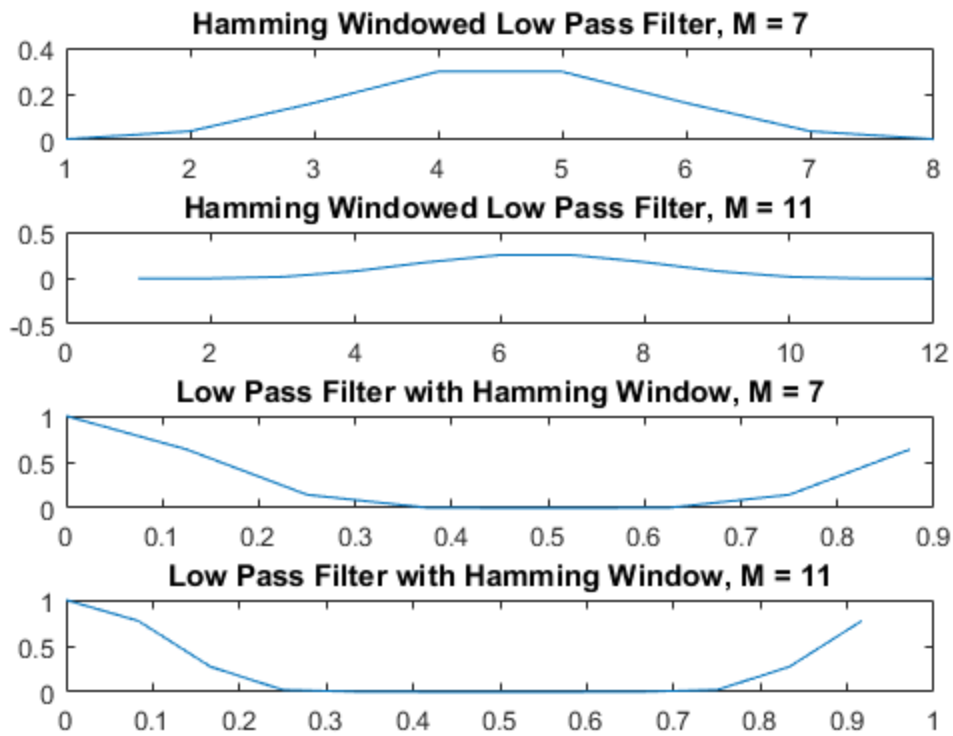
subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Hanning Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Hanning Window, M = 11');

```







DTFT.M

```
% DTFT

function y = DTFT(x,f)

    N = length(x);
    y = zeros(1,N);

    for k = 1:1:length(f)
        for m = 1:1:N;

            y(1,k) = y(1,k) + (x(m)*exp(-1i*2*pi*(m-1)*(f(k)/N)));

        end
    end

end
```

5).

```
% Write the program to test FIR linear phase low pass filter with cut-off
% frequency c = using the following Window having filter length M=7 and 11.
% Use the custom commands in your program:-
% -> Rectangular Window
% -> Bartlett window
% -> Blackman Window
% -> Hamming Window
% -> Hanning window

clc;
clear;

Fc = 0.25; % Wc = 2*pi*Fc

M1 = 7;
M2 = 11;
n1 = 1:1:round(M1/2);
n2 = 1:1:round(M2/2);

h_0 = 2*Fc;

h7 = 2*Fc*sin(2*pi*Fc.*n1)./(2*pi*Fc.*n1);
z1 = fliplr(h7);
h7 = [z1(2:end) h_0 h7];

h11 = 2*Fc*sin(2*pi*Fc.*n2)./(2*pi*Fc.*n2);
z1 = fliplr(h11);
h11 = [z1(2:end) h_0 h11];

% Rectangular Window

W1 = rectwind(M1+1); % Rectangular Window
W2 = rectwind(M2+1); % Rectangular Window
h_7 = fird(h7,W1); % M = 7
h_11 = fird(h11,W2); % M = 11
```

