Lab2

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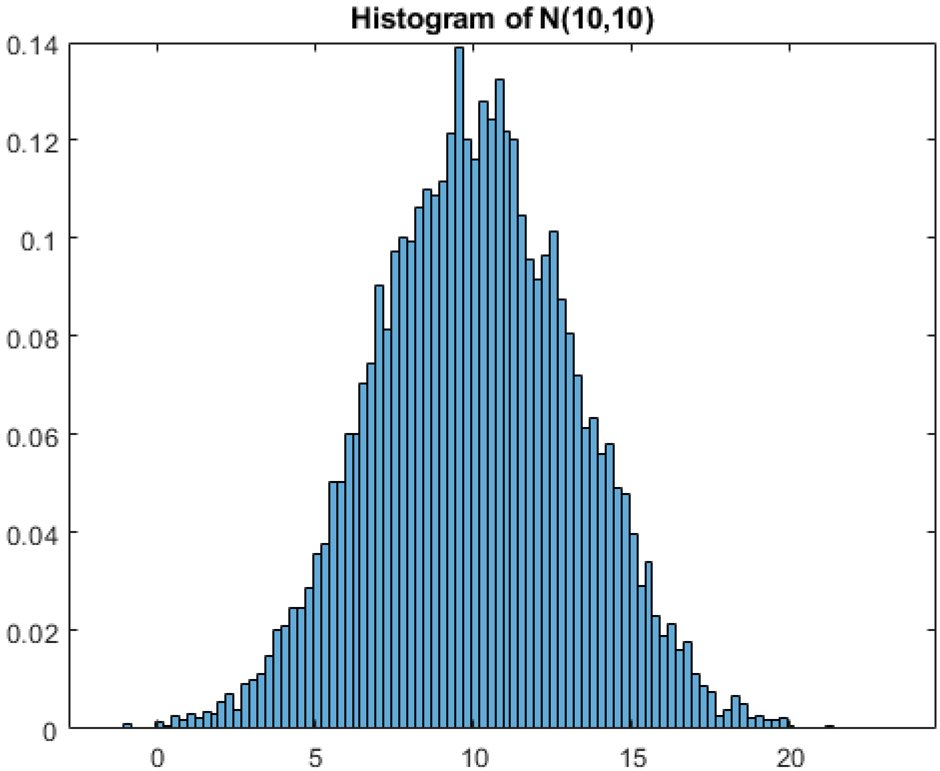
1.

1.1

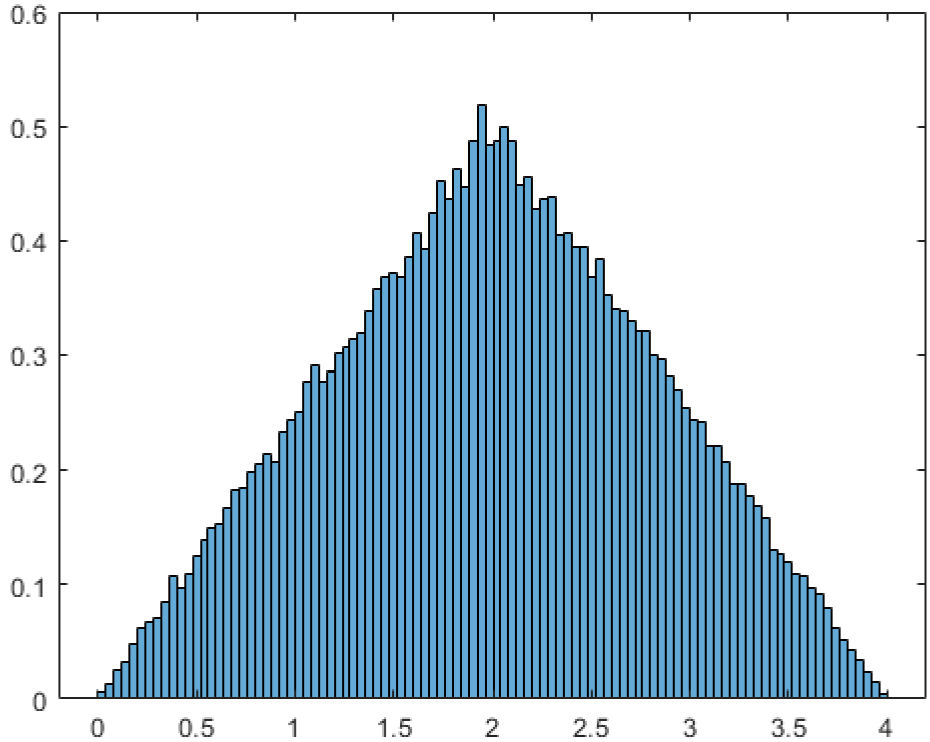
A)

```
n_bin = 100;
N = 10000;
mean = 10;
variance = 10;
x1 = sqrt(variance) * randn(1,N) + mean;
histogram(x1,n_bin,"Normalization",'pdf');
title 'Histogram of N(10,10)'
```



B)

```
N = 100000;
x2 = rand(1,N+1) * 2;
x3 = x2(2:end) + x2(1:end-1);
histogram(x3,n_bin,"Normalization",'pdf');
```

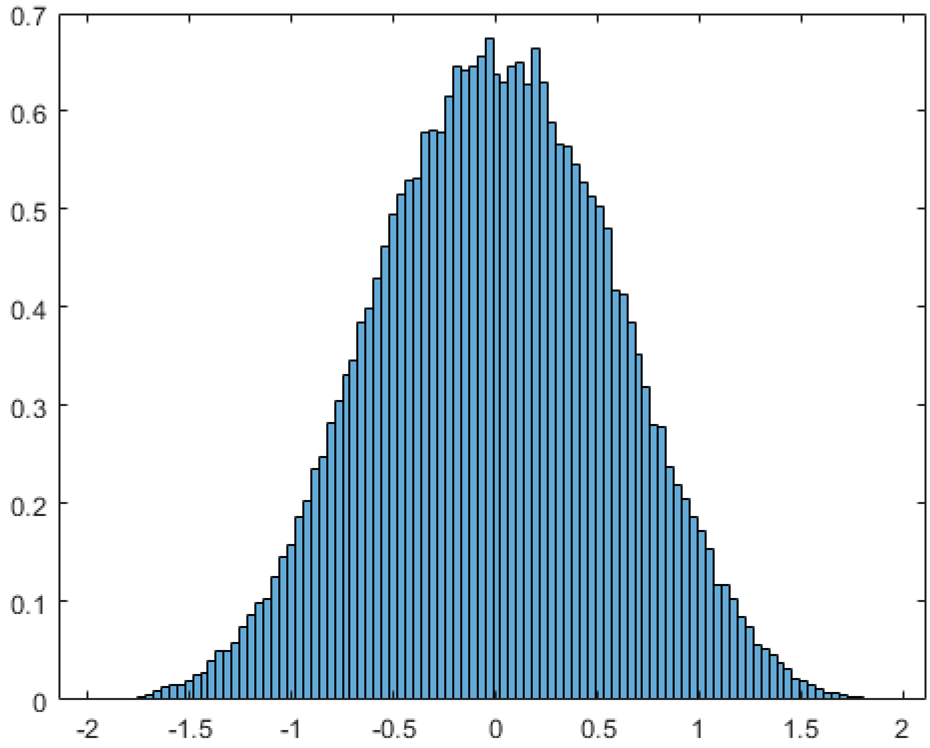


If we want to know PDF of the summation of two uniform distributions, we should convolve the two PDFs.

we know that convolution of two step function will produce triangle function.

C.

```
x4 =zeros(1,N);
for i=1:4
    x4 = x4 + (rand(1,N) - 0.5);
end
histogram(x4,n_bin,"Normalization",'pdf')
```



Just like previous part, convolution of four step function or convolution of two triangle function results this shape.

Based on "CLT", If we sum up a lot of uniform distribution, it will become a normal distribution.

2.

