Lab 2 – Generating and Measuring Waveforms

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***Abstract*—A microprocessor was used to generate three distinct types of waveforms at three separate frequencies. The waveforms were then analyzed using an oscilloscope. Finally, a spectrum analyzer ran a fourier transform on the wave to verify the frequency.**

I. Introduction

MODERN wave form generation often has two components:

- A clock generator
- A microcontroller

This setup has the advantage of being low-cost and also generally reliable.

In this lab, we will use an Si5351 clock generator and ItsyBitsy microcontroller to generate waveforms which can be analyzed on an oscillocsope. With just this setup, we will be able to generate several different frequencies of waveform.

The microcontroller will be programmed in a Python-like language called CircuitPython, which is open-source an easy to pick up for beginners.

II. Experimental Setup

The setup for this lab is a bit technical on both the signal generator and microprocessor sides. So I will enumerate the steps.

1) Gathered materials: Adafruit ItsyBitsy M4 Express, Adafruit Si5351A Clock Generator, breadboard, jumper cables.
2) Soldered SMA connectors to both the ItsyBitsy and the Si5351A.
3) Attached both ItsyBitsy and Si5351A to breadboard.
4) Connected appropriate pins between ItsyBitsy and Si5351A using jumper cables. (Correct pins can be seen in Fig. 1. and **Table 1**.)
5) Downloaded the Mu Editor for programming the ItsyBitsy microcontroller.
6) Updated the bootloader on the ItsyBitsy.
7) Installed CircuitPython to the ItsyBitsy.

III. Measurements and Results

Using the setup, we generated three different waveforms:

- 112.5 MHz, seen in Fig. 2(a).
- 13.55 MHz, seen in Fig. 2(b).
- 10.76 kHz, seen in Fig. 2(c).

Each waveform was visualized using the oscilloscope. We then compared the measured frequencies from the nominal frequencies, and computed the error. The results are in **Table 2**.

TABLE I
ITSYBITSY AND SI5351A PORT CONNECTIONS

ItsyBitsy Pin	Si5351A Pin
3V	Vin
GND	GND
SCL	SCL
SDA	SDA

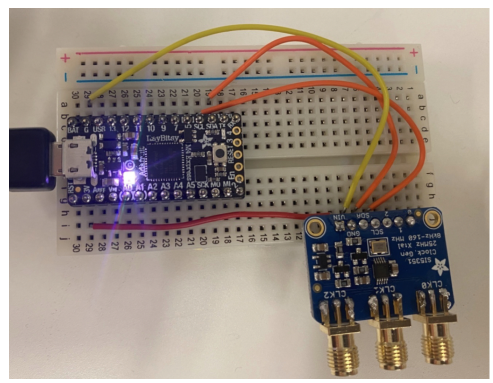


Fig. 1. ItsyBitsy, Si5351A, and breadboard connected using appropriate ports, as described in the documentation.

IV. Analysis

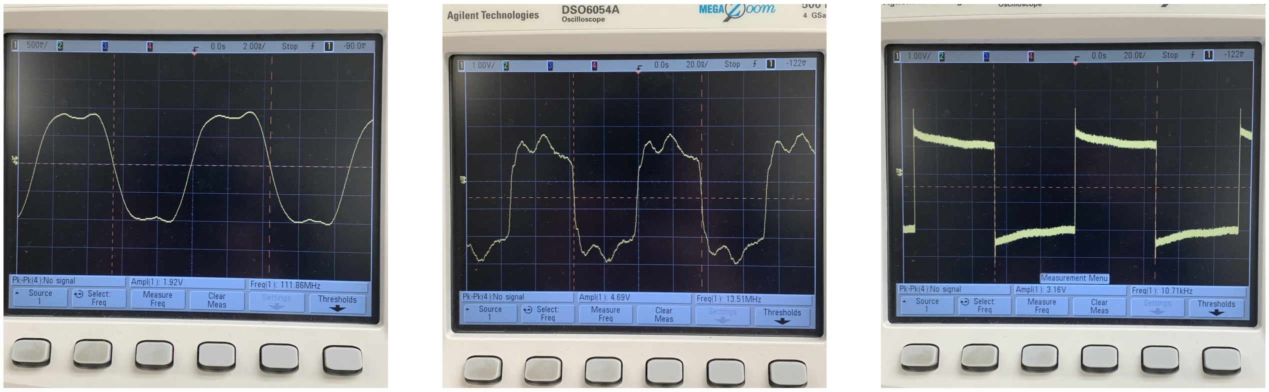
After measuring the on the oscilliscope, we analyzed the waves using a spectrum analyzer. These Fourier-transformed spectra are available in Fig. 3. The data comparing the measured peak frequencies to the nominal waveform frequencies are also available in **Table 3**.

