SMART ADAPTOR: A WIRELESS POWER SWITCH OF HOME APPLIANCES FOR RISK REDUCTION

Harvvey Leonard M. Contreras[1], Jairus T. Guadiz[1], Christine Joy Marasigan[1], Mariane D. Molina[1], and Engr. Irineo P. Quinto[2]
[1]Bachelor of Science In Electronics Engineering, College of Engineering and Information Technology
[2]Faculty Member, Electronics Engineering Area, College Of Engineering And Information Technology

ABSTRACT

As the technology invades our homes, the chance of electrical fires happening increased over recent years. The study, Smart Adaptor is the solution suited in preventing those fires with simple home automation using smart adaptor system which transforms traditional appliances at home into a smart one. It was focused on creating a device to be added to the home appliances that is efficient, reliable and accurate and helped on lessening fire breakouts due to electronic malfunction. The device was tested in two households in Brgy. 150 Tondo, Manila wherein the device was used in two weeks span. The three main components were examined wherein the PIR sensors ability to detect human presence, the smart adaptors capability of turning off appliances and the Main servers monitoring skill were tested. The efficiency was based on the power consumption in two households wherein a decrease of 20-28% in the total power consumption with Smart Adaptor was measured. The average response time of 0.95 seconds proved the reliability of the PIR sensor to detect human presence within the range of 105o within 5.4 meters distance and 2.74 meters width. The connectivity of the PIR and main server had an accuracy of 90% while that of the smart adaptor to the main server was 85%. Hence, the three main components in a system were acceptable to the respondents with 4.35 overall rating. Thus, the system was capable of monitoring home appliances and reduces fire breakouts at the same time.

Keywords: PIR Sensor, Smart Adaptor, Main Server, Alarm System

---

INTRODUCTION

Fire can strike everywhere in structures, buildings, automobiles, and the outdoors. Fires that affect our homes are often the most tragic and the most preventable. Each year, over 75 percent of all civilian fire fatalities occurred as a result of fires in residential buildings- our homes. (Civilian Fire Fatalities in Residential Buildings, 2013-2015)With that, a study was made that can be a solution to prevent those fires happen in our homes.

From 2010 to 2013, most of the fire incidents nationwide were caused mainly by faulty electrical wiring/connection (29.6 percent), unattended flame (25.9 percent), neglected electrical appliances/device (3.9 percent), and other unidentified causes 40.6 percent. Since neglected electrical appliances were also caused of fire incidents, the study focused on monitoring electrical appliances by adding a device to monitor and alert home owners.

This study is derived from the concept of the intelligent socket which is for the purpose of security and protection. It is on the basis of ordinary socket extending more functions against short circuit, overvoltage and lightning. (Feng, Fei*, Jian, & Yan, 2010)But this study provides the same function in simpler approach. The idea is to transform the traditional appliance at home into smart appliance by adding the smart adaptor.

Summary of Previous Literature and Gap

Smart adaptor has been explored by many researchers. One of which is Alhamoud, et al., (2014) that used wireless sensor networks and human activity detection as an efficient approach and concept on saving energy and safety when it comes to appliances left unattended at home. Astrera, et al., (2011) utilized GSM for home automation where the appliances can be controlled from a remote place through the use of mobile phone sending a message containing specific commands to the system and it will be processed, and then an output will be generated. Arduino and NRF24L01(+) was used in the design and implementation of a low cost wireless sensor network by Rahim, et al., (2016). The system is low cost and highly scalable, making it well suited for environmental monitoring.

Even though the smart home system has already been explored there are still some innovations that can be added. This study will utilize lower cost of material for the device to be affordable. The Smart adaptor has an alarm system that will notify the home owner before leaving the house and has the capability to automatically turn OFF the appliances after specific time elapses thus reduce the risk of fire breakouts.

The main purpose of this study is to create an alternative device for home appliances that is efficient, reliable and accurate and lessen fire breakouts due to electronic malfunction. Specifically, it attempts to achieve the following objective:

1. To check if the main controller accurately indicates the same status to that of the adaptor and PIR sensor.
2. To measure the reliability of the PIR on sensing human presence based from its response time.
3. To evaluate the reliability of the alarm system to activate and turn off unattended adaptors.
4. To compare the power consumption before and after using the Smart Adaptor.
5. To measure the overall acceptability of the device from the respondents.

Developing a risk reduction device to prevent loss of property and human life due to fire incidents such as appliances left running and electrical faults is an advantage of the system. Household owners will be able to monitor appliances to prevent overpower consumption and reduced risk from electrical/ electronic failures. This study may also use as a basis for future researchers on topics such as risk reduction, home automation, wireless communication using NRF24L01 Transceiver Module, Arduino based projects, and many more subjects. Moreover, this study centers on the wireless communication of Arduino Microcontrollers with the use of NRF24L01 Transceiver and a PIR sensor which provides more information on the efficiency, reliability, and accuracy of ranging and communication capabilities of these components.

The testing of the prototype was conducted in two households to have comparison of the results. In each room of the house there was one adaptor while the main server was installed near the main door. The testing took place in a residential area in Tondo, Manila for its high number of fires due to electrical failure. The prototype consisted of two adaptors, two PIR sensors and one main server. The placement was at 8m only, wherein two adaptors was used in one household.

The smart adaptor system is limited to households with only one floor and studio type rooms. The Main controller was only placed right beside the main door of the house and is not considered to be tested on other locations of the house. The components for the prototype were commercially available in the Philippines. The two adaptors were attached to appliances such as television and electric fan only. The implementation was done using Arduino Nano and Arduino Mega. The timer and alarm is also embedded in the program which has a maximum of 30 minutes only.

The Smart Adaptor System uses a PIR sensor for detecting human presence which accurately detects body motion on the moment of movement, although it does not detect human presence when there is no more body movement. Therefore, when the room is occupied but the person doesn't move, the reading of the PIR sensor would be no presence detected making the study limited to continuous body movement for precise reading of the PIR sensor of the system.

Conceptual Framework

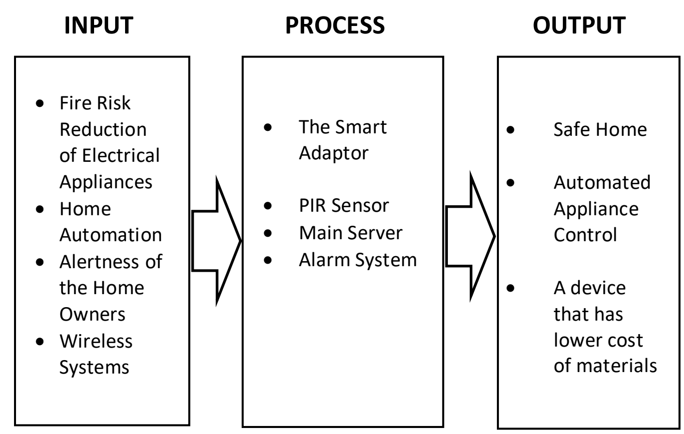

Figure 1. Conceptual Framework

Literature Review

A research done by Alhamoud, et al., (2014) was about an intelligent system for energy saving in smart home. This study explained an efficient approach and concept on saving energy and safety when it comes to appliances left ON at home. It was found out in the paper that energy conservation and safety has always been of great importance to individuals, societies and decision makers around the globe.