1

A)

```
N = 101;
n = 0:N;
x = zeros(N+4,1);
x(4) = 1;
y1 = zeros(N+4,1);
for n = 4:N
   y1(n) = 0.5 * y1(n - 1) - 0.25 * y1(n - 2) + x(n) + 2 * x(n - 1) + x(n - 3);
end
a = [1 -0.5 0.25];
b = [1 2 0 1];
y2 = filter(b,a,x)
```

```
y2 = 105×1
         0
         0
         0
    1.0000
    2.5000
    1.0000
```

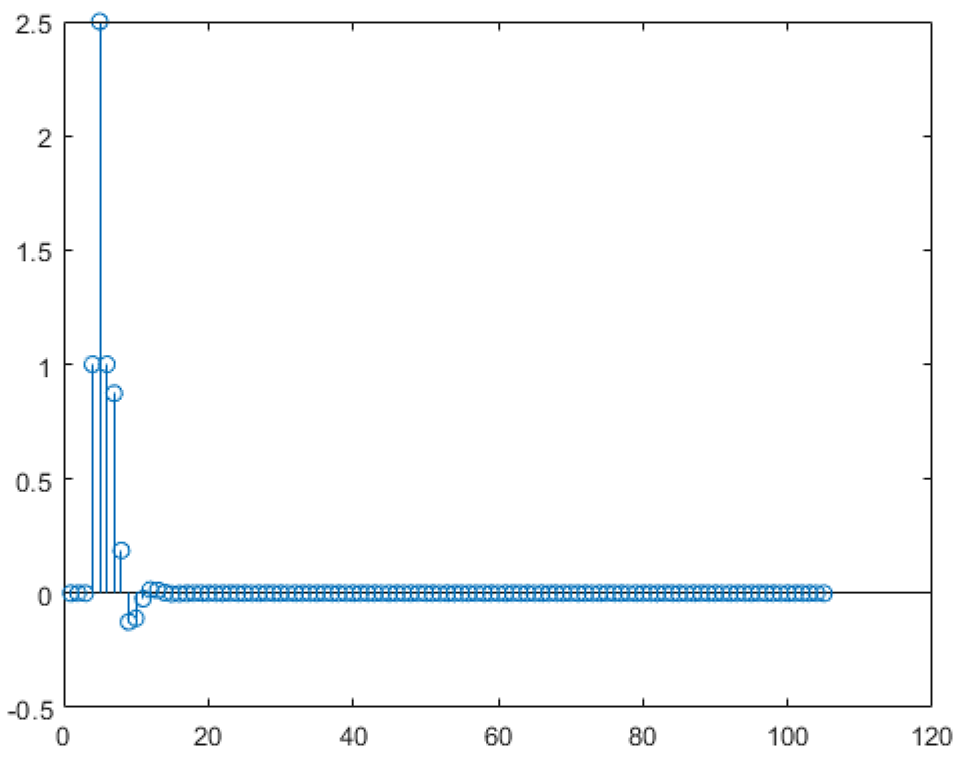
```
    0.8750
    0.1875
   -0.1250
   -0.1094
      ⋮
```

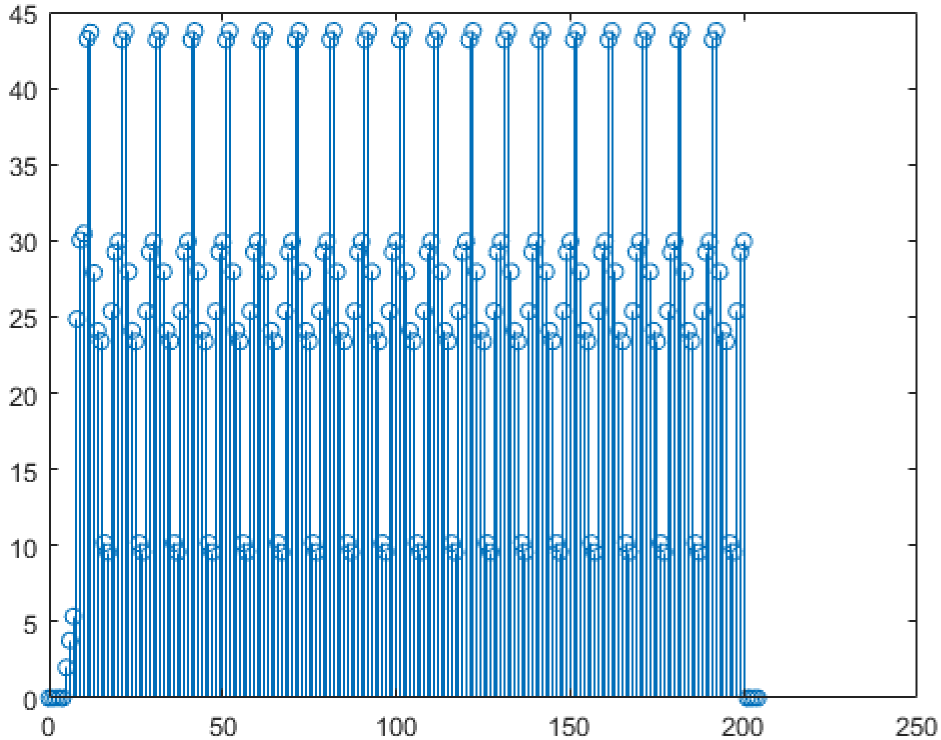
```
y1
```

```
y1 = 105×1
         0
         0
         0
    1.0000
    2.5000
    1.0000
    0.8750
    0.1875
   -0.1250
   -0.1094
      ⋮
```

As the above results, we could observe the non-filter using algorithm is correct!

```
stem(y1)
```

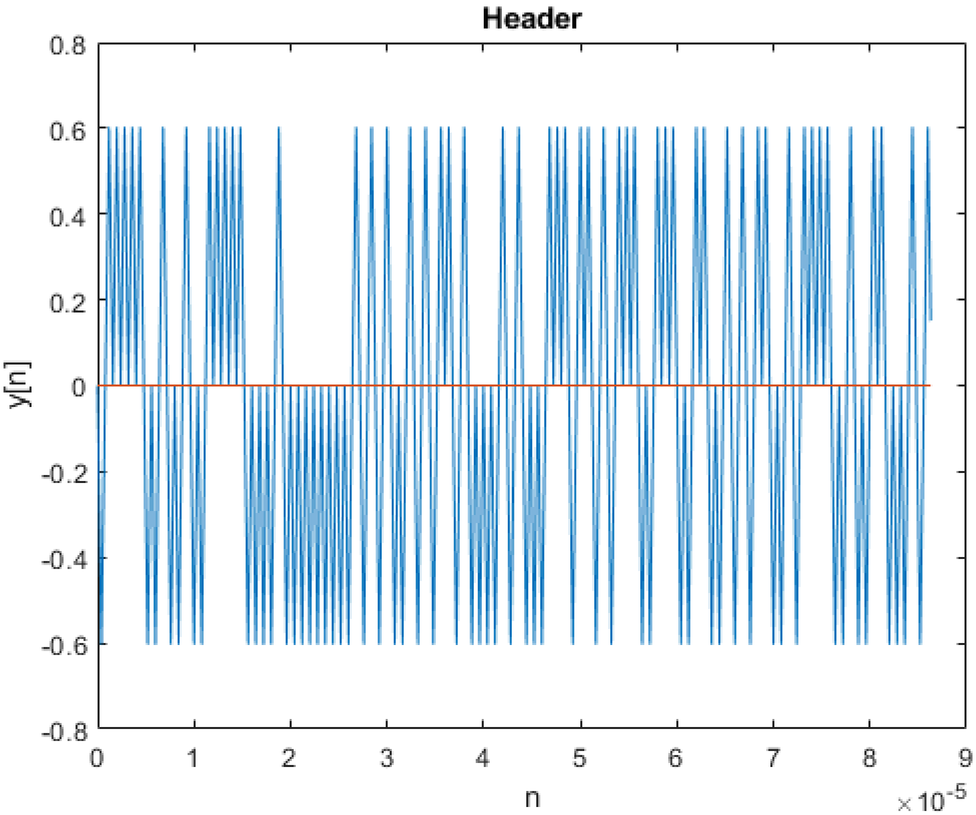




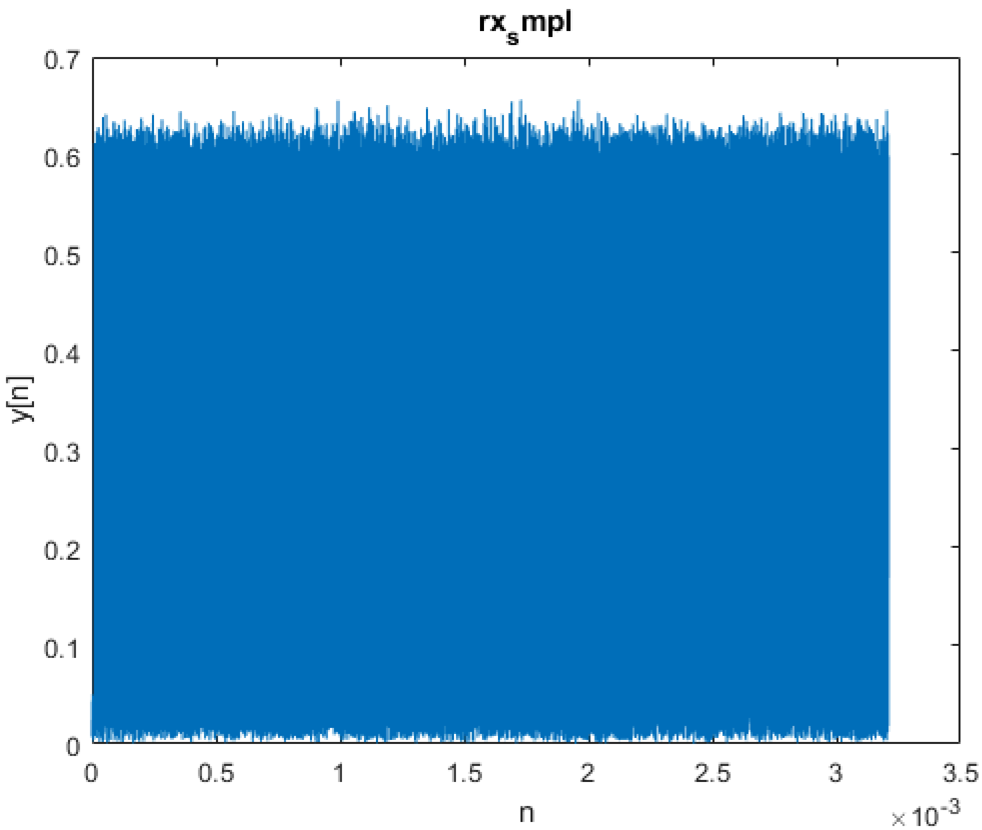
2

```
load('PacketsAndHeader.mat');
r = corr_m(hdr_smpl,rx_smpl);
```

