DSP Laboratory S 01-02

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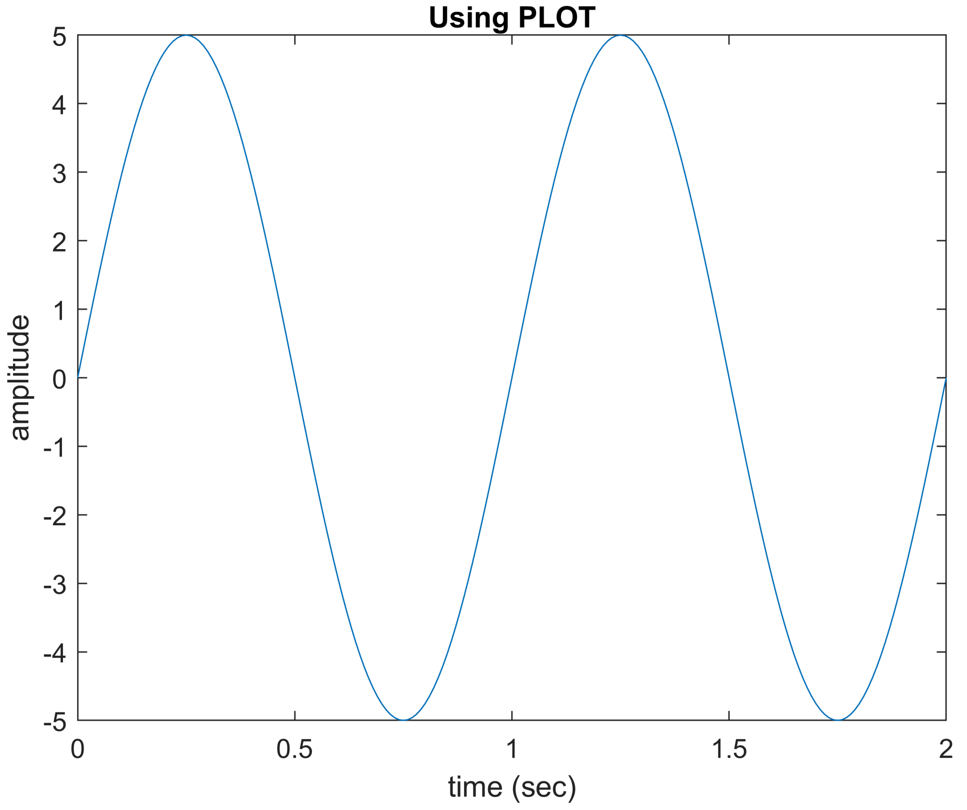
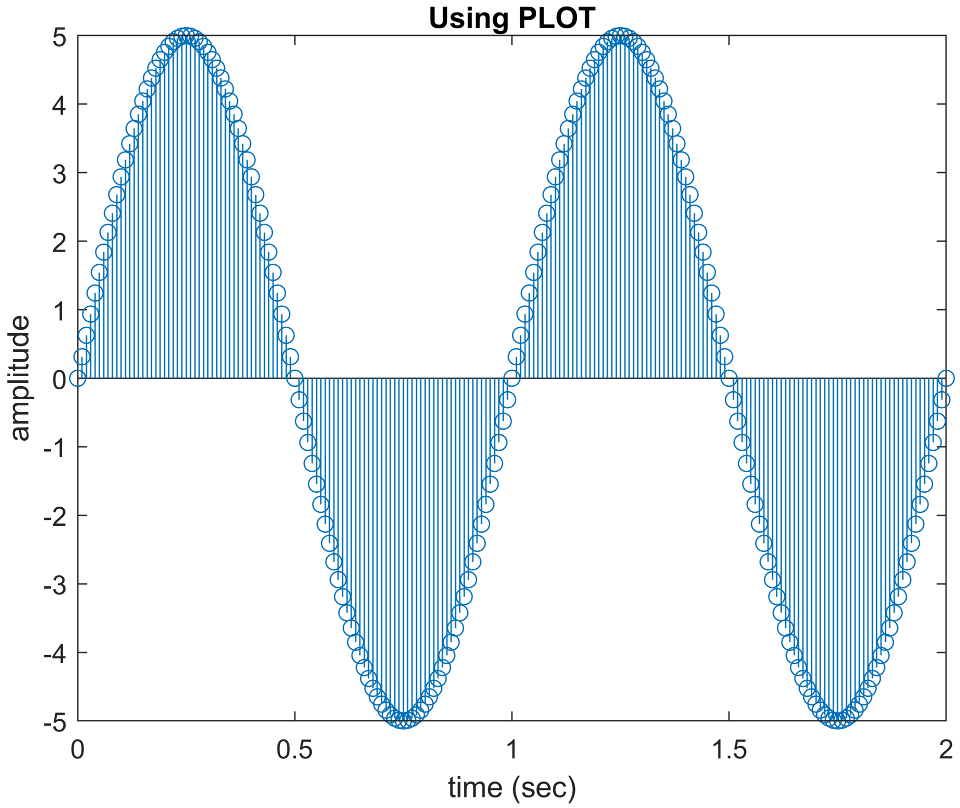
plot

```
clc;
clear;
f=1; % Hz
A=5; % amplitude
t=0:0.01:2;
func=A*sin(2*pi*f*t);
plot(t,func)
xlabel("time (sec)");
ylabel("amplitude");
title("Using PLOT");
```



```
%% stem
clc;
```

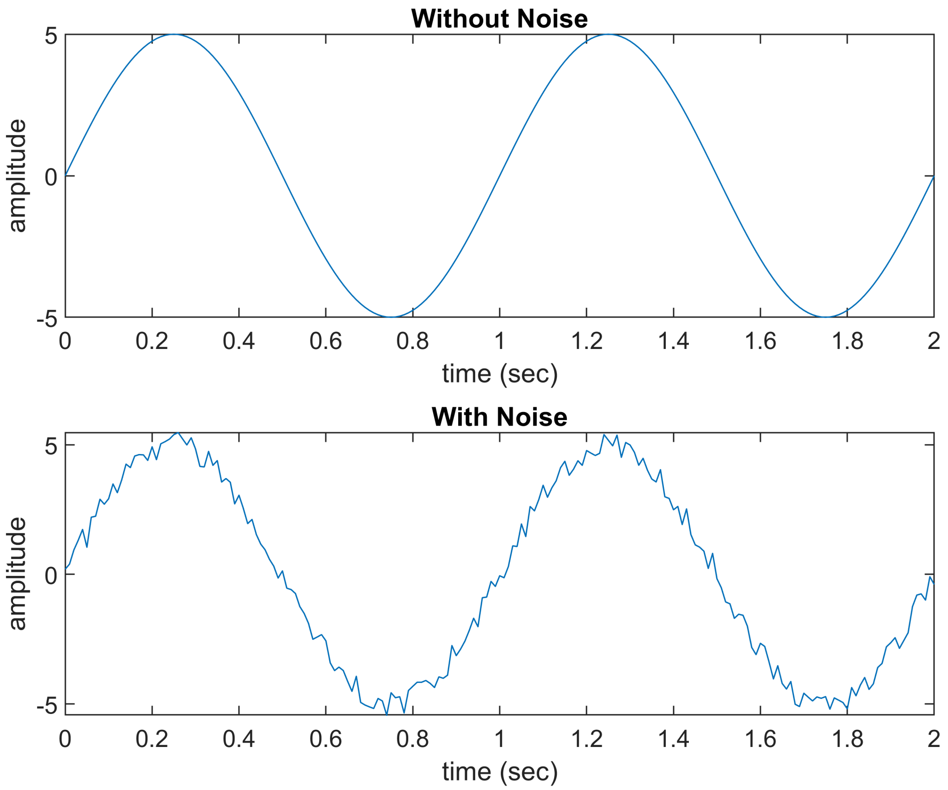
```
clear;
f=1; % Hz
A=5; % amplitude
t=0:0.01:2;
func=A*sin(2*pi*f*t);
stem(t,func)
xlabel("time (sec)");
ylabel("amplitude");
title("Using PLOT");
```



