Fourier Series Analysis via Oscilloscope

Name: Christ-Brian Amedjonekou

Date: 3/18/2019

TCET 3102-E316 (Analog and Digital Com) Lab 2

Spring 2019, Section: E316, Code: 37251

Instructor: Song Tang

Members: ________________________________

____

Table of Contents

Lab #2 SIGNAL ANALYSIS WITH OSCILLOSCOPE AND SPECTRUM ANALYZER

- **Objective**: To experimentally investigate the spectra of various periodic signals.
- **Equipment**: Spectrum analyzer Agilent N1996A, function generator, oscilloscope.

A. THEORY

2.1. Introduction

The previous lab introduced us to time domain and frequency domain (Fast Fourier Transform (FFT) view of a signal using MATLAB. W also learned about frequency components of a signal (harmonics). In this experiment, we are to use hardware to observe real signals and their characteristics. We will utilize oscilloscope and spectrum analyzer. Both oscilloscopes and spectrum analyzers are instruments to view and analyze electronic signals. The difference between an oscilloscope and a spectrum analyzer is that an oscilloscope (normally) allows you to view the signal in the time domain, meaning how the signal changes in response to time, while a Spectrum Analyzer allows you to view the signal in the frequency domain (FFT), meaning how the signal changes in response to different frequencies. Therefore, the oscilloscope plots the Amplitude vs. Time of the signal, while the Spectrum Analyzer plots the Amplitude vs. Frequency of the signal.

B. EXPERIMENT

In this section, we will generate various signal utilizing a function generator and experimentally observe the signals utilizing both oscilloscope and spectrum analyzer. Block diagram of an experimental arrangement is shown in fig.1, where we connect a function generator output to spectrum analyzer and oscilloscope inputs, respectively.

At the spectrum analyzer mode, choose "START FREQUENCY" as zero Hz, choose the proper "STOP FREQUENCY", put the "AMPLITUDE" in linear mode, and use "PEAK SEARCH" for amplitude and frequency measurements. For further detail refer to Agilent CSA Spectrum Analyzer: Measurement Guide and Programming Examples (Manufacturing Part Number: N1996-90028).

Note: In the absence of a spectrum analyzer, an oscilloscope could be used to observe the frequency spectrum of a signal (Figure 2). The "MATH" button offers the option ("FFT") to view Fast Fourier Transform.

