Development of Home Automation Systems Using Global System for Mobile Communication Module

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ABSTRACT

With advancement of technology things are becoming simpler and easier for us. Automatic systems are being preferred over manual system. The purpose of this project is to design and construct Home Automation Using Global System for Mobile (GSM) Communication Module. Using GSM networks, in this project a home power control system has been proposed that will act as an embedded system which can monitor and control appliances and other devices locally using built-in input and output peripherals. The system has a delay of 5 seconds after the SMS to initiate the next command. This project is made up of three vital units. These units are as follows: GSM module unit, relay unit, the microcontroller unit. The GSM module unit provides wireless distance access control to the system. It is the unit through which the commands can be received to perform any operation in the device. A relay is an electromechanical switch used to aid the automatic control of a high power circuit using a low power circuit. while The microcontroller unit controls all other units except the power supply unit. The function of is unit is carried out by a type microcontroller board called Arduino Uno R3, The ATmega328P microcontroller on the board is the heart and brain of the Arduino. The major component that performed the power control of 220v main supply is the automated electromagnetic relay. The term stage is associated to a group of components, which is aimed at achieving a specific purpose. The Home automation using GSM module was designed and constructed to CONTROL 230V±5% AC load. It is rated 2500VA 50Hz.The project was realized.

Keyords: Automation, Network, control appliance, Arduino, microcontroller

INTRODUCTION

Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services [1], [2]. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well. Automation plays an increasingly important role in the world economy and in daily experience. Automatic systems are being preferred over manual system. Through this project we have tried to show automatic control of a house as a result of which power is saved to some extent. GSM based home automation is an electronic device that allows a GSM cell phone to monitor and shut down electrical power supply at home where there are emergency or ugly situations such as fire outbreak, lightning strikes, switching surges, transients, neutral failure and other abnormal conditions or malfunctions that can destroy lives and properties.

GSM based home automation is a system that implements the emerging applications of the GSM technology which enable the users to carry out some task from anywhere in the world via a GSM network [3], [1], [4]. The system is made up of a GSM amplifier unit, Arduino Uno microcontroller, power control and a power supply unit. These sub circuits are designed using passive and active electronic components like capacitors, resistors, diode, transistors, electromagnetic relay, microcontroller and battery.

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Home Automation System

A common definition of Home Automation is of an "electronic networking technology to integrate devices and appliances so that the entire home can be monitored and controlled centrally as a single machine" [5], [4]. Another term that describe the same technology is "domotics", which derives from the Latin word domus, meaning home, and informatics, meaning the study of the processes involved in the collection, categorization, and distribution of data. However, since this technology is still very much in flux, other terms are also used in the literature with equivalent meaning, such as: "smart home, digital home or electronic home".

Furthermore the possible 'solutions are devised through various network technologies. Several issues affecting home automation systems such as lack of robustness, compatibility issue and acceptability among the old and disabled people are discussed. Ciubotaru-Petrescu, et al., 2006 present a design and implementation of SMS based control for monitoring systems [6]. The paper has three modules involving sensing unit for monitoring the complex applications. A processing unit that is, microcontroller and a communication module that uses SIM800L for receiving SMS commands. The SMS is used for status reporting. In their paper, Scaradozzi et al., 2003 view home automation systems as multiple agent systems (MAS) [7]. In the paper home automation system has been proposed that includes home appliances and devices that are controlled and maintained for home management. The major task is to improve performance. In their paper. Alkar et al., 2005 propose an Internet Based Wireless Home Automation System for Multifunctional Devices [8]. This paper proposes a low cost and flexible web-based solution but this system has some limitations such as the range and power failure.

Murthy; 2008 explores primary health-care (PHC) management for the rural population. A solution proposes the use of the mobile web-technologies providing the PHC services to the rural population. The system involves the use of SMS and cell phone technology for information management, transactional exchange and personal communication. Jawarkar, et al., 2008 propose remote monitoring through mobile phone involving the use of spoken commands [9]. The spoken commands are generated and sent in the form of text SMS to the control system and then the microcontroller on the basis of SMS takes a decision of a particular task. Potamitis, et al., 2003 suggest the use of speech to interact remotely with the home appliances to perform a particular action on behalf of the user [10]. The approach is inclined for people with disability to perform real- life operations at home by directing appliances through speech. Voice separation strategy is selected to take appropriate decision by speech recognition.

