

## DEVELOPMENT OF A SMART CONTROL ESTATE MANAGEMENT SYSTEM

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### ABSTRACT

Manual controlling of electrical appliances is widely used in many existing estates. The system designed and implemented in this work gives the user a good control of electrical appliances with the use of the mobile phones. There is also a phase selector for the three power sources (National grid, Generator and Inverter). A thorough survey was carried out at the Heartland Housing Estate, Owerri West, Portharcourt road, Owerri, Imo State, Nigeria which was used as a case study. It was observed that epileptic Power Supply from the national grid and poor communications amongst the Security personnel were prevalent. A cell phone with a functional Subscriber Identification Module (SIM) card was connected to a Dual Tone Multi frequency (DTMF) circuit. Another functional SIM card was inserted in SIM900A and connected to an Arduino Chip for an automatic mobile SMS messenger to the security personnel. This small system has a keypad with each key dedicated to a particular security alert when pressed. The Receiver terminal (Rx) of the SIM900A was connected to the Transmitter terminal (Tx) of the Arduino chip and the Transmitter terminal (Tx) of the SIM900A was connected to the Receiver terminal (Rx) of the Arduino chip. Arduino C was used as the programming language for proper interactivities between the SIM900A and Arduino chip. ATMEGA32 Microcontroller was used to design the automatic transfer system (ATS) which has Analog-to-Digital converter (ADC). Three rectifier circuits were used as the ADC sources representing the three power sources and the ATMEGA32 was programmed using BASIC Programming language. These ADCs were connected to the three power sources for a continuous scanning for the set voltage priorities. A Light Dependent Resistor (LDR) was used in conjunction with Triac and Diac for an automatic switch for the Smart street light. Finally, a smart phone with IP webcam software (installed) was set and a Chrome browser was opened on a Personal Computer (PC) for remote monitoring. The completed prototype of the system was tested. It starts an electronic choke generator remotely via a mobile phone, transferring the loads to the available source out of the three power sources based on priorities with voltage surge protection; performed automatic switching of Water pump; automatically sends SMS to the nearest security personnel in the event of robbery or kidnapping attacks; and monitors devices under control via Hotspot technology.

**Key words:** Automatic Transfer System, Microcontrollers, Light Dependent Resistor, Hotspot and Dual Tone Multi Frequency technologies

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### 1. INTRODUCTION

Automation and control systems began by giving humans a way to apply general timing and have evolved through technology and innovation to be able to sense and act within cycles of time smaller (milliseconds) than human operators can perceive (Aravindhan, et al.; 2017). The main concern in wireless systems design is the integration of technologies to increase customer satisfaction and reduce expenses. Home automation system is a simplified network of hardware and software to carry out many of the activities meant for manpower and in some cases remotely it is done with the help of variety of control systems (Sehgal & More, 2017). Owing to technological advancements, automation and wireless control of devices has become more popular, effective and reliable (Nwankwoke & Magbo, 2016). The myriad of innovations in the communication sector, alongside the availability of mobile phones has made the world a global village by bringing people of diverse clans together. This is possible because at any given point in time people will have the need to communicate and get their job done. Mobile phones are not made for the purpose of making calls or sending SMS only, but also can be gainfully employed for automation and control purposes. It encompasses both home and industrial automation, which will now bridge the gap between homes and industries. The signal consists of the information about the action to be taken, that is, what appliance should be turned off or turned on. The user can make a voice call in order to perform certain actions such as switching lights on or off, get and control the status of any appliance and so on. This innovation will make control of home and industrial appliances easier and less complicated for users. The system used to implement this automated design allows the user to control and know the present state of electrical appliances by cell phone, it can be done by sending signal over the cell phone known as the control phone to the other cell phone as the home-based phone. This controller's cell phone is connected to an interface circuit that detects the Dual Tone Multi- Frequency (DTMF) signals and give the access to a control

unit which controls the home devices and turn the power of these devices on or off. The principle used for cell-phone controlled system is the decoding of DTMF tones.

Wireless technologies like Bluetooth and Wi-Fi have been used in contemporary home security systems using low cost, low power, less complexity RF module. It uses multi-hop communication for data transfer. This multi-hop technique gives out an unlimited range of communication thus giving it an edge over the other wireless technologies. Here the radio frequency transmission system employs Amplitude Shift Keying (ASK) technique with transmitter and receiver operating at 433MHz. Due to high frequency, data can be transmitted to a sufficient distance without attenuation. FPGA modules are highly suitable and compatible for the evolving technology of software defined radios (SDR) due to their configurability, programmability and security. The security to the data can be provided by using certain Encryption techniques. The aim is to transmit certain data wirelessly with high security and also to control output load from any remote place. To make this practical, a compact Transmitter and receiver modules is needed which can operate at 433MHz (Kumar & Rao, 2015).

*Matthew et al, 2015* designed a system to assist and provide support in order to fulfill the needs of elderly and disabled in home based on SMS technology and voice recognition. When automating a home load not available in the visible range, fault identification system in this design helps the user to ensure that their home appliances had gone exactly ON or OFF. Each home load will be having two ON and OFF commands.

The work of *Rodge et al, 2017* illustrated and demonstrated the effective implementation of Internet of Things (IoT) used for monitoring and controlling office appliances through Internet. Additionally, the system also monitors number of visitors inside the office and accordingly controls the electrical appliances to avoid excessive usage of electricity which results in less polluting and greener environment.

The aim of this paper is to integrate the following features in an estate:

- a. Automatic transfer system for three power sources which is novel.
- b. Controlling of generator via mobile phone, this is really a new technology.
- c. Control of appliances which is very cost effective.
- d. Automatic SMS to security personnel in the event of kidnapping and other social vices. This system requires only pressing of a button on the Control Management Table, and an SMS will be sent immediately within 10 seconds (latency).
- e. Energy Management System for street Lights: other works used Light Dependent Resistor (LDR) in conjunction with Microcontroller which are not cost effective but this work uses LDR with only Diac, Triac and a fixed resistor which are very much cost effective and also more rugged because the Diac and Triac can handle up to 700V without breakdown.

