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Design and Construction of a GSM Based Energy Meter Reader and Load Control System

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Abstract: Electricity provides a very convenient form of energy for lighting, heating, cooling, motive power for driving various types of loads and power for a number of utilization applications. Its advantages in modern world are ease of control and cleanliness. This project report is focused on the design and construction of a GSM Based Energy meter reader and load control system. This smart meter has been proposed as an innovation solution aimed at facilitating afford ability and reducing the cost of utilities. This project sought to replace the existing manual reading of electricity meters installed throughout the country (home, agricultural and industrial). The designed GSM Based Energy meter reader and load control system circuit were designed using computer languages of HTML, CSS and Javascript and simple circuitry materials. The GSM based meter was then subjected to Proteus version 8 software for accuracy. Results obtained showed that the resultant design was a sustainable and suitable upgrade from our conventional energy systems. The system will cut costs and improve transparency to a very large extent. Any failure or inconveniences on the customer side can be easily detected and rectified. The electricity board can monitor each individual meter in the network. The server would provide a complete solution for the same, so there would be constant monitoring of the meter reading regularly without the person visiting each house.
Keywords: Energy Meter Reader, Internet of Things, Energy Monitoring, Modulator-demodulator, Liquid Crystal Display, Microcontroller

I. INTRODUCTION

Electricity provides a very convenient form of energy for lighting, heating, cooling, motive power for driving various types of loads and power for a number of utilization applications. Its advantages in modern world are ease of control and cleanliness. Electricity has become one of the basic requirements of human civilization, being widely deployed for domestic, industrial and agricultural purposes [1]. The annual consumption of electrical energy has been increasing rapidly throughout the world. The conversion of sources of energy into electricity for utilization is one way to measure the progress and development of a country in the modern world. An electrical power system is one of the tools of the present age for converting and transporting energy. An Electrical power system consists of three components:

1) Generating stations
2) Transmission systems
3) Distribution systems

These three components of power are integrated together to supply electricity to the consumers [2].

In spite of the very well developed sources of electricity, there are a number of problems with distribution, metering, billing and control of consumption. Electricity is one of the vital requirements for sustainment of comforts of life and so it should be used very judiciously for its proper utilization [1]. But in our country we have lot of localities where we have surplus supply for the electricity while many areas do not even have access to it. Our policies of its distribution are also partially responsible for this because we are still not able to correctly estimate our exact requirements and still power theft is prevailing [1]

Today’s conventional meters use kilowatt-hour as the standard unit of measurement. The billing requires readings to be read once during the period. This creates room for errors as it involves human intervention [3].

A. Statement Of Research Problem

Nowadays, the number of electricity consumers are increasing. It has become a hard task to handle and maintain power especially meter reading. If the consumer is not available at home during meter reading, the billing process will be hindered and human operator again needs to revisit. Going to each and every consumer’s house and generating the bill is a laborious task and requires lots of time. It becomes very difficult especially in rainy seasons. If any consumer did not pay the bill, the operator needs to go to their houses to disconnect the power supply.

In the process, some consumers beat up the utility staff who come to read or disconnect them when they are out of bills and it has led to some staff losing their lives. These process are time consuming and difficult to handle.
Morever, the manual operator cannot find the unauthorized connections or malpractices carried out by the consumer to reduce or stop the meter reading/ power supply. With the aid of this project, a definite solution is preferred which allows power companies to have total control over energy meters and have real time information of same from a remote location.

B. Objectives Of Research

The main objective of the project is to develop a GSM-Based Energy meter reader system and load control. The specific objectives to achieve our main objective are as follows:

1) To design and model the GSM based energy meter reader and load control system circuit.
2) To simulate the circuit using the proteus software.
3) Building of the web page portal for load monitoring and control.
4) Construction and fabrication of the GSM-Based energy meter reader and load control system circuit.

