Generating noise

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This code was developed by Miodrag Bolic for the book PERVASIVE CARDIAC AND RESPIRATORY MONITORING DEVICES: https://github.com/Health-Devices/CARDIAC-RESPIRATORY-MONITORING

Acknoledgement: the author would like to thank W. Owen Brimijoin for his Matlab code for generating the colored noise.


```
% Changing the path from main_folder to a particular chapter
main_path=fileparts(which('Main_Content.mlx'));
if ~isempty(main_path)
    %addpath(append(main_path,'/Chapter2'))
    cd (append(main_path,'/Chapter4/Noise Generation'))
    addpath(append(main_path,'/Service'))
end
SAVE_FLAG=0; % saving the figures in a file
```

Introduction

This notebook relies on the finction additive_noise_model.m that allows us to simulate different types of noise. The noise will be added to 1 Hz sinewave simulating the heartbeat. We will simulate:

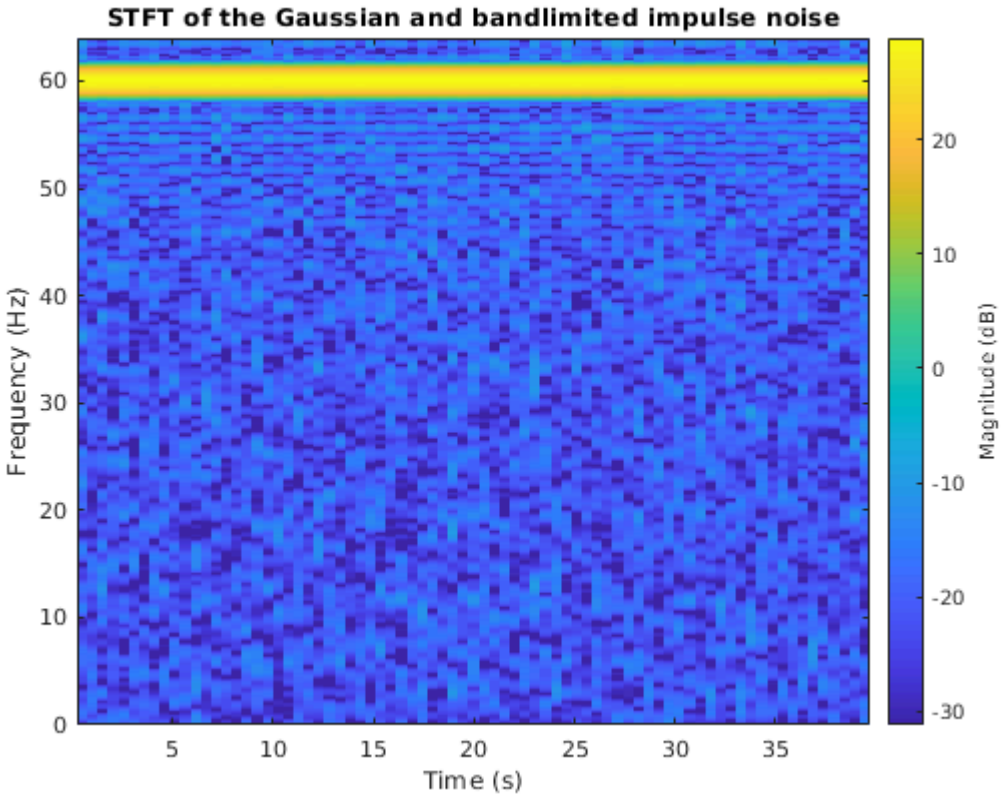
- 60 Hz noise
- motion artifacts that are continous
- impulse noise
- brown + impulse + medium frequency noise

```
fs=250;
N=10000;
T=1/fs;
t = (0:N-1)*T;
beat_freq=1;
```

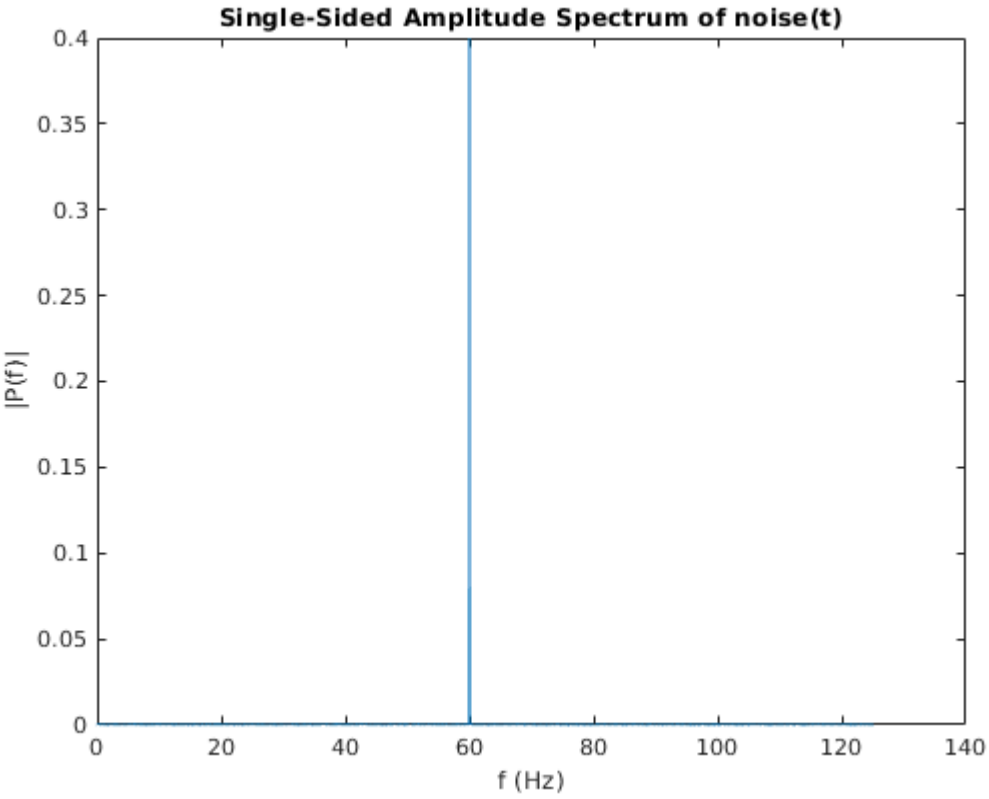
```
s=sin(2*pi*t*beat_freq);
plot(t,s);
    title('Signal of interest')
    xlabel('Time (s)')
    ylabel('Amplitude (V)')
```

