Comparison of Transmission of analog and digital signals

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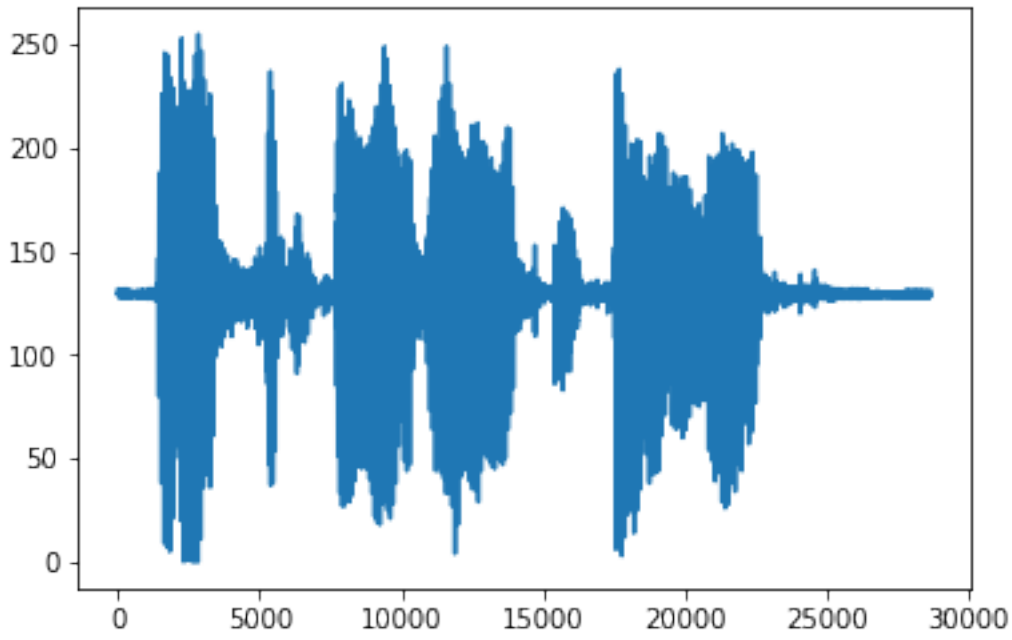
In [7]:
```
%matplotlib inline
import matplotlib
import matplotlib.pyplot as plt
import numpy as np
import IPython
from scipy.io import wavfile
```

In [14]:
```
rate, s = wavfile.read('marySixteen.wav')
plt.plot(s);
print(rate)
IPython.display.Audio(s, rate=rate)
```

```
11025
```

Out[14]: <IPython.lib.display.Audio object>



In [9]:
```
pwd
```

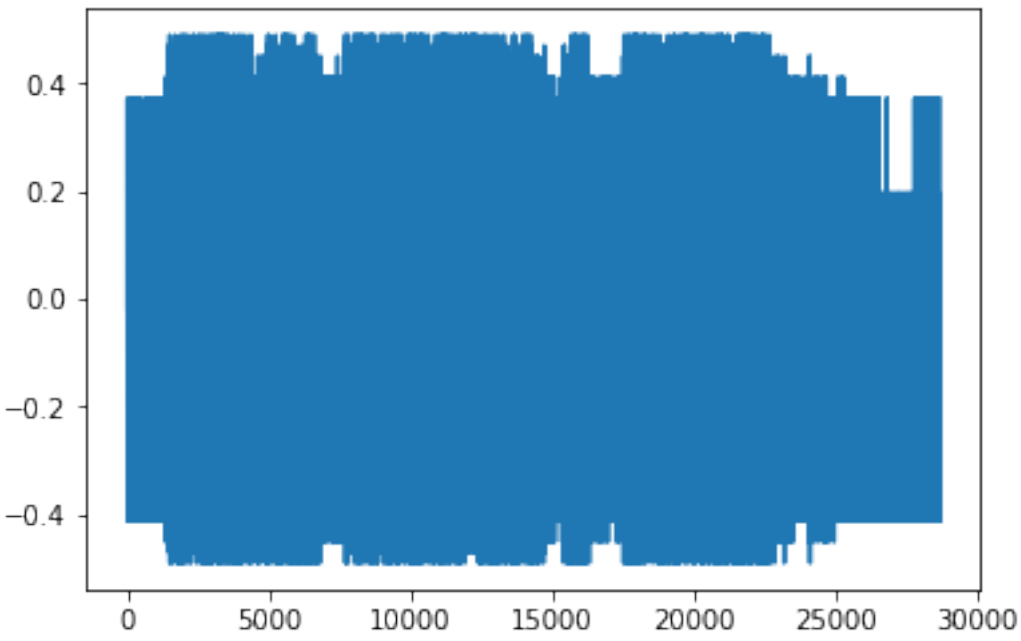
Out[9]:
```
'C:\\Users\\ANSHUL YADAV\\Documents'
```

