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(RESEARCH ARTICLE)

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Automated control of fixed loads and remote sockets: design and evaluation

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Abstract

The world is moving towards the process of automation. From the use of manual vehicles to the use of self-driving cars as people seek comfort, convenience and accessibility. Home automation basically does that, making the devices easily accessible from anywhere in the home. To overcome the challenges associated with standing up to switch on and off home appliances, especially during this pandemic era. Hence, "Automated control of fixed loads and remote Sockets: Design and evaluation" presented. This research describes the evaluation via survey and design of a circuit incorporated with a Bluetooth module and design application for smartphones so that any device connected to the circuit such as fans, lightings, sockets etc can make use of the application to control it. The application once it has been successfully installed in any smartphone and successfully connected to the circuit helps in switching on and off the lights, the fan, sockets, etc It will also help in the regulation of the speed of the devices. This is more effective, reliable, automated, time saving and cost effective.

Keywords: Automation; Control; Wireless; Mobile Application Development

1. Introduction

Since the beginning of time, mankind has always searched for ways to make life more comfortable. From crafting of stone tools to crafting of iron tools up to industrialization, computerization then towards automation of our present age [1]. Communication refers to the creation of a link between points with the aim of exchanging information between them. Communication is carried out using wired such as coaxial cables or wireless such as the use of Bluetooth medium [2]. Over time, the use of wireless mediums for communication has been on the rise and with the introduction of GSM; its importance has been on the increase ever since [3]. The recent trends in the continuous growth of mobile devices like smartphones in its functionality and popularity has caused increase in the demand of mobile application in people's daily lives in helping to make life easier and more comfortable for the general populace [4].

The development of the android mobile operating system coupled with the improvement in artificial intelligence and automation has further laid credence to man's search for comfortable living.

Many Consumers are completely unsatisfied with manual operation and desire to automatically control their loads and sockets with mobile application.

However, Sree presented a Home Automation System (HAS) where the status of each switch is synchronized in the control system, whereby each user interface indicates the status of existing switches in real time [4] while Alheraish designed a M2M (short for machine-to-machine, man-to-machine or mobile-to-machine) communication system over a GSM network in a Home Automation system [5].

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Al-Ali proposed the development and implementation of a Java-based automation system [6] that, via the World Wide Web that can monitor and control home appliances [7] through a design which is based on an embedded stand-alone system [8].

To overcome these difficulties, a research title "Automated control of fixed loads and remote Sockets: Design and evaluation" which can be implemented in developing countries like Nigeria is hereby presented. In this system, there will be an effective control on the fixed loads and remote sockets. This will make consumers appreciate the automation and control of consumers loads with mobile application development via Bluetooth. More so, evaluation, classification and regulation of consumer's loads were the gap filled in this study.

The system will further resolve the stress in putting on and off the lightings then manually regulating load like fan speed.

The need for the hour is not having physical contact with control devices to keep social distance due to the pandemic.

2. Material and methods

The objective of the research was accomplished through the process described in figure 1

The survey was carried out by administering questionnaires to the public. The major coverage areas of this survey were Benin City and its environs in Edo State, Nigeria.

A formula developed by Cochran was used to create a proportional representative sample.

$$n_o = \frac{z^2 pq}{e^2} \quad (2.1)$$

Where n_o is the sample size, z is the desired confidence level's selected critical value, p is the population's estimated proportion of a characteristic, q = 1 p, and e is the desired level of accuracy.

To figure out how big a sample size should be, an infinite area like our large population with unknown degree of variability, the maximum variability was assumed, which is equal to 50% (p =0.5) and taking 95% confidence level with ±5% precision.

Substituting p= 0.5, q =1-0.5 = 0.5, e = 0.05 and z =1.96 in (2.1) gives;

$$\frac{1.96^2 * 0.5 * 0.5}{0.05^2} = 384.16$$

$$\approx 384$$

Anticipating 50% return rate, two times the number of required (768) questionnaires were distributed out of which 501 respondents were returned.

Three methodologies were used to analyze the data collected from the respondents in the survey.: Electrical Transient and Analysis Program (ETAP 12.6 version), Statistical Package for the Social Sciences (SPSS 22 version) and MICROSOFT EXCEL (2016). The results of the analysis are presented in figure 2.7, figure 2.8, figure 2.9 and figure 2.10. Thereafter, material selection for design process, design of block diagram and circuit, design of mobile application and experimental process.

