DEVELOPMENT OF REMOTE CONTROLLABLE POWER STRIP FOR HOME ENERGY MANAGEMENT THROUGH WEB-SERVICES

Aymen Husam ALADHAMİ
aymen.aladhami@yahoo.com
University of Gaziantep, Dept. of Electrical
Electronics Eng. , Gaziantep Turkey

Ergun ERÇELEBİ
ergun.ercelebi@gmail.com
University of Gaziantep, Dept. of Electrical
Electronics Eng. , Gaziantep Turkey

ABSTRACT: In the paper, we have presented development of power strip for management of home power to reduce standby power consumption. The developed power strip integrates many hardware components as AC power socket, XBee module have been used to make communications between central control unit and power strip. Raspberry pi card configured to play the role as a web server and coordinator to switch ON/OFF strip power and measure power consumption of plugged home appliances that collected from power sensor using XBee module. Also, software has been developed using HTML, PHP, Javascript and Phyton to design web page as platform compatible with any internet browser in any smart phone or personal computer. However, our development requires static IP number. We have evaluated in our design under different conditions. We have found the results are satisfactory.

Key words: power strip, Xbee, Rapberry Pi, web server.

INTRODUCTION

Technology has become an integrated part of people's lives and the internet has become a common interface that many devices use for simplify the daily life of people (Pavithra & Balakrishnan, 2015). Access to the Internet is very easy through smart phones and tablets. Smart power strip developed to provide technical solution to meet the comfort needs and energy management (HAN, LEE, & PARK, 2009).

Remote controllable and energy saving room architecture for periodically monitor the power consumption via ZigBee controller with IR code learning functionality, user can control the power outlet and the dimming light. With the advent of mobile phones containing techniques including Bluetooth as well Short Message Service (SMS), Allow to implement home power management, and develop controllable power socket based on microcontroller (LIEN, BAI, & LIN, 2007).

In the same context it was developed platform of smart homes to customize java-based application development platform (JADP) in mobile phone as a result it could be more flexible remote debugger and easy to develop (Chen & Chen, 2008).

Energy management system (EMU) developed based on Wireless Sensor Network (WSN) using XBee-pro ZigBee, Arduino Uno microcontroller and current sensor (ACS712) for control energy consumption and monitor the system in real-time using NILABVEW software, ThingSpeak Website used as Cloud for storing and display sensor data (Abo-Zahhad & Ali, 2015).

The main contribution of this paper is to implement an electronic card which can control household equipment such as television, light and etc., through the internet under any operating system environment. The platform consists of develop programs that allow communication between a remote user and household network.

User can remotely unplug household devices when they are not being used. Wherefore we have developed Remote controllable power strip based on XBee wireless module and minicomputer (Raspberry pi) to allow homeowners to control and monitor power usage of home appliances.

System Architecture

Generally smart power strip architecture consists of three main components (Lamine & Abid, 2014): Central Control Unit, power socket and Communication protocol.
Central Control Unit is the gateway between user and power strip, our development based on Raspberry Pi3 card. The power socket provides the interface between the developed home energy management and the non-smart load appliances in real time. The power socket is designed to provide remote control of non-smart loads thus providing a practical solution to interface the loads with the developed system and schedule on/off status of selected loads. The power socket is responsible for collecting data about the environment around it and sending that data to processor in the network which is measure the power consumption of the different loads and transfer it to the Central Control Unit. Communication protocol; there are many Smart Home Communication Technologies in the market most popular is (X10, Z-Wave, ZigBee, INSTONE, EnOccean) (Withanage & Otto, 2014). The most relevant communication technologies used in smart home systems ZigBee protocol.

Raspberry pi

We used Raspberry Pi3 shown in figure 1. that contains built in 802.11n Wireless LAN that get more flexible and movable anywhere user want to put it, In our development Raspberry Pi will be mediator between user and power strip that

connect to home appliances, the Raspberry Pi is used as the gateway which communicates to personal computer or smartphone using http protocol.

