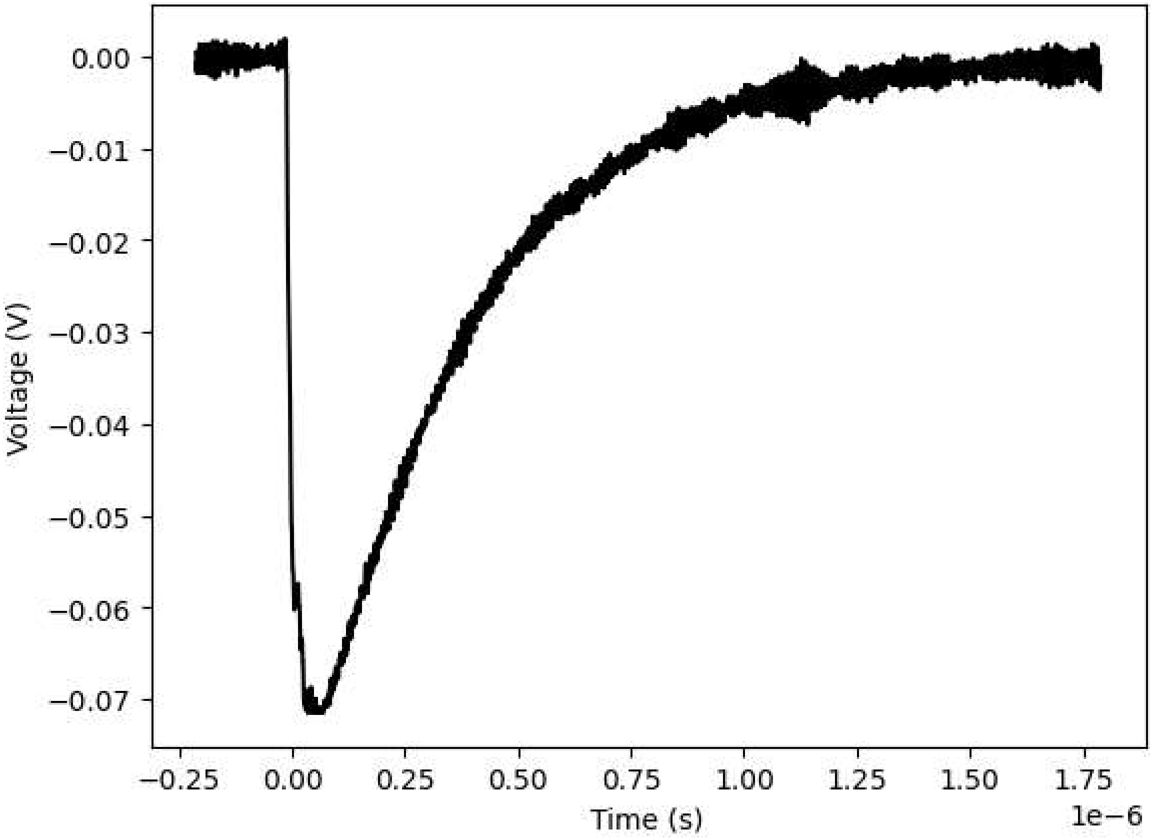
In [ ]:

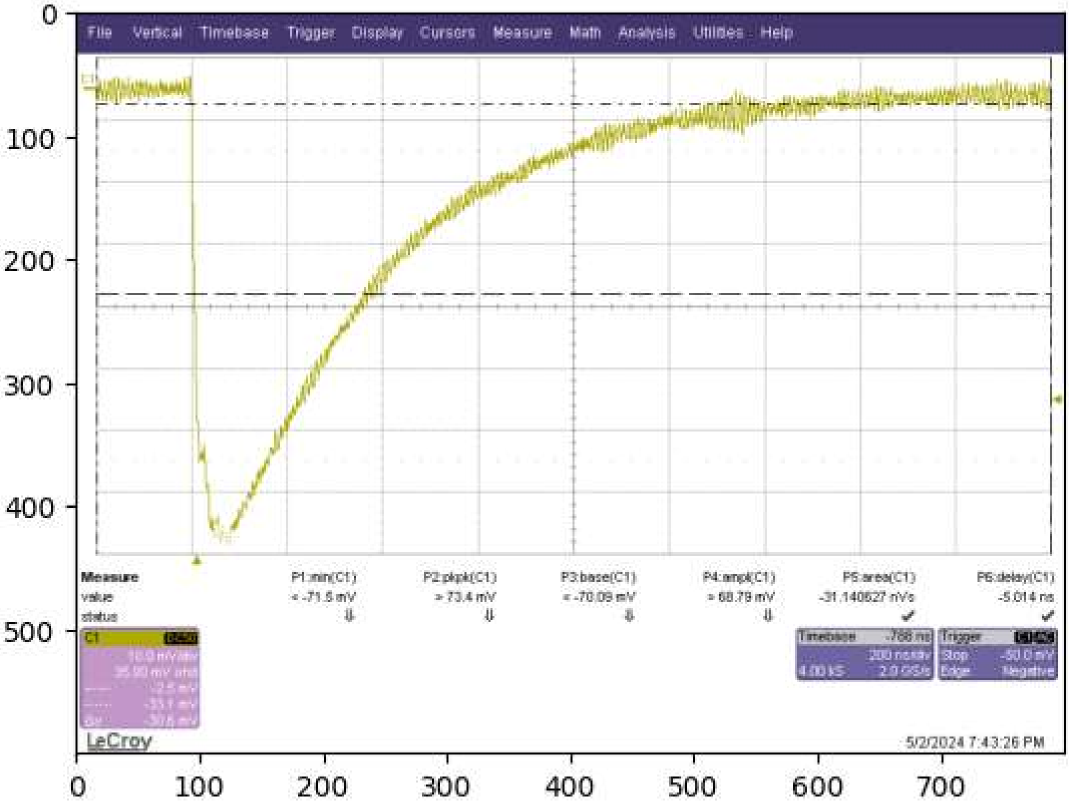
```
from matplotlib import colors as col
from matplotlib.ticker import PercentFormatter
import os
import numpy
import pandas as pd
import random
import matplotlib.image as mpimg
import matplotlib.pyplot as plt
from scipy import stats, signal
from collections import Counter
```

In [ ]:

```
file_path = 'data\\20240502_single_bias_42V_trig_m50mV_box_indoor.txt'
dataset = pd.read_csv(file_path, skiprows=4, delimiter='\t', engine='python')
print(dataset)

plt.clf()
plt.plot(dataset.iloc[:,0],dataset.iloc[:,1], color='#000000')
plt.xlabel("Time (s)")
plt.ylabel("Voltage (V)")
plt.show()

img = mpimg.imread('oscilloscopio_display.png')
imgplot = plt.imshow(img)
plt.show()
```

```
               Time      Ampl
0    -2.123390e-07  0.000375
1    -2.118390e-07  0.000063
2    -2.113390e-07 -0.000250
3    -2.108390e-07 -0.001187
4    -2.103390e-07 -0.001813
...            ...       ...
3997  1.786161e-06 -0.003063
3998  1.786661e-06 -0.002437
3999  1.787161e-06 -0.002437
4000  1.787661e-06 -0.002437
4001  1.788161e-06 -0.001187

[4002 rows x 2 columns]
```




0
100
200
300
400
500
0
100
200
300
400
500
600
700
File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help
C1
LeCroy

Measure	P1:min(C1)	P2:pkpk(C1)	P3:base(C1)	P4:ampl(C1)	P5:area(C1)	P6:delay(C1)
value	< -71.5 mV	> 73.4 mV	< -70.09 mV	> 68.79 mV	-31.140627 nVs	-5.014 ns
status	⇓	⇓	⇓	⇓	✓	✓

C1
10.0 mV/div
35.00 mV ofst
-2.6 mV
-33.1 mV
Δy -30.6 mV

Timebase -788 ns
200 ns/div
4.00 kS 2.0 GS/s

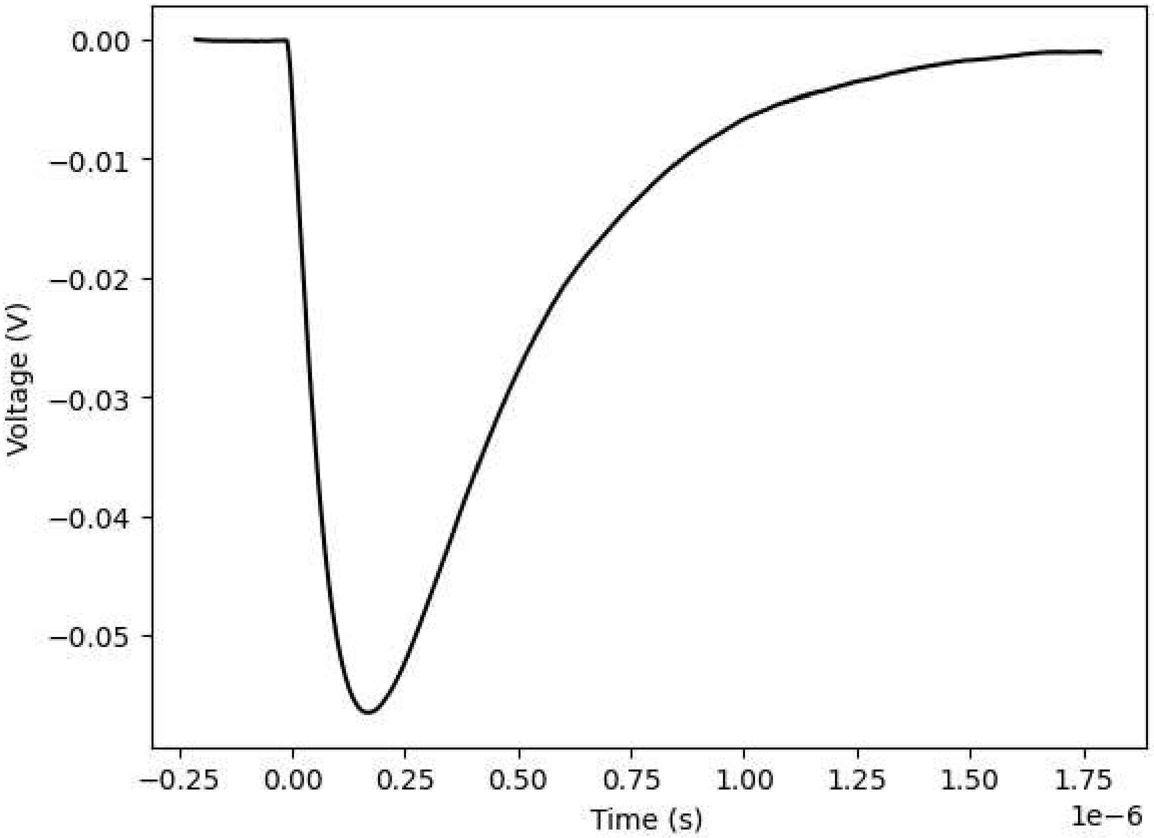
Trigger C1 DC
Stop -50.0 mV
Edge Negative

5/2/2024 7:43:26 PM

Riduco il rumore applicando un filtro passa-basso Butterworth

In [ ]:
```
oreder=1
frequenza_taglio=1 #Hz

sos = signal.butter(oreder, frequenza_taglio, 'low', fs=1000, output='sos')
filtered = signal.sosfilt(sos, dataset.iloc[:,1])
```

```
plt.clf()
plt.plot(dataset.iloc[:,0], filtered, color='#000000')
plt.xlabel("Time (s)")
plt.ylabel("Voltage (V)")
plt.show()
```



Prima misurazione (29/04/2024 44 V -50mV box indoor)

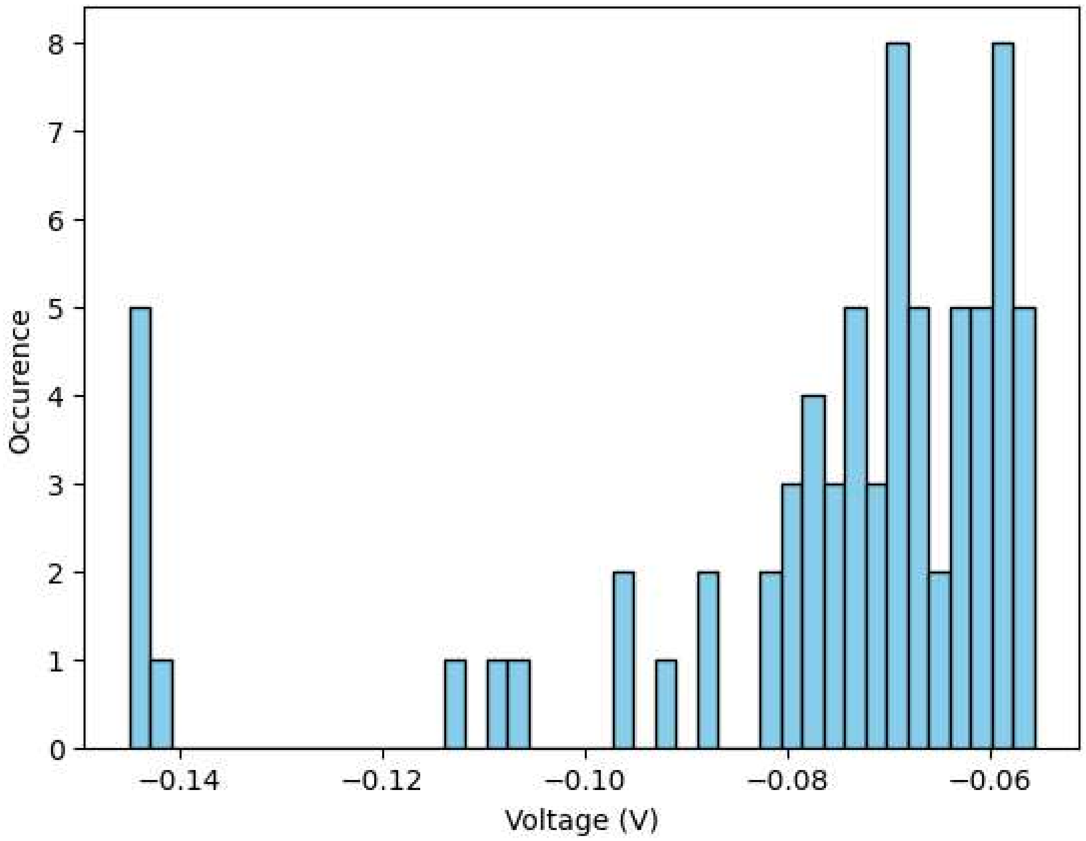
In [ ]:

```
massimi1=list()

massimi1=list()
path_dir='data\\20240429_muons_bias_44V_trig_m50mV_box_indoor'
count1=0
for files in os.listdir(path_dir):
    if os.path.isfile(os.path.join(path_dir, files)):
        count1+=1

print(count1)

for i in numpy.arange(1, count1, 1):
    nome_file=f'C1coil20may{i:05}.txt'
    file_path = os.path.join(path_dir, nome_file)
    dataset = pd.read_csv(file_path, skiprows=4, delimiter='\t', engine='python'
    massimi1.append(min(dataset.iloc[:,1]))
```

```
73
```

In [ ]:

```
num_bin = len(numpy.unique(massimi1))

n, bins, patches = plt.hist(massimi1, bins=num_bin, color='skyblue', edgecolor='

plt.xlabel('Voltage (V)')
plt.ylabel('Occurence')
plt.show()
```