## 2. SYSTEM ARCHITECTURE

The wireless and GSM based Home Automation System (HAS) is developed using different programming languages such as Assembly language, BASIC language, Embedded C, Arduino C and AT commands. The system is based on serial data transmission using SMS over GSM network in order to facilitate the appliances control in a global network environment. Present system ensures a secured exchange of data on GSM communication. A user interface (UI) on the Android enabled mobile phone offers system connection and control utilities GSM based home automation (Computing, 2015). The Serial SIM900A type GSM Modem and Arduino IDE for compiling C Language Code and burning HEX file into microcontroller was used for the development of the SMS circuit. The automatic transfer system flow diagram is shown in Fig. 1. There are three phases (national grid, generator and inverter) respectively. The Analog to Digital Converters helped in feeding the microcontroller with discrete signal for voltage monitor and control. The controller scans through the three phases and selects based on phase priorities.

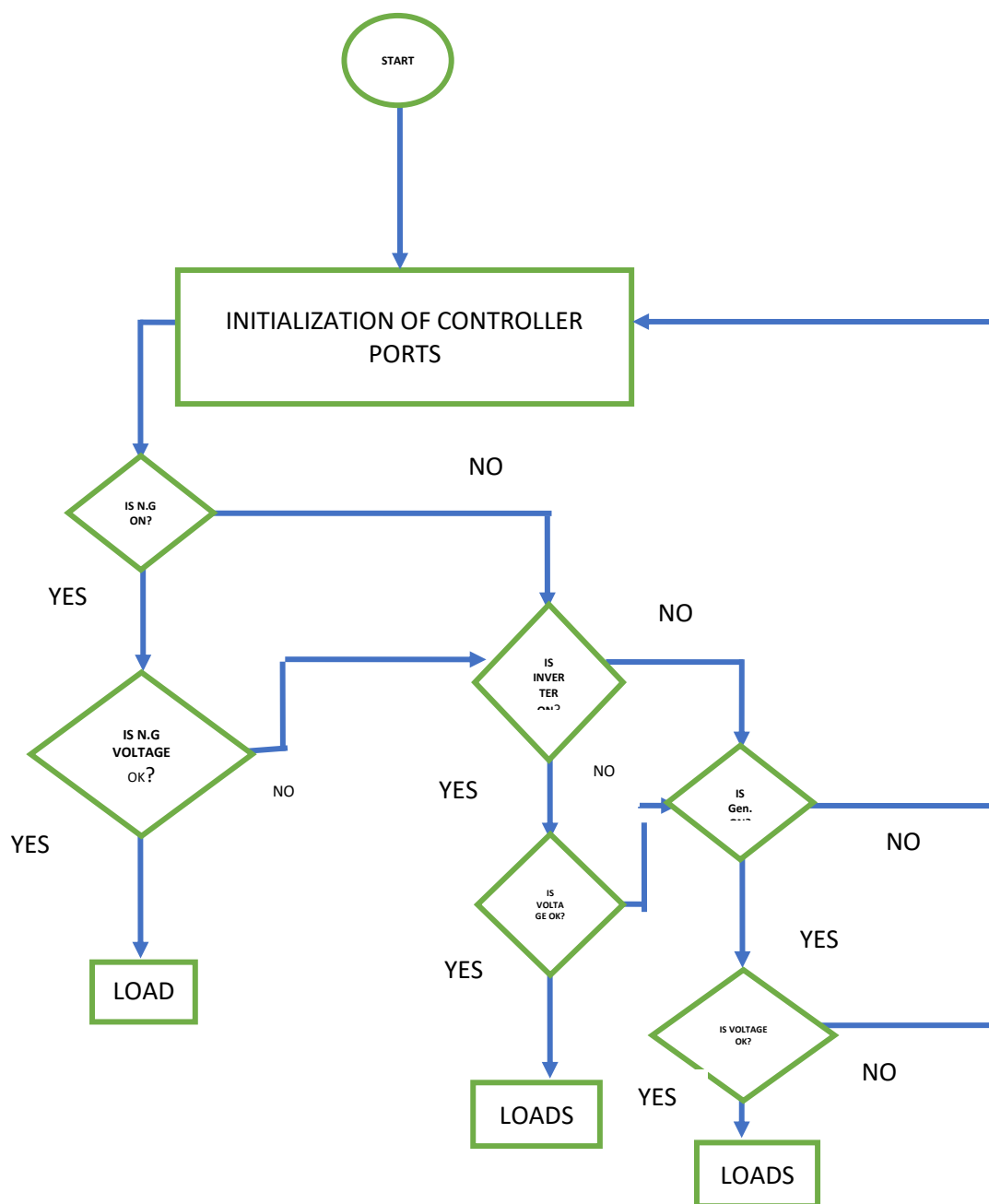


**Fig 1: The flowchart of the Automatic Transfer System**

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 national grid 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 national grid. But if there is power on the national grid but the voltage falls out of allowable range, it ignores the national grid 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 2.