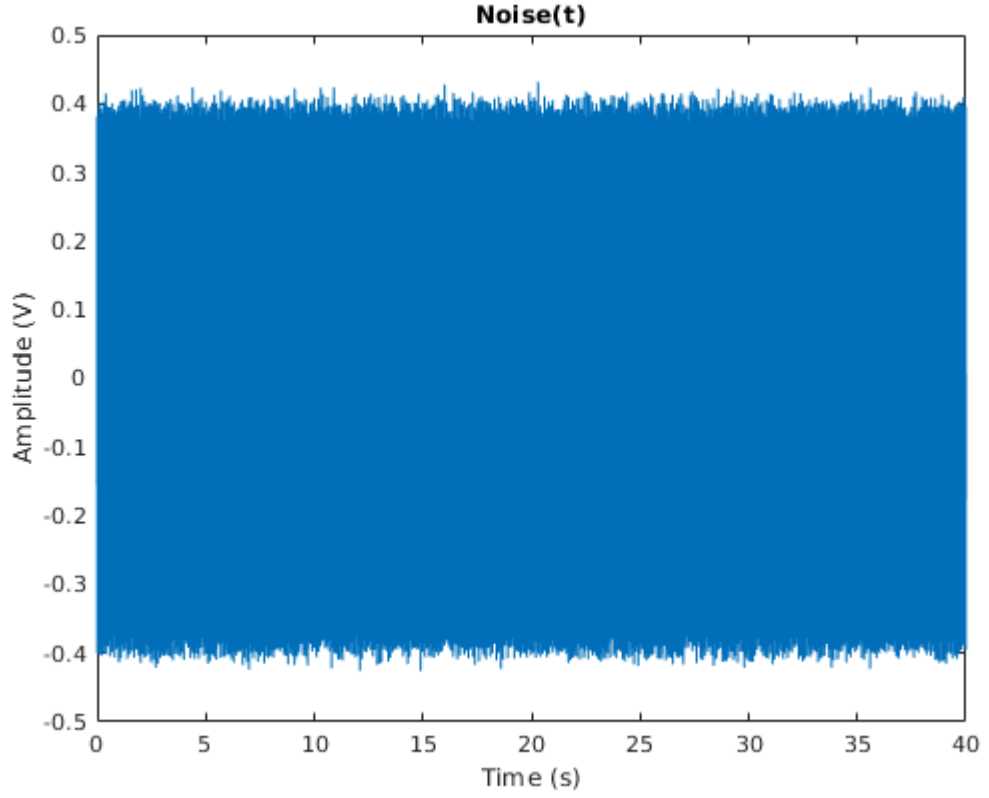
White and 60 Hz noise

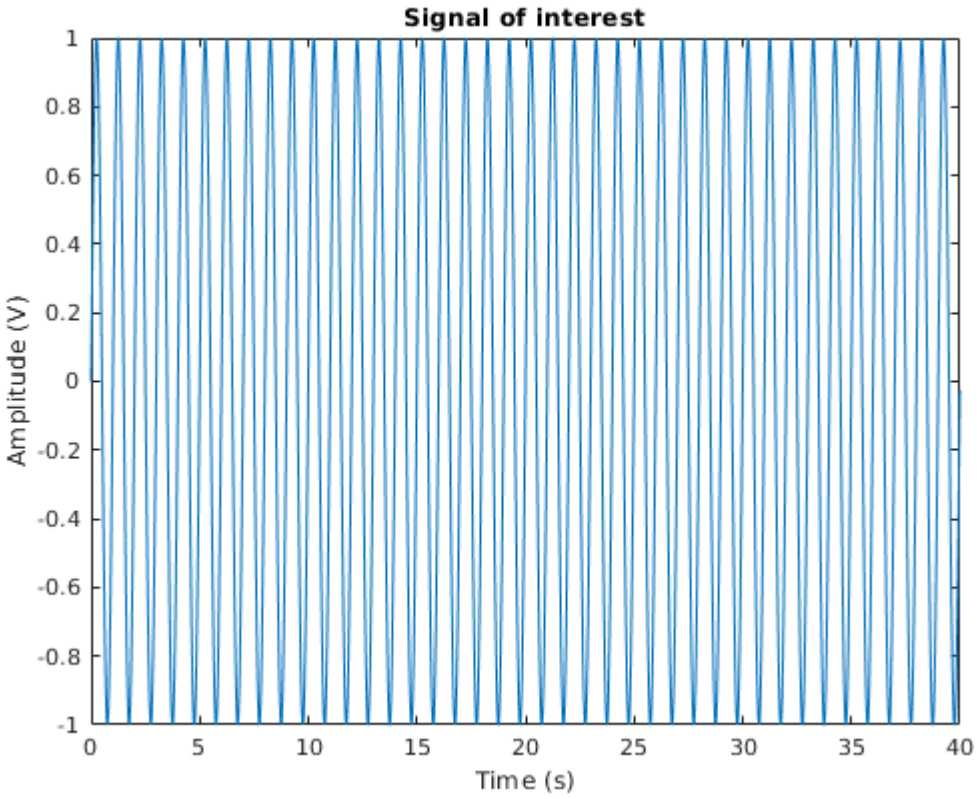
```
s1=s+additive_noise_model(N, fs, 'Gaussian', [0, 0.01], '60 Hz', [0.4], 'Plotting');
```

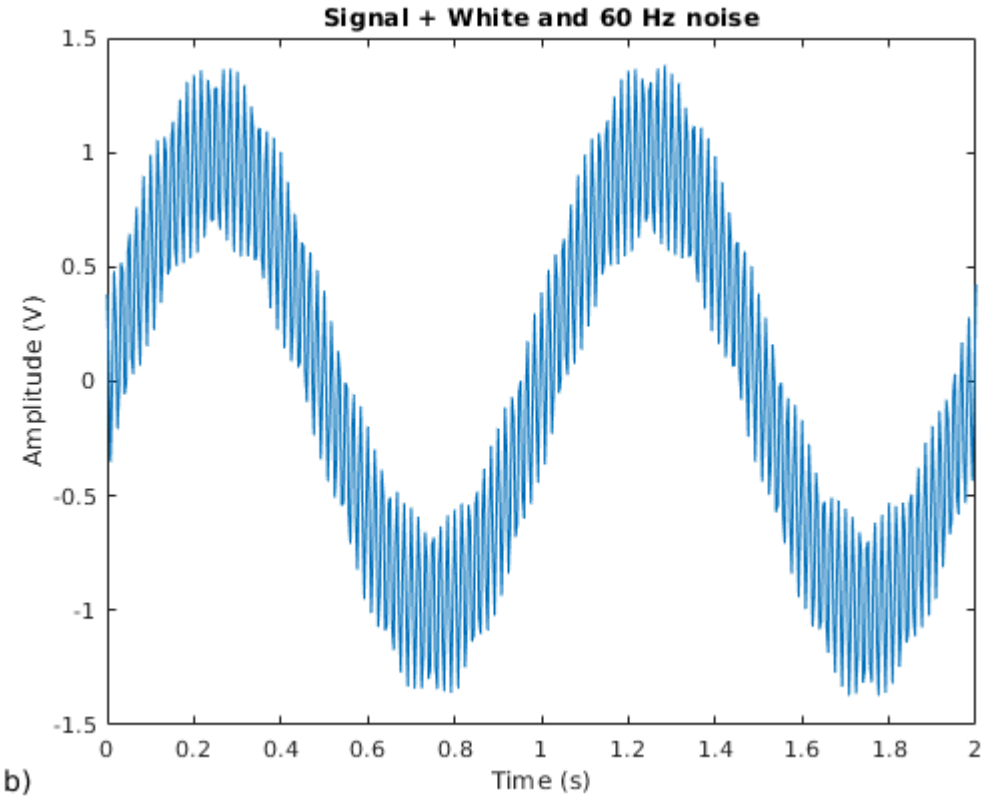



```
plot(t,s1)
title('Signal + White and 60 Hz noise')
    xlabel('Time (s)')
    ylabel('Amplitude (V)')
    xlim([0,2])
    annonation_save('b)',"Fig4.6b.jpg", SAVE_FLAG);
```


Single-Sided Amplitude Spectrum of noise(t)
|P(f)|
f (Hz)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0
20
40
60
80
100
120
140


Noise(t)
Amplitude (V)
Time (s)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0
5
10
15
20
25
30
35
40



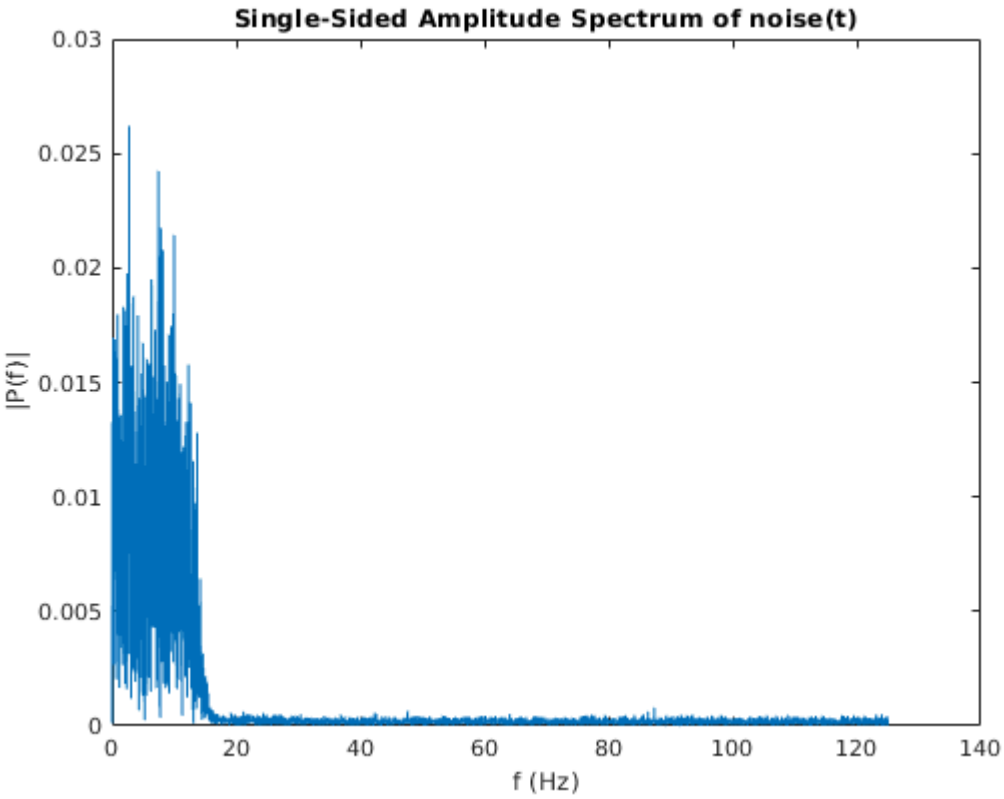


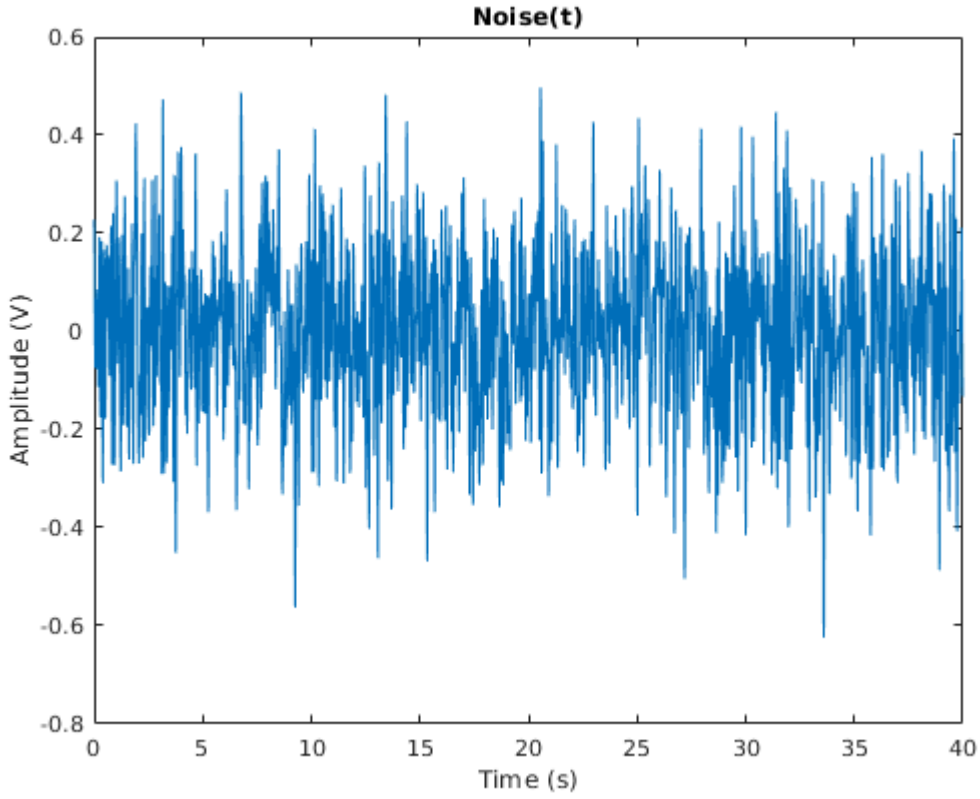
b)