The Mechanical Evolution

The first question that might come to mind is why we would need a Smart Home and why we would want to find different ways of doing ordinary things, such as washing clothes, cooking, or even turning a light on or off. A similar question could have been asked at the beginning of the 20th Century, at the dawn of what can be called the "mechanical revolution". In late 1800's, the middle class was experiencing a shortage of domestic servants which created the need to find new ways to provide help in the home [11]. Such necessity was the initial driving force behind the inventions of the first domestic appliances, which had the purpose of making household chores easier and do more with less. In 1911, Frederick Winslow Taylor published "The Principles of Scientific Management", which advocated the use of efficiency to maximize results through minimal effort (Taylor, F.W. 1911). This theory is today known as Taylorism and, though it was originally intended to be applied in industrial settings, this concept soon spilled over into the domestic realm due to the need at hand. Christine Frederick (1911) was one of the first to recognize that the challenges tackled by Taylorism were also directly applicable to domestic issues and captured these in her book "Household engineering: Scientific Management in the Home", published in 1915. In her book, Frederick predicts that mechanical appliances would be the ones which were to take up the work originally performed by servants "where every possible purely manual task is done by arms of steel and knuckles of copper". She also puts forward the idea of a Smart Home where she foretells that "such machinery will be far more unified than at present with various pieces related to one another", as reported by D. Heckman (2008).

The Electrical Evolution

In spite of the first inventions, most of this new domestic technology would have still been easily recognized by people who had lived in the previous Century. However, electricity, the driving force behind the electrical

revolution, would soon change this familiar landscape beyond recognition. Electrical energy first arrived in the homes around 1920s and, although initially used for lightning purposes only, by 1940s mains electricity was readily available to around 65 per cent of the total of houses in the UK. Soon after it reached a critical mass, producers of electrical appliances inundated the market with all sorts of items. Although some of them were nice-to-have-devices, such as electric popcorns poppers, egg cookers and waffle irons, others were really life changing for the household: refrigerators, washing machines, electric cookers, vacuum cleaners, just to mention the most important. Regardless of their importance, all these electrical appliances were still made with the original need in mind, which was often reminded to people as producers marketed these products with time-saving slogans such as “no longer tied down by housework” or “automatically gives you time to do those things you want to do”. It is interesting to note how some later devices could be hardly classified as time savers and how, in spite of this, they were still quite readily adopted. By early 1980s, around 65 per cent of UK homes had a colour television set and half of them a video recorder. More interesting still, the adoption curve was different from one to another, sometimes regardless of the comfort that they could bring.

Technical Details Of Gsm

GSM is a cellular network, which means that mobile phone can be connected to it by searching for cells in the immediate vicinity. GSM network operate in four different frequency ranges. Most GSM network operates in the 900 MHz or 1800 MHz bands. In 900 MHz band, the uplink frequency band is between 890-915 MHz and the downlink frequency band is 935-960 MHz. In the 1800MHz band, the uplink frequency is between 1710-1785 MHz and the downlink is between 1805-1880 Mhz. also in 1900 MHz band, the uplink frequency band is 1850 Mhz- 1950 MHz. In GSM 900 MHz, the band allocation is 25 MHz band width which is subdivided into 24 carrier frequency channels, each spaced 200 kHz apart. Time division multiplexing is used to allow eight-fall rate to sixteen half-rate speech channels per radio frequency channel. There is eight-radio time slots (giving eight burst penods) grouped into what is called TOMA frame. Half rate channels use alternate frames in the same time slot. The channels data rate is between 270-833kbit/s and the frame duration is 4.615ms. The transmission power in the handset is limited to a maximum of 2 crafts in GSM 900 and I waH in GSM 1800/1900.GSM has used a variety of voice codes.

METHODOLOGY AND ANALYSIS

System Architecture

The figure3.1 shows a block diagram which describes the abstract design and implementation of a home automation system using a microcontroller, GSM Module and other components. The detail lists of the components are given in the chapter 3.2. The block diagram has five major sections which are: microcontroller unit, load output unit, relay module unit, GSM module unit and power supply unit. Each unit of the system are more of less a sub functioning system unit. These units will be described further in subsequent sections of this chapter.