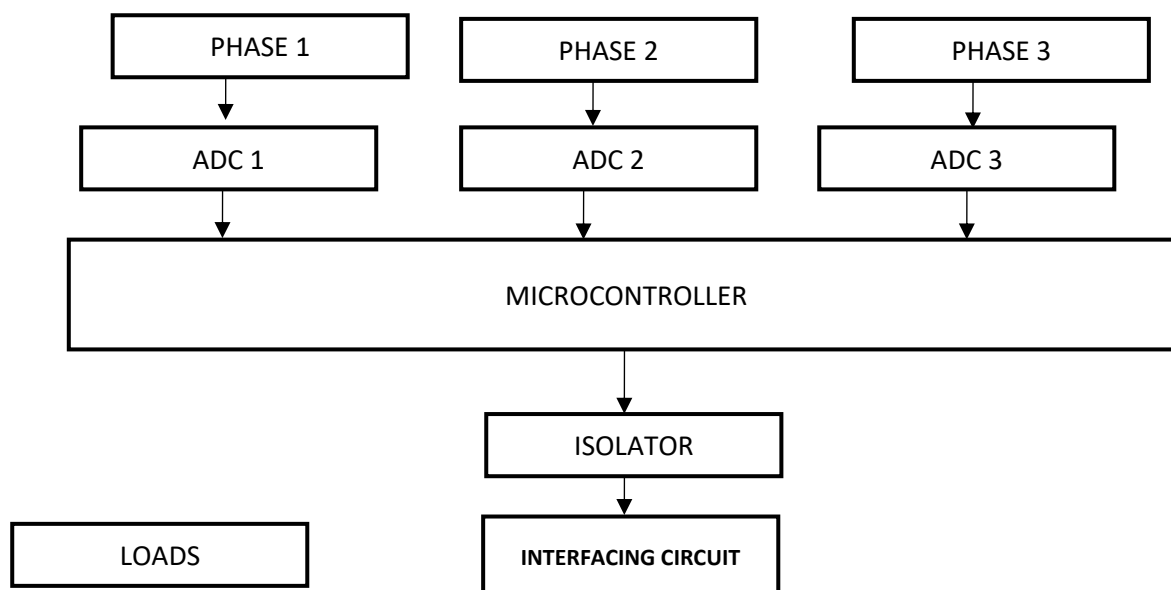


Fig 2: Block diagram of automatic transfer system

Fig. 3 is the overall flow diagram which comprises all the modules or sub-systems used in the work. The system operation is initiated by the operation manager placing a call on the embedded phone number. The receiver's phone picks the call automatically and acts according to the digit(s) sent or pressed on the user's cell phone. The controller executes the commands based on the password included in the codes.

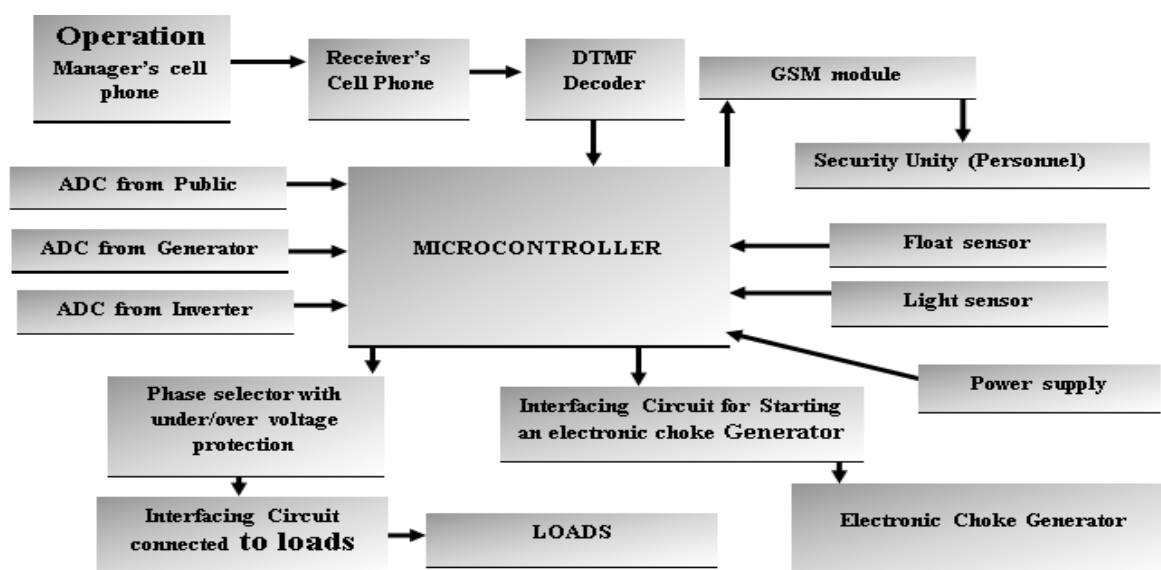


Fig 3: The entire block diagram of the system

### 3. THE ARCHITECTURAL PLAN OF THE ESTATE

Working with parametric objects, ArchiCAD allows the user to create a "virtual building" with virtual structural elements like walls, slabs, roofs, doors, windows and furniture. 2D or 3D representation can also be done using ArchiCAD. The plan of the estate used as the case study of this research was drawn using ArchiCAD. The printout of the estate phase A layout is shown in Fig. 4.

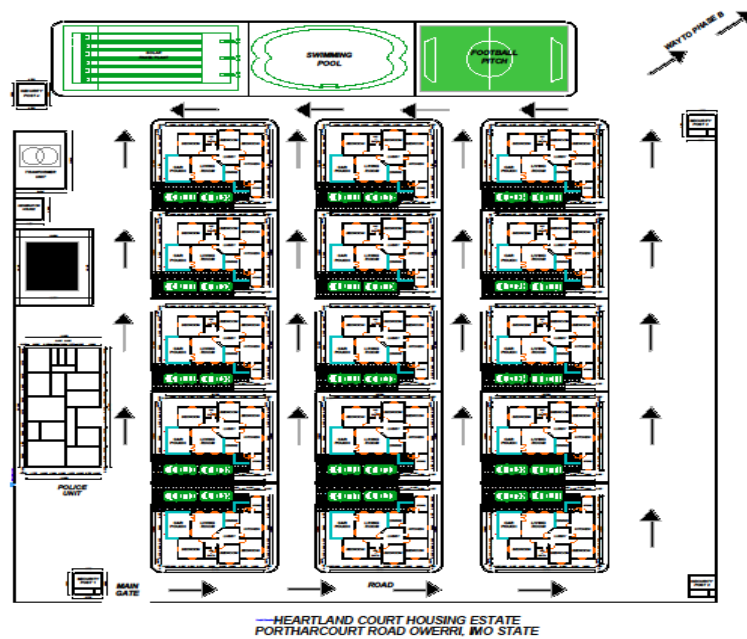


Fig 4: The estate architectural plan

The technologies deployed included the Global System for Mobile Communication (GSM), Dual Tone Multi Frequency (DTMF) and Transceiver technologies. The inter communications of these technologies are properly illustrated in the flowchart of the system in fig. 5.