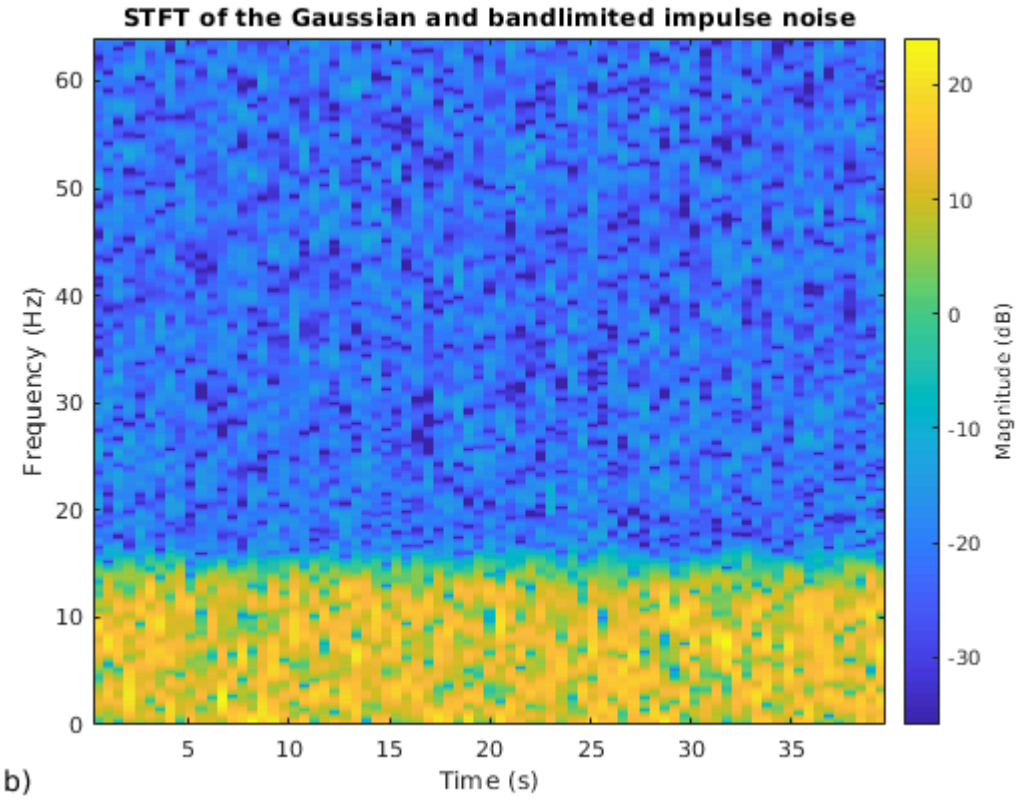
Continous motion artifacts

```
s1=s+additive_noise_model(N, fs, 'Gaussian', [0, 0.01], 'Lowpass', [0.5, 10], 'Plotting
```

```
annonation_save('b)',"Fig4.7b.jpg", SAVE_FLAG);
```

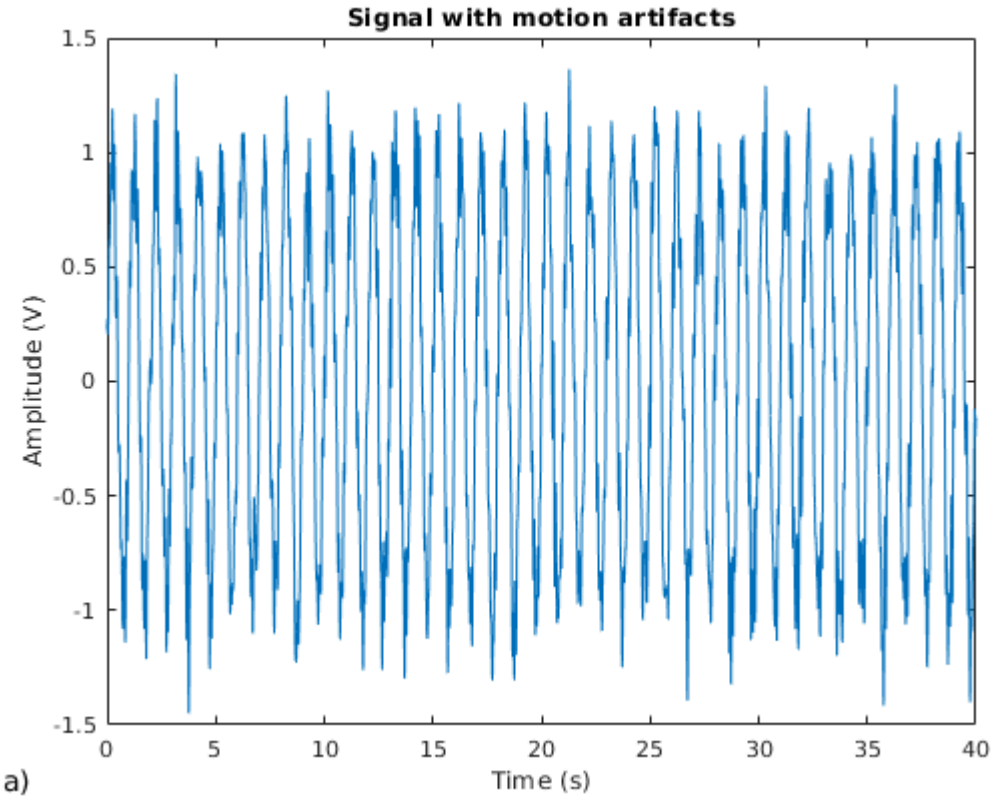






b)

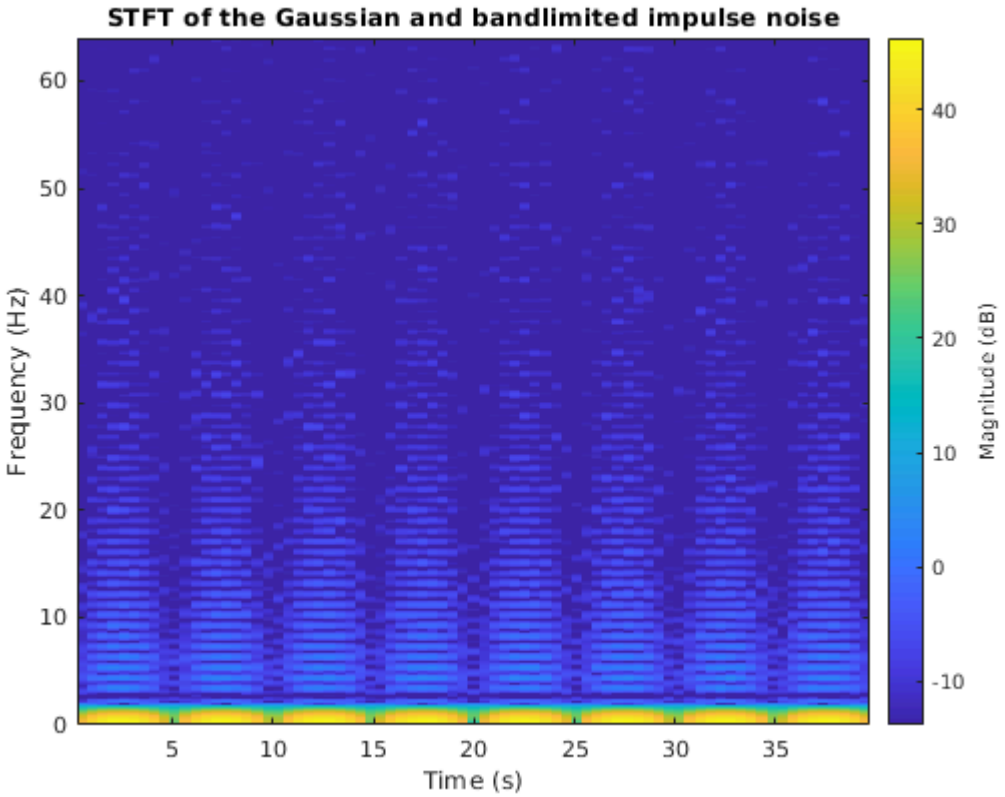
```
plot(t,s1)
title('Signal with motion artifacts')
    xlabel('Time (s)')
    ylabel('Amplitude (V)')
    annonation_save('a)',"Fig4.7a.jpg", SAVE_FLAG);
```