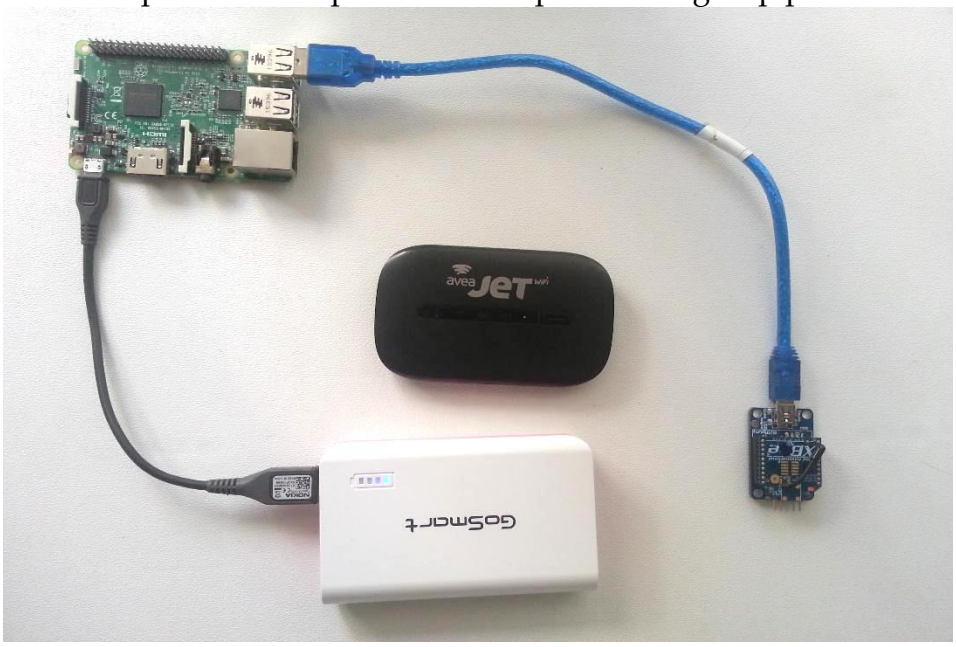

Figure 1: Central Control Unit using Raspberry Pi-3

Web server

Raspberry Pi can be connected to the Router and Internet through wireless LAN and Rj45. One of its configuration Features is to work as a web-server. There are many alternative web servers that may be installing on the raspberry Pi, like Apache and NGINX (raspberrypi, 2017). Apache is a popular web server application the user can install on the Raspberry Pi to allow it to serve web pages. Apache can serve HTML files over HTTP and with additional modules can serve dynamic web pages using scripting languages such as PHP.

There are a new breed tools that reach programming languages like python, JavaScript and Cascading Style Sheets (CSS) to make web server dynamically generate the hypertext markup language. Web page consists of three main components: First is buttons for turn ON/OFF that programmed using JavaScript that call PHP code for calling python script that send digital signals over ZigBee technology to the node. The second component is label text. It is also developed based on Java-PHP which is able to get data stream without any reload page from the database. The Chart is the third component the in web page, Interactive JavaScript charts (highcharts) provides many types of charts and has many advantages, dynamic chart (Spline updating each second) has been used, fetching sensor data that stored in the database with date and time at the moment of reading.

Database

Install MySQL-server database and then the php5-mysql install adds the MySQL libraries to allow PHP to access the MySQL database.
The database that we created include one table and five Columns:

Id: AUTO_INCREMENT attribute can be used to generate a unique identity for new rows.
Current date: date and time at the sensing moment.
Current data: sensing value after making mathematical processing to get Electric current.
Power data: Electric power in Watt.
Status: There are four status cases, status column It contain one of these values (0,1,2,3) as below:
Status = 0: ZigBee Not connected.
Status = 1: No data or Power strip if off.
Status = 2: error data received.
Status = 3: Power strip is ON.

XBee module

The advantages of this module is too small size as a coin and with low power usage. The XBee module communication concepts have either point-to-point or star communication concept. [11]
In addition, it is compatible with many minicomputers and boards, Since a USB port feasible with XBee, there are 11 digital I/O pins and 4 analog input pins in ZigBee. The XBee is linked to Raspberry Pi via USB working in coordinator mode and the other XBee is the End point mode. The pin-20- (DIO0) is set as digital output to control relay to turn ON/OFF, Pin-19- (AD0) is set to work as analog to digital converter which is connected to current sensor (ASC712) and convert the voltage (analog data) coming from V-out of sensor and send it to coordinator as a stream of digital data every 0.5 second.

Power strip hardware

The most important features of the power outlet development is to be simple and uncomplicated. It affects the cost, power consumption and easy to understand.
The transformer steps down the main voltage from 220 V AC to 5 V DC to provide voltage to the electromechanical relay and current sensor. The 5 V to 3.3 V is to provide XBee wireless module with power.

Additionally, the current sensor signal output is connected to the XBee pin-19- (AD1). The analog to digital converter (ADC) of each XBee module has a resolution conversion of 10 bit.

Hall-Effect-Based Linear Current Sensor type ACS712 ±5 A is used and the output is connected to an operational amplifier (op-amp) based signal conditioning circuit so as to read the required analog values to the pins of the analog input of the XBee module (sparkfun, 2017). The (op-amp) IC circuit is used for the conversion from AC to root mean square (RMS) signal and to shift ACS712 sensor zero current from 2.5 V to 0 V . Since the XBee has a built in 10-bits analog-to-digital converter ADC; therefore 10 bits = 1024 steps (0–1023). So the step size using XBee s1 Vref = (3.3 V) then the equation will be (3.3V/1024 = 3.223 mV/step) (Ahmed & Ali, 2017).

