DSP Lab Report

Experiment – 4

Aim:

1) To generate signals of fixed frequency and identify the different harmonics present in it using magnitude spectrum.
2) To observe the use of different windows like Hamming and Blackman in efficient identification of harmonics in a signal.

Code:

Q1)

```
# a = 1, f = 15 Hz


f = 15;

Fs = 120;

dt = 1/Fs;

t = [0:dt:2-dt];


# making a siner of 15 Hz frequency

y = sin(2*pi*f*t);


# taking first 120 samples

DFT1 = fft(y(1:120));

N = length(y(1:120));

L1 = length(DFT1);


k = [0:L1-1];

f1 = Fs/N .* k;


# taking first 130 samples
```

```
DFT2 = fft(y(1:130));
N = length(y(1:130));
L2 = length(DFT2);

k = [0:L2-1];
f2 = Fs/N .* k;

# plotting magnitude spectrum
figure();
stem(f1,abs(DFT1)/L1,color='b');
hold();
stem(f2,abs(DFT2)/L2,color='g');
grid();
title('abs(DFT) VS f');
xlabel('Frequency (Hz)');
ylabel('abs(DFT(y(t)))');
legend(['120 samples';'130 samples']);
```

Q2)

```
# a = 1, f = 60 Hz, ans = after every 8 samples, it will be same

f = 15;
Fs = 120;
dt = 1/Fs;
t = [0:dt:2-dt];

# making siner of frequency 12 Hz
y = sin(2*pi*f*t);
```

```
# taking first 120 samples
DFT1 = fft(y(1:120));
N = length(y(1:120));
L1 = length(DFT1);

k = [0:L1-1];
f1 = Fs/N .* k;

# taking first 128 samples
DFT2 = fft(y(1:128));
N = length(y(1:128));
L2 = length(DFT2);

k = [0:L2-1];
f2 = Fs/N .* k;

# plotting first magnitude spectrum of first 120 and 128 samples
figure();

subplot(2,1,1);
stem(f1,abs(DFT1)/L1,color='b');
grid();
title('abs(DFT) VS Frequency - 120 samples');
xlabel('Frequency (Hz)');
ylabel('abs(DFT(y(t)))');

subplot(2,1,2);
stem(f2,abs(DFT2)/L2,color='g');
```

```
grid();
title('abs(DFT) VS Frequency - 128 samples');
xlabel('Frequency (Hz)');
ylabel('abs(DFT(y(t)))');
```

Q3)

```
# a = 3, A = 160, B = 166

Fs = 200;
dt = 1/Fs;
t = [0:dt:10-dt];

# defining signal
y = 0.1*sin(160*pi*t)+cos(166*pi*t);

x = [215 415 1115 1515 1915];
i = 1;

figure();

# plotting magnitude spectrum for different number of samples
for n=x
  yt = y(1:n);
  DFT = fft(yt);

  k = [0:n-1];
  f = Fs/n .* k;

  subplot(3,2,i);
```

```
  i = i+1;
  plot(f,abs(DFT)/n);
  grid();
  title([num2str(n) ' samples']);
  xlabel('Frequency (Hz)');
  ylabel('abs(DFT(y(t)))');
endfor
```

Q4)

```
# a = 3, blackman window

Fs = 200;
dt = 1/Fs;
t = [0:dt:10-dt];

# defining signal
y = 0.1*sin(160*pi*t)+cos(166*pi*t);

x = [215 415 1115 1515 1915];

i = 1;
figure();

# plotting magnitude spectrum for different number of samples
for n=x
  yt = y(1:n);
  yt = yt .* [blackman(n)]';

  DFT = fft(yt);
```

```
  k = [0:n-1];
  f = Fs/n .* k;

  subplot(3,2,i);
  i = i+1;
  plot(f,abs(DFT)/n);
  grid();
  title([num2str(n) ' samples using Blackman window']);
  xlabel('Frequency (Hz)');
  ylabel('abs(DFT(y(t)))');
endfor
```

Q5)