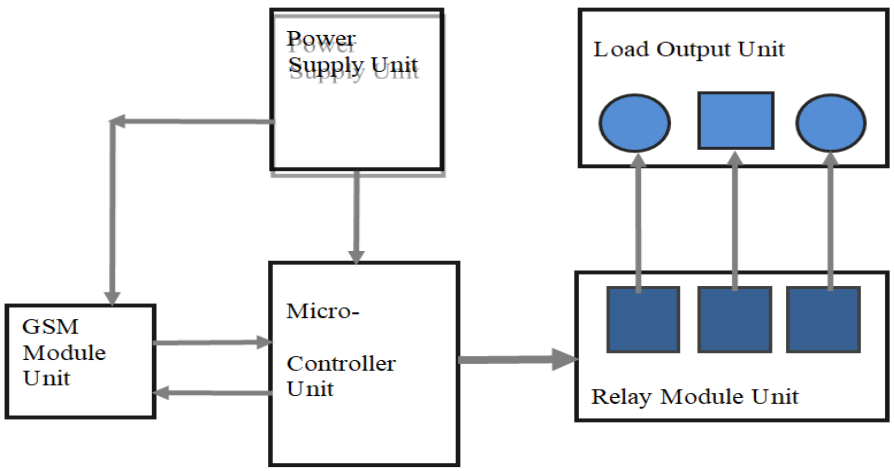

Figure 3.1: Block diagram of the home automation system

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System Composition

The home automation system is composed of mainly hardware components and stimulated with program code as the software component. The block diagram of the system design in figure 3.1 represents mainly the key hardware components that function in different sections. Some of the major hardware components are microcontroller, GSM module etc. However, there are other minor components that are used in the hardware implementation but not shown in the block diagram; these include connector, switch, buzzer etc. There is also equivalent software representation of the hardware components used to implement the software design of figure 3.1. All the units showed in the system architecture are configured with both hardware and software resources.

Hardware Components

This section lists the hardware components used in this work, their names and descriptive terms:

Table.3. 1: List of hardware components for home automation system

S/N	NAME	DESCRIPTIVE TERM
1	Arduino Uno R3	Atmega328 microcontroller
2	GSM module	SIM800L
3	Relay module	Switching control device
4	DC fan	Rotating fan 12volt
5	Wall socket	Electrical material
6	Lamp holder and bulb	Electrical material
7	Buzzer	Sound device
8	Connecting wires	Male to female jumpers etc
9	Battery Connector	Connector
10	Arduino power jack	Male power connector
11	Switch	Power switch

Software Implementation

Arduino and Proteus Integrated Development Environment (IDE) are two major software's used to implement the system.

Arduino IDE is open Source software which is mainly used for writing, compiling and uploading directly into it supported microcontroller [12]. There are several Arduino version releases software IDE. There are also numerous microcontroller boards that are supported by IDE for programming. The microcontroller board includes Arduino Uno, Arduino nano, Arduino Mega and many more. The Arduino IDE version used for this work is version 1.8.8 (refer to Fig 3.2), this is not the recent updated but a stable version and it is an open source. Arduino IDE can be use for several tasks such as writing and editing of the Arduino programming language (which is the major language supported by the IDE); code compiling and debugging can also be done in the environment. The IDE can also be used to download code into any support board. Its environment support both C and C++ language.

Figure 3.2: The Arduino IDE version

Furthermore, Arduino IDE is mainly divided into three sections called Menu Bar, Text Editor and Output Pane. The Arduino IDE runs on operating system such as windows, MAC, Linux OS (Operating Systems) ad runs on java platform; it is also used for debugging, editing, compiling and uploading code in its environment to physical hardware modules.

Proteus IDE is a virtual system modeling (VSM) and circuit simulation application software. It also has virtual system studio, a free universal IDE for Proteus. In addition, Proteus VSM can be used for advanced embedded simulation, offering system level simulation based on schematic circuit. It has a wide range of components in its database or library. In addition to its own database component, more components can be designed in addition as part of the library component if they are not part of the original software library. Such library component includes: Arduino and GSM Library for Proteus etc. It also supports PIC and 8051 microcontroller, and many other project works. The version of the Proteus used for this work is version 8.0 figure 3.3and the platform for design and simulation environment.

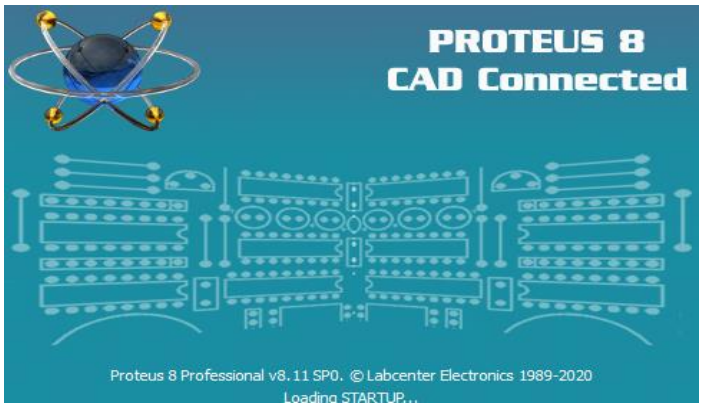

Figure 3.3: The Proteus IDE version

Both software IDEs (Arduino and Proteus) are selected for use because of their following criteria:

- Compatibility
- Hardware representation
- Hardware Simulation before real implementation
- Availability needed Libraries
- Easy to use
- Microcontroller easy to programming

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Software Simulation Design

Figure 3.4 shows the simulation of the hardware design done with Proteus IDE. It represents another level of the system architectural representation.

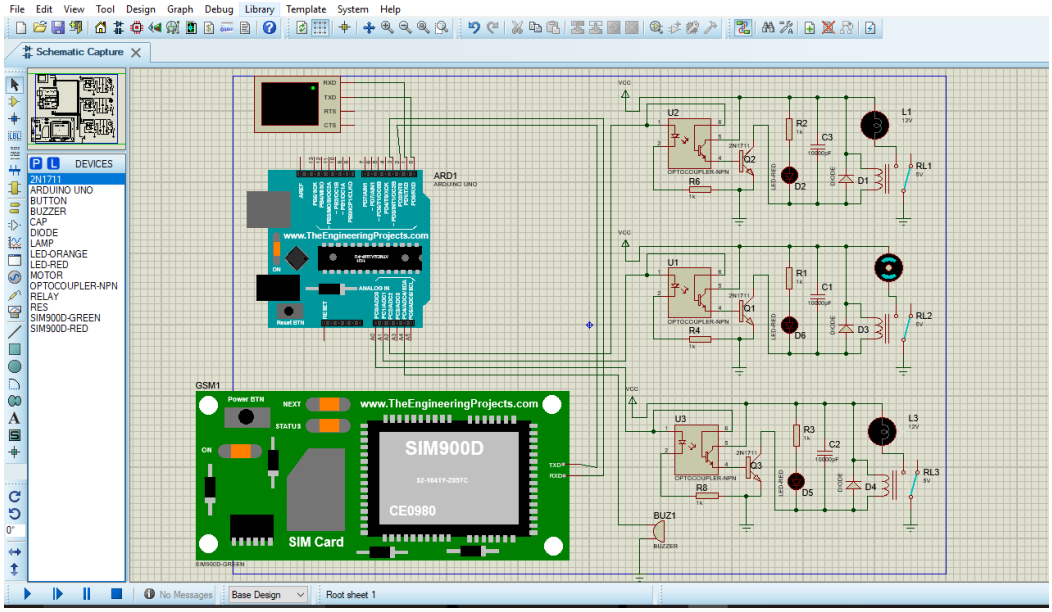

Figure 3.3: Home automation hardware design in Proteus IDE

Operational Program Algorithm

Step 1: Start microcontroller and GSM module

Step 2: Initialize GSM module and Sound devices

Step 3: Use Bulb (bulb, setValue) {OFF}

Step 4: Use Sock (sock, setValue) {OFF}

Step 5: Use Fan (fan, setValue {OFF}

Step 6:top:

Step 7: Scan GSM modulefor SMS message command received

Step 8: If SMS equals B1ON

Step 9: setValue[bulb, ON]

Step 10: goto top

Step 11: If SMS equals S1ON

Step 12: setValue[sock, ON]

Step 13: goto top

Step 14: If SMS equals FON

Step 15: setValue[fan, ON]

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Step 16: If SMS equals B1OFF

Step 17: setValue[bulb, ON]

Step 18: goto top

Step 19: If SMS equals S1OFF

Step 20: setValue[sock, ON]

Step 21: goto top

Step 22: If SMS equals FOFF

Step 23: setValue[fan, ON]

Step 24: goto top

Step 25: If SMS equals STATUS

Step 26: setValue[status(), execute]

Step27: goto top

Hardware Implementation

This section presents the most recognizable hardware components used to achieve the physical prototype of the system. It also provide a brief description, function, usage, importance and their interfacing techniques with other components. In addition, technical and pin configuration details were also included where necessary together with their images used in physical design mode.

