Lab 2

Periodic Signal Spectra and Nonlinearities

2.1 Pre-Lab

1. Calculate the Fourier series for the pulse train shown in Figure 2.1.

2. Now make the pulse width more narrow by a factor of two. What happens to the Fourier series compared to that of Problem 1?

3. Simulate the signal of Problem 1 with MATLAB. Calculate the spectrum of this signal using the `fft` function and print the spectrum. (At least the fifth harmonics should be shown on the graph.) Does the simulation result match the result you get from Problem 1?

4. Describe briefly the roles of half-wave rectiviers, full-wave rectifiers, and hard limiters.

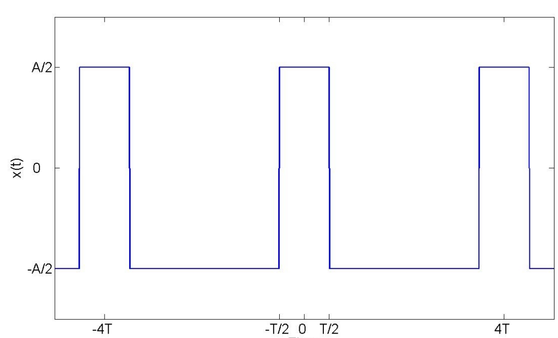

Figure 2.1: Pulse train for Problem 1.

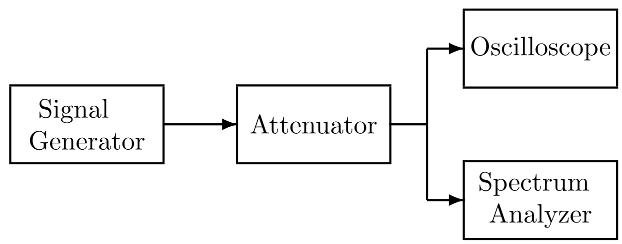

Figure 2.2: Equipment setup for step 2 of Experiment 2

2.2 Overview

In this lab we will become more familiar with the spectrum analyzer and observe the effect of nonlinear circuits on signal spectra.

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

2.3 Procedure

1. Using the programmable pulse generator, create a pulse train as shown in Figure 2.1. Let $T = 25\mu$s and $A = 1$V (note that the period of the signal here is $4T$). Observe the signal on the oscilloscope.

2. Connect this signal to the spectrum analyzer as in Figure 2.2 and observe the frequency domain of the pulse train. Measure the magnitude of the impulses you observe on the spectrum analyzer. What magnitude do you expect to see?

3. Now make the pulse more narrow by a factor of two but keep the same spacing in between pulses. Observe this signal on the oscilloscope and the spectrum analyzer. Record the shape of its spectrum. Does it match what you expect to see?

4. Adjust the signal generator to output a sine wave of frequency 1 kHz. Observe this signal on the oscilloscope. Connect the spectrum analyzer after adjusting the attenuator for the proper amplitude. Record all relevant data (such as amplitude, frequency, etc.).

5. Connect the half-wave rectifier as shown in Figure 2.3. Observe the output of the rectifier on the oscilloscope and on the spectrum analyzer. Record

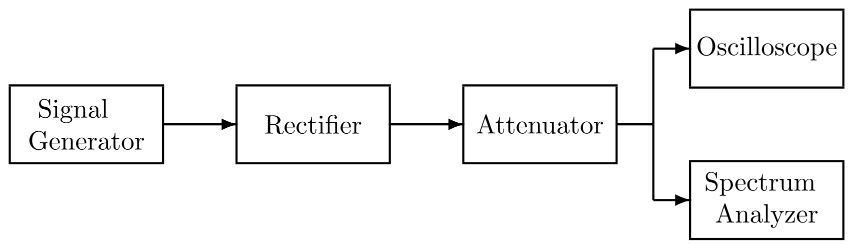

Figure 2.3: Equipment setup for step 5 of Experiment 2

all relevant data. What does the rectifier (a non-linear circuit) do to the output spectrum? How would a linear circuit behave?

6. Repeat step 5 with a full-wave rectifier.
7. Repeat step 5 with a hard limiter.

2.4 Discussion Questions

1. Given an LTI (linear time-invariant) system and an input signal, can there be spectral components in the output that are not present in its input? Explain.
2. Given a nonlinear time-invariant system and an input signal, can there be spectral components in the output that are not present in its input? Explain.