Note

The design calculations, programming codes, questionnaires calculations and others would be published in the extended version of this journal.

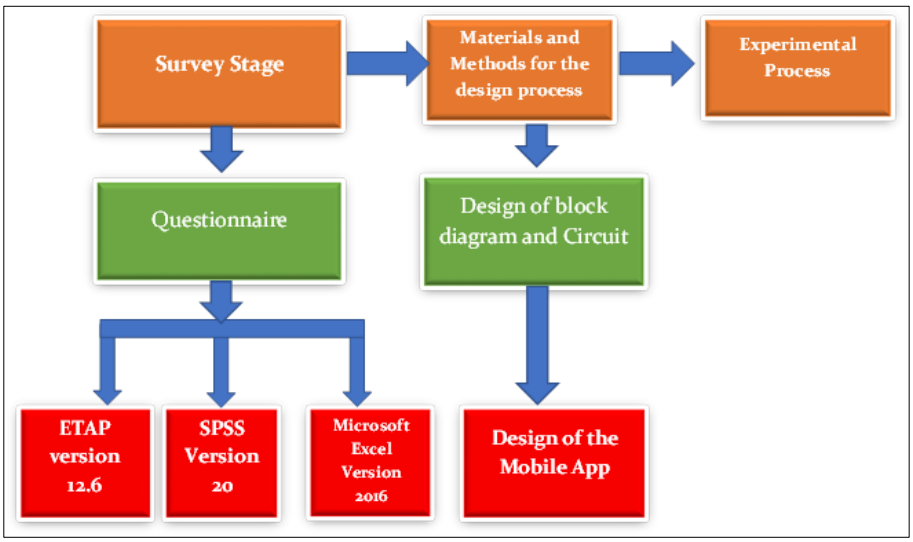

Figure 1 Workflow of Methodology

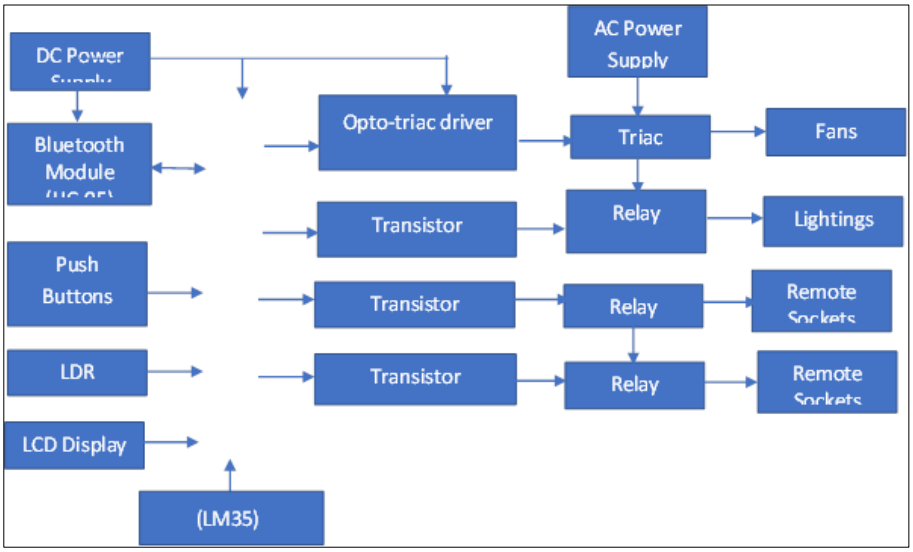

Figure 2 Block diagram of the Circuit

2.1. System design

The circuit consists of three main units and two modes of operation, normal operating procedures as designed by the manufacturer and the mobile application control designed for that purpose, the fan unit make use of the temperature sensor in the circuit. The circuit is set up in such a way that the fan may run normally while using the controls provided. such that any phone connected to the circuit can be used to turn on, turn off or regulate the speed of the fan.