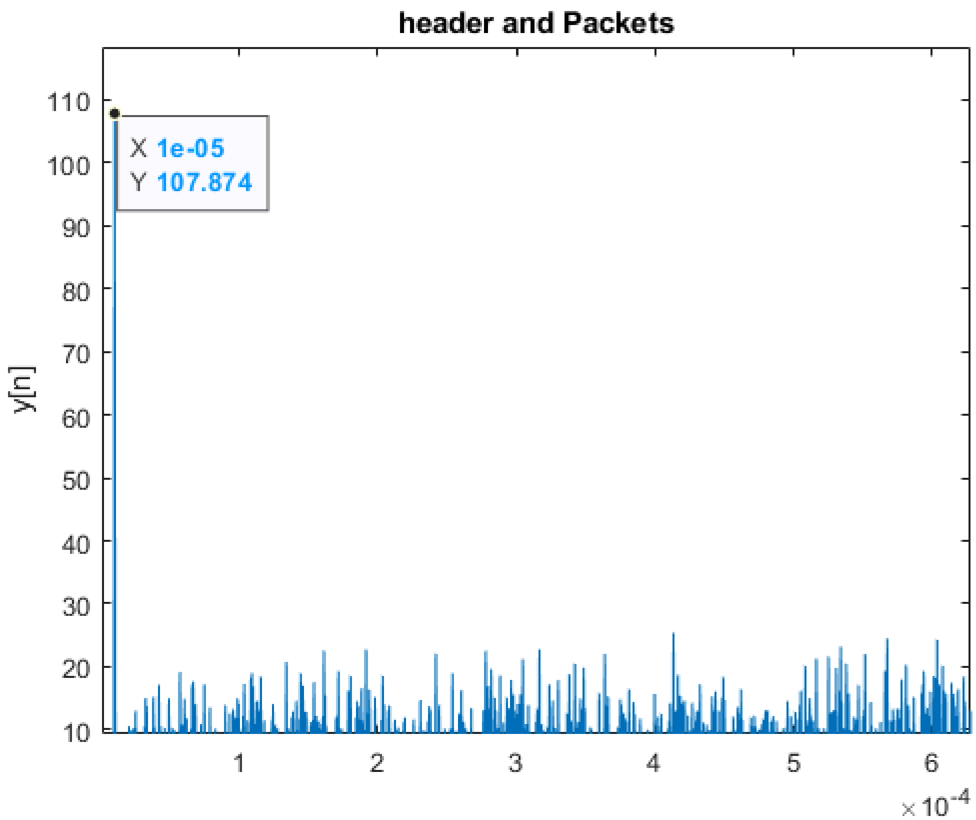
```
fs = 10e6;
t_header = 0:1/fs:(length(hdr_smpl)-1)/fs;
plot(t_header,real(hdr_smpl),t_header,imag(hdr_smpl));
title('Header')
xlabel('n')
ylabel('y[n]')
```




```
t_rx = 0:1/fs:(length(rx_smpl)-1)/fs;
plot(t_rx,abs(rx_smpl))
title('rx_smpl')
xlabel('n')
ylabel('y[n]')
```




```
t_r = 0:1/fs:(length(r)-1)/fs;
plot(t_r,abs(r))
title('header and Packets')
ylabel('y[n]')
```