V. Conclusion

This lab explored wave form generation, visualization, and analysis using a simple and cheap setup. A clock generator

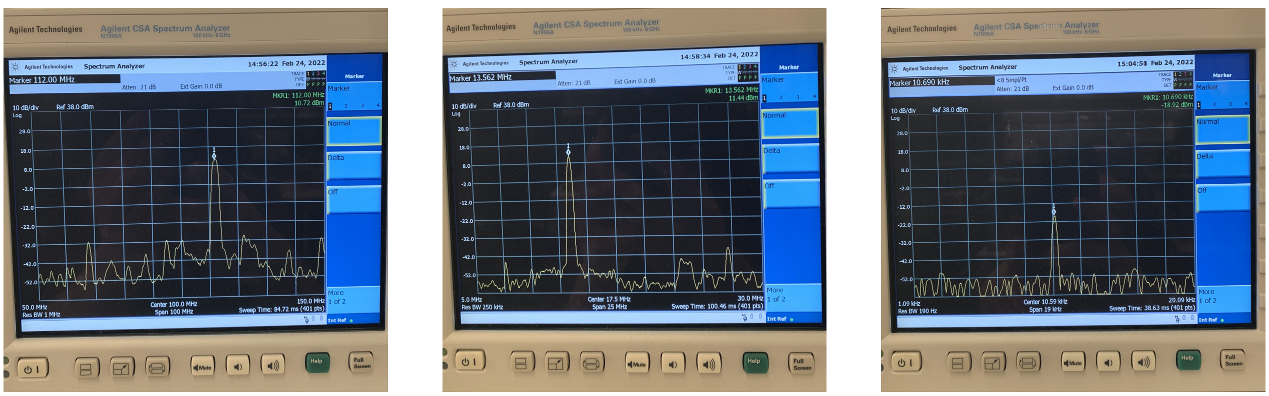
TABLE II
OSCILLISCOPE WAVEFORM FREQUENCIES

Nominal (Hz)	Actual (Hz)	Error
1.125×10^8	1.119×10^8	0.5%
1.355×10^7	1.351×10^7	0.3%
1.076×10^4	1.069×10^4	0.7%



(a) (b) (c)

Fig. 2. Waveform outputs, as seen with the oscilloscope. (a) 112.5 MHz. (b) 13.55 MHz. (c) 10.76 kHz. Deviations from nominal frequencies can be seen in **Table 2**.



(a) (b) (c)

Fig. 3. Frequency spectra, as seen with the spectrum analyzer. (a) 112.5 MHz. (b) 13.55 MHz. (c) 10.76 kHz. Deviations from nominal peak frequencies can be seen in **Table 3**.

TABLE III
SPECTRUM ANALYZER FREQUENCY PEAKS

Nominal (Hz)	**Actual (Hz)**	**Error**
1.125×10^8	1.120×10^8	0.4%
1.355×10^7	1.356×10^7	0.1%
1.076×10^4	1.069×10^4	0.7%

and microcontroller were the essential components.

Despite this primitive setup, we found that the mesaured frequencies in all 6 tests we ran deviated from the nominal frequencies by less than 1% each time. This is a remarkable result—and a testament to technological progress.

ACKNOWLEDGMENTS

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