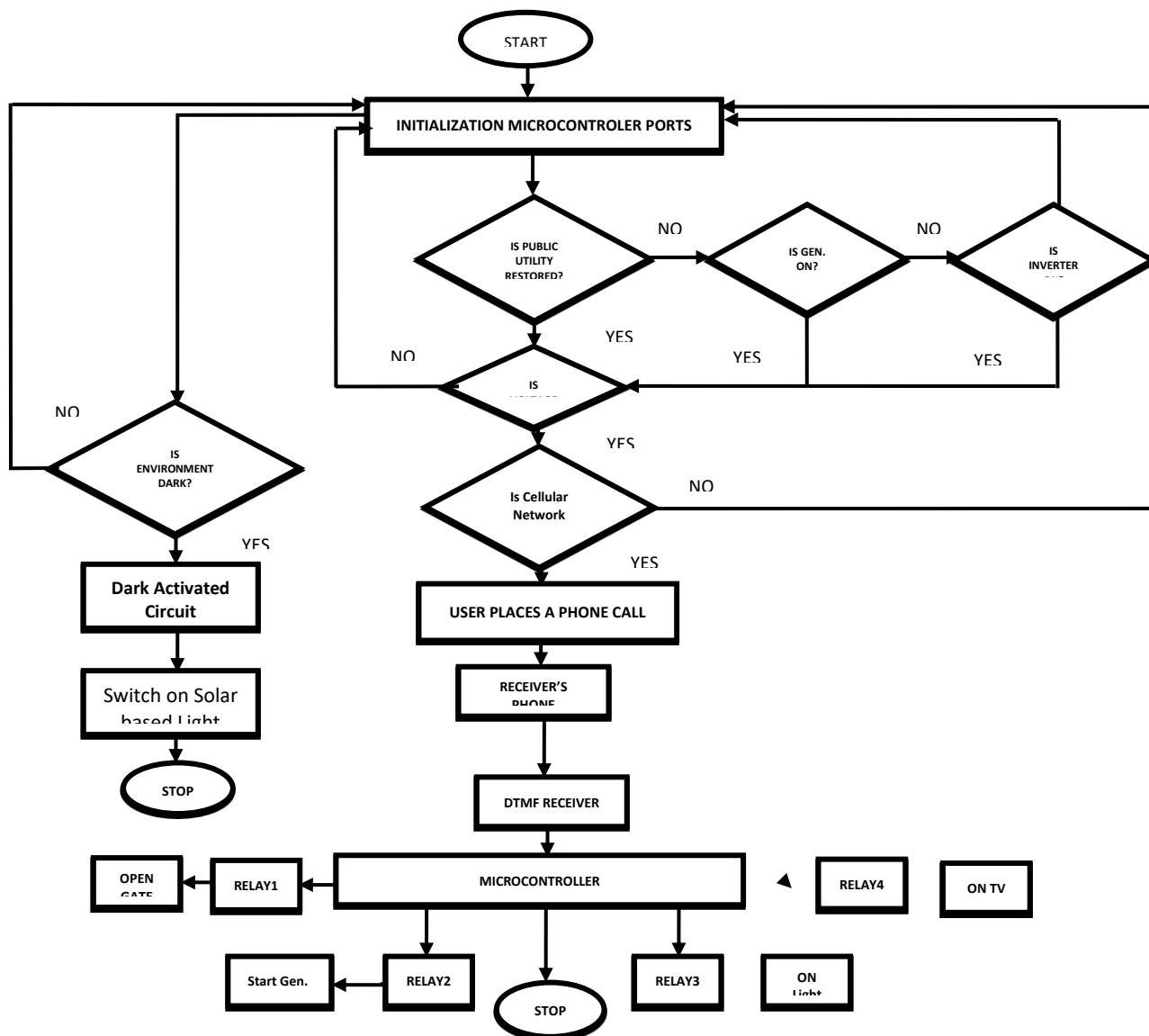


Fig 5: The flowchart of the system

Fig 5 depicts the national grid which has the highest priority because its cost of operation is less expensive compared to the other two. Whenever there is power restoration from the national grid, 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 national grid, it shuts down the inverter and allows it to be charging via the solar panels.

#### 4. SYSTEM CIRCUIT DIAGRAM

The system sub-circuits are shown in Figs. 6 – 8. Fig. 6 comprises the circuit for the automatic transfer system (ATS) which takes care 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. Fig. 7 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.

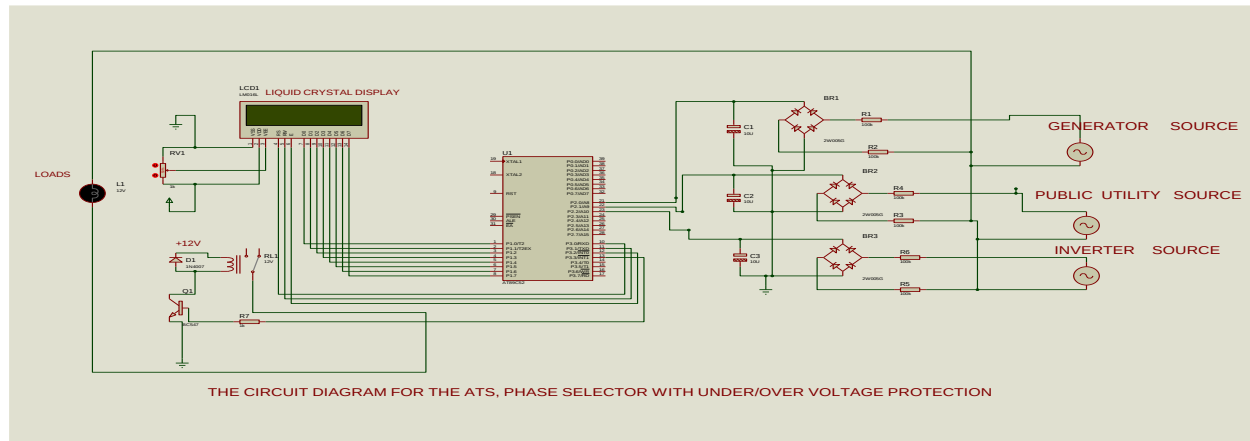


Fig 6: The circuit diagram of the ats, phase selector with under/over voltage protection

Fig 7 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. The overhead tank has been calibrated in such a way that when the water level gets to maximum of the tank, the relay that is interfaced with the power to the Sumo gets de-energize and thereby switches off the Pumping machine. The process is reverse whenever the water level drops below normal.

