REPORT

Zajęcia: Analog and digital electronic circuits
Teacher: prof. dr hab. Vasyl Martsenyuk

Lab 1
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Topic: "Spectral Analysis of Deterministic Signals"
Variant 2

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1 semestr,
Gr.2

1. Problem statement: The objective is to use discrete Fourier transform and its implementation with the help of matrix multiplication

2. Input data:

$x_\mu = [10, 5, 6, 6, 2, 4, 3, 4, 5, 0, 0, 0, 0]^T$

3. Commands used (or GUI):

a) source code

a. Visualizing the Fourier matrix

```
fig, ax = plt.subplots(1, N)
fig.set_size_inches(6, 6)
fig.suptitle(
   r'Fourier Matrix for $N=$%d, blue: $\Re(\mathrm{e}^{+\mathrm{j}
\frac{2\pi}{N} \mu k})$, orange: $\Im(\mathrm{e}^{+\mathrm{j}
\frac{2\pi}{N} \mu k})$' % N)

for tmp in range(N):
   ax[tmp].set_facecolor('lavender')
   ax[tmp].plot(W[:, tmp].real, k, 'C0o-', ms=7, lw=0.5)
   ax[tmp].plot(W[:, tmp].imag, k, 'C1o-.', ms=7, lw=0.5)
   ax[tmp].set_ylim(N-1, 0)
   ax[tmp].set_xlim(-5/4, +5/4)
   if tmp == 0:
      ax[tmp].set_yticks(np.arange(0, N))
      ax[tmp].set_xticks(np.arange(-1, 1+1, 1))
      ax[tmp].set_ylabel(r'$\longleftarrow k$')
   else:
      ax[tmp].set_yticks([], minor=False)
      ax[tmp].set_xticks([], minor=False)
   ax[tmp].set_title(r'$\mu=$%d' % tmp)
fig.tight_layout()
fig.subplots_adjust(top=0.91)

fig.savefig('fourier_matrix.png', dpi=300)
```

b. Visualizing a signal using IDFT

```
if N == 13:
    X_test = np.array([10, 5, 6, 6, 2, 4, 3, 4, 5, 0, 0, 0, 0])

    x_test = 1/N * np.matmul(W, X_test)

    plt.stem(k, np.real(x_test), label='real',
             markerfmt='C0o', basefmt='C0:', linefmt='C0:')
    plt.stem(k, np.imag(x_test), label='imag',
             markerfmt='C1o', basefmt='C1:', linefmt='C1:')

    plt.plot(k, np.real(x_test), 'C0o-', lw=0.5)
    plt.plot(k, np.imag(x_test), 'C1o-', lw=0.5)
    plt.xlabel(r'sample $k$')
    plt.ylabel(r'$x[k]$')
    plt.legend()
    plt.grid(True)

    print(np.allclose(ifft(X_test), x_test))
    print('DC is 1 as expected: ', np.mean(x_test))
```

c. Displaying the W matrix columns

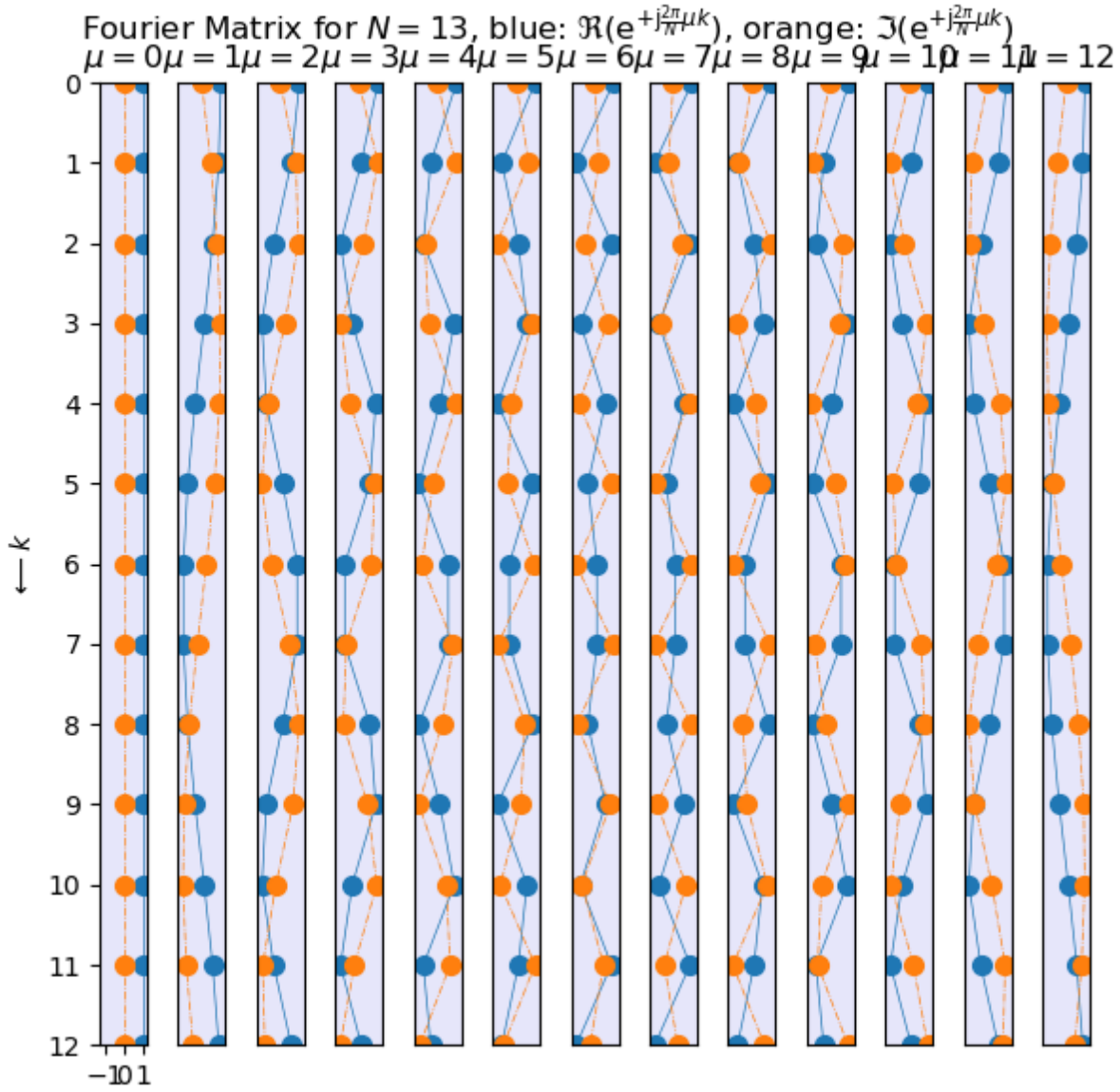
```
if N == 13:
    print(np.conj(W[:, 0])@x_test)
    print(np.conj(W[:, 1])@x_test)
    print(np.conj(W[:, 2])@x_test)
```

