Ryerson University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Title:	ELE
Course Number:	532
Semester/Year (e.g.F2016)	F2021

Instructor:	Soosan Beheshti

Assignment/Lab Number:	4
Assignment/Lab Title:	The Fourier Transform: Properties and Applications

Submission Date:	06-12-2021
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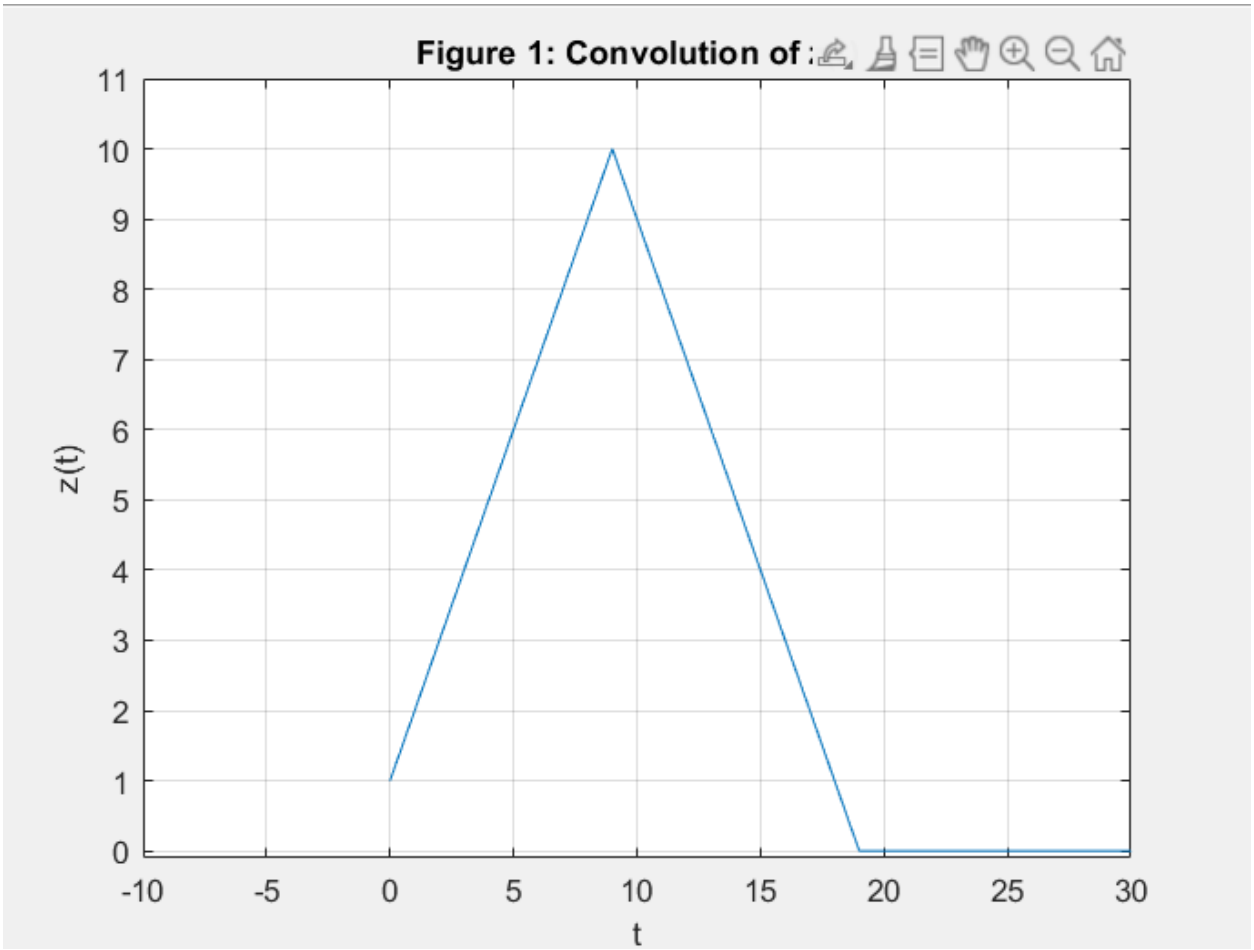
Matlab Code

A1

```
N = 100; PulseWidth = 10; t = [0:1:(N-1)];
x = [ones(1,PulseWidth), zeros(1,N-PulseWidth)];
z = conv(x,x); tt = [0:1:2*(N-1)];
figure; plot(tt,z);
grid on;
axis([-10,30,-0.1,11]);
xlabel('t'); ylabel('z(t)');
title('Figure 1: Convolution of z(t) = x(t)*x(t)');
```