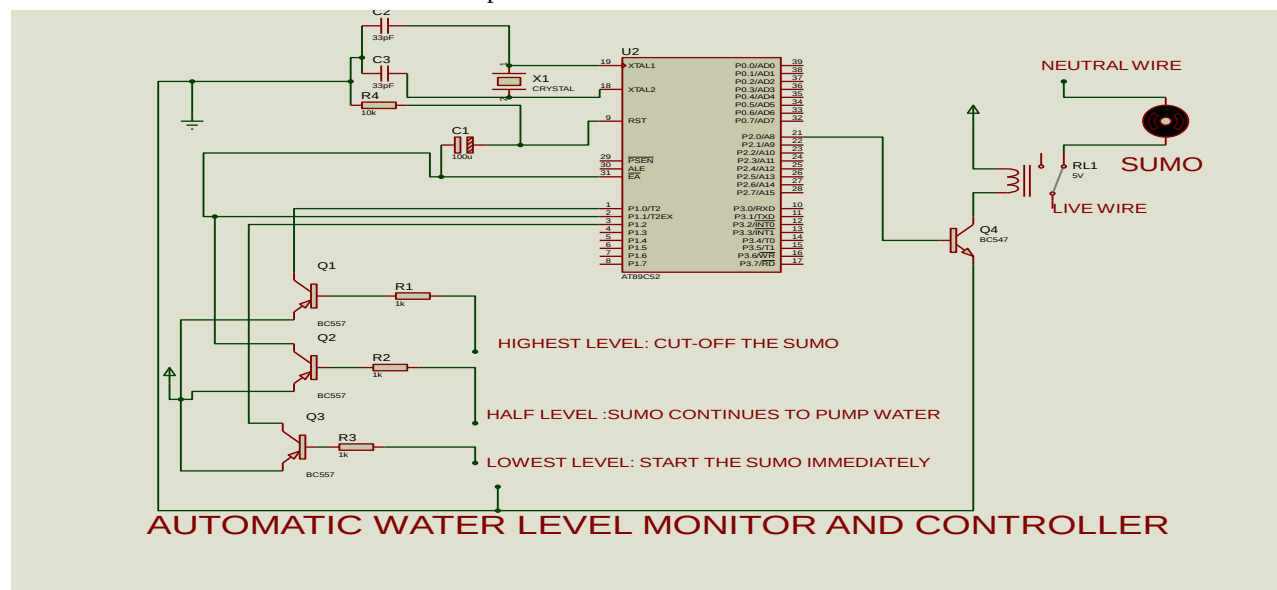


Fig 7: Liquid level monitor and controller

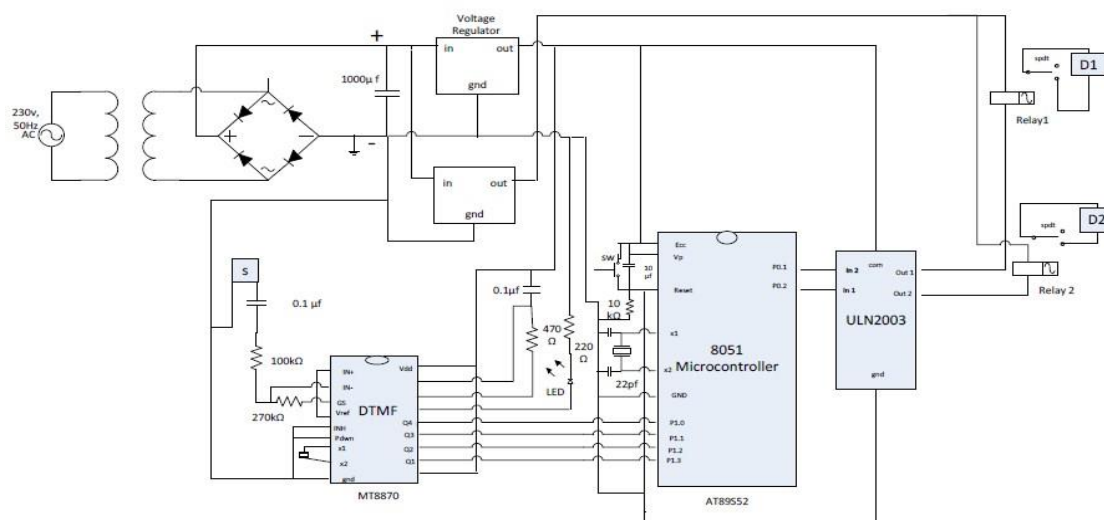


Fig 8: DTMF Circuit

Fig.8 shows the wireless control of electrical appliances within the estate such as starting of an electronic choke generator via a mobile phone, automatic gate opener, and so on. This circuit is also capable of opening the gate to an estate automatically

## 5. PRINCIPLE OF OPERATION OF THE ENTIRE SYSTEM

The operation of the system is quite simple. Whenever there is power restoration from the national grid, 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 national grid, 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. The 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 to 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. The system is very simple to install and maintain within any highly recognized estate.

## 6. RESULT AND DISCUSSION

The Fig. 9 shows the graphical representation of the analog versus digital signals. They are directly proportional to each, as the incoming or analog voltage increases, the digital voltage increases. It was the digital values that were used in programming the microcontroller on what to do when the voltage level changes from a certain value to another. Also, in the phase selection, generator turn-off, under and over voltage protection features were added to the ATS. It was observed that when the analog voltage goes high, the corresponding digital voltage follows suit and the ATS quickly cut off the load from power to avoid damaging of electrical appliances within the estate.