b) screenshots

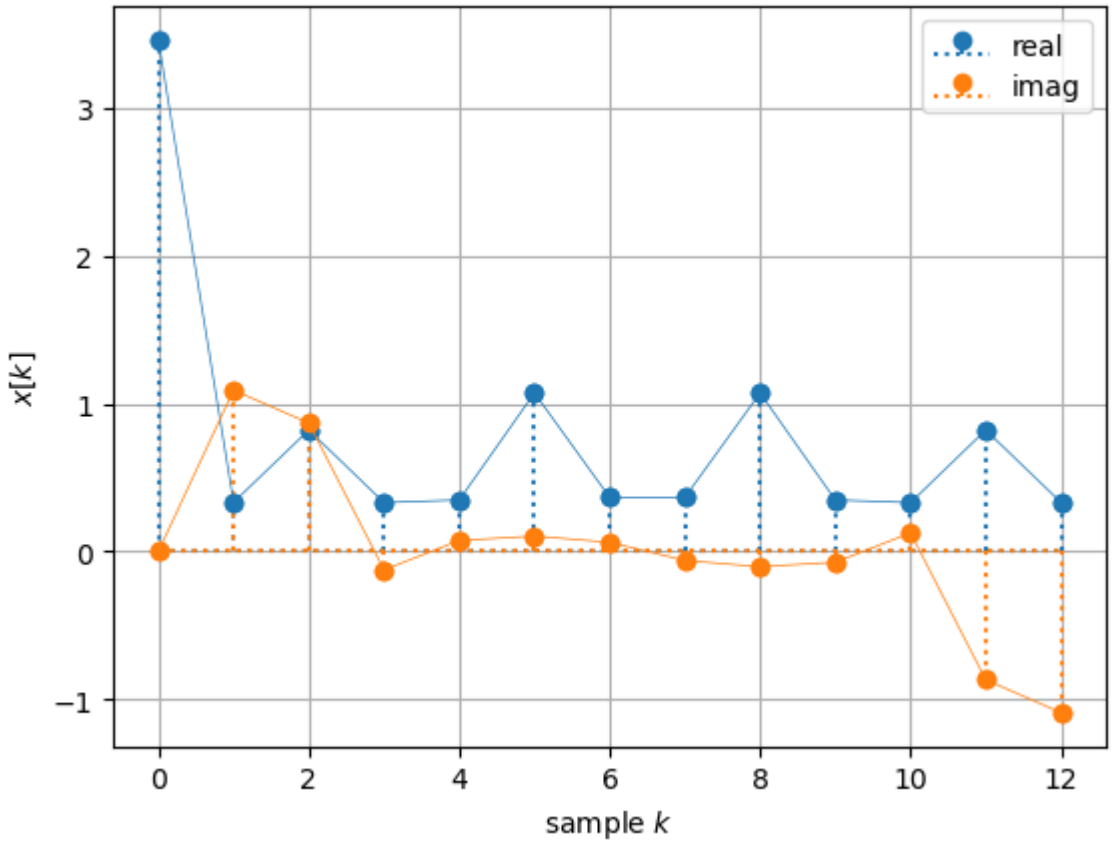
https://github.com/wm64167/AADEC

4. Outcomes:

ad a.



ad b.



ad c.

(9.999999999999998-1.1102230246251565e-16j)
(5.000000000000001+2.525757381022231e-15j)
(5.999999999999999+1.3322676295501878e-15j)

5. Conclusions: For the reasons given, we conclude that discrete Fourier Transform can be used to convert digital signals from For the reasons given, we conclude that discrete Fourier Transform can be used to convert digital signals from the time domain to the frequency domain, enabling analysis and manipulation of signals. Such complex tasks can be simplified with the usage of right tools like Python and its libraries like numpy or matplotlib.