REPORT

Zajęcia: Analog and digital electronic circuits
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Lab 6
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Topic: "Quantization and Signal-to-Noise Ratio"
Variant 2

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1. Problem statement: The objective is to investigate Signal-to-Noise Ratio for different signals

2. Input data:
$\Omega_c = t^3$

3. Commands used (or GUI):

a) source code

Quantizer definition

```
def my_quant(x, Q):
    tmp = Q//2  # integer div
    quant_steps = (np.arange(Q) - tmp) / tmp  # we don't use this

    # forward quantization, round() and inverse quantization
    xq = np.round(x*tmp) / tmp
    # always saturate to -1
    xq[xq < -1.] = -1.
    # saturate to ((Q-1) - (Q\2)) / (Q\2), note that \ is integer div
    tmp2 = ((Q-1) - tmp) / tmp  # for odd N this always yields 1
    xq[xq > tmp2] = tmp2
    return xq
```

Quantizer check function definition

```
def check_quant_SNR(x, dBoffset, title):
    print('std: {0:f}, var: {1:f}, mean: {2:f} of x'.format(np.std(x), np.var(x),
np.mean(x)))
    Bmax = 24
    SNR = np.zeros(Bmax+1)
    SNR_ideal = np.zeros(Bmax+1)

    for B in range(1, Bmax+1):  # start at 1, since zero Q is not meaningful
        xq = my_quant(x, 2**B)
        SNR[B] = 10*np.log10(np.var(x) / np.var(xq-x))
```

```
        SNR_ideal[B] = B*20*np.log10(2) + dBoffset  # 6dB/bit + offset rule

    plt.figure(figsize=(5, 5))
    plt.plot(SNR_ideal, 'o-', label='theoretical', lw=3)
    plt.plot(SNR, 'x-', label='simulation')
    plt.xticks(np.arange(0, 26, 2))
    plt.yticks(np.arange(0, 156, 12))
    plt.xlim(2, 24)
    plt.ylim(6, 148)
    plt.xlabel('number of bits')
    plt.ylabel('SNR / dB')
    plt.title(title)
    plt.legend()
    plt.grid(True)
    print('maximum achievable SNR = {0:4.1f} dB at 24 Bit (i.e. HD
audio)'.format(SNR[-1]))
```

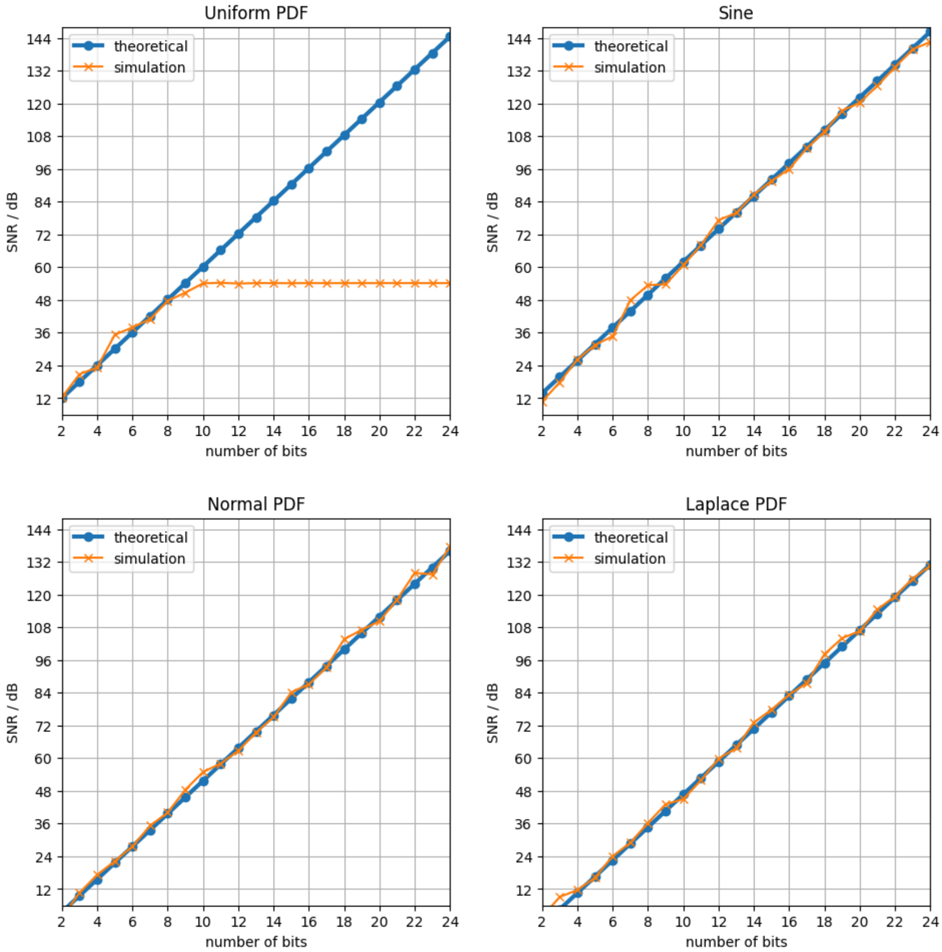
Plotting results

```
np.random.seed(4)
x = np.random.rand(N)
x -= np.mean(x)
x *= np.sqrt(1/3) / np.std(x)
dBoffset = 0
check_quant_SNR(x, dBoffset, 'Uniform PDF')

Omega = 2*np.pi * 997/44100  # use a rather odd ratio: e.g. in audio 997 Hz /
44100 Hz
sigma2 = 1/2
dBoffset = -10*np.log10(2 / 3)
x = np.sqrt(2*sigma2) * np.sin(Omega*k)
check_quant_SNR(x, dBoffset, 'Sine')

np.random.seed(4)
x = np.random.randn(N)
x -= np.mean(x)
x *= np.sqrt(0.0471) / np.std(x)
```

```
dBoffset = -8.5  # from clipping propability 1e-5
check_quant_SNR(x, dBoffset, 'Normal PDF')

np.random.seed(4)
x = np.random.laplace(size=N)
pClip = 1e-5  # clipping propability
sigma = -np.sqrt(2) / np.log(pClip)
x -= np.mean(x)
x *= sigma / np.std(x)
dBoffset = -13.5  # empircially found for pClip = 1e-5
check_quant_SNR(x, dBoffset, 'Laplace PDF')
```

https://github.com/wm64167/AADEC

4. Outcomes:



5. Conclusions:

In conclusion, we investigated the relationship between Signal-to-Noise Ratio (SNR) and different signal types. The results showed that the absolute value of SNR varied depending on the parameter γ. Higher values of γ generally came with higher SNR. This suggests that the parameter γ plays a significant role in controlling the signal strength.