In the study "Passive Infrared (PIR) Sensor Based Security System", PIR based security system which saves the power consumption and the memory space of the recording system has been proposed. Passive Infrared Radiation (PIR) sensor detects the change in infrared radiation of warm blooded moving object in its detection range. According to the change in infrared radiation, there will be a change in the voltages generated which was amplified and used to turn ON the webcam and lighting system through relay. Software was developed and installed in the computer to capture and record the video when the webcam gets turned ON. When an intruder comes in the detection range of the PIR sensor, it actuates the lighting system and the webcam. The software detects the webcam connection; it will start to record and save the video. Once the intruder moves out of detection range of the sensor, the webcam and light gets turn OFF. The software repeats the process. Thus the saves power consumption and the memory space of the recording system as the lamp and webcam will only get turned ON when PIR sensors detects an object. Consequently the system starts recording only when the webcam is turned ON; hence saving memory space. (Chodon, et al., June 2013)

The system used an Arduino and NRF24L01(+) as its main components for wireless communication because according to the study of Low Cost Wireless Sensor Network these two components are low cost and highly scalable allowing them to communicate with their kind at ease even at receiving and sending of signals. (Rahim, A. et al., 2016)

The Adaptor System used a 7inch LCD screen for the main controller. The main function of this component was to indicate the status conditions of the system's components and to control it. According to iTead Studio the 7" Nextion HMI LCD Touch Display is a Seamless Human Machine Interface (HMI) display module solution that provides a control and visualization interface for any Raspberry Pi and Arduino kits. Nextion is mainly applied to IoT or consumer electronics field. It is the best solution to replace the traditional LCD and LED Nixie tube, and, it is best intelligent display module on the market. This screen is also chosen for the study because it is made specifically for the Arduino, and for IoT application, making the system connection reliable. (RobotShop Inc., 2018).

The controlling and monitoring of power sources such as sockets is not a new product to begin with, actually, there are already products available in the market, although the difference of these products from the study is that they are only individual devices which requires separate system such as Alexa, Nest and Google Home to work. The available products on the market are based outside of the country, for instance, is the WeMo switch from Belkin this product is a Wi-Fi based power outlet which may control the socket to turn it ON or OFF (Belkin WeMo Switch, 2015). Another similar product is the Orange MyPlug which function is to control the power of the socket using Zigbee transceiver and GSM interface. (Orange MyPlug, 2015). The most identical kind of product is the Plug Wise where it can turn on/off the power and monitor power consumption. (Safe Plug, 2015).

METHOD

Pre-design Considerations

Location

The location chosen for the study is located in Barangay 150, Tondo Manila because of the congestion of houses in that area which is very prone to fire breakouts. The chosen respondents for the testing of the device were those who have a busy schedule and often leave appliances unattended.

Table 1: List of Components with their Power Rating

Components	Quantity	Power (W)	Total Power (W)
NRF24L01	5	0.0215	0.1075
Arduino Nano	4	0.28	1.12
Arduino Mega	1	0.28	0.28
PIR Sensor	2	0.325	0.65
LCD Touch Display	1	2.5	2.5
		Total	4.6575

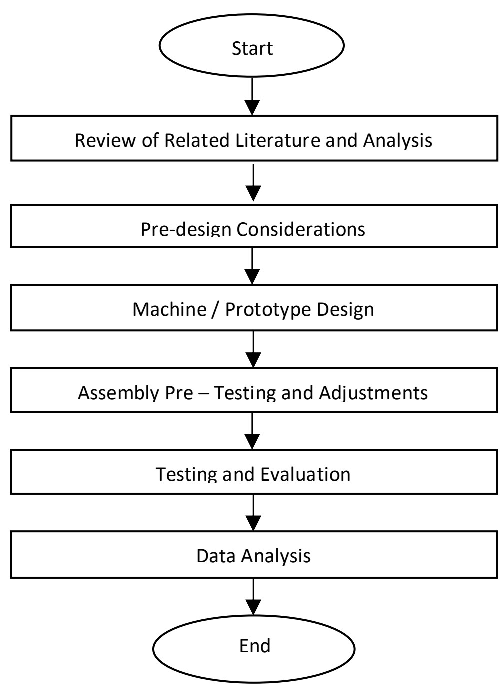

Figure 2. Method

Power Consumption

The study is composed of three different devices which are the main controller, PIR sensor and adaptor. The main controller and the PIR sensor needed a 220V AC source. Therefore it added up to the power consumption of the house. (See Appendix A, Table A.1 for the basis of computation and Appendix F for data sheet of each component)

Cost of Smart Adaptor Usage

As of January 2019, the Manila Electric Company (MERALCO) announced that electricity rate is 9.8385 pesos per kilowatt hour.(Meralco: Electricity rates lower for January, 2019).The calculated consumption rate per day of the Smart Adaptor System is 1.0992 pesos adding only 34.0752 pesos per month in the bill of the user. This price per month is fairly tolerable because the device helped the user to manage unmonitored working appliances.

Table 2: Estimated Cost for Smart Adaptor

Cost per Hour	0.0458 Pesos
Cost per Day	1.0992 Pesos
Cost per Month	34.0752 Pesos
Consumption per Day	0.1118 kWh/day

Formulas:

Cost per Hour = Total Power Consumption (kW) × Electricity Rate (pesos per kWh)

Cost per Day = Cost per Hour × Number of Hours per Day

Cost per Month = Cost per Day × Number of Days per Month

Consumption per Day (kWh) = Total Power Consumption (kW) × Number of Hours per Day

Machine/Prototype Design

Block Diagram of Operation

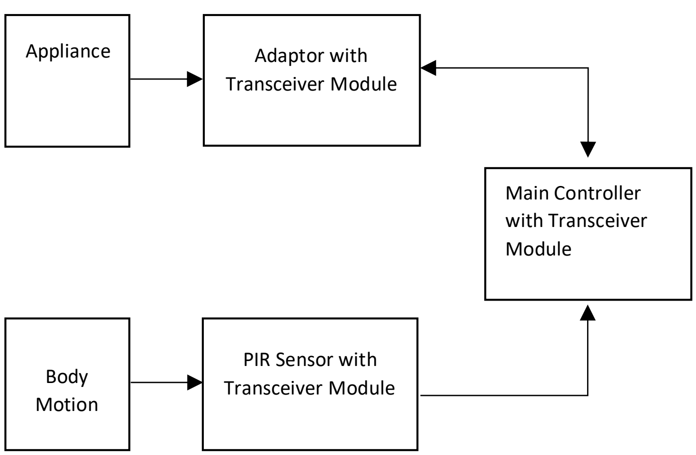

Figure 3. Block Diagram of Operation

The operation of the smart adaptor system starts on two components, the appliance and body motion. The appliance is connected to an adaptor which has an NRF24L01 Transceiver module for communication and is wirelessly connected to the main controller using the Transceiver Module. The body motion on the other hand is for the PIR sensor which on the moment of body motion detection would send a signal to the main controller using an NRF24L01 Transceiver Module as well.