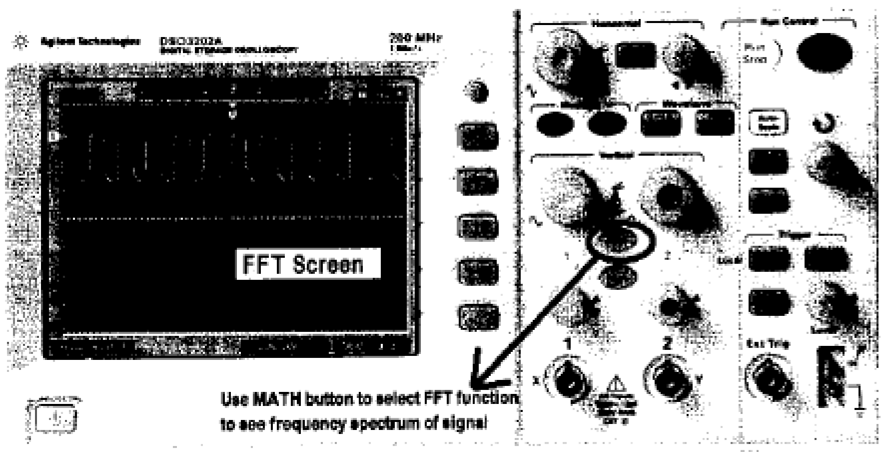


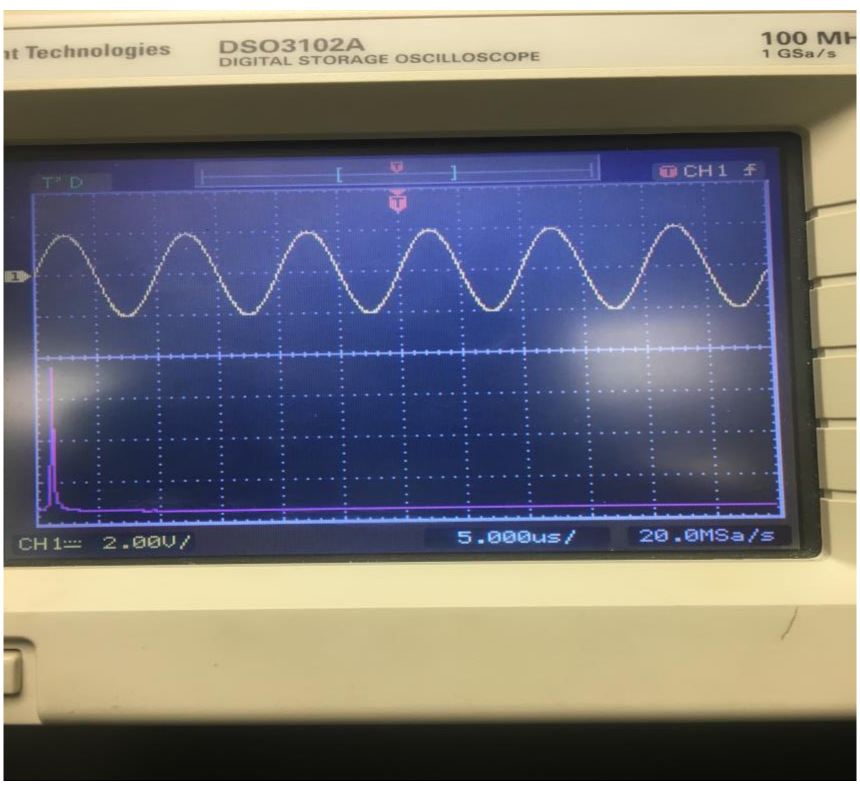
Figure 2: Time and Frequency domain view of signal in an Oscilloscope

Run 1:

- Generate a sinusoidal signal with a frequency of 100 KHz and the amplitude of 2 V. Observe the waveforms on the oscilloscope screen. Vary the Frequency and Amplitude slightly.
- Observe its spectrum on the spectrum analyzer screen.
- Vary the Frequency and observe the effect.
- Vary the Frequency and observe the effect. Show all figures and explain in the lab report