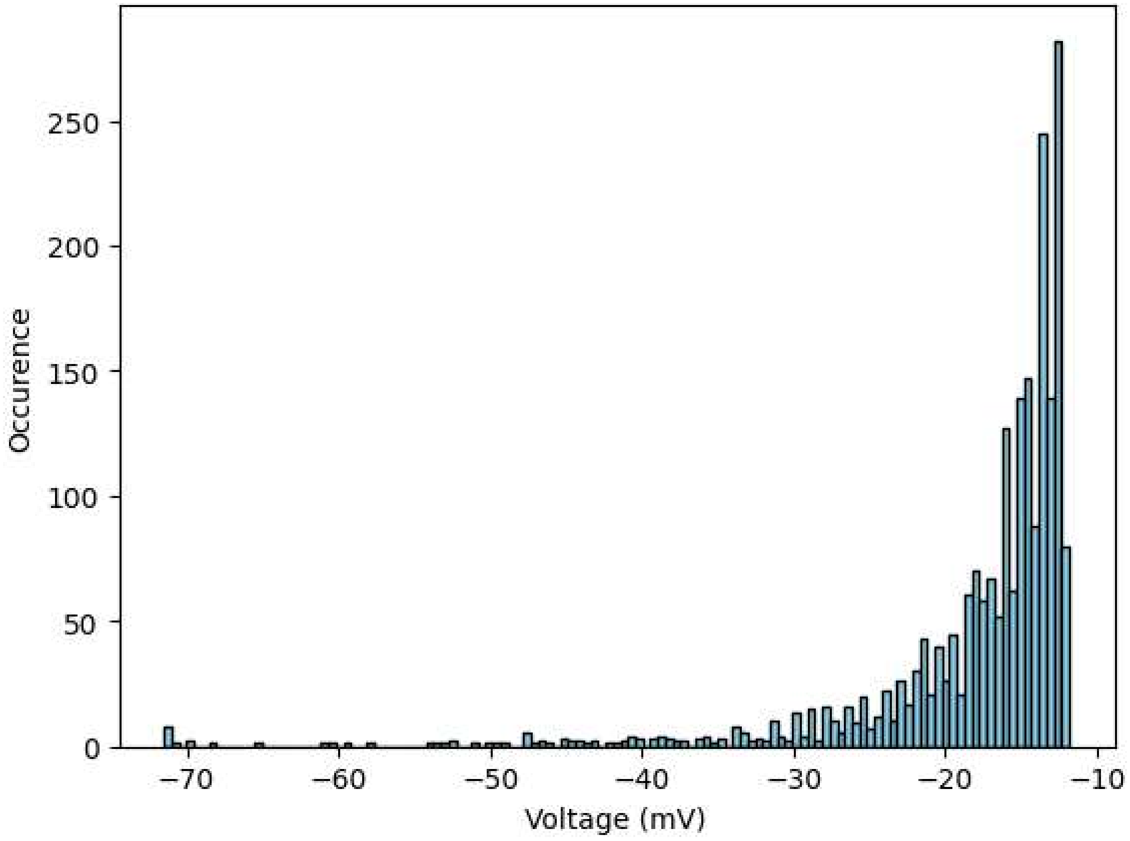


Seconda misurazione (02/05/2024 42 V -10mV box indoor)

```
In [ ]: massimi2=list()
        path_dir='data\\20240502_muons_bias_42V_trig_m10mV_box_indoor'
        count2=0
        for files in os.listdir(path_dir):
            if os.path.isfile(os.path.join(path_dir, files)):
                count2+=1

        print(count2)

        for i in numpy.arange(0, count2, 1):
            nome_file=f'C1coil20may{i:05}.txt'
            file_path = os.path.join(path_dir, nome_file)
            dataset = pd.read_csv(file_path, skiprows=4, delimiter='\t', engine='python'
            massimi2.append(min(dataset.iloc[:,1])*1000)
```

```
2164
```

```
In [ ]: num_bin = len(numpy.unique(massimi2))

        n, bins, patches = plt.hist(massimi2, bins=num_bin, color='skyblue', edgecolor='

        plt.xlabel('Voltage (mV)')
        plt.ylabel('Occurence')

        # plt.text(
        #     -60,
        #     175,
        #     f"Media={numpy.mean(massimi2)}",
        #     fontsize=12,
#     color="black",
#     verticalalignment="top",
# )

# plt.axvline(numpy.mean(massimi2), color='green')

plt.show()
```



Filtro eventuali rumori (In cui, per esempio, dopo il trigger viene attraversato il valore medio un numero di volte maggiore del doppio media)

In [ ]:

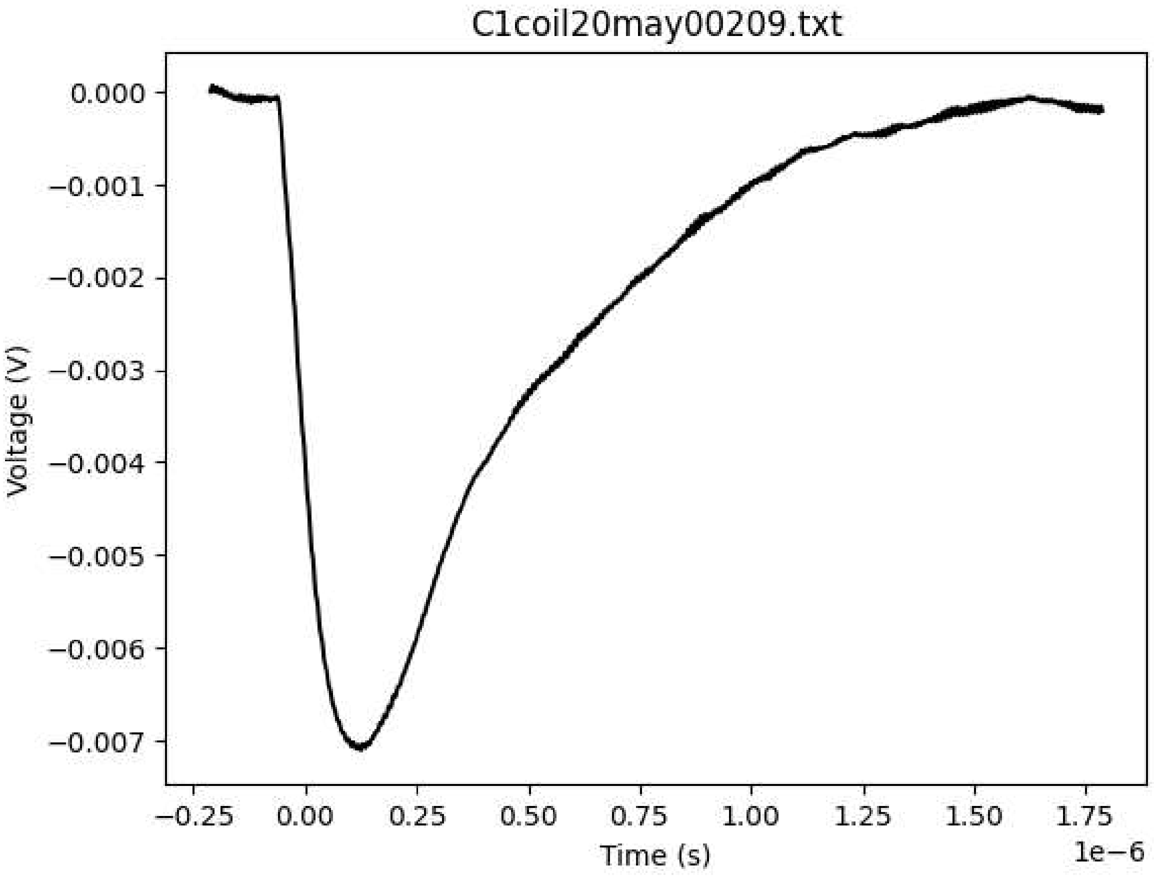
```
massimi3=list()
path_dir='data\\20240502_muons_bias_42V_trig_m10mV_box_indoor'
count3=0
for files in os.listdir(path_dir):
    if os.path.isfile(os.path.join(path_dir, files)):
        count3+=1
```

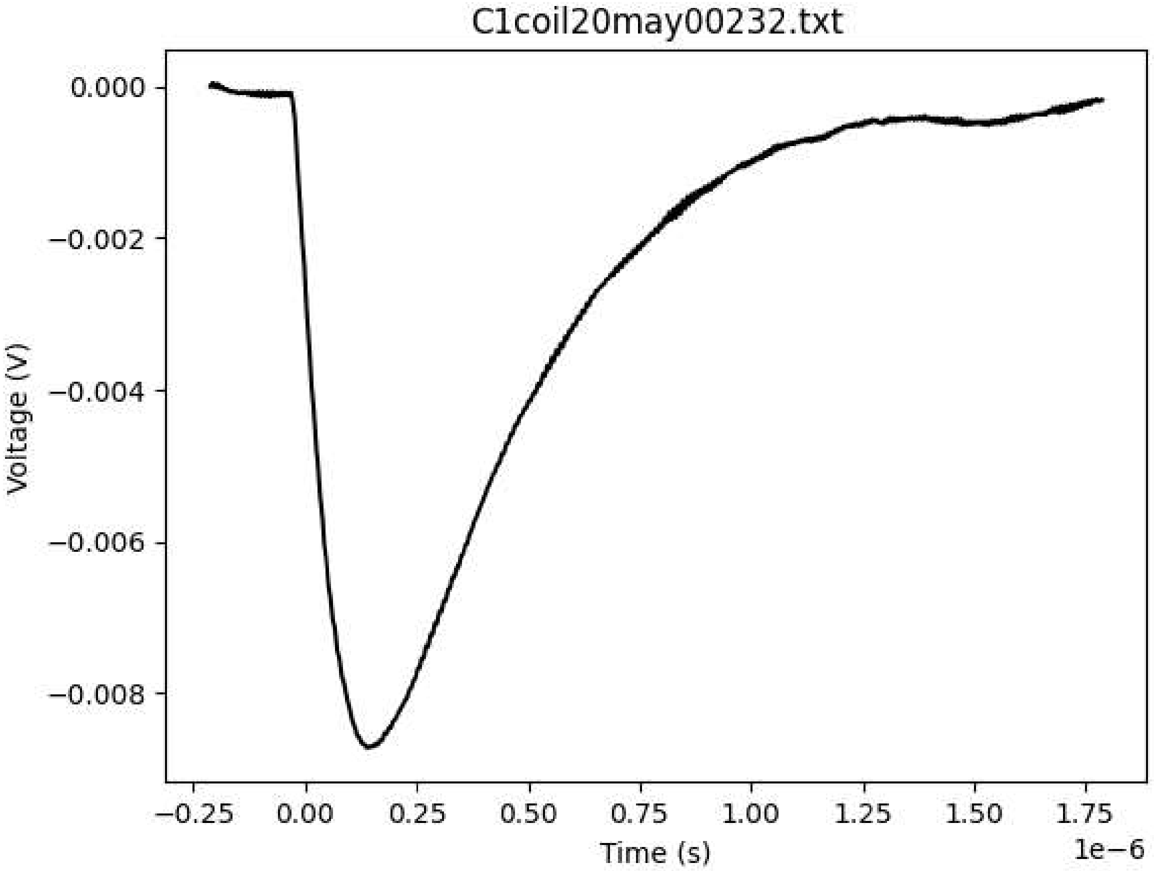
In [ ]:

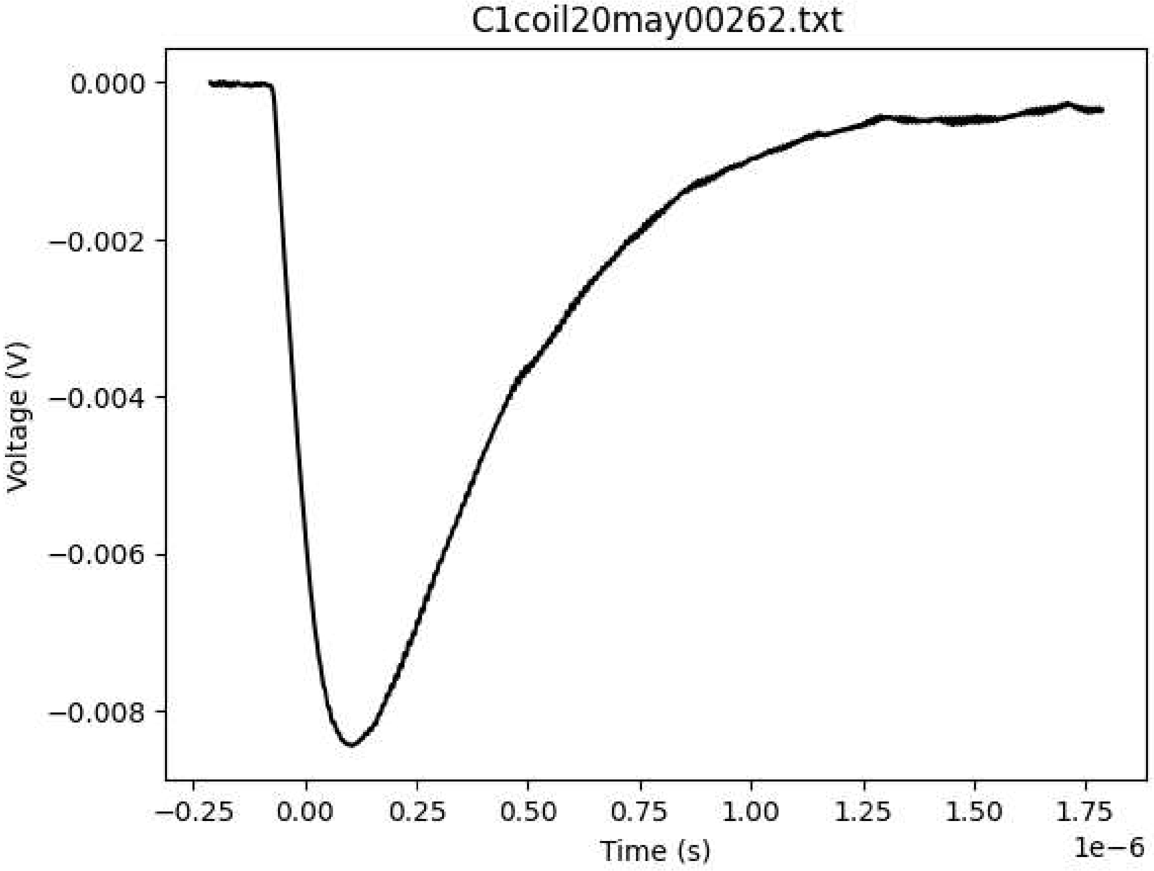
```
attraversamenti=list()
sos = signal.butter(oreder, frequenza_taglio, 'low', fs=1000, output='sos')

for i in numpy.arange(0, count3, 1):
    nome_file=f'C1coil20may{i:05}.txt'
    file_path = os.path.join(path_dir, nome_file)
    dataset = pd.read_csv(file_path, skiprows=4, delimiter='\t', engine='python'
    dataset=dataset[dataset.iloc[:,0]>=0]
    filtered = signal.sosfilt(sos, dataset.iloc[:,1])
    valore_medio=(filtered.max()+filtered.min())/2
    n_attraversamenti=0
    for index, valore in enumerate(dataset.iloc[:,1]):
        if index<len(dataset.iloc[:,1])-1:
            if valore==valore_medio:
                n_attraversamenti+=1
            else:
                valore_successivo=dataset.iloc[index+1,1]
                if valore<valore_medio:
                    if valore_successivo>valore_medio:
                        n_attraversamenti+=1
                elif valore>valore_medio:
                    if valore_successivo<valore_medio:
                        n_attraversamenti+=1
    attraversamenti.append(n_attraversamenti)

media_attarversamenti=numpy.mean(attraversamenti)
```

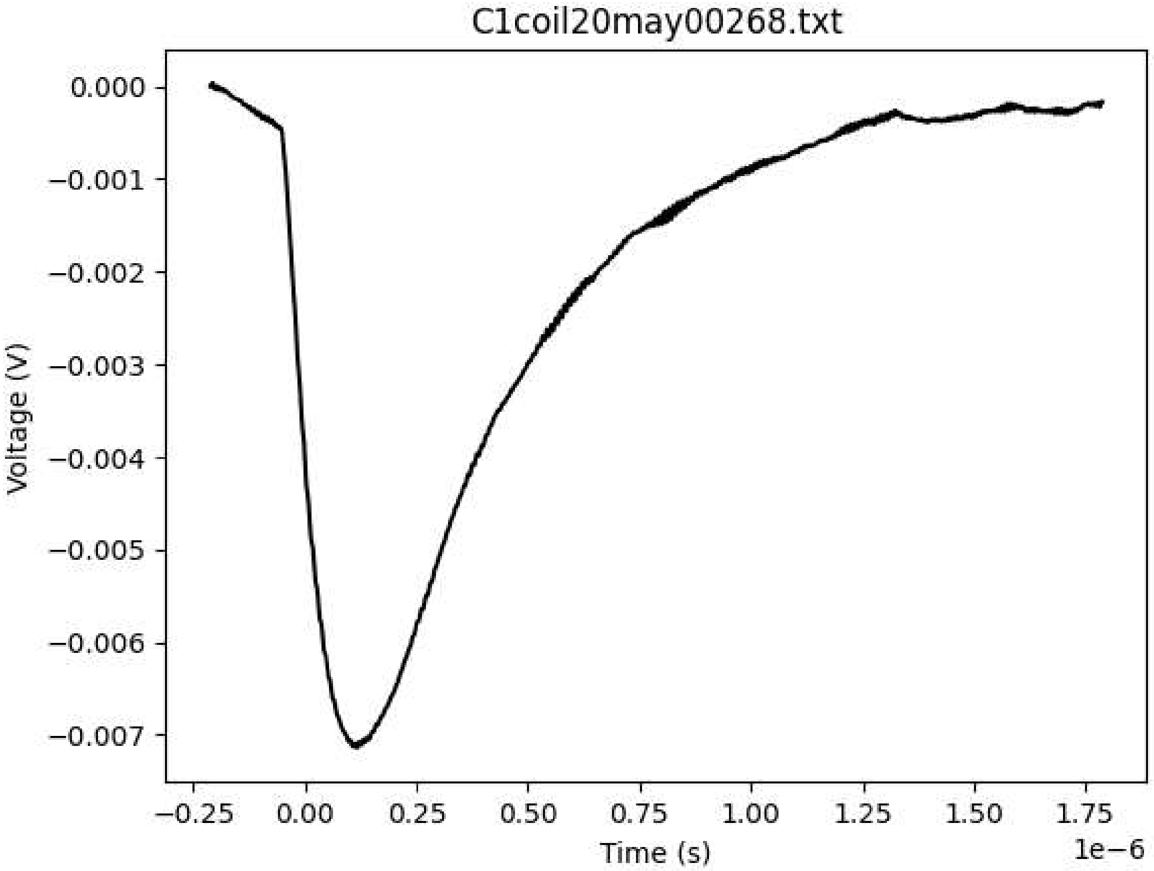
In [ ]:

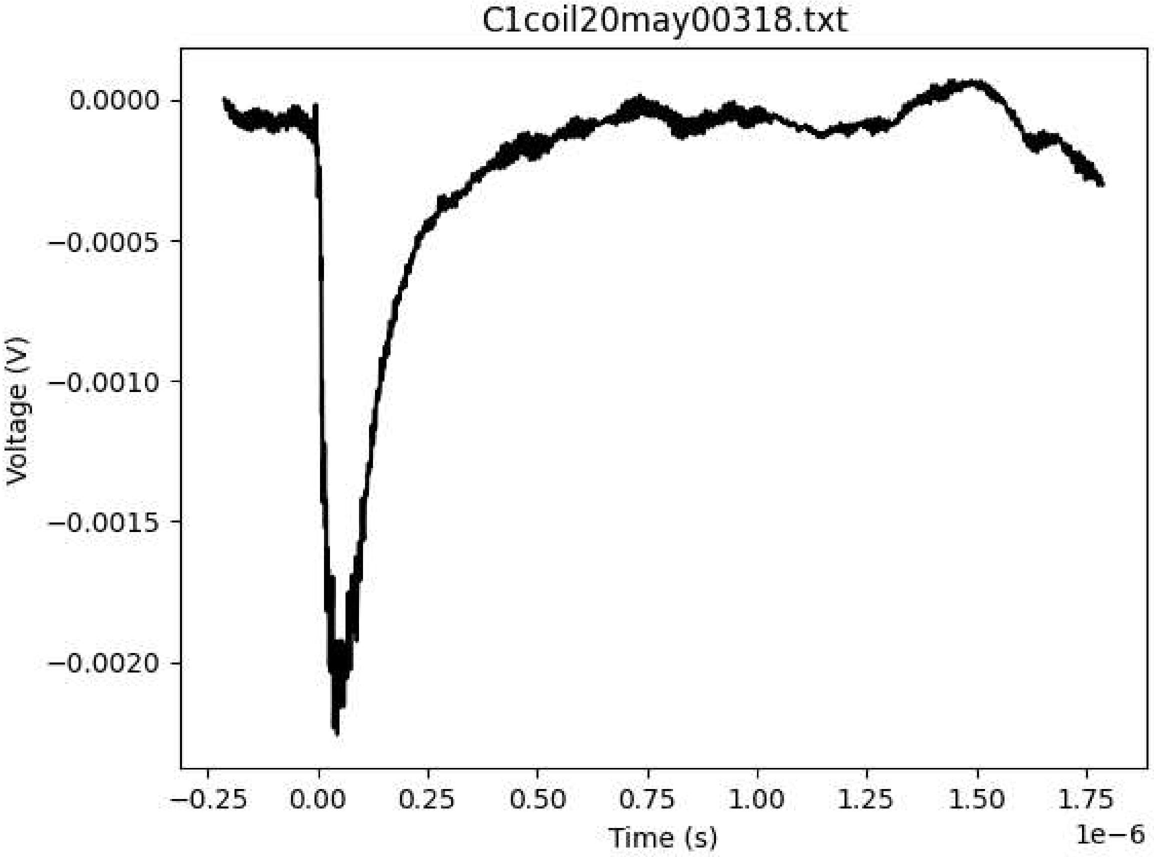
```
massimi4=list()

for i in numpy.arange(0, count3, 1):
    nome_file=f'C1coil20may{i:05}.txt'
    file_path = os.path.join(path_dir, nome_file)
    dataset = pd.read_csv(file_path, skiprows=4, delimiter='\t', engine='python'
    filtered = signal.sosfilt(sos, dataset.iloc[:,1])
    if attraversamenti[i]<2*media_attarversamenti:
          massimi4.append(min(dataset.iloc[:,1])*1000)
    else:
            plt.clf()
            plt.plot(dataset.iloc[:,0], filtered, color='#000000')
            plt.title(nome_file)
            plt.xlabel("Time (s)")
            plt.ylabel("Voltage (V)")
            plt.show()
```

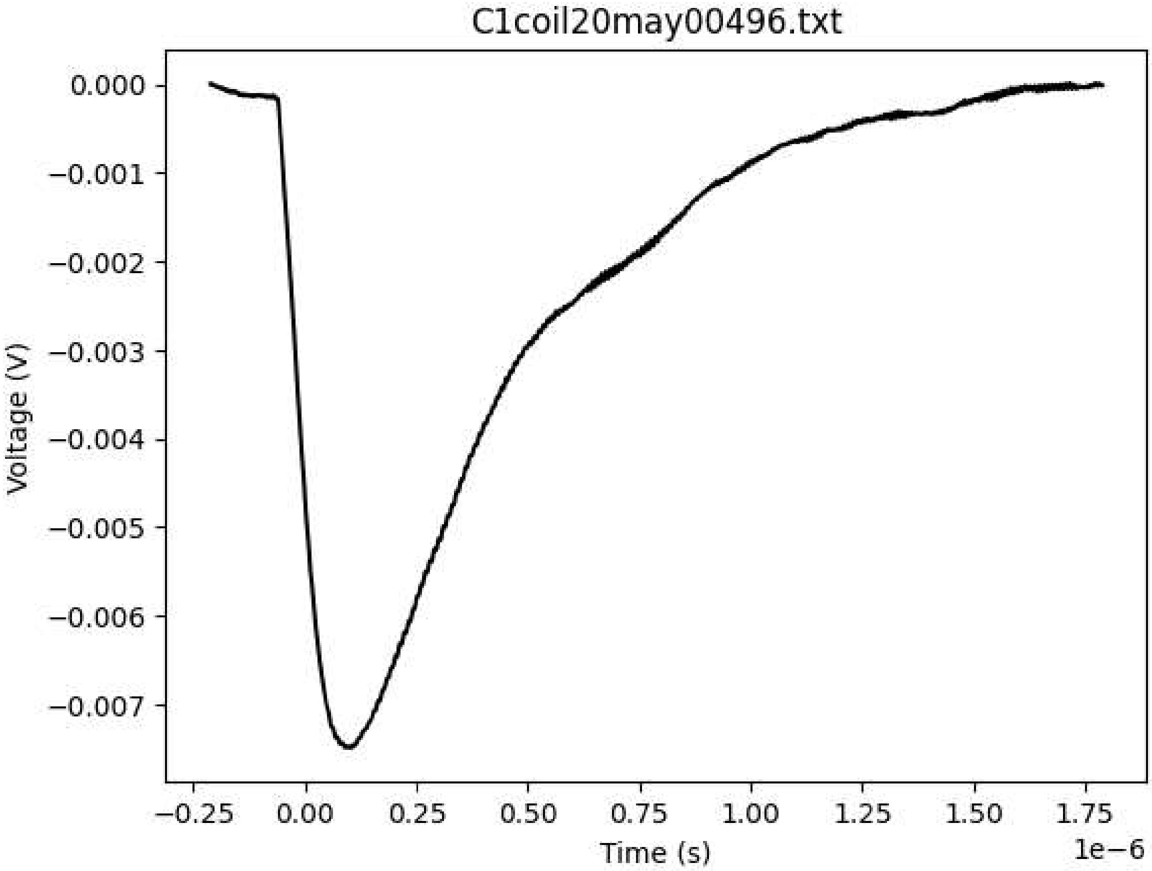


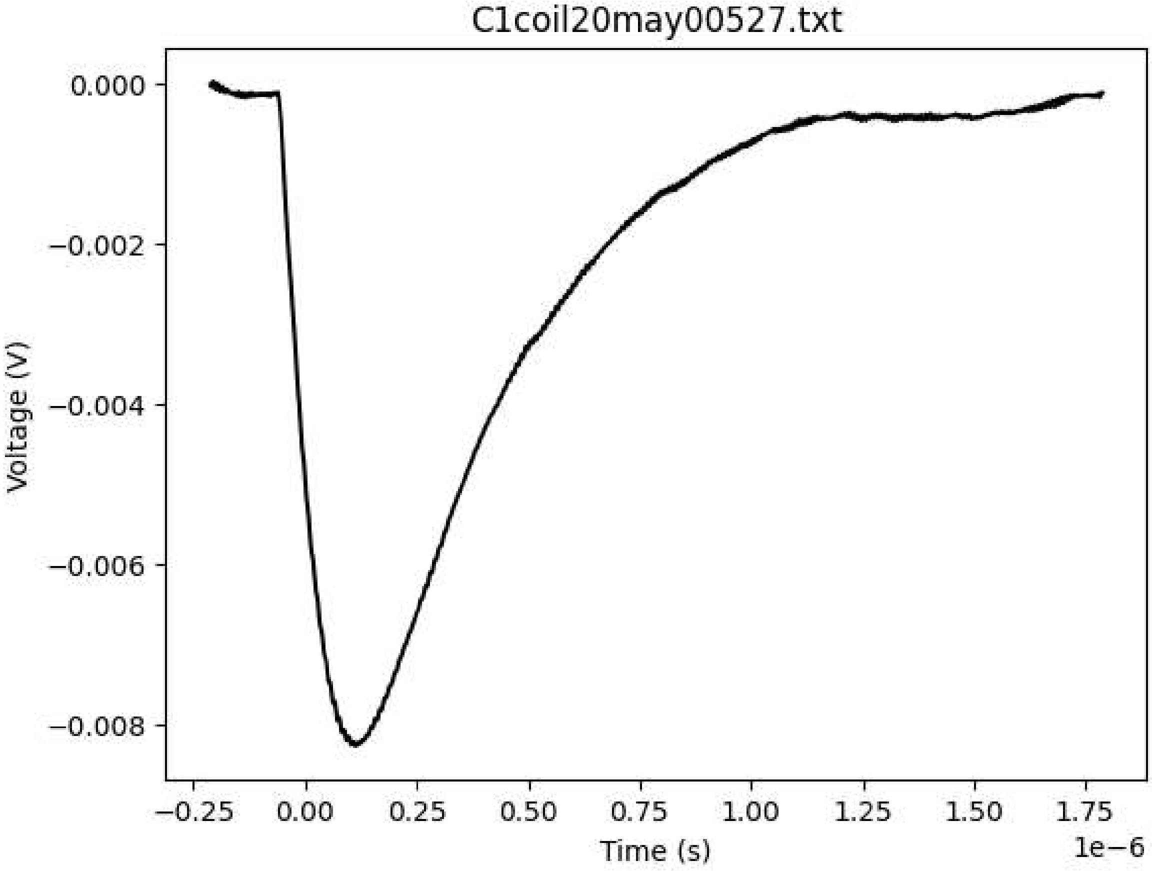

C1coil20may00232.txt
Voltage (V)
0.000
−0.002
−0.004
−0.006
−0.008
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

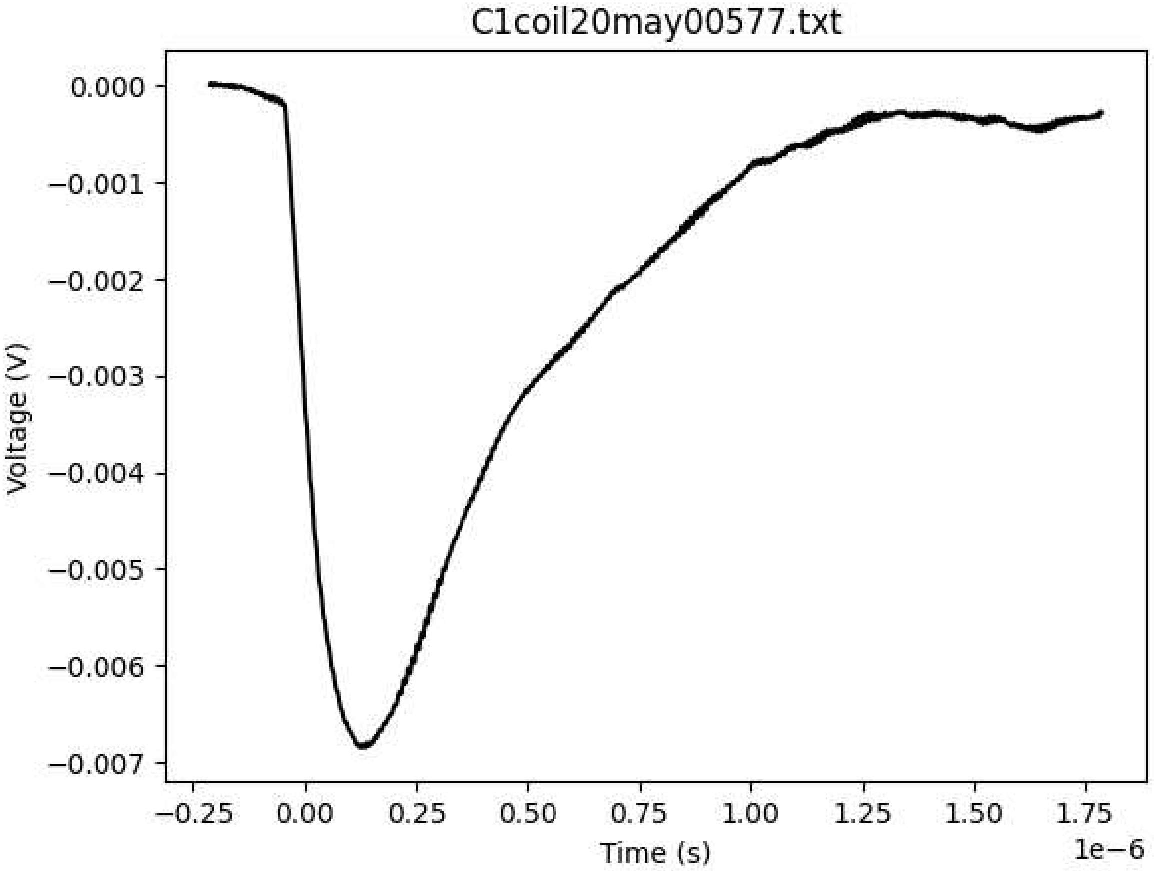

C1coil20may00262.txt
Voltage (V)
0.000
−0.002
−0.004
−0.006
−0.008
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

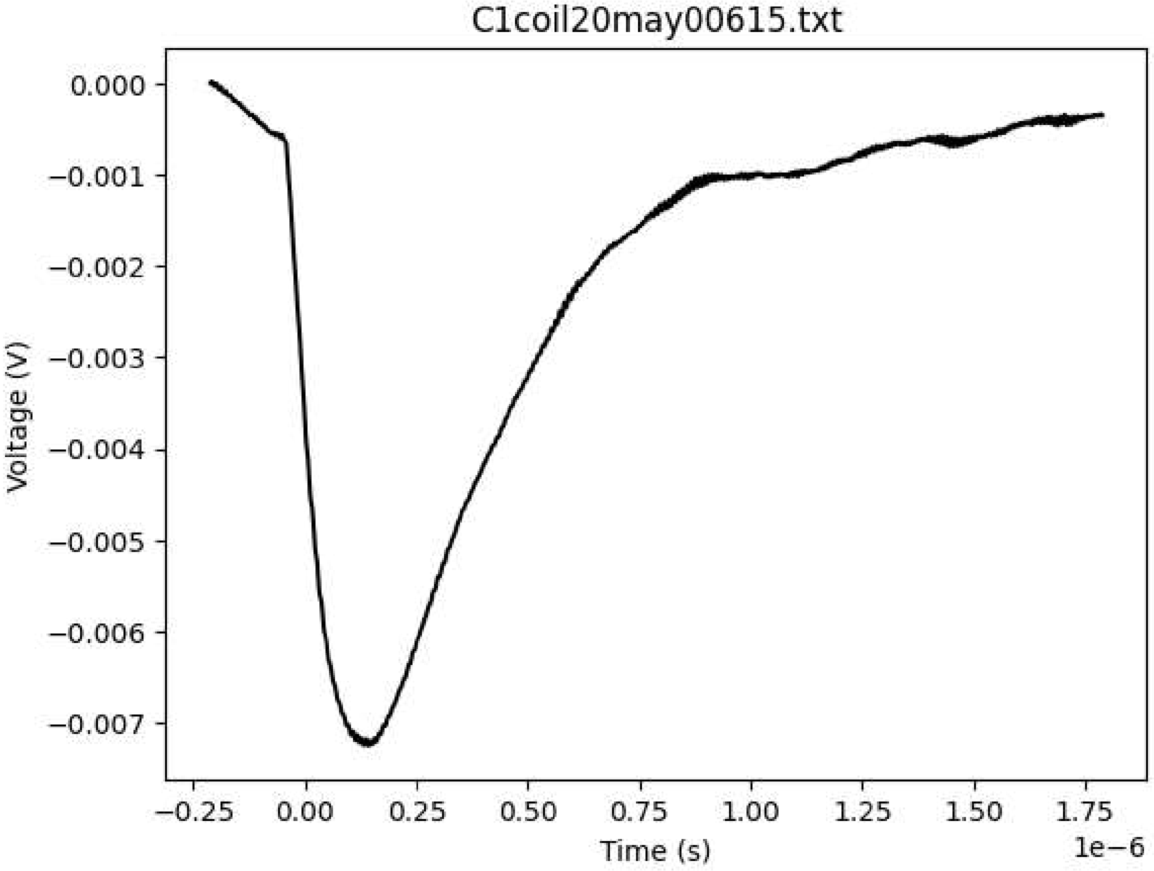

C1coil20may00268.txt
Voltage (V)
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6

