DESIGN AND IMPLEMENTATION OF A SMART CONTROL SYSTEM FOR IMPROVED ESTATE MANAGEMENT

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ABSTRACT

This project work centers on the design and implementation of a smart control system for improved estate management. The design and implementation of this proposed system was achieved through the use of Microcontroller and other units such as internet of things (IoT) WiFi module, Internet Protocol (IP) camera module, Short Message Service (SMS) notification unit, Automatic water supply and control unit. These modules or units were properly interfaced in accordance to the aim and specific objectives of the research work. The IoT WiFi module links the gadgets to the cloud where they can be remotely monitored and controlled. The IP camera connected to the WiFi module makes the gadgets under control to be viewed from anywhere in the world. SMS notification, Automatic intruder picture notification, Automatic water supply and control units interfaced with the Arduino Microcontroller will address the issue of security warning and water wastage in the estate. The system has a control table from which the Estate Gadgets Control Manger (EGCM) can use for easy access and control of the devices as the case may be. The completed prototype of the system is also capable of starting an electronic choke generator. The technologies deployed in the design of the system were WiFi and GSM network technologies.

Key Words: Automation, Arduino, Nodemcu, IoT, IP camera, SMS, WiFi, ATS, EGCM, GSM and DTMF

1.1 INTRODUCTION:

In recent times, people are really in quest for approaches to improve life conditions, comfort and as well the simplicity of handling or controlling electrical machines at lowest cost. Many businesses today are also considering better ways to streamline their production activities and deploy automation where necessary in the production processes. In this process, it is progressively more to see processes that rely on human decisions and manual observation and interaction in the industry. Automation of both home and industrial systems originated by paving a way for humans to apply general timing and have grown over technology and innovation to be able to sense and act within cycles of time smaller (milliseconds) than human perception [1].

2.1 LITERATURE REVIEW

An estate consists of several buildings, mini market, farm land, microfinance bank, water supply, hybrid power supply, conducive environment for recreational activities, security personnel and so on. There abound several types of estates with different characteristic features. Home automation system is a kind of automation systems, which are used specifically for controlling the home appliances and devices mechanically (in some cases remotely) with the help of variety of control systems [2]. It is a known fact in the society that any electrical appliance is controlled with a switch that regulates the operations of the appliance. But due to technological advancements, automation and wireless control of devices has become more popular, effective and reliable(Nwankwoeke & Magbo, 2016).

3.1 MATERIALS AND METHODS

The system proposed in provides two means to control the home appliances: the GSM network, the Internet through a webpage. The real time monitoring has been an important feature that can be used in the home automation systems remotely. As a change in the status of the devices occurs, the user can be informed in real time. The user commands are transferred to a server which is usually done by a PC. The server processes the user commands and sends them to the relevant units. This can help control the appliances. GSM is used as

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a communication medium to help establish connection in places where there may not be proper internet connectivity. The server uses AT commands to communicate with the GSM modem.

Adopting the survey method, systematic method for gathering information from individuals to describe the attributes of the larger population of which the individuals are members [4]. A thorough survey was carried out at the Heartland Housing Estate, Owerri West, Portharcourt road, Owerri, Imo State, Nigeria. It was observed that the stated problems in chapter one of this work was very prevalent especially in the areas of epileptic Power Supply from the normal supply and weak communications amongst the Security personnel. An Oral interview was conducted during data gathering for performance analyses of the existing infrastructures within the estate.

3.2 SYSTEM BLOCK DIAGRAM

The general block and the flow diagrams that depict the entire system prototype are shown in Figures 3.1 and 3.2 respectively. Figure 3.8 shows the various sub-systems and how they interact to make up the entire system. The manager's or user's phone acts as the initiator of communications to other sub-systems. The microcontroller is the brain of this entire system which coordinates activities based on the predefined instructions via codes. There are three phases under monitoring viz the normal supply, generator and inverter. Each of the phases acts an input by which the controller scans through in a cycle of 16 million times in a second (frequency of oscillation is 16MHz).

However, this system deploys ATMEGA32 Microcontroller in the design of the automatic transfer system (ATS) which has Analog-to-digital converter (ADC). Three rectifier circuits represent the ADC sources for the three power sources and the ATMEGA32 was programmed using BASIC Programming language. These ADCs were connected to the three power sources (normal supply, generator and inverter) for a continuous scanning for the set voltage priorities.

Controlling an electronic choke generator remotely, connect a cell phone (NOKIA 105) with a registered SIM card to the DTMF circuit. Set the phone to be on auto answer and the keypad should be outdoor. Now one can place a call on the phone number interfaced with the DTMF circuit. As the phone picks the call automatically, press any button of one's choice, monitor the output terminals and connect a Relay driver Integrated Circuit (ULN2OO3) to the corresponding outputs for an effective wireless control of electrical appliances. This is used in controlling the ON or OFF switch of the electronic generator and any other kind of appliances within the estate.

Finally, set a smart phone with IP-webcam software (installed) and enter the IP address of the mobile phone on a browser on a Personal Computer (PC). The phone video camera starts remote monitoring.

