Low-Cost Handheld Spectrometer and Flicker Meter

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***Abstract*—Whether it is in the classroom or on the job, temporal light modulation (flicker) affects our everyday lives. Flicker has many neurobiological impacts on our body that effect our performance. How we perceive both moving and stationary objects can also change as result of flicker. The goal of this project is to be able to detect flicker characteristics of common light sources by designing a low-cost handheld combination spectrometer and flicker meter. The flicker meter will provide some of the common flicker metrics as identified by the Illuminating Engineering Society (IES): Percent Flicker and Flicker Index. The intention of this design it to allow the user to walk into any lighting environment with this portable device and have light source data performance at their fingertips. The system will utilize the output of a Hamamatsu light sensor with data processing provided by an Analog Discovery 2 and a Raspberry Pi 3B+ (RPi) using Python language coding.**

I. Introduction

Flicker affects us whether we are aware of it or not. This is a result of flicker having visual and non-visual characteristics. Flicker's visual characteristics and impacts on our body are dependent on the amplitude and frequency of the variation [2,3,4]. Temporal light modulation (TLM) is used to describe any change in the intensity or spectral distribution [2,3,4]. TLM is characterized depending on the variation of amplitude and frequency while the term 'flicker' is used to reference a change in the visual perception of that variation [2,3,4]. Temporal light artefacts (TLA) include all visually perceived consequences of TLM. Flicker has been shown to have various negative effects on performance and health, as well as an increase in fatigue [2,6].

Negative Neurobiological Impacts of Flicker

Health effects due to flicker include seizures, migraines, headaches, eye strain, and reduced visual performance [6]. While flicker between 8-30 Hz has the most prominent effects, flicker above the visible threshold can still be perceived subliminally [6]. Even when flicker is beyond visible frequencies it has been shown to still result in many of the negative neurobiological impacts [2,3,6]. Since flicker is often inperceivable, it is important that there are tools to identify and describe it.

Negative Impacts of Flicker on Human Visual Perception

In addition to these health effects, flicker also impacts how we perceive moving and stationary objects as a result of TLA. This poses many concerns for our safety in industrial settings where heavy machinery requires strict safety standards and guidelines to adhere to.

II. Components and Functions

Device Functions

The function of this handheld flicker spectrometer is to capture and calculate the severity of flicker in a room or on a factory floor. This process is done by first interacting and navigating the touch screen and selecting the option to measure flicker. From there the user would then point the sensor on the device towards a light source to capture the luminescence of that light source. Then the meter would graph out the data as a graph light intensity versus time. Then the user would indicate if they wanted to see flicker index, percent flicker, or both by interacting with the touch screen.

Device Components

- Hamamatsu C12880MA
- Diligent Analog Discovery 2
- 1.4 GHz 63-bit quad core Raspberry Pi 3B+
- AdafruitPiTFT 2.8" capacitive touchscreen
- Adafruit 3.7V/1.2A li-polymer battery
- Adafruit Powerboost 1000 Charger
- Aluminum enclosure

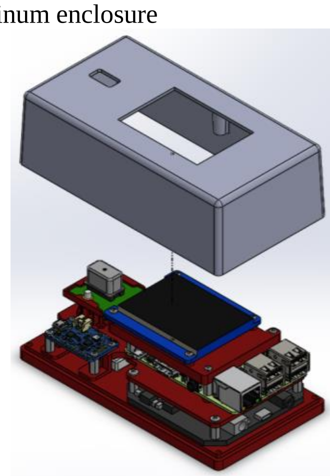

Figure 1. Aluminum Enclosure Assembly

III. Metrics and Equations

Percent Flicker

- Calculated through use of min and max points
- Measures the depth of modulation of flicker
- A = Max. Lux, B = Min. Lux (Figure 3)

$$PF = \frac{A - B}{A + B} * 100 \quad (1)$$

Flicker Index

- Calculation using integral of curve in relation to average lux
- Characterizes the intensity variation based on shape of waveform as well as amplitude
- Area of Lux vs Time (Figure 3)

$$FI = \frac{Area1}{Area1 + Area2} \quad (2)$$

Data Analysis

Using the methods above we were able to acquire many spectral readings of both an Ikea C1 LED bulb and a Compact Fluorescent bulb using both the PC and the Raspberry Pi 4 as the controlling method. These readings in figures 2 and 3 show that the circuit can capture spectral readings using a 20-microsecond exposure time which are accurate when compared with an Mk350D spectrometer. When the cycle time of the C12880MA is calculated with a 5MHz clock and this exposure time, a full capture cycle is accomplished in 104 microseconds. This allows us to potentially take readings at 9615 Hertz. This speed of capture is what will allow this circuit to be used in order to measure flicker.

IV. Conclusions

Using the C12880MA in conjunction with a Raspberry Pi 4 and an Analog Discovery 2 a device can be created which can take accurate spectral measurements and has a speed of measurement which enables it to be capable of being used as a portable flicker meter. Further development into increasing the number of readings per acquisition and the code to interpret the spectrum readings into flicker measurements can yield a compact handheld device capable of taking both spectral and flicker measurements.

Figures and Tables

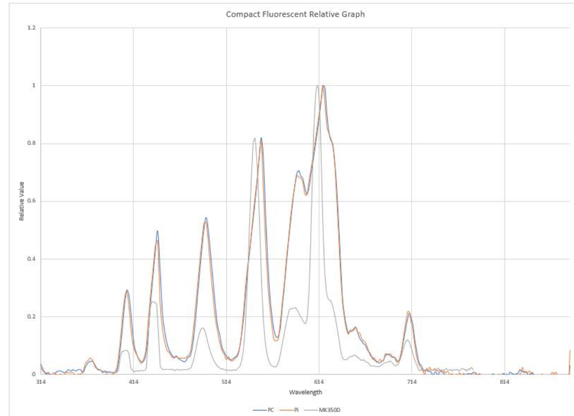

Figure 2 CFL Hamamatsu vs Mk350D Relative Values

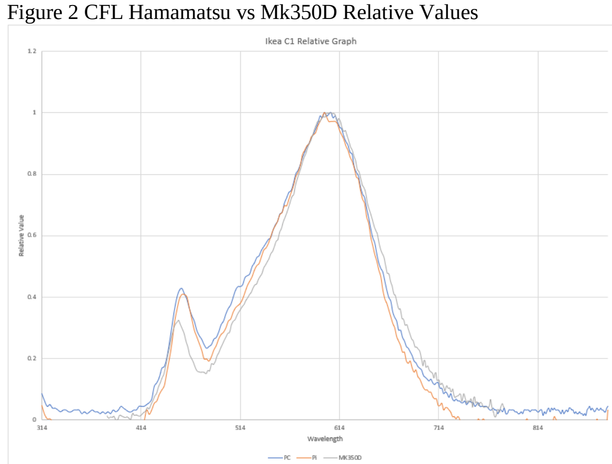

Figure 3 Ikea C1 Hamamatsu vs Mk350D Relative Values

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