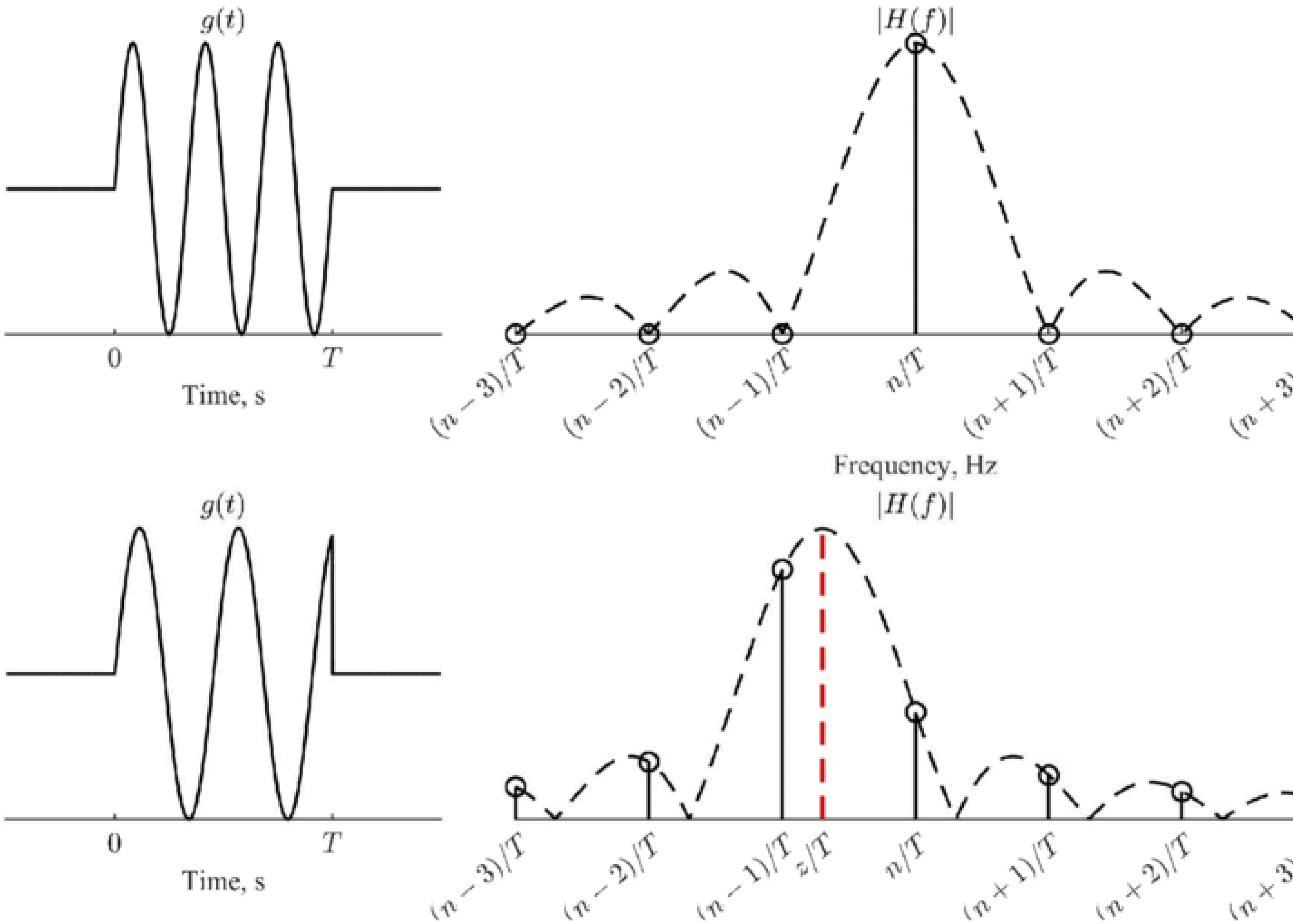
Delay ~= 1e-5 s

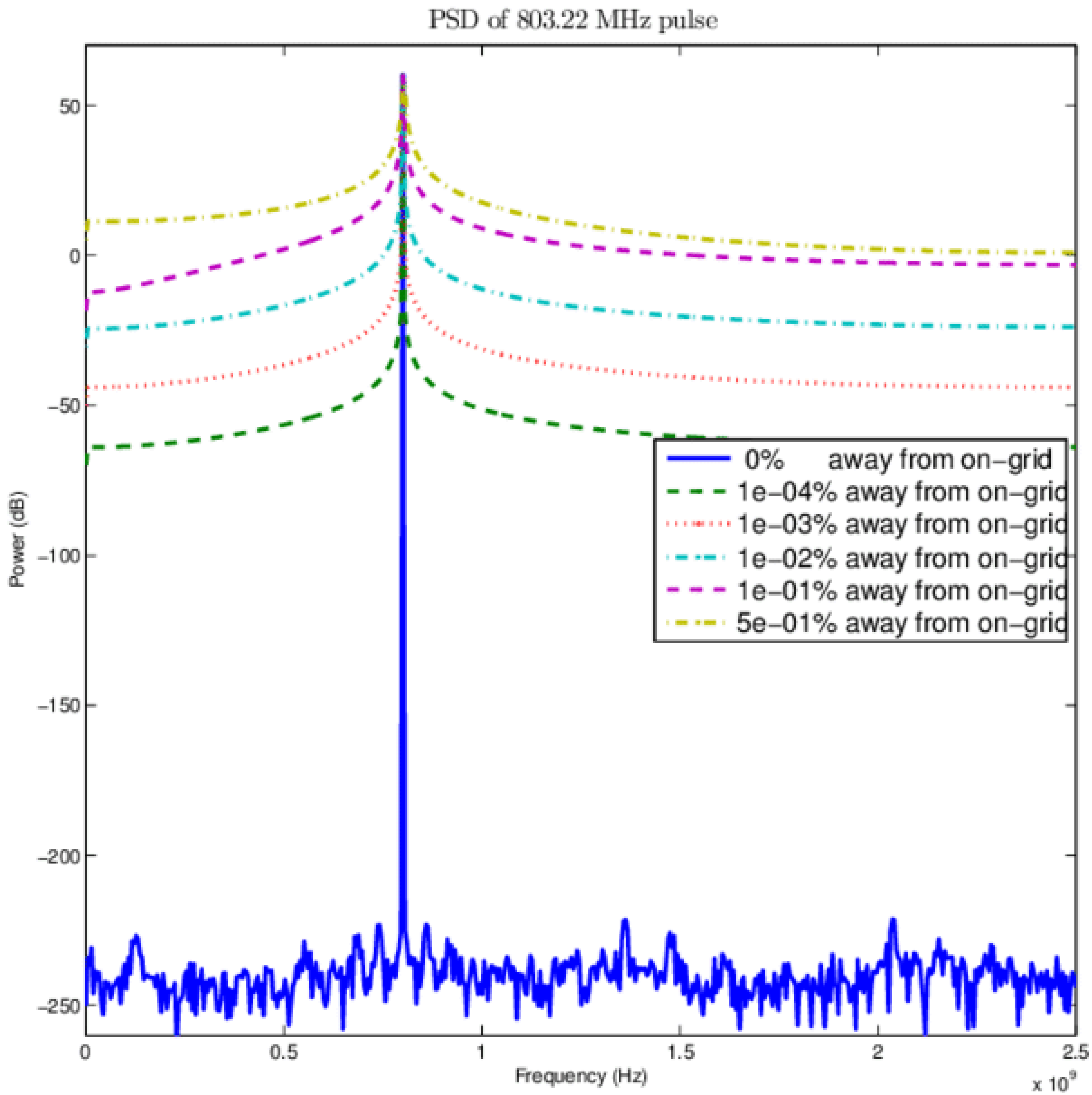
distance = c * D = 300km

3

Spectral Leakage:

Any other type of operation creates new frequency components that may be referred to as **spectral leakage** in the broadest sense. Sampling, for instance, produces leakage, which we call aliases of the original spectral component. For Fourier transform purposes, sampling is modeled as a product between s(t) and a Dirac comb function. The spectrum of a product is the convolution between S(f) and another function, which inevitably creates the new frequency components. But the term 'leakage' usually refers to the effect of *windowing*, which is the product of s(t) with a different kind of function, the window function. Window functions happen to have finite duration, but that is not necessary to create leakage. Multiplication by a time-variant function is sufficient.


g(t)
0
T
Time, s
|H(f)|
(n−3)/T
(n−2)/T
(n−1)/T
n/T
(n+1)/T
(n+2)/T
Frequency, Hz
g(t)
0
T
Time, s
|H(f)|
(n−3)/T
(n−2)/T
(n−1)/T
z/T
n/T
(n+1)/T
(n+2)/T




```
A = 2
```

```
A = 2
```

```
f0 = (250 * 51 / 256) * 1e6
```

```
f0 = 4.9805e+07
```

```
n_fft = 256
```

```
n_fft = 256
```

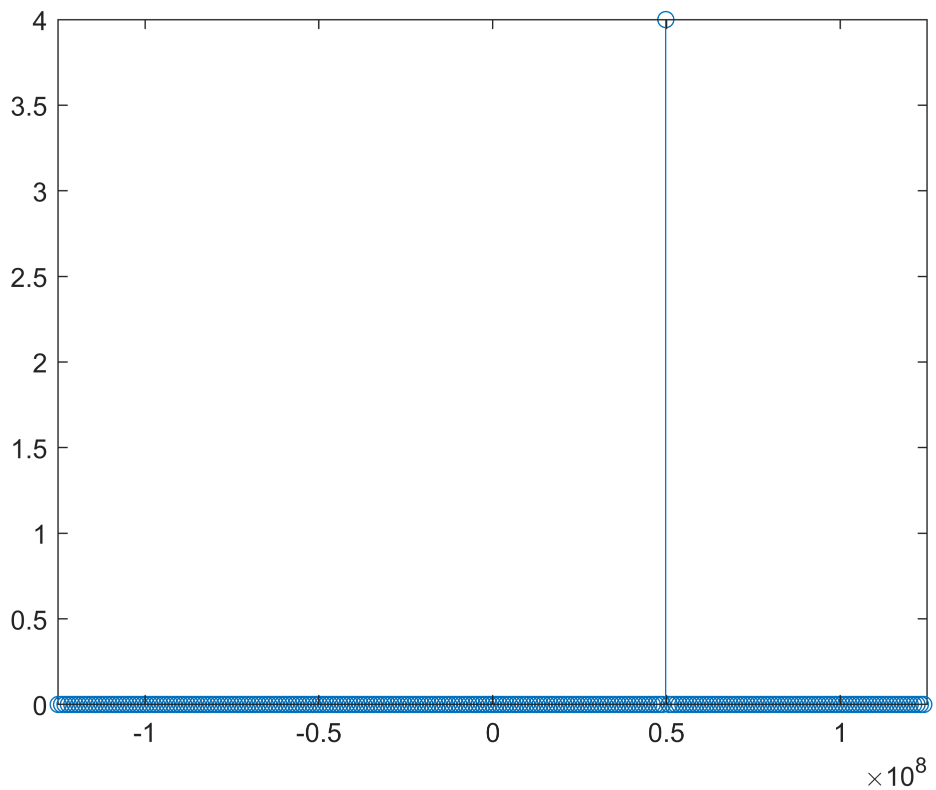
```
fs = 250e6;
ts = 1/fs;
freq_resolution = fs/n_fft
```

```
freq_resolution = 9.7656e+05
```

```
t = (0:n_fft-1);
freq = (0:n_fft-1)/n_fft * fs - fs/2;
x = A*exp(1j*2*pi*t*f0*ts);

Xf = fftshift(fft(x, n_fft)); %not normalized
Xf = fftshift(fft(x, n_fft))/n_fft;

stem(freq, abs(Xf).^2);
xlim([-125e6,125e6]);
```




```
ratio = n_fft * ts * f0
```

```
ratio = 51
```

```
power_time = sum(abs(x).^2)/length(x)
```

```
power_time = 4
```

