ASIAN INSTITUTE OF TECHNOLOGY
SCHOOL OF ENGINEERING AND TECHNOLOGY
TELECOMMUNICATIONS
AT77.02 - SIGNALS, SYSTEMS AND STOCHASTIC PROCESSES

Wave Generation and Fast Fourier Transform

1 Objectives

1. To generate continuous and discrete signals using Matlab.
2. To perform the operations on signals and sequences such as addition, multiplication, scaling, shifting
3. To compute energy and power of a signal.
4. To find the Fourier Transform of a given signal and plotting its magnitude spectrum.

2 Software

Matlab

3 Background and Theory

A periodic signal can be represented as v (t) = v (t+ T_0). In a non periodic or aperiodic signal T_0 has no value. A continuous signal is defined at every instant of time but a discrete signal is defined only at a set of time instants.

Addition, Multiplication - Two signals can be added or multiplied together to create a new signal.

Amplitude Scaling of Signals- A very basic operation performed on signals to vary its strength. It can be mathematically represented as Y(t) = k X(t). Here k is the scaling factor, where:- $k < 1 \rightarrow$ signal is attenuated, $k > 1 \rightarrow$ signal is amplified

Time shifting- this is used to fast forward or delay a signal. It can be represented as Y(t) = X(t - t_0) where t_0 is the time shift. If $t_0 > 0$ then the signal is right shifted or delayed and if $t_0 < 0$ it is left shifted or advanced.

Energy- Energy of a continuous signal is defined as $\int_{-\infty}^{+\infty} |x(t)|^2 \, dt$

Energy of a discrete signal is $\sum_{i=-\infty}^{\infty} |x(n)|^2$

Average power - is defined as $\lim_{x\to\infty} \frac{1}{T} \int_{-\frac{T}{2}}^{+\frac{T}{2}} |x(t)|^2 \, dt$

4 Procedure

4.1 Generating signals

1. Write down a Matlab program to generate a ramp signal, impulse signal, unit step signal, square wave signal, saw tooth signal, triangular signal, sinusoidal wave signal, sinc signal, a ramp sequence, impulse sequence, square wave sequence, saw tooth sequence, triangular sequence, sinusoidal wave sequence and sinc sequence. The code for a ramp signal and ramp sequence has been given to you.

```
%Generation of ramp signal
fs=500;
t=0:1/fs:0.1;
y1=t;
subplot(2,2,1);
plot(t,y1);
xlabel('time');
ylabel('amplitude');
title('ramp signal');
%Generation of ramp sequence
subplot(2,2,2);
stem(y1);
xlabel('n');
ylabel('amplitude');
title('Ramp sequence');
```

4.2 Operations on a continuous signal

1. Generate two sine waves with frequency 4Hz and 8Hz from the below signal in Matlab for 0 to 1s with 0.01 increments and plot both of them. $A = Sin(2\pi ft)$
2. Plot the addition and multiplication of these signals with each other.
3. Plot the amplified signal for 4Hz if the scaling factor k is 10.
4. Plot these time shifted signals for 0 to π with 0.01 increments with 2Hz. $A = 8sin(2\pi ft) B = 8sin(2\pi f(t + 10)) C = 8sin(2\pi f(t - 10))$

4.3 Operations on a discrete signal

1. Plot x[n1]= 1 3 4 6 0 3 8 0 3 and x[n2]= 1 2 2 6 4 9 4 0 6 sequence.
2. Plot the addition and multiplication of these signals with each other.
3. Plot the amplified signal for x[n1] if the scaling factor k is 5.
4. Plot the time shifted signal x[n1 - 3] and x[n1+3].

4.4 Energy and Power of a Signal

1. Write down a Matlab program to compute the energy and power of a discrete signal taking the user input sequence. Eg – for sequence 1 3 5 6 you should get the energy as 71 and power as 17.75

4.5 Magnitude spectrum in frequency domain

Write down programs to calculate FFT and plot magnitude spectrum in frequency domain for the following functions.

1. Sin($100\pi t$) with sampling frequency Fs=1500 Hz and for a duration of 10s
2. Cos($200\pi t$) with sampling frequency Fs=3000 Hz and for a duration of 10s
3. Cos($160\pi t + \pi/3$) with sampling frequency Fs=1500 Hz and for a duration of 10s
4. Square($10\pi t$) with sampling frequency Fs=150 Hz and for a duration of 1s
5. A square pulse with width = 0.2 and Fs = 150Hz
6. A Gaussian pulse with $x = \frac{1}{\sqrt{2\pi 0.01}} \mathrm{e}^{-t^2/(2*0.01)}$ and Fs = 60Hz
7. An exponential function with $x = 2\mathrm{e}^{-5t}$ and Fs= 150Hz

5 Discussion

When computing FFT in Matlab there are several steps involved in the procedure. Explain each step.