```

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;

subplot(4,1,1);
plot(h_7);
title('Rectangular Windowed Low Pass Filter, M = 7');

subplot(4,1,2);
plot(h_11);
title('Rectangular Windowed Low Pass Filter, M = 11');

subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Rectangular Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Rectangular Window, M = 11');

% Blackman Window

W1 = blackmand(M1+1); % Blackman Window
W2 = blackmand(M2+1); % Blackman Window
h_7 = fird(h7,W1); % M = 7
h_11 = fird(h11,W2); % M = 11

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;

subplot(4,1,1);
plot(h_7);
title('Blackman Windowed Low Pass Filter, M = 7');

subplot(4,1,2);
plot(h_11);
title('Blackman Windowed Low Pass Filter, M = 11');

subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Blackman Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Blackman Window, M = 11');

% Bartlett Window

W1 = bartlettd(M1+1); % Bartlett Window

W2 = bartlettd(M2+1); % Bartlett Window
h_7 = fird(h7,W1); % M = 7

```

```

h_11 = fird(h11,W2); % M = 11

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;

subplot(4,1,1);
plot(h_7);
title('Barlett Windowed Low Pass Filter, M = 7');

subplot(4,1,2);
plot(h_11);
title('Barlett Windowed Low Pass Filter, M = 11');

subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Barlett Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Barlett Window, M = 11');

% Hamming Window

W1 = hammingd(M1+1); % Hamming Window
W2 = hammingd(M2+1); % Hamming Window
h_7 = fird(h7,W1); % M = 7
h_11 = fird(h11,W2); % M = 11

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;

subplot(4,1,1);
plot(h_7);
title('Hamming Windowed Low Pass Filter, M = 7');

subplot(4,1,2);
plot(h_11);
title('Hamming Windowed Low Pass Filter, M = 11');

subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Hamming Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Hamming Window, M = 11');

% Hanning Window

W1 = hanningd(M1+1); % Hanning Window
W2 = hanningd(M2+1); % Hanning Window
h_7 = fird(h7,W1); % M = 7

```

```

h_11 = fird(h11,W2); % M = 11

f7 = 0:1:(length(h_7)-1);
f11 = 0:1:(length(h_11)-1);

H_7 = DTFT(h_7,f7);
H_11 = DTFT(h_11,f11);

figure;

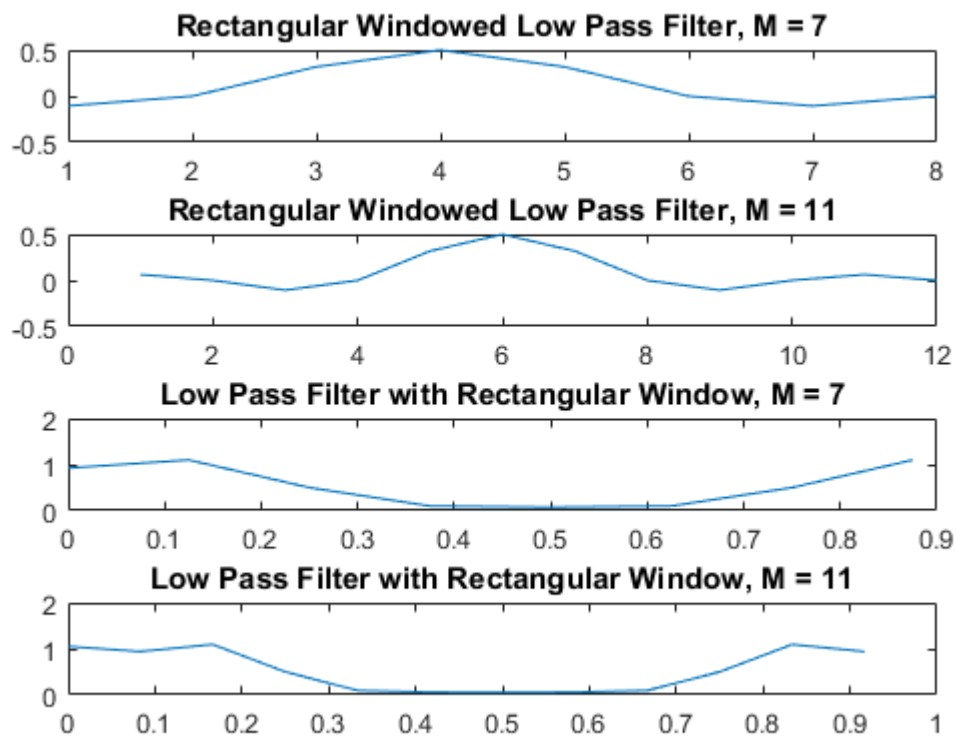
subplot(4,1,1);
plot(h_7);
title('Hanning Windowed Low Pass Filter, M = 7');