II. LITERATURE REVIEW

An electric meter or energy meter is a device that measures the amount of electrical energy consumed by a residence, business or an electrically powered device. Electric meters are typically calibrated in billing units, the most common one being the kilowatt-hour. The main operation of a conventional energy meter is to measure the voltage in volts and currents in ampere which is used to represent energy consumed in joules or in kilowatt-hour [4]. Researchers have proposed different implementation techniques for automatic meter reading(AMR) one as discussed in this report is the GSM Based Automatic Meter reading system which uses the GSM network for communicating with the meter.

A. Traditional Electricity Meters and Its Types

The electrical devices that can detect and display energy in the form of readings are termed as electricity meter. Traditional meters are used since the late 19th century [5]. They exchange data between electronic devices in a computerized environment for both electricity production and distribution. In most of the traditional electricity meter aluminum discs are used to find the usage of power [5]. Today's electricity meter is digitally operated but still has some limitations.
Some of the limitations faced by the traditional electricity meter [7] are as follows:

1) Meters are unreliable in nature as consumer has to anticipate for the monthly electricity bill.
2) The process of measurement is supported by a specific mechanical structure and hence they are called as electromechanical meters.
3) In order to perform meter readings, a great number of inspectors have to be employed.
4) Payment processing is expensive and time consuming.
5) New type of tariffs on hourly basis cannot be introduced with the corresponding meters for encouraging the consumer
6) Development of meter software applications and supportive network infrastructure is complicated.

Besides the above mentioned limitations, there are also several other elements creating a huge gap between the consumer and distributor because of installation of traditional meters. Meters are of distinct types. Even though timely development of electricity meters helps the consumer to gain knowledge with respect to electricity consumption, statistics of the consumption could not be changed. Some of the basic types of electricity meters are explained as follows:

Table 2.1 Various electricity meters

Different Types	Outline
Electrolytic Meter	The whole current passes through the electrolyte. The major drawback is mechanical considerations and adoption by limited localities.
Commutator Meter	Brush-shifting device is used to vary the current load and commutators of small diameter facilitates in insulation attention. The major drawbacks are inadequate load characteristics, maintenance cost and lack of proper insulation.

Mercury Motor Meter	There is a satisfactory performance with the introduction of this meter. The adoption of rotor made a prominent role in supplying the calibration. The momentary short circuit is reduced or even prevented.
D.C Watt Hour Meter	This meter model is developed for heavy current circuits where the temperature coefficient is high. For indication of demand purposes a separate time switch is used. Also, it is a clock-type meter in which voltage variations is less with the reduced shunt loss.
Single Phase Induction Meter	Magnetic conditions are better improved to control the energy consumption and a considerable improvement in performance is also done. Meter inspection is easily assessed as the construction of this model has accessibility of simplifying assembly.
Poly-Phase Watt Hour Meter	Lagging power factors in the meter reflects the characteristics of the current transformer. Attempts for improving high degree of accuracy have been built to avoid troublesome corrections. Interaction effects, calibration and increase in the effects of shunt loss are the greatest drawback of this model.

Source [8]

B. History Of Electric Energy Meter

1) Direct Current (DC)

As commercial use of electric energy spread in the 1880s, it became increasingly important that an electric energy meter was required to properly bill customers for the cost of energy. Edison at first worked on a DC electromechanical meter with a direct reading register, but instead developed an electrochemical metering system, which used an electrolytic cell to totalize current consumption. At periodic intervals the plates were removed, weighed, and the customer billed. [4]

An early type of electrochemical meter used in the United Kingdom was the 'Reason' meter. This consisted of a vertically mounted glass structure with a mercury reservoir at the top of the meter. As current was drawn from the supply, electrochemical action transferred the mercury to the bottom of the column. Like all other DC meters, it recorded ampere-hours. Once the mercury pool was exhausted, the meter became an open circuit. It was therefore necessary for the consumer to pay for a further supply of electricity. The first accurate, recording electricity consumption meter was a DC meter by Dr Hermann Aron, who patented it in 1883. [4]

2) Alternating Current (AC)

