Coat Hanger Light Switch Controller

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1. Introduction

1.1 Objective

The drive to reduce one's carbon footprint is steadily increasing in the US and across the world. However, it is often difficult for people with busy schedules to take time to make their life more sustainable. A simple way everyone can reduce their carbon footprint is by turning off lights in the home when they are not in use, but often times it is easy to rush out in the morning without remembering to turn anything off. On average, every kilowatt hour of energy produces 1.222 lbs of CO_2 [1]. Just one 60 watt bulb someone forgot to turn off would produce 0.659 lbs of CO_2 in 9 hours. This number, though seemingly small, can easily grow to have a serious impact on the atmosphere when accounting for the number of lightbulbs left on in each home as well as the number of homes that sit empty during a weekday across the globe.

1.2 Background

Our goal is to make it easy to reduce CO_2 emissions by automating an easily forgettable task. To achieve this, we will use a coat hanger to detect when a user removes an item, such as a purse or coat, from the hanger and turn the lights off one minute after the removal has been detected, giving the user plenty of time to leave their home and still be able to see their way out.

The coat hanger will communicate with any light switches that are connected to it, indicating to stop the current to the outlet/light fixture. This way, the user only has to take their belongings with them, and the hanger will do the rest. Automating this task will ensure that it gets accomplished.

1.3 High-Level Requirements

- Light switch and hanger must be able to connect wirelessly.
- After removal of object, light must turn off after a short delay to allow for user exit.
- Light switch control must be able to be restored to use as normal in case the object is not returned to the hanger.

2. Design

2.1 Block Diagram

The hanger and light switch fixture are designed to be completely modular such that the light switch fixture can be placed within a fixed radius of the home and still be controlled by the hanger wirelessly. For this to be achieved, this project will require two independent control units and two independent power sources. The pressure sensor, delay circuit, and communication element will allow the Hanger unit to signal the Fixture unit to turn off the light after a fixed time. The Reset component of the Light Fixture unit will allow the light to be operated as normal even if there is not an object on the Hanger fixture.

