

Applied Signals & System (ECE – 205)

Lab-3 Report

Batch- ECE- IoT-1

**Submitted by – Jjateen Gundesha (BT22ECI002) Submitted to - Dr. Nikhil Agrawal**

**Aim:**To explore Parseval's Theorem and the Fourier Transform Time Scaling Property. Parseval's Theorem establishes a relationship between the energy of a signal in the time domain and its frequency domain representation. Additionally, we will investigate how scaling a signal in the time domain affects its Fourier transform. Furthermore, this lab introduces the Laplace transform and examines its properties.

**Theory:**

**Parseval's Theorem:**

Parseval's theorem is a fundamental property of signals in both time and frequency domains. It states that the total energy of a signal in the time domain is equal to the total energy of its Fourier Transform in the frequency domain. Mathematically, it is expressed as:



Where:

* x(t) is the time-domain signal.
* X(ω) is its Fourier Transform.

**MATLAB Code**

clc

clear all

close all

step\_omega=0.01\*pi;

step\_size\_t=0.1;

t=-40:step\_size\_t:40;

length\_t=length(t);

omegax=-(1/step\_size\_t)\*pi:step\_omega:(1/step\_size\_t)\*pi;

length\_omega=length(omegax);

expo\_omega = zeros(length\_omega, length(t)); % Initialize expo\_omega with the correct dimensions

for ii=1:length\_omega

expo\_omega(ii,:)=exp(-1j\*omegax(ii).\*t);

end

[x\_t\_1] = signal\_gen(t, 5, 1, 0.2, 0.5, 10,...

step\_size\_t, length\_t);

%Enery of the signal in time domain

data=abs(x\_t\_1).^2;

energy\_t=my\_int\_fun(data, step\_size\_t);

subplot(3,1,1), plot(t, [x\_t\_1])

[X\_omega\_1, omegax] = computation\_of\_FT(x\_t\_1, step\_size\_t, expo\_omega, omegax, length\_omega);

%Magnitute spectrum

X\_omega\_Mag\_1=abs(X\_omega\_1);

%Phase of the

Angle\_X\_omega\_1=atan(imag(X\_omega\_1)./real(X\_omega\_1) );

%Enery of the signal in Fre. domain

data=abs(X\_omega\_Mag\_1).^2;

energy\_fre=(1/(2\*pi))\*my\_int\_fun(data, step\_omega);

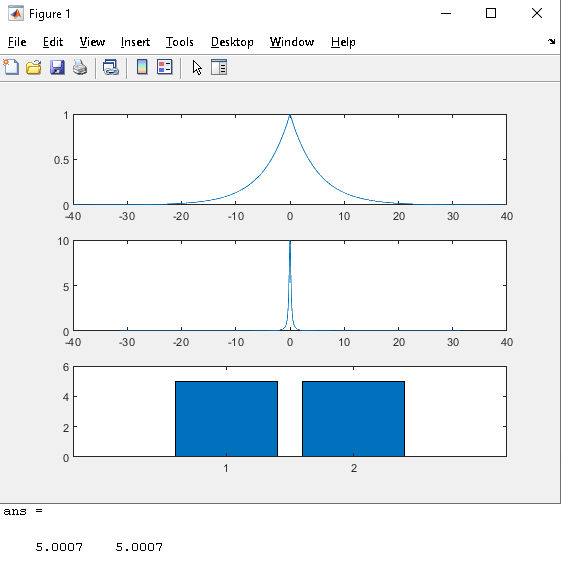
%Integration function

subplot(3,1,2), plot(omegax, [X\_omega\_Mag\_1] );

subplot(3,1,3), bar([energy\_t, energy\_fre ]);

pause(1)

[energy\_t, energy\_fre ]



**Fourier Transform Time Scaling Property:**

The Fourier Transform Time Scaling property relates changes in the time domain to the frequency domain. It states that compressing or expanding a signal in the time domain results in a corresponding compression or expansion in the frequency domain. Mathematically, for a time-scaled signal

x(at), the Fourier Transform is given by:



**MATLAB Code**

clc

clear all

close all

step\_omega=0.1\*pi;

step\_size\_t=0.01;

t=-40:step\_size\_t:40;

length\_t=length(t);

omegax=-(1/step\_size\_t)\*pi:step\_omega:(1/step\_size\_t)\*pi;

length\_omega=length(omegax);

expo\_omega = zeros(length\_omega, length(t)); % Initialize expo\_omega with the correct dimensions

for ii=1:length\_omega

expo\_omega(ii,:)=exp(-1j\*omegax(ii).\*t);

end

[x\_t\_1] = signal\_gen(t, 9, 1, 0.7, 1, 10,...

step\_size\_t, length\_t);

[x\_t\_2] = signal\_gen(t, 9, 1, 0.7, 1, 20,...

step\_size\_t, length\_t);

subplot(3,1,1), plot(t, [x\_t\_1; x\_t\_2])

[X\_omega\_1, omegax] = computation\_of\_FT(x\_t\_1, step\_size\_t, expo\_omega, omegax, length\_omega);

[X\_omega\_2, omegax] = computation\_of\_FT(x\_t\_2, step\_size\_t, expo\_omega, omegax, length\_omega);

%Magnitute spectrum

X\_omega\_Mag\_1=abs(X\_omega\_1);

X\_omega\_Mag\_2=abs(X\_omega\_2);

%Phase of the

Angle\_X\_omega\_1=atan(imag(X\_omega\_1)./real(X\_omega\_1) );

Angle\_X\_omega\_2=atan(imag(X\_omega\_2)./real(X\_omega\_2) );

%theoertical calculation of phase and magnitute

for ii=1:length(omegax)

X\_omega\_Mag\_the(ii)=0;

Angle\_X\_omega\_the(ii)=0;

end

subplot(3,1,2), plot(omegax, [X\_omega\_Mag\_1; X\_omega\_Mag\_2] );

subplot(3,1,3), plot(omegax, [Angle\_X\_omega\_1; Angle\_X\_omega\_2] );

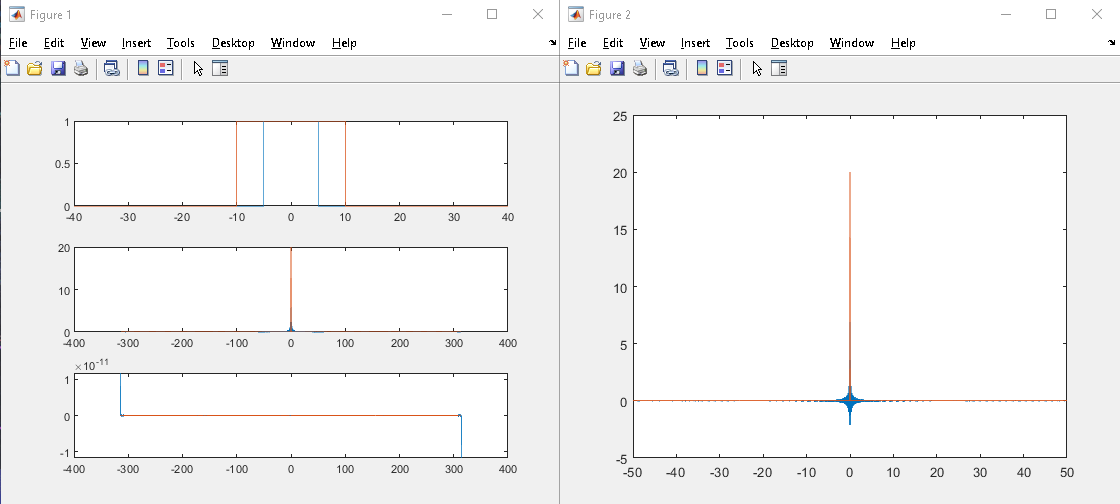
pause(1)

figure, plot(omegax/(2\*pi), real([X\_omega\_1; X\_omega\_2]) );

% [x\_t\_recover, t] = computation\_of\_IFT...

% (X\_omega, omegax, step\_omega, t);

% subplot(2,2,4), plot(t, real(x\_t\_recover));



**Conclusion:**

In conclusion, Parseval's theorem provides a useful tool for comparing the energy of a signal in both the time and frequency domains. The Fourier Transform time scaling property allows us to understand how changes in the time domain affect the frequency domain representation of a signal. These concepts are fundamental to signal processing and have practical applications in various fields.