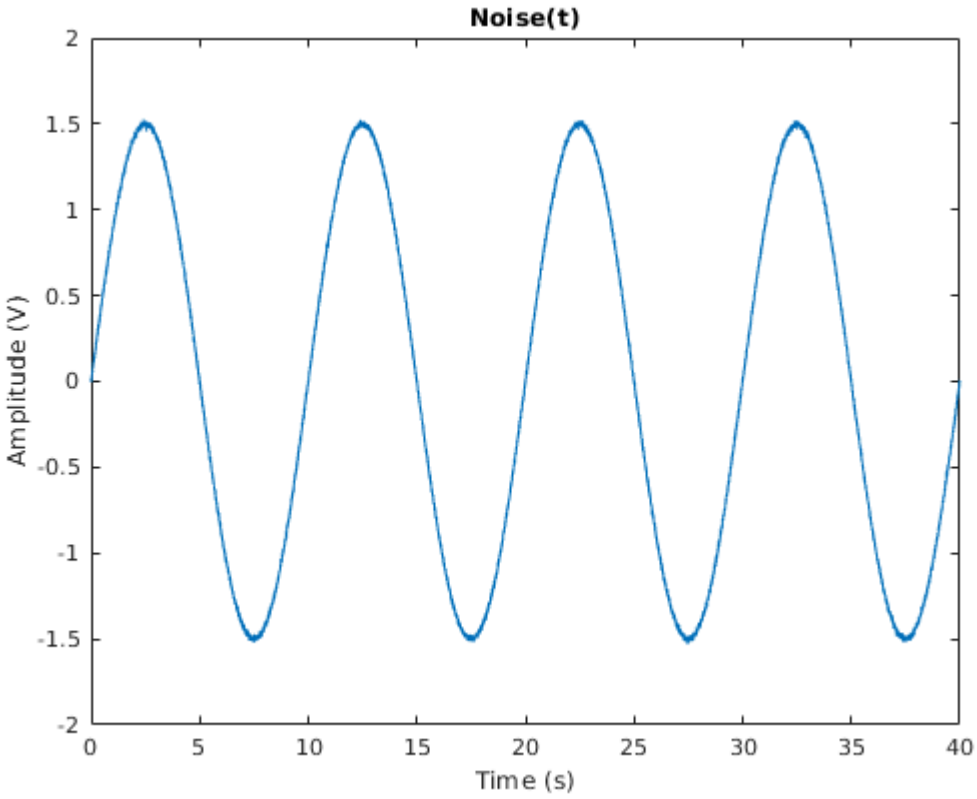
a)

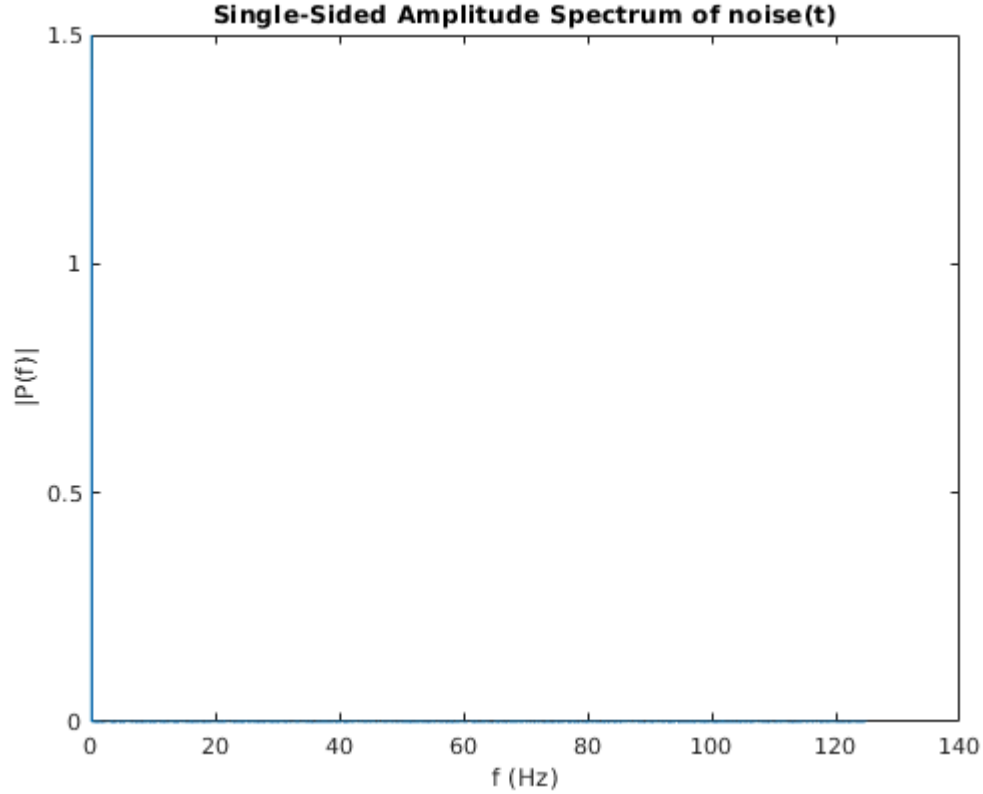
Baseline shift

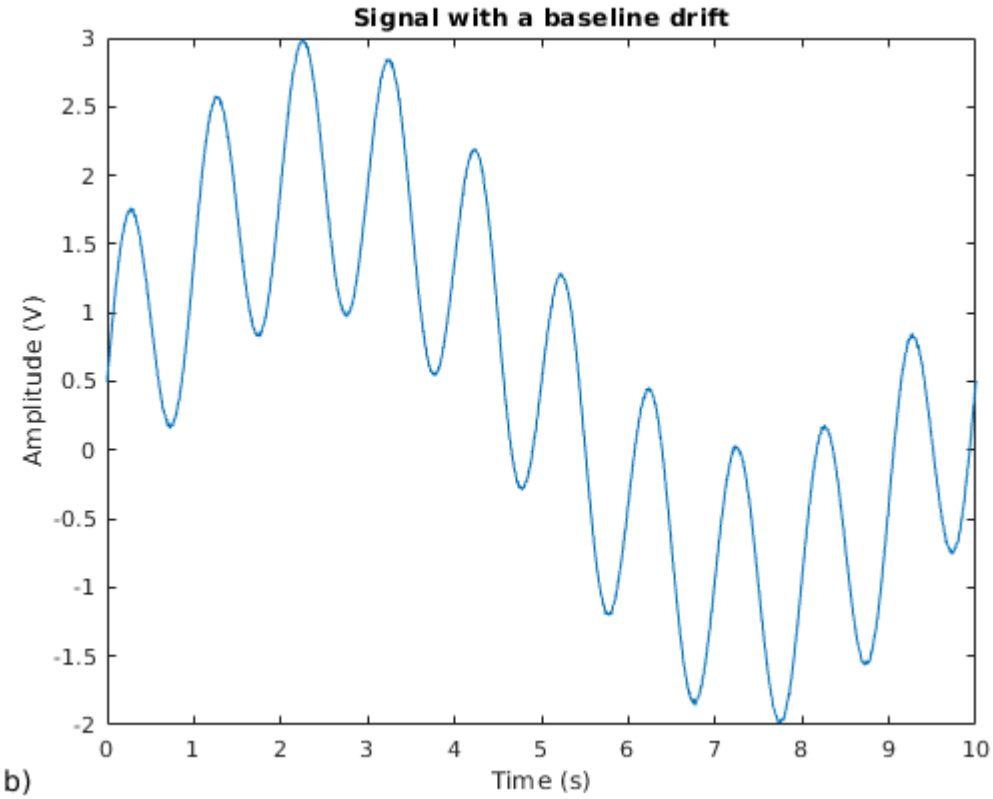
```
noise=0.5+additive_noise_model(N, fs, 'Gaussian', [0, 0.01], 'NarrowBand', [1.5, 0.1],
```




```
s1=s+noise;
plot(t,s1)
title('Signal with a baseline drift')
    xlabel('Time (s)')
    ylabel('Amplitude (V)')
    xlim([0,10])
    annonation_save('b)',"Fig4.6b.jpg", SAVE_FLAG);
```

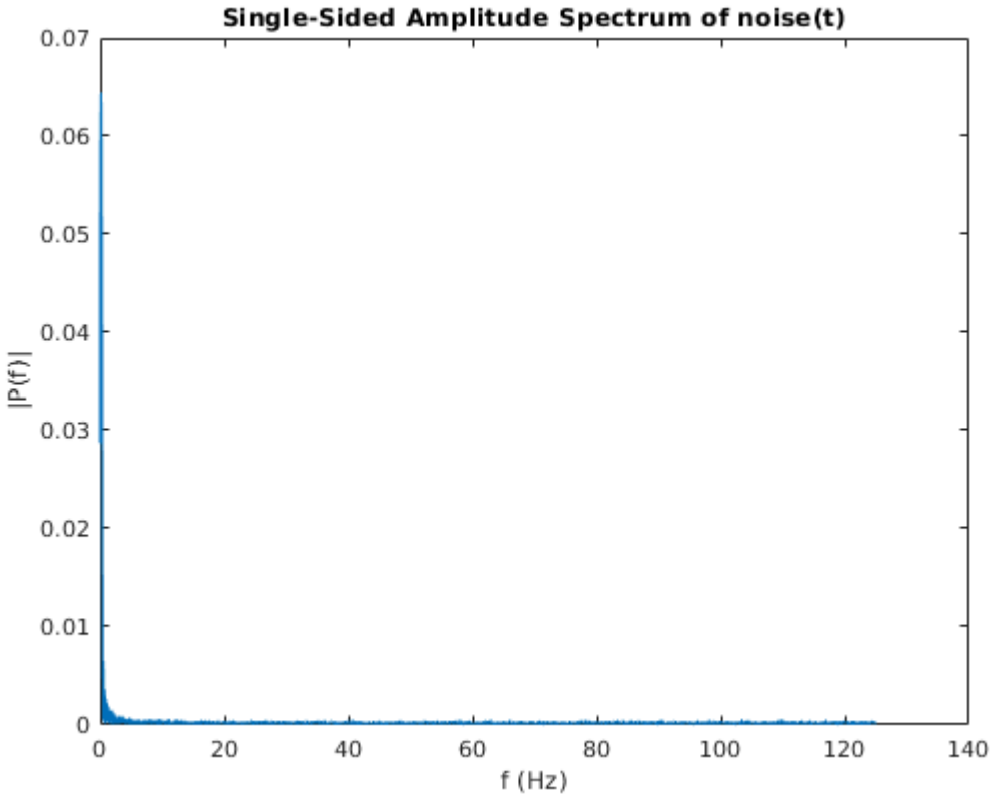

Noise(t)
Amplitude (V)
Time (s)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
5
10
15
20
25
30
35
40