This study is basically composed of three (3) main parts which is the adaptor itself, main controller and a PIR sensor. The connection of these three (3) was a wireless connection where the NRF24L01 Transceiver Module was used to communicate the devices whereas the main controller of the adaptor would indicate their status. Lastly, the adaptor was Arduino based which also have a manual switch. A special feature of the Smart Adaptor system is a separate sensor which is located on a certain location which maximized its sensing radius. The sensor is specifically for room monitoring to know if the surrounding room is occupied by an individual.

The following materials will be used to develop the prototype:

1. HC-SR501 PIR Motion Detector

   The PIR sensor on the system was used for room occupancy monitoring. The number of PIR sensor was depended on the number of rooms the user wants to monitor.

2. ATMEGA 2560

   The arduino mega was used to power up the LCD screen and store the codes needed to display the correct status on the screen and control the main controller, PIR sensor and adaptor.

3. Arduino Nano 3.0 (ATMEGA 328)

   The arduino nano is the main component of the adaptor wherein it is the one to control the relay module of the system which is the ON and OFF ability of the adaptor and PIR sensor.

4. NRF24L01 Transceiver Module

   The NRF24L01 Transceiver module was used for wireless communication of the main controller, PIR sensor and the adaptor. When the PIR sensor detects human presence and there is an appliance plugged into the adaptor, the NRF24L01 will send feedback to the main controller.

5. NX4827T043 LCD Screen

   The LCD touch screen has two functions: the icons displayed is used to control the adaptors while the color indicates the status of the appliances plugged into the adaptor.

6. Alarm (Piezo Buzzer)

   The alarm notified the owner after a certain time is met, indicating that there is still an appliance left running on an unoccupied room.

7. Timer (Embedded in the Program)

   The timer will start counting when the sensor does not detect any human presence. The maximum time that can be set in the main controller is 30 minutes. Timer will trigger the alarm when it reached the last minute of the allotted time. When the alarm stops ringing and the owner did not made any action on the manual switch of the adaptor and main controller, the adaptor will be automatically turned off.

8. SRD-5VDC-SL-C Relay

   Relay was used to cut off the power supplied by the outlet to appliance once the adaptor is turned off. This component of the adaptor helped the household owner in minimizing the power consumption.

9. 5V Power Supply

   The 5V Power Supply was used to power up the Arduino mega and Arduino nano.

10. Push Button Switch

    Switch was used for manual power controlling of the adaptor.

Process Flow Chart

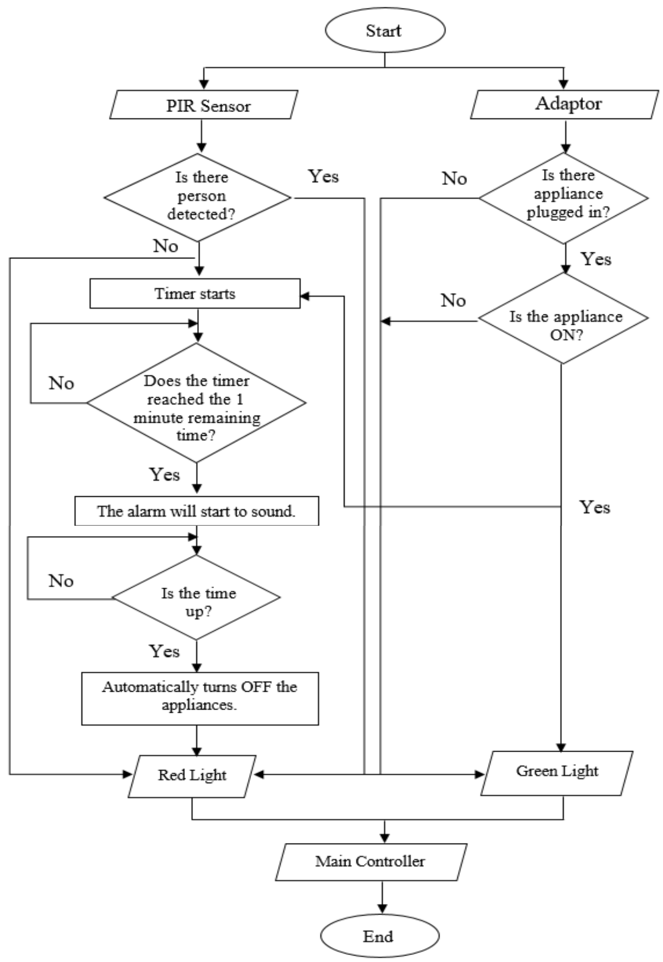

Figure 4. Process Flow Chart

The concept of the Smart Adaptor System starts when there is a plugged in and turned on adaptor, once this happen, the adaptor will send a signal to the main controller that it is turned on. On the other hand, when the smart adaptor may be turned OFF using the main controller or by manually switching it went OFF. The adaptor indication will flash in a form of a green light if it is ON and a red light if it is OFF. The second part of the Smart Adaptor System is the PIR sensor which purpose is to indicate if the room it is applied on is occupied or not. The PIR sensor will send a signal to the main controller once human presence is detected in the room and would indicate in the form of a green light. On the other hand, once there is no more human presence in the room, it will then send a signal to the main controller and would indicate in red light. The moment the adaptor is ON and there is no human presence detected within the room, a timer will start. The time on the timer will be set by the user and once the last minute of the set up time is met, the alarm of the system will sound until the last minute ends and would automatically turn OFF the adaptor.