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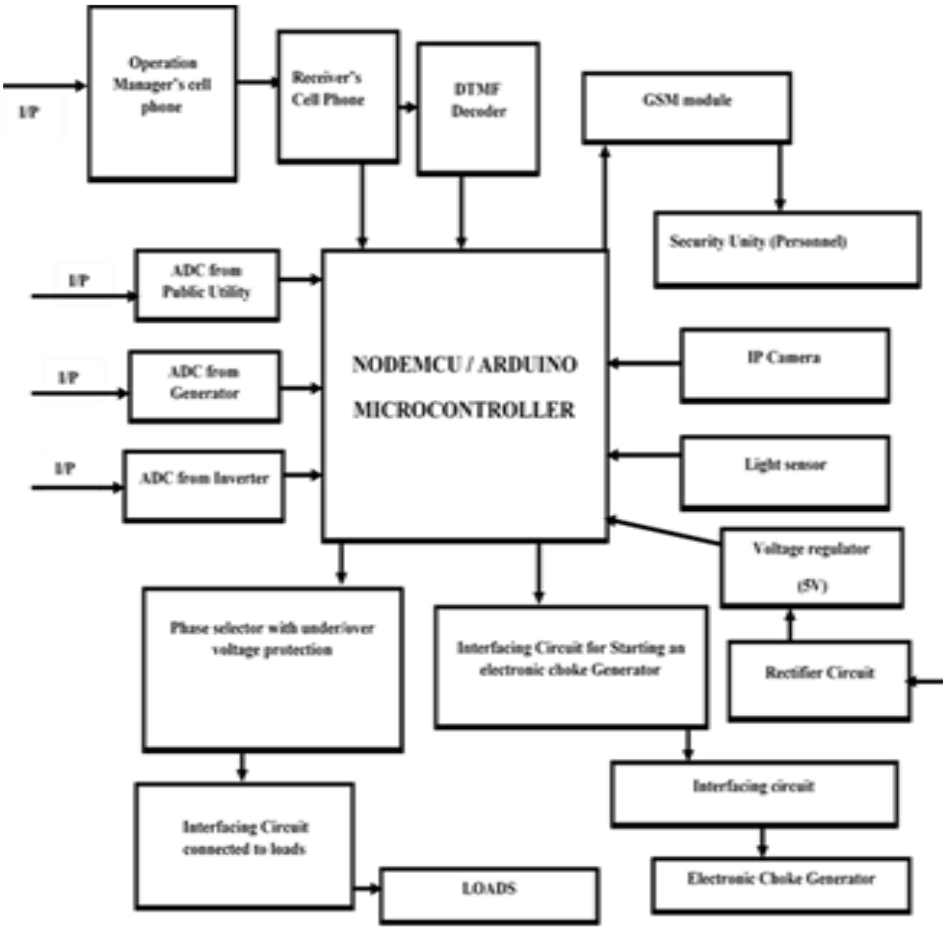

Figure 3.1: Overview System Block Diagram

3.3.1 Automatic Transfer Switch unit

The automatic transfer system creates the platform for power to be automatically transferred to all the connected loads within the estate. The system scans through the phases via the three ADCs and switches according to the coded priorities. For instance, if there is power in the normal supply phase, it quickly checks the voltage level whether it falls within the acceptable range. And if the voltage is within the allowable range, it ignores other sources and switches to the normal supply. But if there is power on the normal supply but the voltage falls out of allowable range, it ignores the normal supply phase. Then it automatically moves to Inverter phase to check voltage level. If it is within the allowable range, it transfers power to the estate. But if the battery of the inverter is very low that makes the output voltage to be less than the acceptable range, it ignores the inverter phase and then moves to the generator phase. But before it checks the voltage level, it first starts the electronic choke generator automatically. All these processes are summarized in fig.3.4.