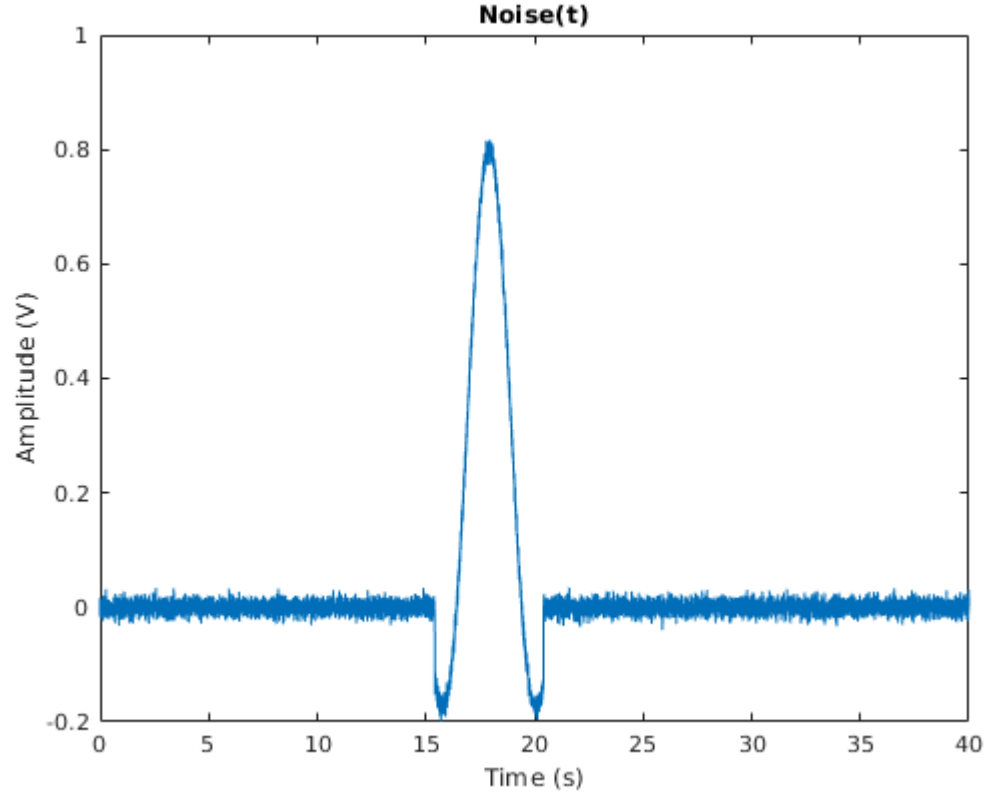

Single-Sided Amplitude Spectrum of noise(t)
|P(f)|
f (Hz)
1.5
1
0.5
0
0
20
40
60
80
100
120
140

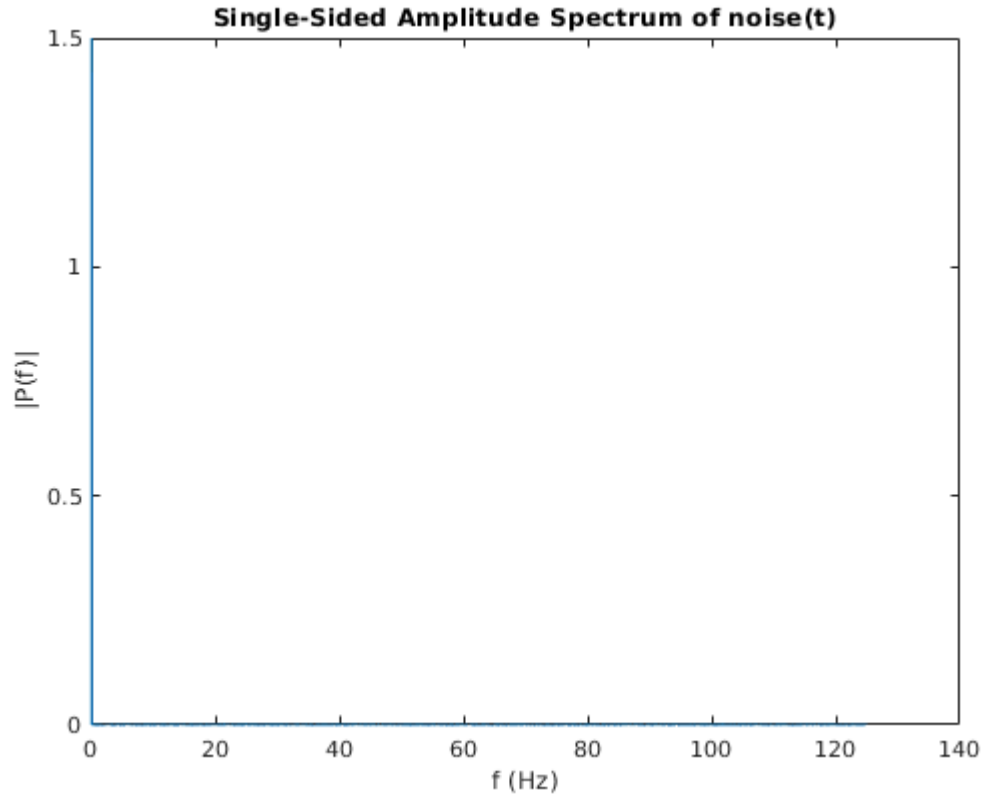


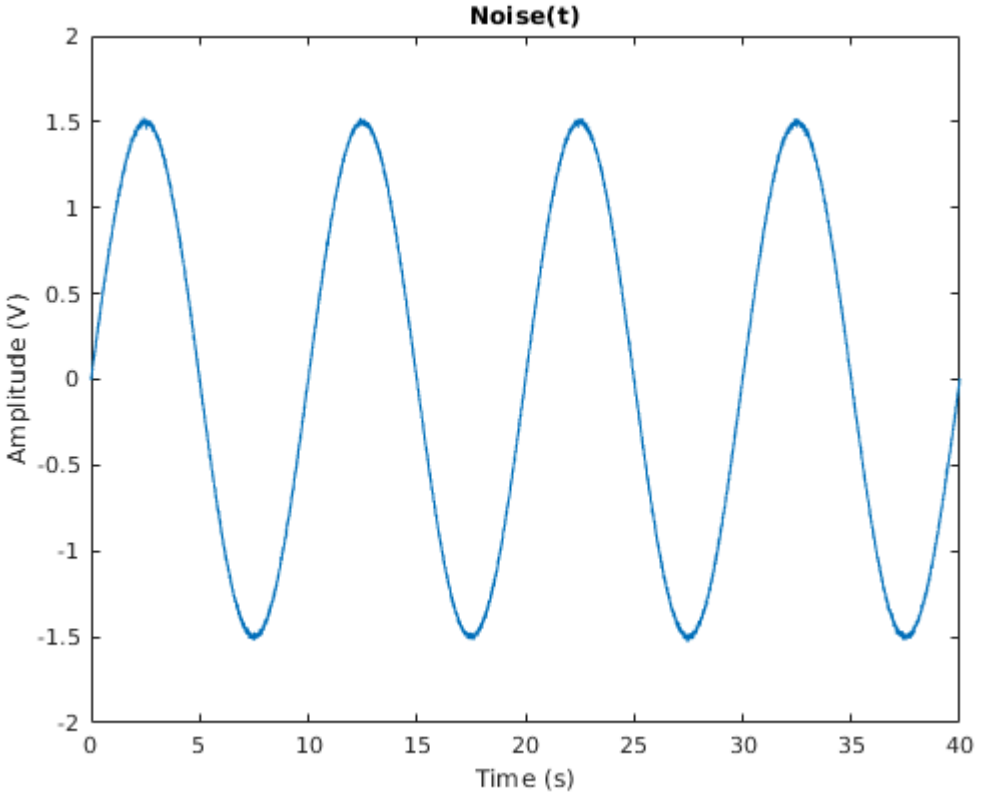
Impulse noise

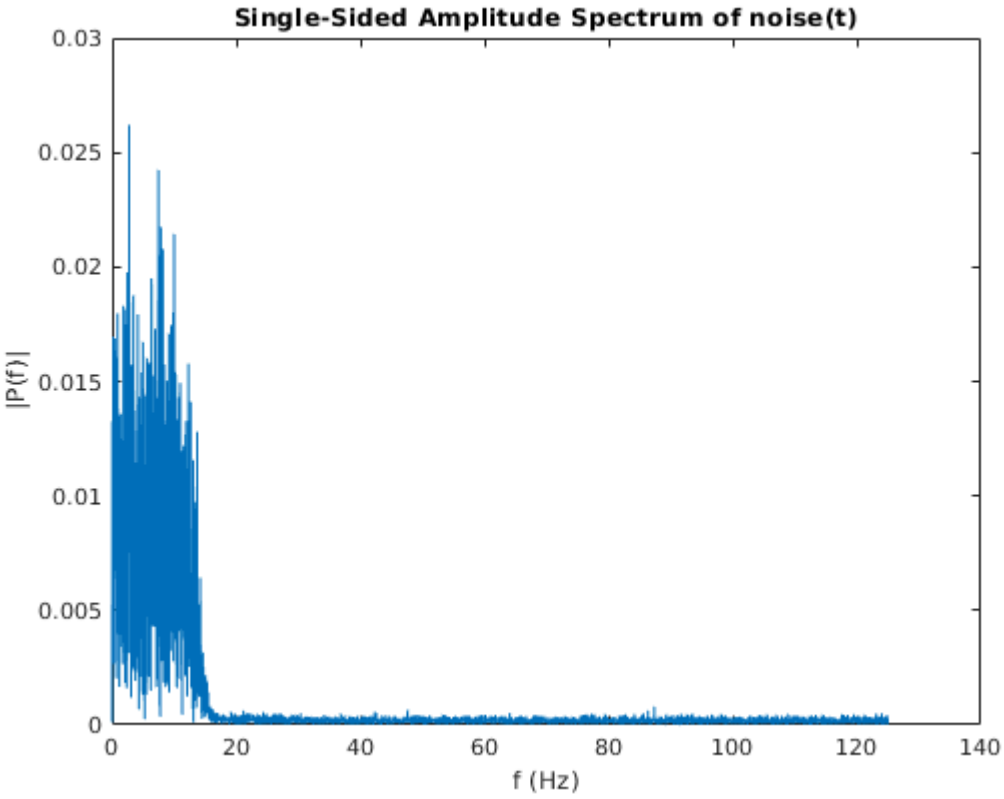
```
noise=additive_noise_model(N, fs, 'Gaussian', [0, 0.01], 'Impulse', [1.2, 1.5], 'Plotti
annonation_save('b)',"Fig4.8b.jpg", SAVE_FLAG);
```