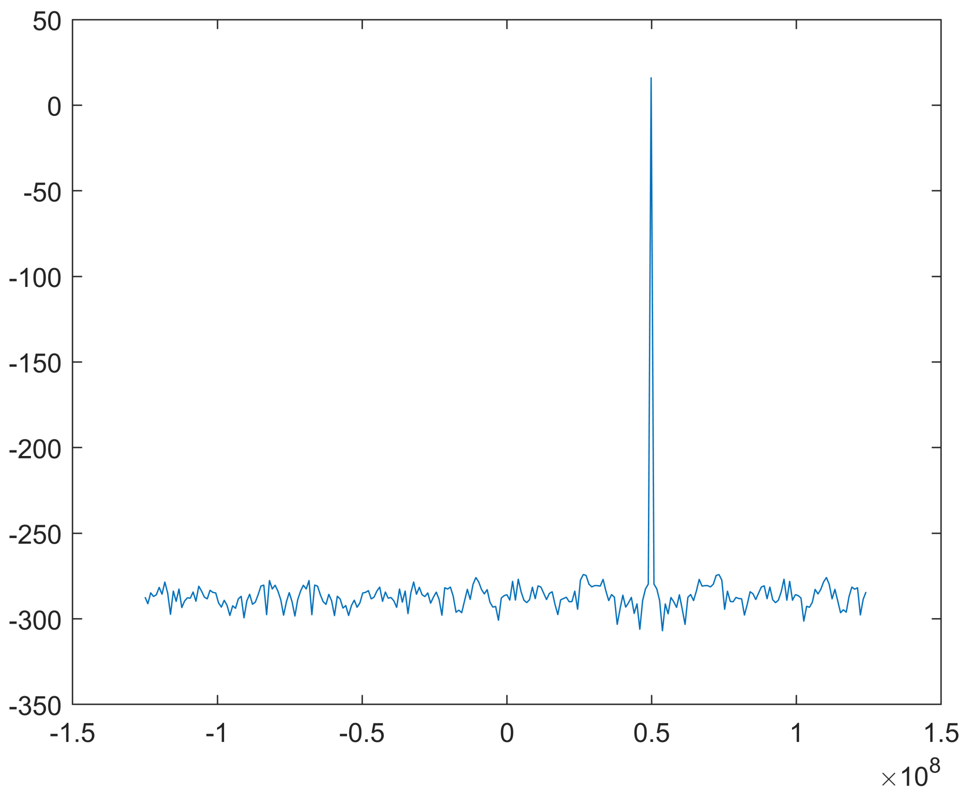
```
power_freq = sum(abs(Xf).^2)
```

```
power_freq = 4
```

```
R = 50
```

```
R = 50
```

```
plot(freq, 10 * log10(abs(Xf).^2/(2*R))+30)
```




```
A = 2
```

```
A = 2
```

```
f0 = (250 * 51.5 / 256 ) * 1e6
```

```
f0 = 5.0293e+07
```

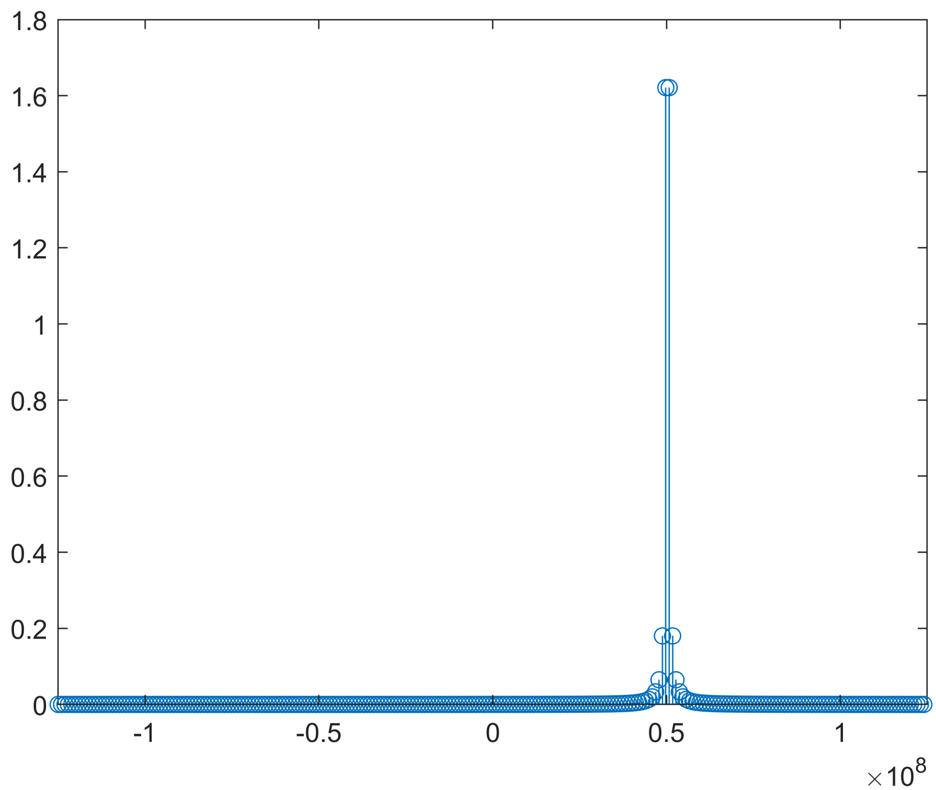
```
n_fft = 256
```

```
n_fft = 256
```

```
fs = 250e6;
freq_resolution = fs/n_fft
```

```
freq_resolution = 9.7656e+05
```

```
ts = 1/fs;
t = (0:n_fft-1);
freq = (0:n_fft-1)/n_fft * fs - fs/2;
x = A*exp(1i*2*pi*t*f0*ts);
Xf = fftshift(fft(x, n_fft))/n_fft;
stem(freq, abs(Xf).^2)
xlim([-125e6,125e6])
```




```
ratio = n_fft * ts * f0
```

```
ratio = 51.5000
```

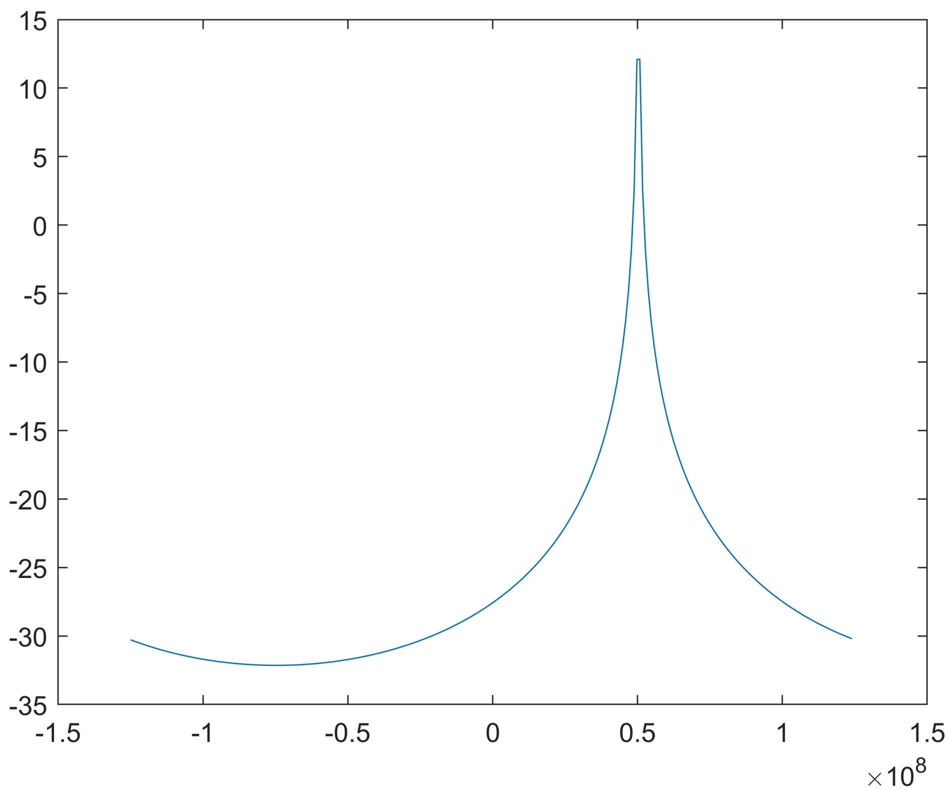
```
power_time = sum(abs(x).^2)/length(x)
```

```
power_time = 4
```

```
power_freq = sum(abs(Xf).^2)
```

```
power_freq = 4.0000
```

```
R = 50;
plot(freq, 10 * log10(abs(Xf).^2/(2*R))+30)
```




```
A = 2
```

```
A = 2
```

```
f0 = (250 * 51 / 256) * 1e6
```

```
f0 = 4.9805e+07
```