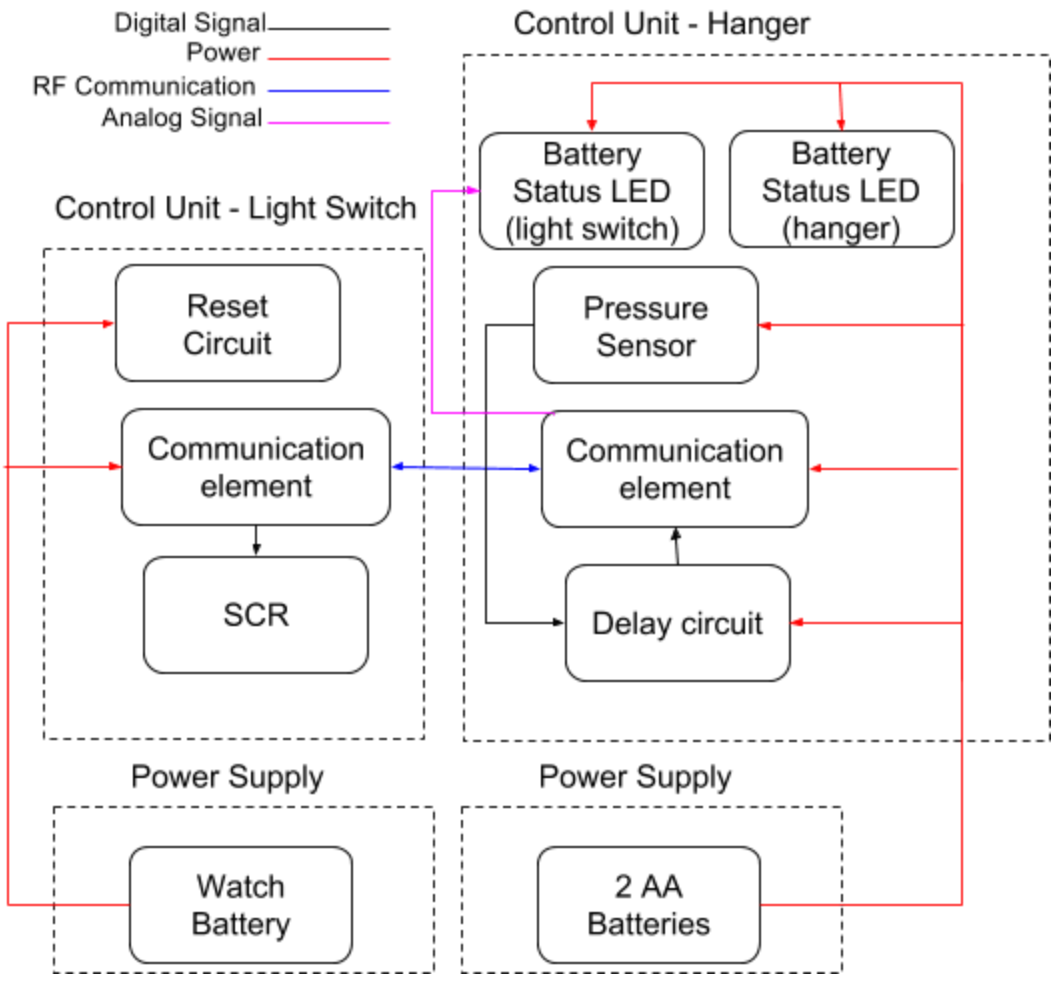


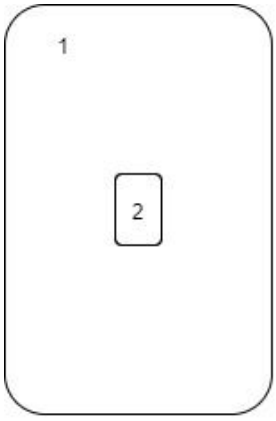
Figure 1: Block Diagram

2.2 Physical Description

For this project, the electronics should fit into a standard sized coat hanger. The pressure sensor will be place on the underside of the "hook" portion of the hanger so as to register the mass of whatever is on the hanger.

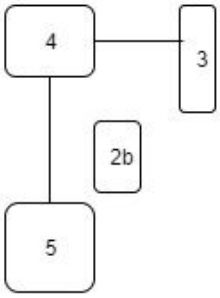
Figure 2: Physical Design

The light switch portion should take the place of a standard light switch cover, and will use the already-existing switch as the manual input for "Reset" so as to allow the user control whether there is an item on the hanger or not.

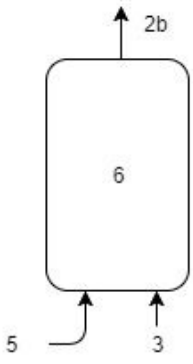


1. Electronically Isolated housing
2. Hole for standard switch
2b. Light switch circuitry
3 Reset circuit-uses light switch as reset
4. Power (house)
5. Communication
6. SCR: interacts with light switch circuitry and reset circuitry

Layer 1



Layer 2



Layer 3

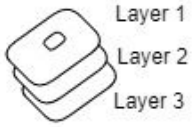


Figure 3: Physical Design

2.3 Hanger

2.3.1 Watch Battery

For the hanger, we have selected a watch battery because its small size is capable of fitting into a standard aspect of a coat hanger. Output: power

2.3.2 Battery Status LED (Hanger)

This LED will indicate when the voltage from the battery gets low, showing the user when it is necessary to change out the battery in the hanger itself. Inputs: Power, signal from communication device.

2.3.3 Battery Status LED (Light Switch)

This LED, despite being located on the hanger, will indicate when the battery in the Light Switch fixture is low. The reasoning behind this placement is that the user will likely be interacting more with the hanger than with the fixture. Inputs: Power, signal from communication device.

2.3.4 Delay Circuit

The delay circuit will be located between the pressure sensor and the Hanger communication element. This will delay the signal to turn off the light by an amount of time so as to not turn out lights before the user leaves the house. Inputs: pressure sensor output, power. Output: dealyed pressure sensor output.

2.3.5 Pressure Sensor

The pressure sensor will likely be a physical element which changes resistance depending on the amount of force applied. When designing, the circuit including this element will likely have to be tuned to ignore the weight of an empty hanger. Input: power. Ouput: variable current based on the pounds of force exerted on the sensor.