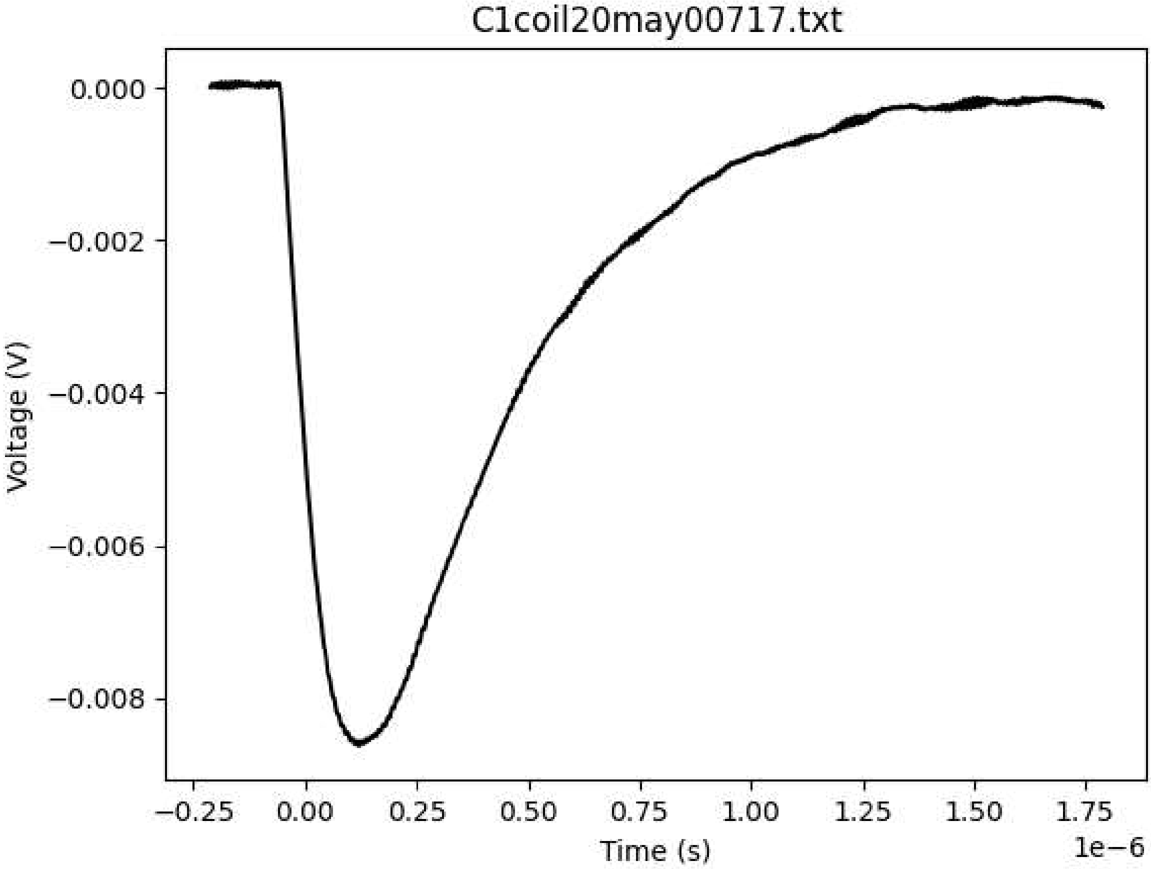

C1coil20may00318.txt
Voltage (V)
0.0000
−0.0005
−0.0010
−0.0015
−0.0020
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6

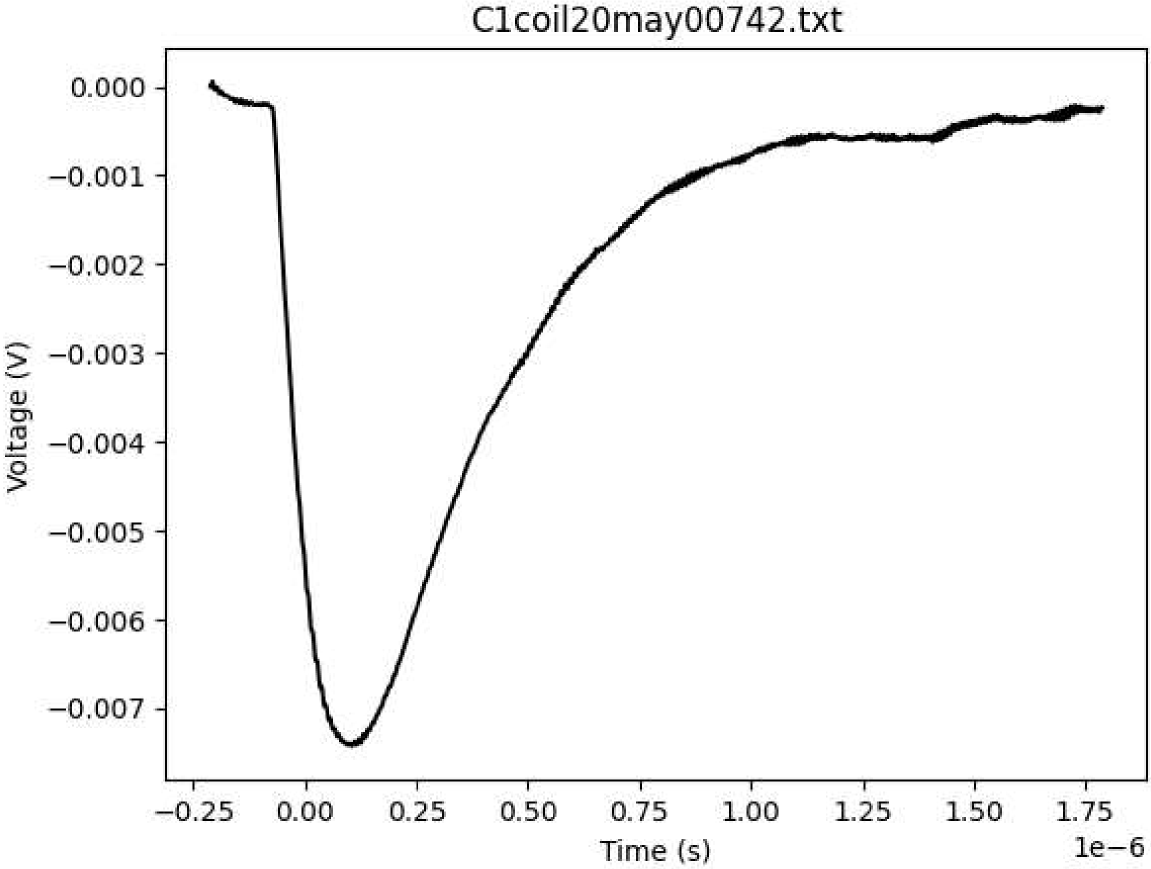

C1coil20may00496.txt
Voltage (V)
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6
Time (s)

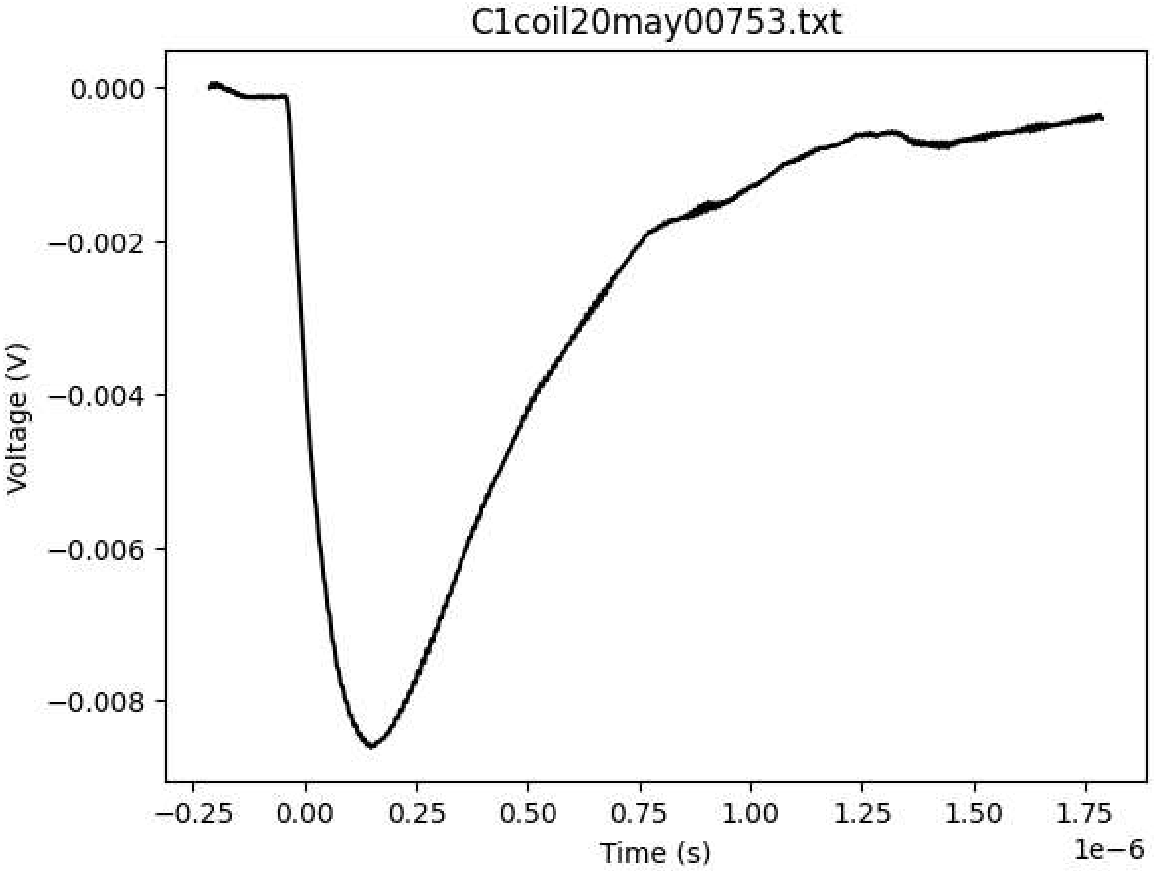

C1coil20may00527.txt
Voltage (V)
0.000
−0.002
−0.004
−0.006
−0.008
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6
Time (s)

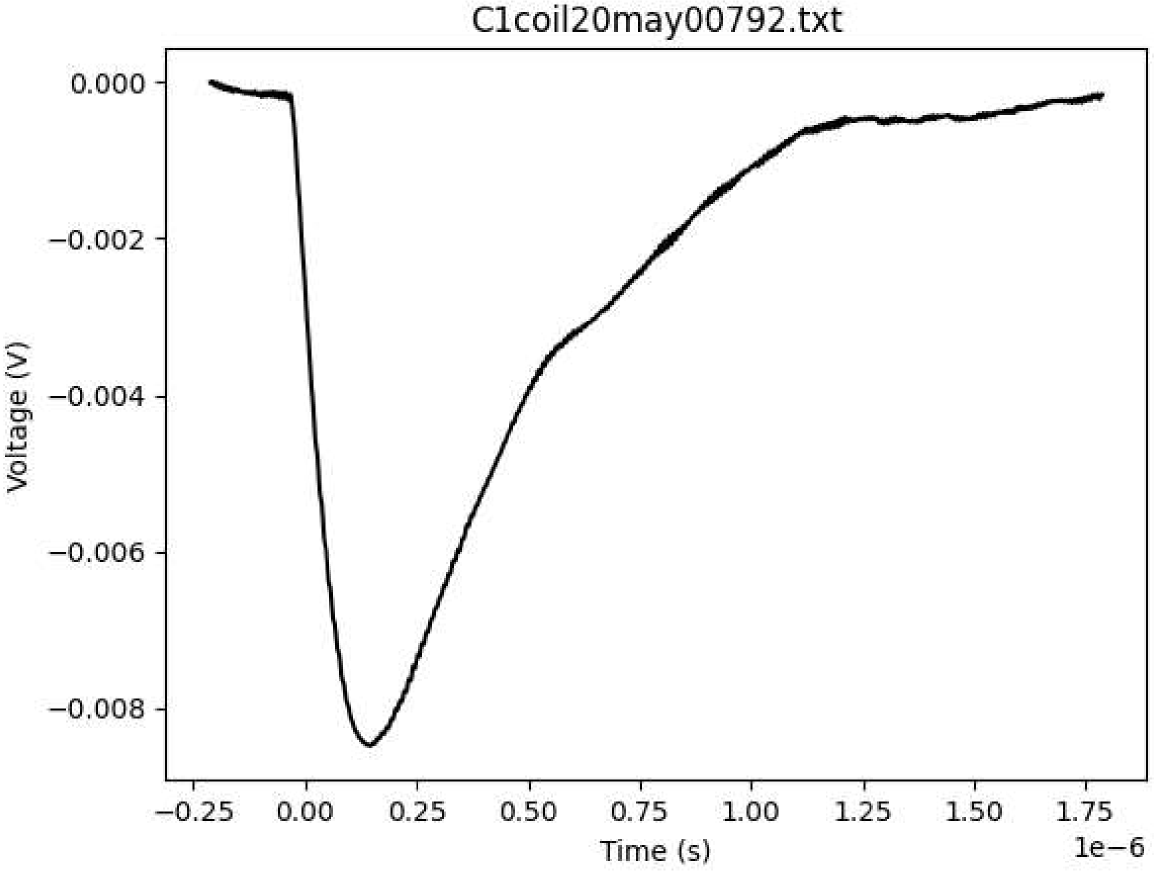

C1coil20may00577.txt
Voltage (V)
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

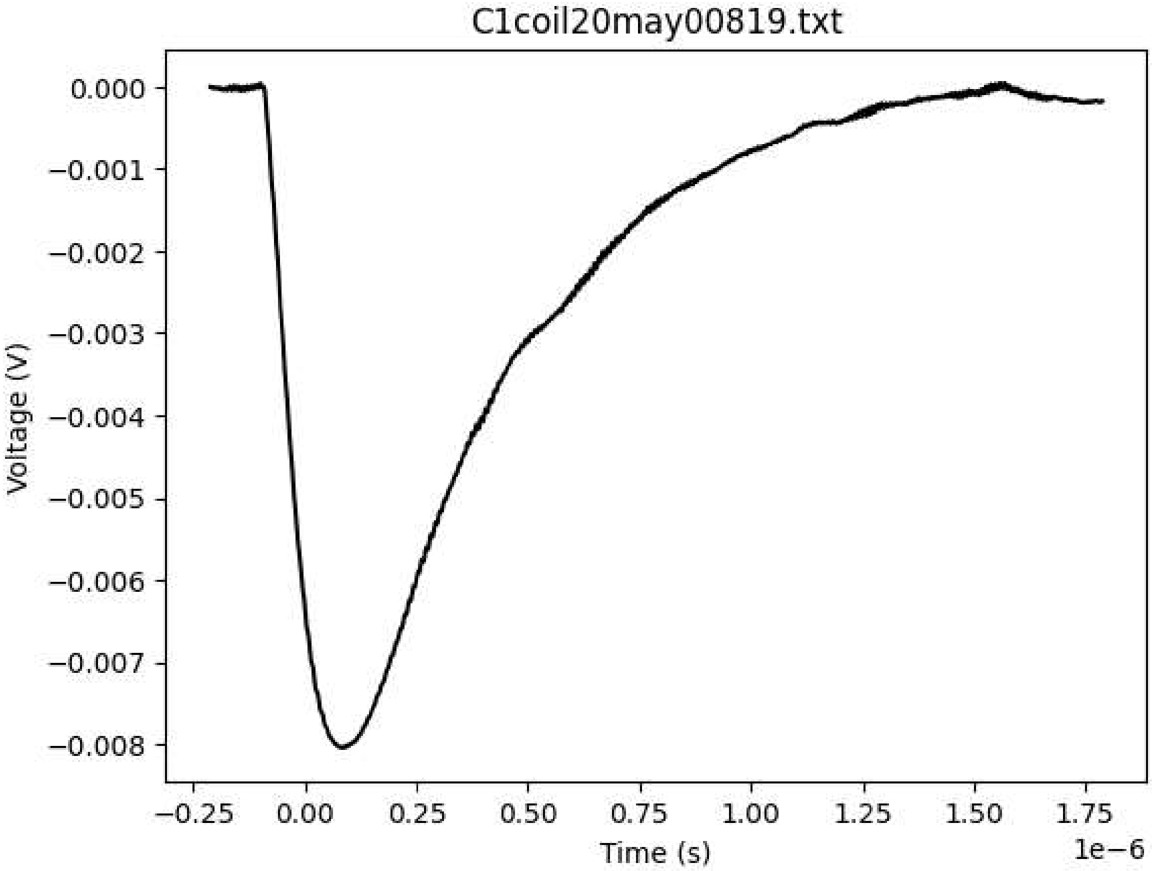

C1coil20may00615.txt
Voltage (V)
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

