Voltage and Current Calculations

June 11, 2018

1 Voltage & Current Server Calculations

Below are the calculations performed by the server on the data recieved from the board.

In [1]:
```
# Import needed libraries, and variables
import math
import cmath
import numpy as np
import matplotlib.pyplot as plt
from power_analyzer.settings import V_IN, I_IN
```

In [2]:
```
# Define some functions to quickly make graphs.
def graph(values, x_label="", y_label=""):
    # Uncomment the bellow line for high-res graphs
    plt.figure(num=None, figsize=(8, 6), dpi=300, facecolor='w', edgecolor='k')
    x = np.arange(len(values))
    plt.scatter(x, values)
    plt.xlabel(x_label)
    plt.ylabel(y_label)
    plt.show()

def graph_tuple(t_values, x_label="", y_label=""):
    # Uncomment the bellow line for high-res graphs
    plt.figure(num=None, figsize=(8, 6), dpi=300, facecolor='w', edgecolor='k')
    x = np.arange(len(t_values[0]))
    for idx, values in enumerate(t_values):
        plt.scatter(x, values, label=str(idx))
    plt.xlabel(x_label)
    plt.ylabel(y_label)
    plt.legend(loc='upper left')
    plt.show()
```

1.1 Paste data here

Below is some raw data we've measured from the device. There is a good variety of data. Including voltage measurements that are rectified and measurements that are taken when there was no current flowing through the Current Transformer (CT).

In [3]:
```
# voltages = [835,823,798,768,725,676,621,567,489,428,361,316,272,246,193,174,163,176,18
# currents = [835,823,798,768,725,676,621,567,489,428,361,316,272,246,193,174,163,176,18
```

In [4]:
```
# One wierd current (TODO: Check to make sure that one point isn't causing a problem.)
# voltages = [343,283,238,205,184,183,194,218,242,285,333,387,446,513,582,643,689,737,76
# currents = [457,437,440,450,461,471,480,487,492,495,495,494,489,484,476,465,454,442,43
```

In [5]:
```
# Rectified data
# voltages = [125,94,65,36,8,0,0,0,0,0,0,0,0,0,0,18,43,72,98,133,162,187,205,223,234,2
# currents = [189,162,130,106,72,46,21,4,0,0,0,0,0,0,4,31,57,85,112,144,172,200,228,248,
```

In [6]:
```
# bad data (No Current from CT)
# voltages = [104,104,104,104,104,104,104,104,104,104,104,104,104,104,104,104,104,104,10
# currents = [123,123,123,123,123,124,124,124,123,123,124,123,123,123,123,123,123,123,12
```

In [7]:
```
# Data calculated today
#voltages = [49,32,38,52,91,149,232,320,404,498,586,689,778,866,933,996,1024,1024,1024,1
#currents = [365,364,363,365,369,375,386,394,406,420,433,442,457,466,477,485,493,495,494
```

