

Assignment 2: Fourier Series and Fourier transformations

Problem 1: Fourier Series Expansion (8M)

(i) Given a periodic square wave signal $x_1(t)$ with the following characteristics: - Period T of 2 seconds. - Amplitude A of 3 units. - It is defined as $x_1(t) = \begin{cases} 3, & 0 \leq t < 1 \\ -3, & 1 \leq t < 2 \end{cases}$

and (ii) $x_2(t) = 3 + \sqrt{3}(\cos 2t + \sin 2t + \sin 3t - 0.5 * \cos(5t + \pi/3))$

a. Plot the original signals ($x_1(t)$ and $x_2(t)$) and the reconstructed signal using the first n (let's say $n = 0, 1, 2, 3, 4, 5$) harmonics of the Fourier series. Compare the two plots. Write what you observe (important observations).

Problem 2: Fourier Transform (4M)

Given a continuous-time signal $x(t)$ defined as:

$$x(t) = e^{-2t} \cdot u(t)$$

where $u(t)$ is the unit step function.

b. Plot the magnitude and phase of $X(f)$ as functions of frequency f .

Problem-3: Frequency Analysis (Theory Questions) (8M)

Fourier Series Theory Questions:

1. Applications in Signal Processing: Describe how Fourier series is used in signal processing. Provide examples of how it can be applied in audio processing and image compression.
2. Cybersecurity: Discuss the role of Fourier series in cybersecurity. How can Fourier analysis help in detecting irregular patterns or anomalies in network traffic data?
3. Data Analysis: Explain how Fourier series is relevant in data analysis. Provide examples of how it can be used to analyze time-series data in fields like finance and IoT.
4. IT Engineering: In what ways can Fourier series be applied in IT engineering, partic-

ularly in the design and optimization of computer algorithms? Provide examples.

Fourier Transform Theory Questions:

5. Image Processing: How is the Fourier transform applied in image processing? Explain the concept of image frequency domain representation and its significance.

6. Data Science: Describe the role of the Fourier transform in data science and machine learning. Provide examples of applications in feature extraction and data preprocessing.

7. Cybersecurity and Encryption: Discuss how the Fourier transform is used in encryption and cybersecurity. Explain the concept of frequency-domain encryption and its benefits.

8. Big Data: In the context of big data analytics, how can Fourier analysis be utilized to process and analyze large datasets efficiently?

These theory questions can help IT engineers understand the broader applications of Fourier series and transformations in IT, cybersecurity, data science, and related fields. By connecting theory to practical use cases, engineers can appreciate the importance of these mathematical tools in solving real-world problems.