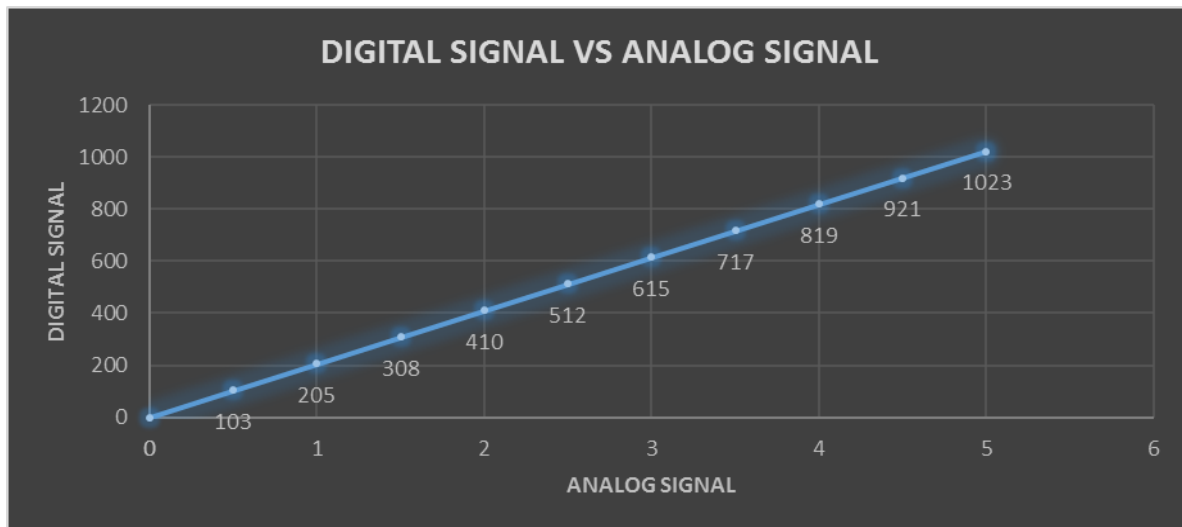


Fig. 9 Graphical representation of the Analog vs Digital signals after ADC Calibrations

Fig. 10 shows the simulated result of when public utility was restored using proteus software. It was observed that when power from the national grid was restored, the ATS quickly transferred the power to the loads in the estate. The system responded as predefined or programmed.

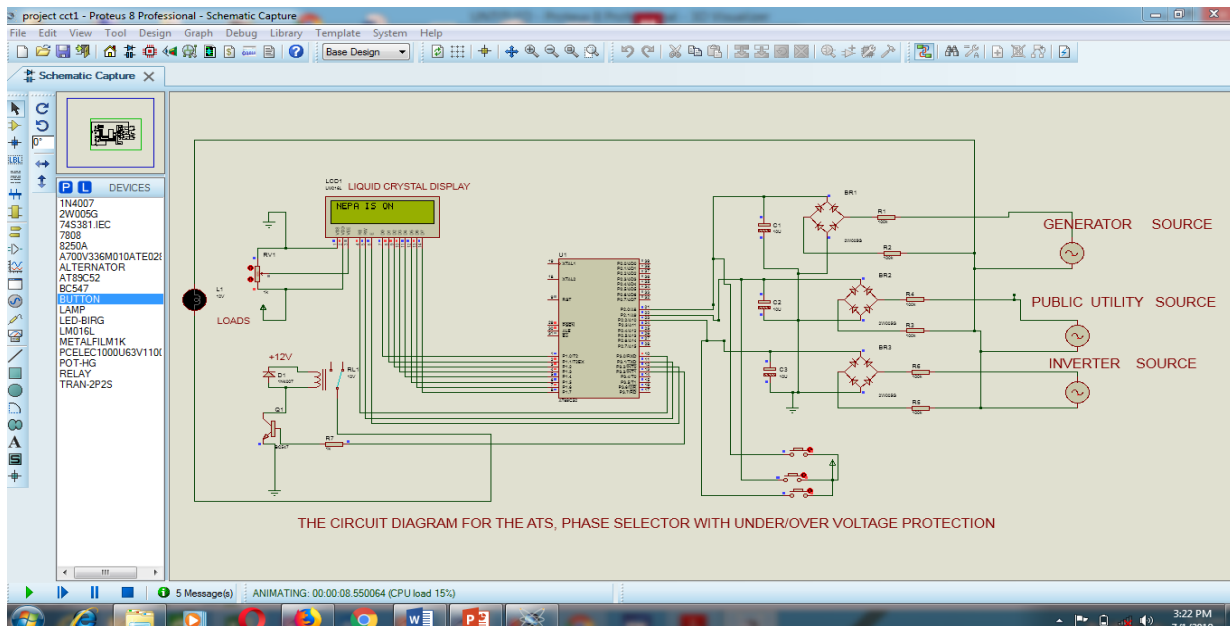


Fig. 10: The simulated result of the circuit representing the National Grid in use

Fig. 11 shows the simulated result of when Inverter was energized using proteus software. It was observed that when inverter was switched on, the system quickly transferred its output (power) to the loads in the estate. The system responded as predefined or programmed.