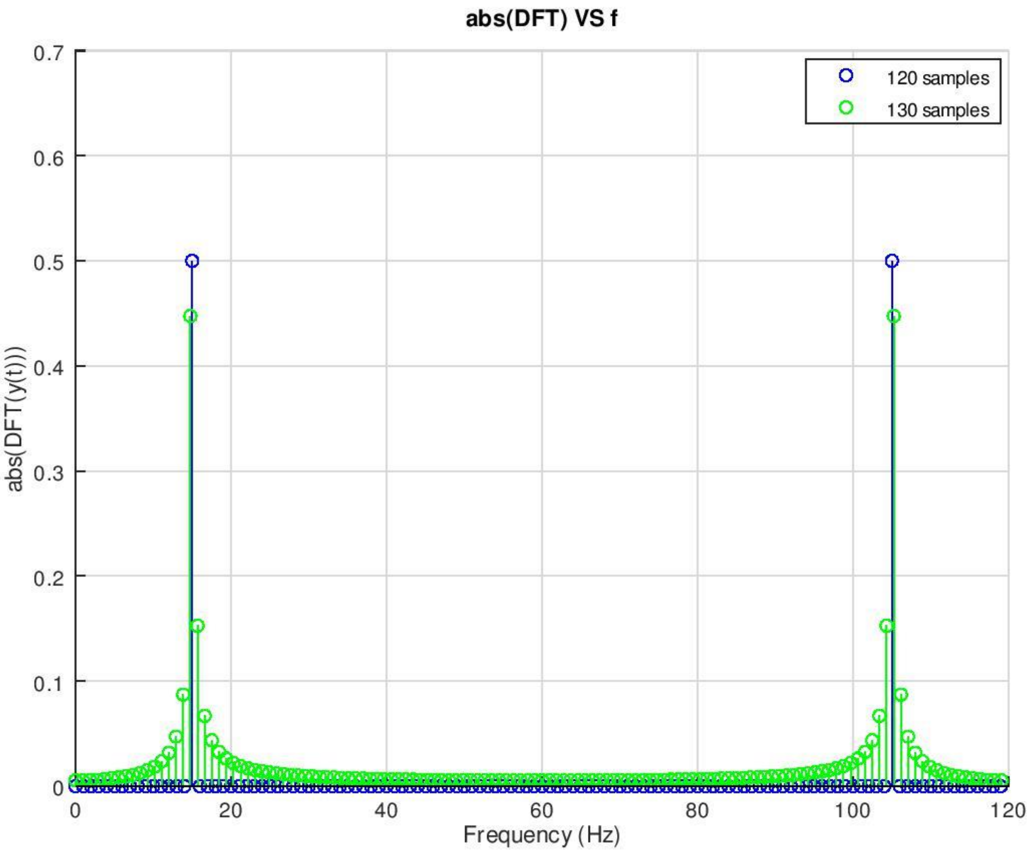
```
# loading data
y = load('Exp4Data3.txt');

ycopy = y;

# plotting magnitude spectrum using hamming window
y = y .* [hamming(500)]';

DFT = fft(y,10000);

N = 10000;
x = [0:1/N:1-1/N];
subplot(2,1,1);
plot(x,abs(DFT)/N);
```

```
grid();
title('Hamming Window');
xlabel('Frequency (Fs)');
ylabel('abs(DFT(y(t)))');



y = ycopy;


# plotting magnitude spectrum using rectangular window
DFT = fft(y,10000);


N = 10000;
x = [0:1/N:1-1/N];
subplot(2,1,2);
plot(x,abs(DFT)/N);
grid();
title('Rectangular Window');
xlabel('Frequency (Fs)');
ylabel('abs(DFT(y(t)))');
```

Graphs and Observations:

Q1)

