CENG 3131: Lab for Telecom & networks – Lab 2 Fourier analysis of a Square Wave

Goals: Analyze the spectrum of a sin wave and square wave using Matlab and Multisim.

1. Introduction

In this Lab you will learn frequency domain analysis, bandwidth, and data rate.

Read through the entire lab and scan any supplied files before starting work. Note, before running a simulation, you should always have a general understanding of how your circuit works.

2. TASK 1: Frequency components

Based on the Matlab problem2 in homework 1, do square wave form simulation

Use the parameter setting :

```
Fs = 1000;            % Sampling frequency
T = 1/Fs;             % Sampling period
L = 2000;             % Length of signal
t = (0:L-1)*T;        % Time vector

S % use for loop to generate square waveform with 1000 sin wave components

% Plot in time domain
plot(1000*t, S)
title('Signal')
xlabel('t (milliseconds)')
ylabel('X(t)')

% Fourier transform
Y = fft(S);
F = Fs*(0:(L/2))/L;
P2 = abs(Y/L);
P1 = P2(1:L/2+1);
P1(2:end-1) = 2*P1(2:end-1);

% Plot in frequency domain
plot(F,P1)
title('Single-Sided Amplitude Spectrum of S(t)')
xlabel('f (Hz)')
ylabel('|P1(f)|')
```

1. Now add more frequency components together. Use 1000 frequency components, each component has an odd multiplication increase of frequency from 1 and odd division decrease of amplitude from 1. Use for loop to achieve it.
2. Add all the components together. Scale it with the factor 4/π.
3. Transform it into frequency domain.

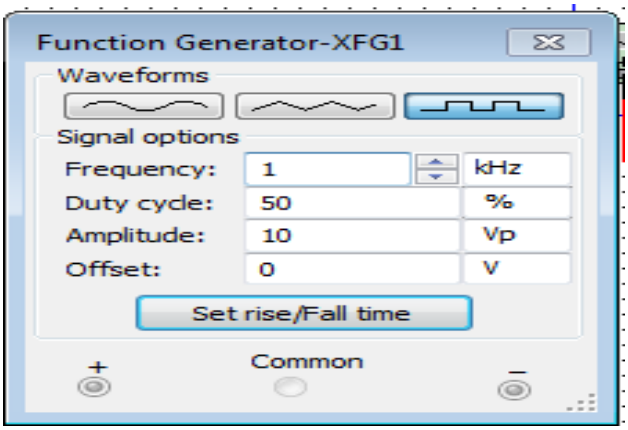
Question:

1. In mathematical way, please write down the expression of the square waveform with infinite sin waveform components.
2. Give the spectrum figure and point out the first five frequency components on figure.
3. In your report, please include the Time Domain and Frequency Domain schematic of the simulation.

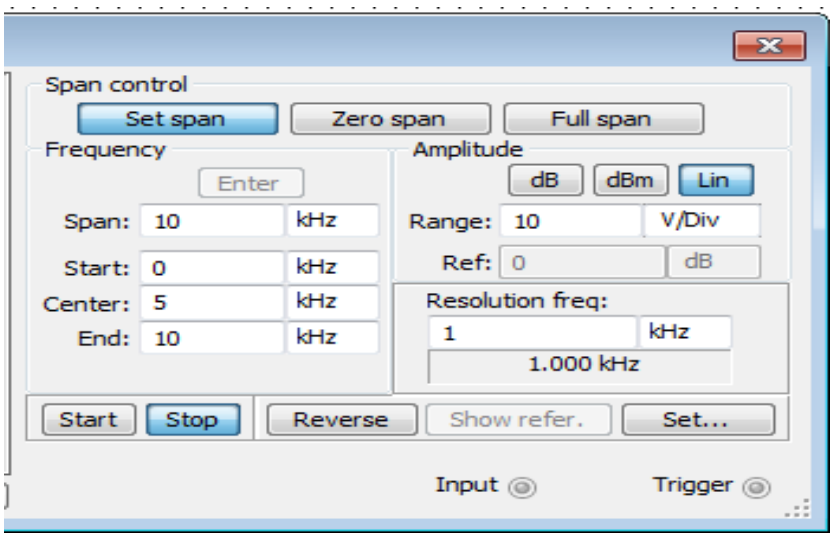
3. TASK 2: Build the simulation system

For this task you will build a test simulation using Multisim.

1. Use a function generator (10v amplitude, offset of 0v).



2. A scope
3. A spectrum analyzer. For the spectrum analyzer you might use 10 KHz for the span, starting at 0, center at 5 KHz, and ending at 10Kz. Then adjust it as the frequency increases.



Question:

1. In your report, please include the schematic of the simulation.
2. Using your simulation record the first five spectral lines for the following frequencies of a square wave.

Frequency	Spectral Line 1 (freq,amplitude)	Spectral Line 2 (freq,amplitude)	S.L. 3 (freq,amplitude)	S. L. 4 (freq,amplitude)	S.L 5 (freq,amplitude)
1 k hz					
2 k hz					
5k hz					
10 k hz					

3. Compare the theoretical results (task 1) and the simulation results (task 2) and discuss your conclusion in your lab book.

4. TASK 3: Investigate bandwidth and data rate

1. Use the task two simulation.
2. Set the frequency to 2 kHz.

Question:

1. If we use the square wave to transmit digital data (0s and 1s), what will be the data rate. Note data rate is the bits per second. (if two bits contain in one period)
2. Then, if we use the first three components to represent square wave, what is the bandwidth? (Refer to lecture)
3. Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with two signal levels. What can be the maximum bit rate?

5. TASK 4: Matlab for Musical notes

Run the code *music.m* given in blackboard. What is the name of the music? Have fun!

6. Laboratory Report

In no later than 14 days from the starting time your lab section, provide the TA a hard copy of a lab report following the CENG 3131 Lab report Template given on the Black Board. You can write it down to the lab book or include your report in lab book. Each student will submit one lab report to the TA. Your report should have the reporting requirements needed for all tasks. **The TA will take off a significant number of points if your does not follow the lab template.**

7. GRADING POLICY

1. Completion of Task 1 with results included in lab report (20%)
2. Completion of Task 2 with results included in lab report (35%)
3. Completion of Task 3 with results included in lab report (30%)
4. Completion of Task 4 with results included in lab report (5%)
5. Completeness, quality, and correctness of the lab report (10%)