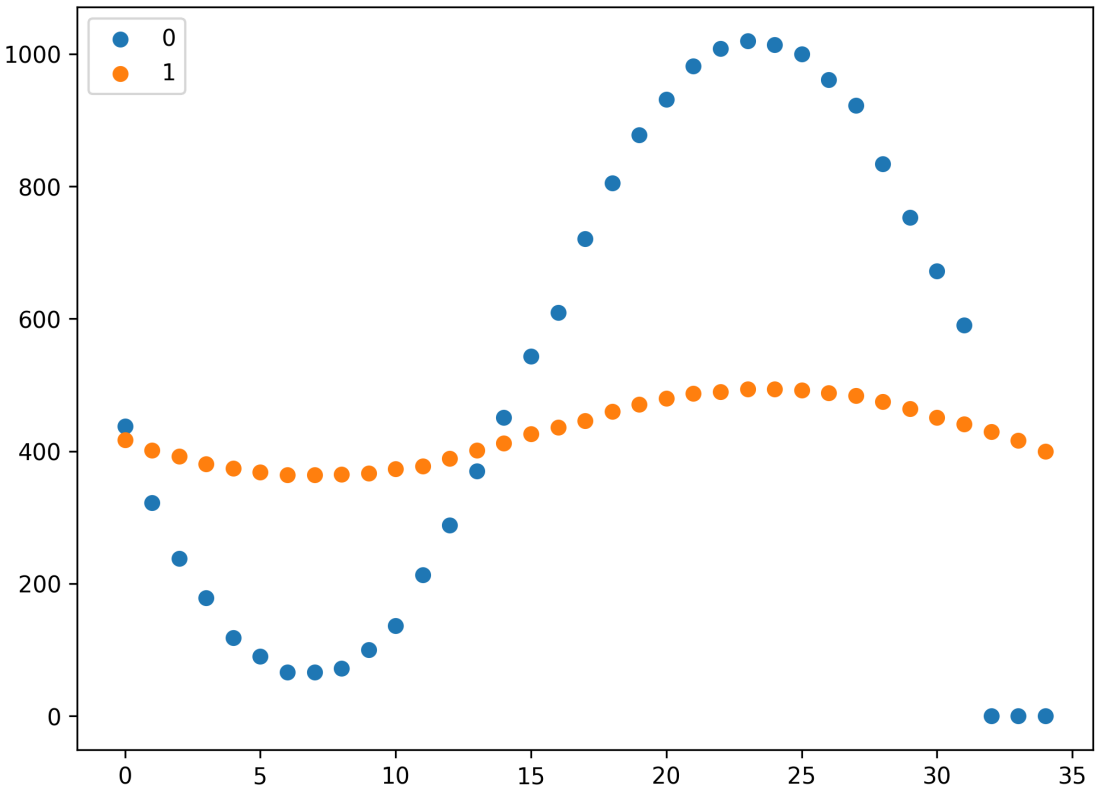
In [8]:
```
# 1
voltages = [438,322,238,178,118,90,66,66,72,100,136,213,288,370,451,543,609,721,805,878,
currents = [417,401,392,381,374,368,364,364,365,367,373,377,389,401,412,426,436,446,460,
```

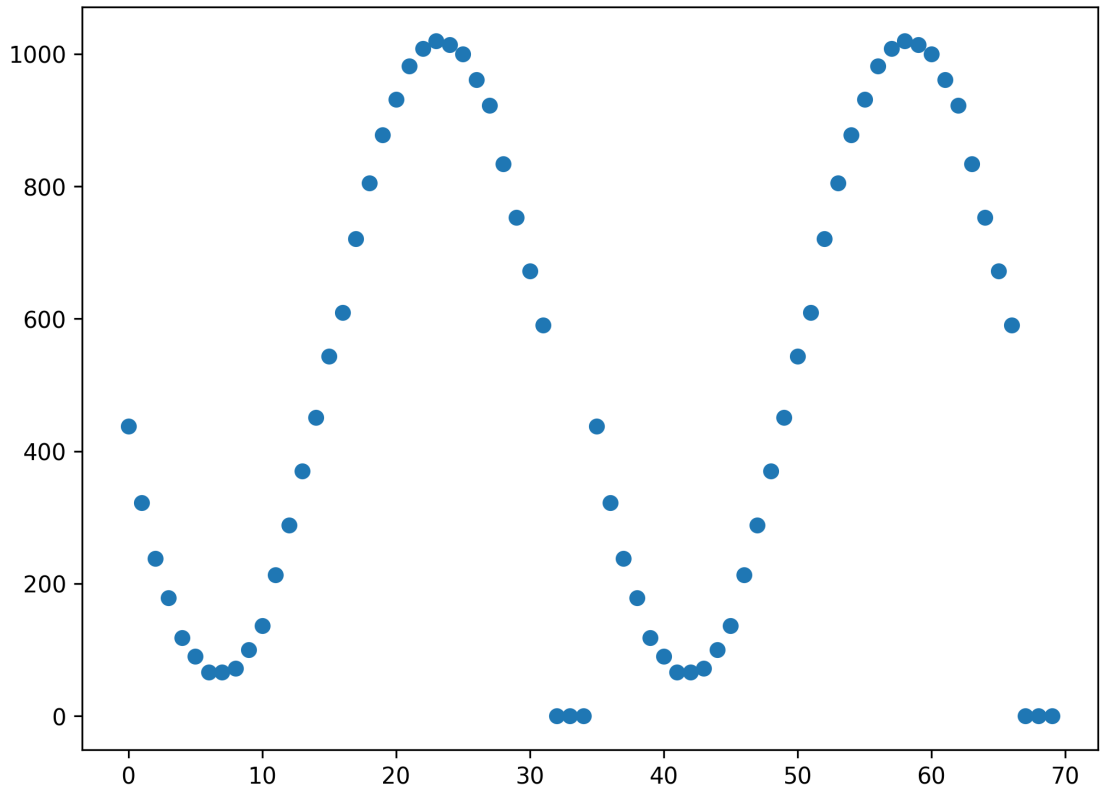
In [9]:
```
ideal_voltages = 120*np.sin(np.arange(32)*2*math.pi/32)
```