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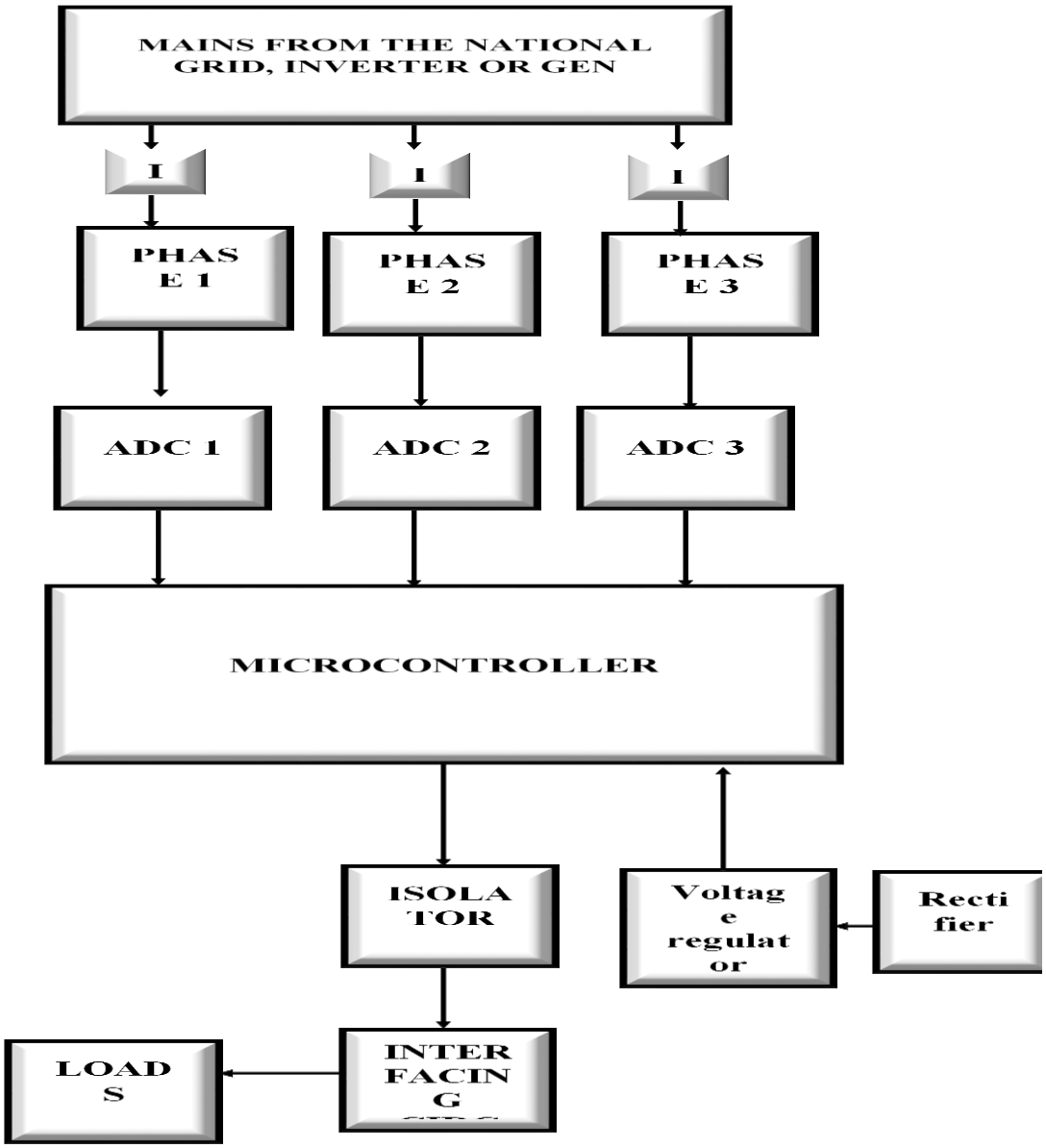

Fig.3.4: Block Diagram of Automatic Transfer System

3.2 The ATS Flowchart

Fig. 3.5 depicts the normal supply flow diagram which has the highest priority because its cost of operation is less expensive compared to the others. Whenever there is power restoration from the normal supply, the system switches to it and shuts down the generator if it was in use before the power restoration. And if it was the Inverter system that was on before the restoration of power from the normal supply, it shuts down the inverter and allows it to be charging via the solar panels.

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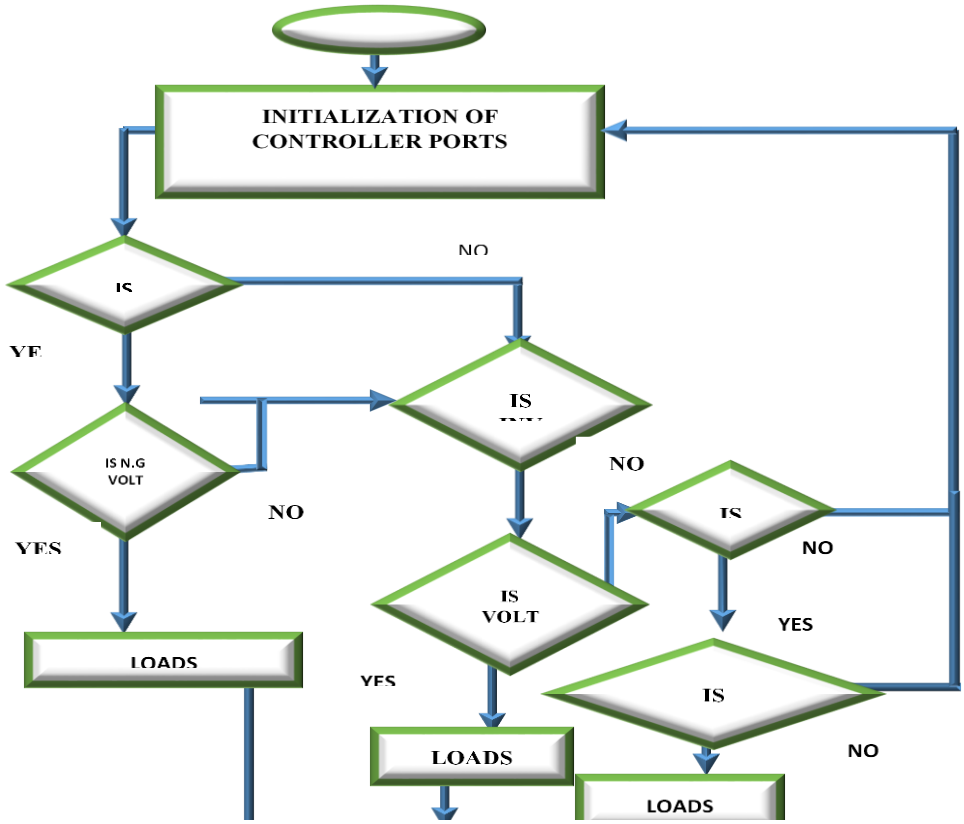

3.3.3 System Circuit Design for the ATS

The system sub-circuit shown in figs.3.11 comprises the circuit for the automatic transfer system (ATS) which takes cares of keeping power uninterrupted provided the three power sources to the estate are functional. It also has surge protection against both under and over voltage protection. The Liquid Crystal Display (LCD) helps to display the particular phase of power in use.