Microcontroller Unit

The microcontroller unit controls all other units except the power supply unit. The function of is unit is carried out by a type microcontroller board called Arduino Uno R3. The Arduino Uno R3 board is a very common microcontroller board. The board was mounted with ATmega328P microcontroller. The board also consist of many other components such as reset button, crystal oscillator, voltage regulator LEDs, etc. that easier the used of the ATmega328P as it was mounted on the board. Arduino Uno R3 has14 digital input/output (I/O) pins. Six (6) pins can be used as pulse width modulation (PWM) outputs, six (6) analog input pins. It has a reset button, a USB connection, a power barrel jack, and an ICSP header. The ATmega328P microcontroller on the board is the heart and brain of the Arduino Uno R3 board, its trigger its I/O pins and makes other unit perform their function based on programmed code. In the system architecture, this unit is centralized between other units (Refer to Fig3.1), due to its major role in which it plays in the whole system. The figure and tables below show an image of Arduino

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Uno R3, pin configuration and the technical specification.

Table 3.2: Arduino Uno Pin Configuration

Figure 3.4: The Arduino Uno R3

Pin Category	Pin Name	Brief Description
Power	Vin, 3.3V, 5V,GND	Vin: Input voltage to Arduino when using an external power source (6-12V). 5V: Regulated power supply used to power microcontroller and other components on the board. 3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA. GND: Ground pins.
Reset	Reset	Resets the microcontroller.
Analog Pins	A0 – A5	Used to measure analog voltage in the range of 0-5V
Input-Output Pins	Digital Pins D0 - D13	Can be used as input or output pins. 0V (low) and 5V (high)
Serial	Rx, Tx	Used to receive and transmit TTL serial data.
External Interrupts	2, 3	To trigger an interrupt.
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output.
SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication.
Inbuilt LED	13	To control the inbuilt LED.
I2C	A4 (SDA), A5 (SCA)	Used for I2C communication.
AREF	AREF	To provide reference voltage for input voltage.

Table 3.3: Arduino Uno Technical Specifications

Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage for Vin pin	7-12V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 Ma
DC Current on 3.3V Pin	50 Ma
Flash Memory	32 KB (2 KB is used for Bootloader)
SRAM	2 KB

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EEPROM	1 KB
Frequency (Clock Speed)	16 MHz
Communication	IIC, SPI, USART

Relay Module Unit

A relay module usually has more than one (two and above) relay with its associated switching and protecting components. A relay is an electromechanical switch used to aid the automatic control of a high power circuit using a low power circuit. A relay module therefore can have two relays or four or eight typical relays on one board as a module with some other enhancing electronic component that make it easier to be used with microcontrollers. In this system, a four channel relay module was employed. The figure below shows the clear description of the four channel relay module that was used in the system. In addition, the relay module specifications and pin out configuration are show below.

Figure 3.5: The four channel relay module

Module Features	**Specifications**
Supply voltage	3.75V-6V
Trigger current	5Ma
Current when the relay is active	~70mA(single), ~300mA (all four)
Relay maximum contact voltage	250VAC, 30VDC
Relay maximum current	10A

The Four-Channel Relay Module Pin Configuration

Pin Number	**Pin Name**	**Brief Description**
1	GND	Ground of the relay module
2	IN1	Input to trigger relay 1
3	IN2	Input to trigger relay 2
4	IN3	Input to trigger relay 3
5	IN4	Input to trigger relay 4
6	Vcc	Power Supply for the relay module
7	Vcc	Power supply selection jumper
8	JD-Vcc	Alternative power pin for the relay module

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Power Supply Unit

The power supply unit is the backbone for the whole automation system. The power supply unit is represented by some couple of batteries. Due to different power (voltage and current) requirements by different components used in the hardware implementation of the system, two battery types were used. One type is a rechargeable 2000mA (2Amps) of 4 volts and the other is 2A of 9 volts non rechargeable battery as shown in fig (3.6) and fig (3.7) respectively. The images of these batteries are shown below. The division of power supply unit make the system safe against any component been damaged. Secondly, it enables the component to work effectively and required power is provided.

The GSM module unit was used to power by the battery whose power rating is 2 Amps 4 Volts rechargeable battery. The microcontroller unit-Arduino Uno R3 and the DC Fan Load were powered by the non-rechargeable 2Amps 9 Volts battery. The Relay module and the buzzer are not directly powered

RESULTS

Construction

The term stage is associated to a group of components, which is aimed at achieving a specific purpose. This has been broken down in the previous chapter. Each of the stage will now be treated more elaborately**.**

Power Supply Unit (Psu)

The power supply unit is the backbone for the whole automation system. The power supply unit is represented by some couple of batteries. Due to different power (voltage and current) requirements by different components used in the hardware implementation of the system, two battery types were used. One type is a rechargeable 2000mA (2Amps) of 4 volts and the other is 2A of 9 volts non rechargeable battery. The division of power supply unit make the system safe against any component been damaged. Secondly, it enables the component to work effectively and required power is provided.