System Design

1. Main Controller

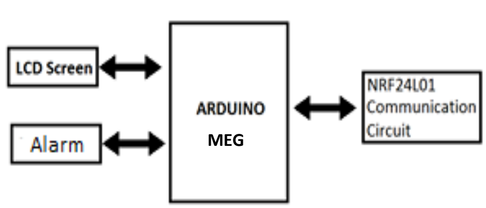

Figure 5. Structure of Main Controller

The main controller was composed of an LCD screen and was powered by an arduino mega whereas the communication system relayed on the NRF240L01 Transceiver. The major function of the main controller was to indicate the status of the PIR sensors and adaptors and control their power. The main controller was equipped with an alarm to notify the owner after a certain time, indicating that there was still an appliance left running on an unoccupied room. The controller was a touch screen and has icons to easily identify the appliances plugged into the adaptor. (See Appendix G, Figure G.1 for the Schematic Diagram and Figure 2 for the 3D Model)

2. PIR Sensor

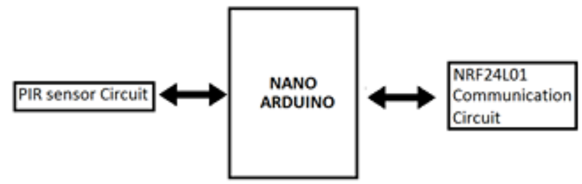

Figure 6. Structure of the PIR Sensor

The PIR sensor was used for room occupancy monitoring. The number of PIR sensors will depend on the number of rooms the user wants to monitor. In order for the sensor to monitor its location, it will be controlled by arduino nano. Arduino nano is the chosen controller for the system because of flexibility and compact size. This PIR sensor arduino was able to communicate with the other devices of the system because it was also equipped with a NRF24L01 Transceiver. Also, it functioned as a timer where it will start counting if the sensor detects unplugged appliance and no human presence. After a certain time was met, the user may program the Smart Arduino system to automatically turn off the adaptors or indicate status of the main controller. The PIR sensor was chosen because it has a function relies on the change of heat on the area of detection which is aligned to the purpose of the system on human presence monitoring. (See Appendix G, Figure G.3 for the Schematic Diagram and Figure G.4 for the 3D Model)

3. Adaptor

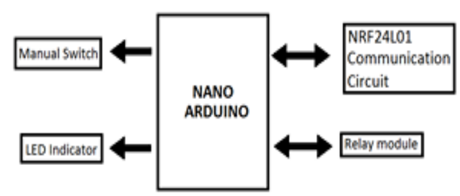

Figure 7. Structure of the Adaptor

The Adaptor is the main component of the system, the number of adaptors depends on the numbers of appliances the owner wanted to control and monitor. The Adaptor was required to have a separate source of 5V for the supply of its controller, which was a Nano Arduino as well. There were requirements of a separate power source for the adaptor in order to prevent standby electricity loss once the adaptor was plugged in on the socket. The adaptor's arduino nano was the one who controlled the relay module of the system which served as the ON and OFF ability of the adaptor. The concept behind the ON and OFF of the adaptor was that it will cut off the outlet's power supply to the appliance through the use of the relay. Its communication system was also based on the NRF24L01 Transceiver module. The adaptor has a switch for manual power controlling.(See Appendix G, Figure G.5 for the Schematic Diagram and Figure G.6 for the 3D Model)

Assembly Pre-Testing and Adjustments

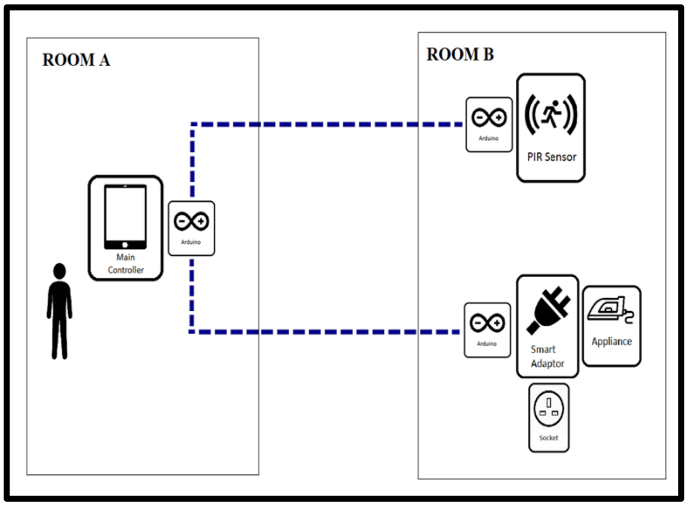

Figure 8. Structure of the System for Testing

In the pre-testing, the distance and angle between the components was tested in order to check the connection and there was no delay. The position of the device was not the same in every house, thus it was required to find first the best position of the device to ensure that there were no or at least few obstacles that may affect the system.

After the construction of the device, the proponents conducted five trials to determine if the device operated properly.

As for the pre-testing, the measurement of the beam width of the PIR sensor and range of the NRF24L01 was used to verify the distance and range specified in the specification sheet. The gathering of data was done in an open space with the use of a protractor for the angle and a tape measure to gather the maximum range of the PIR sensor. On the other hand, the testing of the range of the NRF24L01 was done on an open space by using a tape measure between the distances of the main controller, sensor, and adaptor. Both pre-testing were done on open space in order to know the maximum potential of the system.

Testing and Evaluation

The device was tested on a barangay in Tondo, Manila for a span of five days with five trials replicated in 2 weeks. The necessary information for the study were gathered by conducting survey to the residents of a particular barangay in Tondo, Manila. Two sets of questionnaires were prepared and distributed to the respondents. The first set was to determine the respondents who were always busy and often leave their house unattended. The second set was for the residents of the house where the device was implemented. (See Appendix I for survey questionnaire)

A. Testing the Efficiency

The efficiency of the device was tested and the power consumptions with and without the smart adaptor system were compared in five trials. Individual power consumption on two certain appliances on two different household was measured using a power meter, the power was measured with and without the smart adaptor system.

After tabulating the measurement of the two households, the rating was classified by the use of the Likert scale. The mean difference on the power consumption between household with and without the smart adaptor was the basis for the rate of reduction of the power consumption. The measured rate of reduction of power consumption was compared on the acceptable rate of reduction based from the respondents. The rate of reduction determined the acceptability of the device. Higher rate indicates that the device is acceptable while lower rates implies unacceptability.

B. Testing the Accuracy

The testing of the accuracy of the system is based on the right detection of the PIR and the Smart Adaptor and indication of the main controller regarding the status of each adaptor and sensor. There were two tests done with five trials each. The first test was the communication between the two PIR sensor and Main controller. A PIR sensor monitored room was tested by entering and leaving the room and the main controller is verified if it displays the right status. On the other hand, the communication between the two adaptors and the main controller was done by turning on and off the two adaptor to verify that the Main controller shows the appropriate indications.

The overall accuracy of the system was based on the mean of the actual and detected values of the PIR sensor and the adaptor. The Likert Scale was used to interpret the results having five trials each. If the total accuracy of the system is 0-20%, the interpretation is that the device is “very inaccurate”, 21%-40% is “Inaccurate”, 41%-60% is “Average”, 61%-80% is “Accurate” and lastly, 81% - 100% is “Very Accurate”

Scale for Accuracy:

0-20% – Very Inaccurate
21%-40% – Inaccurate
41%-60% – Moderately Accurate
61%-80% – Accurate
81%-100% – Very Accurate

C. Testing the Reliability

The reliability of the device was measured by the response time of the device during each trial. The response time was measured by the time in seconds it took the data to be transmitted from the PIR and the adaptor to the main controller and vice versa. The response time of the PIR was obtained using a timer wherein the certain time of human presence was noted and the time of reaction was measured as the main server indicate the status of the PIR. The total time gap was the difference between the time of presence and the time of reaction. Also, the response time of the adaptor was obtained using a timer. The time when the adaptor was attached to the appliance was measured and the time that the main server indicate the status of the adaptor was recorded as time of reaction. The difference of the time of activation and time of reaction was the total time gap. The response time of the alarm system of the main controller was tested in five trials. There was five different time that was set on the main controller. A timer was used to measure the set-off time which was a minute before the alarm activates. The difference of the set time to the set-off time and the expected time to the actual time that the alarm activates was computed to determine if there was significant difference observed on the results.