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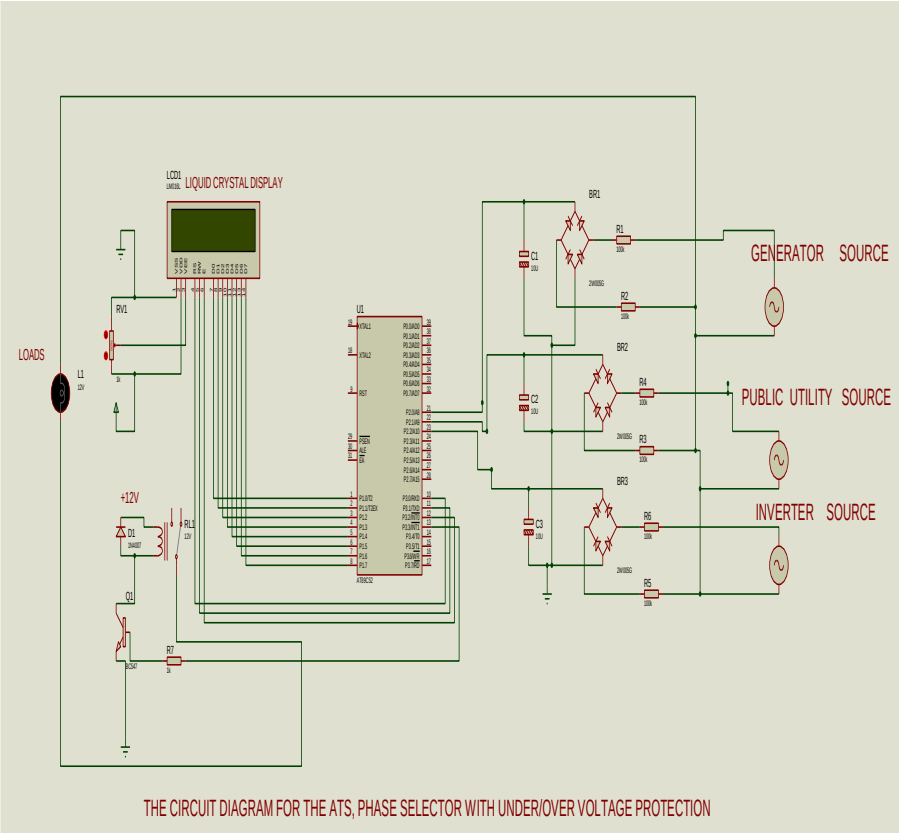

Plate 3.11: The Circuit Diagram of the ATS, Phase Selector with under/over voltage protection

1.3.6 System Circuit Design for the Smart Water Level Monitor and Controller

Fig.3.16 is the circuit responsible for Uninterrupted Water Supply System (UWSS) to ensure that there is constant water supply to the estate without any form of human interface except in the event of maintenance or fault correction.

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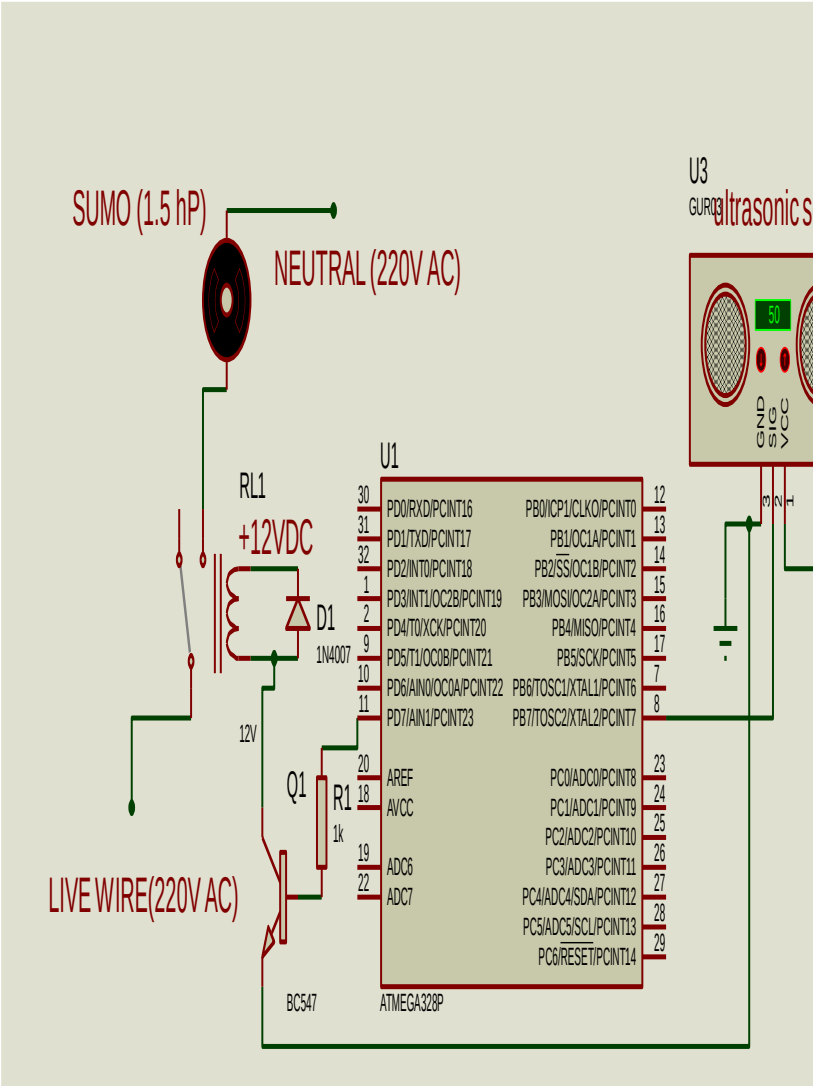

