Light of the World

Joe Altura, Brian Appleton, Sean Baur, James Yurkovich

Introduction

The engineering world has taken a major turn toward designing energy efficient devices and technologies. The automotive industry is shifting to hybrid and plug-in hybrid electric vehicles, while large commercial buildings are installing power management systems. One of the most ubiquitous usages of energy is lighting. Compact fluorescent lamps (CFLs) and light emitting diodes (LEDs) are two solutions to the problem of designing a more energy-efficient light bulb.

Problem Description

While the use of LED bulbs would greatly reduce the energy usage in any home or business, these products have still faced somewhat limited adoption. From personal experience, one of the deterrents from these better technologies is the "harsh" white light that they give off, as opposed to the softer, warmer light of traditional incandescent lighting. Current LED white light is produced usually by encasing a blue source in a material that absorbs the blue light and re-emits it throughout the spectrum to make white. An alternative would be to mix the output of four distinct LEDs (red, green, blue, and white) which can be tuned to generate a desired output. This has of course been attempted, but the different characteristics of each device has proved to be difficult when designing a coherent source. A main issue is that it is hard to "tune" the output to a true white (as each device is different), and any initial success is short-lived; each diode ages differently, and could produce a drastically different shade of white after time.

The common 60 watt incandescent light bulb lasts approximately 1,200 hours, while an equivalent LED (800 lumens) uses 6-8 watts and lasts approximately 50,000 hours. Incandescent lighting is still the predominant light source, however, mainly because it can be expensive to revamp an entire building's lighting scheme.

Proposed Solution

We propose to design and build a prototype LED bulb that fits into the standard light socket – a "plug and play" LED bulb. This bulb will combine red, blue, and green LEDs to obtain different colors of light, as opposed to a single LED with a filter. LEDs operate at about 10% of the energy cost of incandescent bulbs, and do not contain toxic substances (i.e. mercury) like compact fluorescent lightbulbs.

Demonstrated Features

- Efficiency equal to or increased over traditional light bulbs
- Ability to select white balance by balancing brightness output of a combination of three LEDs: red, green, and blue.
- Processing algorithms to determine necessary control signal to LEDs to simplify interface to a simple 0-100 brightness user interface (or something similarly simple)
- Control from central "control hub" or mobile device to individual bulbs

Available Technologies

- High power light emitting diodes: online vendors such as Digikey and Mouser supply many varieties of high-powered LEDs that are intended for household lighting. Additionally, specialty LED lighting suppliers (e.g., ledsupply.com) provide arrays of these LEDs mounted to heat spreaders.
- AC/DC switching converters: we require an efficient, accurate, and compact method of providing DC current to our LEDs. AC/DC switching converters such as the LNK605 (in conjunction with a miniature transformer) live up to the challenge. A switching converter has the advantage of being very efficient. To achieve dimming, we may use techniques such as varying the duty cycle of the output waveform.

- Wireless communication / Powerline networking: These standards already exist and we are considering implementing them into our LED bulb to achieve brightness, color, and on/off control. More research is required to determine which standard is the most practical.
- CNC Routing / 3D printers: Our project is somewhat unique in that we must build our prototype from scratch. The Stinson-Remick learning center features these technologies that will certainly help in obtaining any custom parts or pieces that we require.

Engineering Content

Communication
We will need some way to communicate with the bulbs in our system, but the communication protocol has not been decided and must be researched more. Additionally, it is currently undecided as to whether our "control center" will be a central hub that we also produce, or perhaps a mobile device such as a smartphone. The two factors of what communication protocol we will use, as well as the interface device, must be considered together and will represent one of the largest engineering challenges that we face for this project.

Heat Dissipation
Heat is a major concern in solid-state lighting, and our ambitious ideas about fitting this system into a package that can be plugged into existing sockets may make this an incredible engineering problem. Because this is so non-related to electrical engineering and our experiences in class, this presents another major interdisciplinary engineering challenge.

Lighting
For this project, we will need to be able to determine the required current that needs to be delivered to each LED module to produce the desired light output. This will require testing and quality control to ensure that we know what our light output will be (especially if we are trying to mix lights to produce certain colors).

User Interface
Because our communication protocol is currently undecided, the user interface is somewhat of a toss-up at this point. Depending on the route that we decide to take as far as a control hub is concerned, we will have to adapt our user interface in a way that makes sense.

Feedback
As we have yet to get our hands on any actual LEDs, we are unsure as to how they differ, and how they may change over time. If either of these effects are significant, it will add a considerable engineering challenge to incorporate some sort of feedback to adjust current output to ensure a consistent user experience. Our current, preliminary ideas are to either to incorporate photosensing via a photoresistor circuit connected to a microcontroller, or current feedback circuitry to achieve similar feedback. The challenge here would be to devise a control scheme that would have a good response to potential degradation of performance in the LEDs.

Conclusions
Creating an energy efficient, "plug and play" LED light with corresponding control system plays toward several prominent trends in engineering design. First, there is a major focus on conserving energy and making both commercial and residential buildings green by using less energy. Related to this is the idea of being able to control multiple aspects, such as smart grids. Our design would give consumers a more energy efficient solution that has control over dimming, color, and power. Even if our final product ends up costing more than competitor products, the added functionality and the "plug and play" aspect will appeal to many consumers.