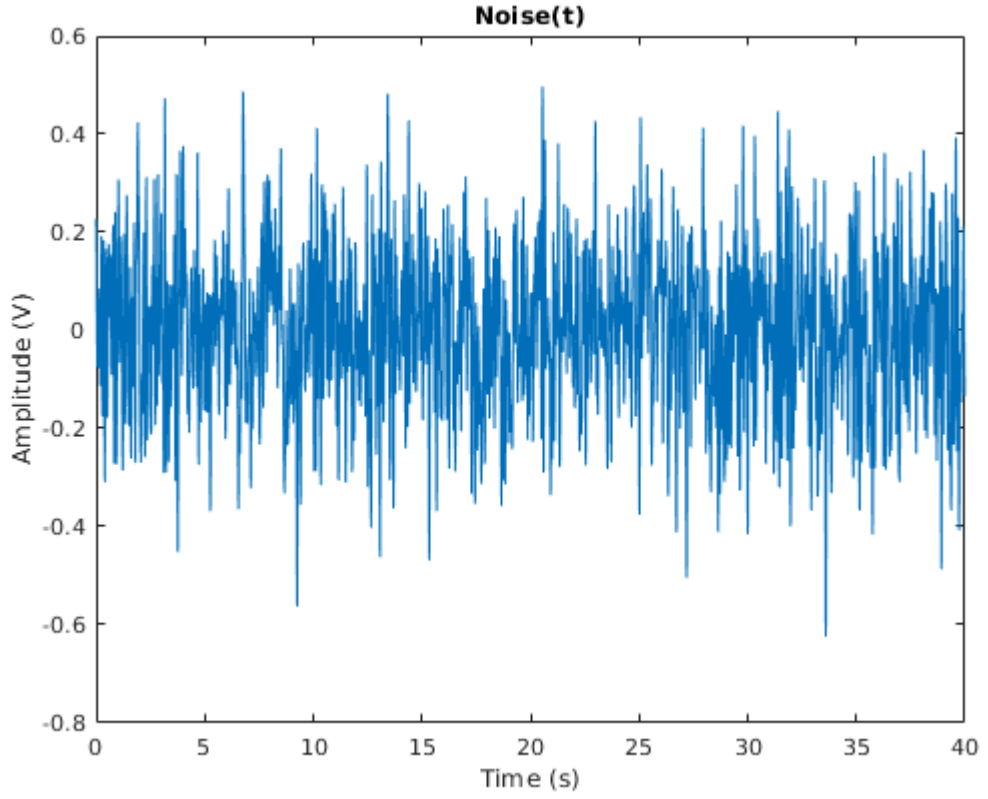

Single-Sided Amplitude Spectrum of noise(t)
|P(f)|
f (Hz)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
20
40
60
80
100
120
140

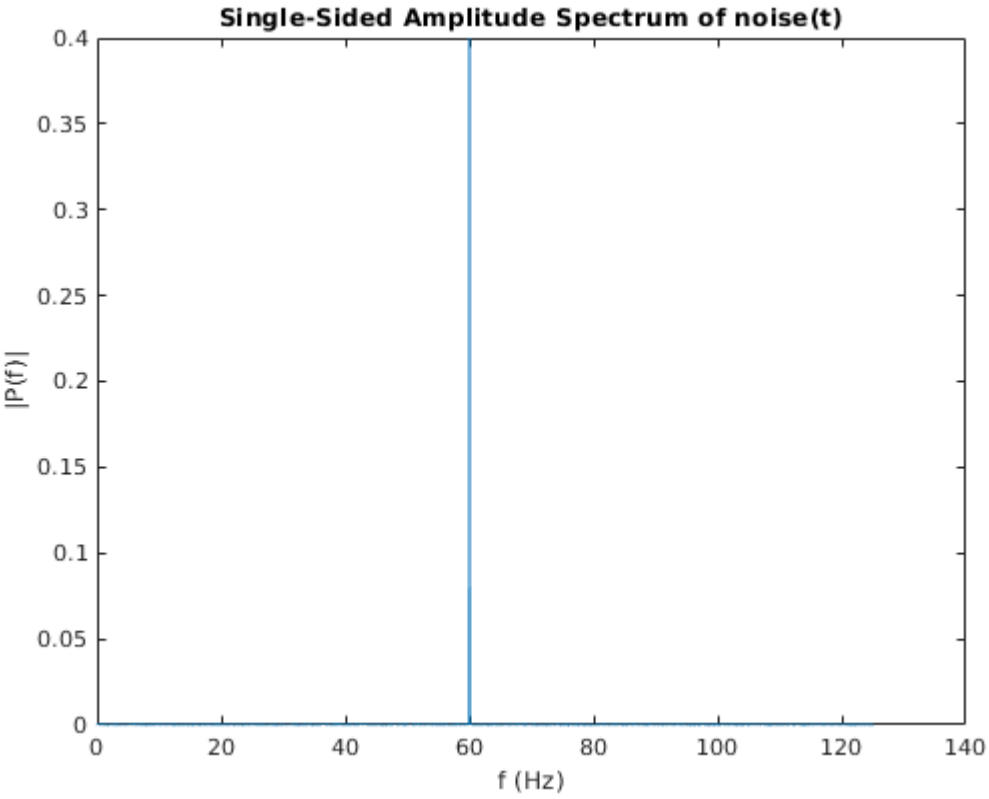

Noise(t)
Amplitude (V)
Time (s)
1
0.8
0.6
0.4
0.2
0
-0.2
0
5
10
15
20
25
30
35
40

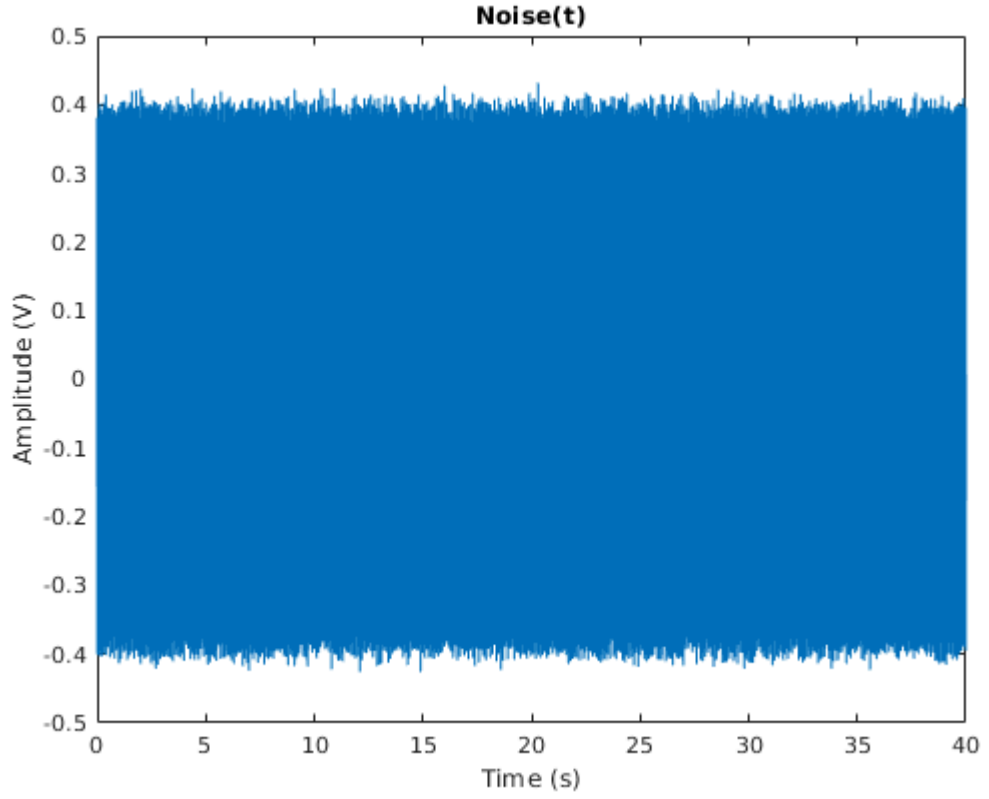

Single-Sided Amplitude Spectrum of noise(t)
|P(f)|
f (Hz)
0
0.5
1
1.5
0
20
40
60
80
100
120
140