subplot

```
clc;
clear;
f=1; % Hz
A=5; % amplitude
t=0:0.01:2;
func3=A*sin(2*pi*f*t);
n= -0.5 + 1.*rand(201,1);
nfunc=zeros(1,201);
for i=1:201
   nfunc(1,i)=func3(1,i)+n(i,1);
end
subplot(2,1,1)
plot(t,func3)
xlabel("time (sec)");
```

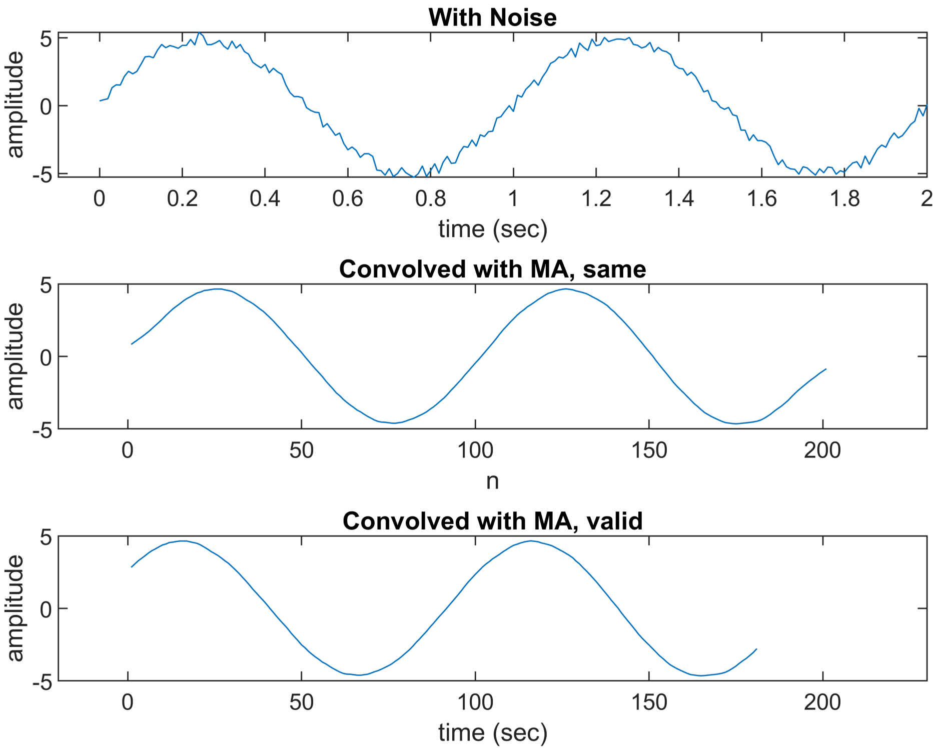
```
ylabel("amplitude");
title("Without Noise");
subplot(2,1,2)
plot(t,nfunc)
xlabel("time (sec)");
ylabel("amplitude");
title("With Noise");
```



conv

```
clc;
clear;
f=1; % Hz
A=5; % amplitude
t=0:0.01:2;
t2=0:0.01:2.1;
func=A*sin(2*pi*f*t);
n= -0.5 + 1.*rand(201,1);
nfunc=zeros(1,201);
for i=1:201
   nfunc(1,i)=func(1,i)+n(i,1);
end
M1=0;
M2=20;
h=(1/(M1+M2+1))*ones(1,21);
n_ma_same=conv(nfunc,h,'same');
```

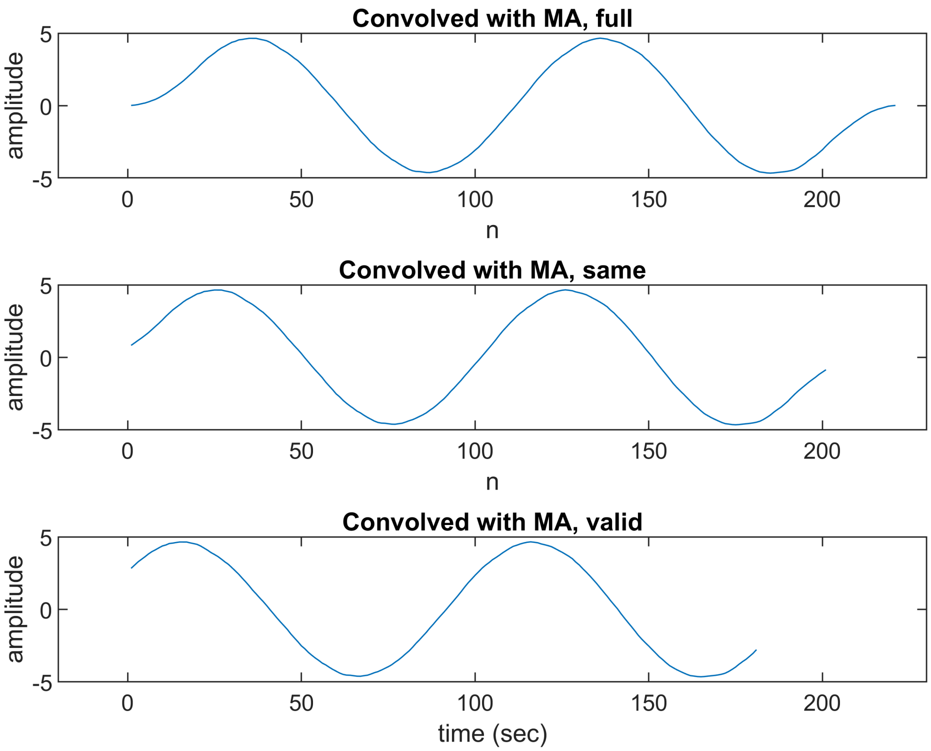
```
n_ma_valid=conv(nfunc,h,'valid');
subplot(3,1,1)
plot(t,nfunc)
xlabel("time (sec)");
ylabel("amplitude");
title("With Noise");
xlim([-0.1,2])
```