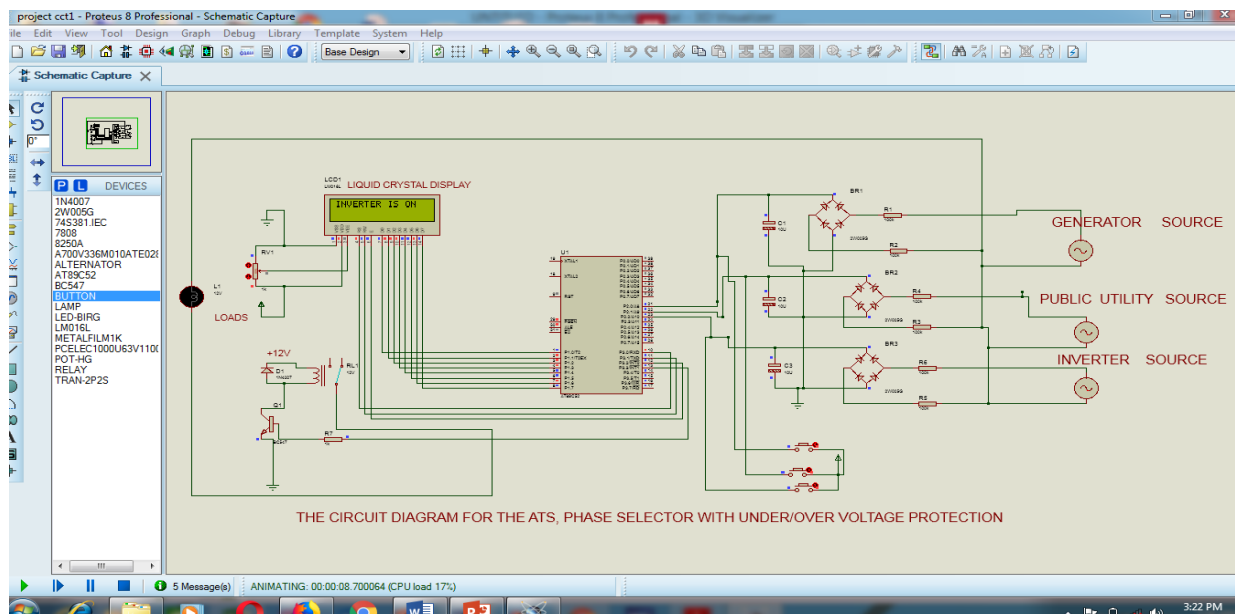


Fig. 11: Inverter in use

Fig. 12 shows the simulated result of when a generator was energized using Proteus software. It was observed that when power from the national grid was restored, the ATS quickly transferred the power to the loads in the estate. The system responded as predefined or programmed

The simulated result of the smart street light for energy management is shown in Fig. 12. It was observed that when the proteus torch flashed on it, the bulb came on as predefined.

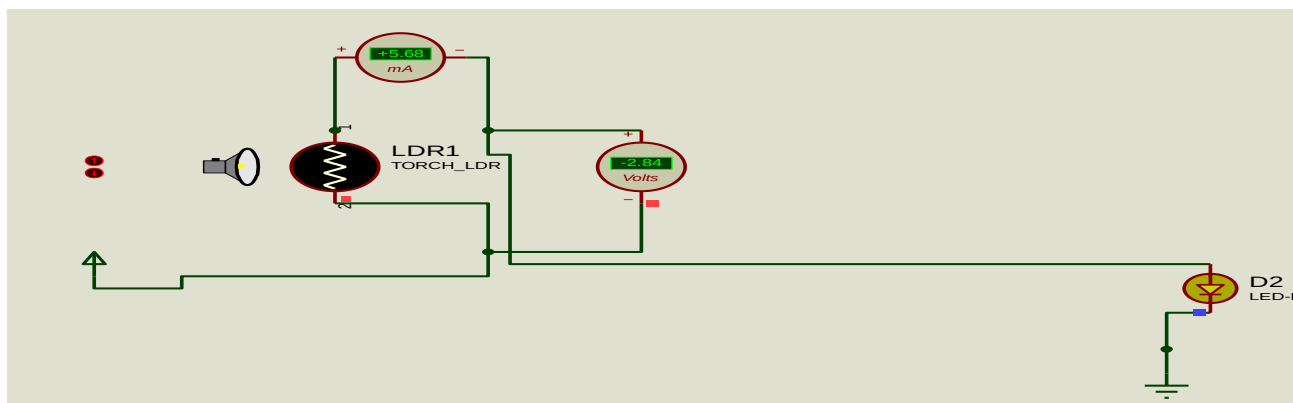


Fig 12: Smart Street Light simulated result

Since the system is made up of several modules of which demands a separate voltage level for maximum operation, a power supply of three different voltage levels was designed to supply 14V, 12V and 5V where needed in the entire system. Fig. 13 shows the simulated result of the voltage source for the several subsystems. The results obtained helped in getting different voltage levels for different sub-systems that require different voltage levels such as the controller (+5v), the relays (+12v) and +14v as the source voltage for further connections of sub-circuits.