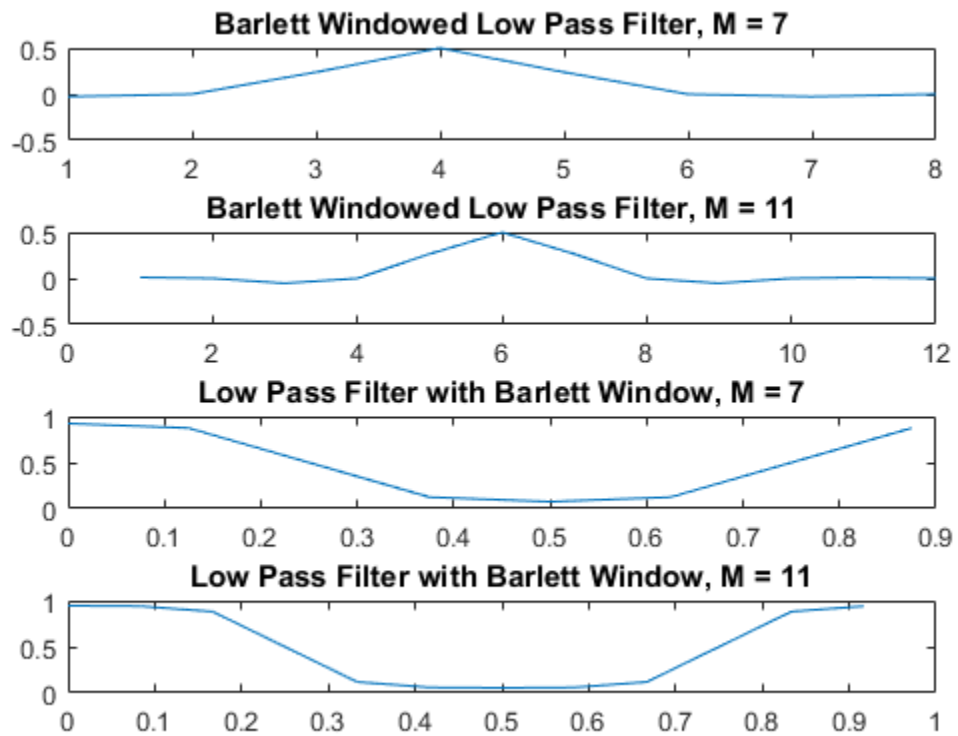
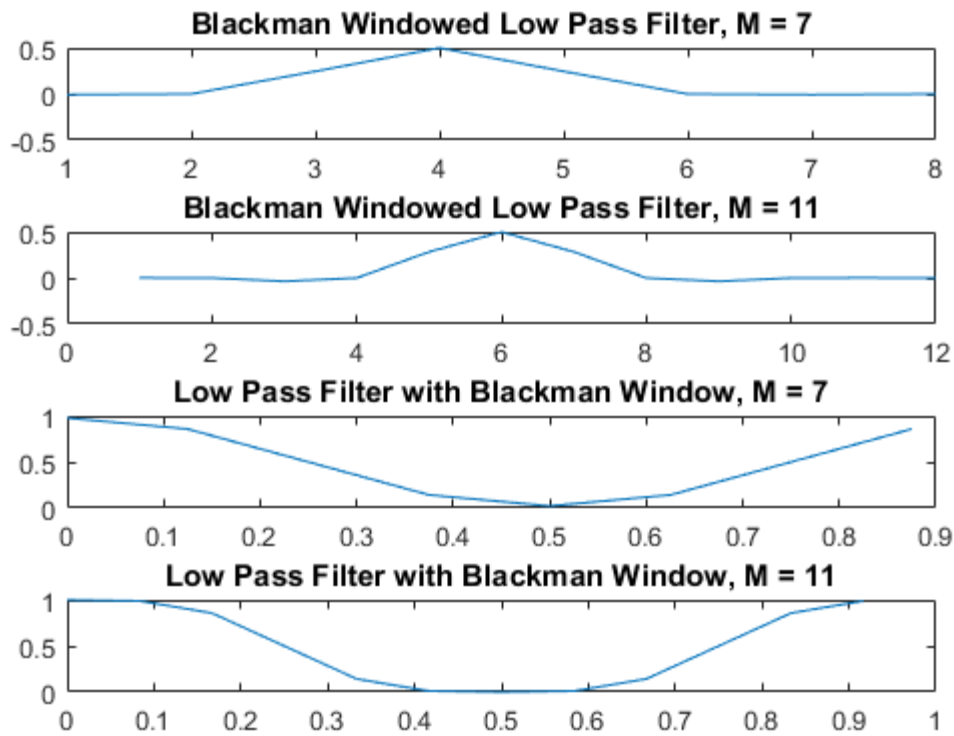
subplot(4,1,2);
plot(h_11);
title('Hanning Windowed Low Pass Filter, M = 11');