conv M1=0; M2=20; full, same, valid

```
clc;
clear;
f=1; % Hz
A=5; % amplitude
t=0:0.01:2;
func=A*sin(2*pi*f*t);
n= -0.5 + 1.*rand(201,1);
nfunc=zeros(1,201);
for i=1:201
   nfunc(1,i)=func(1,i)+n(i,1);
end
M1=0;
M2=20;
h=(1/(M1+M2+1))*ones(1,21);
n_ma_full=conv(nfunc,h,'full');
n_ma_same=conv(nfunc,h,'same');
```

```
n_ma_valid=conv(nfunc,h,'valid');
subplot(3,1,1)
plot(n_ma_full)
xlabel("n");
ylabel("amplitude");
title("Convolved with MA, full");
xlim([-20,230])
subplot(3,1,2)
plot(n_ma_same)
xlabel("n");
ylabel("amplitude");
title("Convolved with MA, same");
xlim([-20,230])
subplot(3,1,3)
plot(n_ma_valid)
xlabel("time (sec)");
ylabel("amplitude");
title("Convolved with MA, valid");
xlim([-20,230])
```


Convolved with MA, full

Convolved with MA, same

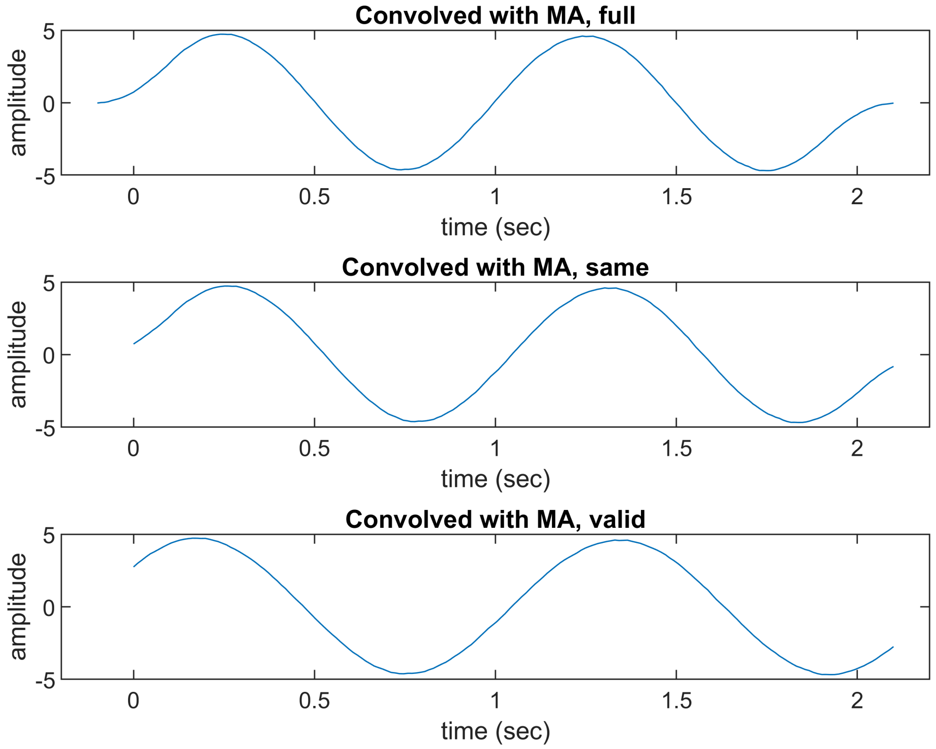
Convolved with MA, valid

Based on the plots, full displays the whole convolved signal, same, an output of the same length with the input signal, and valid, an output only for the common valid section.

conv M1=0; M2=20; full, same, valid, time-plotted

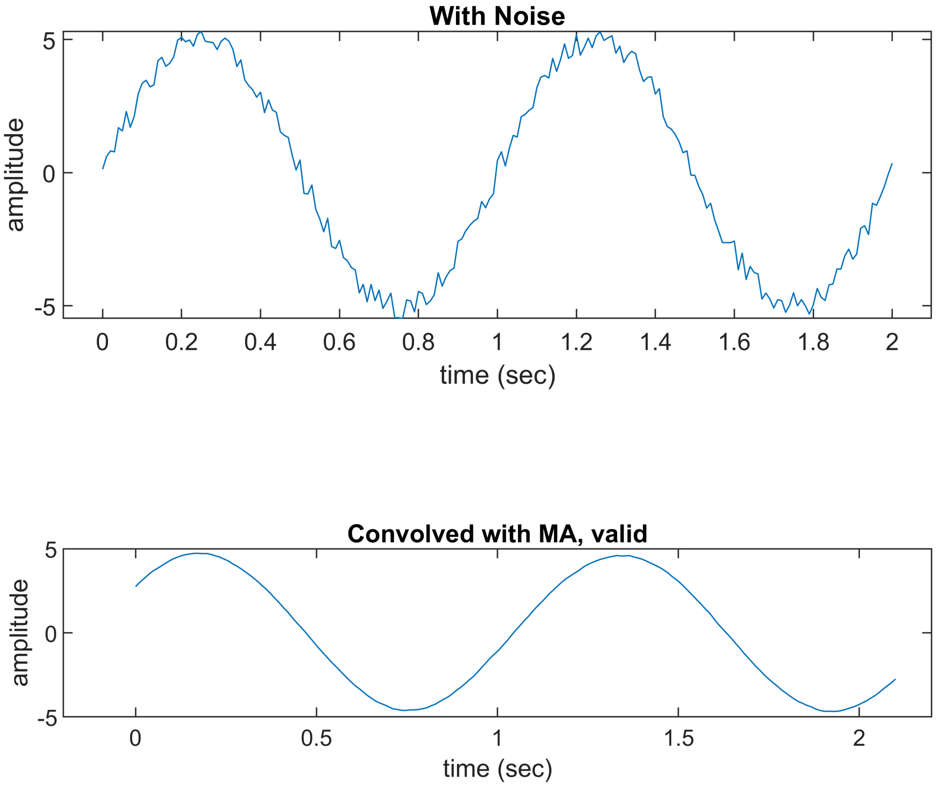
```
clc;
```

```
clear;
f=1; % Hz
A=5; % amplitude
t=0:0.01:2;
t1=linspace(-0.1,2.1,221);
t2=linspace(0,2.1,201);
t3=linspace(0,2.1,181);
func=A*sin(2*pi*f*t);
n= -0.5 + 1.*rand(201,1);
nfunc=zeros(1,201);
for i=1:201
   nfunc(1,i)=func(1,i)+n(i,1);
end
M1=0;
M2=20;
h=(1/(M1+M2+1))*ones(1,21);
n_ma_full=conv(nfunc,h,'full');
n_ma_same=conv(nfunc,h,'same');
n_ma_valid=conv(nfunc,h,'valid');
subplot(3,1,1)
plot(t1,n_ma_full)
xlabel("time (sec)");
ylabel("amplitude");
title("Convolved with MA, full");
xlim([[-0.2,2.2]])
subplot(3,1,2)
plot(t2,n_ma_same)
xlabel("time (sec)");
ylabel("amplitude");
title("Convolved with MA, same");
xlim([[-0.2,2.2]])
subplot(3,1,3)
plot(t3,n_ma_valid)
xlabel("time (sec)");
ylabel("amplitude");
title("Convolved with MA, valid");
xlim([-0.2,2.2])
```