Plate 3.16: System Circuit Design for the Smart Water Level Monitor ar

Controller

3.3.4 Circuit Design of the Wearable alert System

The wearable alert system has been designed in such a way that it can send different messages corresponding to the buttons pressed. From fig. 3.12, it can be seen that there are five buttons and each has a dedicated message to send if pressed. The idea here is that in case of attacks of any kind, at a particular gate in an estate that has more one gate, the security personnel at that gate one should be able to inform other colleagues at the other gates to intervene.

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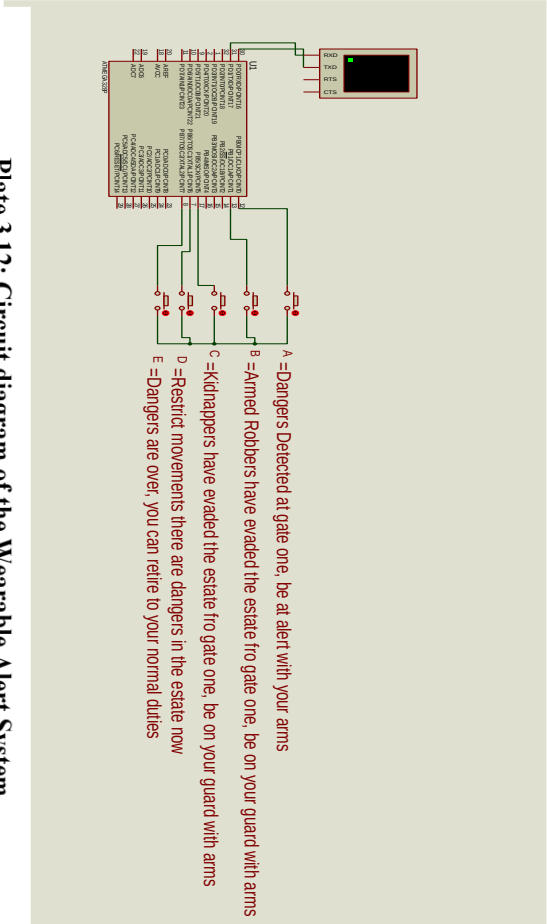

Plate 3.12: Circuit diagram of the Wearable Alert System

3.5.1 The Basic parameters are for the water level monitoring and control

Let the total height of the tap =X (distance between the sensor and the floor);
Let the Current height=Y (distance between the water inside and the sensor);
Let the distance measured by the system=Z (Actual height of the water inside the bucket under the sensor);
Total height of the smart water reservoir (SWR) is about 25cm=0.25m;
This implies that;

$$X = Y + Z \qquad 3.1$$

Hence, the height of the water in the bucket to be measured is thus;

$$Z = X - Y \qquad 3.2$$

Given the speed of sound in air to be approximately 340ms-1. The instantaneous distance x is calculated as

$$x = (34000 cms^{-1} \times dt)/2 = 170 \times t \quad \text{(in metres)} \qquad 3.3$$

Therefore, the instantaneous distance of water level in the bucket or any container (object) placed away from the sensor with respect to the wave time of flight was computed using equation (3.3).

3.6.1 System Circuit Design of Automation of Electrical Appliances using IoT for easy remote load reprogramming and scheduling

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Figure 3.13 shows the complete circuit diagram of the system which involves the proper interfacing of the major modules such as Arduino Module, Nodemcu module, Crystal Display Module (LCD) module, relay module and other discrete components integration.