Graph -



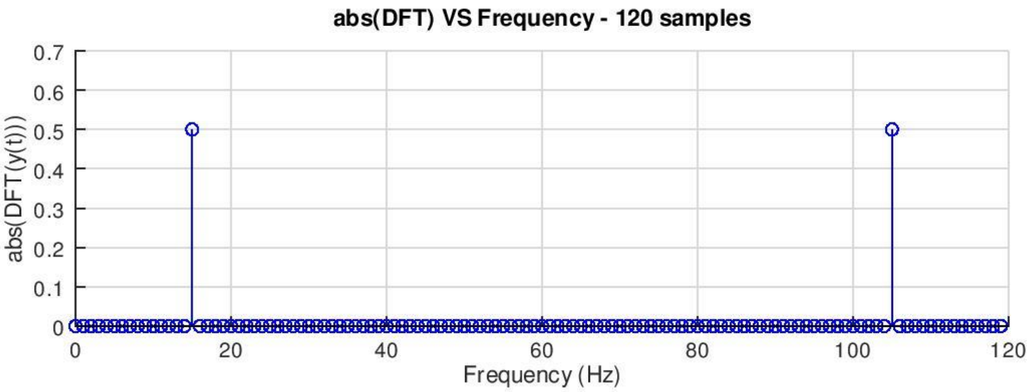
Observations –

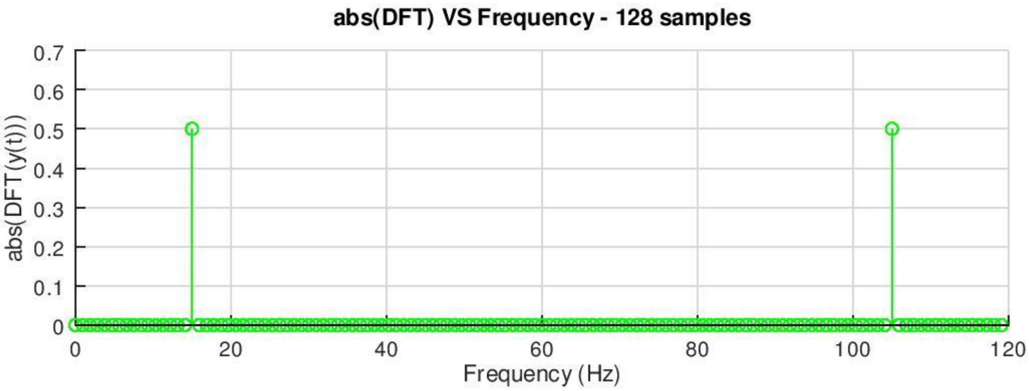
In the 120 samples case, the frequency components of the signal, ie only 15 Hz is shown exactly.

In the 130 samples case, other frequency components which are not present in the signal are also shown. This is because the signal is does not end with a complete cycle.

Q2)

Graph -





Observations –

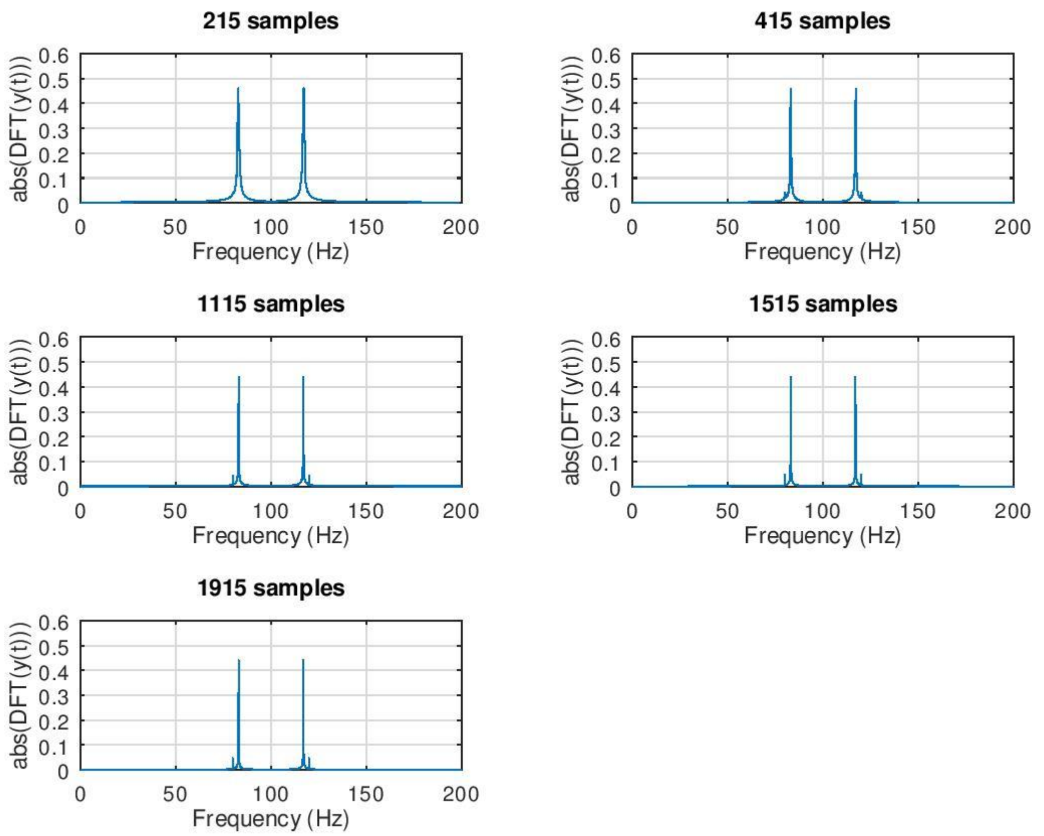
The graph of magnitude spectrum will look same as the one for 120 samples as long as the signal ends with a complete cycle of 15 Hz signal. Since sampling frequency is 120 samples/second and frequency of the signal is 15 Hz, 120/15 = 8 samples complete a cycle. Hence, a signal with 128, 136, 144 … samples will give the same magnitude spectrum as the one for 120 samples.