ACS712 ±5 A 185 mV/A output sensitivity, 100 mV/A for ±20 A, and 66 mV/A for ±30 A, sensor Vout data range between 1.5-3.5 V as the datasheet.
So the form of the equation will be: Current = (((3.3 / 1024) * (Vout)) / (0.185*2)).

Hardware implementation and experiment

The implementation of this work starts with selecting the operating system that we prefer. In this project we have selected raspbian operating system. Now, we have to boot the operating system that we have selected with the necessary configurations. The various configurations which can be done are such as changing the password for default user, the configuration settings are done according to the users need.
After the configuration settings are done, the python program is to be typed in the leaf pad. Leaf pad is created by file manager->right click->create->blank file->enter a file name.py- > click ok.
Next the program is saved. A web page is designed and PHP Script written in leaf pad also and saved as index.php. The first ZigBee configured to work as coordinator linked with Raspberry Pi, The second XBee configured to work as Endnode. The (op-amp) IC circuit connected to current sensor and the output of circuit connected to XBee shown in figure 2. Raspberry Pi is connected to the internet through the Router, and Router configured to forward port 80 to Raspberry Pi to work as web server. We accessed to main web page of power strip through Smart phone shown in figure 3. Using IP address. The various devices like Lights ON/OFF can be controlled shown in figure 4. 70 W and 40 W bulbs are plug in power strip separately. Directly power data appear in web page.

