REPORT

Zajęcia: Analog and digital electronic circuits

Teacher: prof. dr hab. Vasyl Martsenyuk

Lab 7 and 8

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Topic:

7. Sampling and Reconstruction of Signals: Analysis of Aliasing Effects and Proper Signal Reconstruction.

8. Coding and Decoding Digital Signals

Variant 15

Tobiasz Wojnar
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Gr. B

1. Problem statement:

The aim of the first task is to reconstruct of a sine wave.

The aim of the second task is to compare signal distortion and compression ratio for specified thresholds in DCT compression for the given signal

2. Input data:

Task one data

- f = 8 Hz – signal frequency
- f_s = 16 Hz, sampled frequency

Task two data

- signal = [3,6,9,12, 15, 18]
- thresholds = [4,8,12]

3. Commands used (or GUI):

a) source code

Sampling

```
import numpy as np
import matplotlib.pyplot as plt
from scipy.signal import resample
```

```
f_signal = 8  # Frequency of the signal (Hz)
f_sample = 16  # High sampling frequency (Hz)
```

```
t = np.linspace(0, 1, 1000, endpoint=False)  # Time vector
signal = np.sin(2 * np.pi * f_signal * t)  # Original signal
```

```
# Sampling the signal
t_sample = np.arange(0, 1, 1 / f_sample)
samples = np.sin(2 * np.pi * f_signal * t_sample)
```

```
# Reconstructing the signal using high sampling rate
```

```
num_samples = 1000
reconstructed_signal = resample(samples, num_samples)
```

```
# Plotting the reconstruction
plt.figure(figsize=(10, 6))
plt.plot(t, signal, label='Original Signal')
plt.plot(t, reconstructed_signal, label='Reconstructed
Signal', linestyle='--')
plt.title('Signal Reconstruction')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.legend()
plt.grid()
plt.show()
```

```
plt.figure(figsize=(10, 6))
plt.plot(t, signal, label='Original Signal 8Hz')
plt.stem(t_sample, samples, linefmt='g-', markerfmt='go',
basefmt=' ', label='Sampling frequency 16Hz')
plt.title('Aliasing Demonstration')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.legend()
plt.grid()
plt.show()
```

Trade off analysis

```
import numpy as np
import matplotlib.pyplot as plt
from scipy.fftpack import dct, idct
```

```
signal = np.array([3, 6, 9, 12, 15, 18])
N = len(signal)
```

```
# Function for compression, reconstruction, and analysis
def analyze_tradeoff(signal, thresholds):
    original_size = len(signal)
    results = {"thresholds": [], "compression_ratios": [],
"distortions": []}
```

```
    for threshold in thresholds:
        # Apply DCT
        dct_coeffs = dct(signal, norm='ortho')

        # Apply Thresholding (Compression)
        compressed_coeffs = np.where(abs(dct_coeffs) >
threshold, dct_coeffs, 0)

        # Calculate Compression Ratio
        compressed_size = np.count_nonzero(compressed_coeffs)
        compression_ratio = original_size / compressed_size

        # Reconstruct Signal
        reconstructed_signal = idct(compressed_coeffs,
norm='ortho')

        # Calculate Distortion (MSE)
        mse = np.mean((signal - reconstructed_signal) ** 2)

        # Store Results
        results["thresholds"].append(threshold)

results["compression_ratios"].append(compression_ratio)
        results["distortions"].append(mse)

    return results
```

```
# Perform Analysis for a Range of Thresholds
thresholds = np.linspace(4,12,3)  # Threshold values
results = analyze_tradeoff(signal, thresholds)
```

```
print("Threshold | Compression Ratio | Mean Squared Error
(Distortion)")
print("----------|-------------------|-----------------------
--------")
for i in range(len(thresholds)):
     print(f"{thresholds[i]:10}|{results['compression_ratios']
     [i]:19.2f}|{results['distortions'][i]:32.2f}")
```

```
# Plot Compression Ratio vs. Distortion
```