Q3)

Observations –

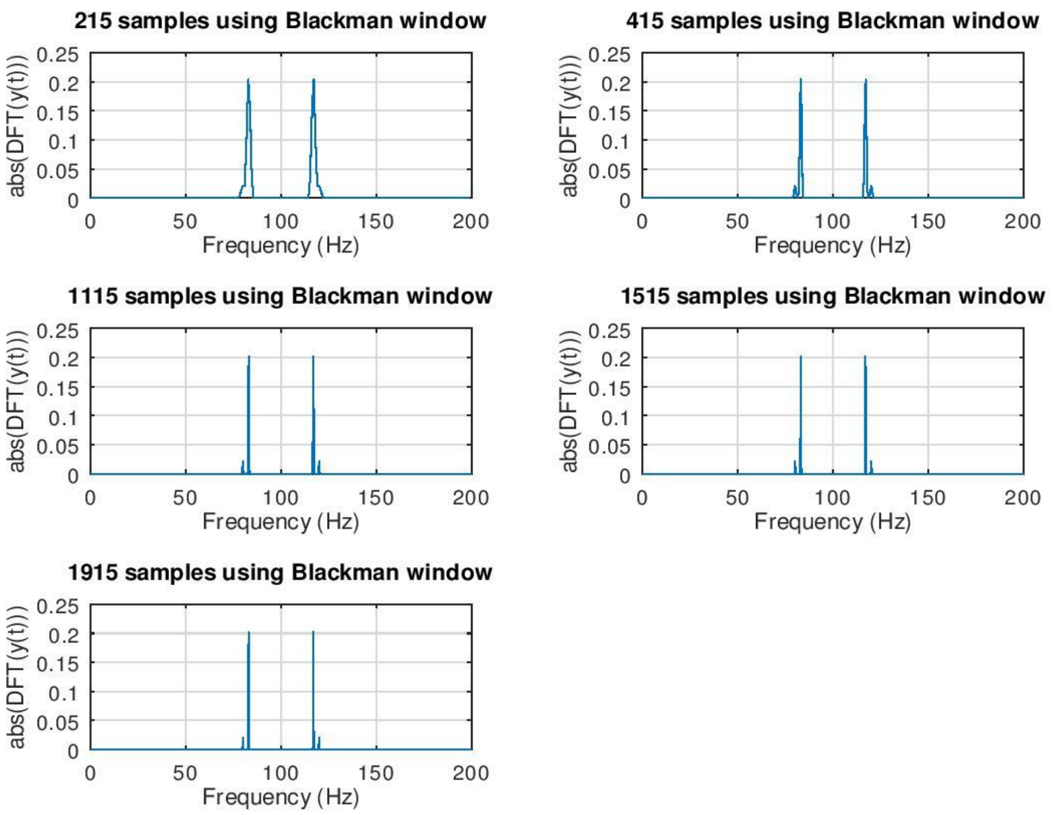
We see from the graphs that more the samples we take for magnitude spectrum, we get better resolution and the actual harmonics that are present in the signal can be easily identified.

From the last graph, it can be seen that the signal consists of two dominant frequencies, 80 Hz and 83 Hz.