The next is the lighting unit, like the fan, two modes also become available for the lighting point: operating the light using the switches designed for such purpose and making use of the android application designed for use with the circuit. Third is the sockets units are incorporated into the circuit for use in supplying power to other appliances and devices that

make use of electricity. These sockets unit are incorporated into the circuit such that the sockets can be controlled by making use of the switches designed for it by the manufacturers as well as any phone that has been connected to the circuit via blue tooth see figure 3 for module.

The next step after the design of the circuit is the programming of the microcontroller. It's an embedded system solution using C/C++ programming language in programming the microcontroller.

After completion of the design, tests were carried out to ensure everything is working according to Specification. After tests have been carried out and the circuit is seen to be in perfect condition, the circuit was then packaged carefully.

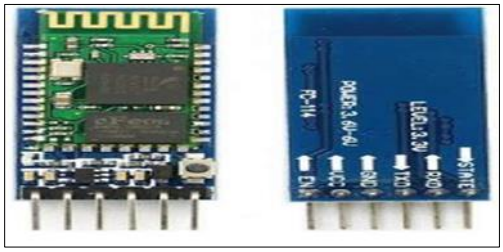

Figure 3 Bluetooth module

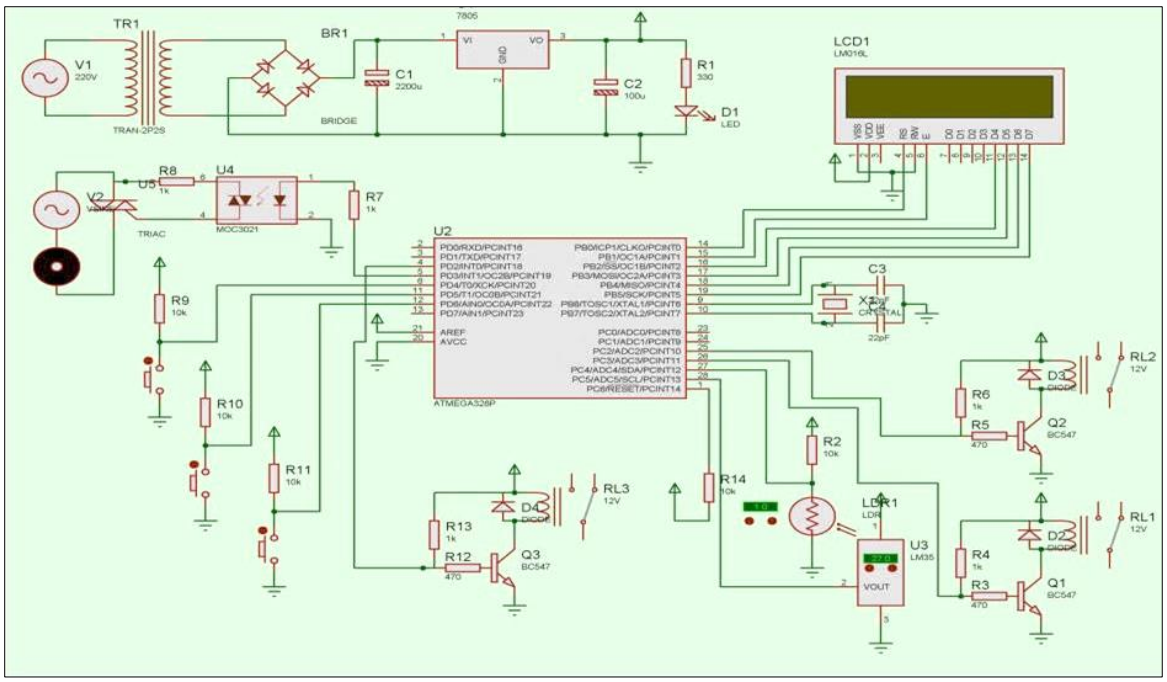

Figure 4 schematic diagram of the system

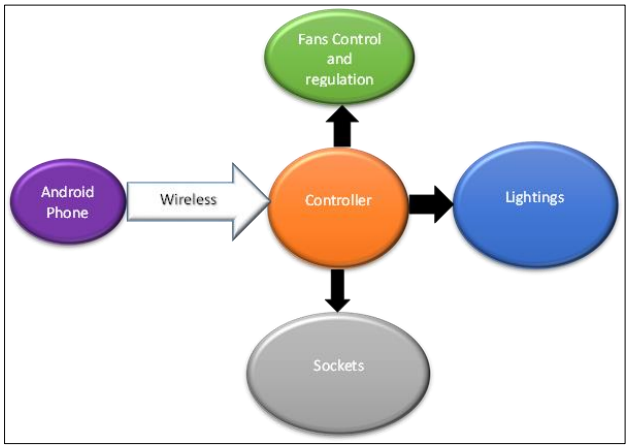

Figure 5 Architecture of the system

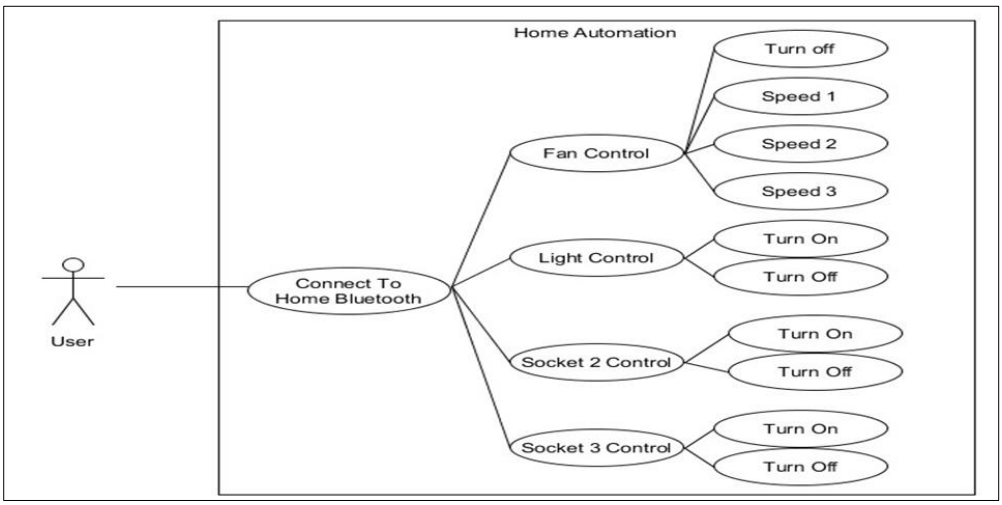

Figure 6 Use-case diagram of the system

2.2. Software development of the App