To measure the response time of the device, the total time gap was measured by the PIR sensor and the status was indicated in the Main Controller and by the difference in time when there is human presence detected as when well as when appliance plugged in the adaptor and the status is indicated. The Likert Scale interpreted the results as:“Very Reliable” if the total time gap is 1 second, “Reliable” if the total time gap is 2 seconds, “Moderately Reliable” if the total time gap is 3 seconds, “Unreliable” if the total time gap is 4 seconds, and “Very Unreliable” if the total time gap is 5 seconds.

D. Testing the Overall Acceptability

In testing the overall acceptability of the device, the results from the survey was used.In each question, the rating was tabulated from ten random respondents. The overall acceptability was based on the mean result in each question and Likert Scale was used to interpret the results.

Scale for Overall Acceptability:

4.20-5.00 – Very Acceptable
3.40-4.19 – Acceptable
2.60-3.39 –Moderately Acceptable
1.80-2.59 - Unacceptable
1.00-1.79 – Very Unacceptable

Statistical Treatment

The statistical treatment that was used for computing the efficiency, reliability and accuracy is arithmetic mean. The results will then be analyzed using the Likert scale. Reliability was measured by means of measuring the response time of the device during each trial. For the reliability of the alarm system of the main controller, t-test was used. The test aims to determine whether significant differences were observed between the set time and alarm. Accuracy was measured by means of observing whether the controller indicates the status of the devices correctly.

RESULTS AND DISCUSSION

A. Pre- Testing

Table 3
Beam Width of the PIR Sensor

No. of Trials	Angle (°)		Distance (m)		Width (m)	
	Hori-zontal	Verti-cal	Hori-zontal	Verti-cal	Hori-zontal	Verti-cal
Trial 1	105°	90°	2m	2m	3.12m	1.92m
Trial 2	105°	90°	4m	4m	5.2m	2.80m
Trial 3	105°	90°	6m	6m	4.30m	3.96m
Trial 4	105°	90°	7m	7m	1.10m	1.12m
Trial 5	105°	90°	8m	8m	0m	0m
Mean	105°	90°	5.4m	5.4m	2.74m	1.96m

The measurement of the beam width of the PIR requires the mean of the angle, distances and width. The measured mean of the angle when PIR was placed horizontally is 105°while 90° if vertical, whereas the mean of the distance is 5.4m for both positions, and the mean of the width is 2.74m for horizontal and 1.96 for vertical.

The pre-testing determined the maximum capability of the components of the smart adaptor system. The site of testing was an open space to know the maximum range and beam width of the systems components. The angle measured using a protractor for the beam width of the PIR when placed horizontally was 105° and 90° if vertical. The measurement is approximately near to the specification of the sensor which is less than 120°. The distance used were measured from the center of the PIR to the distance tabulated in the table, this is done with the use of a tape measure. The measured width was taken from the range on which the PIR senses human presence on the designated distance. The results show that maximum distance which can be covered from the center is up to 7m only with 1.12mwidth, while the minimum distance which can be covered from the center is up to 4m only with 5.2 m width. Based from the obtained measurements, the widest coverage was on the mid center which has a 4m length and 5.2m width.

Table 4
Range of the NRF24L01

No. of Trials	Distance (m) Main Controller to Adaptor	Detected	Distance (m) Main Controller to PIR	Detected
Trial 1	2	Yes	2	Yes
Trial 2	4	Yes	4	Yes
Trial 3	6	Yes	6	Yes
Trial 4	8	Yes	8	Yes
Trial 5	10	No	10	No

To measure the range of the NRF24L01, five trials were done wherein five distances were tested if there was a detection of adaptor in the main controller. The results shown that the maximum distance it has a detection was 8m since no detection obtained in 10m distance.

The pre-testing was done to ensure the best position of the devices for the actual testing. Results indicate that the optimum position of the PIR is at the center which was 4m length and 5m width.

B. Testing the Efficiency

Table 5
Power Consumption of each Household using Electric Fan

No. of Trials	Household 1 (Power Consumption in kWh)		Household 2 (Power Consumption in kWh)	
	With Smart Adaptor	Without Smart Adaptor	With Smart Adaptor	Without Smart Adaptor
Trial 1	0.3089	0.4909	0.3112	0.4952
Trial 2	0.3346	0.3991	0.3256	0.3899
Trial 3	0.2315	0.3529	0.2318	0.3532
Trial 4	0.2225	0.2973	0.2235	0.2893
Trial 5	0.2025	0.2628	0.2085	0.2621
Mean	0.2600	0.3606	0.2601	0.3579

The testing was done with the use of a power meter to measure the power consumption of the appliance. The mean of the power consumed of each household with and without the smart adaptor on two different appliances, namely the electric fan and TV was computed. The first appliance measured for both households is an electric fan. On household 1, the mean computed with the smart adaptor was 0.2600kWh, while the mean without the smart adaptor was 0.3606kWh. On the other hand, household 2 got a mean of 0.2601kWh with the use of the smart adaptor, and a mean of 0.3579kWh without the use of the smart adaptor. Almost 28% was deducted on the power consumed by electric fan which results to 1 peso deduction on the total bill for 1 week of usage of the system on both households. The decrease on the power consumption was because the household owner were able to monitor the unattended appliances which was then turned off immediately. Whereas without the use of the smart adaptor, the devices were left unattended resulting to more power consumption.

Table 6
Power Consumption of each Household using Television

No. of Trials	Household 1 (Power Consumption in kWh)		Household 2 (Power Consumption in kWh)	
	With Smart Adaptor	Without Smart Adaptor	With Smart Adaptor	Without Smart Adaptor
Trial 1	0.3002	0.3298	0.3102	0.3298
Trial 2	0.2403	0.2986	0.2501	0.2887
Trial 3	0.2102	0.2587	0.2162	0.2698
Trial 4	0.1614	0.2195	0.1612	0.2284
Trial 5	0.1296	0.1896	0.1265	0.1999
Mean	0.2083	0.2592	0.2128	0.2633

The second appliance tested for both households was a television which on household 1 got a mean of 0.2083kWh with the use of the smart adaptor, and a mean of 0.2592 without the use of the system. On household 2, with the use of the system, the computed mean was 0.2128kWh, while mean computed without the use of the adaptor was 0.2633kWh.The household got a decrease on their consumption. Almost 20% was deducted on the power consumed by television which results to 50 centavo deduction on the total bill for 1 week of usage of the system on both households.