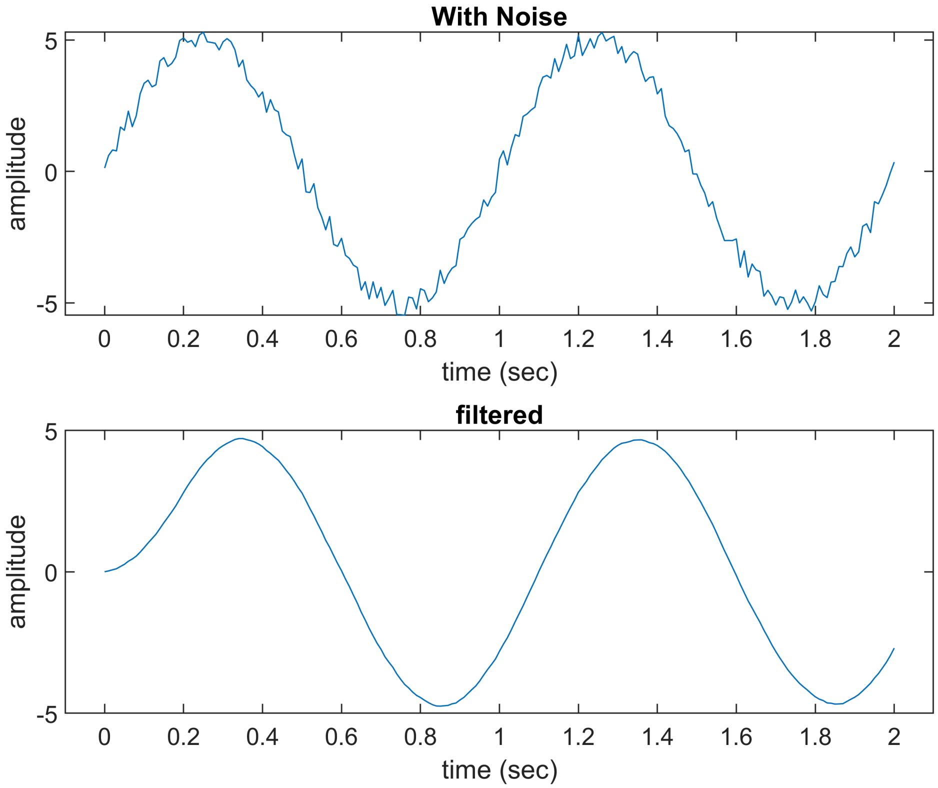


filter

```
clc;
clear;
f=1; % Hz
A=5; % amplitude
t=0:0.01:2;
func=A*sin(2*pi*f*t);
n= -0.5 + 1.*rand(201,1);
nfunc=zeros(1,201);
for i=1:201
   nfunc(1,i)=func(1,i)+n(i,1);
end
M1=0;
M2=20;
windowsize= M1+M2+1;
b=(1/(M1+M2+1))*ones(1,21);
a=1;
filtered_f=filter(b,a,nfunc);
subplot(2,1,1)
plot(t,nfunc)
xlabel("time (sec)");
ylabel("amplitude");
title("With Noise");
xlim([-0.1,2.1])
```



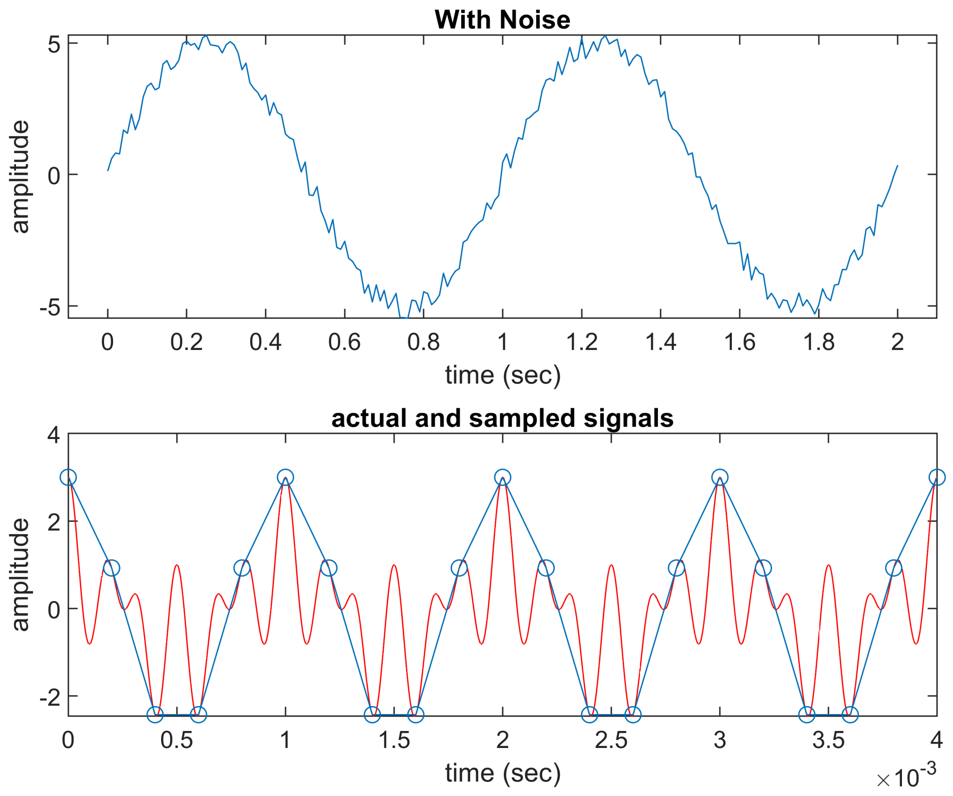
```
subplot(2,1,2)
plot(t,filtered_f)
xlabel("time (sec)");
ylabel("amplitude");
title("filtered");
xlim([-0.1,2.1])
```



Filter acts like the 'same' condition when using conv.