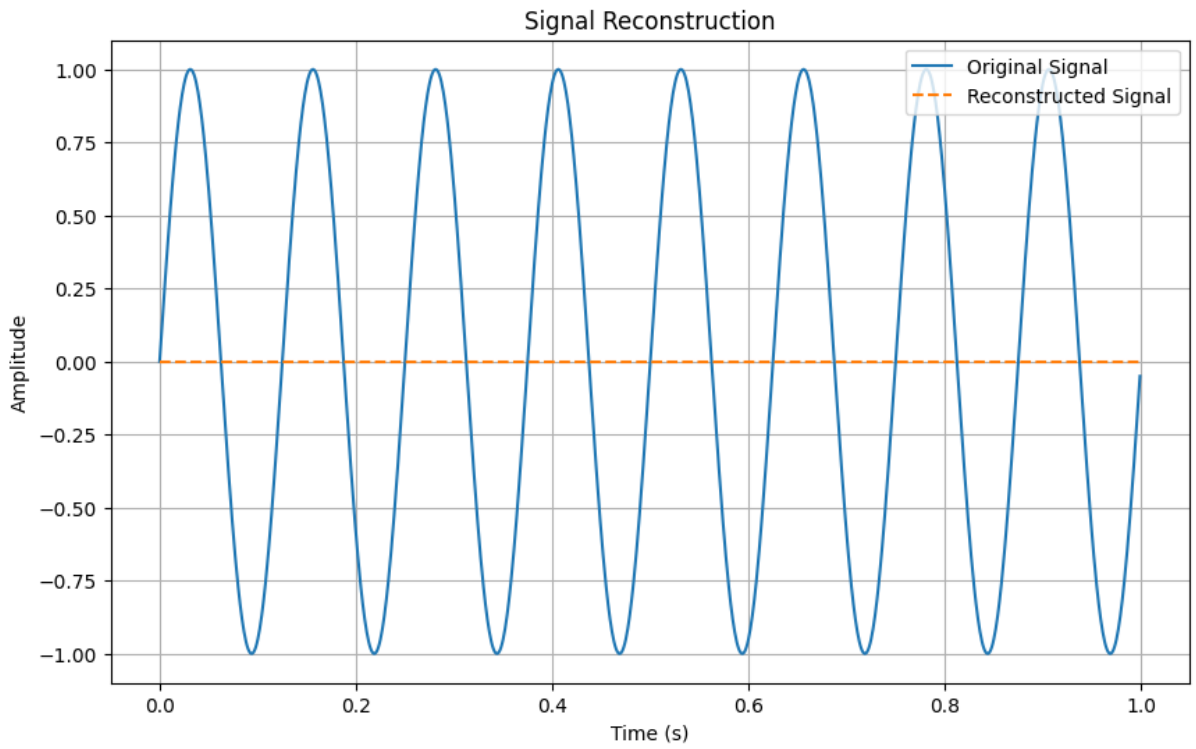
```
plt.figure(figsize=(8, 6))
plt.plot(results["compression_ratios"],
results["distortions"], marker='o')
plt.title("Trade-off Between Compression Ratio and Signal
Distortion")
plt.xlabel("Compression Ratio")
plt.ylabel("Mean Squared Error (Distortion)")
plt.grid()
plt.show()
```