2.3.6 Communication Element

The communication element in our project will likely be LPWAN (Low Power Wide Area Network) and as such should be capable of low bitrate and low power over time. This is advantageous because this application should not require a large amount of data transfer, and conserve power such that the power element does not need to be switched out as often. Input: power, output from the delay circuit. Output: RF signal to create state change of light switch.

2.4 Light Switch

2.4.1 Watch Battery

The slim profile of a watch battery makes it a more suitable for the light switch fixture, as the intended housing is thin and similar in shape to a standard light switch cover. Output: power.

2.4.2 SCR

The power to the light will be controlled by a Silicon Controlled Rectifier, which will allow current when there is an item on the hanger (or when the system has been "reset") and stop current when it is off. Input: communication element output. Output: light control.

2.4.3 Reset Circuit

The reset circuit will exist to return control to the light switch so that if there is no object on the hanger, the light switch is still usable. Input: the physical light switch position. Output: current control returned to light switch

2.4.4 Communication Element

This communication element will likely be identical to the communication element in the Hanger circuitry. Input: power, output from other communication element. Output: RF signal to other communication element, signal to SCR to communicate change in state of light switch.

2.5 Block Requirements

Component	Requirements
Battery (Hanger and Fixture)	1. Must last 10-20 days 2. Must maintain .7A current for the diode current 3. Must have 1.5-3.3 V potential to power the communication element. 4. Must be replaceable by a standard consumer (easily removed/inserted) 5. Cost effective (<5 dollars/battery).
LED (Hanger and Fixture)	1. Must turn on when the associated battery is running below 60% voltage capacity 2. Must be visible when coat is removed from hanger
Delay Circuit	1. Must successfully delay the communication signal from the hanger by 60 +/- 10 seconds.
Pressure Sensor	1. Must redirect current indicating presence of an object when experiencing force greater than or equal to .125 kg (discounting the weight of the hanger itself)
Communication Elements	1. Must communicate over a range of 20 +/- 5 meters (distance from a light switch to the location of the hanger near the entry point of the house).
Reset Circuit	1. Must restore control to the external light switch after the light switch is turned off and back on manually.
SCR	1. Must control standard house current (120 AC) upon receiving 0.5A current from the communication element or standard mechanical switch.

Figure 4: Block Requirements

2.6 Risk Analysis

The communication element will pose the greatest risk to the successful completion of our project. We have tentatively selected LPWAN as our method of communication, since the low power and local network seem ideal for the project [3]; however, other options available may be simpler, and we may be complicating the circuit by selecting this method. Consistent communication between the two devices is another part of the risk, as the behavior of our

devices should be always repeatable. If the communication device does not consistently relay information from the coat hanger to the light switch, the project will not be completed.

3 Ethics and Safety

There are several potential safety hazards in our product. One major safety concern is that the light switch directly interacts with the house current, which contains up to 120 V. This could easily electrocute a user if not correctly implemented. To prevent this, we will house our light switch control unit inside the conventional light switch casing for protection against electrocution.

We are responsible for not causing harm to users of our product. If a user plugged in a life support device into an outlet that was controlled by a light switch that communicated with our coat hanger, it could have devastating consequences. This would go against the IEEE code of ethics #9, as we could be injuring someone [2]. To avoid this situation, we would put a warning on the product if it were to go to market warning that a user affixing our device to a light switch that controls an outlet should consider what they use the outlet for and to avoid installing it where it could turn off a critical device. Another safety concern related to this same IEEE code is taking the hanger outside. This is not advised, as if a user is doing something light-critical and another person triggers the pressure sensor, they could injure themselves. To combat this, there will be a warning on the hanger itself stating not to take it outside the home without disabling its functionality.

References

[1] Carbonfund.org, “How We Calculate.”, 2016, [Online]. Available: carbonfund.org/how-we-calculate/. [Accessed: 17 - Sept-2017].

[2] Ieee.org, "IEEE IEEE Code of Ethics", 2016. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 17- Sept-2017].

[3] Sena Technologies, "Zigbee OEM Module ProBee ZE10 Datasheet", 2010, [Online]. Available: http://www.antaira.com/core/media/media.nl?id=223016&c=685553&h=432ae2e6ef44abee2767&_xt=.pdf. [Accessed: 20- Sept-2017].