In [19]:
```
# the analog signal is simply rescaled between -100 and +100
# largest element in magnitude:
norm = 1.0 / max(np.absolute([min(s), max(s)]))
print(max(s))
sA = 100.0 * s * norm

# the digital version is clamped to the integers
sD = np.round(sA)
plt.plot(sA-sD)
```

```
255
```

Out[19]:
```
[<matplotlib.lines.Line2D at 0x2591d25bc18>]
```



In [20]:
```
# we will be computing SNRs later as well, so let's define a function
def SNR(noisy, original):
    # power of the error
    err = np.linalg.norm(original-noisy)
    # power of the signal
    sig = np.linalg.norm(original)
    # SNR in dBs
```

```
            return 10 * np.log10(sig/err)


        print ('SNR = %f dB' % SNR(sD, sA))
```

```
SNR = 22.610268 dB
```

```
In [21]: IPython.display.Audio(sA, rate=rate)
```

```
Out[21]: <IPython.lib.display.Audio object>
```

```
In [22]: IPython.display.Audio(sD, rate=rate)
```

```
Out[22]: <IPython.lib.display.Audio object>
```

```
In [23]: def repeater(x, noise_amplitude, attenuation):
             # first, create the noise
             noise = np.random.uniform(-noise_amplitude, noise_amplitude, len(x))
             # attenuation
             x = x * attenuation
             # noise
             x = x + noise
             # gain compensation
             return x / attenuation
```

```
In [24]: def analog_tx(x, num_repeaters, noise_amplitude, attenuation):
             for n in range(0, num_repeaters):
                 x = repeater(x, noise_amplitude, attenuation)
             return x
```

```
In [27]: def digital_tx(x, num_repeaters, noise_amplitude, attenuation):
             for n in range(0, num_repeaters):
                 x = np.round(repeater(x, noise_amplitude, attenuation))
             return x
```

```
In [28]: NUM_REPEATERS = 70
         NOISE_AMPLITUDE = 0.2
         ATTENUATION = 0.5

         yA = analog_tx(sA, NUM_REPEATERS, NOISE_AMPLITUDE, ATTENUATION)
         print ('Analog trasmission: SNR = %f dB' % SNR(yA, sA))

         yD = digital_tx(sD, NUM_REPEATERS, NOISE_AMPLITUDE, ATTENUATION)
         print ('Digital trasmission: SNR = %f dB' % SNR(yD, sA))
```

```
Analog trasmission: SNR = 14.274716 dB
Digital trasmission: SNR = 22.610268 dB
```

```
In [29]: IPython.display.Audio(yD, rate=rate)

Out[29]: <IPython.lib.display.Audio object>

In [30]: IPython.display.Audio(yA, rate=rate)

Out[30]: <IPython.lib.display.Audio object>

In [31]: NOISE_AMPLITUDE = 0.3

         yA = analog_tx(sA, NUM_REPEATERS, NOISE_AMPLITUDE, ATTENUATION)
         print ('Analog trasmission: SNR = %f dB' % SNR(yA, sA))

         yD = digital_tx(sD, NUM_REPEATERS, NOISE_AMPLITUDE, ATTENUATION)
         print ('Digital trasmission: SNR = %f dB' % SNR(yD, sA))

Analog trasmission: SNR = 12.523043 dB
Digital trasmission: SNR = 11.780455 dB


In [32]: IPython.display.Audio(yD, rate=rate)

Out[32]: <IPython.lib.display.Audio object>
```