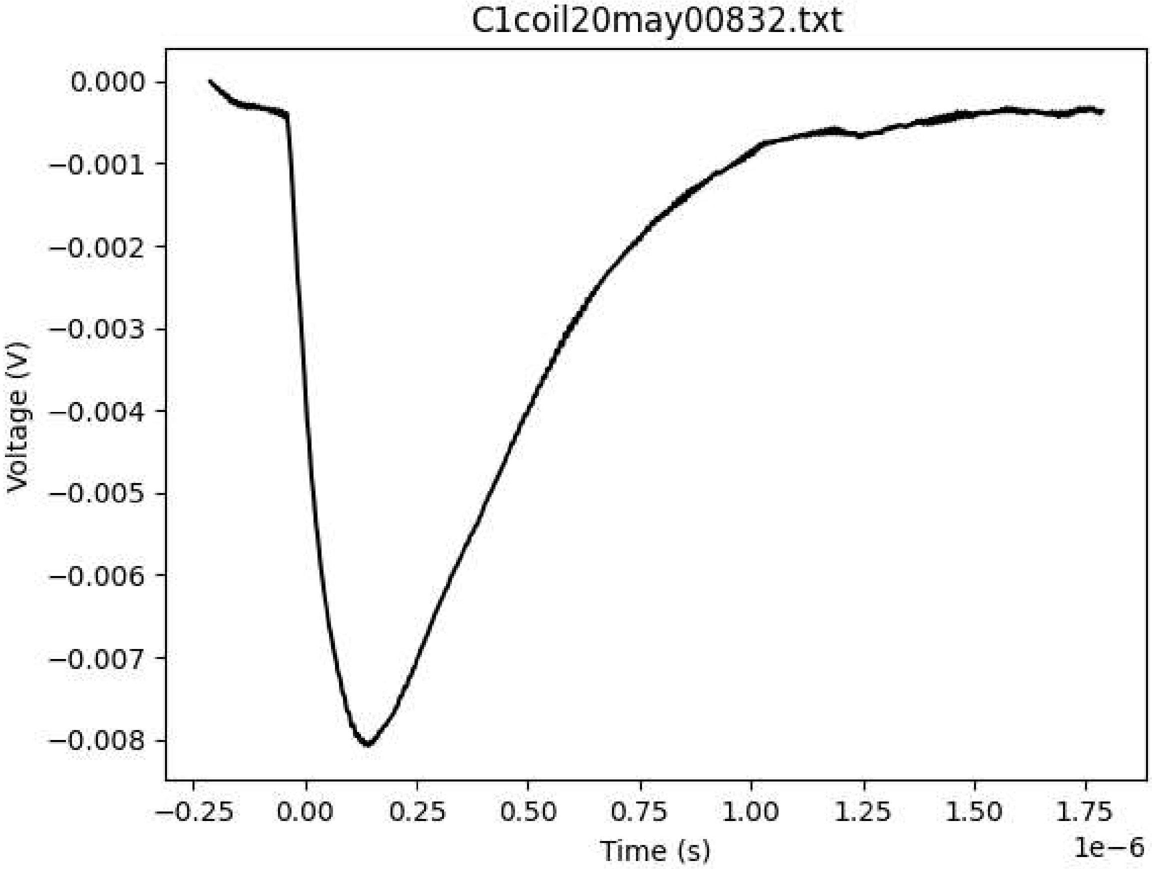

C1coil20may00717.txt
Voltage (V)
0.000
−0.002
−0.004
−0.006
−0.008
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

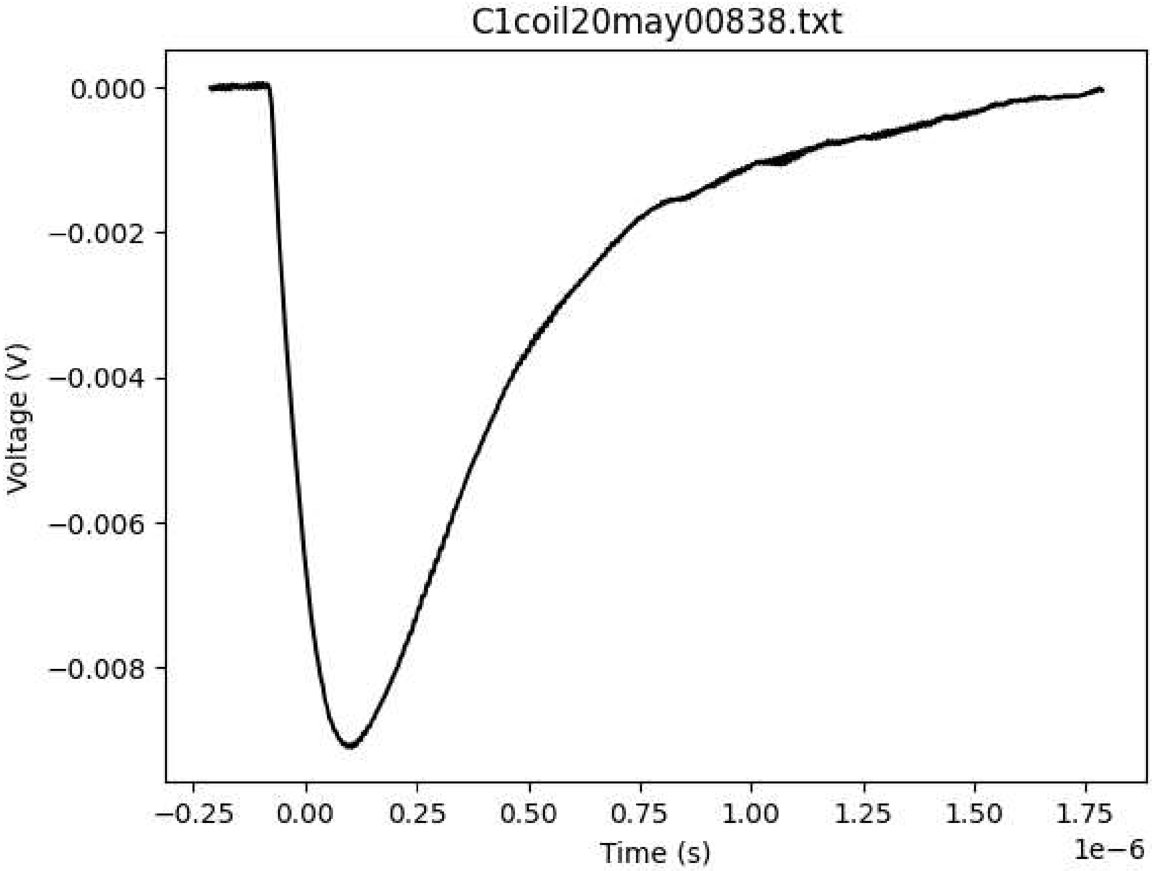

C1coil20may00742.txt
Voltage (V)
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

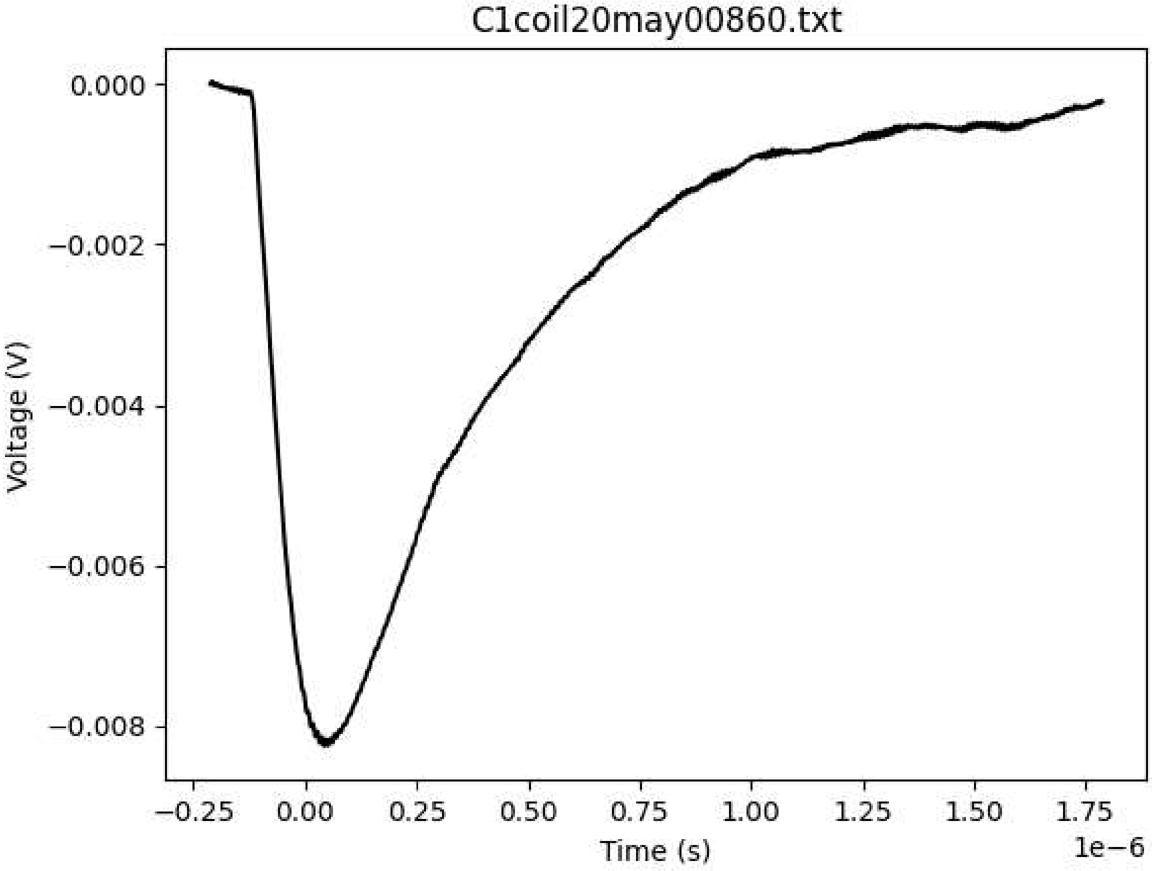

C1coil20may00753.txt
Voltage (V)
0.000
−0.002
−0.004
−0.006
−0.008
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6

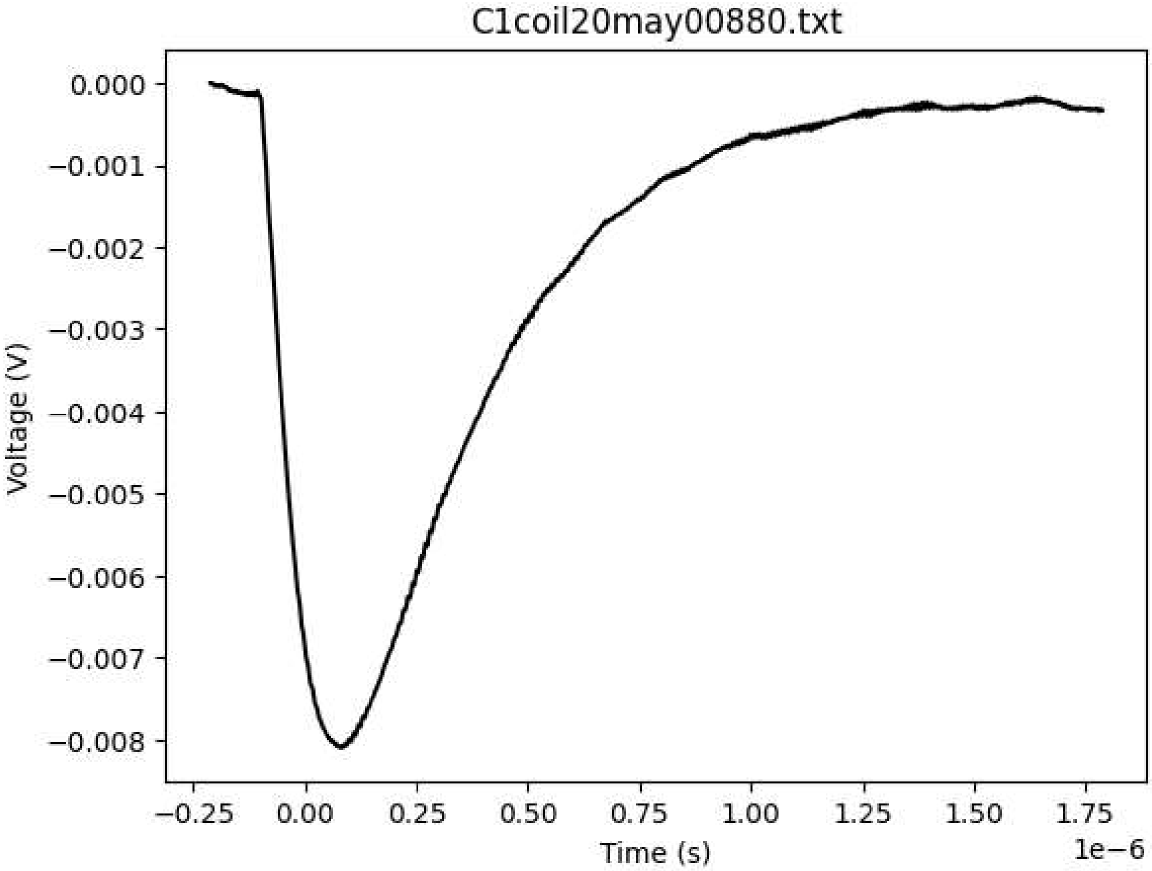

C1coil20may00792.txt
Voltage (V)
0.000
−0.002
−0.004
−0.006
−0.008
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6

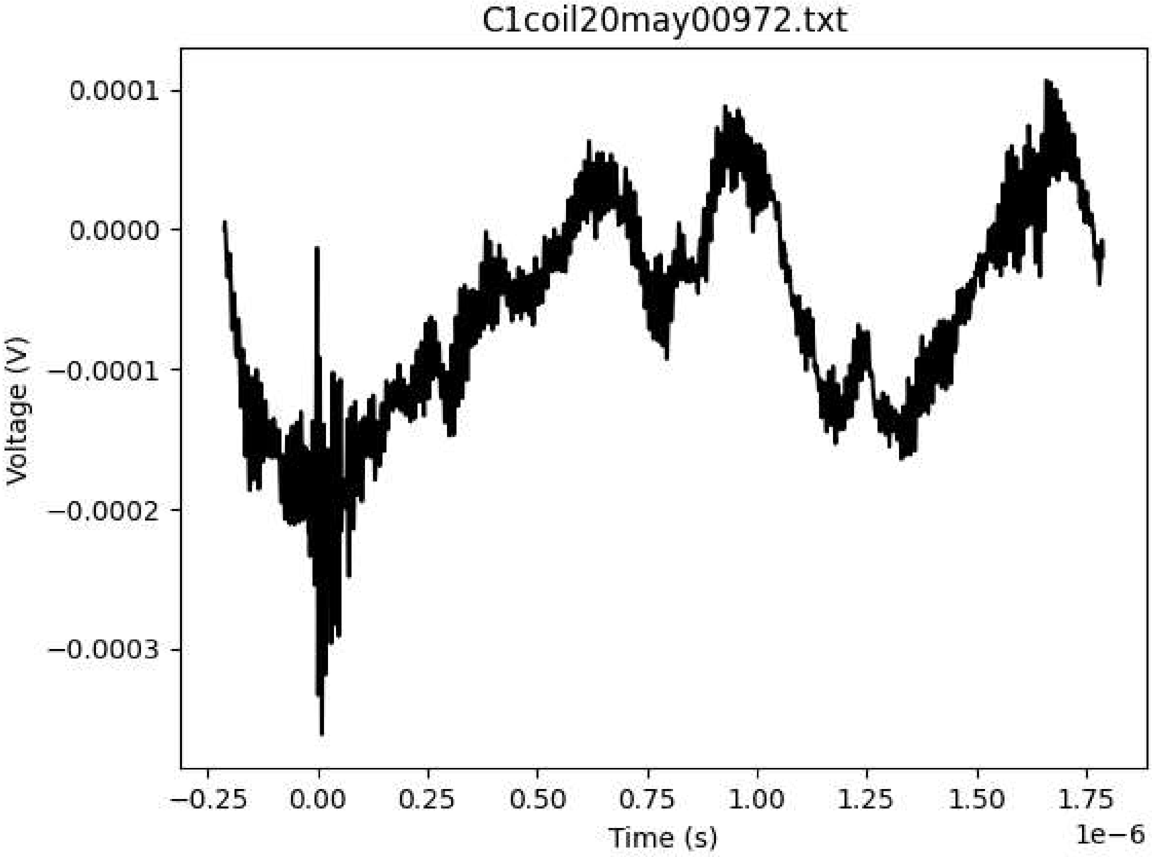

C1coil20may00819.txt
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.008
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

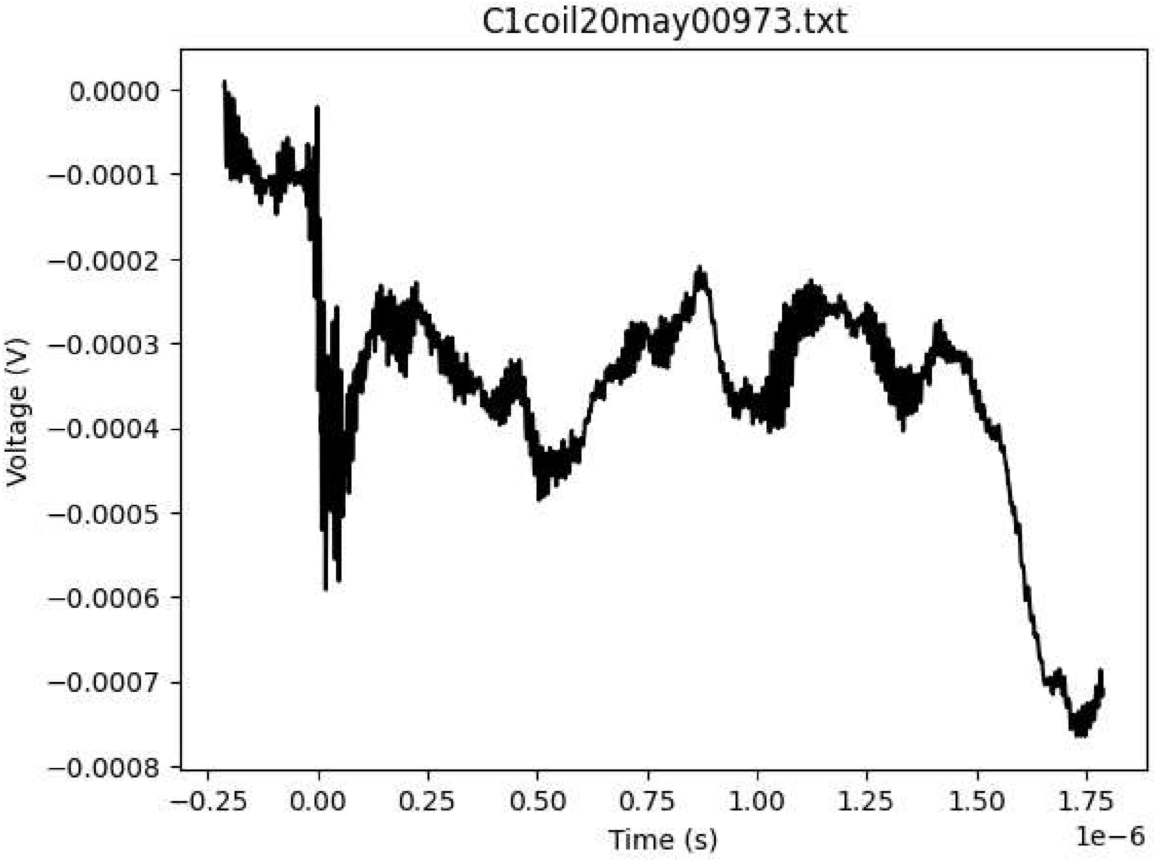

C1coil20may00832.txt
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.008
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