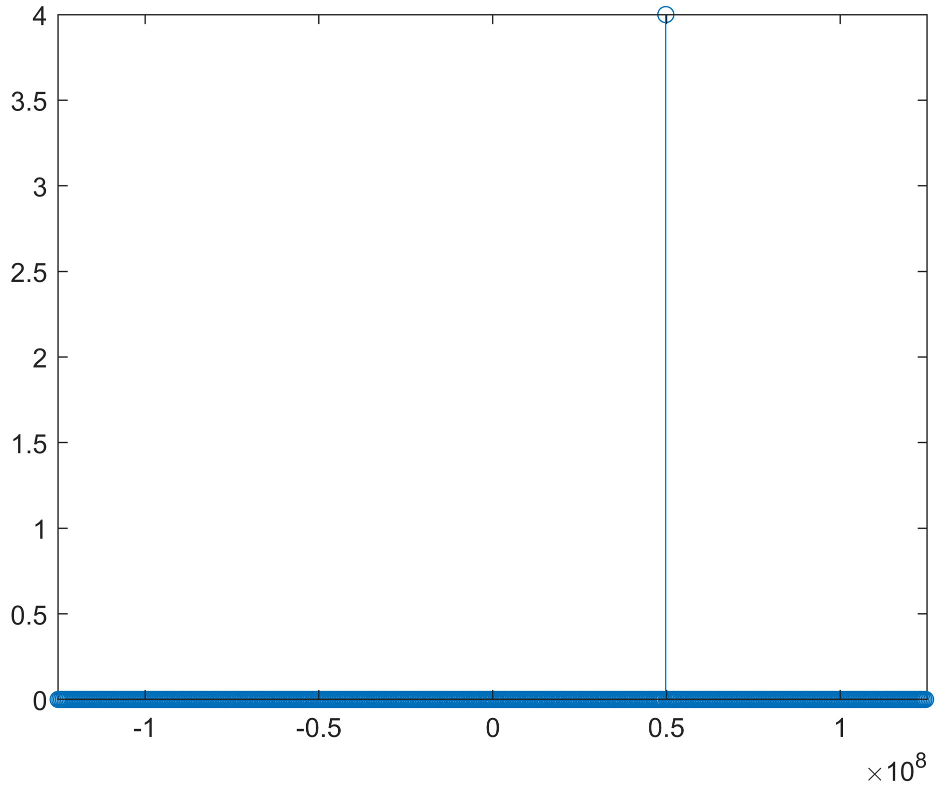
```
n_fft = 512
```

```
n_fft = 512
```

```
fs = 250e6;
freq_resolution = fs/n_fft
```

```
freq_resolution = 4.8828e+05
```

```
ts = 1/fs;
t = (0:n_fft-1);
freq = (0:n_fft-1)/n_fft * fs - fs/2;
x = A*exp(1i*2*pi*t*f0*ts);
Xf = fftshift(fft(x, n_fft))/n_fft;
stem(freq, abs(Xf).^2)
xlim([-125e6,125e6])
```




```
ratio = n_fft * ts * f0
```

ratio = 102

```
time_power = sum(abs(x).^2)/length(x)
```

time_power = 4

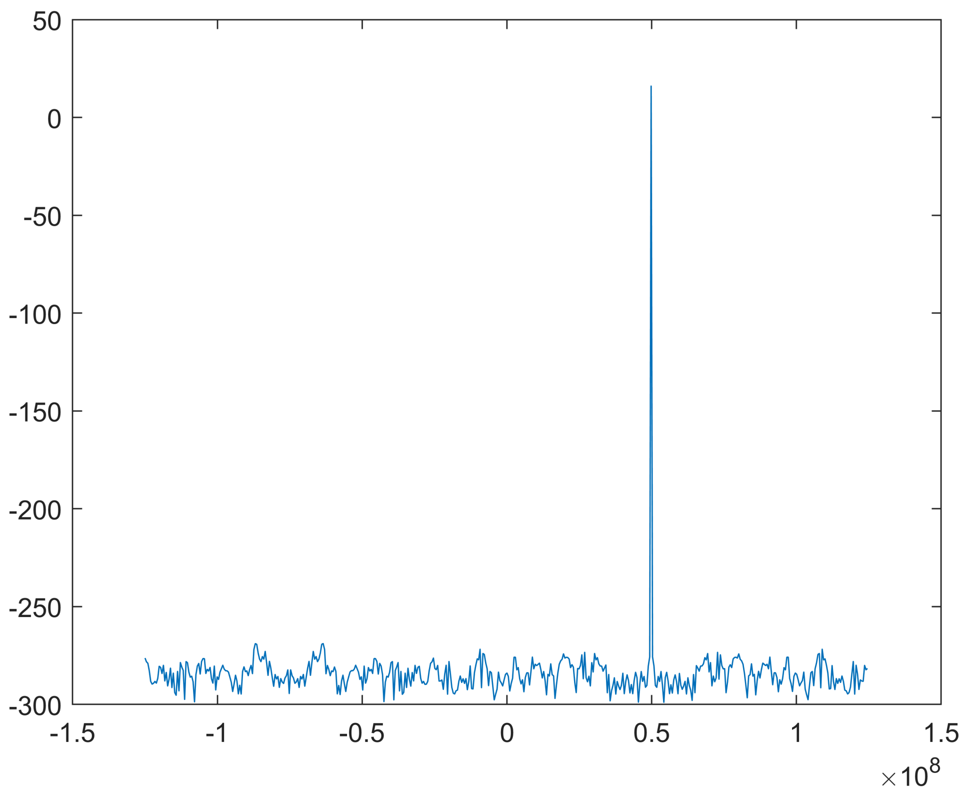
```
freq_power = sum(abs(Xf).^2)
```

freq_power = 4

```
R = 50
```

R = 50

```
plot(freq, 10 * log10(abs(Xf).^2/(2*R))+30)
```




```
A = 2
```

```
A = 2
```

```
f0 = -(250 * 51 / 256 ) * 1e6
```

```
f0 = -4.9805e+07
```

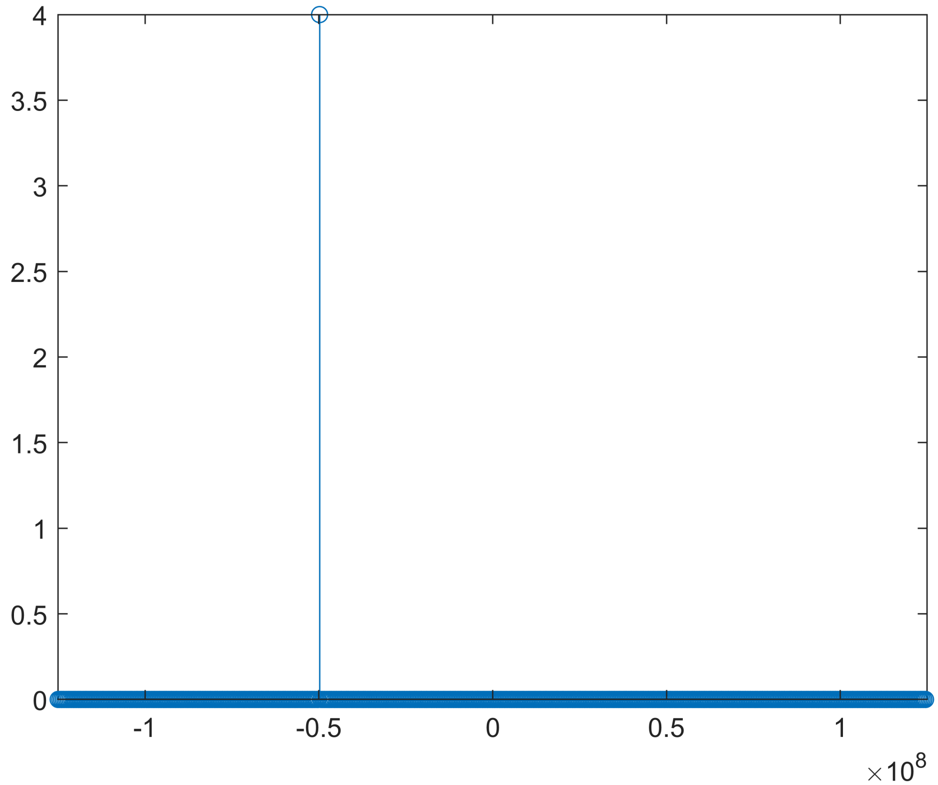
```
n_fft = 512
```

```
n_fft = 512
```

```
fs = 250e6;
freq_resolution = fs/n_fft
```

```
freq_resolution = 4.8828e+05
```

```
ts = 1/fs;
t = (0:n_fft-1);
freq = (0:n_fft-1)/n_fft * fs - fs/2;
x = A*exp(1i*2*pi*t*f0*ts);
Xf = fftshift(fft(x, n_fft)); %not normalized
Xf = fftshift(fft(x, n_fft)) /n_fft;
stem(freq, abs(Xf).^2)
xlim([-125e6,125e6])
```




```
ratio = n_fft * ts * f0
```

```
ratio = -102
```

```
time_power = sum(abs(x).^2)/length(x)
```

```
time_power = 4
```