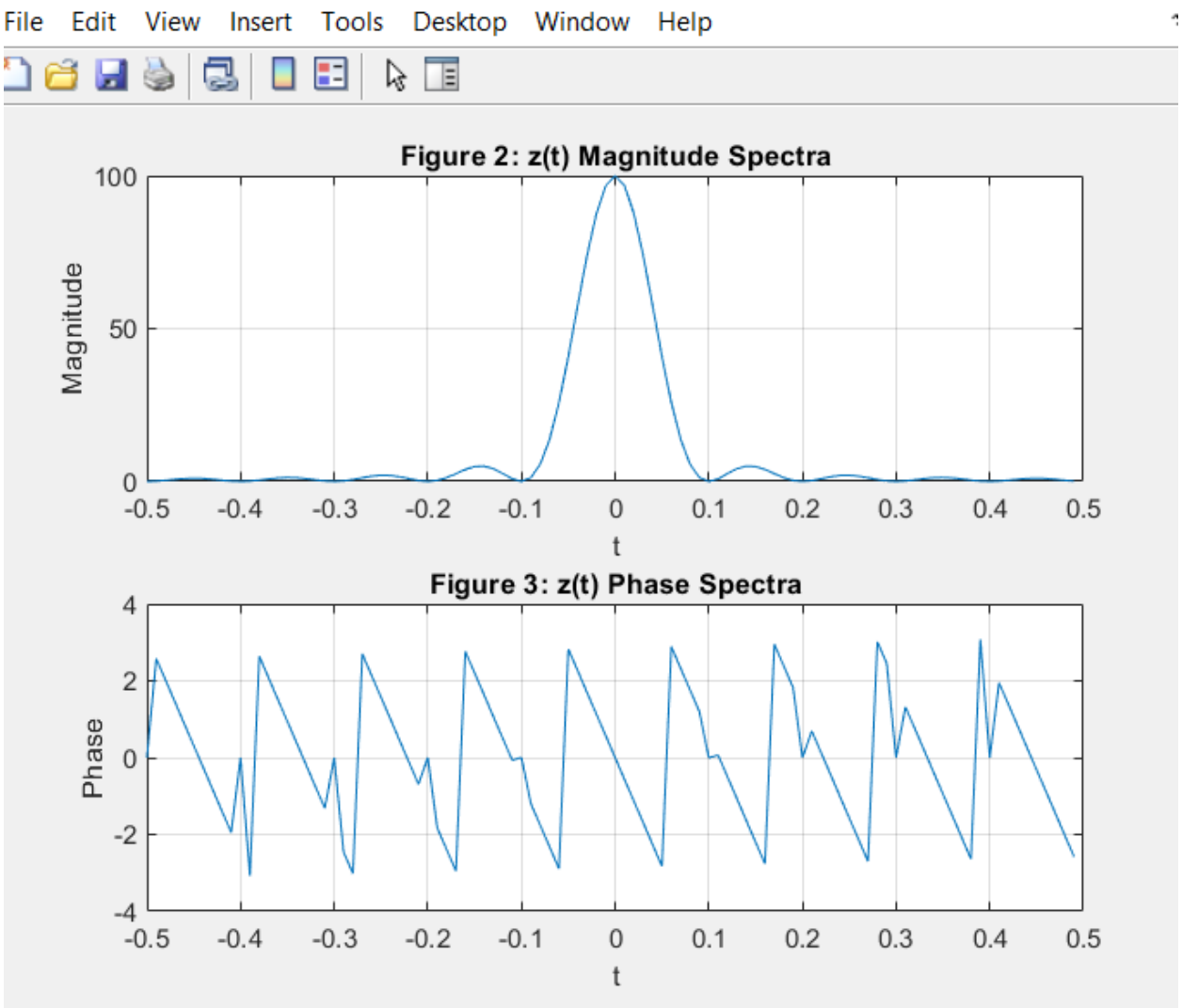


A2

```
Xw = fft(x);
f = (-(N/2):1:(N/2)-1)*(1/N);
w = 2*pi*f;
Zw = Xw.*Xw;
```

A3

```
figure;
subplot(2,1,1);
plot(f,fftshift(abs(Zw)));
grid on;
title('Figure 2: z(t) Magnitude Spectra');
xlabel('t'); ylabel('Magnitude');
subplot(2,1,2); plot(f,fftshift(angle(Zw)));
grid on; title('Figure 3: z(t) Phase Spectra');
xlabel('t');
ylabel('Phase');
```



A4

```
xx = fft(x);
zz = xx.*xx;
ztw = ifft(zz);
figure;
plot(ztw);
grid on; %axis([-10 25 -10 25]);
title('Figure 4: Time Domain Convolution');
xlabel('t');
ylabel('z(t)');
figure;
subplot(2,1,1);
plot(f,fftshift(abs(zz)));
grid on; %axis([-10 25 -10 25]);
title('Figure 5: Frequency Domain Convolution Magnitude');
xlabel('w');
ylabel('Magnitude');
subplot(2,1,2);
plot(f,fftshift(angle(zz)));
grid on; %axis([-10 25 -10 25]);
title('Figure 6: Frequency Domain Convolution Phase');
xlabel('w');
ylabel('Phase');
```