Aliasing in Time

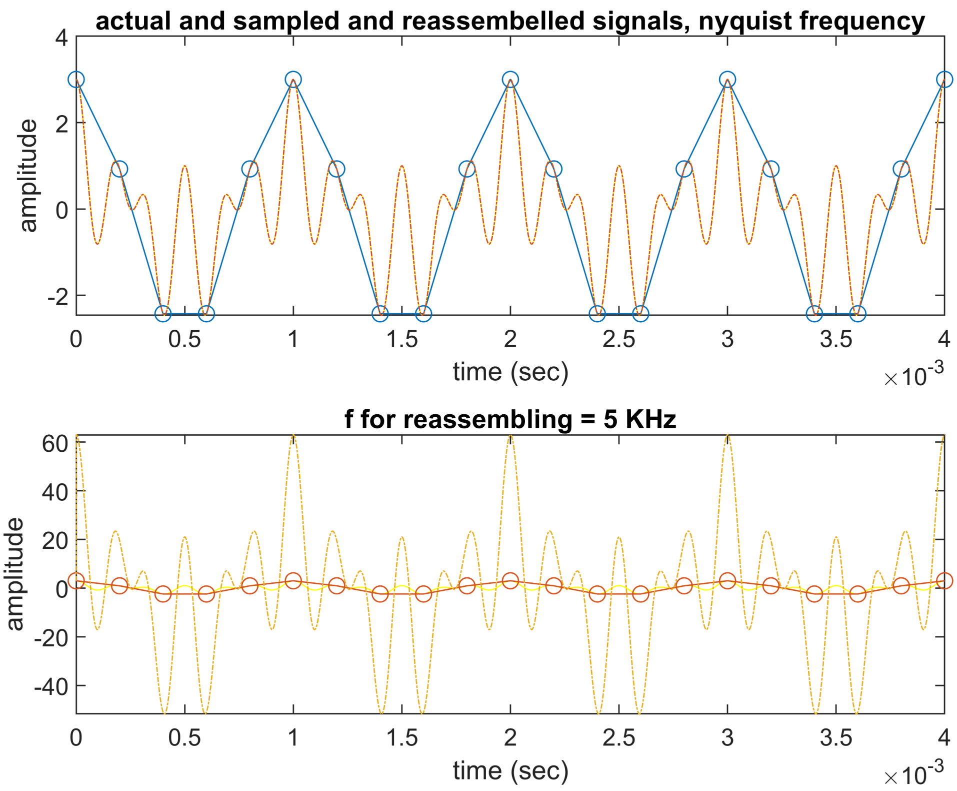
```
clc;
clear;
f1=1000;
f2=4000;
f3=6000;
ta=0:0.00000001:0.004;
ts=0:(1/5000):0.004;
xs=cos(2*pi*f1*ts) + cos(2*pi*f2*ts) + cos(2*pi*f3*ts);
xa=cos(2*pi*f1*ta) + cos(2*pi*f2*ta) + cos(2*pi*f3*ta);

plot(ta,xa,'r')
hold on
plot(ts,xs,'-o')
xlabel("time (sec)");
ylabel("amplitude");
title("actual and sampled signals");
```



Aliasing in Time

```
clc;
clear;
rng default
f1=1000; f2=4000; f3=6000;
fc=5000;

ta=0:0.00000001:0.004;
ts=0:(1/fc):0.004;

xs=cos(2*pi*f1*ts) + cos(2*pi*f2*ts) + cos(2*pi*f3*ts);
xa=cos(2*pi*f1*ta) + cos(2*pi*f2*ta) + cos(2*pi*f3*ta);

h1=sinc(0:(1/2*fc):0.004);
rsignal1= filter(h1,1,xa);

h2=sinc(0:(1/fc):0.004);
rsignal2= filter(h2,1,xa);

subplot(2,1,1)
plot(ta,xa,'y')
hold on
plot(ts,xs,'-o')
hold on
plot(ta,rsignal1,'-.')
```

```
xlabel("time (sec)");
ylabel("amplitude");
title("actual and sampled and reassembelled signals, nyquist frequency");
subplot(2,1,2)
plot(ta,xa,'y')
hold on
plot(ts,xs,'-o')
hold on
plot(ta,rsignal2,'-.')
xlabel("time (sec)");
ylabel("amplitude");
title("f for reassembling = 5 KHz");
```


actual and sampled and reassembelled signals, nyquist frequency

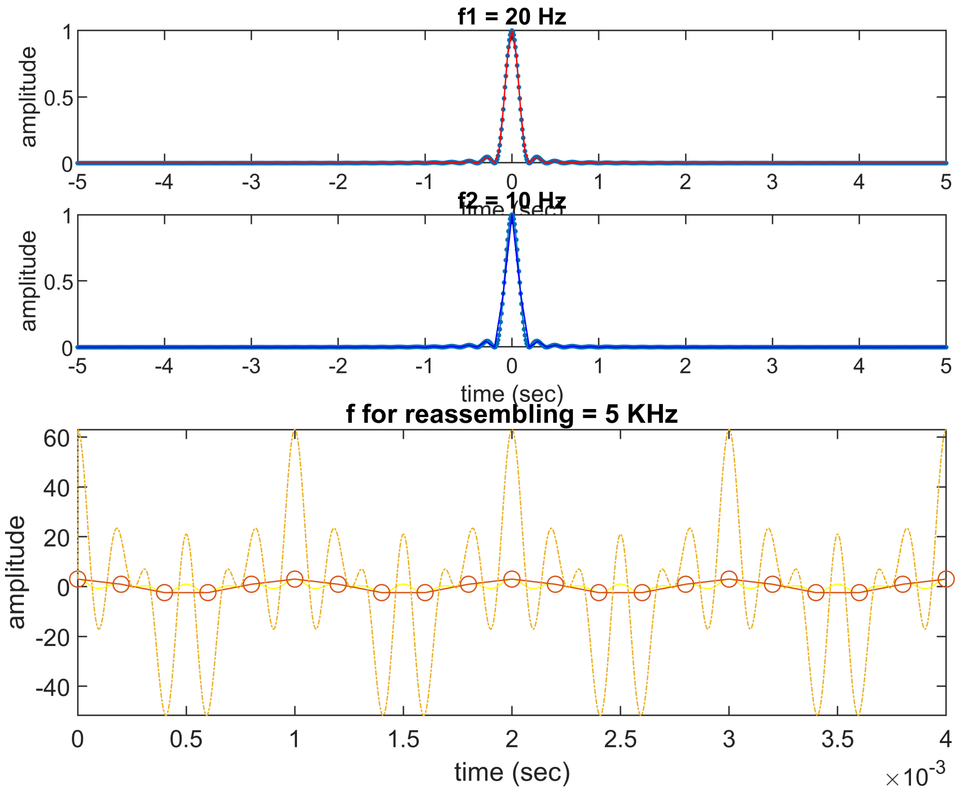
f for reassembling = 5 KHz

When reassembling the samplled signal without paying attention to the nyquist frequency, we would be unable to detect the exact actual signal; however, by considering the nyquist frequency or more, the actual signal would almost perfectly be detected.