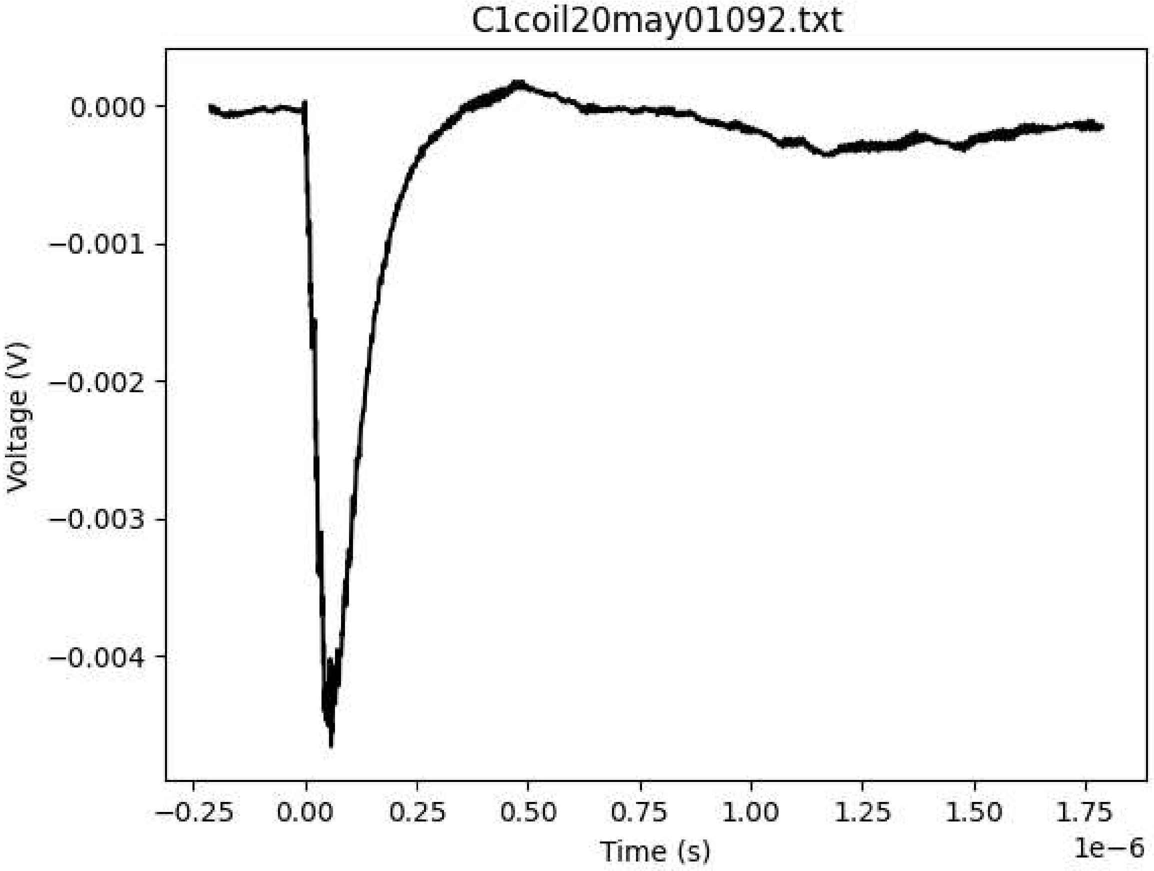

C1coil20may00838.txt
0.000
−0.002
−0.004
−0.006
−0.008
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

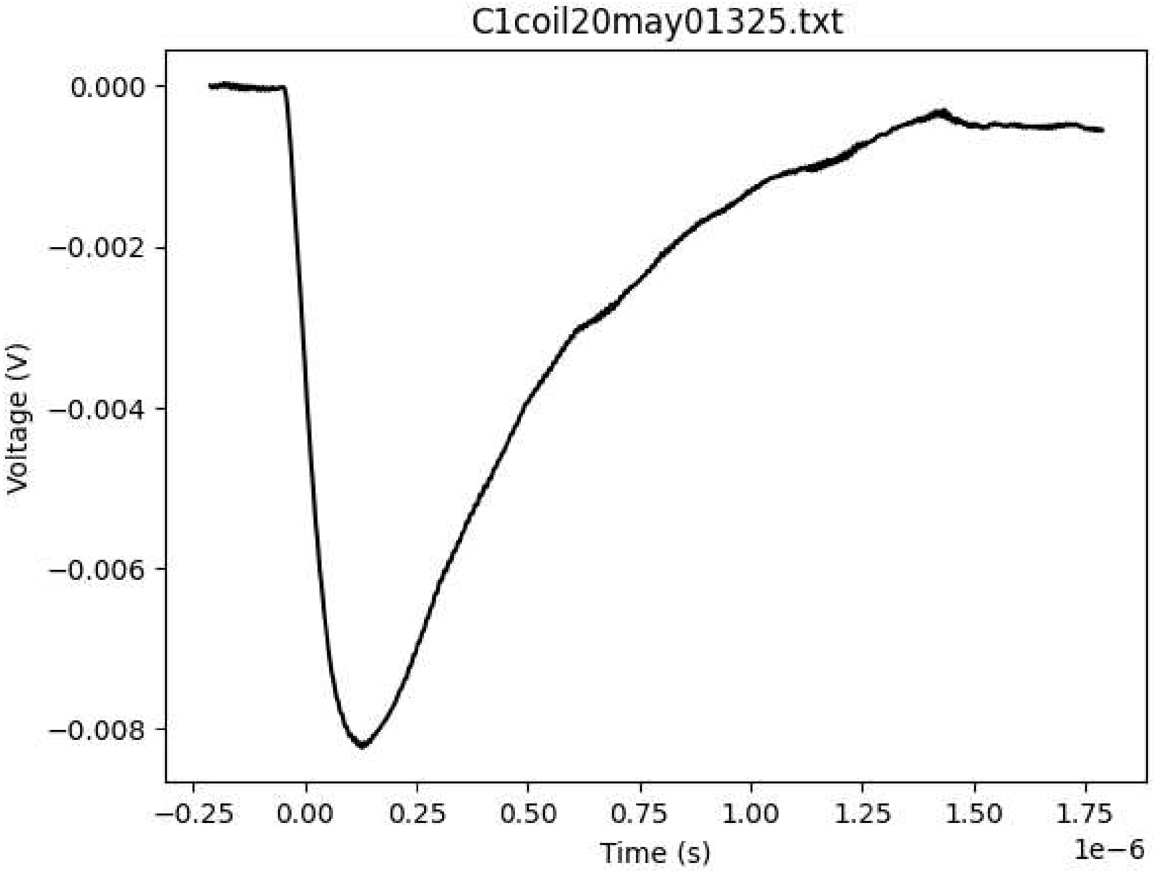

C1coil20may00860.txt
0.000
−0.002
−0.004
−0.006
−0.008
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

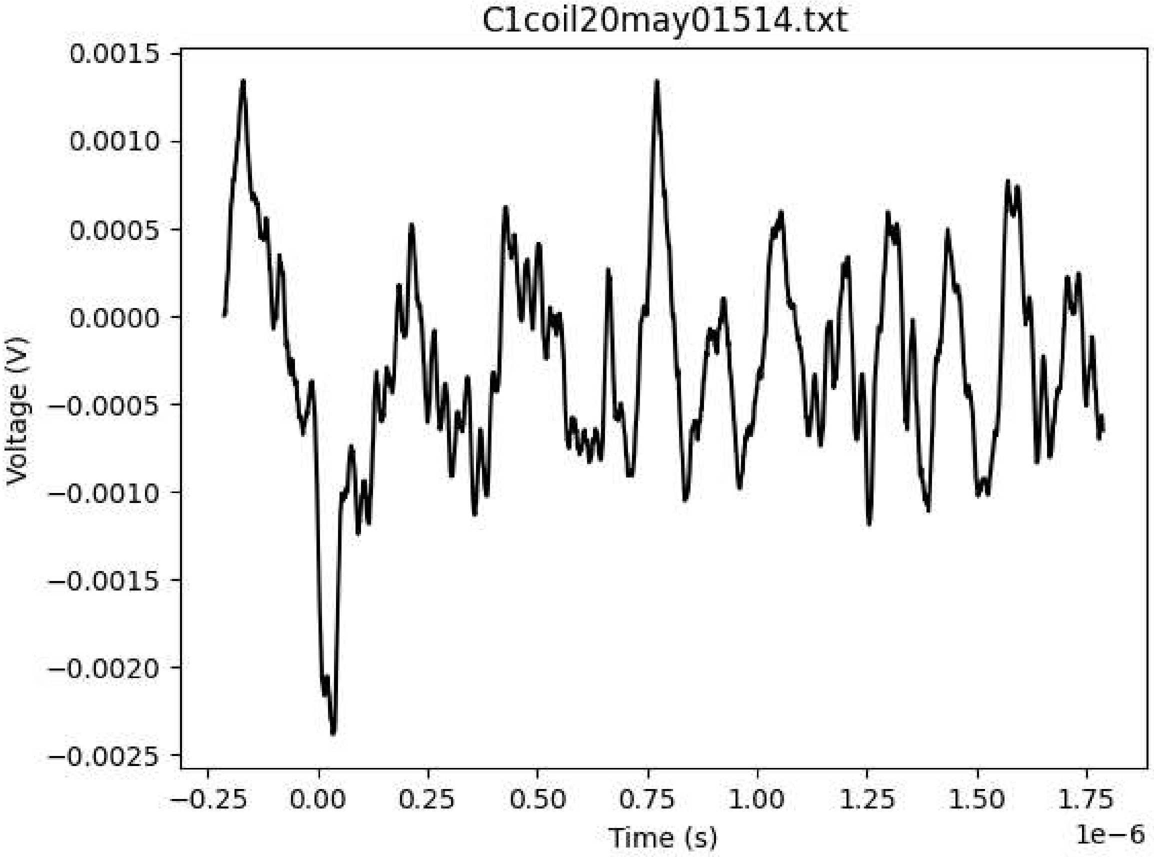

C1coil20may00880.txt
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.008
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

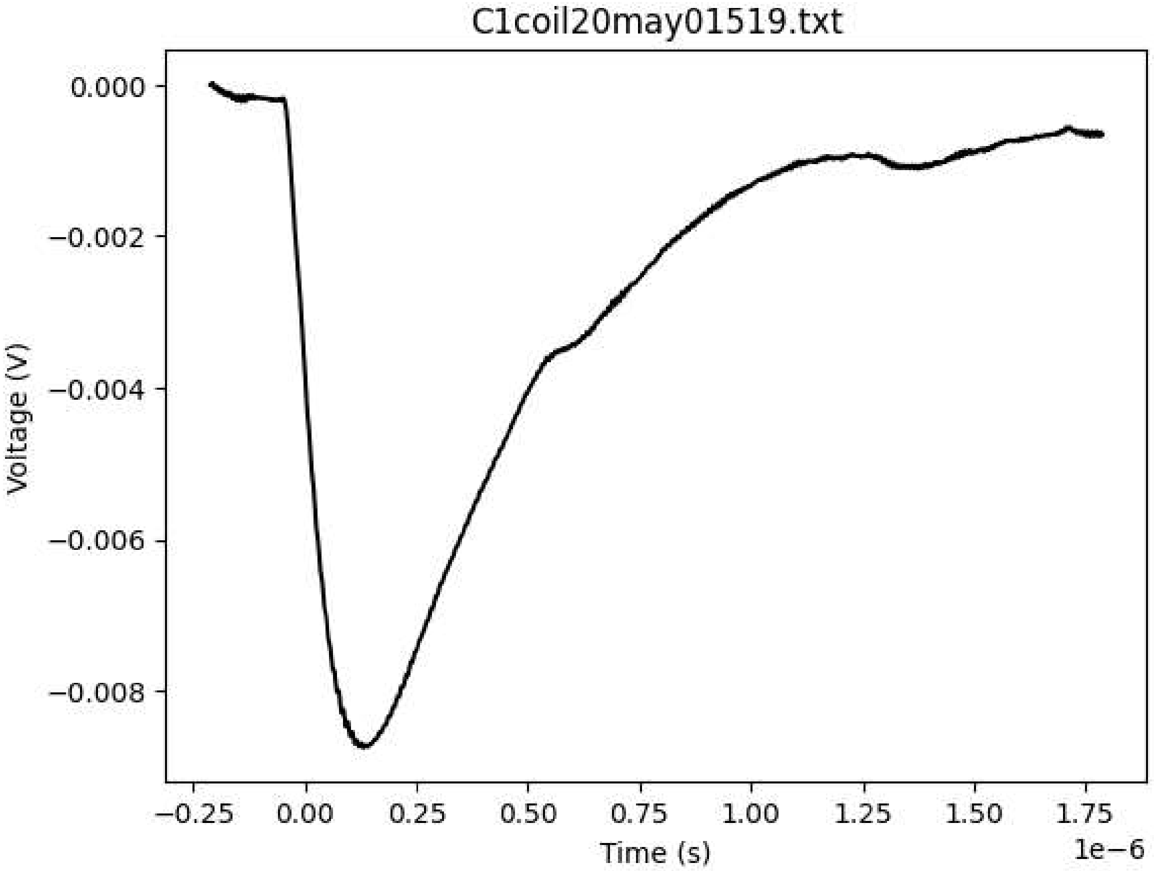

C1coil20may00972.txt
0.0001
0.0000
−0.0001
−0.0002
−0.0003
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

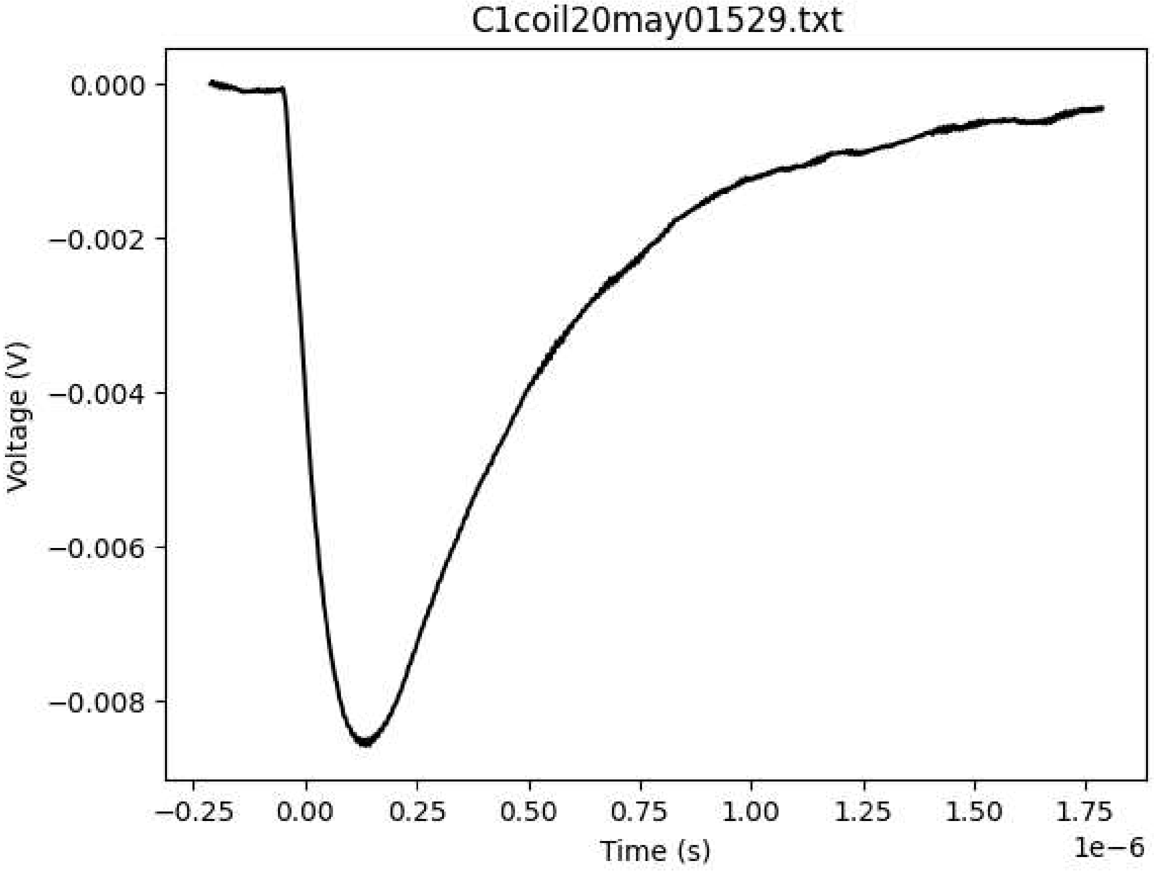

C1coil20may00973.txt
Voltage (V)
0.0000
−0.0001
−0.0002
−0.0003
−0.0004
−0.0005
−0.0006
−0.0007
−0.0008
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

