DEVELOPMENT OF AUTOMATED POWER CONTROL SYSTEM FOR HOME APPLICATIONS

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Abstract: Nocturnal voltage spike or surge has been identified as one of the causes of fire incidents in homes. Buildings that are largely hit by this disaster are those whose households forget to switch off all power sources before they go to sleep. Consequences of fire outbreak are more often than not devastating resulting into loss of lives and properties. Hence, there is need for a control system that will allow occupant to switch off home appliances in an easy and fast manner either from the comfort of the bedroom or anywhere in the building to improve safety. This paper presented development of home controlled system which could be operated via ubiquitous android phones for switching off all power sources in a room, offices and business outlets. The system comprised power supply unit, Bluetooth module interfaced with programmable microcontroller for switching on and off appliances via relays based on the input from application on smart phone. The system was implemented on a circuit board after simulation on Proteus software. For the purpose of testing the functionality of the system, six home appliances were used as candidates for testing and the results revealed that the automated control system was functional and could facilitate the switching on and off home appliances without hitches or network delay. The device is recommended for homes, shops, and office outlets.

Keywords: Android phones, microcontroller, bluetooth module, relay, liquid crystal display

Introduction

The evolutionary development of mobile communication standards has also been accompanied by production of handheld smartphones, tablet and sophisticated android phones not only for voice communication but also for gaining access to a number of high definition applications. In recent times, the use of small handheld smartphones to control home appliances is gaining momentum to reduce energy wastage, improve security, safety, and prevent incongruent occurrences.

Research efforts that have delved on automated control of home appliances in the past include Abu et al. (2018), Cristina et al. (2021), Jatakia and Jadhav (2022) and Bhandarkavthe and Dessai (2016) who developed an IOT-based smart controlled home system using Raspberry Pi The automated system requires communication network for sending signal to control home accessories. An internet based home controlled system was implemented by Kulkarni et al. (2017) and Satish et al. (2015) while. Bilal and Khalid (2015) proposed wireless smart controlled system for elderly and physically challenged individuals. This was based on the use of Xbee transceivers interfaced with microcontroller. Barma et al. (2016) constructed a lightning controlled system which monitors weather condition and switches on and off light bulbs when sun intensity was low and high. On the other hand, Nikita and Kumar (2018), Dandge et al. (2016), Patrick et al. (2015) and Saurav et al. (2017) implemented home automation system using android based smart phone application employing Wireless Fidelity (WIFI) module. A programmable logic controller based home controlled system for fault detection and controlling home appliances was developed elsewhere (Saurav et al., 2017). Krishna et al. (2016) developed home controlled system using infra-red sensing scheme. However, Kingsley and Emannual (2017) and Amusa et al. (2017) constructed a device based on the application of GSM technology for the control of home appliances, which has its functions rooted in sending short message service to PIC16F877A microcontroller for coordination and processing of control commands to switch on and off home appliances. The performance of the system is tied to the communication network and may suffer from delayed delivery.

More recently, home and office appliance control system which detects the presence and absence of human beings in room and also monitors the ambient temperature of the room was developed by Usman et al. (2021). The system switches on light when it detects the presence of a person and the room is dark while fan is put on when the ambient temperature of the room is above temperature threshold. The work does not account for how other home appliances like socket outlet, cooker unit may be switched on and off as infrared sensor utilized in the work for detecting the presence of human beings cannot detect the status of these appliances.

This work develops a home-controlled system consisting of Blue tooth module interfaced with arduino board and which is controlled by iPhone Operating System (IOS) application on the smart phone. The system facilitates control of many home appliances including cooker unit, socket outlet at large distance away from home in fast and cost-effective manner and without suffering from network hitches or delay.

Materials and Methods

System Overview

Figure 1 shows the block diagram of home controlled system. The system is made up of five units including input unit, processing unit, power supply unit, display unit and output unit.