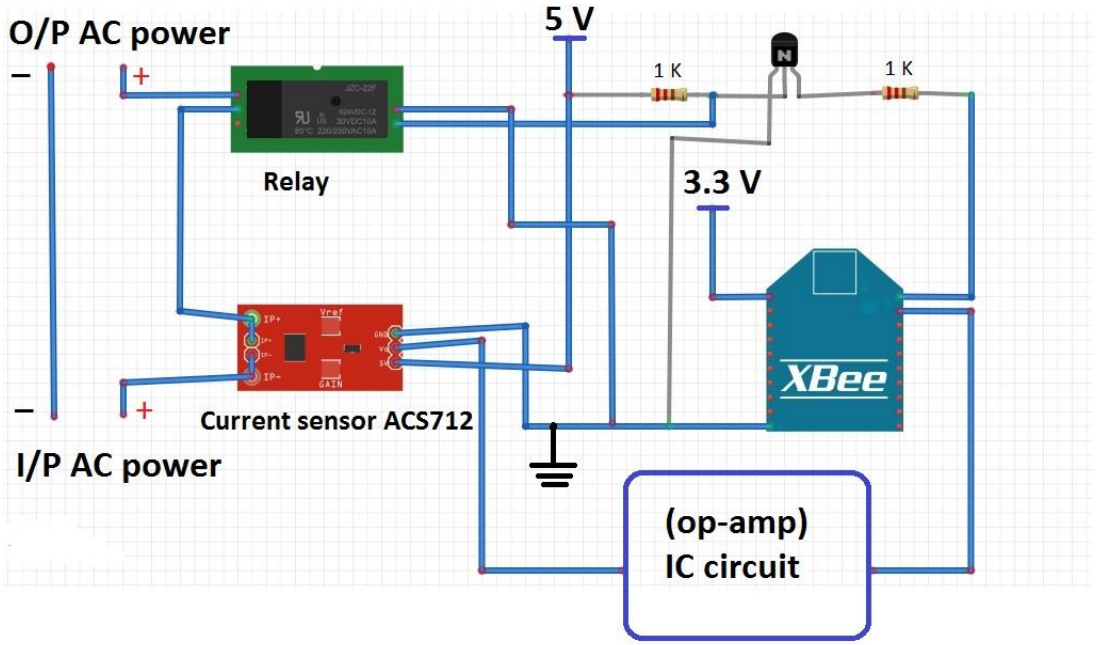

Figure 2: Circuit diagram

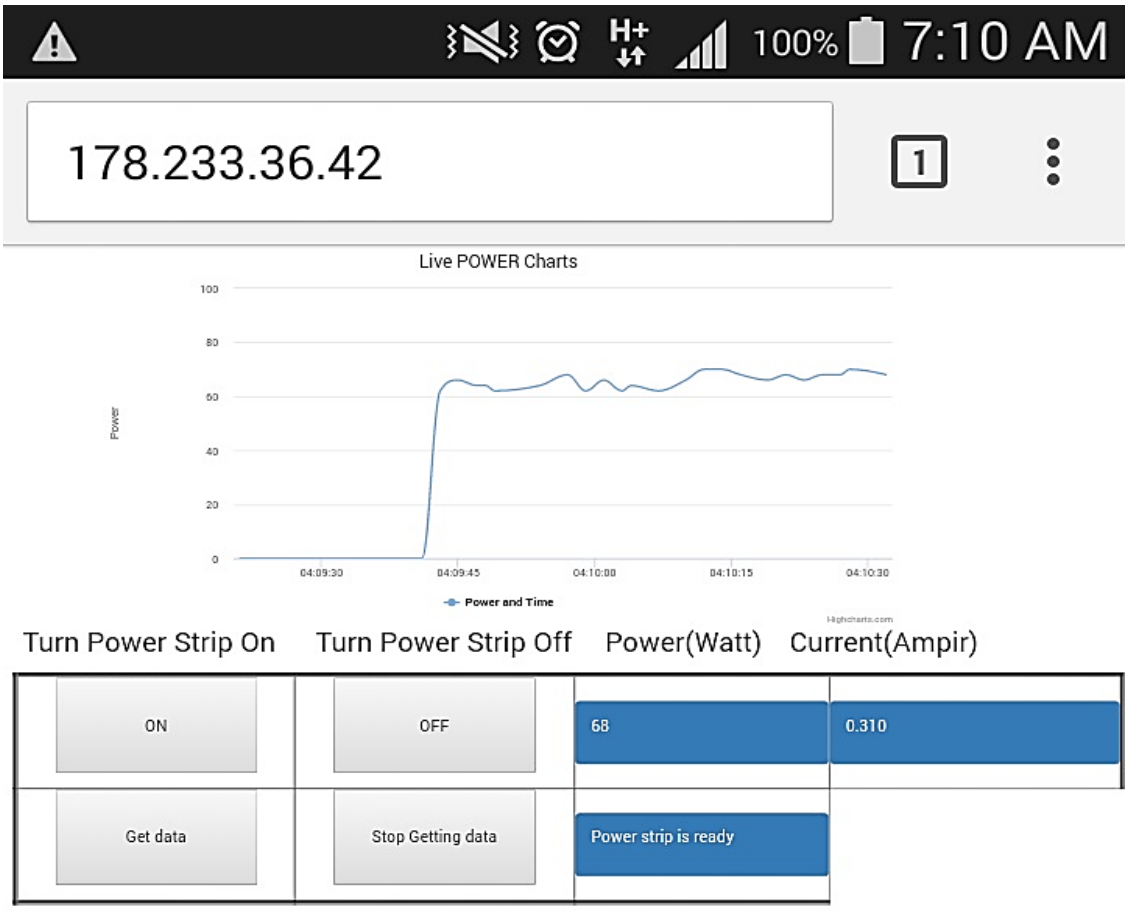

Figure 3: Power strip web-page

Figure 4: Controlling the bulb by using tablet

CONCLUSION AND FUTURE APPLICATIONS

In this paper, we have presented our development for wireless power strip to remote control and current sensing in order to manage home appliances. We developed the power strip along with a cost effective using minicomputer (raspberry pi) and ZigBee communication protocol. The raspberry Pi is configured to work as web-server and different Languages used to design a web-page as a platform for monitoring and controlling. The main advantage of our proposed work is to make the home owners able to manage home appliances remotely anywhere and anytime over the internet. It had been developed to be scalable to add more nodes and can add different sensors as required.
So that, a part of our future work is to develop the system to adapt with different places hospitals, hotels, banks, etc.

REFERENCES

Abo-Zahhad, M. A., & Ali, A. (2015). Design and implementation of building energy monitoring and management system based on wireless sensor networks. *In Computer Engineering & Systems (ICCES), 2015 Tenth International Conference on*, (pp. 230-233).
Chen, J. F., & Chen, T. (2008). A java development platform in mobile system for smart home. *In Future Generation Communication and Networking, 2008. FGCN'08. Second International Conference on*, (Vol. 2, pp. 226-229).

HAN, J., LEE, H., & PARK, K.-R. (2009). Remote-controllable and energy-saving room architecture based on ZigBee communication. *IEEE Transactions on Consumer Electronics, 55(1)*.

Lamine, H., & Abid, H. (2014). Remote control of a domestic equipment from an Android application based on Raspberry pi card. *In Sciences and Techniques of Automatic Control and Computer Engineering (STA), 2014 15th International Conference on*, (pp. 903-908).

LIEN, C.-H., BAI, Y.-W., & LIN, M.-B. (2007). Remote-controllable power outlet system for home power management. *IEEE Transactions on Consumer Electronics, 53(4)*.

Pavithra, D., & Balakrishnan, R. (2015). IoT based monitoring and control system for home automation. *Communication Technologies (GCCT), 2015 Global Conference on*, (pp. 169-173).

Withanage, C. A., & Otto, K. (2014). A comparison of the popular home automation technologies. *In Innovative Smart Grid Technologies-Asia (ISGT Asia), 2014 IEEE*, (pp. 600-605).