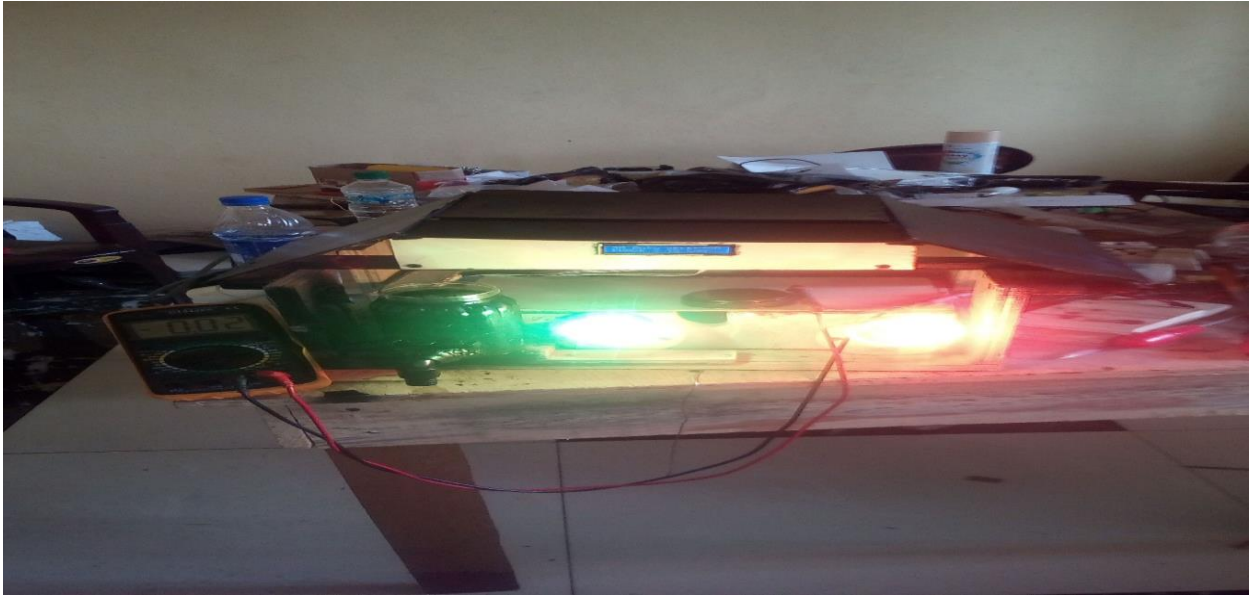


Fig. 14(a) The entire system result during the final test

Fig. 14(a) shows the result obtained from the entire system during the system test. Here the green alternating current bulb represents the water pumping machine for water supply when the tank is empty. It can be seen from the diagram that the green bulb is on, which means the water supply pump is on and the overhead tank is gradually filled. This continues until the tank is filled. As soon as the tank is filled, the green bulb switches off, showing that the Pump has stopped pumping until the water level drops below normal.

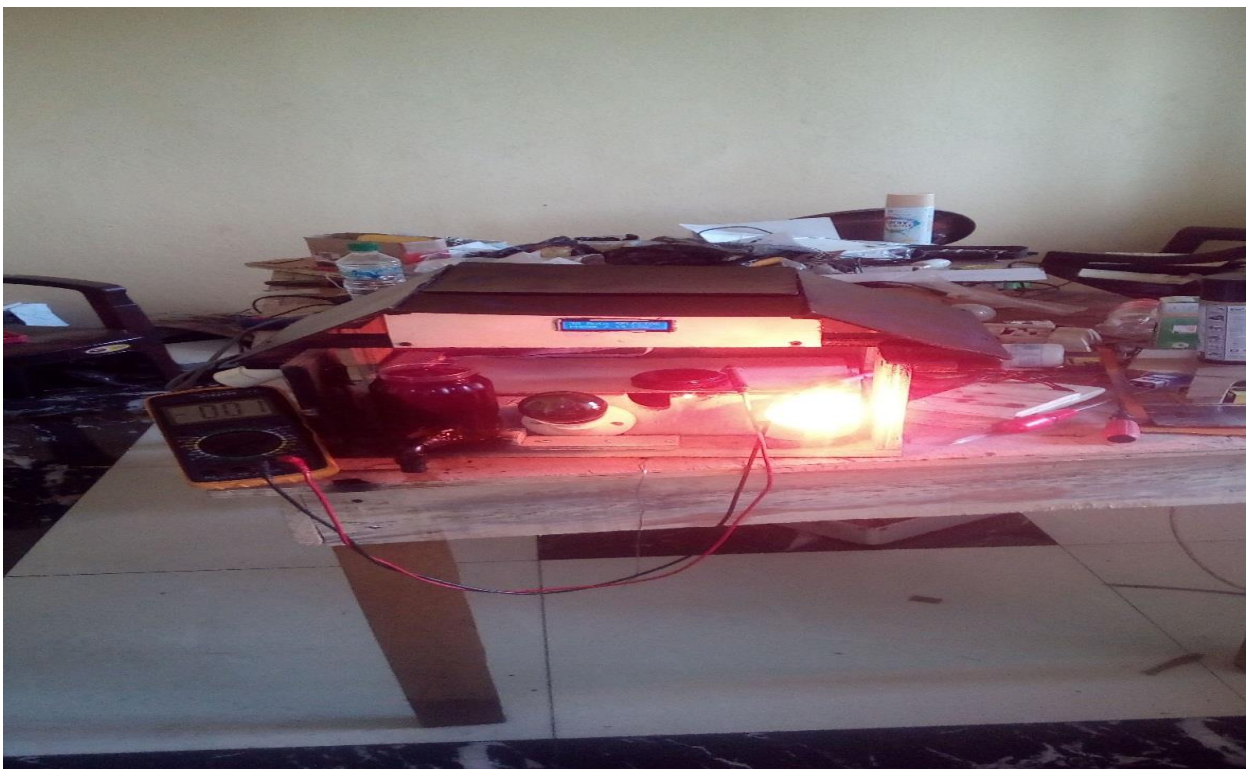


Fig. 14(b) The entire system result during the final test

Fig. 14(b) depicts the conditions where the overhead tank is filled and the green bulb is now off. Also in fig.15 (b), the red bulb indicates a successful controlling of the appliances within the estate. It also has a port for connecting any electronic choke generator for a remote control.

## 7. CONCLUSION

The Design and implementation of a smart control estate management system (SCEMS) using GSM and DTMF technologies has been successfully developed and tested. It is a fast and efficient approach to control the gadgets within an estate. This system can automatically transfer power to the loads by selecting the right phase based on the priorities of the available power sources and at the same time switch off generator or inverter in the event of case of power restoration from the national grid. With this system, one can remotely switch on or off an electronic choke generator from any location in the world as long as there is GSM network within the vicinity. It can serve as a better alternative to manual control of gadgets within an estate as it is very helpful in emergency situations. This system is capable of eliminating the work of a gate man in estates or homes, where it can be used to open the gate while approaching home without the need for honking and calling the attention of people in the house. One might forget to switch an appliance off before leaving the house, and on getting to the office, one can remotely turn off the device to avoid unnecessary energy consumption. With this system, the regular occurrence of armed robbers or kidnappers attacking people on an attempt to switch on or off the generator placed outside at odd hour of the night will be totally eliminated. In many estates, whenever the Sumo is switched on to pump water, there is always a standby person who will help to switch off the pump when the overhead tank is filled up and thereby making it seemly unavoidable to attend to other activities. This situation is overcome with this system. This system can also be deployed in a company or office that has Local Area Network (LAN) and the Control Room Manager can be monitoring the daily activities in each office with the aid of a Smart Phone camera. This is done by connecting the Smart phone to a Laptop wirelessly via Hotspot.

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