Lab 1

Introduction

1.1   Pre-Lab

1. Calculate the exponential Fourier series coefficients for each of the three waveforms listed below:

   (a) $x(t) = A\sin(2\pi f_0 t)$

   (b) The square wave in Figure 1.1.

   (c) The triangular wave in Figure 1.2.

   In Problems 1b and 1c, begin by writing an analytical expression for each waveform.

2. Use MATLAB to draw the graphs of Fourier series coefficients versus the integers according to the results you got for each of the parts of Problem 1.

3. Explain the difference between dB, dBW, dBmW, dBV, dBmV, and dBμV.

4. Familiarize yourself with the spectrum analyzer by reading the documentation provided.

1.2   Overview

In this lab you will become familiar with the particular equipment that we will use throughout the term. You will also observe the spectrum of some common waveforms and compare their observed spectrum with theory (from the Pre-Lab).

$\underline{\text{WARNING:}}$ The spectrum analyzer is very sensitive to high input voltage levels. The input of each spectrum analyzer has the maximum input voltage level labeled in YELLOW (usually less than 1 Volt). Before connecting any input to the analyzer, check that the signal is an order of magnitude smaller
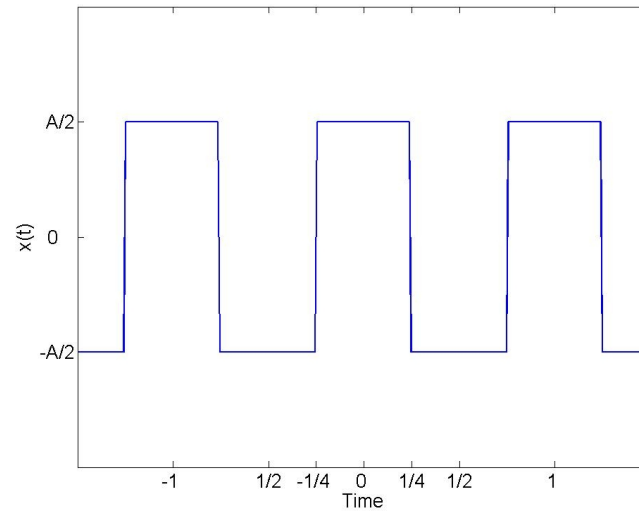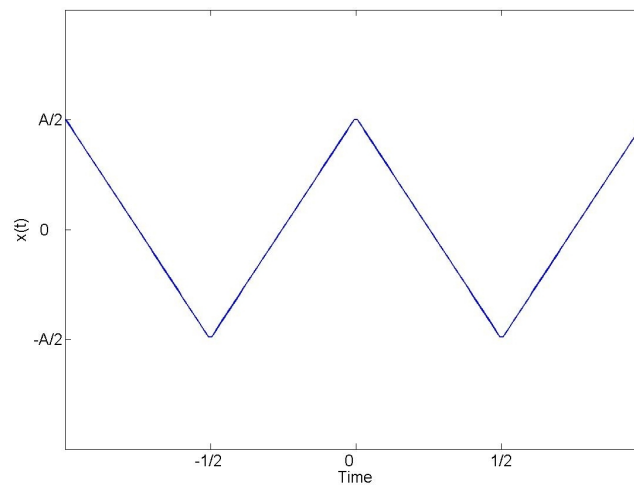
Figure 1.1: Square wave for Problem 1b

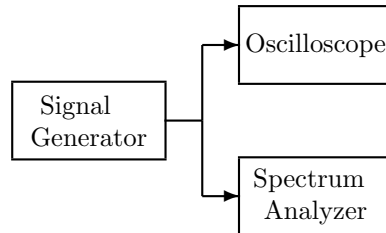Figure 1.2: Triangular wave for Problem 1c

Figure 1.3: Equipment setup for Experiment 1

than the maximum. No signal with DC component magnitude greater than 100 mV should be fed into the spectrum analyzer.

1.3 Procedure

1. Connect the signal generator to an attenuator and then to the oscilloscope and adjust the generator as necessary to output a sine wave at the desired (safe) voltage level of 0.2 Volts peak-to-peak with zero DC offset and a frequency of 10 kHz.

2. Connect this signal to the spectrum analyzer (see Figure 1.3) and observe the sine wave in both the time and frequency domain. (Use a T-connector to make the the parallel connection shown.) Measure the magnitude of the impulses you observe. You should see an impulse at DC and one each at +10 and -10 kHz. The magnitude of these impulses should be

$$20 \log \left(\frac{V_{\text{peak}}/\sqrt{2}}{V_{\text{ref}}} \right) = 20 \log \left(\frac{0.1/\sqrt{2}}{0.224} \right) = -10 \text{ dBm}$$

   (for a 0 dBm reference level). If the reference is set to +10 dBm, the ±10 kHz pulses will be placed at $-10-10 = -20$ dBm from the top line across the spectrum analyzer screen.

3. Decrease the amplitude of the sinusoid by one half. Record this level on the oscilloscope and the dBm value on the spectrum analyzer. Does it match what you expect to see?

4. Change the frequency of the input signal to 40 kHz. What happens to the spectrum? Does it match what you expect to see?

5. Repeat steps 1–4 for the square wave.

6. Repeat steps 1–4 for the triangular wave.

1.4   Discussion Questions

1. Use Formula (1.1) to calculate the theoretical magnitude of the exponential Fourier series coefficients in dB.

$$\text{Theoretical Magnitude } = 20\log \frac{\sqrt{2}a_n}{V_{\text{ref}}} \qquad (1.1)$$

   where a_n is the exponential Fourier series coefficients and V_{ref} is the reference voltage of the spectrum analyzer. Note that this magnitude is used to compare with what you see on the spectrum analyzer. It is not the real magnitude of the exponetial Fourier series coefficients in dB.
   Plot a graph of this magnitude versus the integers for each of the three waveforms.

2. For comparison (use the figure you generated for 1), plot the magnitude of the spectrum observed on the spectrum analyzer. Does it match the theoretical magnitude from 1?