In designing the android application for the circuit, the generally accepted Android Studio was used. It is the official integrated development environment (IDE) for Google's Android operating system built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. Some of the features of android studio include: Gradle-based build support, Android-specific refactoring and quick fixes, Lint tools to catch performances, usability, version compatibility and other problems. The user interface of the app was designed with XML and the functionality implemented with Java. Figure 3.1 shows the GUI for the android application designed for the mobile devices. The menus for the fan, the light, socket 1 and socket 2 can be clearly seen from the result. It can also be noticed that there is a drop-down menu for the fan and the light as well as the Bluetooth symbol at the top right-hand corner to indicate connectivity.

3. Results

The results from evaluation of this research were graphically carried out. (Refer figure 7, 8, 9 and10) and the results as shown on the Graphical user interface (GUI) for the Android Application (Refer figure 11 and 12)

Table 1 Some fixed and flexible Consumer's Loads for automation control

S/N	Some fixed loads for remote control	Some flexible loads for remotely controlled sockets
1	Lightings	Washing machine
2	Tv	Dish washers
3	Heating system	Phone chargers
4	Refrigerators	Air-conditioner
5	Freezers	Dehumidifier
6	DVD	Heat recovery ventilation system (HRV)
7	Coffee maker with bean grinder	Clothes driers
8	Satellite dish	Pool pumps
9	Standing or table fans	Plug-in hybrid electric vehicle (PHEV)
10	Ceiling fans	Blenders

Table 2 Satisfaction with manual Operation of Consumer's Loads

Electricity Consumers Response	Frequency (n)	Percentage (%)
Very satisfied	3	0.598
Satisfied	42	8.383
Not very satisfied	88	17.565
Completely unsatisfied	368	73.453
Total	501	100