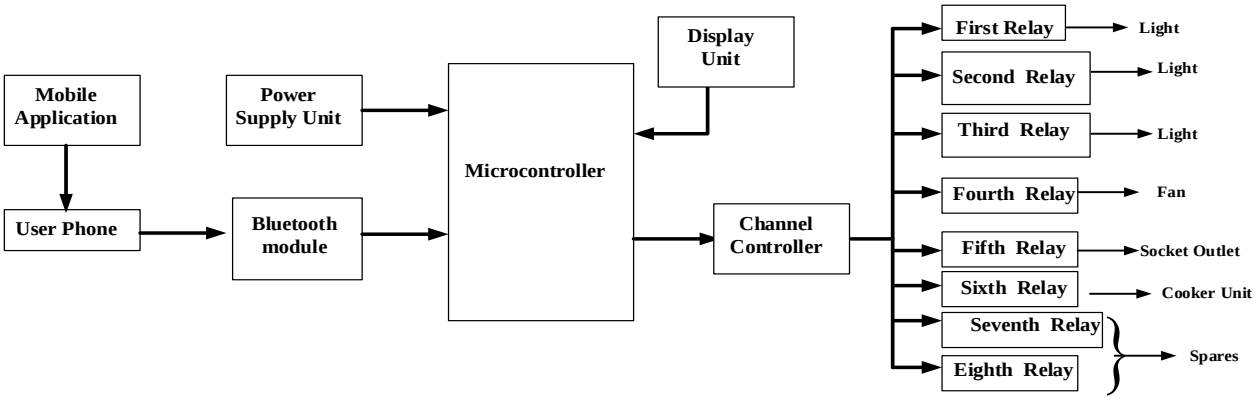

Figure 1: Block diagram of home controlled system

Power Supply Unit

The power supply unit of the system transforms the Alternating Current (A.C.) power supply to Direct Current (D.C.) form. It employs step down transformer for stepping down 220V A.C supply to 12V A.C and which in turn is transformed into D.C supply using full wave bridge rectifier. The filtering capacitors in the circuit are utilized to remove the A.C ripples while LM7805 regulator is used to regulate the D.C output to 5V which power the relays and Arduino microcontroller board.

Input Unit

The input unit consists of graphical user interface application on the android IOS phone for sending commands to the microcontroller-based Arduino board

Processing Unit

This unit consists of Bluetooth module interfaced with microcontroller. The microcontroller is utilized to store all the instructions required for switching ON and OFF home appliances. In this work, ATMEGA 328D is utilized and is programed using C-programming language.

Display Unit

This consists of the Liquid Crystal display (LCD) for displaying information on the system. The LCD is configured to read code from appropriate input pins while the microcontroller acts accordingly to turn ON and OFF a particular load. A 16×2 LCD display is utilized in this work and is preferred to seven segment LCD and other multi segment LCDs because of lower cost, easy programming as well as having no limitation in displaying special and custom characters, animations etc. A 16×2 indicates 16 characters per each of the two lines with each character representing 5×7 pixel matrix. It consists of command register for storing the instructions sent to the LCD. A command is an instruction given to LCD to do a predefined task including initialization, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD.

Output Unit

This unit utilizes channel controller to interface the instruction coming from the microcontroller to the relay in order to select and switch ON/OFF appliances. Relays are used in this work to trigger on and off appliances.

Overall Automated System Design

Figure 2 illustrates the circuit diagram of home controlled system which consists of various sub units including power supply unit, input unit, processing unit, display unit and output unit. The circuit architecture is simulated on Proteus software as