Aliasing in Frequency

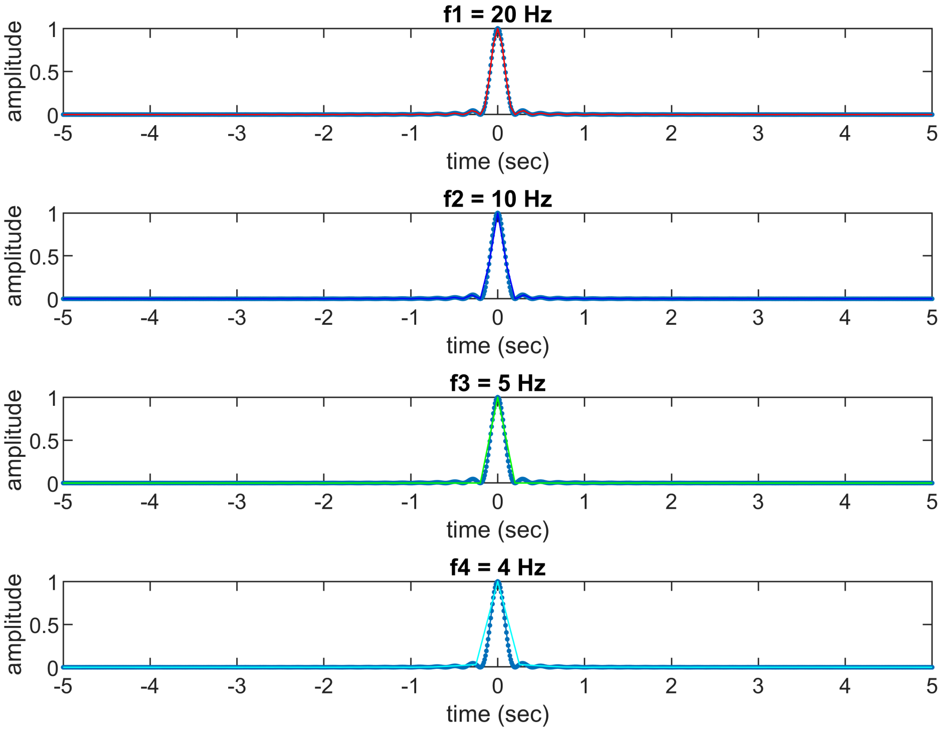
```
clc;
clear;
f1=20; f2=10; f3=5; f4=4;
ta= -5:0.01:5;
ts1= -5:(1/f1):5;
ts2= -5:(1/f2):5;
ts3= -5:(1/f3):5;
```

```
ts4= -5:(1/f4):5;

xa=(sinc(5*ta)).^2;
x1=(sinc(5*ts1)).^2;
x2=(sinc(5*ts2)).^2;
x3=(sinc(5*ts3)).^2;
x4=(sinc(5*ts4)).^2;

subplot(4,1,1)
plot(ta,xa,'.-')
hold on
plot(ts1,x1,'r')
xlabel("time (sec)");
ylabel("amplitude");
title("f1 = 20 Hz");

subplot(4,1,2)
plot(ta,xa,'.-')
hold on
plot(ts2,x2,'b')
xlabel("time (sec)");
ylabel("amplitude");
title("f2 = 10 Hz");
```



```
subplot(4,1,3)
plot(ta,xa,'.-')
hold on
```

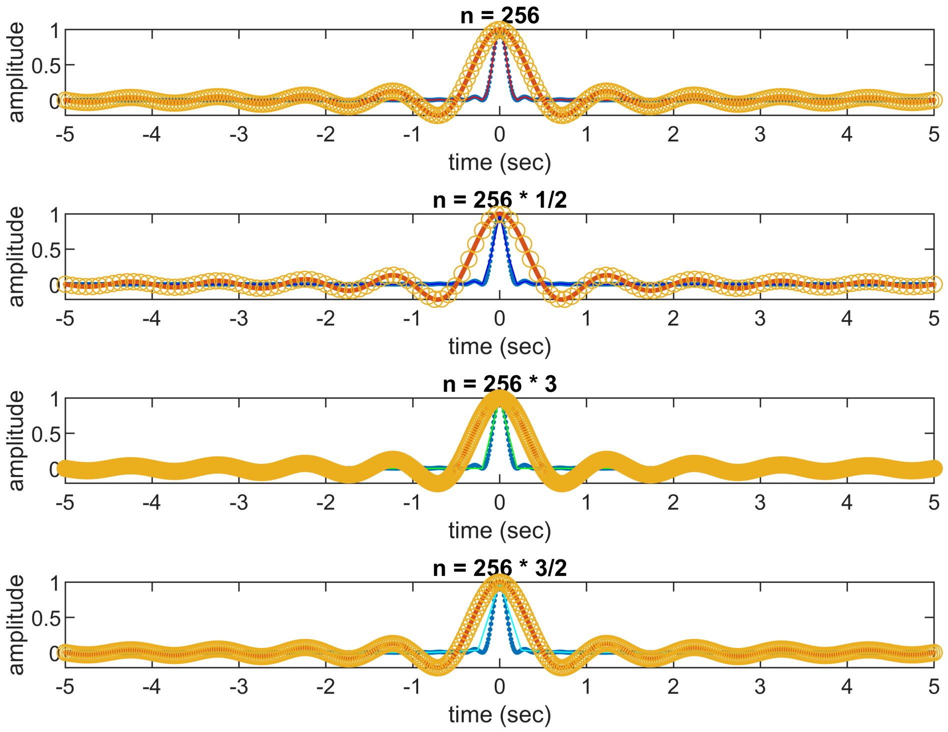
```
plot(ts3,x3,'g')
xlabel("time (sec)");
ylabel("amplitude");
title("f3 = 5 Hz");

subplot(4,1,4)
plot(ta,xa,'.-')
hold on
plot(ts4,x4,'c')
xlabel("time (sec)");
ylabel("amplitude");
title("f4 = 4 Hz");
```



The plots show that the more the sampling frequency, the more accurate the resultant signal.

```
clc;
clear;
n1=256; n2=0.5*n1; n3=3*n1; n4=1.5*n1;
ta= -5:0.001:5;
ts1=linspace(-5,5,n1);
ts2=linspace(-5,5,n2);
ts3=linspace(-5,5,n3);
ts4=linspace(-5,5,n4);

xa=sinc(2*ta);
x1=sinc(2*ts1);
```

```
x2=sinc(2*ts2);
x3=sinc(2*ts3);
x4=sinc(2*ts4);

subplot(4,1,1)
plot(ta,xa,'.')
hold on
plot(ts1,x1,'o')
xlabel("time (sec)");
ylabel("amplitude");
title("n = 256");

subplot(4,1,2)
plot(ta,xa,'.')
hold on
plot(ts2,x2,'o')
xlabel("time (sec)");
ylabel("amplitude");
title("n = 256 * 1/2");

subplot(4,1,3)
plot(ta,xa,'.')
hold on
plot(ts3,x3,'o')
xlabel("time (sec)");
ylabel("amplitude");
title("n = 256 * 3");

subplot(4,1,4)
plot(ta,xa,'.')
hold on
plot(ts4,x4,'o')
xlabel("time (sec)");
ylabel("amplitude");
title("n = 256 * 3/2");
```