2 Voltage

This section converts raw measurements from the Analogue to Digital Coverter (ADC) to the voltages that were being measured.

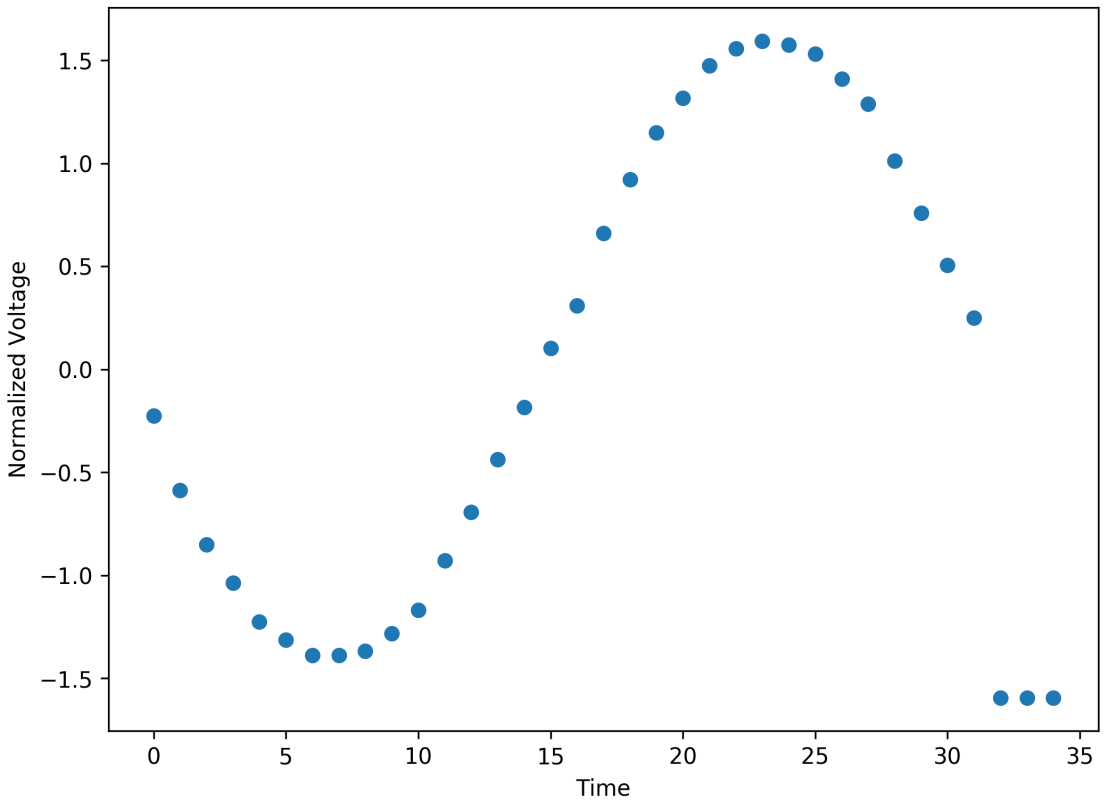
In [10]:
```
# Take a look at the data we have to look at.
graph_tuple((voltages, currents))
# print((len(voltages), len(ideal_voltages)))
# graph_tuple((voltages, ideal_voltages))

# Visually test the periodicy (is this a word?) of the wave.
graph(np.concatenate((voltages, voltages), axis=0))
```