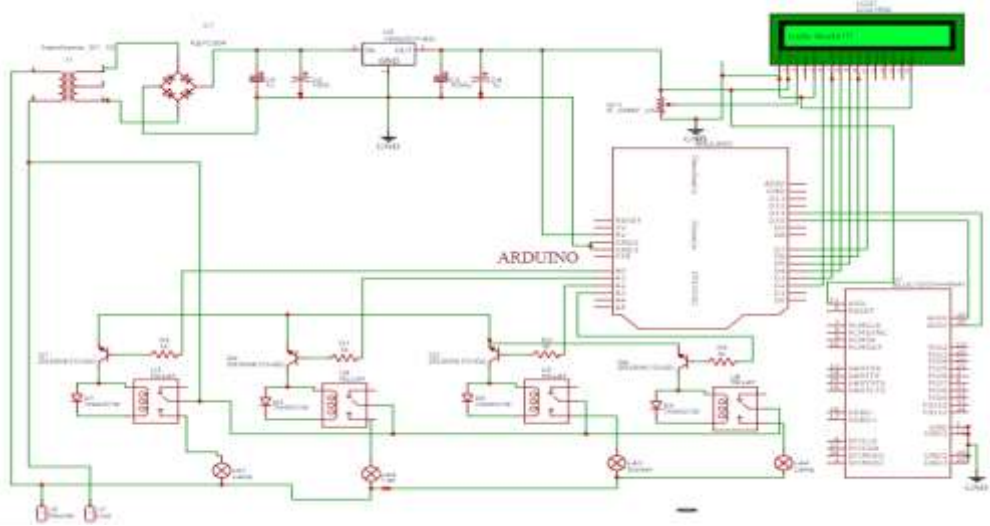

Figure 2: Circuit diagram

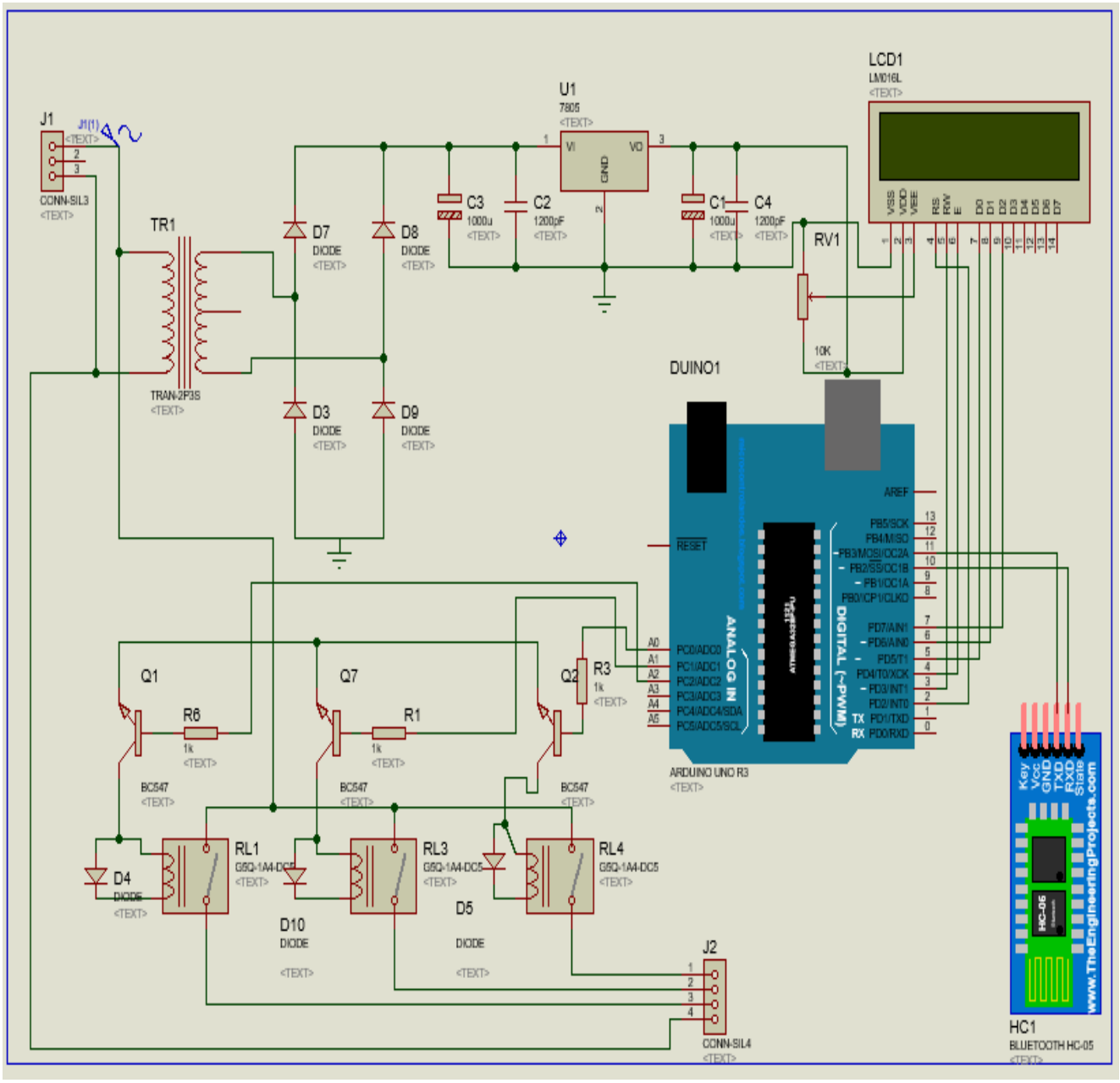

Figure 3: Home controlled architecture simulated on the Proteus.

Results and Discussion

The developed system

The developed model of automated power control system is presented in Figure 4 while Figure 5 shows the internal features of automated power control system. This is realized by arranging circuitry components on the Vero board with their leads protruding through the holes. The leads are soldered to the tracks and they are linked on either sides of the board through wires. This guarantees neat and reliable connections. The Vero board connections are placed in an enclosure or casing for protection from moist or water. Accessories attached to the automated system for the purpose of assessment of its functionality include one (13A) socket outlet, cooker unit and three lamp holders with 60W bulb each and OX fan.

