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Remote Controlled Advanced Power Strip Using Raspberry Pi for Effective Energy Management

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Abstract

The use of power strips at homes and offices has become widespread. It is majorly used to extend power from the main source to devices in many cases multiple devices. Power strips has a lot of advantages, so also dangers and disadvantages associated with the wide use. This paper explores the dangers and disadvantages with the view of bringing them to the fore. The paper goes further to review the issue of power strip control and goes ahead to introduce the use of Raspberry Pi in aiding the possibility of remotely controlling the use power strips.

Keywords: Power strips; Raspberry Pi; Standby power

Introduction

The benefits associated with power strips are undeniable. Several devices that work together can be plugged in at once, like devices ranging from televisions to DVD players, decoders to phone chargers etc. There are a lot of different types of load. However, as with most electrical devices, there are inherent dangers and disadvantages if not properly used. The result of misuse of power strips can go from limiting the benefits derivable to being fatally devastating. Howbeit understanding the proper use and also improving on the technology involved in the operation and construction of power strips can not only make one enjoy the benefits, you can also be assured of the safety of the devices, home, office as well as lives.

Young et al. [1] observed that as a larger percentage of people become conscious with preserving electric power as well as the fuels that are used in generating electric power, there is an increasing demand for electronic devices and products that help the concerned homeowner observe and reduce their power consumption. There are organizations that seek to minimize power usage at the stage of manufacture by providing buyer-recognizable icons on these types of products and electronic devices. These icons provide easy means for consumers to know energy-efficient products and consequently make an easy choice when shopping, providing encouragement to purchase energy efficient products over other less efficient power consuming products. The possibility of more sales provides motivation to manufactures to work towards energy-efficiency. Other manufacturers and their products aim to provide power consumption awareness by providing means for observing the rate at which power is being consumed. Companies like Power Meter and Hohm makes provision for an interactive user interface for taking records and analysis of trends in power consumption, while the Kilowatt, a portable device that stands in-between the electronic product and the power outlet, makes the measurement of the rate of power consumption of the particular electronic device possible. The withdrawal of devices such as the Hohm and Power Meter leaves the need for a centralized easy-to-use, monitoring system. When combined with hardware with the capacity to monitor such as the killo-watt, the system offers a useful interface for quantifying, controlling, and reducing the power consumption of a particular home. The Advanced Power Strip is designed to help environmentally conscious consumers fulfill their desire to observe as well as control their power usage. These advanced power strips can function like any other various outlets, power strip with surge protection, but will also be able to transmit the power status on each of the outlets wirelessly. Furthermore, the web-enabled user interface gives additional support in managing power consumption by controlling individual outlet separately.

Common Problems Associated with Power Strips

Power strips or extension cord consists of electrical sockets and makes provision for extra cable length and flexibility to permanent wall sockets that are most times placed in ambiguous and difficult-to-reach places. Extension cords are mostly used in parts of the office or house with a high number of electrical or electronic appliances, such as the sitting room since wall sockets there are very few (Figure 1).

Extension cords or power strips most times include a main switch that allow or disallow power flow to the whole strip. This conveniently allows someone to cut off power to all the plugged-in electronic devices at once. However, other types of strips make provision for separate switches for individual outlet, making it very easy if one is interested in cutting off power supply selectively as some appliances such as computers and printers should not simply be unplugged. Doing

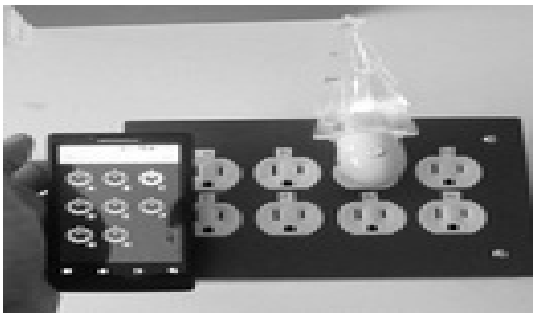

Figure 1: Phone interface and the power strip.