0
1
1000
800
600
400
200
0
0
5
10
15
20
25
30
35

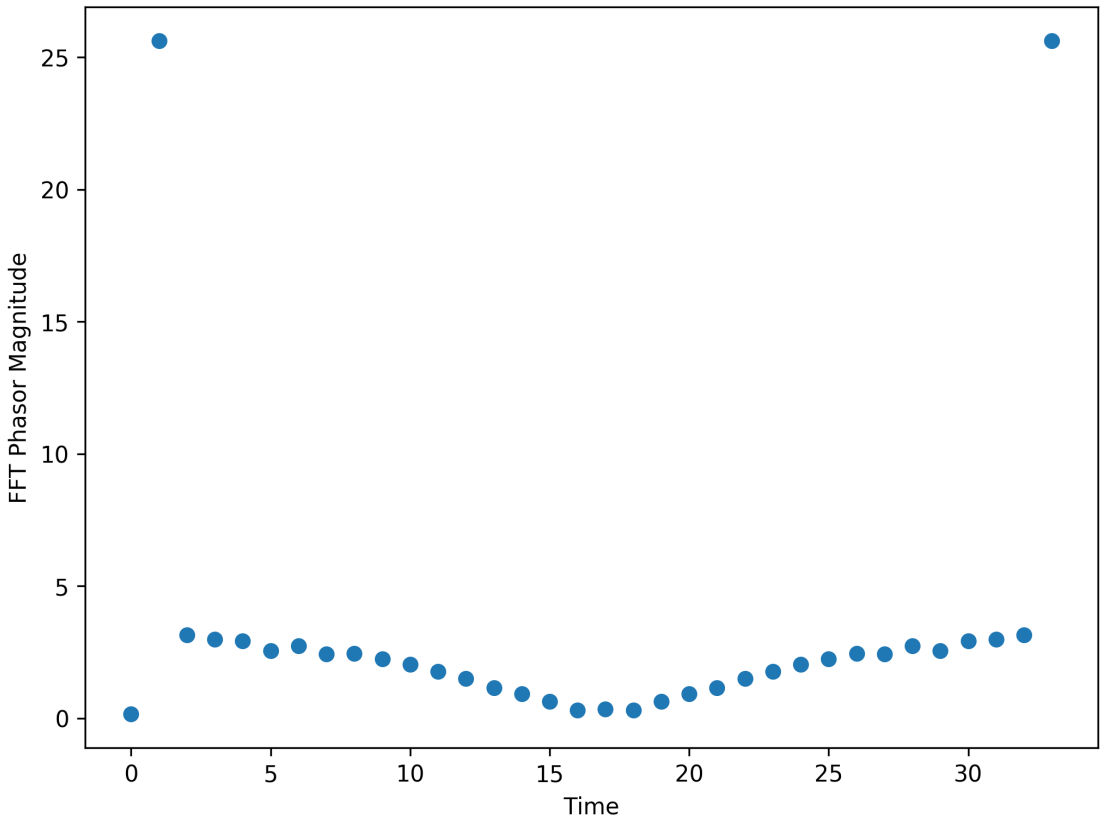


In [11]:
```
# The core of the calculation

np_voltages = np.array(voltages)
Vin = V_IN

# translated_v = (np_voltages/Vin["num_bits"])*Vin["max_val"]

# Vmax = max(translated_v)
# Vmin = min(translated_v)
# offset = (Vmin + Vmax)/2.0

# translated_v = (translated_v - offset)/Vin["scale_factor"] / math.sqrt(2)

#Test
translated_v = ((np_voltages/1024*3.2))

Vmax = max(translated_v)
Vmin = min(translated_v)
offset = (Vmin + Vmax)/2.0

translated_v = (translated_v - offset)
```

```
graph(translated_v, x_label="Time", y_label="Normalized Voltage")
v_min = min(translated_v)
v_max = max(translated_v)
print("Min: " + str(v_min) + " Max: " + str(v_max))
fft = np.fft.fft(translated_v, 34)