In the two following scripts, I didn't have plotted the spectrums which are added to the current version.

```
% Frequency Aliasing edited
clc;
clear;
n1=256; n2=0.5*n1; n3=3*n1; n4=1.5*n1;
ta= -5:0.001:5;
ts1=linspace(-5,5,n1);
ts2=linspace(-5,5,n2);
ts3=linspace(-5,5,n3);
ts4=linspace(-5,5,n4);

xa=sinc(2*ta);
x1=sinc(2*ts1);
x2=sinc(2*ts2);
x3=sinc(2*ts3);
x4=sinc(2*ts4);

w=linspace(-2*pi,2*pi,128);

za=freqz(xa,1,w);
z1=freqz(x1,1,w);
z2=freqz(x2,1,w);
z3=freqz(x3,1,w);
z4=freqz(x4,1,w);
```

```
subplot(4,1,1)
plot(w/pi,log(log(abs(za))),'.')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
hold on
plot(ta,xa,'o')
hold on
plot(w/pi,log(abs(z1)),'.')
hold on
plot(ts1,x1,'o')
xlabel("frequency");
ylabel("amplitude");
title("n = 256");

subplot(4,1,2)
plot(w/pi,log(log(abs(za))),'.')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
hold on
plot(ta,xa,'o')
hold on
plot(w/pi,log(abs(z2)),'.')
hold on
plot(ts2,x2,'o')
xlabel("time (sec)");
ylabel("amplitude");
title("n = 256 * 1/2");

subplot(4,1,3)
plot(w/pi,log(log(abs(za))),'.')
```

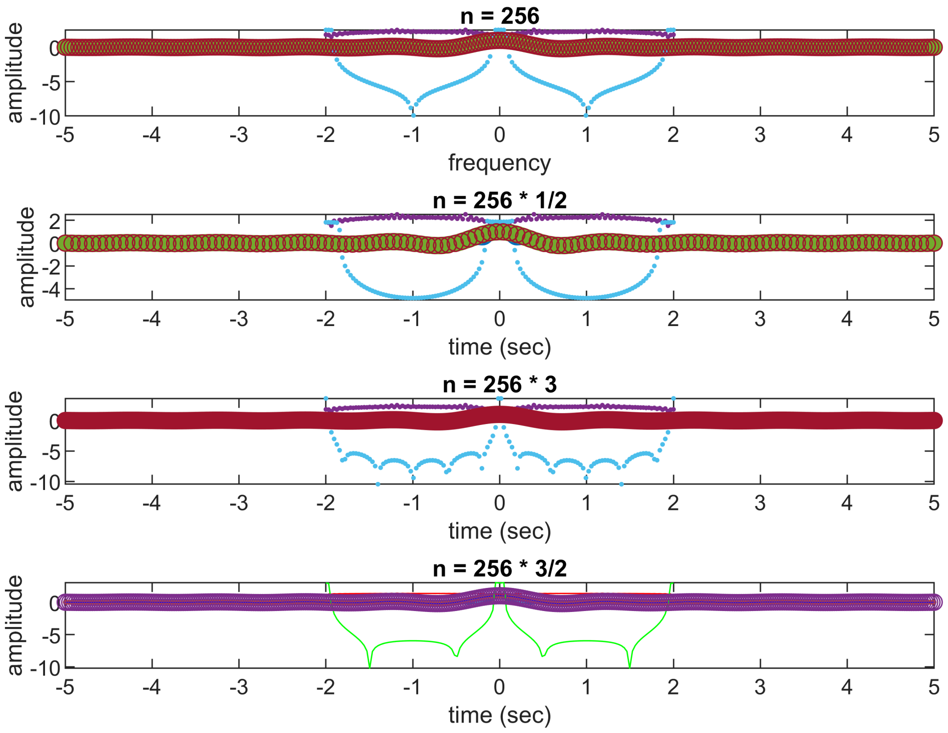
```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
hold on
plot(ta,xa,'o')
hold on
plot(w/pi,log(abs(z3)),'.')
hold on
plot(ts3,x3,'o')
xlabel("time (sec)");
ylabel("amplitude");
title("n = 256 * 3");

subplot(4,1,4)
plot(w/pi,log(log(log(abs(za)))),'r')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
hold on
plot(ta,xa,'b')
hold on
```

```
plot(w/pi,log(abs(z4)),'g')
hold on
plot(ts4,x4,'o')
xlabel("time (sec)");
ylabel("amplitude");
title("n = 256 * 3/2");
```



```
clc;
clear;
%% Aliasing in Frequency
f1=20; f2=10; f3=5; f4=4;
ta= -5:0.01:5;
ts1= -5:(1/f1):5;
ts2= -5:(1/f2):5;
ts3= -5:(1/f3):5;
ts4= -5:(1/f4):5;

xa=(sinc(5*ta)).^2;
x1=(sinc(5*ts1)).^2;
x2=(sinc(5*ts2)).^2;
x3=(sinc(5*ts3)).^2;
x4=(sinc(5*ts4)).^2;

w=linspace(-2*pi,2*pi,128);

za=freqz(xa,1,w);
```

```
z1=freqz(x1,1,w);
z2=freqz(x2,1,w);
z3=freqz(x3,1,w);
z4=freqz(x4,1,w);

subplot(4,1,1)
plot(ta,xa,'.-')
hold on
plot(ts1,x1,'r')
hold on
plot(w,za,'.-')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
hold on
plot(w,z1,'r')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```

subplot(4,1,2)
plot(ta,xa,'.-')
hold on
plot(ts2,x2,'b')
hold on
plot(w,za,'.-')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
hold on
plot(w,z2,'r')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```

subplot(4,1,3)
plot(ta,xa,'.-')
hold on
plot(ts3,x3,'g')
hold on
plot(w,za,'.-')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
hold on
plot(w,z3,'r')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

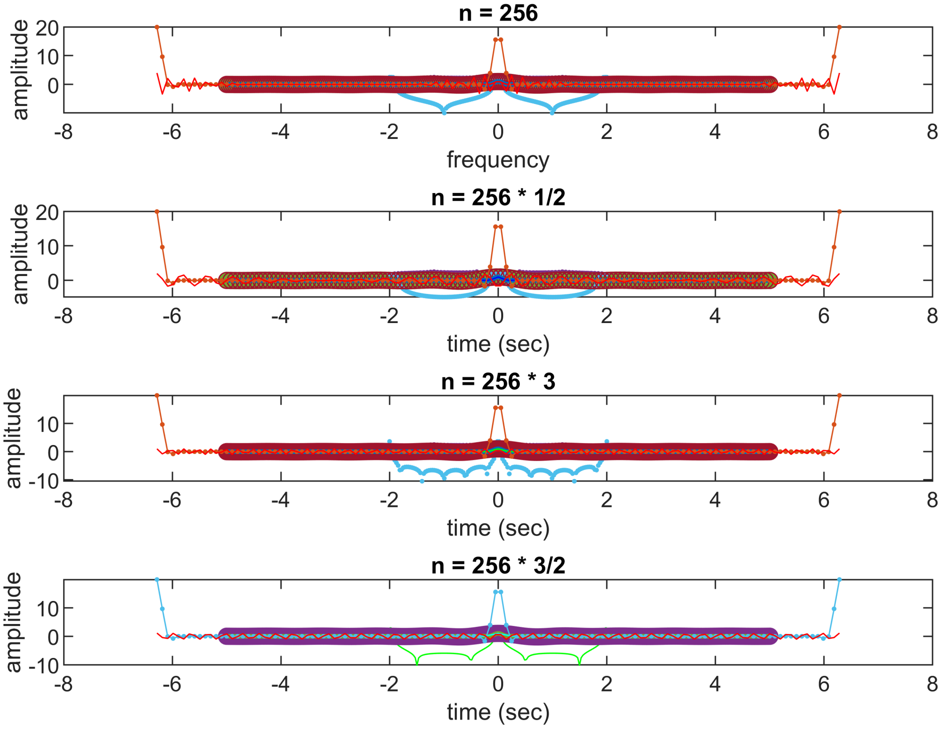
```