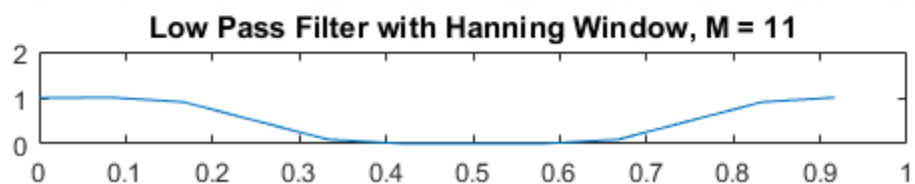
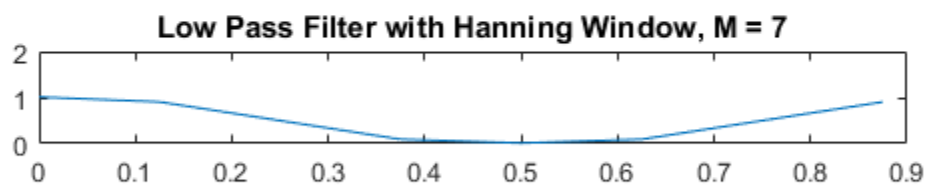
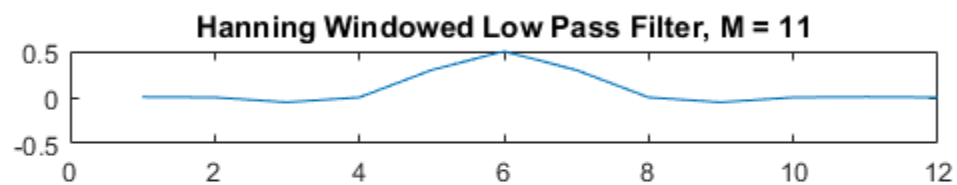
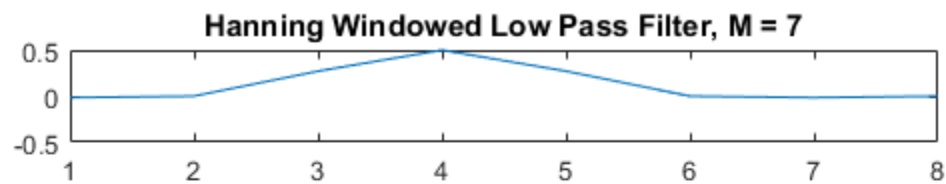
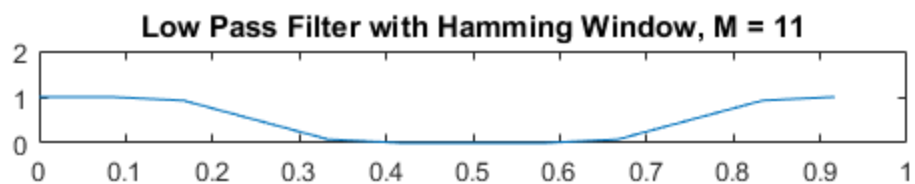
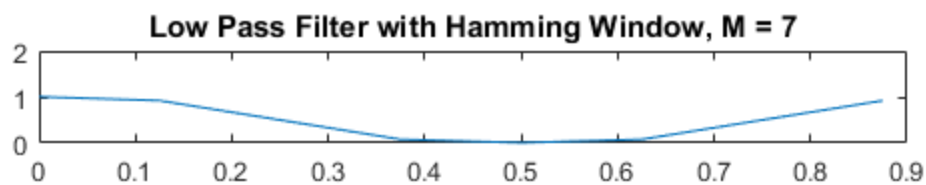
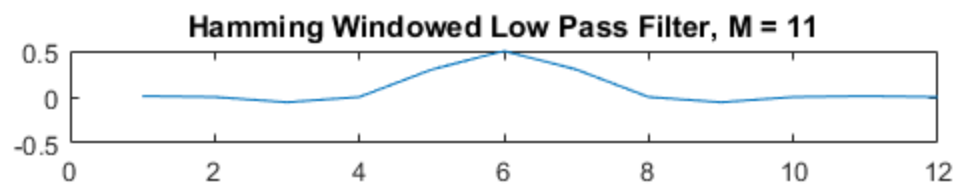
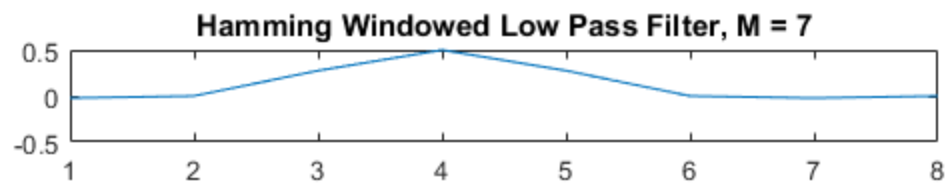
subplot(4,1,3);
plot(f7/length(h_7),abs(H_7));
title('Low Pass Filter with Hanning Window, M = 7');