Mounting Of The Components

The mounting of the components were placed according to block diagram below.

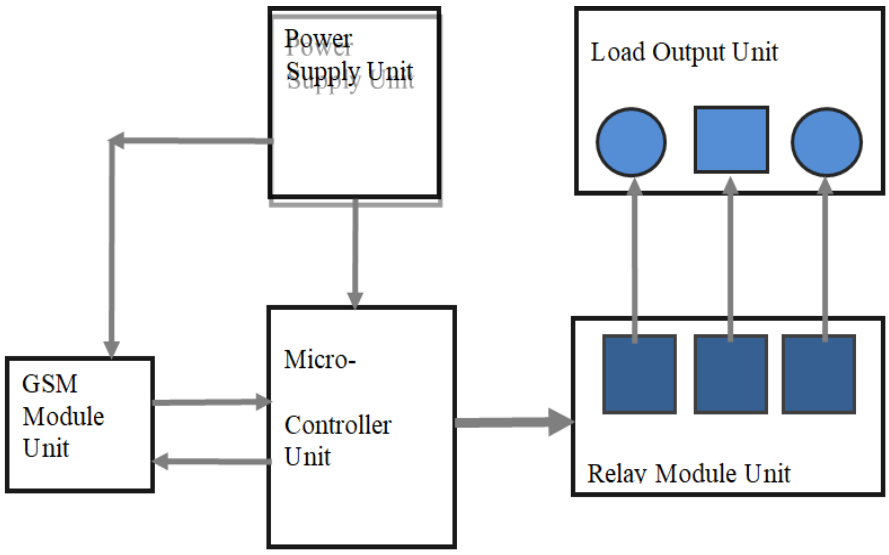

Figure 4.1: Block Diagram

Patrax is an electrical installation box used for housing electrical/electronic components. It is made of plastic material, 50×20mm rectangular shape with 10mm thickness.

This box houses the control unit.

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Fig. 4.2: patrax

Interconnection Of Components

The interconnections of the circuit were done using a PVC connecting wire.

This enabled the necessary connections at different sections of the circuit to be made by extending the terminals or connection made with a wire to a deserved point in the circuit. Connecting wires is a flexible wire made from copper and will be used to connect component or subsystems.

Fig.4.3: PVC wire

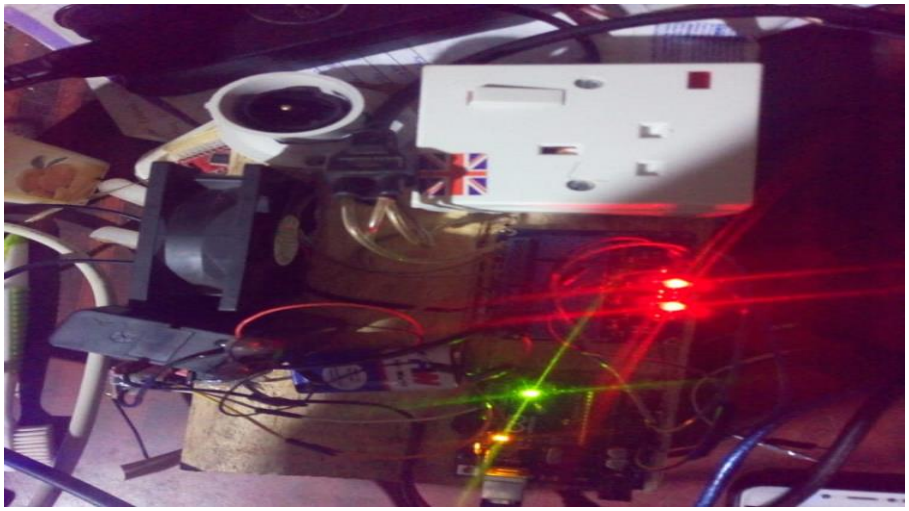

Fig.4.4: project during testing

Fig.4.5. Complete construction of the project

CONCLUSION

The Home automation using GSM module was designed and constructed to CONTROL 230V±5% AC load. It is rated 2500VA 50Hz.

This project has really exposed me to the use of electronic component. To a large extent I have come to appreciate the theories learned over the years. It is a fact that this is not exhaustive. It can still be improved to get a more sensitive and precise output voltage control.

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