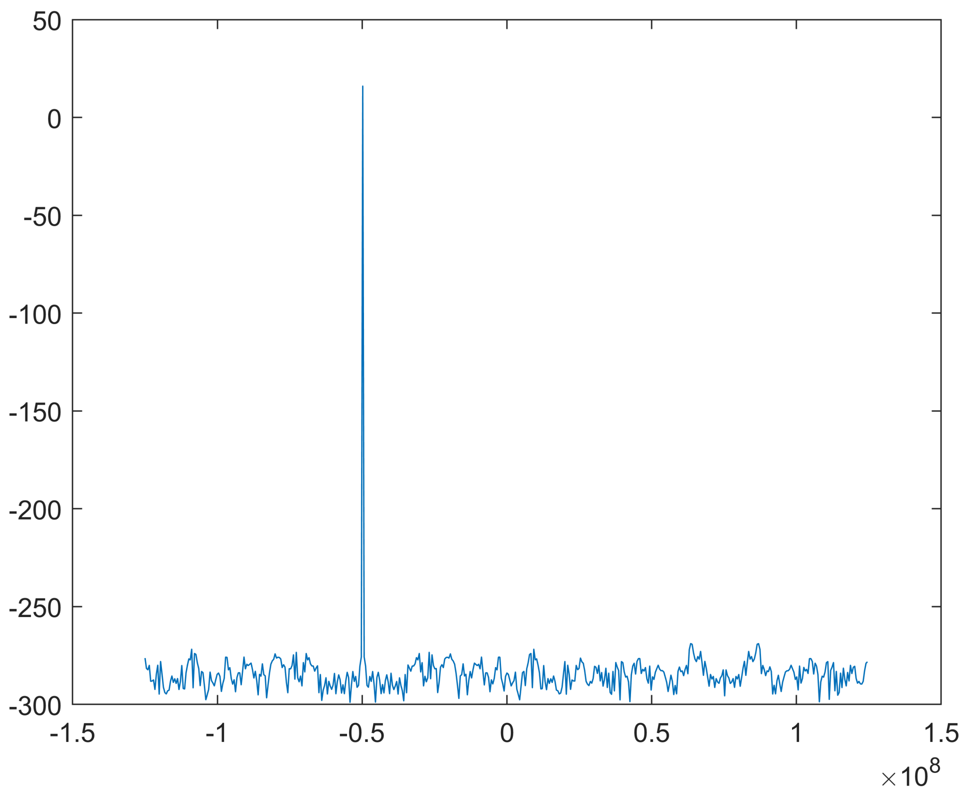
```
freq_power = sum(abs(Xf).^2)
```

```
freq_power = 4
```

```
R = 50
```

```
R = 50
```

```
plot(freq, 10 * log10(abs(Xf).^2/(2*R))+30)
```




```
A = 4
```

```
A = 4
```

```
f0 = (250 * 153 / 256 ) * 1e6
```

```
f0 = 1.4941e+08
```

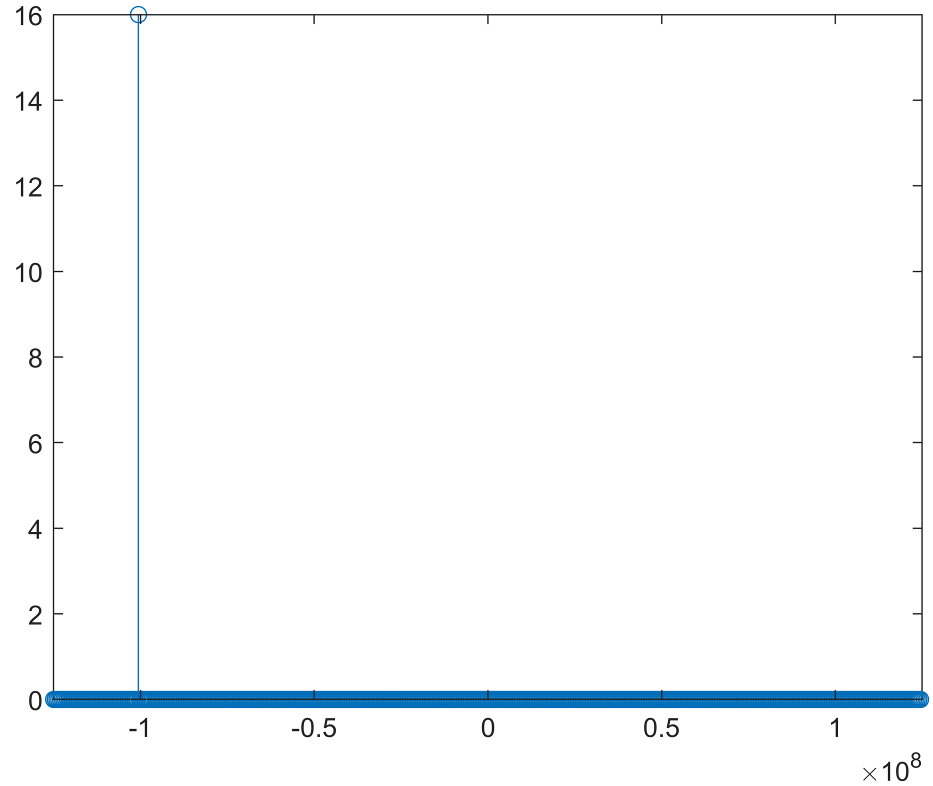
```
n_fft = 512
```

```
n_fft = 512
```

```
fs = 250e6;
freq_resolution = fs/n_fft
```

```
freq_resolution = 4.8828e+05
```

```
ts = 1/fs;
t = (0:n_fft-1);
freq = (0:n_fft-1)/n_fft * fs - fs/2;
x = A*exp(1i*2*pi*t*f0*ts);
Xf = fftshift(fft(x, n_fft))/n_fft;
stem(freq, abs(Xf).^2)
xlim([-125e6,125e6])
```




```
ratio = n_fft * ts * f0
```

ratio = 306

```
time_power = sum(abs(x).^2)/length(x)
```

time_power = 16

```
freq_power = sum(abs(Xf).^2)
```

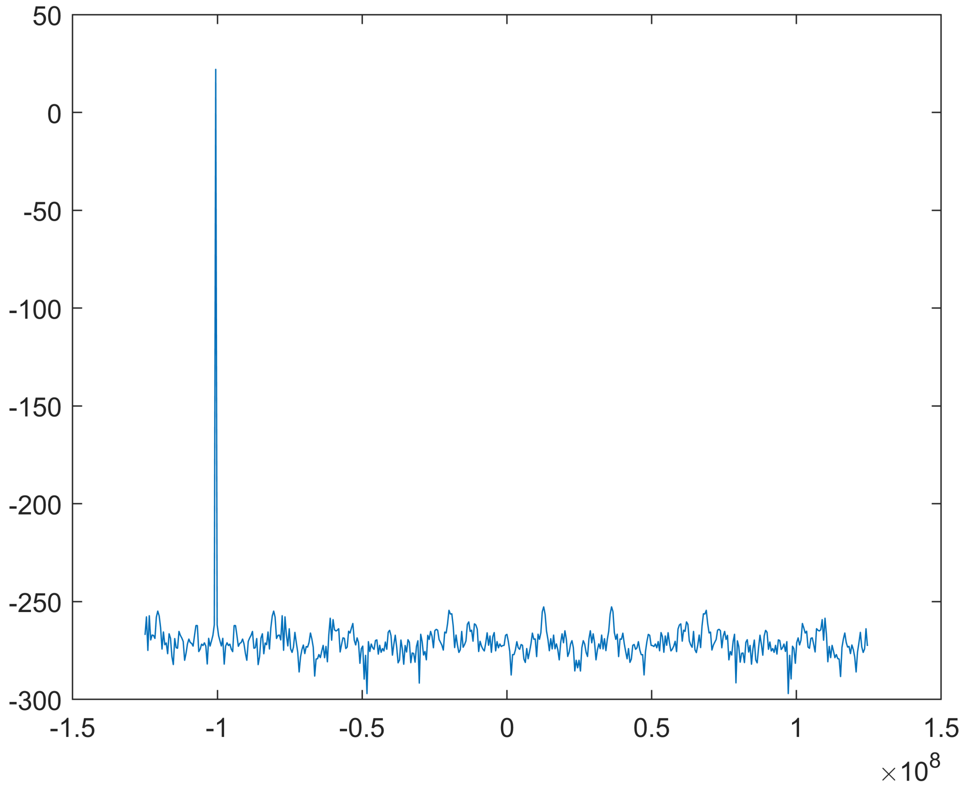
freq_power = 16

```
R = 50
```

R = 50

Whenever the Frequency is higher than sampling frequency the below spectrum will be resulted.

```
plot(freq, 10 * log10(abs(Xf).^2/(2*R))+30)
```



By increasing n_fft we will have better (not higher) frequency resolution. (frequency resolution = fs/n_fft)

```
A = 2
```

```
A = 2
```

```
f0 = (250 * 51.5 / 256 ) * 1e6
```

```
f0 = 5.0293e+07
```