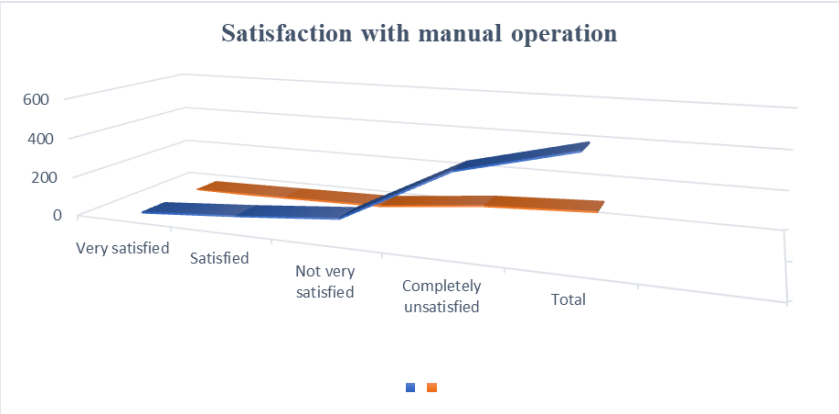

Figure 7 Satisfaction with manual Operation of Consumer's Loads

Table 3 Desire to control loads with mobile App

Electricity Consumers Response	Frequency (n)	Percentage (%)
Yes	359	71.657
No	65	12.974
If I can	77	15.369
Total	501	100