graph(np.absolute(fft), x_label="Time", y_label="FFT Phasor Magnitude")
abs_fft = np.absolute(fft)
```




```
Min: -1.59375 Max: 1.59375
```




```
In [12]: abs_fft[33]
```

```
Out[12]: 25.624320874642667
```

```
In [13]: abs_fft[1]/34*2/math.sqrt(2)
```

```
Out[13]: 1.0658312384564603
```

2.1 Calculated complex voltage

This section outputs the calculated complex voltage, it's magnitude and phase.

```
In [14]: final_voltage = fft[1]/17/(0.8210632221e-2+0.1164355735e-3j)
         final_voltage
```

```
Out[14]: (-84.3045854963006+163.05767835275984j)
```

```
In [15]: np.absolute(final_voltage/math.sqrt(2))
```

```
Out[15]: 129.79805392511696
```

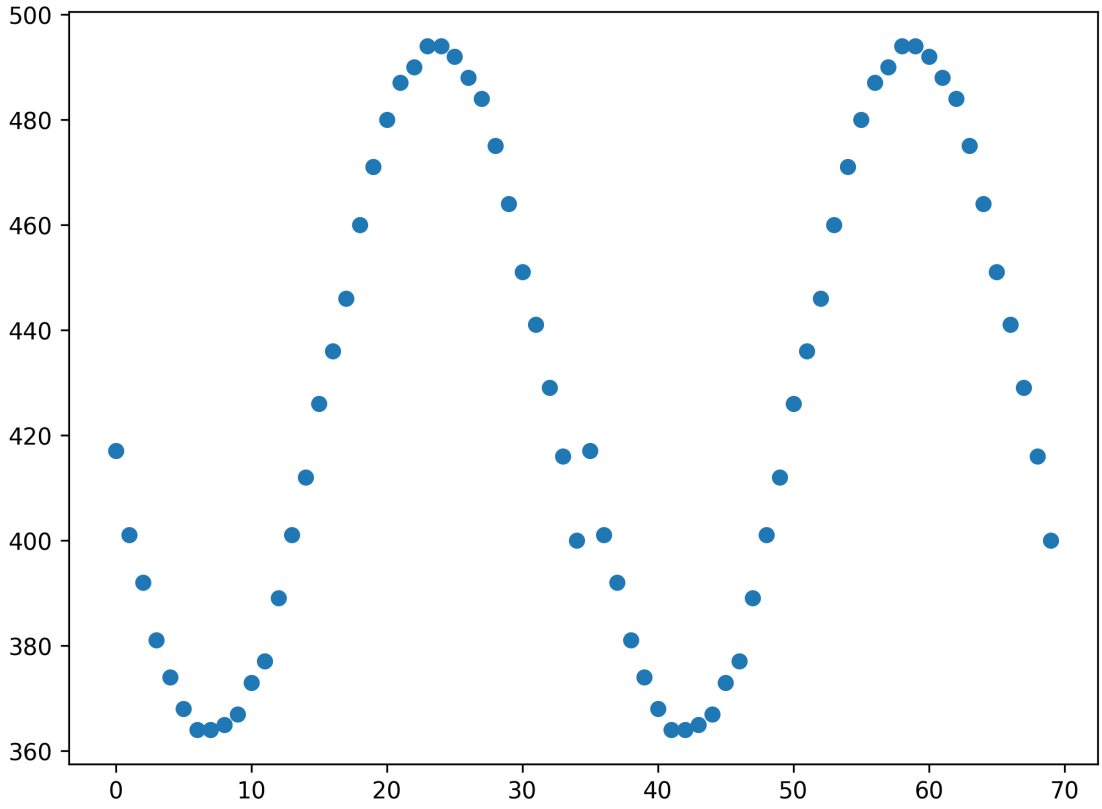
```
In [16]: cmath.phase(final_voltage)*180/math.pi
```

```
Out[16]: 117.3400079199999
```