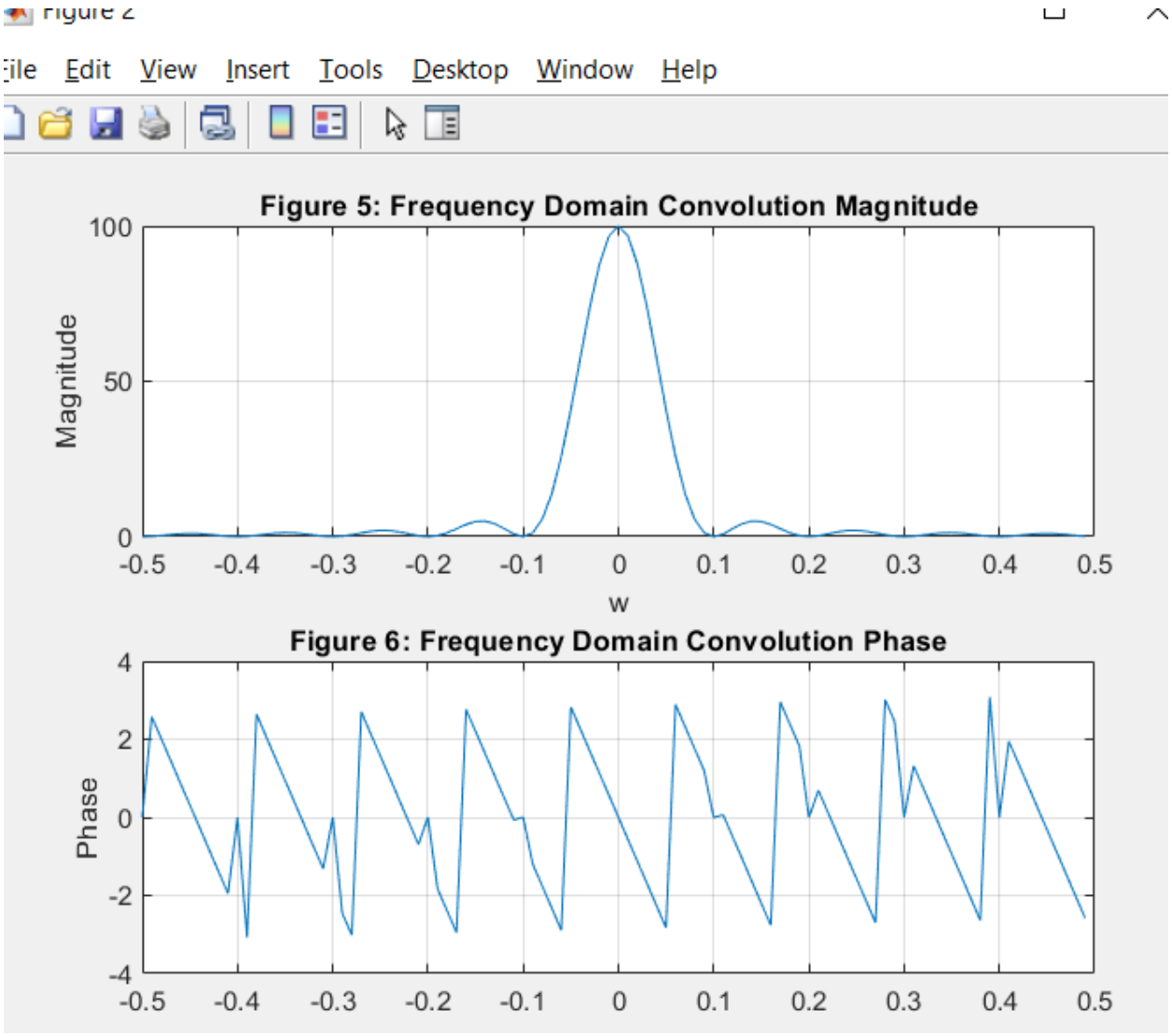
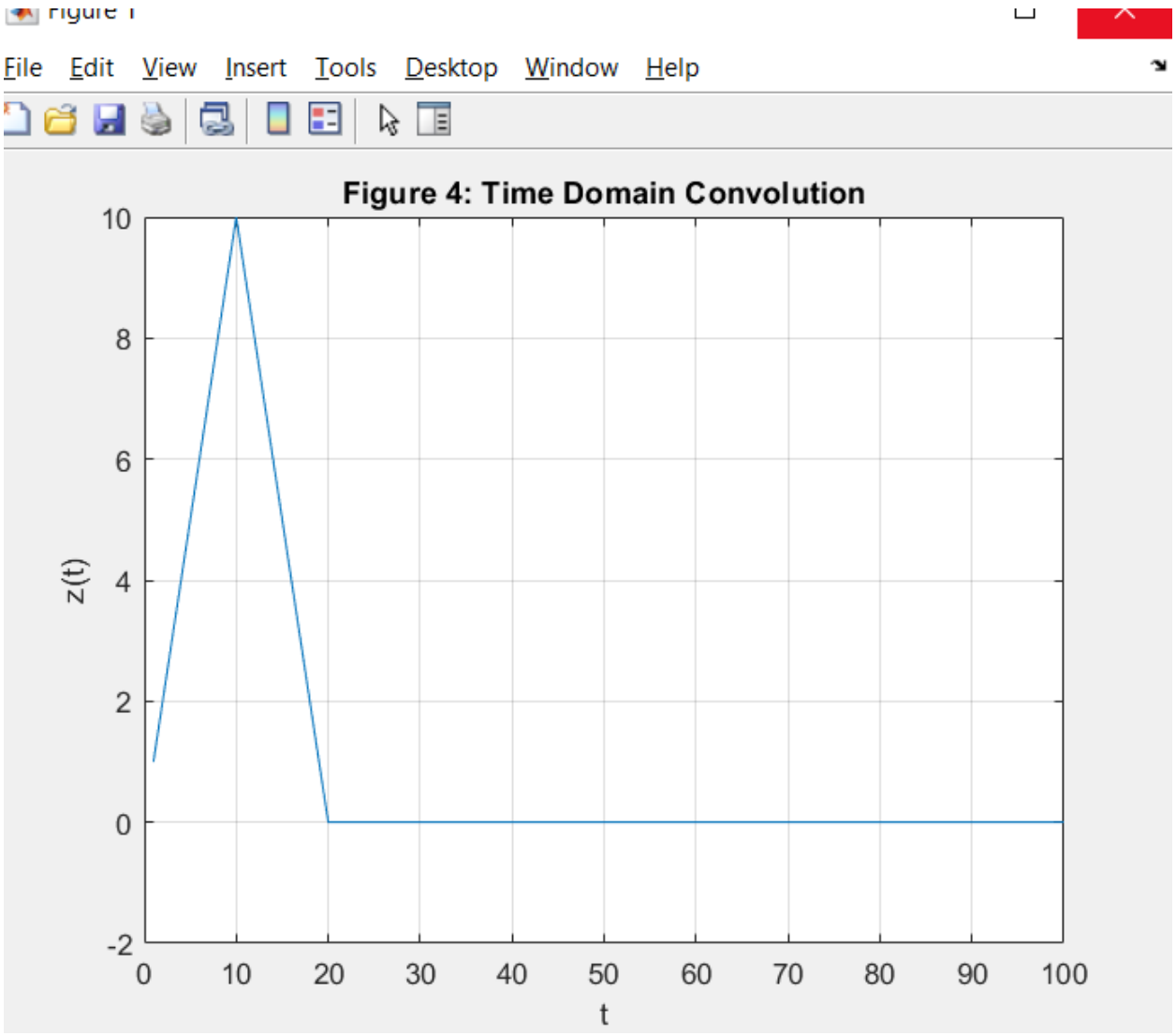


Figure 2
File Edit View Insert Tools Desktop Window Help
Figure 5: Frequency Domain Convolution Magnitude
Magnitude
100
50
0
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
w
Figure 6: Frequency Domain Convolution Phase
Phase
4
2
0
-2
-4
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5



A5

```
N = 100; PulseWidth = 10;
t = [0:1:(N-1)];
x = [ones(1,PulseWidth), zeros(1,N-PulseWidth)];
Xf = fft(x);
f = [-(N/2):1:(N/2)-1]*(1/N);
figure;
subplot(2,1,1); plot(f,fftshift(abs(Xf))); grid on;
xlabel ('\omega');
ylabel('|Z(\omega)|');
title ('Figure 7: X(\omega) with original pulse width = 10');
subplot(2,1,2); plot(f,fftshift(angle(Xf))); grid on;
title ('Figure 8: Phase of X(\omega) with pulse width = 10');
```

```
xlabel ('\omega');
ylabel('\angle Z(\omega)');
% Magnitude and Phase when pulse width = 5
N = 100; PulseWidth = 5;
t = [0:1:(N-1)];
x = [ones(1,PulseWidth), zeros(1,N-PulseWidth)];
Xf = fft(x);
f = [-(N/2):1:(N/2)-1]*(1/N);
figure;
subplot(2,1,1); plot(f,fftshift(abs(Xf))); grid on;
xlabel ('\omega');
ylabel('|Z(\omega)|');
title ('Figure 9: X(\omega) with pulse width = 5');
subplot(2,1,2); plot(f,fftshift(angle(Xf))); grid on;
title ('Figure 10: Phase of X(\omega) with pulse width = 5');
xlabel ('\omega');
ylabel('\angle Z(\omega)');
% Magnitude and Phase when pulse width = 25
N = 100; PulseWidth = 25;
t = [0:1:(N-1)];
x = [ones(1,PulseWidth), zeros(1,N-PulseWidth)];
Xf = fft(x);
f = [-(N/2):1:(N/2)-1]*(1/N);
figure;
subplot(2,1,1); plot(f,fftshift(abs(Xf))); grid on;
xlabel ('\omega');
ylabel('|Z(\omega)|');
title ('Figure 11: X(\omega) with pulse width = 25');
subplot(2,1,2); plot(f,fftshift(angle(Xf))); grid on;
title ('Figure 12: Phase of X(\omega) with pulse width = 25');
xlabel ('\omega');
ylabel('\angle Z(\omega)');
```

