SIGNALS AND SYSTEMS

Introduction to Discrete-Time Fourier Transform (DTFT)

DTFT

- To analyze discrete-time, non-periodic signals.

Importance in Digital Signal Processing

- Analyzing the frequency content of signals

DTFT *vs* Fourier Series

- Applies to non-periodic discrete signals
- Fourier Series applies to periodic signals.

Discrete-time signals

- Sequences of values, each representing the signal at specific discrete time intervals.

  Example: $x[n]=\{3,-1,0,2\}$

- The output is a continuous function of frequency
- The DTFT of a discrete-time signal $x[n]$ is
- DTFT Formula

$$X(w) = \sum_{n=-\infty}^{\infty} x[n]e^{-jwn}$$

DTFT *vs* DFT

- DTFT provides a continuous frequency representation.
- DFT is used for finite signals and yields discrete frequency samples
- DTFT is a function of a continuous variable, it can't be computed inside a digital system.
- DFT samples the DTFT points to recover the original signal.

Properties of DTFT

- Linearity
- Time-Shifting
- Frequency-Shifting
- Convolution in Time Domain

Magnitude and Phase Spectra

- The magnitude spectrum, $|X(W)|$ shows the strength of each frequency component.
- The phase spectrum, $\angle X(\omega)$ shows the phase shift of each component.
- Magnitude spectrum helps in understanding signal energy distribution
- Phase spectrum reveals timing information.

Examples of DTFT

- DTFT of an Exponential Sequence
- DTFT of a Cosine Sequence
- Visual Representations

Applications of DTFT

- Signal Filtering
- System Response Analysis
- Signal Modulation
- Speech and Audio Processing


Thank you