3 Current

This is the calculation section for the current. It's a little bit different. It has a magical formula that Nathan derived to convert voltage values measured into the real current values flowing through the wire.

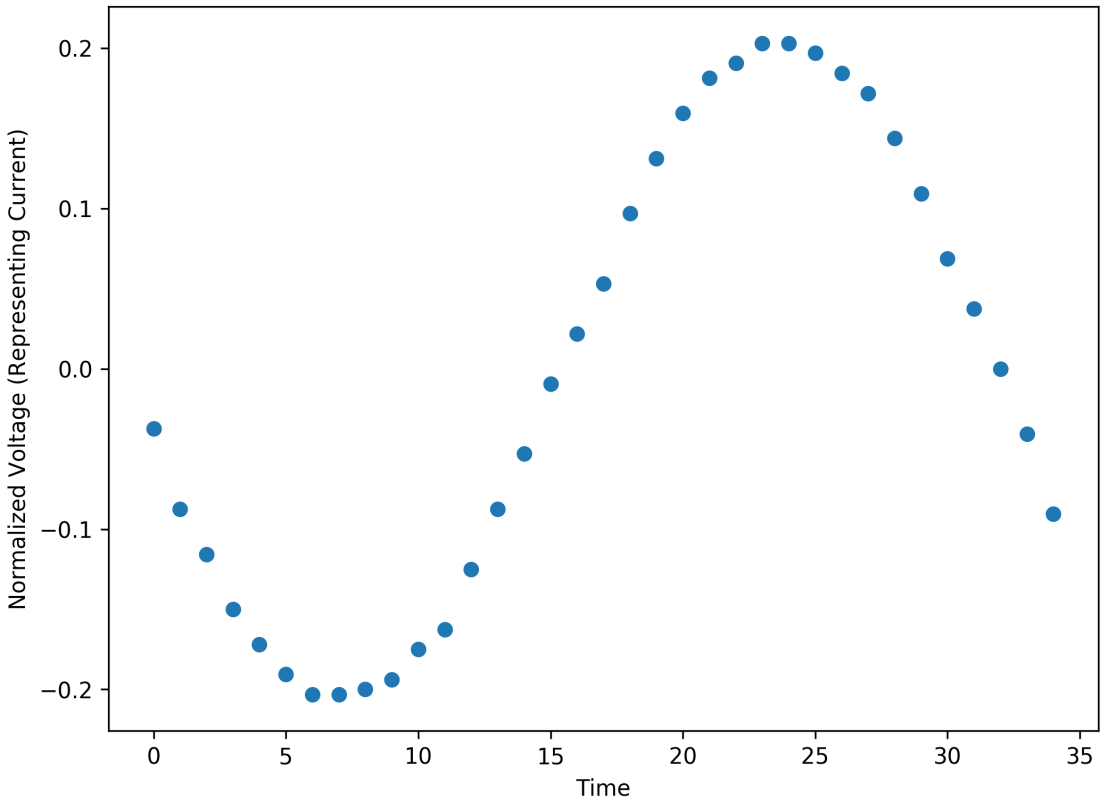
In [17]:
```
# Define the number of windings on the inductor
N = 2000

# Test the periodicy of the wave. (Data for this one is not as good.)
graph(np.concatenate((currents, currents), axis=0))
```