The estimated consumption of the smart adaptor is 0.0047kWh while the actual consumption is 0.0039kWh. (See Appendix E for Computation).The difference on the amount of consumption makes the smart adaptor more efficient because even though the device consumes power, its capability to automatically turn off the plugged appliances helps in reducing power consumption as well as to reduce the risk of having fire breakout due to unsupervised appliances.

The results obtained from the study was similar to the result of the study conducted by Derahman, et al., wherein NRF24L01 Transceiver module was also used. It shows that the NRF24L01 implementation which uses lightweight protocol and has the capability to revert to sleep when there is no packet transmission could reduce the power consumption.

C. Testing the Accuracy

Table 7
Human Detection Result in Household 1

No. of Trials	PIR 1			PIR 2		
	Human Presence		Accuracy (%)	Human Presence		Accuracy (%)
	Actual	Detected		Actual	Detected	
Trial 1	Y	Y	100%	Y	Y	100%
Trial 2	N	N	100%	N	N	100%
Trial 3	Y	N	0%	Y	N	0%
Trial 4	N	N	100%	N	N	100%
Trial 5	Y	Y	100%	Y	Y	100%
Mean			80%	Mean		80%

Table 8
Human Detection Result in Household 2

No. of Trials	PIR 1			PIR 2		
	Human Presence		Accuracy (%)	Human Presence		Accuracy (%)
	Actual	Detected		Actual	Detected	
Trial 1	Y	Y	100%	Y	Y	100%
Trial 2	N	N	100%	N	N	100%
Trial 3	Y	Y	100%	Y	Y	100%
Trial 4	N	N	100%	N	N	100%
Trial 5	Y	Y	100%	Y	Y	100%
Mean			100%	Mean		100%

The accuracy of both PIR sensors in household 1 showed in table 7 resulted a mean of 80% while household 2 in table 8, got an accuracy of 100% for both PIR sensors. The overall accuracy for both households amounts to 90%.This percentage means that the PIR sensor can detects human presence very accurate based on the Likert scale shown wherein 90% falls between the range of 81-100 percentage.

Table 9
Appliance Detection Result in Household 1

No. of Trials	Adaptor 1			Adaptor 2		
	Television		Accuracy (%)	Electric Fan		Accuracy (%)
	Actual	Detected		Actual	Detected	
Trial 1	Y	Y	100%	Y	N	0%
Trial 2	N	N	100%	N	N	100%
Trial 3	Y	Y	100%	Y	Y	0%
Trial 4	N	N	100%	N	N	100%
Trial 5	Y	Y	100%	Y	Y	100%
Mean			100%	Mean		60%

Table 10
Appliance Detection Result in Household 2

No. of Trials	Adaptor 1			Adaptor 2		
	Television		Accuracy (%)	Electric Fan		Accuracy (%)
	Actual	Detected		Actual	Detected	
Trial 1	Y	Y	100%	Y	Y	100%
Trial 2	N	N	100%	N	N	100%
Trial 3	Y	Y	100%	Y	Y	100%
Trial 4	N	N	100%	N	N	100%
Trial 5	Y	Y	100%	Y	N	0%
Mean			100%	Mean		80%

The accuracy of two adaptors in two households got different results. For household 1 showed in table 9, adaptor 1 got 100% and adaptor 2 got 60% accuracy. On the other hand, household 2 showed in table 10, got 100% accuracy for adaptor 1 and 80% for adaptor 2. The overall accuracy for the adaptor is 85%.It also means that the adaptor is considered very accurate in detecting electrical appliances since 85% falls between the range of 81-100 percentage in the Likert scale.

D. Testing the Reliability

Table 11
Response Time of the PIR in Household 1

No. of Trials	PIR 1			PIR 2		
	Human Presence		Total Time Gap (ms)	Human Presence		Total Time Gap (ms)
	Time of Presence	Time of Reaction		Time of Presence	Time of Reaction	
Trial 1	11:16:15.8 AM	1:16:16.8 AM	1000ms	10:35:11.3 AM	10:35:12.1 AM	800ms
Trial 2	11:30:45.1 AM	1:30:46.3 AM	1200ms	10:55:36.7 AM	10:55:37.6 AM	900ms
Trial 3	1:15:20.5 PM	1:15:21.8 PM	1300ms	12:14:18.5 PM	12:14:19.2 PM	700ms
Trial 4	1:39:56.9 PM	1:39:57.7 PM	800ms	2:47:48.9 PM	2:47:49.9 PM	1000ms
Trial 5	2:12:32.6 PM	2:12:33.8 PM	1200ms	2:51:29.3 PM	2:51:30.3 PM	1000ms
Mean			1100ms	Mean		880ms

The table 11 shows that the slowest response time in household 1 for PIR 1 is 1200ms while the fastest is 800ms while for PIR 2 the slowest is 1000ms and the fastest is 700ms. The mean response time was computed and results shows that for PIR 1 the total gap time is 1100ms and 880ms for PIR 2. The resulted time gap using two PIR sensors were very reliable since 1100ms and 880ms were close to 1000ms which corresponds as very reliable in the Likert Scale. The results obtained was fast since the household had one floor only with studio type rooms thus there was no big obstacles that the PIR encountered. The position of the PIR was also a factor because the tests were done beforehand in the pre-testing.

Table 12
Response Time of the PIR in Household 2

No. of Trials	PIR 1 Human Presence: Time of Presence	PIR 1 Human Presence: Time of Reaction	PIR 1 Total Time Gap (ms)	PIR 2 Human Presence: Time of Presence	PIR 2 Human Presence: Time of Reaction	PIR 2 Total Time Gap (ms)
Trial 1	8:17:55.4 AM	8:17:56.2 AM	800ms	7:30:11.2 AM	7:30:12.2 AM	1000ms
Trial 2	8:30:43.0 AM	8:30:43.9 AM	900ms	7:45:47.5 AM	7:45:48.4 AM	900ms
Trial 3	9:40:26.2 AM	9:40:26.9 AM	700ms	7:50:52.7 AM	7:50:53.5 AM	800ms
Trial 4	9:45:45.3 AM	9:45:46.1 AM	800ms	8:11:37.8 AM	8:11:38.6 AM	800ms
Trial 5	9:50:11.1 AM	9:50:12.2 AM	1100 ms	9:30:14.1 AM	9:30:15.4 AM	1300ms
	Mean		860ms	Mean		960ms

The table 12 shows that the slowest response time in household 2 for PIR 1 is 1100ms while the fastest is 700ms while for PIR 2 the slowest is 1300ms and the fastest is 800ms. The mean response time was computed and results shows that for PIR 1 the total gap time is 860ms and 960ms for PIR 2.