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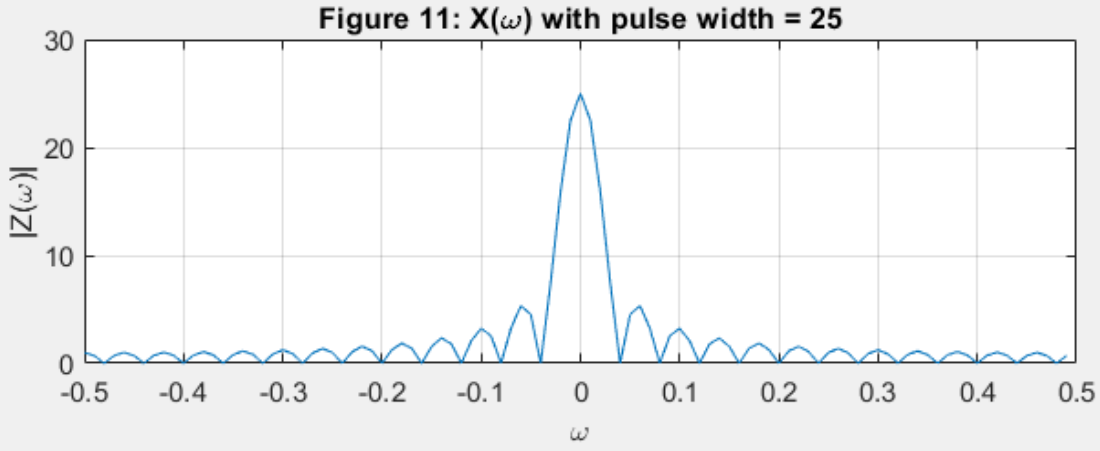