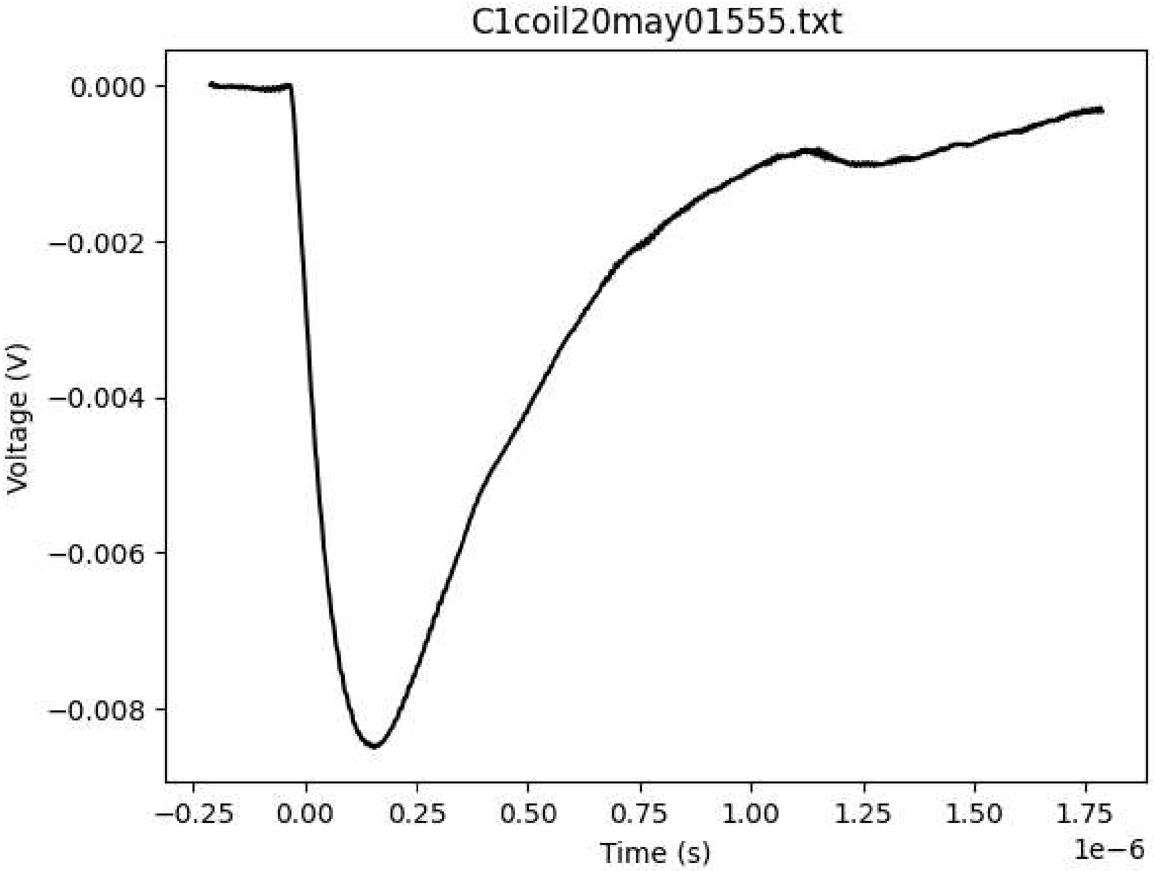

C1coil20may01092.txt
Voltage (V)
0.000
−0.001
−0.002
−0.003
−0.004
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

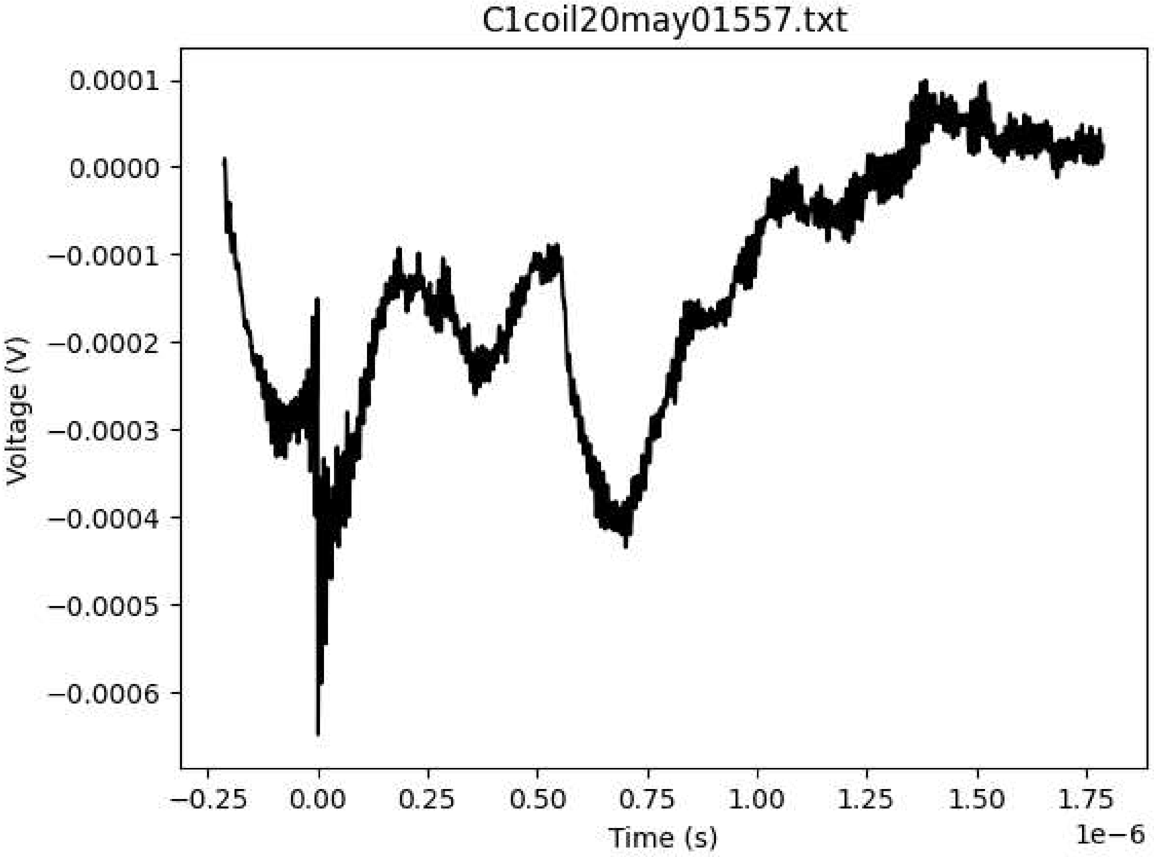

C1coil20may01325.txt
Voltage (V)
0.000
−0.002
−0.004
−0.006
−0.008
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6

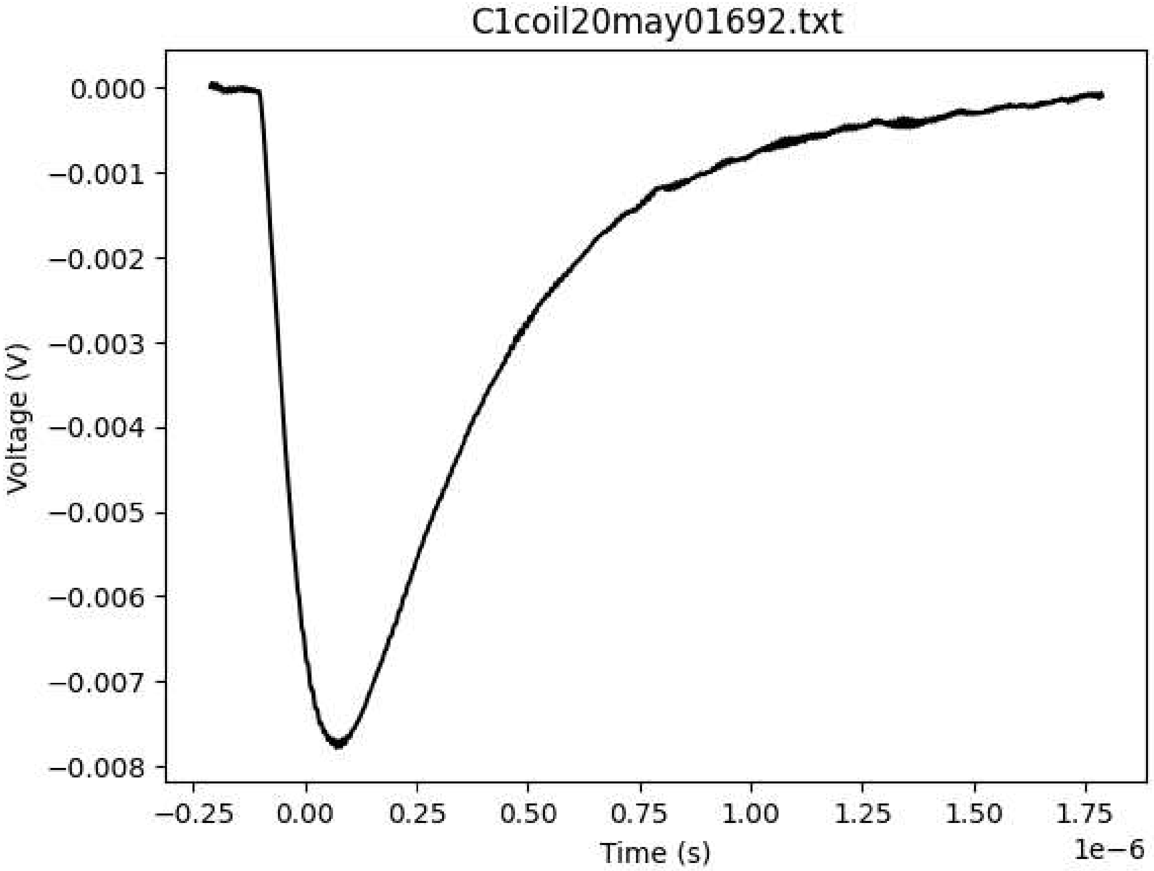

C1coil20may01514.txt
Voltage (V)
0.0015
0.0010
0.0005
0.0000
−0.0005
−0.0010
−0.0015
−0.0020
−0.0025
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6

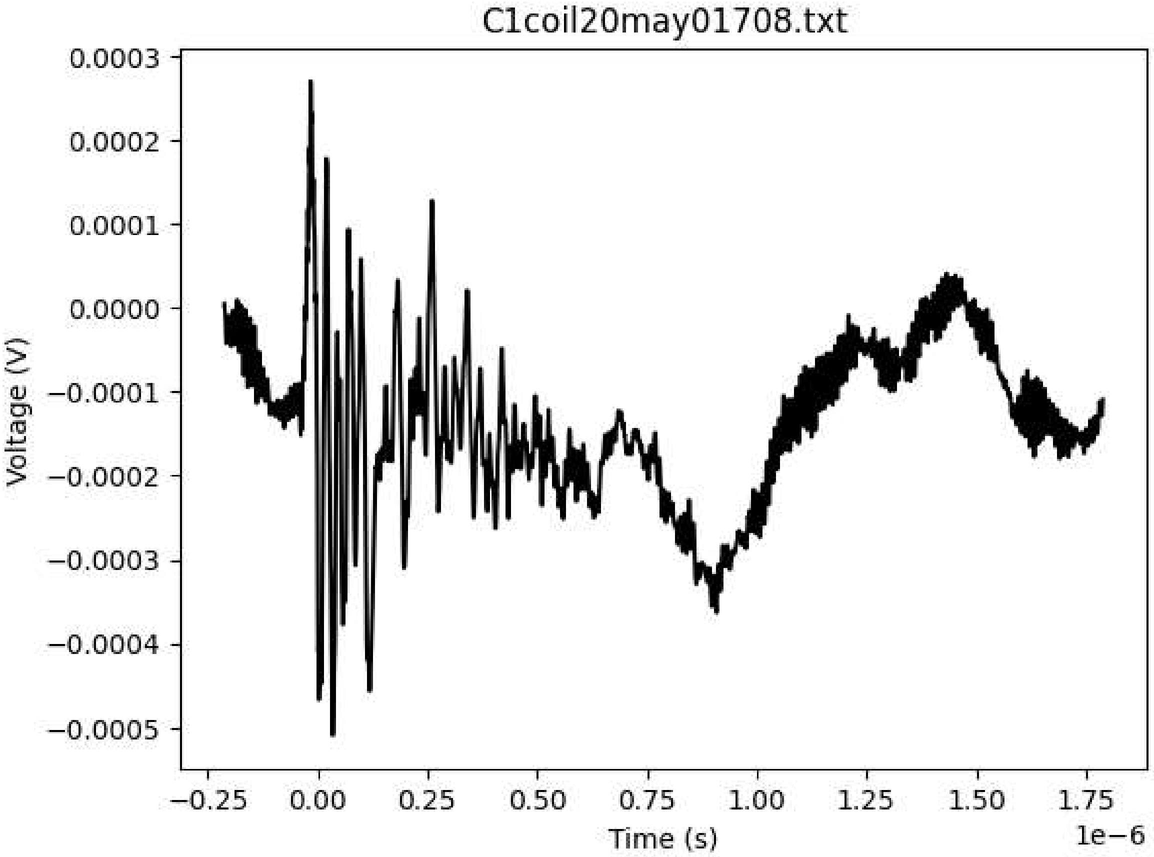

C1coil20may01519.txt
0.000
−0.002
−0.004
−0.006
−0.008
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

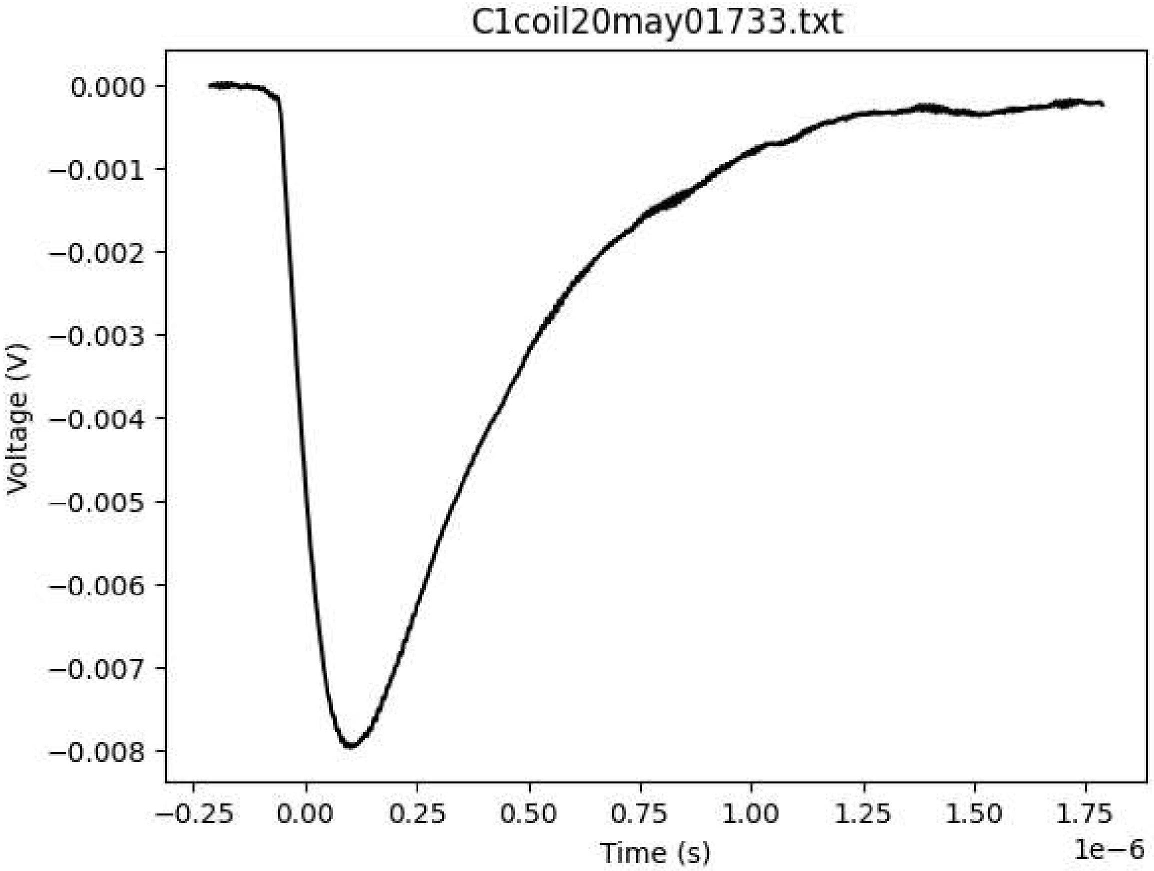

C1coil20may01529.txt
0.000
−0.002
−0.004
−0.006
−0.008
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

