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Remote Household Appliance Monitoring and Control System using Short Messaging Service (SMS)

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Abstract
Home automation allows home owners to remotely control household appliances and monitor electrical consumption. This paper entitled Remote Household Appliance Monitoring and Control System using Short Messaging Service (SMS) aims to provide an affordable, easy to use and reliable device which will allow home owners to remotely switch ON and OFF electrical appliances and monitor electrical consumption from one's home through an SMS notification. The device was designed to include SMS Module, an Arduino Microcontroller, Current Transformer (CT) sensor, and Voltage Sensor. The device capability to accurately read the electrical consumption of the home appliances is compared to a standard multi-tester device reader. The device functionality to switch ON and off a specific line was also tested. The result shows that there is no significant difference between the voltage and ampere readings of the Remote Household Appliance Monitoring and Control System using Short Messaging Service (SMS) to the standard multi-tester device reader. The result also shows that after series of test the device can properly on and OFF a specific targeted electrical line.

Keywords: Appliance monitoring, control system, home automation.

Introduction
The use of various computer technologies and mobile devices such as cellular phones in various aspect of the society are undeniably important. The rapid innovation in technology paves the way to various research topics and design relating to automation. One of the in demand topic in automation includes the application of computing to secure, monitor and remotely control home appliances. Researchers in this area are associated with home automation.

Home automation according to Atlam and Wills [1] enables the user to control various home appliances remotely. This is usually done by sending commands to a central controller where all home appliances are connected. According to Moreno and Linden [2] home automation is usually composed of several component such as the sensor or interface (input), a controller that sends commands to an output device called actuators. These devices are connected through a network which uses several protocols where user can use to exchange information from the system.

Most Home automation are installed to secure one's home or even remotely control and monitor home devices or appliances. Pampattiwar et. al [3] designed and developed a home automation system that includes Smart Doorbell, Regulating Appliance, Reminders, Alarms and Wireless Speaker. Smart doorbell sends a SMS message to a home owner whenever a doorbell is rung. An email is also send to the home owner containing a picture of the visitor. The Regulating Appliance module works by controlling the on and off of home fans and lights. The Reminders module works by sending reminders to home owners about important appointments or routines. The alarm module allows the user to set alarms for specific date and time. The Wireless speaker module allows the user to connect a phone via a Bluetooth to the system to remotely play audio clips.

Kumar and Singh [4] developed architecture for home automation system that can remotely control home appliances using smart phone's Bluetooth. The architecture includes the use of Arduino Uno, Android Application development, relay Module and Bluetooth connectivity.

Moreover, Surve and Vaidya [5] proposed a system that uses a Raspberry pi, Android Application, Wifi and Relay Circuit. The android application is used to control the appliances via a Wifi connection. The Rasberry pi is configured and the corresponding relay is used to switch on and off the home appliances.

In addition, Baidya and Kumar [6] have developed a home automation system using ESP8266 Wi-Fi module and Arduino Uno Controller R3 to control home appliances using Wi-Fi and an android smart phone application. Home appliances are connected to relays which are connected to the controller ESP8266 Wi-Fi module and Arduino Uno Controller R3. The device is then connected to a web server and by using the smart phone application one can send commands to the server to on and Off the AC devices attached to the device.

The proponents of this study on the other hand use the SMS Module, Arduino Microcontroller, Current Transformer (CT) sensor, and Voltage Sensor to monitor the electric consumption in real time. Using the aforementioned components, the device is capable of accurately reading the electrical consumption of home appliances and allowing home owners or end-users to regularly monitor their electric consumptions. Moreover, the device can also switch ON and off a specific power line using the appropriate command sent remotely using an SMS message. This will permit home owners to remotely switch on or off their home appliances to regulate electric consumption or to prevent overheating and consequently fire and other untoward incidents caused by plugged-in and unattended devices.

Objectives of the Study

This paper focuses on the design and development of a home automation system to allow end-users to remotely monitor their electric usage and control the power supply of home appliances thereby promoting proper usage and conservation of energy. Specifically, the study was designed to monitor the electric consumption of an electric appliance by sending inquiry to the system and remotely turn on and off electric flow to various appliances using specific commands sent through SMS.

Materials and Methods

This study uses Prototyping as a step for the implementation of the System Development Life Cycle (SDLC) and uses the Descriptive method to analyze and present the research findings.

As a developmental research, this study includes the development of Remote Household Appliance Monitoring and Control System using Short Messaging Service (SMS). The researchers used the Prototyping process model to determine the necessary processes in the development of the home automation device. Prototyping according to Abdelhak [7], prototyping process model is a process of building a concrete preliminary model of the proposed system. Prototypes allow the discovery of more new ideas along the entire developmental process and thus after several iterations, new features and ideas are gradually considered into the design that makes the prototype evolved into the final product.

