Home Automation Diagnostic System

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Abstract

With the expansion of the lighting industry, there has been an increase in LEDs being used in new infrastructure. Comparing with incandescent and fluorescent lights, LEDs are more energy efficient, require less maintenance, and are compatible with the internet of things. However, troubleshooting a malfunctioning LED is a tedious task for an electrician as there are not effective ways of diagnosing them. A probable solution is a handheld device that can measure multiple lighting parameters such as temperature, luminosity, color temperature, and flicker percentage. Through photometric testing and analysis, the data collected from the sensors will be sent to a cloud service and then compared with the manufacturer's performance standards. If a parameter's value does not match the manufacturers', an electrician can pinpoint the issue. Additionally, an LCD screen will display real time data of the sensors. Furthermore, our device will be compatible with the developing smart hub systems (Amazon Echo, Google Home, etc.), This allows it the control of lighting devices on a specific network.

Hardware System

- Arduino Mega.
- ESP 8266 for Wi-Fi communication.
- TCS34725 for RGB measurement.
- TSL2561 for luminosity measurement.
- MLX 90614 for non-contact temperature sensing.
- GL5516 for flicker measurement.
- Foxnovo 2.8 inch TFT for LCD screen display.

Sensors will be used to gather lightning parameters for photometric analysis. The following is initial design for hardware system.

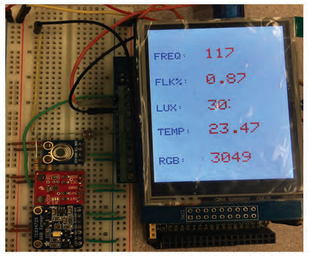

Figure 1. Overview of Hardware System

Figure 2. Final Device Prototype

Software System

For sensors, open source libraries were used, assigned unique I2C addresses, and put together to measure data simultaneously.

For data logging, Wi-Fi communication was activated using ESP 8266 shield to send sensory data to online cloud, ThingSpeak. This allows users to keep track of lightning parameters in chronicle order. This way users are able to see the trends in data and are able to pinpoint premature aging of LEDs.

For flicker measurement, the following standard calculation is implemented.

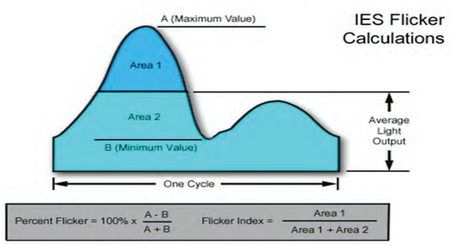

Figure 3. Diagram illustrating percent flicker and index

Methodology

To test this device, we simulated a flickering environment for LEDs. We used a tube with flat black interior to measure from equal distance and to not get disturbed by other adjacent LEDs. The control variable is the distance from LED to our device and the temperature of LED. The manipulated variable is the voltage under LED from 120V to 0V using Variac.

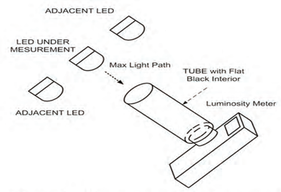

Figure 4. Illustration of Environment & how we measured values

Figure 5. Environment setup showing tube, variac and LED under test

Analysis & Results

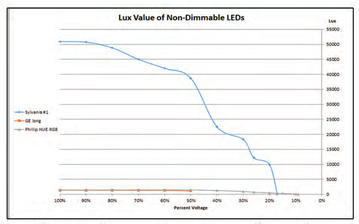

Figure 6. lux vs. voltage for non-dimmable

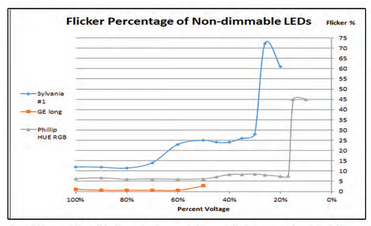

Figure 7. flicker % vs. voltage for non-dimmable

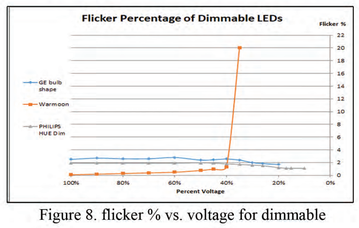

Figure 8. flicker % vs. voltage for dimmable

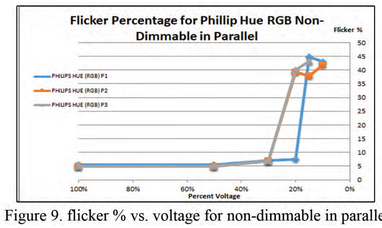

Figure 9. flicker % vs. voltage for non-dimmable in parallel

Six types of LEDs were tested; three dimmable, and three non-dimmable. The dimmable LEDs were from reputable companies such as Philips and GE. These LEDs did not cause any flickering when underloaded. However, cheaper LEDs from less reputable companies such as Wamoon did cause flickering (threshold at 35%). This could be due to improper voltage driver in the LED.

For the non-dimmable LEDs, we successfully simulated a flickering environment by varying the voltage on the variac. We found that the luminosity was proportional to voltage, as expected. Furthermore, a threshold voltage was found when the LEDs started to flicker and thus, the flicker percentage is exponentially proportional to voltage. The voltage thresholds were 15%, 45% and 50% for Philips Hue, Sylvania and GE long LED, respectively.

Data Logging

Everytime a measurement is done, the measured lightning parameters are sent and stored into online cloud, ThingSpeak. Users can access data from either a computer or their smartphone. The following are plot visualization of data from a computer and smartphone application.

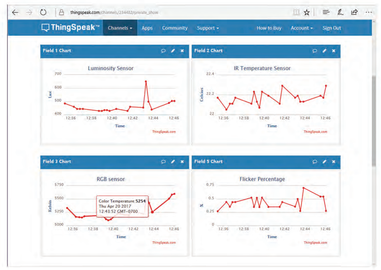

Figure 10. Desktop UI

Figure 11. Smartphone UI

Casing Prototype

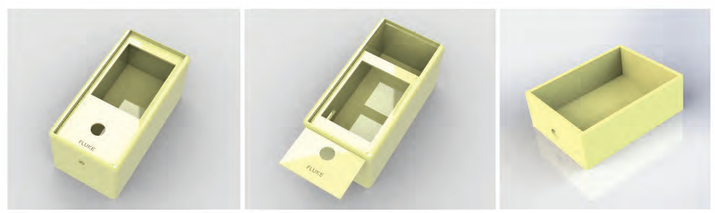

Figure 12. Intended design for prototype

This is our intended casing prototype for the final product. To make the device portable, a 9V battery will be attached and all parts besides sensors will be placed into one part, and another part will be a placeholder for the sensors. There will be a switch to turn the device on and off as well as a button to start and stop a measurement. The main part and the sensor part will be connected via wires.

Acknowledgements

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Future Work

- Document work for next year group.
- Write a specification sheet for the device.
- Diagnose dimmable LEDs.
- Expand to Smart System

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