The response time of the PIR sensor was tested by using a stopwatch to get the time gap of the between the moment of human presence and reaction of the PIR sensor. Therefore, the lesser the time gap would mean faster response time of the PIR sensor. The recorded time gaps of the two PIR sensors were computed for the mean, where all means were close to 500ms. According to Kiwan (2013), IR sensors typically have 500ms response time. Since the results were close to 500, the system could be considered reliable.

Table 13
Response Time of the Adaptor in Household 1

No. of Trials	Adaptor 1 Television: Time of Activation	Adaptor 1 Television: Time of Reaction	Adaptor 1 Total Time Gap (ms)	Adaptor 2 Electric Fan: Time of Activation	Adaptor 2 Electric Fan: Time of Reaction	Adaptor 2 Total Time Gap (ms)
Trial 1	12:30:55.0 PM	12:30:56.0 PM	1000 ms	11:17:42.3 AM	11:17:43.3 AM	1000 ms
Trial 2	1:15:27.2 PM	1:15:28.4 PM	1200 ms	11:45:27.8 AM	11:45:28.7 AM	900 ms
Trial 3	1:45:31.1 PM	1:45:31.9 PM	800 ms	12:02:29.1 PM	12:02:29.9 PM	800 ms
Trial 4	2:15:43.5 PM	2:15:44.3 PM	800 ms	1:11:24.2 PM	1:11:25.5 PM	1300 ms
Trial 5	2:45:29.0 PM	2:45:29.9 PM	900 ms	2:13:51.1 PM	2:13:52.3 PM	1200 ms
	Mean		940 ms	Mean		1040 ms

The table 13 shows that the slowest response time in household 1 for adaptor 1 is 1200ms while the fastest is 800ms while for adaptor 2 the slowest is 1300ms and the fastest is 800ms. The mean response time was computed and results shows that for adaptor 1 the total gap time is 940ms and 1040ms for adaptor 2.

Table 14
Response Time of the Adaptor in Household 2

No. of Trials	Adaptor 1 Television: Time of Activation	Adaptor 1 Television: Time of Reaction	Adaptor 1 Total Time Gap (ms)	Adaptor 2 Electric Fan: Time of Activation	Adaptor 2 Electric Fan: Time of Reaction	Adaptor 2 Total Time Gap (ms)
Trial 1	6:45:27.3 AM	6:45:28.3 AM	1000 ms	6:14:12.6 AM	6:14:13.4 AM	800 ms
Trial 2	7:20:11.5 AM	7:20:12.7 AM	1200 ms	6:45:56.7 AM	6:45:57.7 AM	1000 ms
Trial 3	8:10:52.7 AM	8:10:53.5 AM	800 ms	7:15:12.4 AM	7:15:13.4 AM	1000 ms
Trial 4	8:55:13.8 AM	8:55:14.9 AM	1100 ms	7:50:15.7 AM	7:50:16.7 AM	1000 ms
Trial 5	9:40:52.3 AM	9:40:53.2 AM	900 ms	8:15:11.7 AM	8:15:12.6 AM	900 ms
	Mean		1000 ms	Mean		940 ms

The table 14 shows that the slowest response time in household 1 for adaptor 1 is 1200ms while the fastest is 800ms while for adaptor 2 the slowest is 1000ms and the fastest is 800ms. The mean response time was computed, and results shows that for adaptor 1 the total gap time is 1000ms and 940ms for adaptor 2.

The response time of the adaptors were also tested by using a stopwatch. The response time was based on the time gap between the moment of activation from the adaptor and its moment of indication in the main controller.

Table 15
Response Time of the Alarm System of the Main Controller

No. of Trials	Main Server Timer (minutes): Set Time	Main Server Timer (minutes): Set-Off Time	Alarm Timer (minutes): Expected Time of Alarm	Alarm Timer (minutes): Alarm Activates	Difference of Set time and Set off time (milli-seconds)	Difference of the Expected and Actual Alarm (milli-seconds)	Response of the Adaptor: Turn OFF
Trial 1	30	29:57.9	29	28:57.5	2100ms	2500ms	Yes
Trial 2	20	19:59.8	19	18:19.4	200ms	40600ms	Yes
Trial 3	10	10:00.9	9	9:01.1	900ms	1100ms	Yes
Trial 4	5	5:02.0	4	4:01.8	2000ms	1800ms	Yes
Trial 5	2	2:00.7	1	1:00.2	700ms	200ms	Yes
	Mean				1180ms	9240ms	Yes

The gathered data was done by using a stop watch to check if the set off time of the buzzer was correct. In the five trials, the response of the Smart Adaptor was almost on-time from the indicated time in the main server. There was a slight difference in some of the trials in expected time of the alarm indicated in the main server but this may be negligible to the overall reliability of the alarm system. After the last minute is finished, the main controller was able to turn off the adaptor automatically making the alarm system to be reliable to turn off unattended appliances.

Table 16
T-test Results for Set Time and Alarm

Variables	t-statistic	p-value
Difference of Set Time and Set Off Time - Difference of the Expected and Actual Alarm	-0.997	0.375

In addition to the actual time performance of the trial, the set time and alarm results was subjected to a Paired Sample t-test. The test aims to determine whether significant differences were observed between the set time and alarm.

The computed t-statistic was -0.997 with a p-value of 0.375. Since the computed p-value of the t-statistic is greater than the level of significance of 0.05, this leads to the conclusion that no significant differences were observed between the set time and alarm results. (See Appendix K for the Statistical Analysis) Since there was no difference between the set time and alarm, the alarm system of the device was considered accurate.

E. Testing the Overall Acceptability

Table 17
Overall Acceptability of the System

No. of Respondents	Questions			
	Efficiency	Accuracy	Reliability	Overall Rating
1	4	4	4	4
2	5	5	5	5
3	4	5	4	3
4	5	4	5	4
5	4	4	4	4
6	5	5	5	4
7	4	5	4	3
8	5	5	5	5
9	4	5	4	3
10	4	4	5	4
Mean	4.4	4.6	4.5	3.9
Overall Acceptability				4.35

The overall acceptability of the system was done with the product survey review which had questions relating to the efficiency, accuracy, reliability and overall rating of the system. The product survey review was given to 10 respondents of the households who were able to use the smart adaptor system. It showed that the efficiency got a mean of 4.4, accuracy 4.6, reliability 4.5 and an overall rating of 3.9.

The overall acceptability is equal to 4.35 which fall under the range of 4.20-5.00 in the scale and thus the device is very acceptable to the respondents.

CONCLUSION

The Smart Adaptor as a power switch for home appliances contributes to the risk reduction in homes. The system is efficient, accurate and reliable in different aspect. The wireless connection of the system made it easier to turn off appliances connected to the smart adaptor as well as monitoring those appliances using the main controller. The result proved that the main controller is a good monitoring device for appliances and for displaying the PIR sensor's detection.

