Exploring Aliasing

Setting up an aliased wave

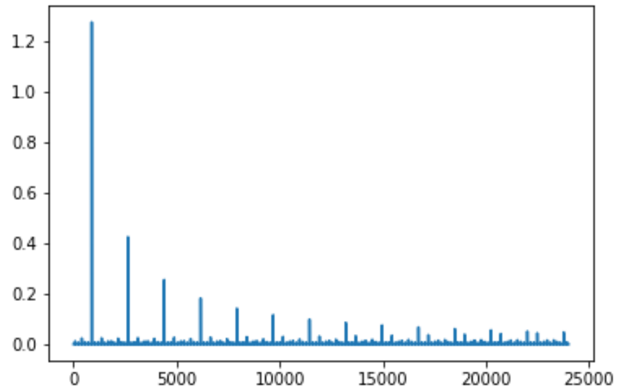
In [169]:

```
import numpy as np
import cmath
import matplotlib.pyplot as plt
```

In [170]:
```
class waveGen:

        def __init__(self, freq, BufferSize, waveType, vol):

                self.sampleRate = 48000
                self.bufferSize = BufferSize
                self.buffer = np.empty(BufferSize, dtype=np.com
plex)
                self.frequency = freq
                self.omega = 0
                self.updateOmega()
                self.last = complex(1,0)
                self.type = waveType
                self.volume = vol

        def sineGen(self):

                #start = timer() #reduce function!!! functools
                for i in range(0, self.bufferSize):
                        self.buffer[i] = self.last
                        self.last=self.last*self.omega

                return self.volume * np.imag(self.buffer).astyp
e(np.float32)

        def squareGen(self):
                #start = timer()
                for i in range(0, self.bufferSize):
                        self.buffer[i] = np.sign(self.last)
                        self.last=self.last*self.omega

                return np.real(self.volume * self.buffer).astyp
e(np.float32)

        def updateOmega(self):
                self.omega = cmath.exp(1j*(2*cmath.pi * self.fr
equency / self.sampleRate))

        def updateFreq(self, val):
                self.frequency = val
                self.updateOmega()

        def updateFPS(self, val):
                self.sampleRate = val
                self.updateOmega()
```

In [171]:
```
sampleRate = 48000
length = 48000
freq = 880
wave = waveGen(freq, length, 'square', 1)
```

In [172]:
```
square = wave.nextFrame()
freqSpec = np.fft.fft(square)
#linespaceing
T = 1.0 / sampleRate

#x angle of plot
xf = np.linspace(0.0, 1.0/(2.0*T), length//2)

#ploting the graph
plt.plot(xf, 2.0/length * np.abs(freqSpec[:length//2]))
plt.show()
```



in a pure square wave we would expect to see peaks on every other harmonic

whareas we can see here that the harmonics have looped back on themselfs, creating a background noise of around .05 decebals across the spectrum.

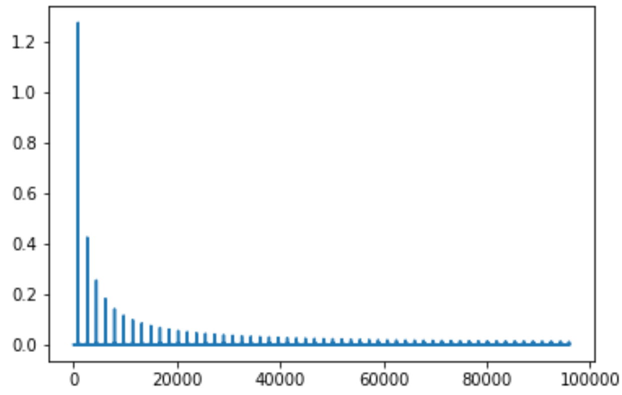
This distortion is allready baked into the wave, so we can try the same again by increasing the FPS, therby increasing the nyquist window

The Over Sample wave

In [173]:

```
#an 8 times over sampled wave
overSampling = 4
wave.updateFPS(sampleRate*overSampling)
wave.updateBuffSize(length*overSampling)

#generate data
square2 = wave.nextFrame()
freqSpec2 = np.fft.fft(square2)

#linespaceing
T = 1.0 / (sampleRate*overSampling)

#x angle of plot
xf = np.linspace(0.0, 1.0/(2.0*T), length * overSampling//2)

#ploting the graph
plt.plot(xf, 2.0/(length*overSampling) * np.abs(freqSpec2[:leng
th * overSampling//2]))
plt.show()
```

```
/usr/lib/python3.6/site-packages/ipykernel_launcher.py:27: Co
mplexWarning: Casting complex values to real discards the ima
ginary part
```