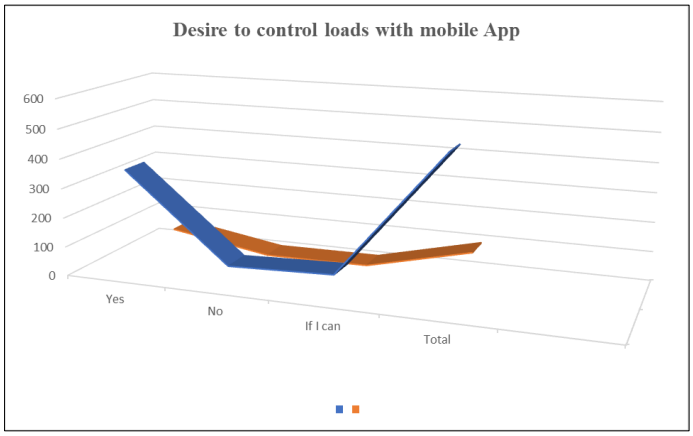

Figure 8 Desire to control loads with mobile App

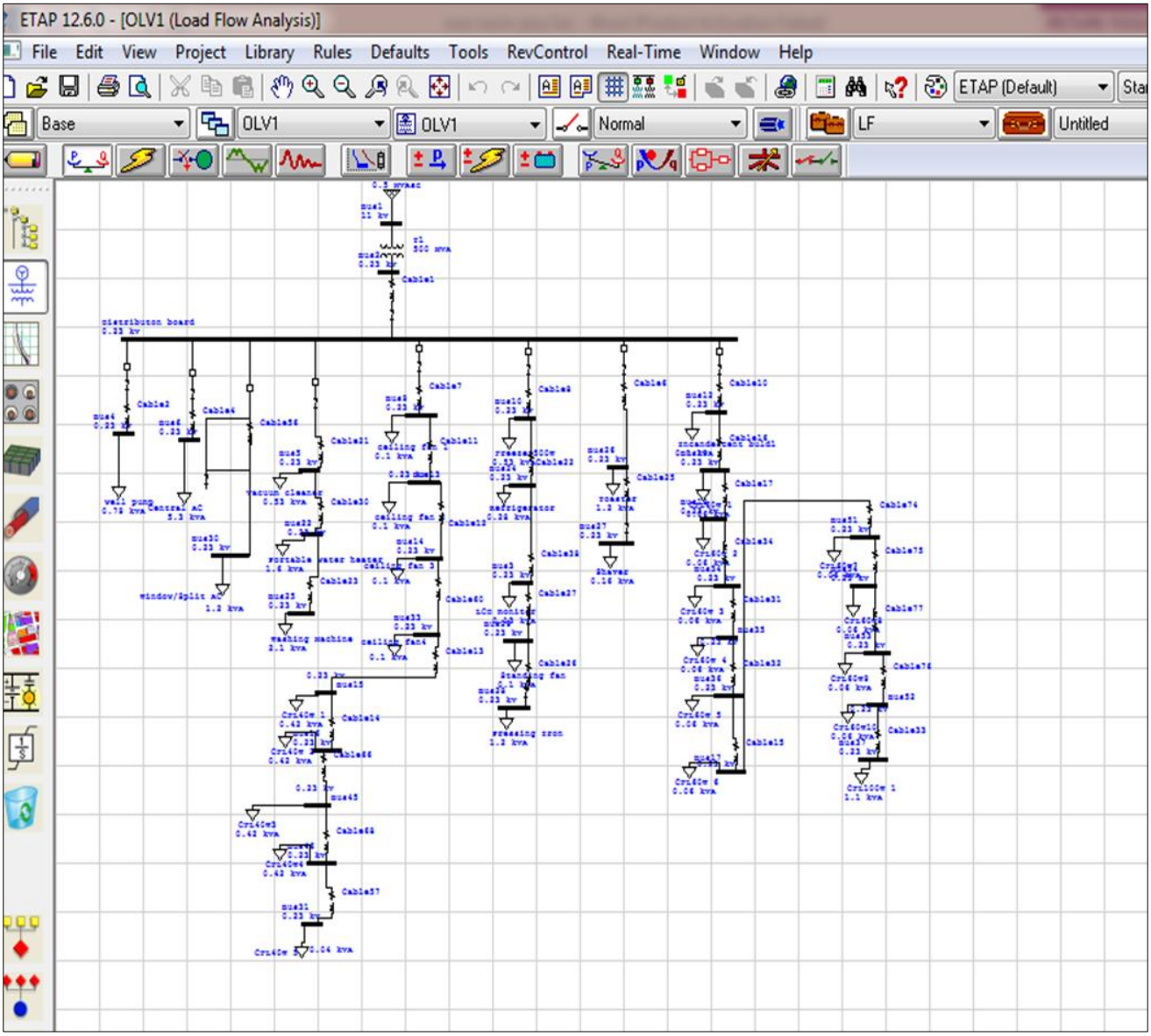

Figure 9 Analysis of consumer's loads with ETAP version 12.6

Table 4 The frequency and Percentage of Consumer's loads left on

S/N	ITEM	FREQUENCY	PERCENTAGE
1	Refrigerator 16 CU. Ft	399	9.062
2	Freezer 15 CU. ft (Upright	452	10.265
3	Freezer 15 CU. ft (Chest)	412	9.357
4	Satellite dish	455	10.333
5	100Watt incandescent bulb	378	8.585
6	25Watt compact fluorescent bulbs	388	8.812
7	40W DC-compact fluorescent bulbs	257	5.837
8	CFL bulb (60-Watt equivalent)	299	6.791

9	CFL bulb (40-Watt equivalent)	365	8.289
10	CFL bulb (75-Watt equivalent)	376	8.539
11	CFL bulb (100-Watt equivalent)	234	5.315
12	Standing or table fan	188	4,269
13	Ceiling fan	200	4.542