The connectivity of the PIR to the main server had an accuracy of 90% while that of the smart adaptor to the main server was 85%. Based from the Likert Scale, the main server and smart adaptor was considered very accurate in terms of detecting the human presence and plugged electrical appliances respectively.

The observed trials generalized that the PIR sensor has an accurate detection of human presence within its range. The average response time of 0.95 seconds proved that the PIR sensor used was made the system reliable.

The alarm system of the device was tested. It was shown in all trials that the alarm rings in approximately 1 minute left before the appliances were turned off automatically by the server. This means that the alarm system of the device was reliable to alert the house owners when there are unplugged appliances at the same time, no human presence detected by the PIR.

The measured sensing range of PIR is about 105o within 5.4m distance and width of 2.74m. The power consumption using Smart Adaptor in a span of one week is approximately 20-28% lesser than the power consumption of the household without the Smart Adaptor. The reduction of power consumption of 20-28% was actually higher than the expectation of most respondents which was at 11%-20%. The 0.0039kWh power consumption of the Smart Adaptor has a negligible effect on the household overall consumption.

The reliability of the device was proven by the result of the t-test made which determined the significant difference between the set time and alarm of the main server. The result showed that there was no significant difference was observed since the computed p-value of the t-statistic is greater than the level of significance of 0.05. Therefore, the alarm system of the device was considered reliable. Based on the results obtained, therefore, the Smart Adaptor is an efficient power switch for risk reduction.

RECOMMENDATION

Based on the study conducted and analysis, the following recommendations have been made:

- Use a PIR motion detector that allows multiple adaptors to be connected to it and is capable of transmitting accurate signal to the main server.
- Display the timer on the main server so the user can see when the timer starts counting down.
- Place the PIR sensor in the best position that it can cover the whole area and able to transmit signals to the main server.
- Look for components that are capable of sending and receiving signals more than 6m in distance for the adaptor, PIR sensor and main server.

REFERENCES

5 common causes of electrical fires. (2016, October 17). Retrieved from Firefighting 101:https://www.firerescue1.com/fire-products/fire-safety-for-children/articles/1206100-5-common-causes-of-electrical-fires/

Adafruit. (2017) Retrieved from: https://www.adafruit.com/product/2050

Alhamoud, A., Ruettiger, F., Reinhardt, A., Englert, F., Burgstahler, D., Böhnstedt, D., Steinmetz, R. (2014). SMARTENERGY.KOM: An intelligent system for energy saving in smart home.

Arduino Nano. (n.d.). Retrieved from Farnell: http://www.farnell.com/datasheets/1682238.pdf

Arduino Uno. (n.d.). Retrieved from Farnell: https://www.farnell.com/datasheets/1682209.pdf

Artificial Intelligence and Electronics Society (2017, August 24). Home automation and PIR (Passive Infrared Sensor). Retrieved from A Medium Corporation[US]:https://medium.com

Astrera, D. E., Belecina, A. B., Dolores, J., Dumaplin, D., & Eroles, L. (April 2011). SMS Controlled Home Appliances Management System.

Balahadia, F., Trillanes, A., & Armildez M.R. (2018 January 08) Temporal Analysis and Geo-mapping of Fire Incidents in the City of Manila.

Belkin WeMo Switch (2015, June) Belkin WeMo Switch. Retrieved from:https://www.belkin.com

Bojanczyk, K. (2013, September 11). Redefining Home Energy Management Systems. Retrieved from Green Media:

https://www.greentechmedia.com/articles/read/home-energy-management-systems-redefined#gs.kWCmgXI

Cambridge Dictionary. (2018). Cambride Univeristy Press.

Chodon, P., Adhikari, D. M., Nepal, G. C., Biswa, R., Gyeltshen, S., & Chencho. (June 2013). Passive Infrared (PIR) Sensor Based Security System. (IJEECS) International Journal of Electrical, Electronics and Computer Systems, Vol: 14 Issue: 2.

Civilian Fire Fatalities in Residential Buildings. (2013-2015). TFRS Volume 18, Issue 4.

Dejan. (2017). Arduino Wireless Communication – NRF24L01 Tutorial. Retrieved from How To Mechatronics: https://howtomechatronics.com/tutorials/arduino/arduino-wireless-communication-nrf24l01-tutorial/

Derahman, M., Mohamed, M., Muhamed, A., Abdullah, A., Basery, M., Baharom, S., & Abdullah, M. K. (n.d.). Home Switch Automation System Based on Ultra Low Power Wireless Solution. Faculty of Computer Science and Information Technology, Universiti Putra Malaysia, 43400, Selangor, Malaysia.

Electrical Fires in the home increased by 35% in the last year. (2016, September 2). Retrieved from Co-Operative:https://www.co-operative.coop

Feng, J., Fei*, W., Jian, D., & Yan, Z. (2015). Design of Socket Based on Intelligent Control and Energy Management. (IJACSA) International Journal of Advanced Computer Science and Applications, 105-110.

HC-SR501 PIR Sensor. (n.d.). Retrieved from Components 101: https://components101.com/hc-sr501-pir-sensor

HC-SR501 PIR MOTION DETECTOR. (n.d.). Retrieved from https://www.mpja.com/download/31227sc.pdf

In the Know: The top 3 causes of fire in PH. (2018, March 01).

iTead Studio. 7" Nextion HMI LCD Touch Display. Retrieved from https://www.robotshop.com/en/7-nextion-hmi-lcd-touch-display.html

Justin (2013, November) Retrieved from:http://wwwmisc.ws

Kiwan, A. (2013, October 28). The infrared motion sensor. Retrieved from www.ecnmag.com

Leading Causes of Fire in the Philippines. (2015, May 27). Retrieved from http://www.anosresearchmanufacturing.com/leading-causes-of-fire-in-the-philippines/

MERALCO (2019). Meralco: Electricity rates lower for January,2019. Philippines: CNN Philippines Staff.

Nordic Semiconductor ASA. (2006, March). Retrieved from SparkFun Electronics: https://www.sparkfun.com/datasheets/Components/nRF24L01_prelim_prod_spec_1_2.pdf

Orange MyPlug. (2015, June) Orange My Plug. Retrieved from: https://www.my-plug.fr

Paredes, J. (2017, July 6). Add WiFi to Arduino UNO. Retrieved from Arduino Project Hub: https://create.arduino.cc/projecthub/jeffpar0721/add-wifi-to-arduino-uno-663b9e

Rahim, A., Ali, Z., Bharti, R., & N.S.P, S. S. (2016, May). Design and Implementation of a Low Cost Wireless Sensor Network using Arduino and nRF24L01(+). International Journal of Scientific Research Engineering & Technology (IJSRET), 5(5), 307-309.

Safe Plug. (2015, June) Safe Plug. Retrieved from: https://www.safeplug.com