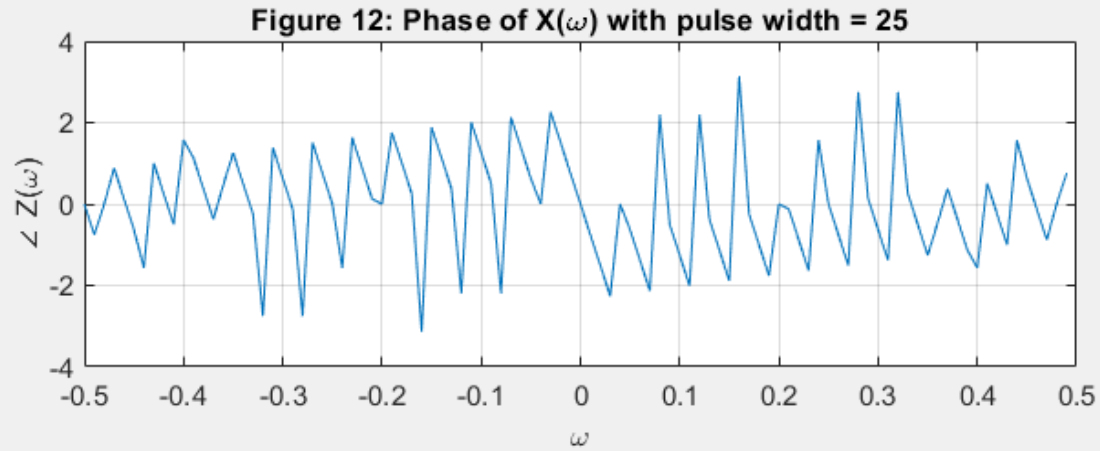
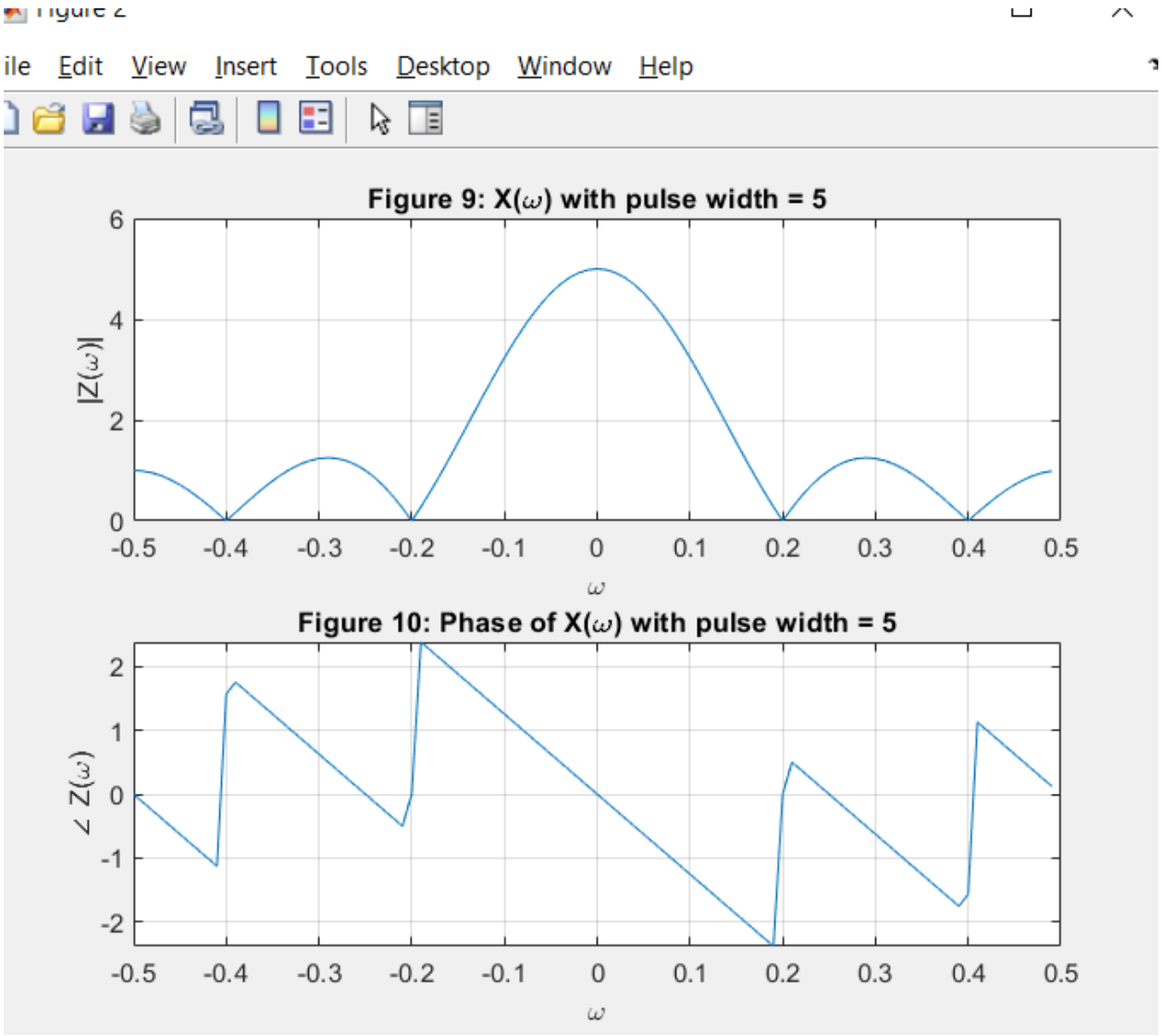
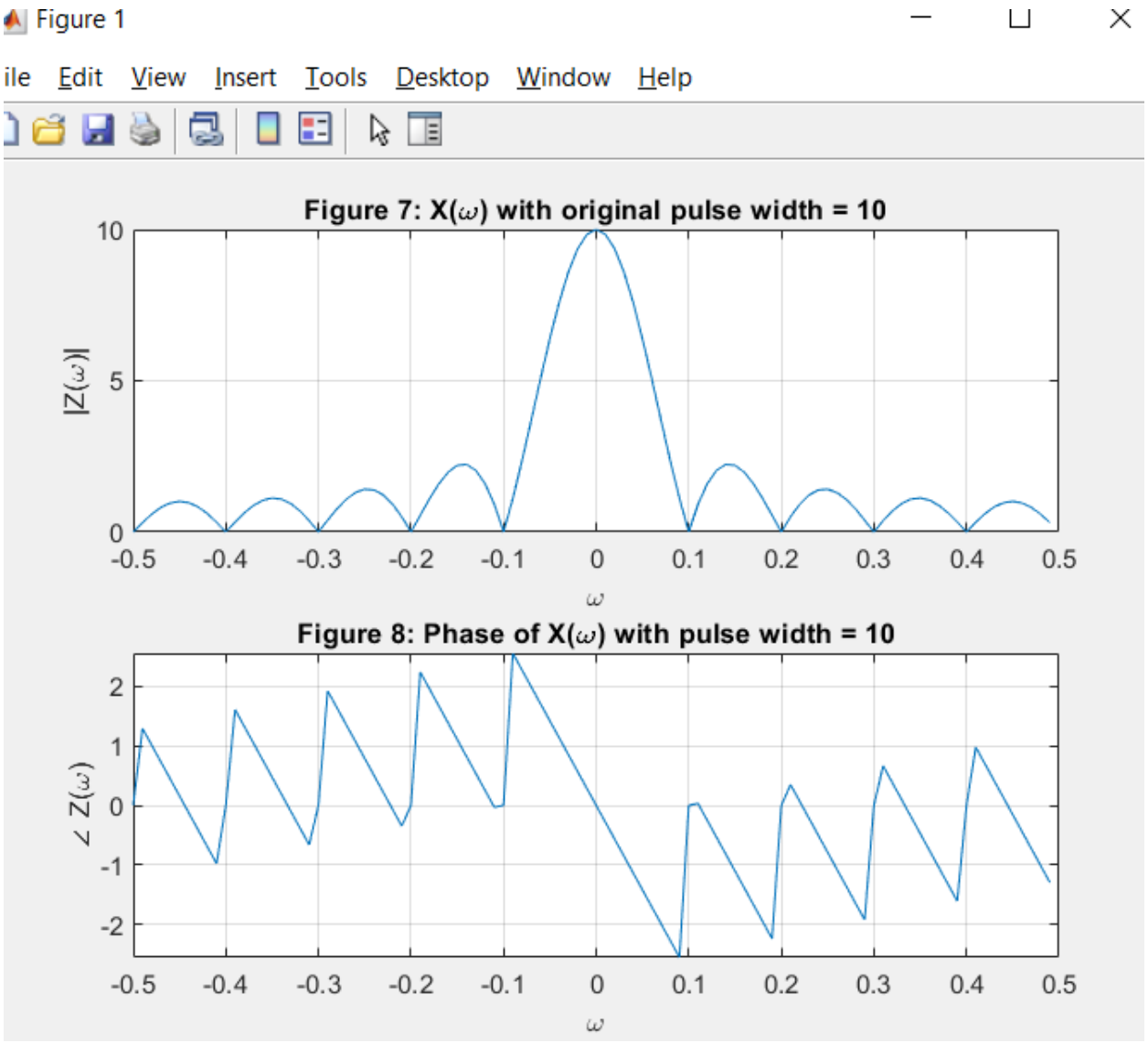