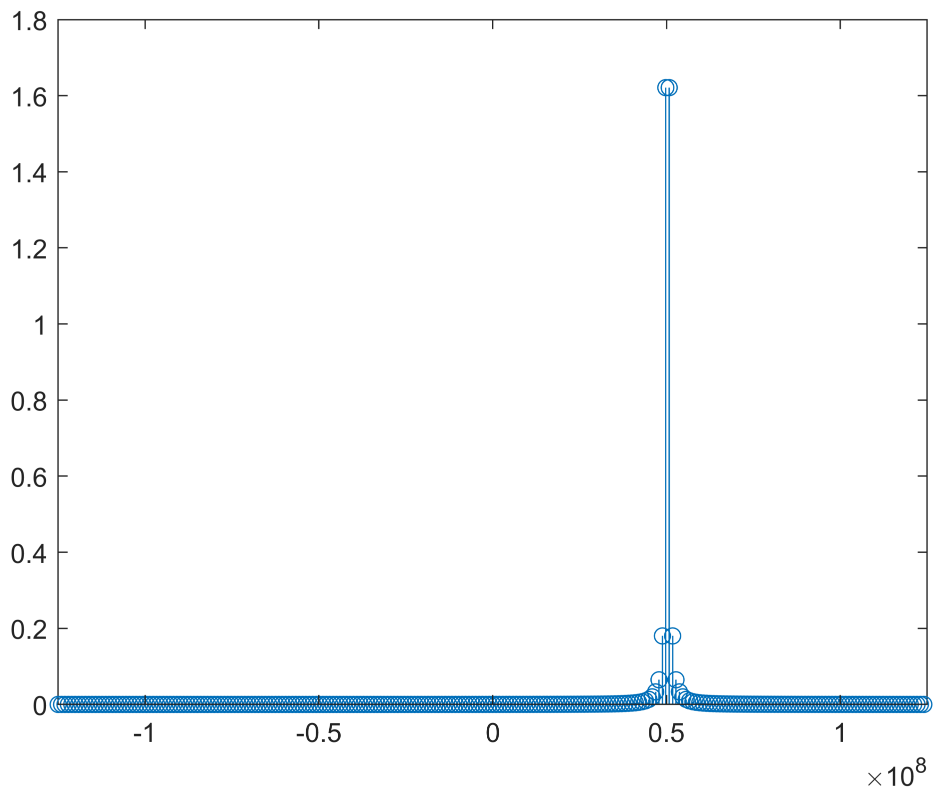
```
n_fft = 256
```

```
n_fft = 256
```

```
fs = 250e6;
freq_resolution = fs/n_fft
```

```
freq_resolution = 9.7656e+05
```

```
ts = 1/fs;
t = (0:n_fft-1);
freq = (0:n_fft-1)/n_fft * fs - fs/2;
x = A*exp(1i*2*pi*t*f0*ts);
Xf = fftshift(fft(x, n_fft))/n_fft;
stem(freq, abs(Xf).^2)
xlim([-125e6,125e6])
```




```
A = 2
```

```
A = 2
```

```
f0 = (250 * 51.5 / 256 ) * 1e6
```

```
f0 = 5.0293e+07
```

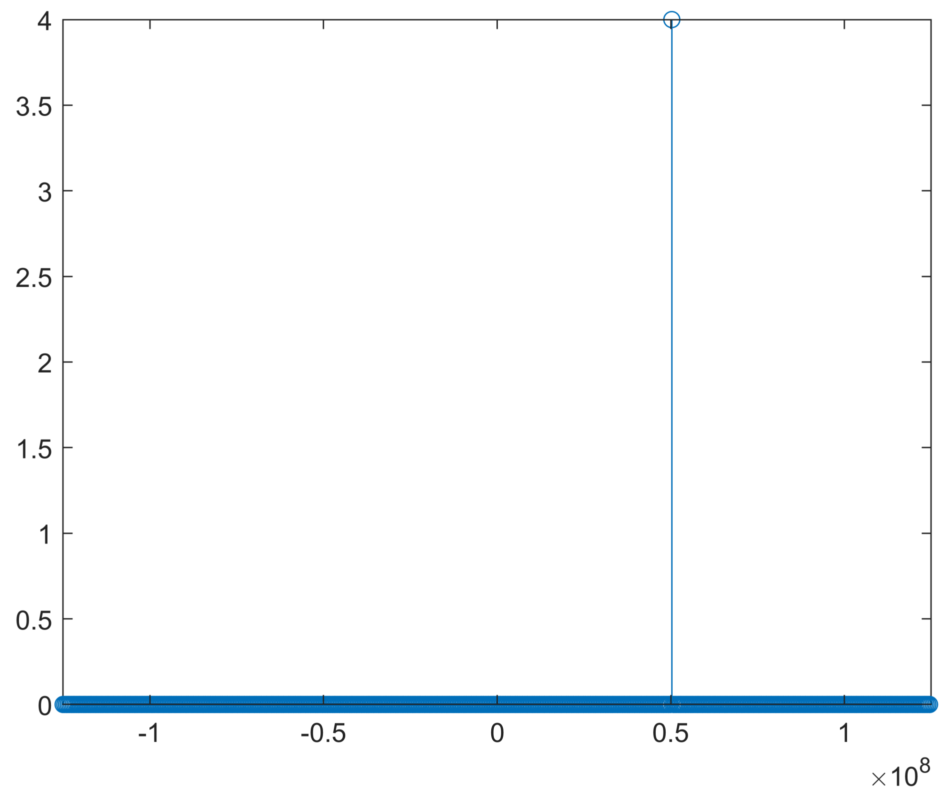
```
n_fft = 512
```

```
n_fft = 512
```

```
fs = 250e6;
freq_resolution = fs/n_fft
```

```
freq_resolution = 4.8828e+05
```

```
ts = 1/fs;
t = (0:n_fft-1);
freq = (0:n_fft-1)/n_fft * fs - fs/2;
x = A*exp(1i*2*pi*t*f0*ts);
Xf = fftshift(fft(x, n_fft))/n_fft;
stem(freq, abs(Xf).^2)
xlim([-125e6,125e6])
```




```
A = 2
```

```
A = 2
```

```
f0 = (250 * 51.25 / 256 ) * 1e6
```

```
f0 = 5.0049e+07
```

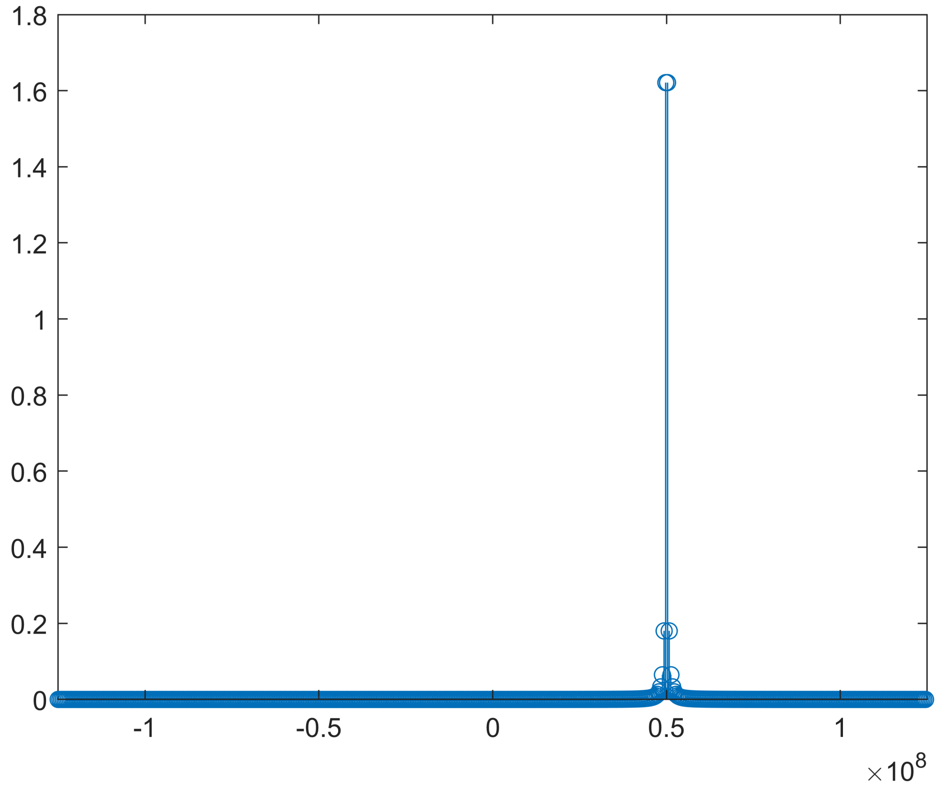
```
n_fft = 512
```

```
n_fft = 512
```

```
fs = 250e6;
freq_resolution = fs/n_fft
```

```
freq_resolution = 4.8828e+05
```

```
ts = 1/fs;
t = (0:n_fft-1);
freq = (0:n_fft-1)/n_fft * fs - fs/2;
x = A*exp(1i*2*pi*t*f0*ts);
Xf = fftshift(fft(x, n_fft))/n_fft;
stem(freq, abs(Xf).^2)
xlim([-125e6,125e6])
```



Functions

```
function r = corr_m(x, y)
r = zeros(1, abs(length(y) - length(x)) + 1);
for i=1:length(r)
    r(i) = sum(x.*conj(y(i:i+length(x)-1)));
end
end
```