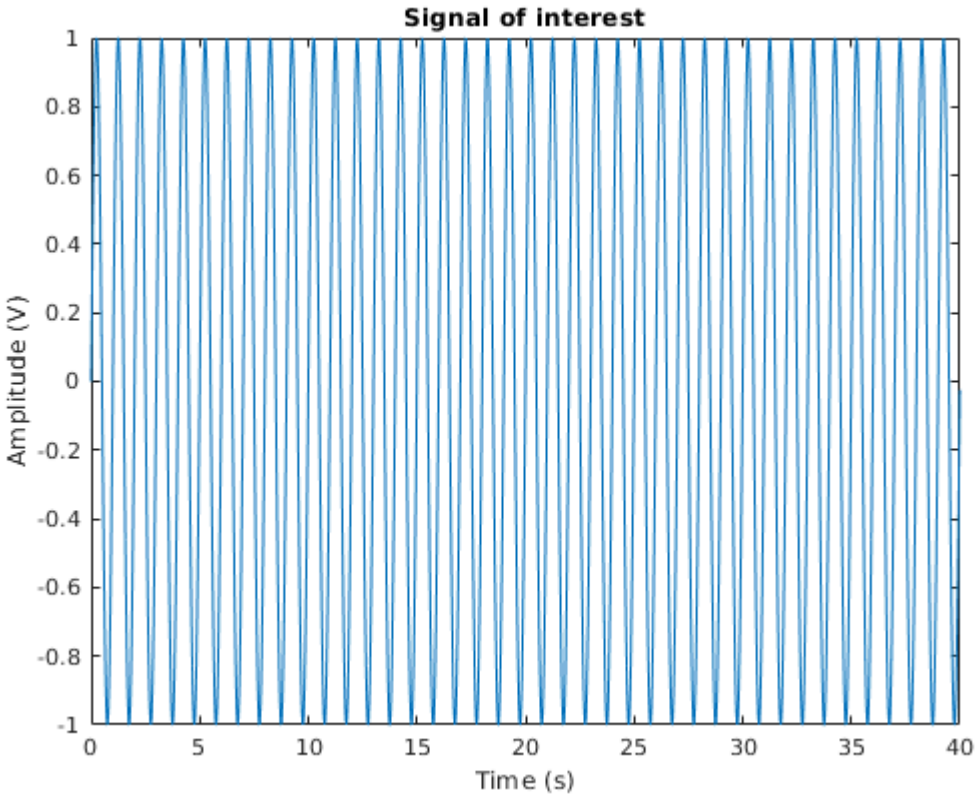

Noise(t)
Amplitude (V)
Time (s)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
5
10
15
20
25
30
35
40

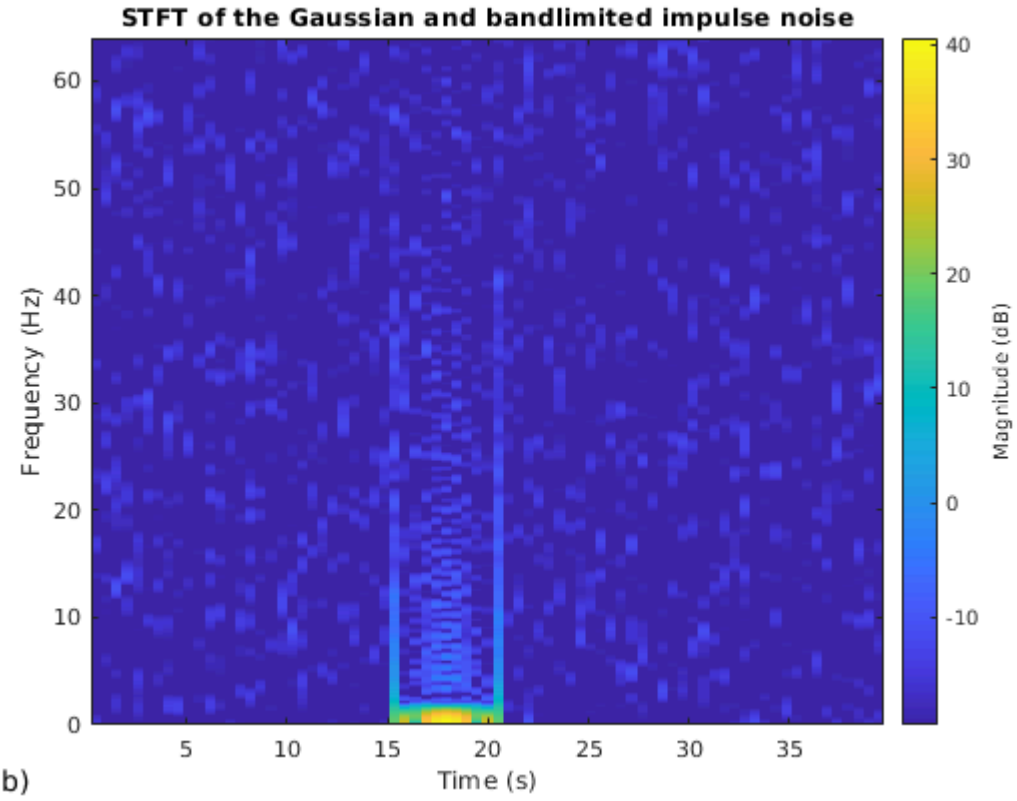

Single-Sided Amplitude Spectrum of noise(t)
|P(f)|
f (Hz)
0.03
0.025
0.02
0.015
0.01
0.005
0
0
20
40
60
80
100
120
140


Noise(t)
Amplitude (V)
Time (s)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
5
10
15
20
25
30
35
40


Single-Sided Amplitude Spectrum of noise(t)
|P(f)|
f (Hz)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
120
140


Noise(t)
Amplitude (V)
Time (s)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0
5
10
15
20
25
30
35
40

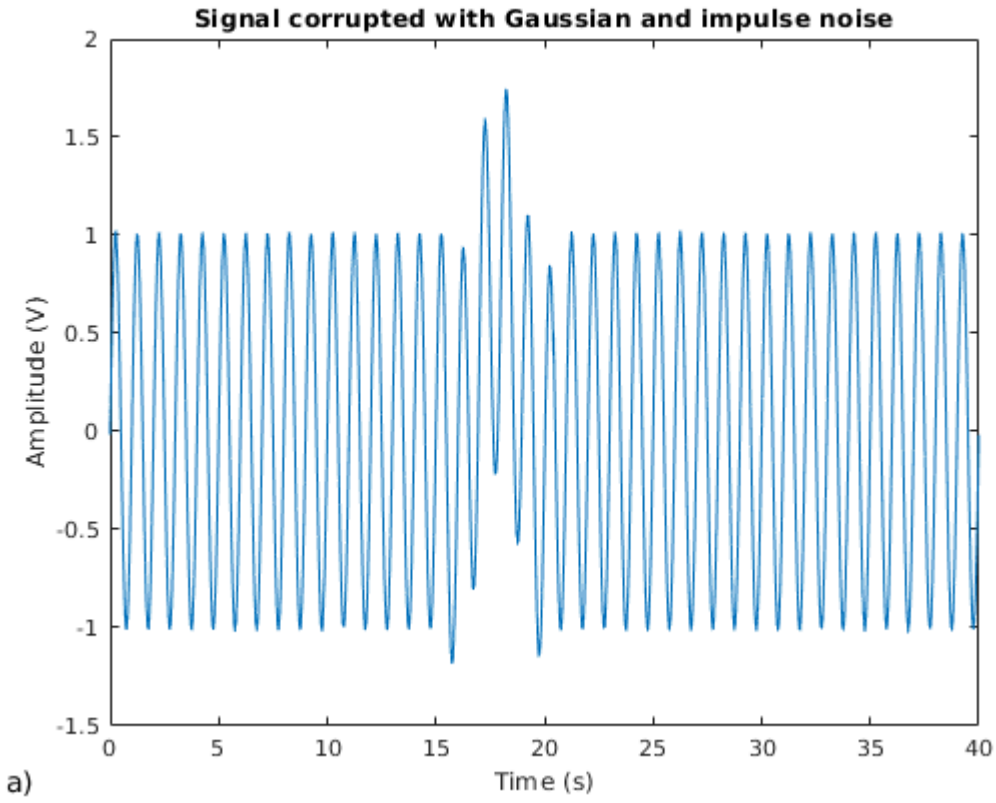




b)

```
s1=s+noise;
plot(t,s1)
%title('Signal + impulse noise')
    xlabel('Time (s)')
```

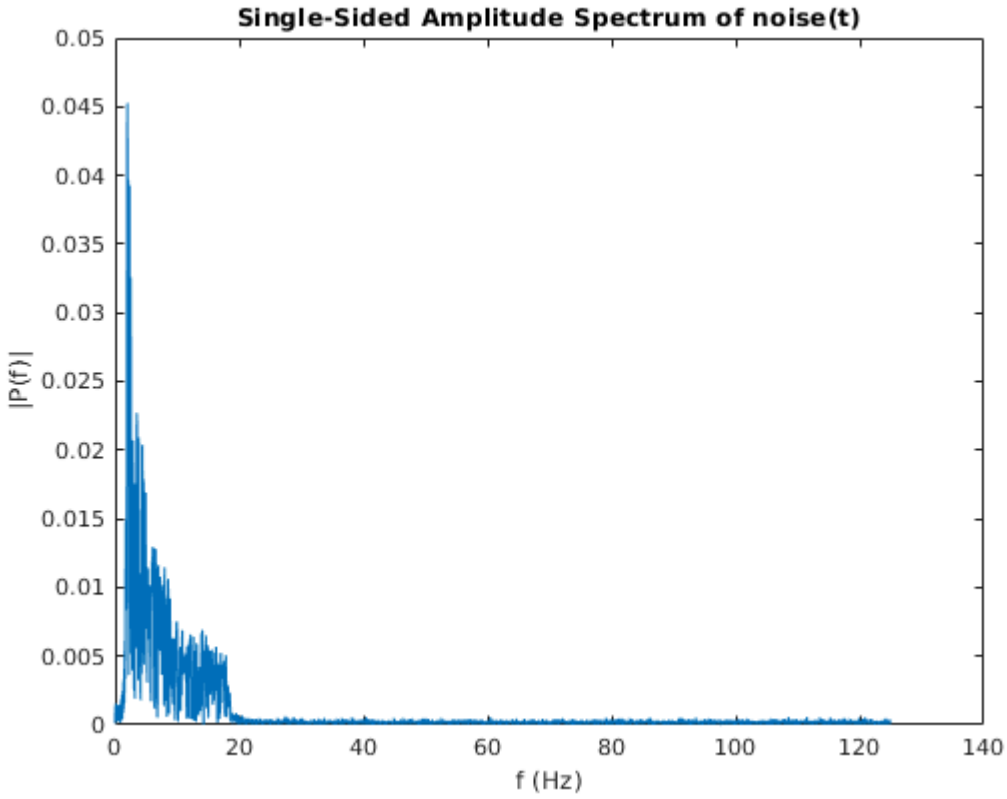
```
    ylabel('Amplitude (V)')

title('Signal corrupted with Gaussian and impulse noise')
annonation_save('a)',"Fig4.8a.jpg", SAVE_FLAG);
```