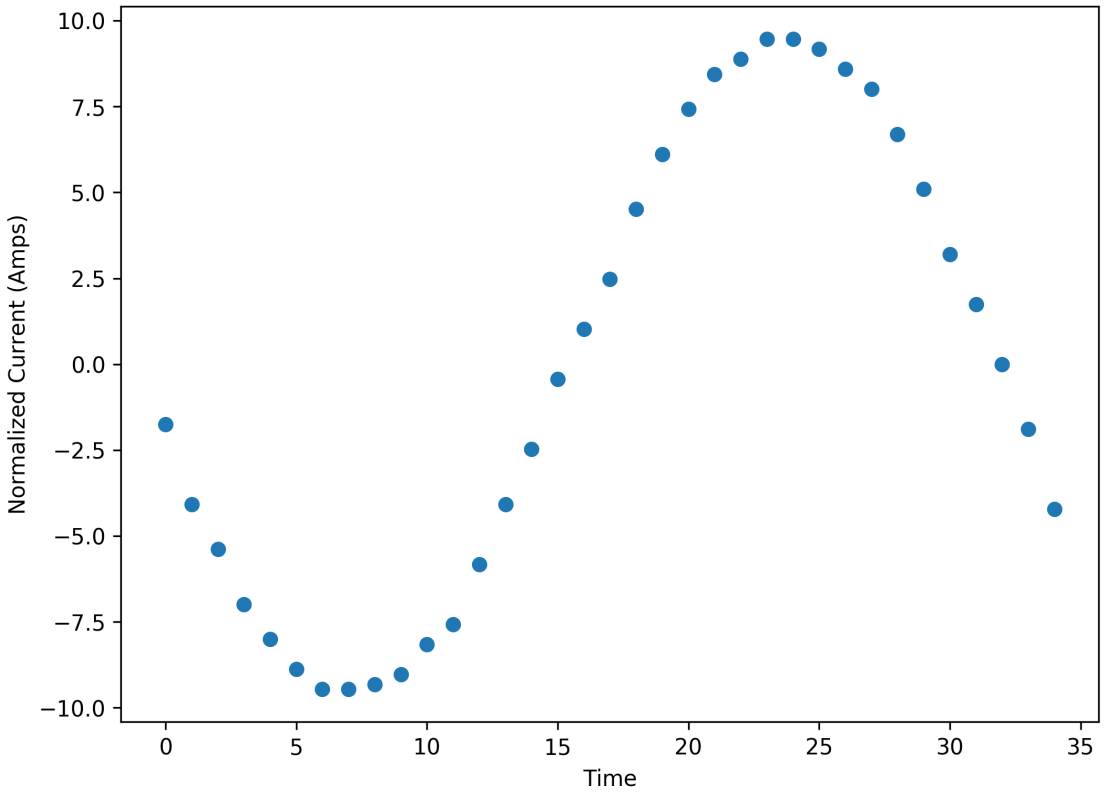
In [18]:
```
np_currents = np.array(currents)
Iin = I_IN
print(I_IN)
translated_i = ((np_currents/1024*3.2))

Imax = max(translated_i)
Imin = min(translated_i)
offset = (Imin + Imax)/2.0
```

```
        translated_i = (translated_i - offset)

        # Normalize
        graph(translated_i, x_label="Time", y_label="Normalized Voltage (Representing Current)"

        x = translated_i
        # Convert Voltage to current
        # (6.406266326*10^12-5.308287991*10^9*I)*N^2*x
        # /(2.715290040*10^14*N+(1.326246007*10^9*I)*x-1.600357741*10^12*x)
        #translated_i = (6.406266326E3-5.308287991j)*N*N*x \
        #             /(2.715290040E5*N+1.326246007j*x-1.600357741E3*x)
        translated_i = (5.435676114E3-2.093686304E1j)*N*N*x \
                    /(2.333452378E5*N+5.30498089j*x-1.376431233E3*x)

        graph(translated_i, x_label="Time", y_label="Normalized Current (Amps)")
```