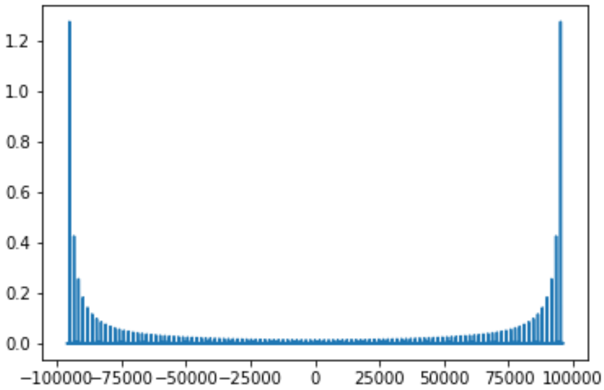
it can be seen here that the distortion is much less apparent.

the nyquist value here should be at 96,000 HZ

It is notable that the distortion here is higher in the higher range

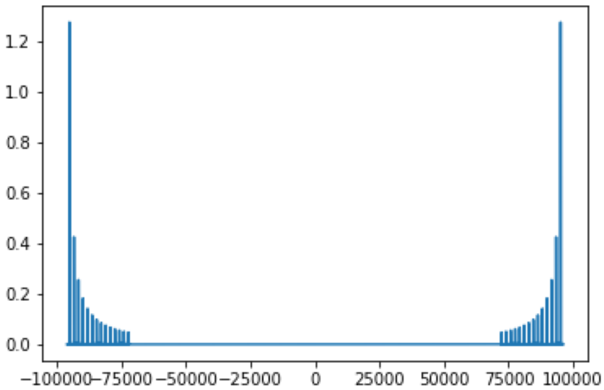
the full data of the fft looks like this, and may provide a better idea of how to downSample

In [174]:
```
#linespaceing
T = 1.0 / (sampleRate*overSampling)

#x angle of plot
xf = np.linspace(-length*2, 1.0/(2.0*T), length*overSampling)

#ploting the graph
plt.plot(xf, 2.0/(length*overSampling) * np.abs(freqSpec2))
plt.show()
```



to filter here at 24000 HZ we want to nullify all values bettween -24000 and 24000

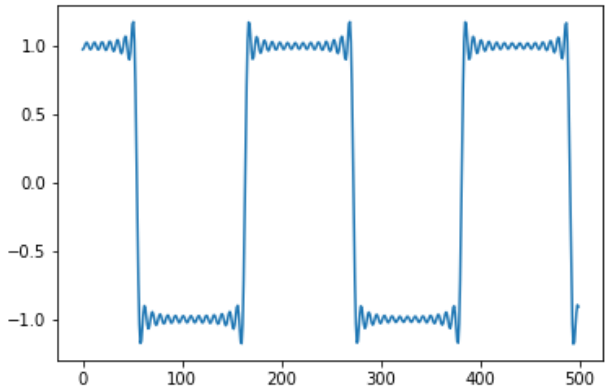
In [175]:
```
cutoff = sampleRate // 2

freqSpec3 = freqSpec2
for i in range(cutoff, sampleRate * overSampling - cutoff):
        freqSpec3[i] = 0

#ploting the graph
plt.plot(xf, 2.0/(length* overSampling) * np.abs(freqSpec3))
plt.show()
```



we can return this to the time domain and then downSample

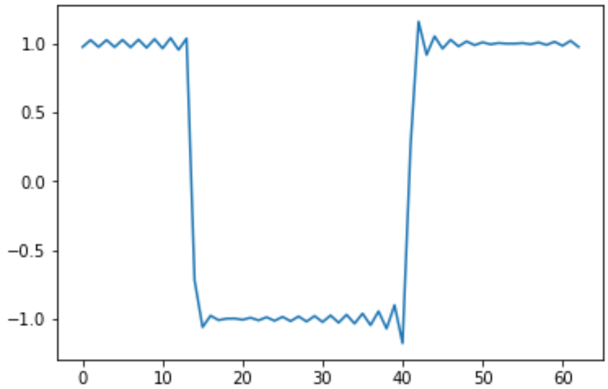
In [176]:

```
fltSqr = np.fft.ifft(np.real(freqSpec3))
plt.plot(np.real(fltSqr[:500]))
plt.show()
```



In [177]:

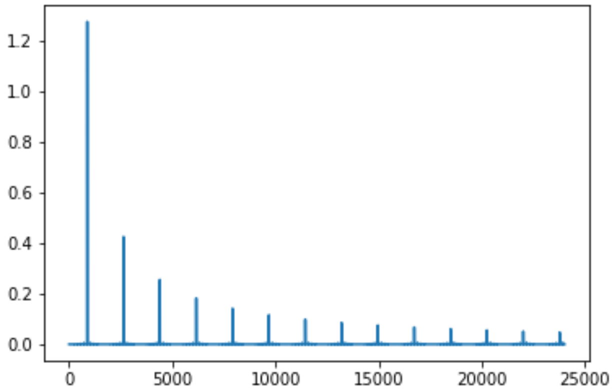
```
downSampled = np.empty(sampleRate)

for i in range(len(fltSqr)):
    if i % overSampling == 0:
        downSampled[i//overSampling] = np.real(fltSqr[i])

plt.plot(downSampled[:63])
plt.show()
```

