**Frequency Domain Representation Using DTFT - MATLAB Example**

**1. Introduction**

In digital signal processing, signals are often analyzed in the frequency domain. The Discrete-Time Fourier Transform (DTFT) provides a representation of a discrete-time signal in terms of its frequency content.

**2. Discrete-Time Fourier Transform (DTFT)**

For a discrete-time signal , the DTFT is given by:

Where: (DTFT)

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* : Time-domain discrete signal
* : Frequency-domain representation
* : Normalized frequency in radians/sample, ranging from to

**3. Example Signal**

Consider the signal:

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This is a finite-duration pulse of length 5.



**4. MATLAB Code to Compute DTFT**

clc;

clear;

% Define the time-domain signal x[n]

n = 0:4;

x = ones(1, length(n)); % x[n] = 1 for n = 0 to 4

% Define the frequency range

omega = linspace(-pi, pi, 1000);

X = zeros(size(omega)); % Initialize DTFT result

% Compute DTFT manually

for k = 1:length(omega)

X(k) = sum(x .\* exp(-1j \* omega(k) \* n));

end

% Plot Magnitude and Phase

figure;

subplot(2,1,1);

plot(omega, abs(X), 'LineWidth', 2);

xlabel('\omega (rad/sample)');

ylabel('|X(e^{j\omega})|');

title('Magnitude Spectrum');

grid on;

subplot(2,1,2);

plot(omega, angle(X), 'LineWidth', 2);

xlabel('\omega (rad/sample)');

ylabel('\angleX(e^{j\omega})');

title('Phase Spectrum');

grid on;

**5. Output Explanation**

* The **magnitude spectrum** shows the strength of each frequency component.
* The **phase spectrum** shows the phase shift associated with each frequency component.

This example demonstrates how a simple time-domain signal can be transformed into its frequency domain counterpart using DTFT in MATLAB.

**6. Conclusion**

Understanding the frequency domain representation is essential for analyzing and designing digital filters, communication systems, and more. The DTFT provides an exact frequency representation of a signal with infinite frequency resolution.