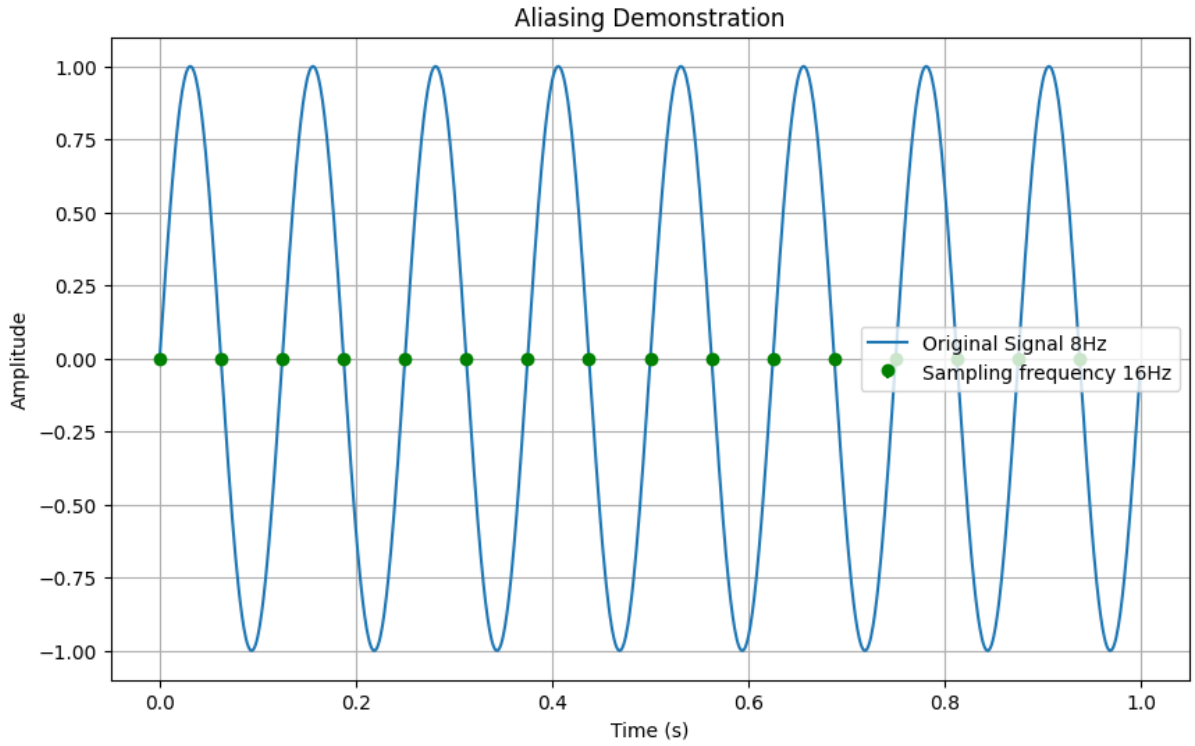
b) Link to remote repositorium

https://github.com/TobiaszWojnar/DSP

4. Outcomes:

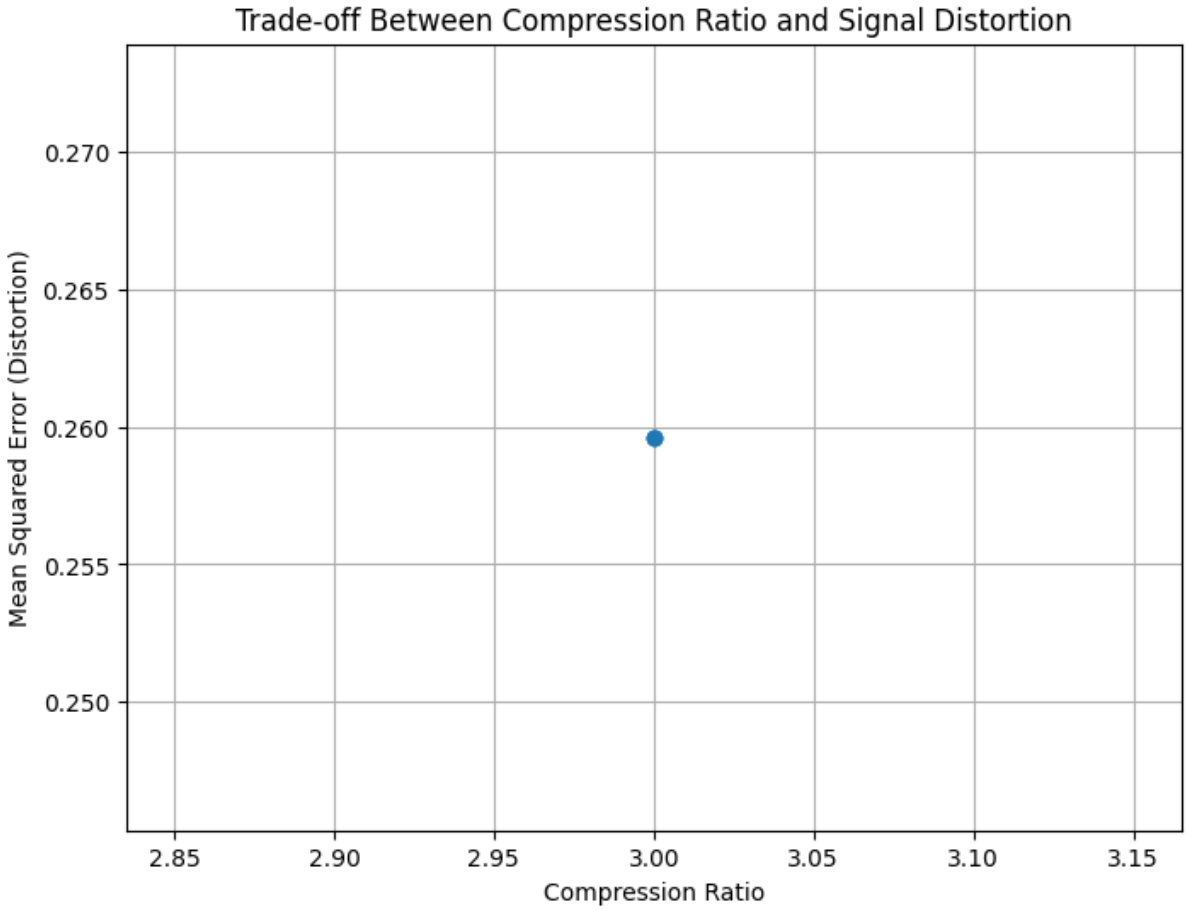
Signal reconstruction





Trade off analysis

Threshold	Compression Ratio	Mean Squared Error (Distortion)
4	3	0.26
8	3	0.26
12	3	0.26



5. Conclusions

The application of DCT did not successfully transformed the original time-domain signal into a frequency-domain representation. Since sampling frequency was exactly twice as signal frequency. Due to this reason we always sampled signal when the amplitude was equal to zero.