ile Edit View Insert Tools Desktop Window Help
Figure 9: X(ω) with pulse width = 5
|Z(ω)|
ω
Figure 10: Phase of X(ω) with pulse width = 5
∠ Z(ω)
ω



A6

```
N = 100; PulseWidth = 10;
t = [0:1:(N-1)];
x = [ones(1,PulseWidth), zeros(1,N-PulseWidth)];
wt = x.*(exp(1i*(pi/3).*t));
wtw = fft(wt);
f = [-(N/2):1:(N/2)-1]*(1/N);
figure;
subplot(2,1,1); plot(f,fftshift(abs(wtw))); grid on;
xlabel ('t');
ylabel('|w+(t)|');
title ('Figure 13: Magnitude plot of w+(t)');
subplot(2,1,2); plot(f,fftshift(angle(wtw))); grid on;
xlabel ('t');
```

```
ylabel('\angle w+(t)');
title ('Figure 14: Phase plot of w+(t)');
%
%Magnitude and Phase plots for w-(t)
N = 100; PulseWidth = 10;
t = [0:1:(N-1)];
x = [ones(1,PulseWidth), zeros(1,N-PulseWidth)];
wt = x.*(exp(-1i*(pi/3).*t));
wtw = fft(wt);
f = [-(N/2):1:(N/2)-1]*(1/N);
figure;
subplot(2,1,1); plot(f,fftshift(abs(wtw))); grid on;
xlabel ('t');
ylabel('|w-(t)|');
title ('Figure 15: Magnitude plot of w-(t)');
subplot(2,1,2); plot(f,fftshift(angle(wtw))); grid on;
xlabel ('t');
ylabel('\angle w-(t)');
title ('Figure 16: Phase plot of w-(t)');
%Magnitude and Phase plots for wc(t)
N = 100; PulseWidth = 10;
t = [0:1:(N-1)];
x = [ones(1,PulseWidth), zeros(1,N-PulseWidth)];
wt = x.*cos((pi/3).*t);
wtw = fft(wt);
f = [-(N/2):1:(N/2)-1]*(1/N);
figure;
subplot(2,1,1);
plot(f,fftshift(abs(wtw))); grid on;
xlabel ('t');
ylabel('|w+(t)|');
title ('Figure 17: Magnitude plot of wc(t)');
subplot(2,1,2);
plot(f,fftshift(angle(wtw))); grid on;
xlabel ('t');
ylabel('\angle w+(t)');
title ('Figure 18: Phase plot of wc(t)');
```

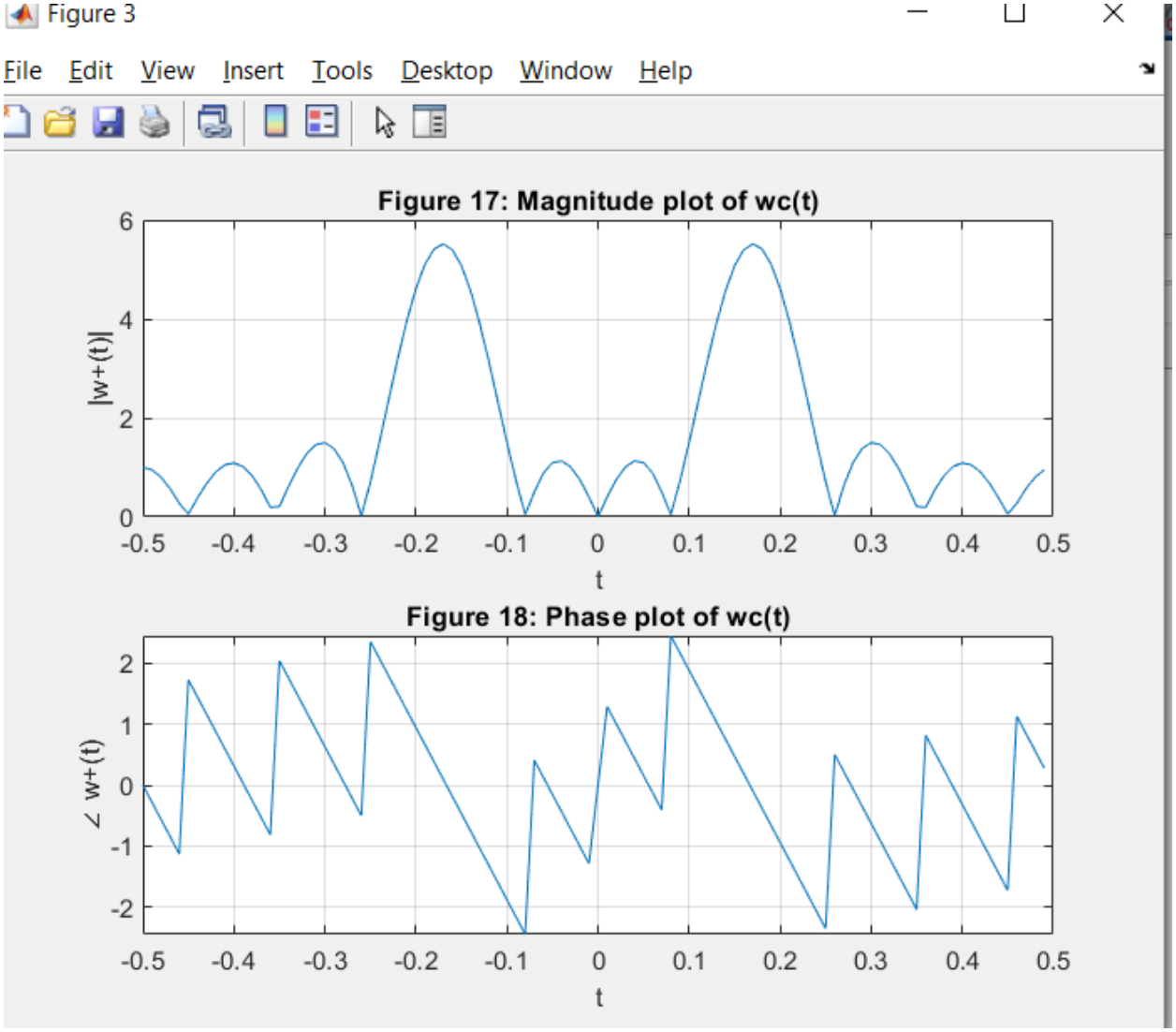


Figure 3
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Figure 17: Magnitude plot of wc(t)
|w+(t)|
t
Figure 18: Phase plot of wc(t)
∠ w+(t)
t