Figure 4: The developed model of automated power control system with accessories

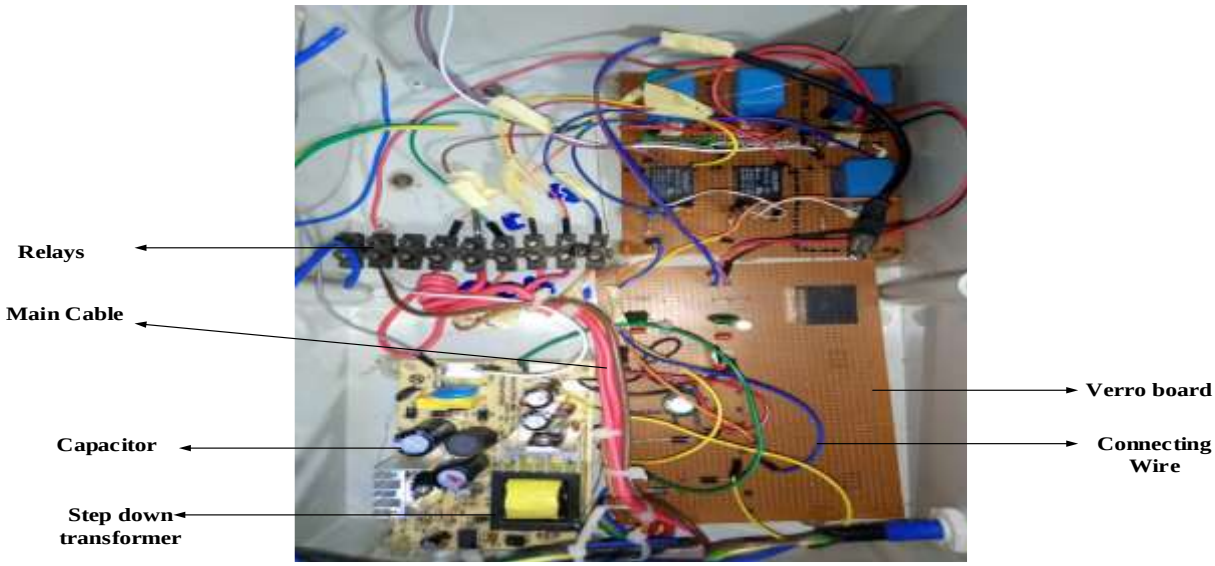

Figure 5: Internal circuit of automated power control system

Performance Test Results

Figure 6 indicates the results of the performance test on each unit of automated power control system. A multimeter is used to ensure that all the stages are fed with requisite voltage. From Figure 6, it is revealed that each unit in the automated power control system is operational and performs to satisfaction when tested.

Figure 6: developed system under test

It is observed that the system in operational mode starts up after elapse of 5s and in the process, LCD displays the name content, sequential interlock and initializes connection or pairing between different sub unit of the system. Figure 7 shows a

snapshot of mobile application interface command for sending instructions to the system. It consists of eight buttons which may be pressed on and off for switching home appliances.

Figure 7: A snapshot of buttons used for controlling the home appliances

For the purpose of testing, six home appliances including three light bulbs, fan, 13A socket outlet, and cooker socket are used as candidates for testing. These appliances are connected to the output of developed system and are switched on and off using command interface buttons of Figure 7. The experiment is carried out in electrical repair and maintenance laboratory of D.S. Adegbenro I.C.T. polytechnic, Itori-Ewekoro, Ogun State. The distance from testbed to the mobile phone user is 10m. Buttons 1 -3, respectively are used for turning on and off three incandescent 100W bulbs, button 4 is used to turn on and off 13A socket outlet, while button 5 is used for switching the OX fan. Button 6 on the other hand, switches ON and OFF cooker unit. Buttons 7 and 8 are used for spare loads. It is observed that the system responds promptly to the command and switches on and off appliances without delay. In addition, the distance between the test bed and mobile phone user is increased to 20m; it is also found that the system receives command from mobile entity and switches on and off appliances appropriately. Furthermore, test also reveals that the system receives command instructions from mobile user and is functional even if the distance from the operator to the test bed is increased to within 35-50m.

Conclusions

The quest to control home appliances in an efficient and fast manner in residential buildings and offices without necessity for communication network motivates the design and development of home controlled system in this work. The system consisted of power supply unit for providing the required voltage for the system, mobile interface command for accessing the Bluetooth module and microcontroller as well as output unit for carrying the connected loads. The microcontroller received instruction from mobile interface and which in turn sends control commands to the relays for switching ON and OFF the connected loads. The system could be accessed by familiar android or smart phones and is useful in homes, buildings and offices for energy management and for safeguarding lives and properties from disaster that may crop up from sudden voltage spike or surge.

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