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such can easily cause damages. Indicator lights are often included on switches to allow for easy identification of the sockets that are off or on, models that are more advanced often incorporate one or more fuses to prevent power surges from damaging devices plugged in to the power strip. Power strips have issues involved with their use and they include:

Standby power

Standby power is defined by Bertoldi et al., [2] as the total amount of electrical power used up by consumer electronics when it is not performing its main function or switched off completely. Electronic devices that can be controlled remotely, electrical apparatus with external low-voltage power supplies, as well as devices with constant digital displays are the most notorious users of standby power. The power consumed in standby mode is actually deemed small, usually 0.5 to 30 watts. However, standby power is continuously consumed as long as the appliance is plugged in, and more and more new electronic devices have features that make them consume standby power. While consumption of standby power by individual electronic devices could be small, the collective total is substantial. Bertoldi et al., [2] recently the estimated the range of standby power use to between 3 and 10 percent of total residential electricity use. Taking this further and aggregating all the electronic devices and appliances in a particular country, the total standby power consumed over a certain period represents a substantial fraction of the total energy used over the same period. It is estimated that the standby power consumption in the European Union (EU) ranges from 5 to 10 percent of total electricity consumption in residential areas. Standby power is also consumed in commercial buildings (by office and building equipment and appliances, e.g., personal computers, copiers, phone systems, hot-water pumps, central computing devices). A theoretical investigation by Bertoldi et al. [2] suggested that standby power consumed should not be more than 10 percent of total consumption in commercial buildings.

Fire outbreak

Thousands of fires incidences each year are the result of the misuse and overloading of extension cords, power strips and surge protectors. Regrettably, poor quality or defective power strips only increase the hazards and risk from overloading and misuse. Some of the causes of fire outbreaks as listed by Tripplite [3] include:

Daisy-chaining: Interconnecting power strips which can cause overloads and fires. Extension cords also fall under this category.

Improper routing: Routing cords through walls, ceilings, floors, windows or similar openings.

Overloading: Power strips are designed to be used with several low-amperage loads, such as desktop computers and peripherals. Power strips are not supposed to be connected to high-amperage loads, such as refrigerators, space heaters, microwave ovens or air conditioners that are likely to overload the strip.

Improper plug connection: The power strip cord and device cords most not be hanging out of receptacles. Power strips and devices must not be suspended from the power cord.

Thermal distress: Power strips, plugs or cords that are hot to the touch, melted, burned, frayed, scorched or discolored are dangerous.

Damaged power strips: Power strips, cords and components should not be dirty, stained, crushed, cut, broken, kinked, warped, knotted, twisted, loose, frayed or otherwise damaged.

Improper environmental conditions: The power strip must not be installed in a moist environment or a location with excessive heat or limited air circulation.

From power strips to advanced power strips

According to the Australian government, an electrical "power-board" was developed by electrical engineer called Peter Talbot in 1972. Even though the product was a big success, it was not patented eventually lost the market share to other producers [4].

Peter Talbot worked on the invention of power strip which is also known as Extension block, plug board, tailer lead, power board, power bar, plug board, etc. Power strip is a block of a number of electrical sockets that is attached to one end of a flexible cable (usually with a mains plug on the other end), thus providing the possibility of powering multiple electrical devices to be powered from a single electrical socket. Power strips are often beneficial when there are many electrical devices in close proximity. Some of the power strips available often include a main switch to turn all connected devices ON or OFF. These types can only be used with simple gadgets, such as lights, but not with most computers, which must use follow a shutdown procedure by using commands from the software. Some power strips have individually switched outlets.