Following the Prototyping method, the researchers identified the scope and significance of the study as well as conducted feasibility study to determine the research operational, technical, schedule and economic requirements during the Planning Phase. During the analysis phase, the researchers designed the architectural model of the system. The researchers established all the functional requirements of the device and the necessary materials needed in the development stage. In the design phase, the researchers developed the proposed device taking into consideration all the necessary revision after each testing and evaluation. The testing and evaluation was done continuously until the device is functioning according to its specified requirements.

The researchers used the Descriptive research model to collect, record, tabulate and present the result of the system evaluation.

Descriptive research is a study of status which aims to solve problems and improve practices trough observation, analysis and description. Descriptive research can also be found in Developmental Research, Observational Research and Correlational Studies [8]. Under the Correlational Studies, the researchers determine and analyze the relationship between the readings of the development system as well as a standard power controller device.

The researchers established all the functional requirements of the device and the necessary materials needed in the development stage. Figure 1 depicts the architectural design of the system, showing the components as block elements.

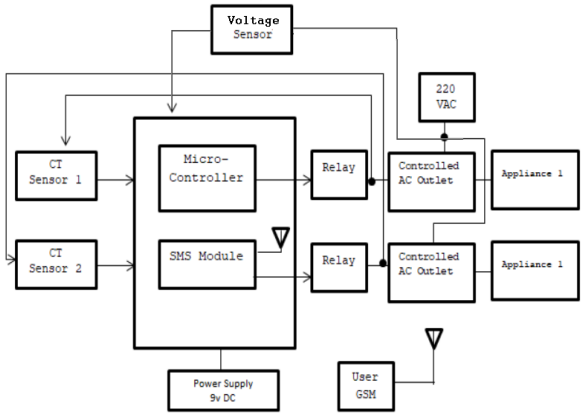

Fig. 1: System Architecture

The microcontroller is a powerful microcomputer providing a high-flexible solution for embedded systems. It contains a dedicated Programmable and Erasable Read-Only Memory (PEROM) providing an industry-standard instruction set and pin out. The microcontroller will receive requests from the SMS module and responds appropriately, either to switch on or off the power line or return the electrical consumption of an attached appliance.

The Arduino Uno board is based on ATmega328P. With 6 analog inputs, 14 digital input/output pins, a 16 MHz quartz crystal, a USB interface, reset button, power jack and an ICSP header,it can be connected to a computer or powered by an AC to DC adapter or battery.

The Subscriber Identifying Module (SIM) attached to the microcontroller enables the system to receive SMS message. This input is processed by the SMS module and forwarded to the microcontroller for interpretation and processing.

The SIM and the microcontroller works as one since a library file for SMS functions are embedded with an

Arduino source code/sketch.

Current Transformer (CT) sensor serves as the input data or value to the Arduino Microcontroller. It is the device which determines the amount of current passing through an AC Power Outlet as this current is consumed by an Appliance. The data fed by the CT sensor to the microcontroller is used to calculate Power Consumed.

The External Power Supply powers the Arduino Microcontroller and the SMS Module with a 9V Direct Current (DC) power source.

The 220 VAC Power Supply (220 V) passing through the Controlled AC Outlet powers the attached appliances and its connectivity to the appliances is controlled by solid-state relay. The Power Controller Device has two independent power lines, namely line A and line B where the power consumption can be monitored and controlled.

Voltage Sensor detects voltage levels generated by the power line. It connects to both lines (line-to-line or line-to-ground). The output of sensor is the voltage reading which is feed to the Arduino. The system needs only one voltage sensor since electrical circuit is in parallel and voltage in this circuit is equal. To accurately calculate power consumption voltage is needed to be accurate rather than assuming it as 220 volt always, because it is constantly fluctuating.

The Relay circuit is acting like switches that can cut-off the power from 220 VAC Power Source. The microcontroller operates the solid-state relay indirectly turning the attached appliances On or Off. It is the circuit that is working on the principle of switching operation of the transistor where when the base current is zero (0), it acts as open switch (cut-off) and when the base current reaches a threshold value, it is a closed switch.

The device has its own Subscriber Identifying Module (SIM) attached to it. The User, using a GSM phone, interacts and operates the system using SMS command messages. The SMS keywords understood by the system includes: On, Off and Status. The system will switch on the appliance if it receives the ON command and turns off the appliance for OFF command. Meanwhile, if it receives the STATUS command, the system will send an SMS message to the user containing the current electric consumption of the appliance.

The test was undergone to determine the overall accuracy of the device to read the electric consumption of the home appliance and to properly on and off the target line for a set of appliance.