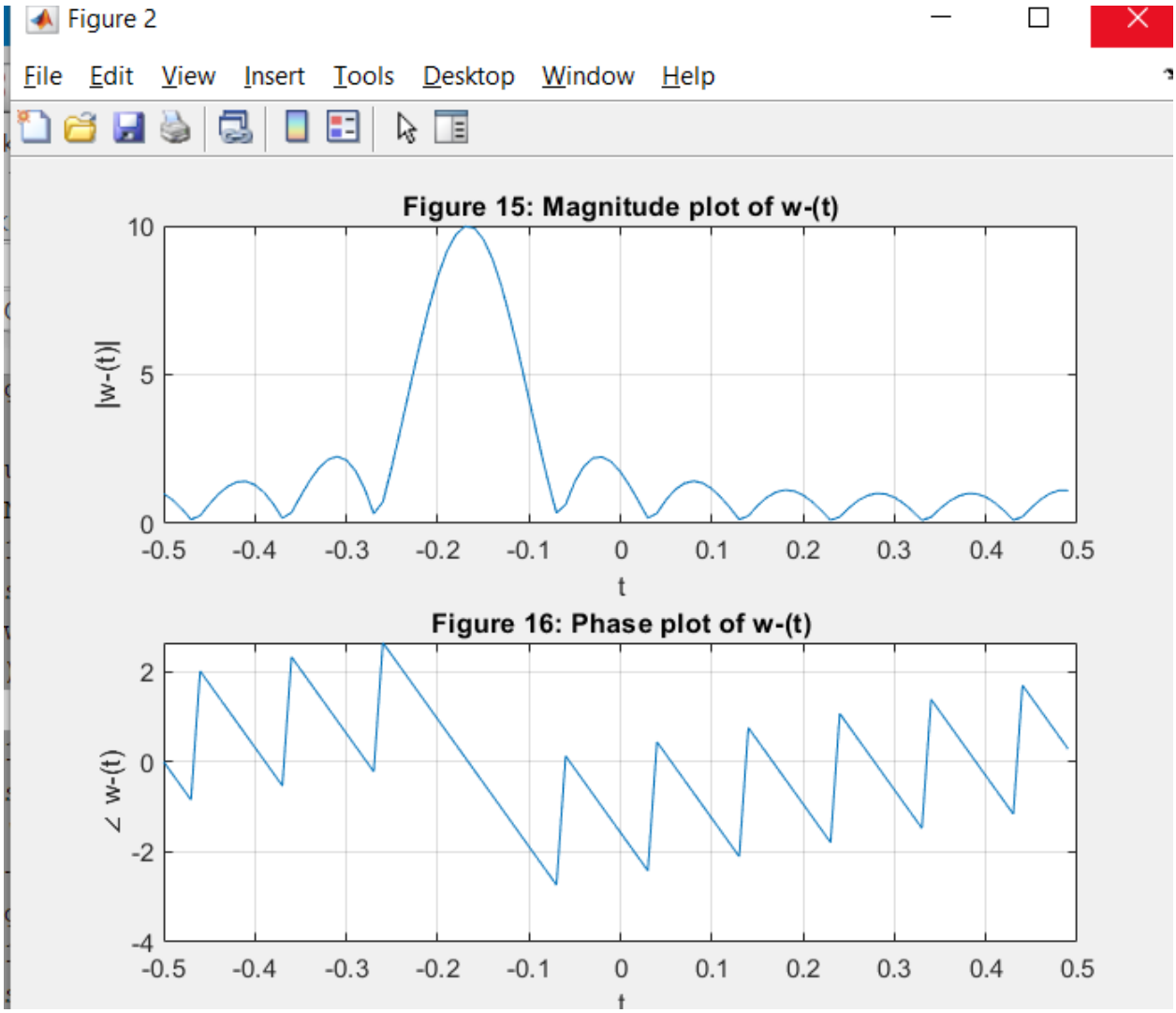
Figure 2
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Figure 15: Magnitude plot of w-(t)
|w-(t)|
10
5
0
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
t
Figure 16: Phase plot of w-(t)
∠ w-(t)
2
0
-2
-4
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
t

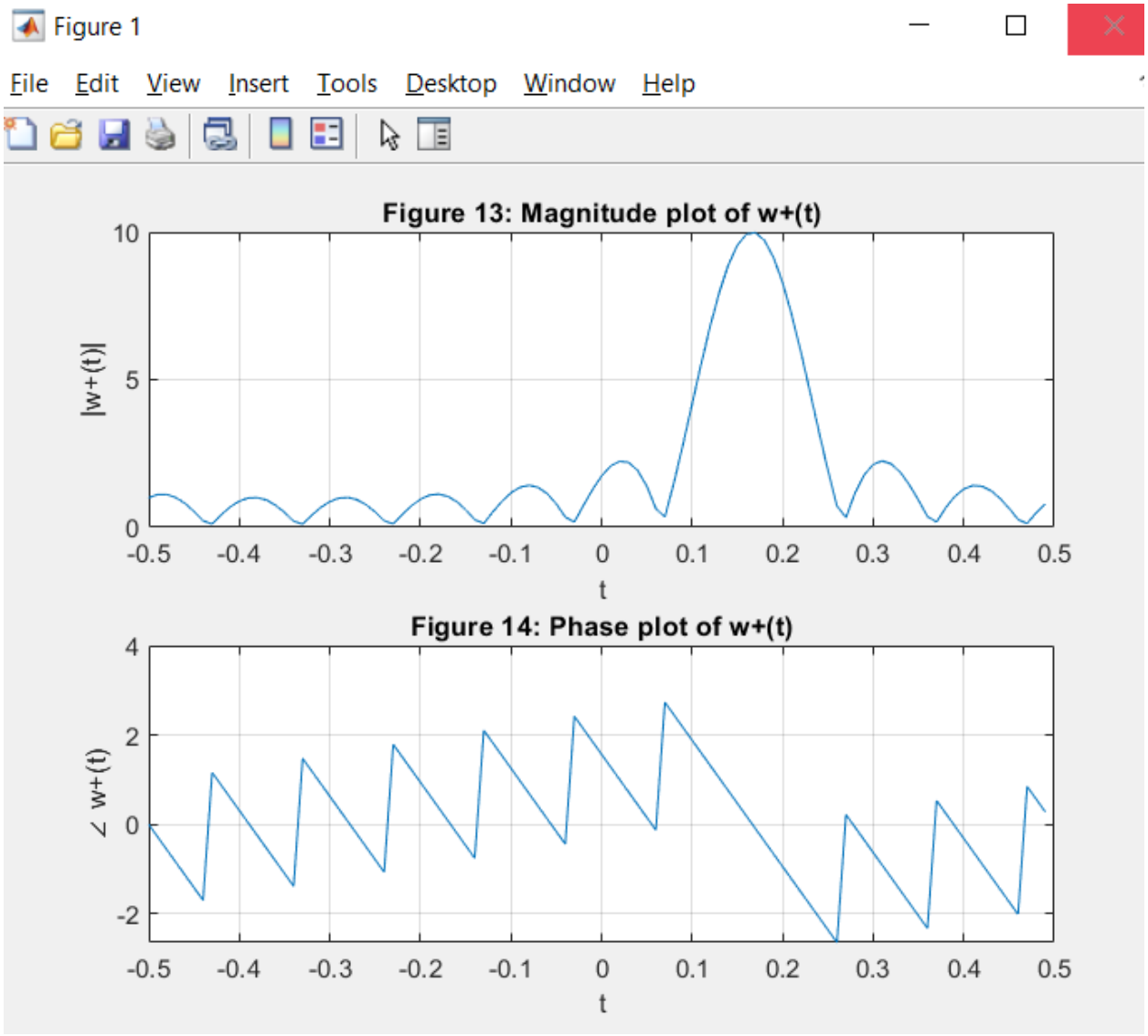
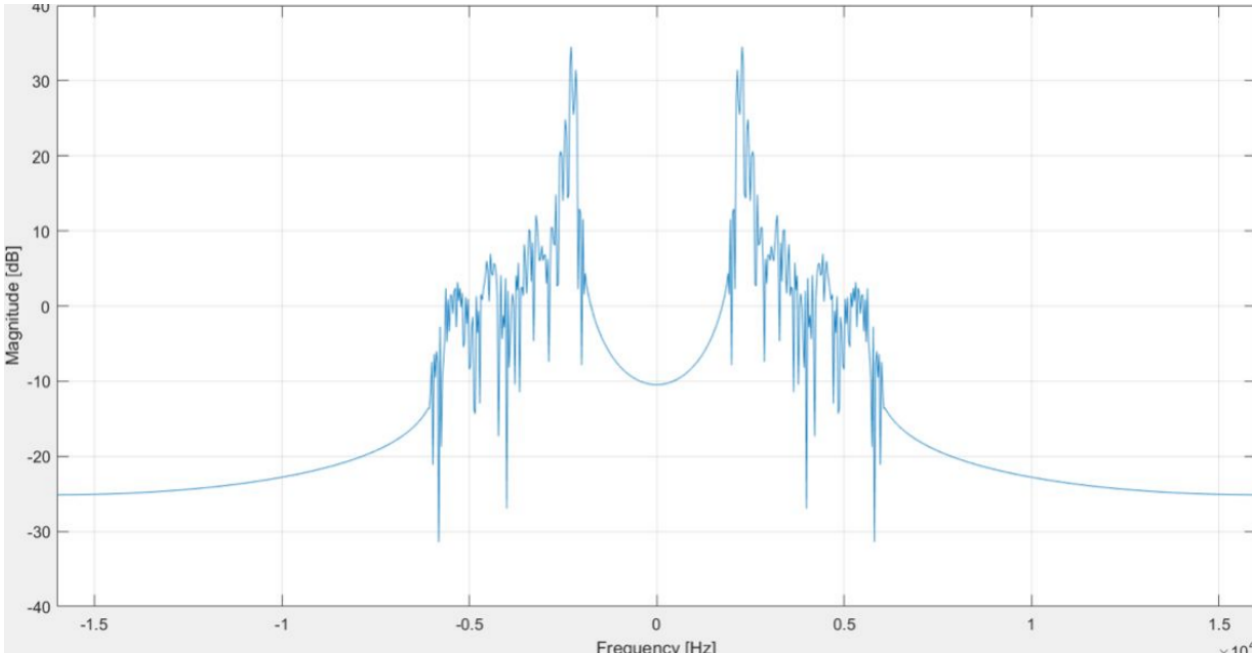