The use of Advanced Power Strips (APS) is one approach to eliminate standby power loss from various electronic products commonly used in the home. Entertainment electronics make up 60% of all plug load consumption by home electronics while home office electronics make up 31% of all plug load consumption by home electronics [5]. With such a large percentage of home electronics plug load consumption, implementing APS for entertainment and home office electronics would reduce energy consumption across the residential market. As the efficiencies of mechanical system increase due to improvements in technology and standards and thermal envelopes increases due to strict residential building energy codes, consumers increasingly introduce more appliances as well as electronics into the home, creating a moving target for plug-load energy reduction. From refrigerators to microwave oven, toasters, pool pumps, cell phone chargers, plug loads are different in types and they are abundant, and as a group progressively increase the energy budget in the modern homes. As there are so many electrical gadgets and appliances all around the house, it becomes easy for busy home owners and residents to leave things like computers, lights and TVs on unconsciously even when they are not in use, thereby resulting in significant 'active' power waste. The rise in miscellaneous electric loads (MELs) also use energy in the form of 'vampire' or 'phantom' loads: many devices continue to draw current no matter how small as long as they remain plugged into the sockets, even after the electronic device have been switched off [6]. Typical homes having about 40 to 45 plug loads can have vampire loads account for nearly 10% of the total household electricity use. Energy wastes due to plug loads can be pernicious; each device could need just mere low level of power to be in standby mode (and even less in off mode), so there is little or no motivation for the appliance user or homeowner to walk around and switch off power strips, much less unplug each electronic device that is not in use at that particular moment. To effectively reduce both vampire and active loads there would be a need for a more convenient solution. In the recent years, there have been growing interest in measuring plug-load energy use through sub-metering, and initial studies have concentrated majorly on creating an record of household MELs and their attendant power draw characteristics for (On, Off, and Standby states) to identify savings opportunities Bertoldi et al., [2] and Roth et al. [7]. From field test results, it was observed that most times,

appliance users do not take the time or put in the extra effort to unplug unused appliances [8]. As these findings have shown, automation appears to be the perfect solution to reducing vampire loads without necessarily meddling with the way individuals make use of their plug loads. Advanced Power Strips (APS) with the aid of raspberry pi would provide the necessary balance of convenience and intelligent control to meet this need.

Advance power strip is an evolving technology that comprises products offering an assortment of different control mechanisms, and till date there have been very few third-party technical assessments to evaluate their efficiency and cost-effectiveness at automating energy savings without necessarily needing changes in the behaviours of users. The conceptual framework and the results presented here address if and how power strip devices would function in turning off unused appliances and or reduce vampire loads. This evidence is important for efficiency programs to determine how and where advance power strip can be a cost-effective solution. The design of advanced power strips are meant to enable the ease of saving energy in entertainment centres, homes and offices where consumer electronic concentration are typically high. In spite of the numerous advantages the advanced power strip has to offer, a lot of people do not understand how they work, where they should be installed, neither do they know what to expect from their operation. The actual benefits derivable will largely depend on how people utilize them, as advance power strip products inherently affect the operation of the devices they control.

There are power strips with energy saving features that use sensors to detect when appliances go into standby mode and immediately switch off the strip. The consumption of standby power by computer peripherals and other equipment is greatly reduced consequently saving energy and money.

As shown in Table 1 there are different types of APSs on the market, but they all operate on the same basic principle of shutting off the supply power to devices that are not in use. This project will create a remote control strips over the internet which can be controlled from anywhere it will be a web-controlled power strip with Raspberry pi serving as an interface.

Methodology

The primary aim of building this project is to control the power strip remotely. That means we need to know the status of each point on the power strip as well as be able to either switch it on or off. This would require a system capable of reading the status of each point as well as receive and transmit information. That is where the Raspberry Pi would be of use. The Raspberry Pi is a credit-card sized computer that plugs into your TV and a keyboard [9]. It is a capable little computer which can be used in electronics project and can do some things which computer can do. The Raspberry Pi must carry a Wi-Fi dongle to connect it to the router. Basically we can plug in up to eight appliances to the power strip and turn them on and off independently from an internet enabled mobile device like a phone or tablet. By setting up port-forwarding on our wireless router, we can control our appliances from anywhere in the world. There is the need to configure the Raspberry Pi GPIO pins using the Wiring Pi. Using SSH to control the LEDs should do, however the interface would not be very user friendly and typing the commands each time could be discouraging and annoying. That's why a graphical interface would be better (Figure 2).