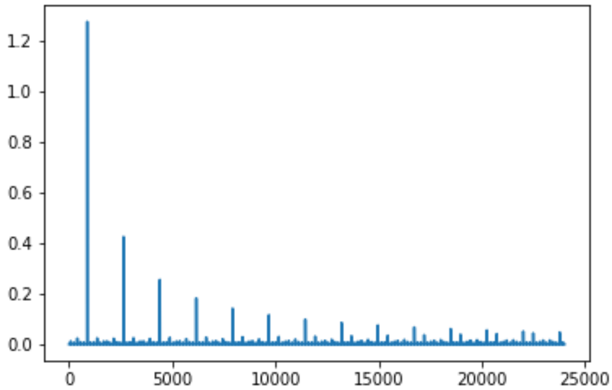


lets veiw this in the frequecy domain, and compare with our original graph

In [178]:

```
DSFreqSpec = np.fft.fft(downSampled)
#linespaceing
T = 1.0 / (sampleRate)
#x angle of plot
xf = np.linspace(0.0, 1.0/(2.0*T), sampleRate // 2)
#ploting the down sampled graph
plt.plot(xf, 2.0/length * np.abs(DSFreqSpec[:length // 2]))
plt.show()


#linespaceing
T = 1.0 / length
#x angle of plot
xf = np.linspace(0.0, 1.0/(2.0*T), length//2)
#ploting the original graph
plt.plot(xf, 2.0/length * np.abs(freqSpec[:length//2]))
plt.show()
```

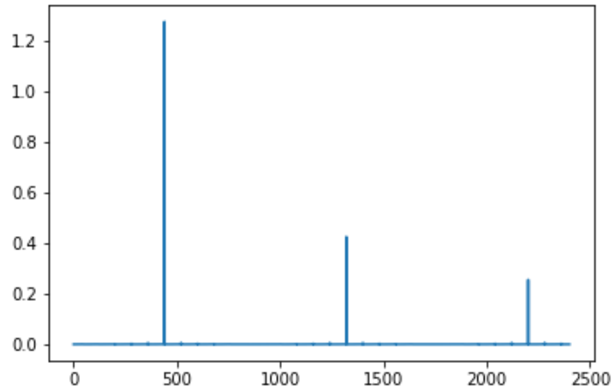




there is clearly still some Distortion, but there is at least much less

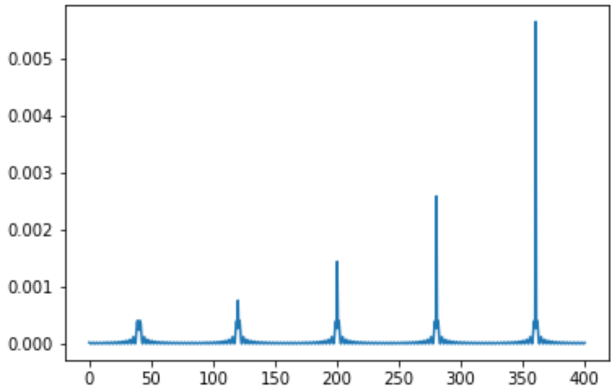
heres a zoom on a distored area to show more clearly

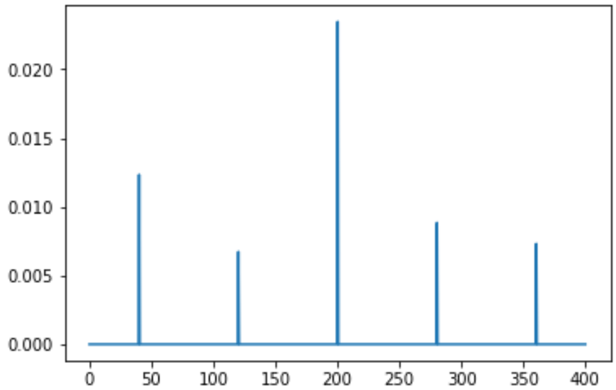
In [179]:
```
zoom = 10
#linespaceing
T = 1.0 / length * zoom
#x angle of plot
xf = np.linspace(0.0, 1.0/(2.0*T), length//zoom)
#ploting the original graph
plt.plot(xf, 2.0/length * np.abs(DSFreqSpec[:length//zoom]))
plt.show()
```



and a little closer... focusing on the distortion, with the original signal distortion plotted below

In [185]:
```
zoom = 60
#linespaceing
T = 1.0 / length * zoom
#x angle of plot
xf = np.linspace(0.0, 1.0/(2.0*T), length//zoom)
#ploting the original graph
plt.plot(xf, 2.0/length * np.abs(DSFreqSpec[:length//zoom]))
plt.show()
plt.plot(xf, 2.0/length * np.abs(freqSpec[:length//zoom]))
plt.show()
```





it can be seen here that by using this method a background distortion is prevelent across the spectrum of ~0.005 decibal at a 4 times overSample rate

thereby reducing the distortion levels by aproximatly 4 times

This method is however computatioaly complex and far from perfect

a priority should be in avoiding the FFT in filter design, and finding methods that can avoid high levels of over sampling