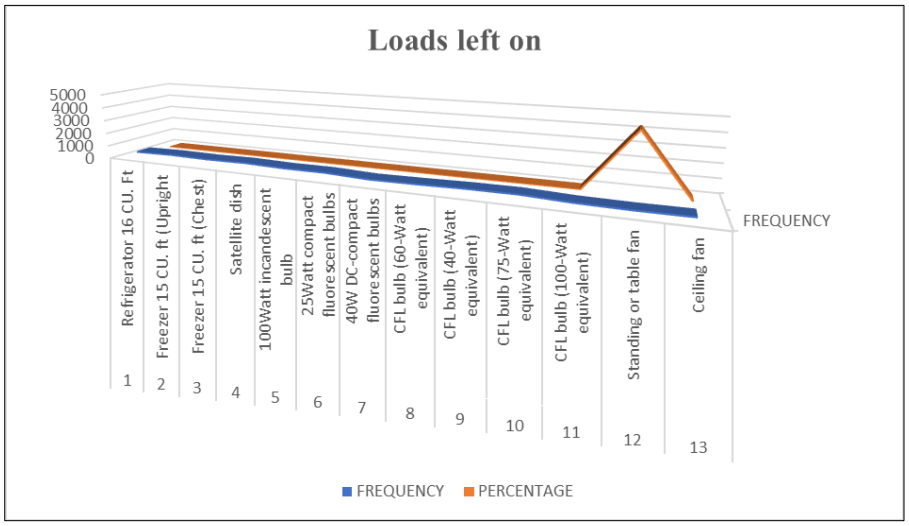

Figure 10 Frequency and percentage of loads left ON

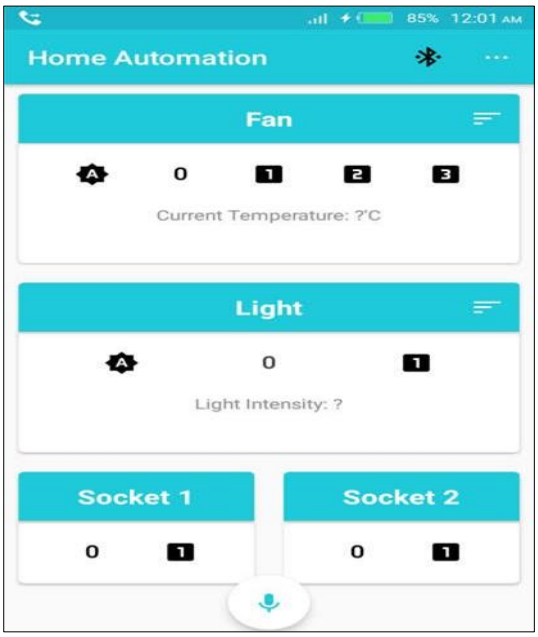

Figure 11 The Graphics User Interface (GUI) for the Android Application

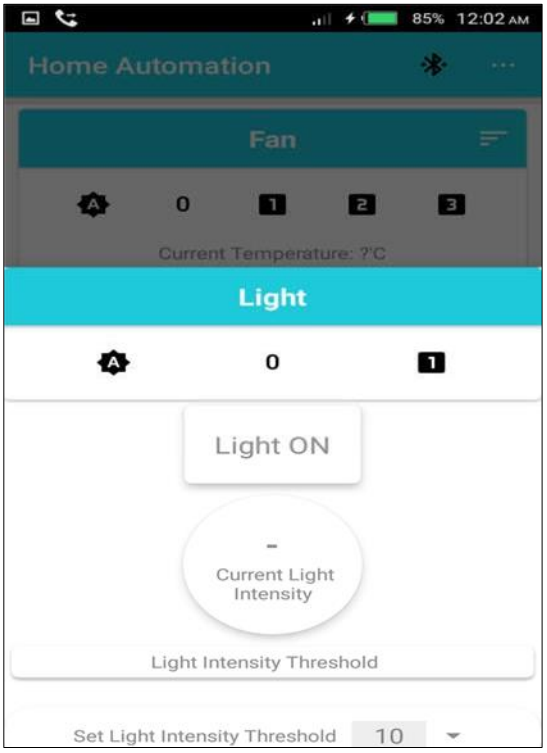

Figure 12 The Drop-Down Menu for the Light

4. Discussion

The figure 11 above shows the drop-down menu for the light. Just like the fan, "A" stands for the automatic mode, "0" stands for the switch off and "1" stands for switch on. From the figure above, we can also see a display for the current light intensity which will be in percentage and also, a display for the light intensity threshold which is the default value at which we set the intensity of the light. The sockets do not need any dropdown menu because they only have two modes: "0" for switch off and "1" for switch on. These are clearly visible in figure 11 above where socket 1 and socket 2 are part of the home page.

The speed of Fans can be regulated with mobile App while remote sockets and fixed loads can be controlled without being touched during this period of pandemic.

5. Conclusion

The design and assessment issues have been addressed in this study of an automation control for fixed loads and remote sockets using a microcontroller and a Bluetooth module in conjunction with a mobile application without incurring additional cost of wiring. To demonstrate this, the fan with its temperature regulation was used, bulb for lighting and sockets for loads.

During this pandemic and post-pandemic, users of the system can now control and operate their home appliances from anywhere in their vicinity as long as they are within the range of Bluetooth connectivity to keep social distancing and be safe. This system allows our homes to be automated, intelligent and more comfortable for our use.

Compliance with ethical standards

Acknowledgments

The authors thank the electricity customers in the Benin City Area of Edo State, Nigeria, for their cooperation in allowing the tests to be done at the time of this study.

Disclosure of conflict of interest

The authors have declared no conflict of interest

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