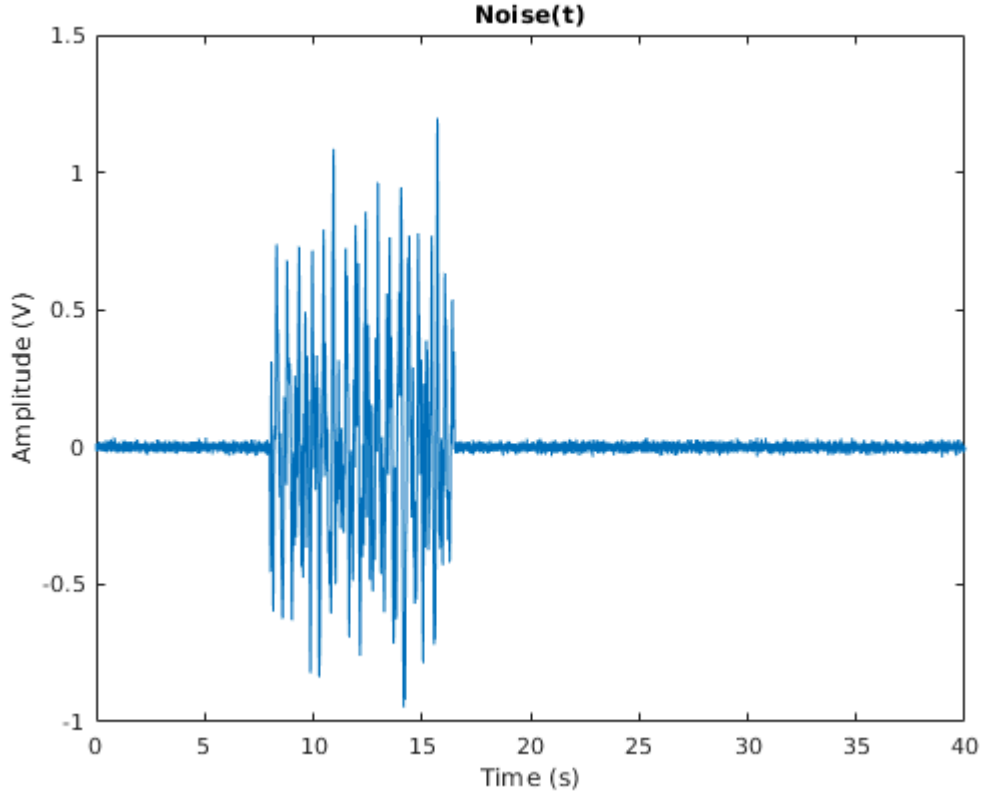


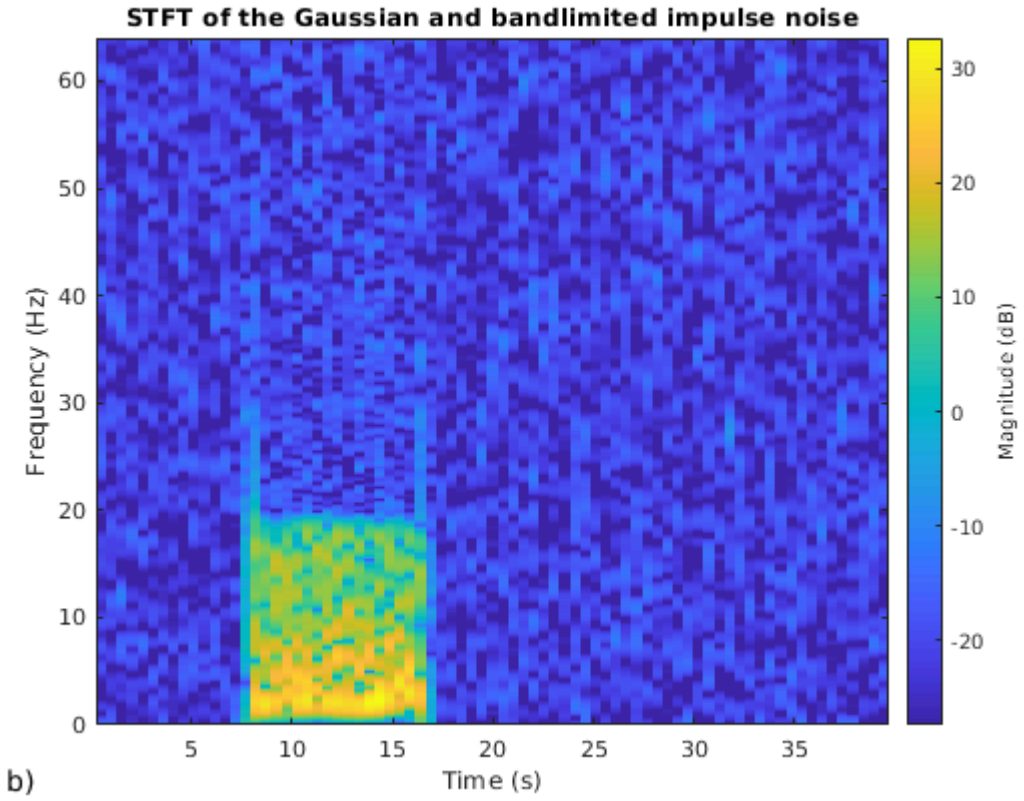
Brown + impulse + medium frequency noise

This is the noise signal generated based on the model proposed in [Li09] in which the brown noise if generated first and then filtered in the range between 1.5 and 18 Hz. This noise corresponds to motian artifact such as moving clothes over the transducer.

```
s1=s+additive_noise_model(N, fs, 'BandLimited Impulse', [5, 1.8, 18], 'Gaussian', [0, 0
annonation_save('b)',"Fig4.9b.jpg", SAVE_FLAG);
```

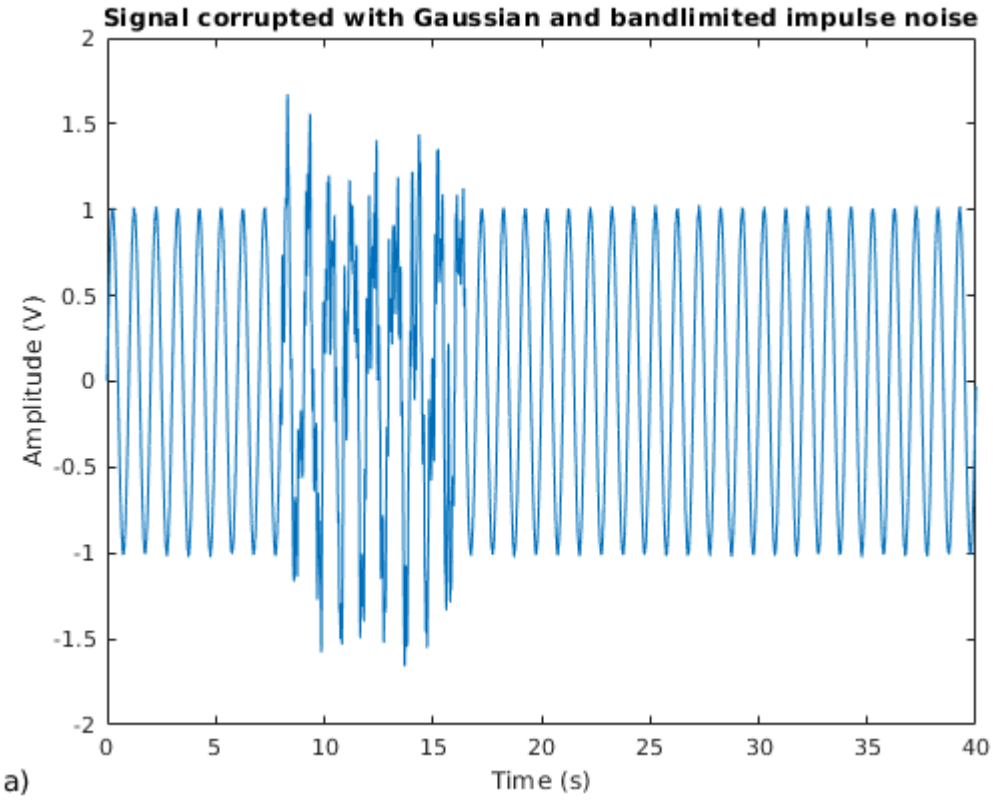

Single-Sided Amplitude Spectrum of noise(t)
|P(f)|
f (Hz)
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
20
40
60
80
100
120
140


Noise(t)
Amplitude (V)
Time (s)
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30
35
40



b)

```
plot(t,s1)
%title('Signal + Brown + impulse + bandpass noise')
    xlabel('Time (s)')
    ylabel('Amplitude (V)')

title('Signal corrupted with Gaussian and bandlimited impulse noise')
annonation_save('a)',"Fig4.9a.jpg", SAVE_FLAG);
```



a)

References

[Li09] Q. Li et al, "Artificial arterial blood pressure artifact model and an evaluation of a robust blood pressure and heart rate estimator," BioMedical Engineering OnLine volume 8, Article number: 13 (2009).