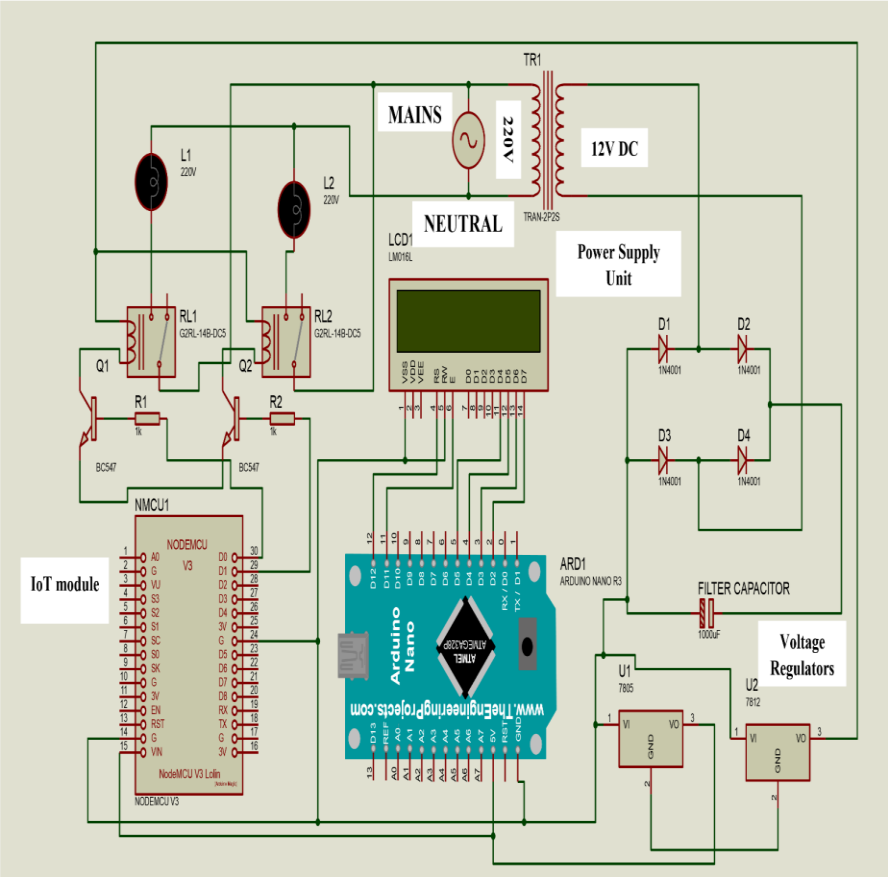

Plate 3.13: System circuit diagram for the IoT section and voltage monitoring

Nodemcu Controller Module is interfaced with a relay circuit for easy switching of AC based loads using just a 5V signal from the General Purpose Input or Output pins of the Nodemcu. This is made by connecting an NPN bipolar transistor which requires a biasing base voltage of 1.5V for signal transition from the emitter to the collector of the transistor. The signal diode at the coil part of the relay is for polarity creation. And this also helps in avoiding erotic switching of signal.

3.9 General design component values and associated calculations

BC 547 common-emitter current-gain and the associated calculations:

From the data sheet of BC547 NPN transistor as shown in figure 3.14:

The following values were obtained;

(i) Emitter current = I_E = -100mA

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(ii) Base current = I_B = 20mA

(iii) Collector current = I_C = 100mA

(iv) Base-Emitter Voltage = V_{BE} = 0.7v

Calculating the gain factor (β) of the NPN transistor used:

Recall:

$$\text{Gain factor } (\beta) = \frac{I_C}{I_B} = \frac{100\,x\,10^{-3}}{20\,x\,10^{-3}} = \mathbf{5}$$

This implies that an input current to the emitter will have a gain factor of 5.

This is enough to switch the DC relay in the circuit.

Finding the relationship of collector current (output current) to emitter current (input current) which is known as α. This is calculated thus;

$$\boldsymbol{\alpha} = \frac{\Delta I_C}{\Delta I_E} \textbf{ or } = \frac{\beta}{\beta+1}$$

Therefore $\boldsymbol{\alpha} = \frac{\beta}{\beta+1} = \frac{5}{5+1} = \frac{5}{6} = \mathbf{0.83}$

This implies that the input current at the emitter reached the collector at 83% output current to input current.

To find the accurate value for the biasing resistor connected at the base of the transistor, Figure 3.8 is used in accordance with the associated equations.

Recall ohm's law;

Base-emitter of BC 547 transistor = 0.7v (Datasheet). That is V_{BE} = 0.7v

Voltage across R_1 resistor = $\frac{V_{CC} - V_{BE}}{I_B} = \frac{5v - 0.7v}{20\,x\,10^{-3}} = \frac{4.3}{20\,x\,10^{-3}} = \frac{4.3}{2}\,\boldsymbol{x\,10^2 = 2.15\,x\,10^2 = 215\Omega.}$ The biasing resistor value is 215Ω, approximately 220Ω which is commonly available in the market.

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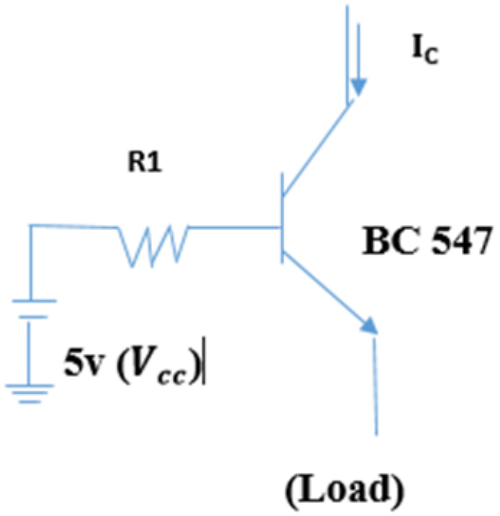

Figure 3.14: Relay Switching transistor

3.3.8 Principle of Operation of the entire system

The operation of the system is quite simple. The system has three different power sources such as Normal supply, Generator and Inverter. The normal supply has the highest priority because its cost of operation is less expensive compared to the other two. Whenever there is power restoration from the normal supply, the system switches to it and shuts down the generator if it was in use before the power restoration. And if it was the Inverter system that was on before the restoration of power from the normal supply, it shuts down the inverter and allows it to be charging via the solar panels.

However, to control any appliance remotely, one needs to place on a dedicated phone number used in this work. And system has been configured in such a way that the receiver cell phone embedded in the main system picks incoming calls automatically. This makes it easy for one switch on or off any gadget within the estate by decoding the number pressed on the keypad of the embedded cell phone. With the help of Programming, every number on the keypad is dedicated to a particular function and are subject to changes if need be. There is also part of this system that is wearable for a quick SMS to the security personnel in the event of robbery attacks or other related vices within the estate. The Mobile Android IP-Webcam is mainly for remote monitoring of the gadgets under control. Lastly, the jamming sub-system, though it is already banned in some countries helps to interrupt communications amongst the perpetrators. The system is very simple to install and maintain within any highly recognized estate.