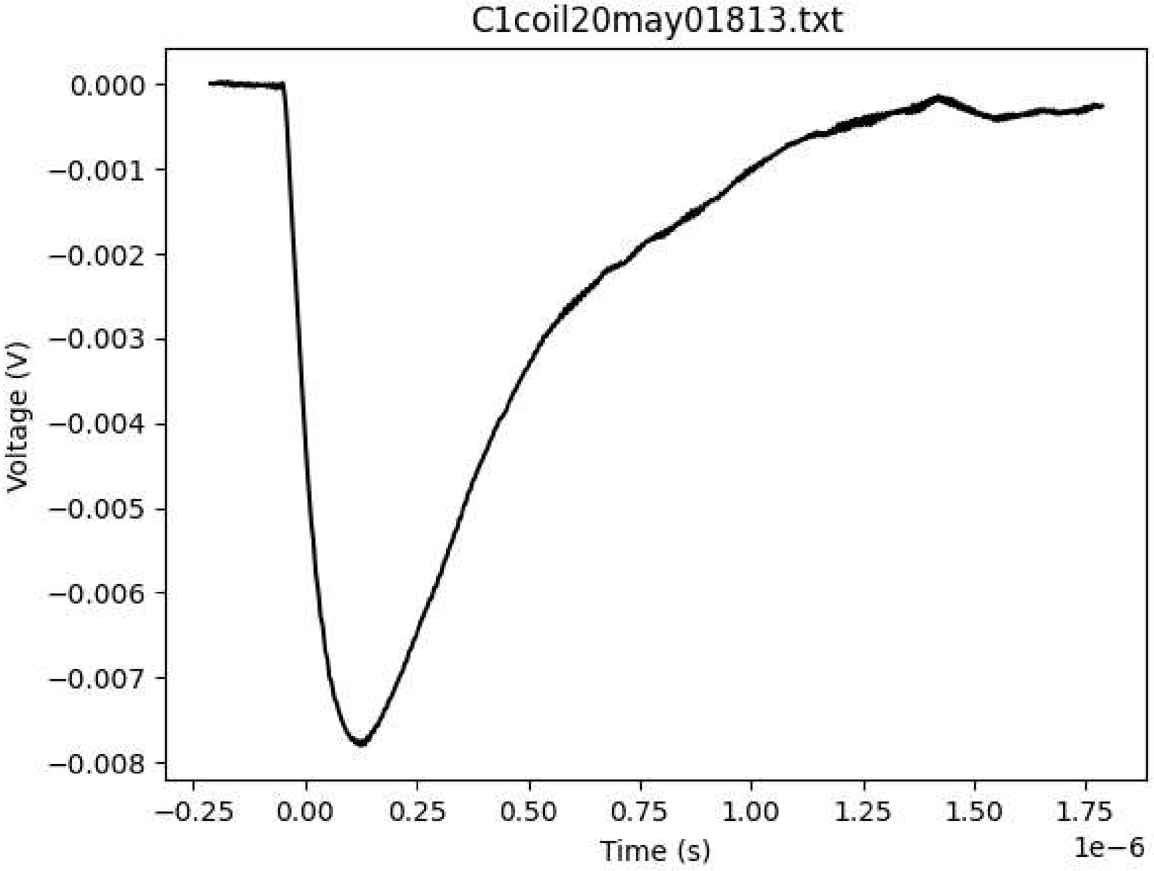

C1coil20may01555.txt
0.000
−0.002
−0.004
−0.006
−0.008
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

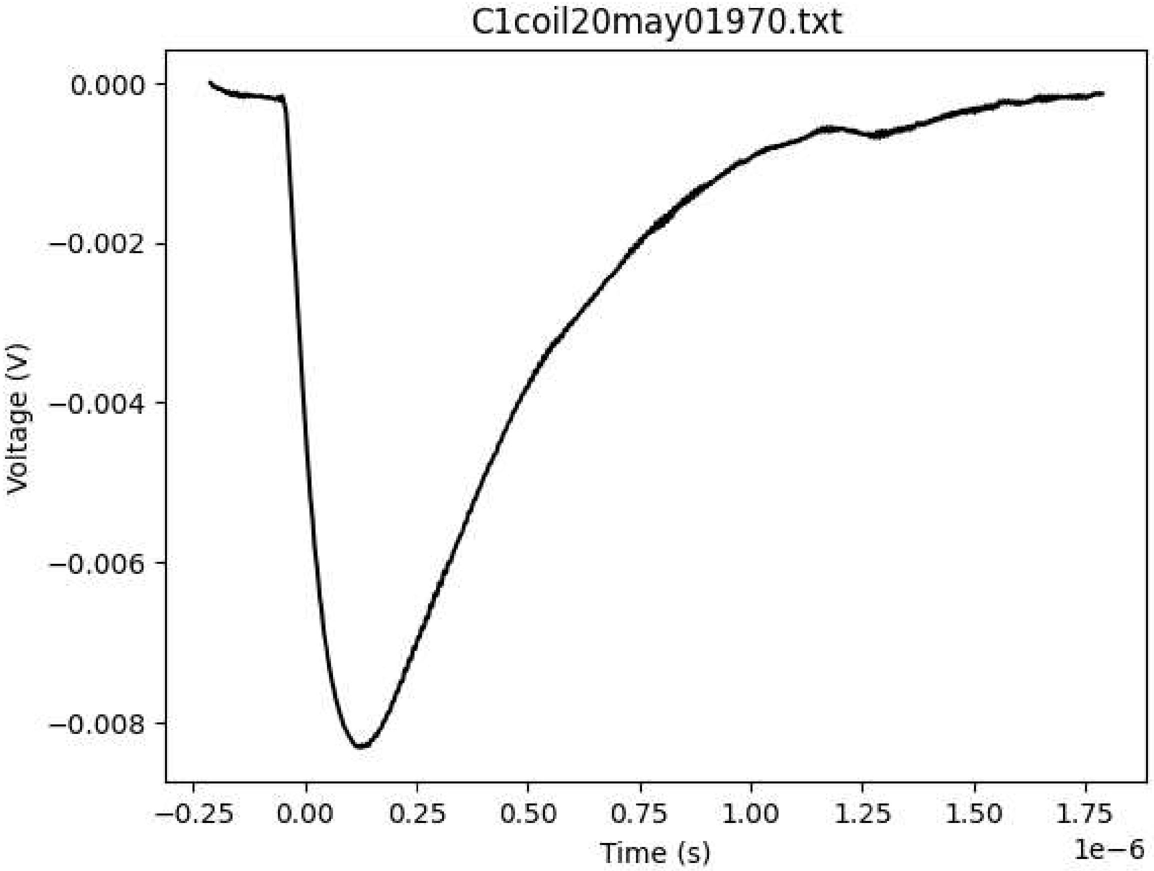

C1coil20may01557.txt
0.0001
0.0000
−0.0001
−0.0002
−0.0003
−0.0004
−0.0005
−0.0006
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6

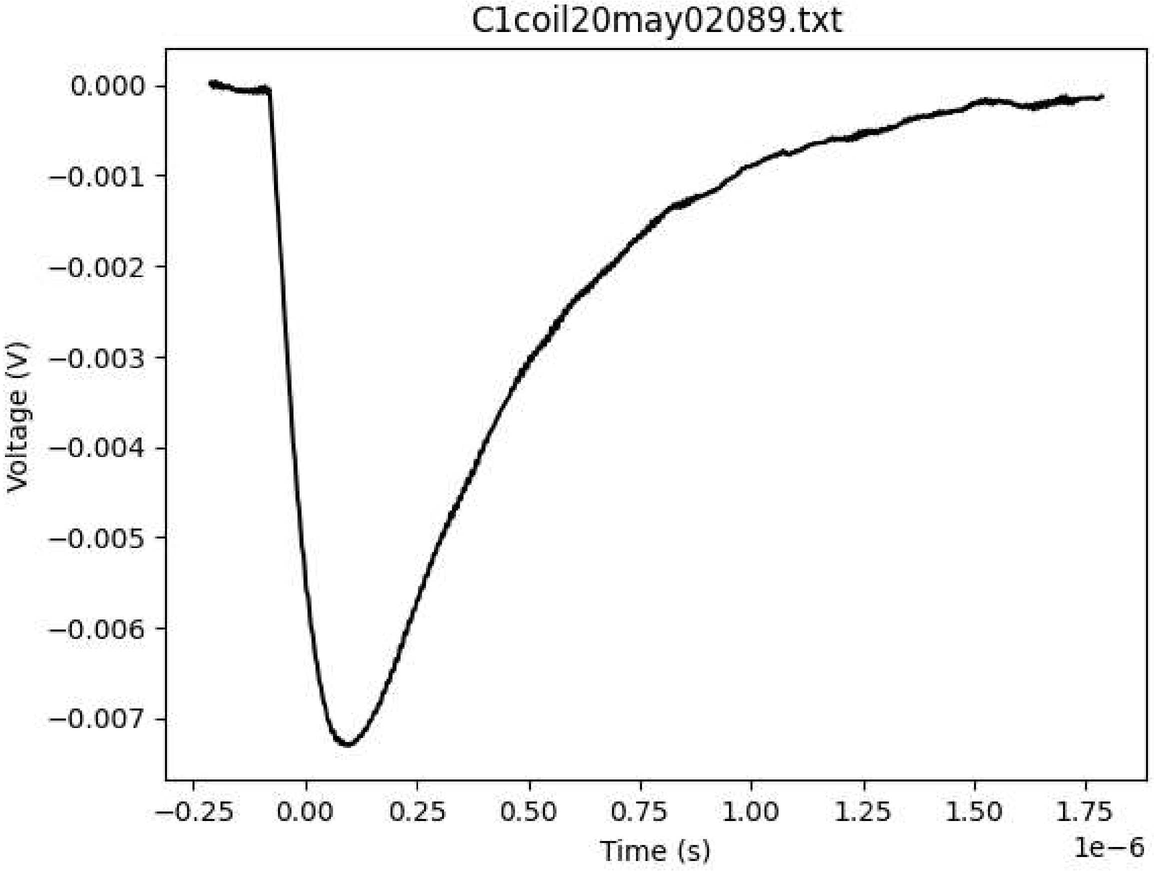

C1coil20may01692.txt
Voltage (V)
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.008
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6

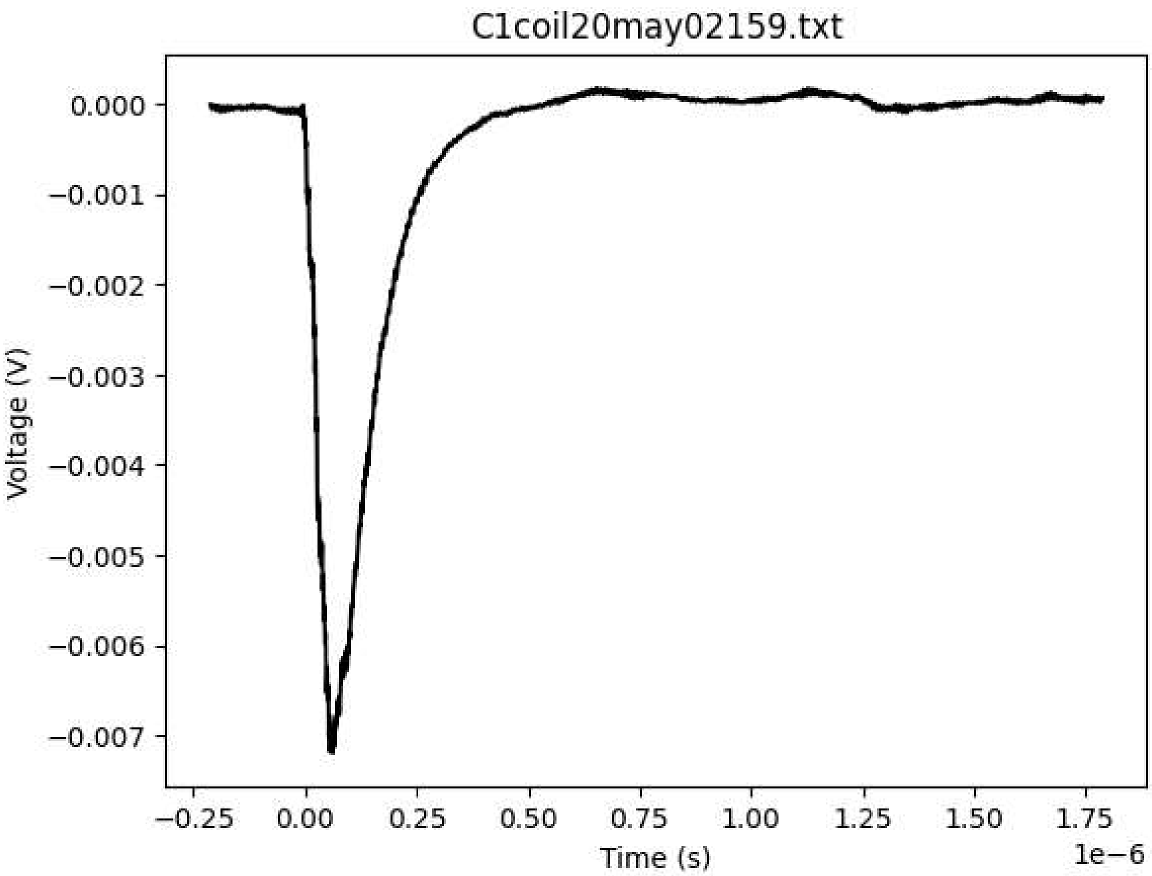

C1coil20may01708.txt
Voltage (V)
0.0003
0.0002
0.0001
0.0000
−0.0001
−0.0002
−0.0003
−0.0004
−0.0005
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6


C1coil20may01733.txt
Voltage (V)
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.008
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6


C1coil20may01813.txt
Voltage (V)
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
−0.008
Time (s)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1e−6

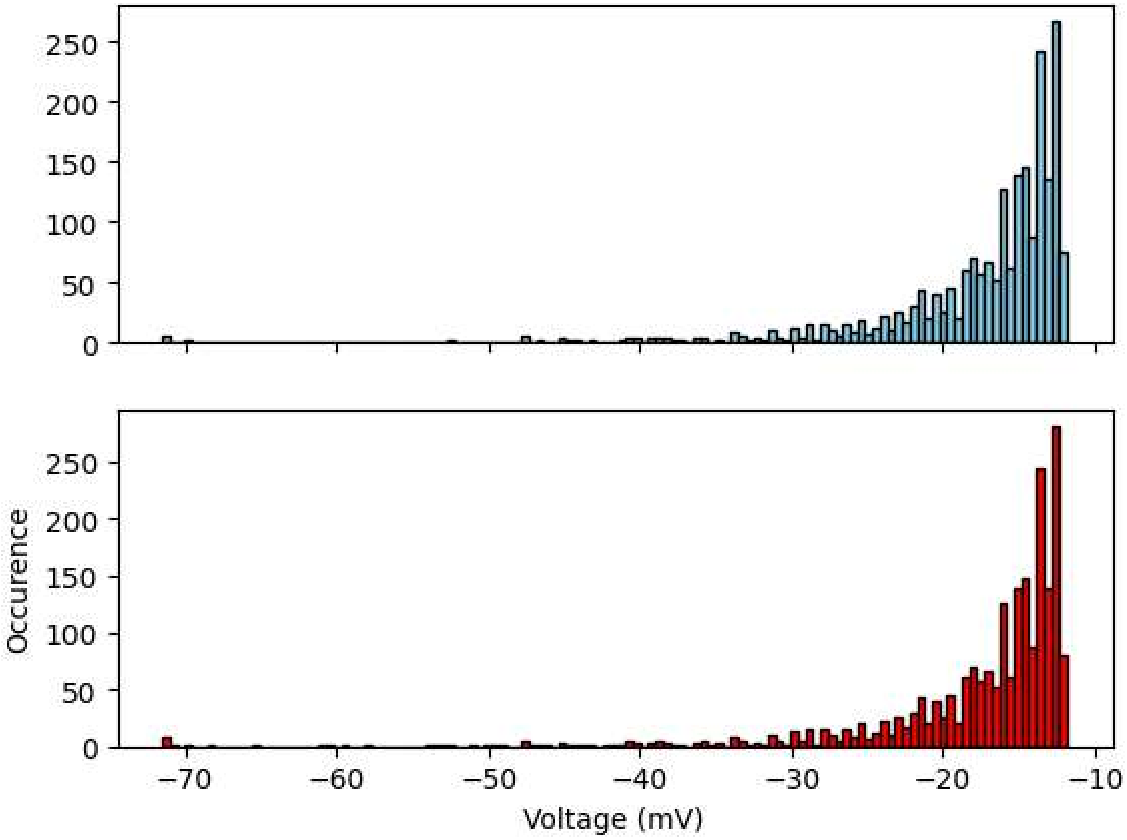

C1coil20may01970.txt
0.000
−0.002
−0.004
−0.006
−0.008
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6


C1coil20may02089.txt
0.000
−0.001
−0.002
−0.003
−0.004
−0.005
−0.006
−0.007
Voltage (V)
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Time (s)
1e−6



In [ ]:

```
fig, (ax1, ax2) = plt.subplots(2, 1, sharex=True)
num_bin = len(numpy.unique(massimi4))
n, bins, patches = ax1.hist(massimi4, bins=num_bin, color='skyblue', edgecolor='
n, bins, patches = ax2.hist(massimi2, bins=len(numpy.unique(massimi2)), color='r
# plt.axvline(numpy.mean(massimi2), color='green')

plt.xlabel('Voltage (mV)')
plt.ylabel('Occurence')

plt.show()
```


250
200
150
100
50
0
Occurence
−70
−60
−50
−40
−30
−20
−10
Voltage (mV)