Results and Discussion

However, programming an app for each Operating System (Android, IOS, Mac, Windows phone, and Linux.) would not only be long it would also require knowing a lot of programming languages for almost nothing. Doing this would also require one to create an application running on the Raspberry Pi. Making it this way would be tiring and time wasting. A simple website would do a better job in this case, it's compatible with all devices and we would only need to be able to write just four languages: JavaScript, CSS, PHP and HTML. We indeed need to install a web server on the Raspberry Pi. In our case, we don't need a MySQL database, only a HTTP server and its PHP extension.

A relay board is a high quality item of a 5V 8-channel relay interface board. It can be controlled directly by a wide range of microcontrollers such for AVR, PIC, ARM and so on. In 8-channel relay interface board, each one needs 15-20 mA driver current. Equipped with high-current relay (DC30V 10A AC250V 10A), the standard interface can be controlled directly by microcontroller, but in this case the relay is being driven by the Raspberry Pi. Package included: 1 × 8 channel relay modules. Relay board provides a convenient way to add relay outputs to one's work, allowing it to switch high-current loads, such as AC appliances, motors and more. The board includes four SPDT

	Timer power switch	Activity monitor power switch	Remote switch power switch	Master controlled power switch	Master-less power switch
Cost	3	5	1	3	5
Features	Power strip automatically turns off outlets based on pre-set schedule.	Power strip looks for signs of activity in the room, and turns off outlets if none is detected.	Power strip can be turned off by the user via a switch.	When a primary device (such as a computer or TV) is turned off by the user the power strip automatically turns off the controlled outlets where the peripheral devices (such as the printer or game console) are plugged in.	When all of the controlled devices are turned off, the power strip turns off power to those outlets completely, eliminating all of the vampire loads.
Possible drawbacks	You have to set up the timer and stick to your schedule for maximum energy savings.	Motion sensors don't always work perfectly.	To save any energy, you have to remember to turn off the power strip each time.	It can be tricky to select which appliance should be your "master" device.	Turning off one high-powered appliance could turn off the entire strip.
What to look for	Digital or dial timer.	Motion sensor or an infrared "eye" that detects remote control use around the TV or stereo.	A tethered switch or a remote switch.	One outlet is labelled as the "master."	No "master" outlet. Description may include "automatic switching" or "power detection".

Table 1: Comparison of different types of advanced power strip.

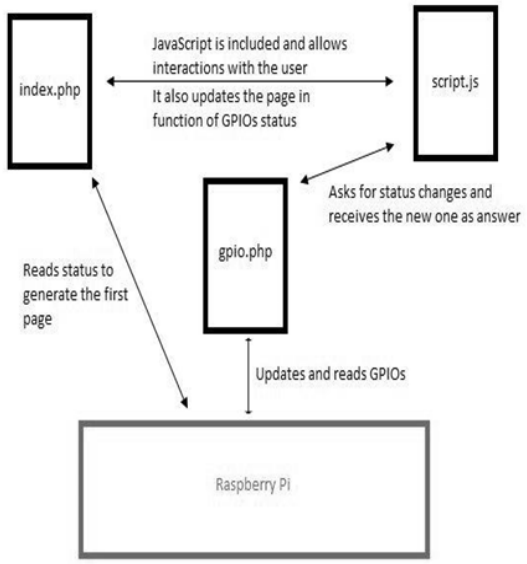

Figure 2: The block diagram of raspberry pi.

relays, relay driver circuits, and protection diodes. The relay contacts are electrically isolated from the rest of the board, which allows the board to be used in a wide variety of applications including both AC and DC loads.

Conclusion

The web controlled 8-channel power strip could be developed into a mainstream product if further work is done to reduce the size and cost of the unit. This project is innovative but it also has its own limitations. In the first case if internet is not available it then means that access to the control of the power strip is cut off. Secondly, to remotely control the power strip the owner must also carry a mobile device with him. Thirdly, it would be expensive to set up port forwarding so as to be able to reach it from anywhere in the world.

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