Test cases were derived by sending SMS to the device to turn on or off a specific line and determine the electric consumption per line.

The researchers using SPSS and Microsoft Excel recorded, tabulated and presented the result using Persons Correlation, frequency and percentage.

Person's Correlation is a measure of the linear association of two variables. The value of correlation using Person's Correlation close to zero means low association and values closer to -1 means strong negative association and values closer to +1 indicate a positive strong linear association between two variables [9].

Results and Discussion

The researchers undergo several test cases to determine the functionality and accuracy of the device.

Table 1 shows the correlation and the significance of the data collected from the 32 conducted tests pertaining to the electrical consumption of appliances attached in Line A.

The researchers performed 32 tests to determine whether the device accurately reads the electrical consumption of Line A. Voltage and Ampere were recorded during the test to determine the accuracy of the device to accurately read the electrical consumption of the appliances attach into it. The readings from the device were compared to the readings from a standard Multi-tester Reader.

Table 1: Correlation between the Remote Household Appliance Monitoring and Control System and Standard Multi-tester Reader (Line A).

Category	r	Correlation	Significance
Remote_Monitoring_Device VS Multi_Tester_Reader (Volts Reading)	0.998	Positive	No Significant Difference
Remote_Monitoring_Device VS Multi_Tester_Reader (Ampere Reading)	0.994	Positive	No Significant Difference

The result shows that the Correlation between the Remote Household Appliance Monitoring and Control System and the Standard Multi-tester Reader in Line A volts reading is 0.998 and 0.994 in ampere reading. This result means that there is no significant difference between the readings of the two devices. The result implied that the Remote Household Appliance Monitoring and Control System can accurately read the electrical consumption of the Line a Appliances.

Using the same method in Line A, the researchers performed 32 tests cases and collected the results for appliances attached in Line B. The result of the test in Line B appliances is shown in Table 2.

Table 2: Correlation between the Remote Household Appliance Monitoring and Control System and Standard Multi-tester Reader (Line B).

Category	r	Correlation	Significance
Remote_Monitoring_Device VS Multi_Tester_Reader (Volts Reading)	0.998	Positive	No Significant Difference
Remote_Monitoring_Device VS Multi_Tester_Reader (Ampere Reading)	0.998	Positive	No Significant Difference

The result conducted in Line 2 shows that the voltage reading of the Remote Household Appliance Monitoring and Control System and Standard Multi-tester Reader has a correlation of 0.998 and the ampere reading has a correlation of 0.998.

The result shows that the test conducted resulted to a positive correlation between the two readings and that the readings of the two devices in Line B have no significant difference.

This implies that the Remote Household Appliance Monitoring and Control System accurately read the electrical consumption of appliances connected to Line B.

According to Frost [10], the relationship of the two data sets should be accurately reflected by the strength of its relationship. Thus, the result of the test conducted in the study shows that the readings of the Remote Household Appliance Monitoring and Control System has fairly strong positive relationship with the result of a standard multi-tester device at 0.998 correlation coefficient.

Table 3 shows the number of test cases performed to determine the accuracy of the system to properly on and off a specific power line.

The researchers performed 64 tests. This includes 32 SMS to ON a specific electrical line and 32 SMS to OFF a specific Line.

Table 3: Test Conducted to ON/OFF a specific Electrical Line.

Category	No. of Test Conducted	No. of Test Successfully performed	Percentage
Yes	32	32	100
No	32	32	100
Overall	64	64	100

The result shows that from the 64 test cases conducted, the result shows that the device accurately switches ON and OFF a specific target electrical line. The result shows that the capability of the device to properly turn ON and OFF a line from a received SMS is functioning accurately.

Conclusion and Recommendation

Based on the results presented, the Remote Household Appliance Monitoring and Control System using SMS accurately reads the electrical consumption of the home appliance attached to the device and remotely performed the turning ON and OFF of the targeted line.

The study is contemporary, well suited for people on the go and at the same time it promotes energy conservation by allowing the end-user to remotely switch off any home appliance that was left running.

It is also indispensable for home owners as they are promptly updated of their electrical consumption and they have the option to remotely switch off a particular appliance. Ultimately, they will have better control of their expenses arising from using home appliances.

Lastly, the system is cost-effective and realistic as it uses SMS and Arduino Microcontroller, technologies which are readily available and affordable for home owners.

To make life even better and at the same time help in energy conservation, the researchers recommend extending the system that will allow the end-user to set a threshold of electrical consumption by appliance and once the limit is reached, the system may either automatically shut down the concerned unit or notify the user to confirm the unit shut down. The system may also be enhanced by allowing the user to schedule when the appliance should turn on or shut down, leading towards smart home system.

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