subplot(4,1,4)
plot(ta,xa,'.-')
hold on
```

```
plot(ts4,x4,'c')
hold on
plot(w,za,'.-')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
hold on
plot(w,z4,'r')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```



```
clc;
clear;
%% singen function
n=0:49;
w=linspace(0,pi,50);
x=zeros(50,50);
for i=1:50
    x(:,i)=singen(w(1,i),n);
end
```

```
clc;
clear;
%% DFT withou Matlab's built-in functions

t = linspace(-2*pi,2*pi,128);
```

```
f1=pi/16; f2=5*pi/16; f3=9*pi/16; f4=13*pi/16;
xt= cos(2*pi*f1*t) + cos(2*pi*f2*t) + cos(2*pi*f3*t) + cos(2*pi*f4*t);
tic
Xf_DFT=myDFT(xt);
toc;
```

```
Elapsed time is 0.036670 seconds.
```

```
tic
Xf_fft=fft(xt);
toc;
```

```
Elapsed time is 0.022855 seconds.
```

```
Xf_fftshift=fftshift(Xf_fft);

x_ifftshift=ifftshift(Xf_fft);
x_ifft=ifft(Xf_fft);


subplot(2,3,1)
plot(t,((Xf_DFT)),'r')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
xlabel("frequency");
ylabel("amplitude");
title("DFT");
grid
subplot(2,3,2)
plot(t,((Xf_fft)),'b')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

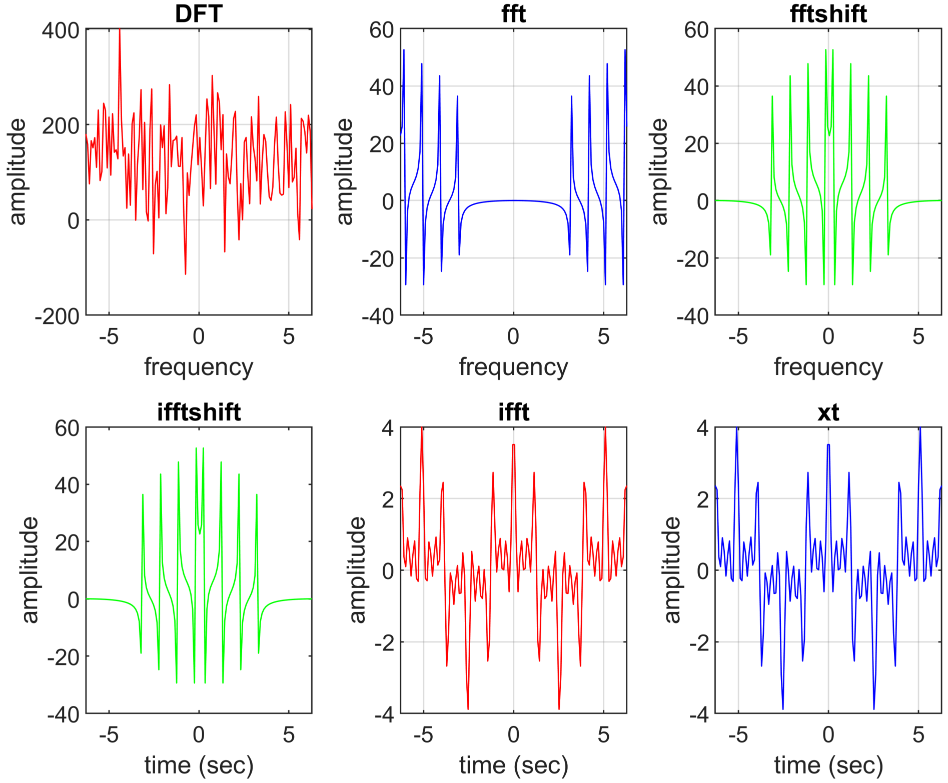
```
xlabel("frequency");
ylabel("amplitude");
title("fft");
grid
subplot(2,3,3)
plot(t,((Xf_fftshift)),'g')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
xlabel("frequency");
ylabel("amplitude");
title("fftshift");
grid

subplot(2,3,4)
plot(t,((x_ifftshift)),'g')
```

```
Warning: Imaginary parts of complex X and/or Y arguments ignored
```

```
xlabel("time (sec)");
ylabel("amplitude");
title("ifftshift");
subplot(2,3,5)
plot(t,((x_ifft)),'r')
xlabel("time (sec)");
ylabel("amplitude");
title("ifft");
grid
subplot(2,3,6)
plot(t,((xt)),'b')
xlabel("time (sec)");
ylabel("amplitude");
title("xt");
grid
```



Functions

```
function X=myDFT(x)
N=numel(x);
%X=zeros(1,N);
for k=1:N
    X(k)=sum(x.^exp(-1j*2*pi*k/N*(0:N-1)));
end
end
```

```
function x=singen(w0,n)
N=numel(n);
    for k=1:N
        x=(sin(w0.*n(1,:))).*ones(1,N);
    end
end
```