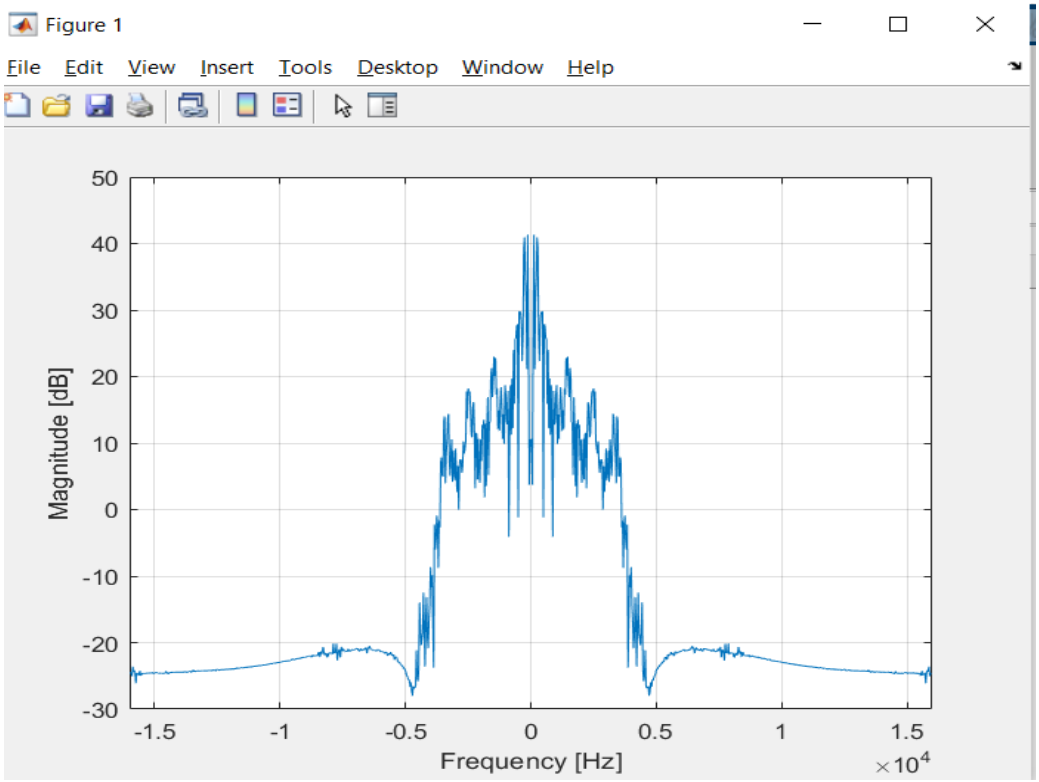
Figure 1
File Edit View Insert Tools Desktop Window Help
Figure 13: Magnitude plot of w+(t)
|w+(t)|
10
5
0
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
t
Figure 14: Phase plot of w+(t)
∠ w+(t)
4
2
0
-2
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
t

B.



Convolution between hChannel and xspeech

Because the hChannel filter includes stop band portions not within 2kHz and 6kHz range, when sound(conv(xspeech, hChannel), 32000) command is performed, the audio creates a lot of static. Static is produced when waves with frequencies in certain stop band frequency ranges are not detected.



Xspeech

When comparing the sound produced by this to the sound produced by the convolution between the original xspeech and hChannel, the difference is striking. While the shifting xspeech convolution's sound quality isn't great, the words that are being stated are audible. The original xspeech convolution sound quality, on the other hand, is extremely low and virtually incomprehensible.

z = conv(xspeech, hChannel)
sound(z, 32000) Poor Audio Quality
z = conv(xspeech.*osc(2031.25,80000), hChannel)
sound(z, 32000) Good Audio Quality