215 samples
415 samples
1115 samples
1515 samples
1915 samples
abs(DFT(y(t)))
Frequency (Hz)
0 0.1 0.2 0.3 0.4 0.5 0.6
0 50 100 150 200

Q4)



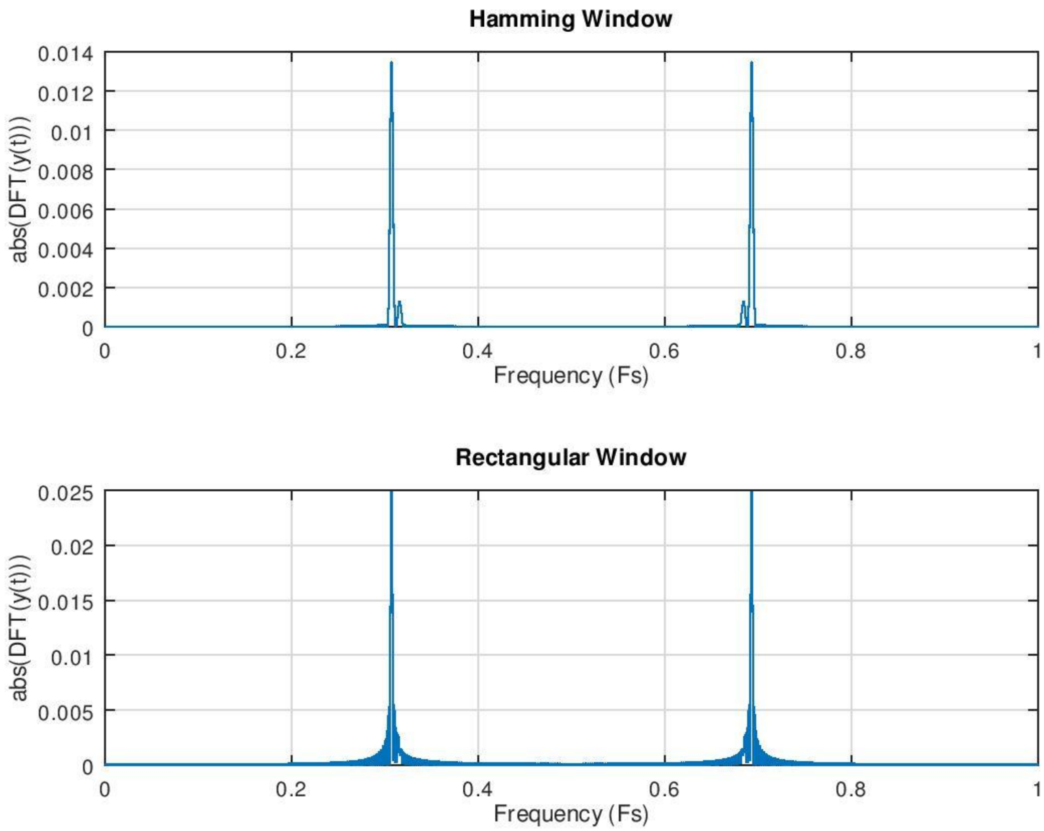
215 samples using Blackman window
415 samples using Blackman window
1115 samples using Blackman window
1515 samples using Blackman window
1915 samples using Blackman window
abs(DFT(y(t)))
Frequency (Hz)
0 0.05 0.1 0.15 0.2 0.25
0 50 100 150 200

Observations –

We see that using time domain windows reduces the number of samples required for good resolution for identification of different dominant frequencies present in the signal. The time domain windows like Blackman, Hamming and Hanning windows reduce the signal values at the ends which cause the presence of absent frequencies. Hence we need less samples to identify the dominant frequencies.

Q5)

Graphs –



Observations –

From the magnitude spectrum made using Hamming window, we can easily observe that the signal has dominant frequencies 0.307 Fs and 0.3156 Fs. From the rectangular window magnitude spectrum, the 0.3156 Fs frequency signal is difficult to identify.

Conclusions –

Q1)

The magnitude spectrum is plotted and it is seen that if the cycle is not complete, then unwanted frequency components show up in the magnitude spectrum.

Q2)

From this it is seen that as long as the cycle of the siner is complete, the exact frequency of the signal can be identified using magnitude spectrum.

Q3)

The magnitude spectrums for different number of samples were plotted and it is seen that greater number of samples give better resolution of magnitude spectrum.

Q4)

The magnitude spectrums using different time domain windows were plotted. It is seen that a good resolution is obtained even with lesser number of samples.

Q5)

The magnitude spectrum of the signal is plotted and its dominant frequencies is identified. It is done better when a time domain window is used.