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3.11 System Implementation

Figure 4.1 shows the graphical representation of the analog and digital signal results obtained. When the light sensor was exposed to light, its output value changed from 100KΩ to about 3Ω on a digital ohmmeter. Analog to digital conversion technique was deployed to match the results based on a standard analog to digital metrics.

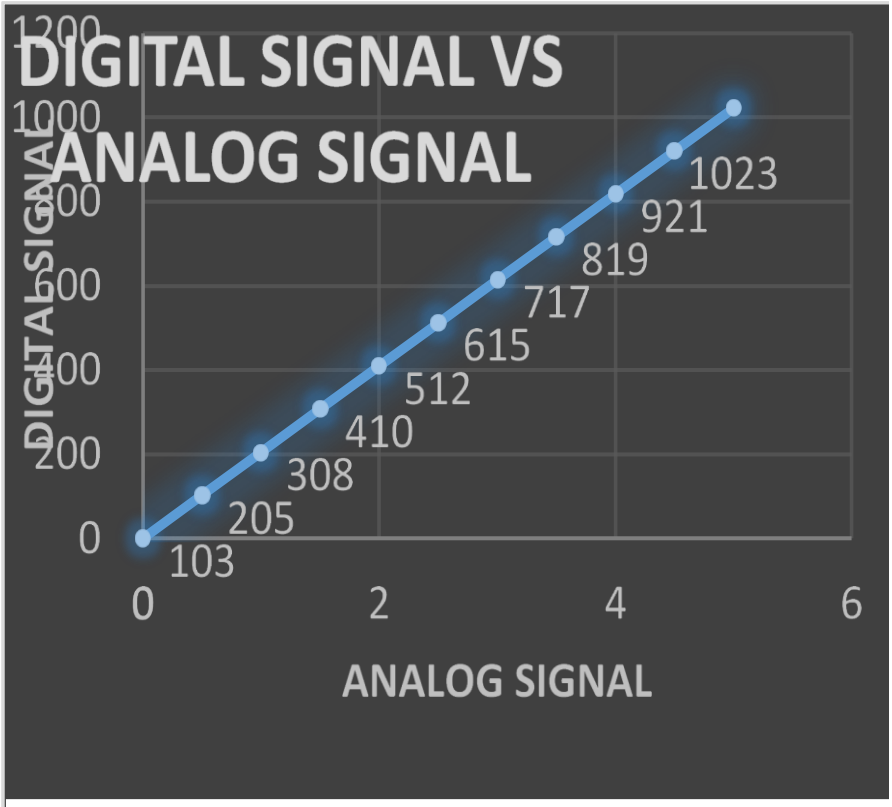

Figure 4.1 shows the graphical representation of the analog and digital signal results obtained.

Figure 4.5 shows the entire sub-system in one form. This device is now a complete system that is capable of delivering the functions outlined in the problem statement. The results obtained in the test stages were presented in chapter four.

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Plate 3.15: System Implementati

4.1 Test Results for the IoT Based Real-time Communication System

After writing the Arduino sketch (code) and uploaded, it was monitored through the Arduino Serial Monitor located at the top right corner of the Arduino Integrated Development Environment (IDE). The Internet Protocol (IP) Address of the WiFi module (ESP8266/32) was detected. A browser such as Firefox, Opera mini, Chrome, Internet explorer and so on could be used to access the WiFi Module and be able to control the connected devices remotely.

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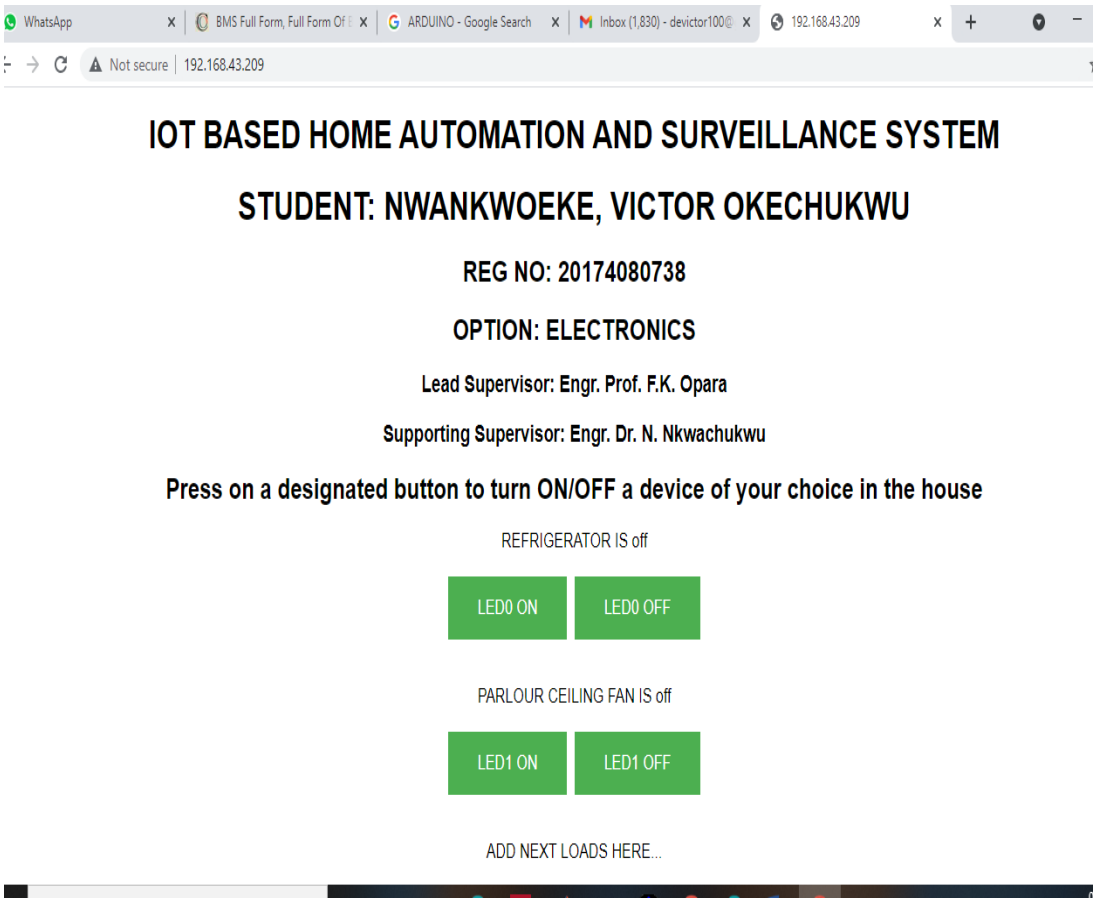