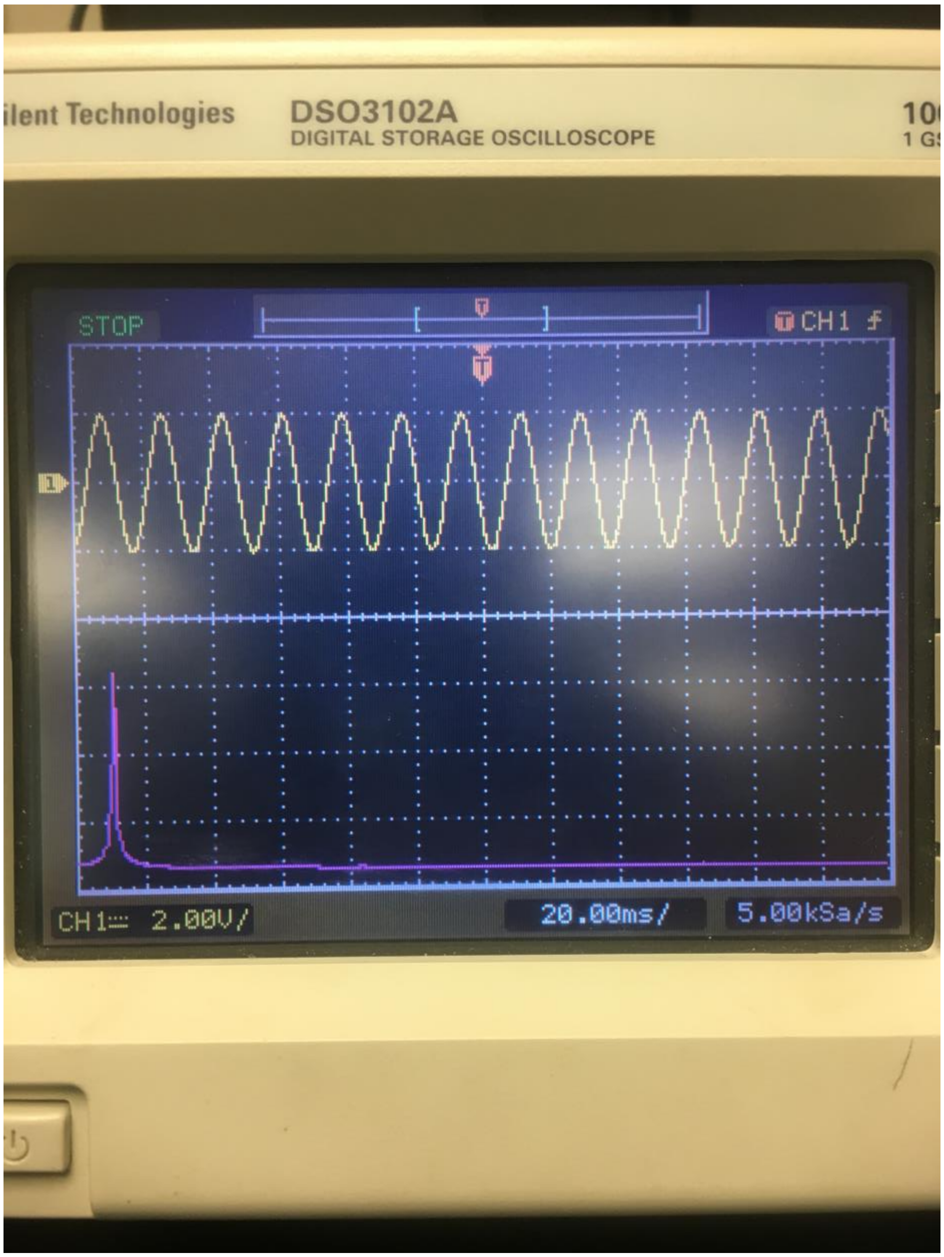
Run 1 Part 1:

- We set the frequency to 100 KHz and the amplitude of 2 V. So, for the Spectrum, we end up seeing one spike with a magnitude of 100 KHz.



Run 1 Part 2:

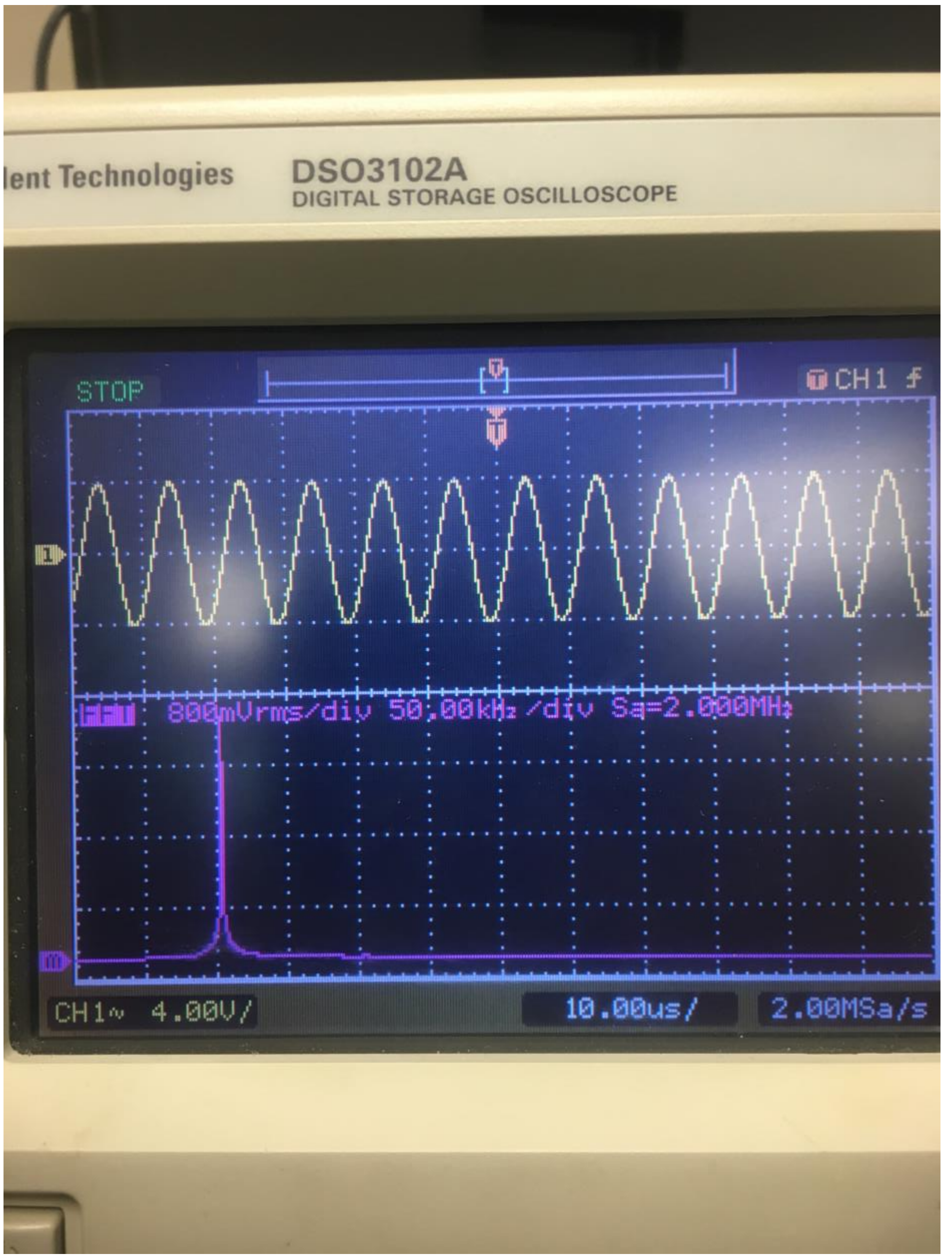
- We set the frequency to 75 KHz and the amplitude of 2 V. So, for the Spectrum, we end up seeing one spike with a magnitude of 75 KHz.



Run 1 Part 3:

- We set the frequency to $100\ KHz$ and the amplitude of $4\ V$. So, for the Spectrum, we end up seeing one spike with a magnitude of $100\ KHz$. Nothing really changed with the spectrum here.

Run 2:

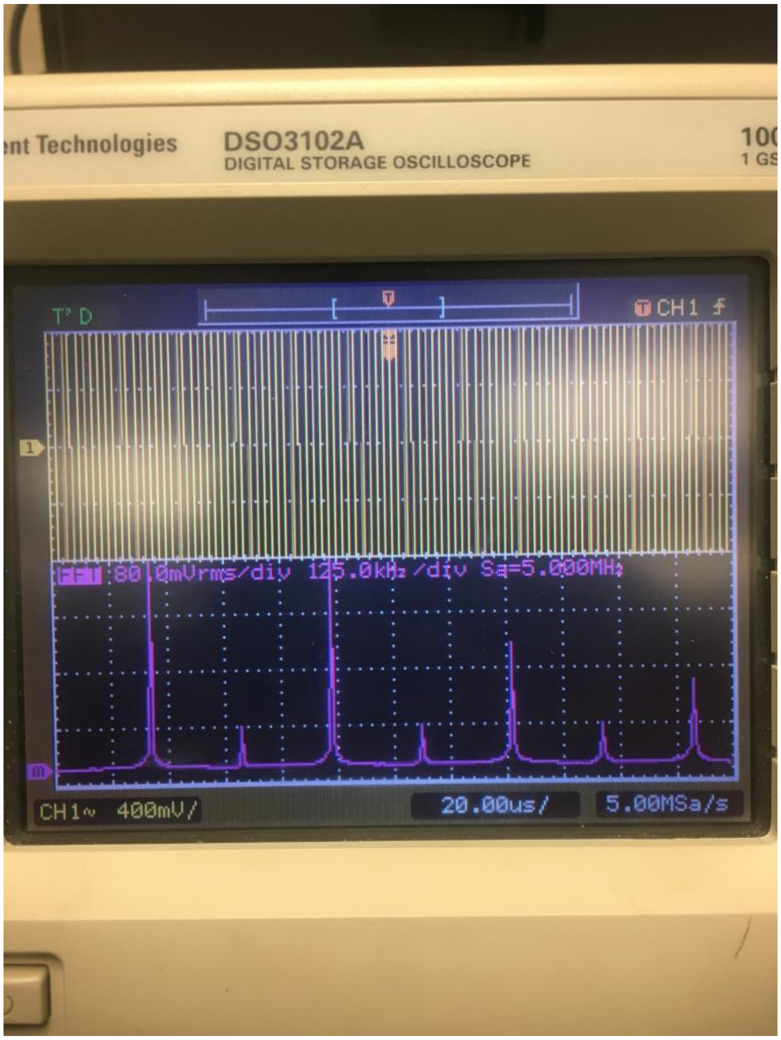


- Generate a square wave with an amplitude of 2 V and period of $T = 0.01\ ms$. Observe the signal in the oscilloscope screen.

- Observe its spectrum on the spectrum analyzer screen. Why is it different from Run 1?
- What is the fundament frequency? Why do even frequencies appear?
- Change the pulse width from $T\ to \frac{T}{2}$. What do you see in the frequency domain and why?

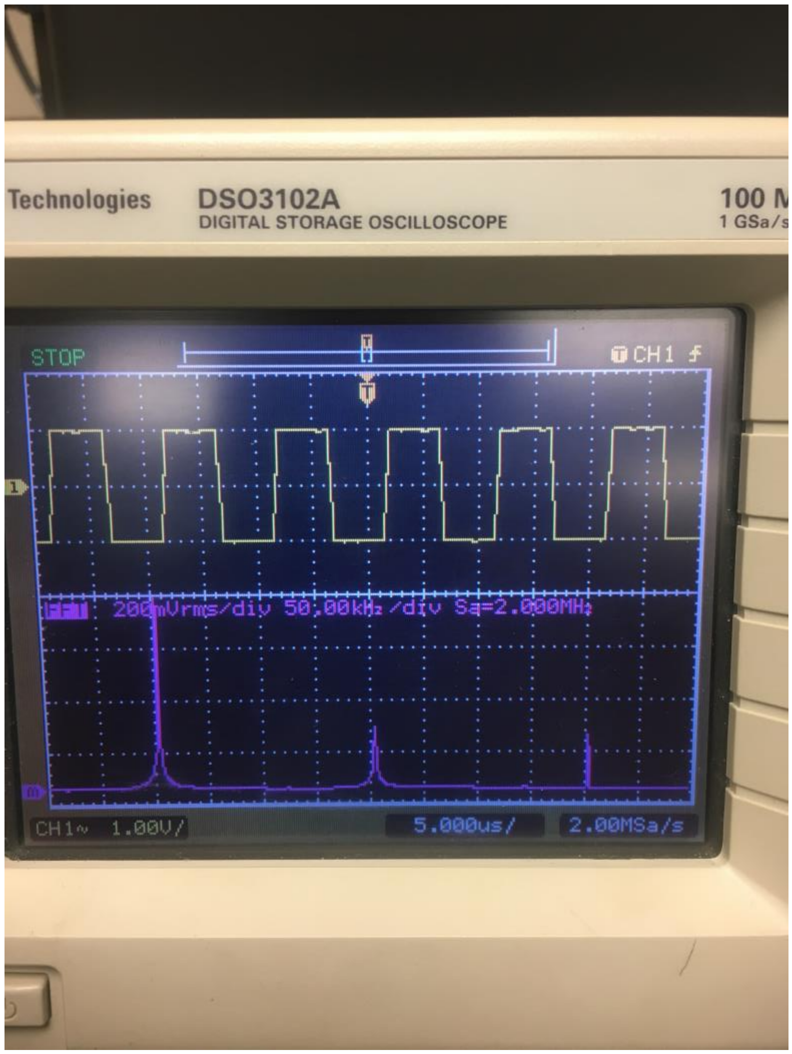
Run 2 Part 1:

- We generated a square wave with an amplitude of $2\ V$ and period of $T = 0.01\ ms$ here.
- The fundamental frequency is $100\ KHz$.



Run 2 Part 2:

- Change the pulse width from T to $\frac{T}{2}$. What do you see in the frequency domain and why?
- We see that there are no even harmonics.

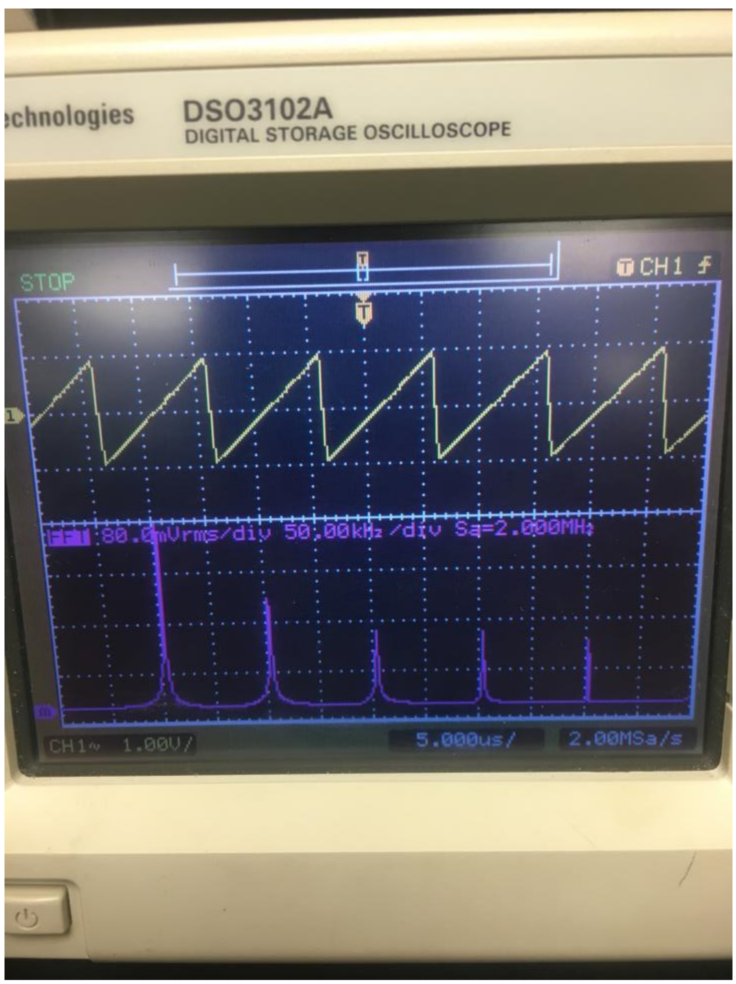


Run 3:

- Generate a sawtooth signal with the same frequency and amplitude as Run 2
- Observe the signal on both the oscilloscope and analyzer screens.
- Explain what you see.

Run 3 Part 1:

- We generated the sawtooth signal with the same frequency and amplitude as Run 2, shown below.
- For the spectrum, we see that the sawtooth wave has all harmonics (even and odd).



Conclusion:

- We were able to show the differences in spectrum across the three wave types. We illustrate the effect that amplitude and frequency have on sinusoids, pulse width on square waves, and we discover that the sawtooth signal contains all harmonics (even and odd).