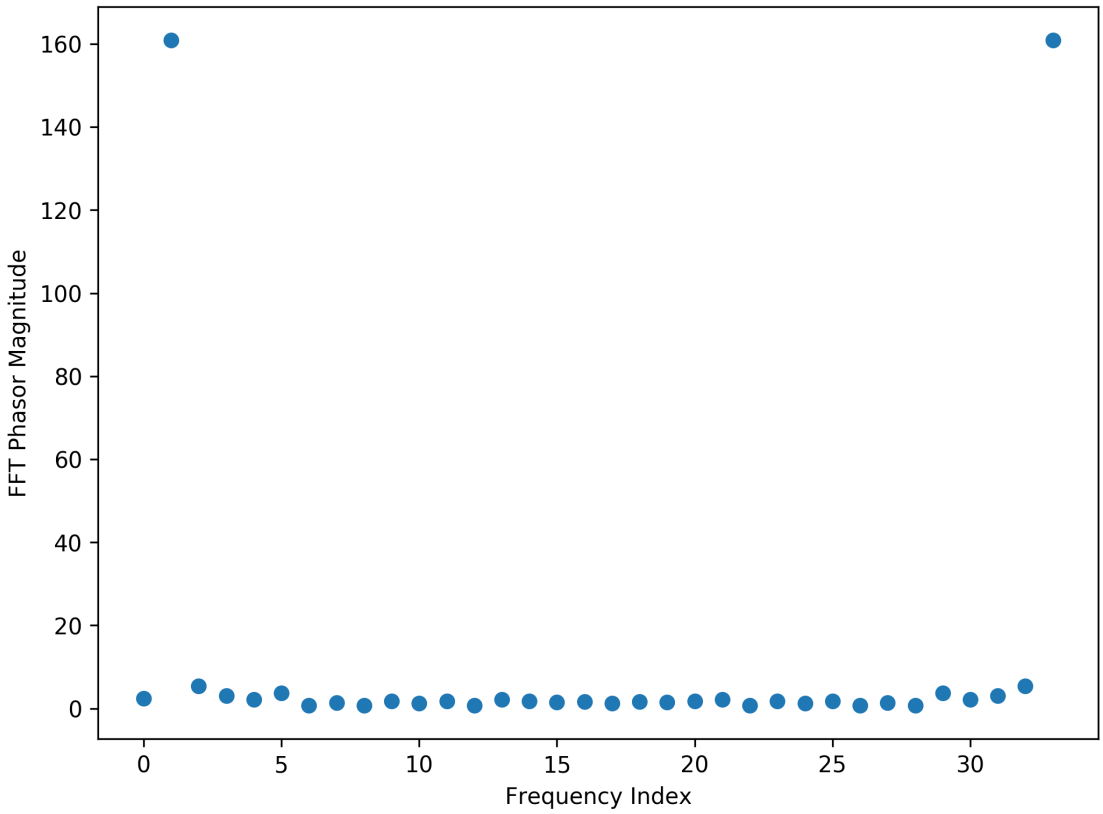
```
{'resistance': 42, 'num_bits': 1024, 'scale_factor': 0.45445, 'secondary': 0.2, 'max_val': 3.1,
```




```
/home/ubuntu/.local/lib/python3.5/site-packages/numpy/core/numeric.py:544: ComplexWarning: Casti
  return array(a, dtype, copy=False, order=order, subok=True)
```



In [19]:
```
fft_i = np.fft.fft(translated_i, 34)

graph(np.absolute(fft_i), x_label="Frequency Index", y_label="FFT Phasor Magnitude")
abs_fft_i = np.absolute(fft_i)
```



3.1 Calculated Complex Current

This is the section where the complex current and it's magnitude are outputed.

```
In [20]: final_current = fft_i[1]/17
         print(final_current, abs(final_current)/math.sqrt(2))
```

```
(-2.8079915715342056+9.037871734012482j) 6.6920827156524645
```