Figure 4.3a: Output of the IoT webpage (Off States of Loads)

Figures 4.3a and 4.3b demonstrated the output webpage of the WiFi Module as displayed on the serial monitor on a PC. To access the devices online, the IP address of the ESP8266/32 was entered on the Search bar using any of the available browsers (Firefox, Opera mini, Chrome, Internet explorer). Three different loads were controlled in the design viz; the ceiling fan, the bulb and the socket-outlet. From the webpage displayed, the IP address of the WiFi Module was noted as 192.168.43.209 (private class C network).

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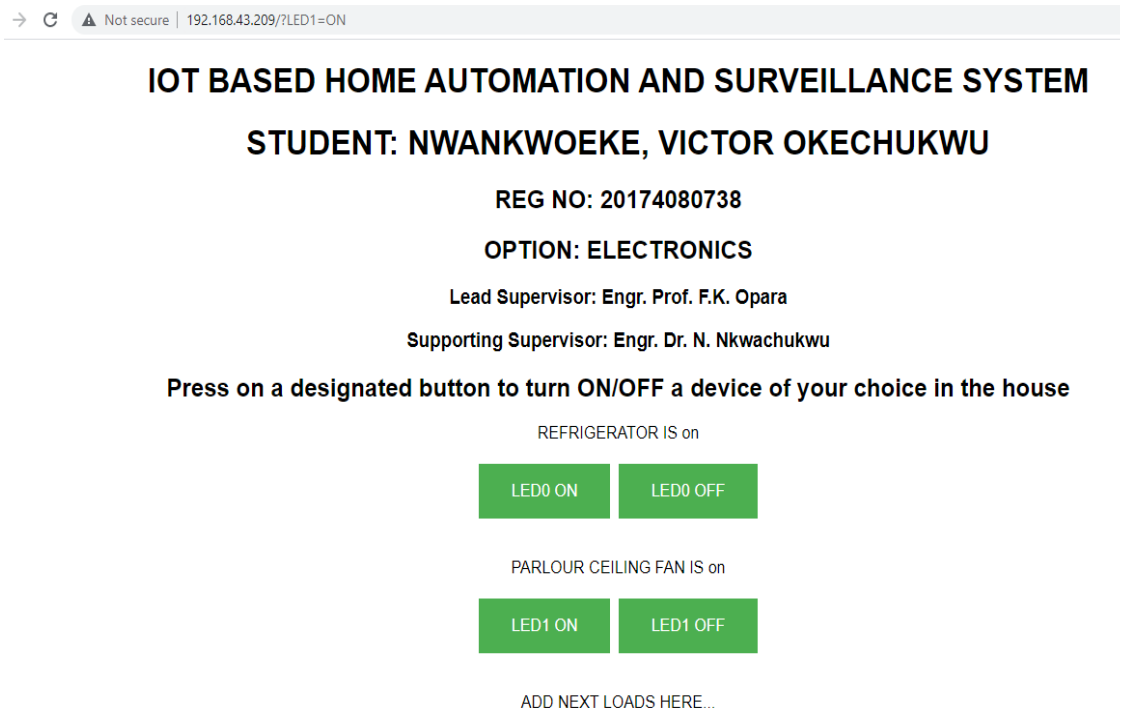

Figure 4.3b: Output of the IoT webpage (On States of Loads)

5.1 Conclusion

The Design and implementation of a smart control system for improved estate management using GSM, IoT and DTMF technologies has been successfully developed and tested. The different hardware and software components used were properly described. Some constraints were encountered in the course of the implementation. The system is a fast and efficient approach for controlling the operations of major electrical gadgets within an estate. It aids the security agents in monitoring and securing the lives and property of the people living in therein. This equipment works in any housing estate with strong signal strength. The system is scalable, it can accommodate more gadgets if need be.

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