subplot(4,1,4);
plot(f11/length(h_11),abs(H_11));
title('Low Pass Filter with Hanning Window, M = 11');

```







DTFT.M

```
% DTFT
function y = DTFT(x,f)

    N = length(x);
    y = zeros(1,N);

    for k = 1:1:length(f)
        for m = 1:1:N;

            y(1,k) = y(1,k) + (x(m)*exp(-1i*2*pi*(m-1)*(f(k)/N)));

        end
    end
end
```

BARTLETTD.M

```
% Bartlett Window
function y = bartlettd(L)

    n = 1:1:L;
    y = 1 - 2*abs(n - (L/2))/L;

end
```

BLACKMAND.M

```
% Blackman Window
function y = blackmand(L)

    n = 1:1:L;
    y = 0.42 - 0.5*cos(2*pi*n/L) + 0.08*cos(4*pi*n/L);

end
```

HAMMINGD.M

```
% Hamming Window

function y = hammingd(L)

    n = 1:1:L;
    y = 0.54 - 0.46*cos(2*pi*n/L);

end
```

HANNINGD.M

```
% Hanning Window

function y = hanningd(L)

    n = 1:1:L;
    y = 0.5 - 0.5*cos(2*pi*n/L);

end
```

RECTWIND.M

```
% Rectangular Window
function y = rectwind(L)
    y = ones(1,L);
end
```

FIRD.M

```
% Custom Filter

function y = fird(x,h)

    y = x.*h;

end
```

[illegible]