The first specimen of the AC kilowatt-hour meter produced on the basis of Hungarian OttóBláthy's patent and named after him. These were the first alternating-current watt-hourmeters, known by the name of Bláthy-meters. Also around 1889, Elihu Thomson of theAmerican General Electric company developed a recording watt meter (watt-hour meter) basedon an ironless commutator motor. This meter overcame the disadvantages of the electrochemical type and could operate on either alternating or direct current. [4] In 1894 Oliver Shallenberger of the Westinghouse Electric Corporation applied the induction principle previously used only in AC ampere-hour meters to produce a watt-hourmeter of the modern electromechanical form, using an induction disk whose rotational speedwas made proportional to the power in the circuit. Although the induction meter would onlywork on alternating current, it eliminated the delicate and troublesome commutator of the Thomson design. [4]

C. Types Of Meters

The main operation of a conventional energy meter is measuring the voltage in volts and current in amperes to give the energy used in joules or kilowatt-hour. The Electromechanical energy meter and electronic energy meter are the two categories of a basic energy meter. The most commonly used energy meter is the electromechanical induction watt-hour meter.

1) Electromechanical Meters

The Electromechanical induction meter operates by measuring the revolution of the electrically conducive and a non-magnetic metal which is rotating at the speed which is proportional to the power that is passing through the meter. The number of rotation or number of revolution is proportional to the power utilization [4].

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The Voltage coil consumes a small and relatively constant amount of power, typically around 2 watts which is not registered on the meter. The current coil similarly consumes a small amount of power in proportion to the square of the current flowing through it, typically upto a couple of watts at full load, which is registered on the meter.

The disc is acted upon by two coils. One coil is connected in such a way that it produces a magnetic flux in proportion to the voltage and the other produces a magnetic flux in proportion to the current. The field of the voltage coil is delayed by 90 degrees, due to the coil's inductive nature and calibrated using a lag coil. A permanent magnet exerts an opposing force proportional to the speed of rotation of the disc. The equilibrium between these two opposing forces results in the disc rotating at a speed proportional to the power or rate of the energy usage. The disc drives a register mechanism which counts revolution. The type of meter described above is used on a single-phase AC supply. [4]

The amount of energy represented by one revolution of the disc is denoted by the symbol "Kh" which is given in units of watt-hours per revolution. The value 7.2 is commonly seen. Using the value of Kh, one can determine their power consumption at any given time by timing the disc with a stop watch

$$\boldsymbol{P = \frac{3600.Kh}{T}} \qquad \textbf{(2.1)}$$

Where

T = time in seconds taken by the disc to complete one revolution

P = power in watts.

For example, if Kh = 7.2 as above and one revolution took place in 14.4 seconds, the power is 1800 watts. This method can be used to determine the power consumption of household devices by switching them ON one by one [4]

2) Electronic Meters

Electronic meters display the energy used on an LCD or LED display, and some can also transmit readings to remote places. In addition to measuring energy used, electronic meters can also record other parameters of the load and supply such as instantaneous and maximum rate of usage demands, voltages, power factor and reactive power used etc. They can also support time-of –day billing. For example, recording the amount of energy used during on-peak and off-peak hours. Image of electromechanical meter and electronic meter are shown below.

Figure 2.1: Traditional Electromechanical Meter Vs Electronic meter [9]

3) Smart Meter

Smart Meter is an environmentally friendly energy meter that is used for measuring the electrical energy in terms of KWh (Kilowatt - hours). It is simply a device that affords a direct benefit to the consumers who want to save money on their electricity bill. They belong to a division of Advanced Meter Infrastructure and are responsible for sending meter readings automatically to the energy supplier. Accurate meter reading will be provided with the inclusion of firm benefits from the Smart Meter. They record the consumption on the basis of hourly or less than hourly intervals. A Smart Meter has non-volatile data storage, remote connect or disconnect capability, tamper detection and two-way communication facilities. They perform remote reporting of the collected data to the central meter. This central meter monitors the functionality of the Smart Meter. From an operational perspective, use of Smart Metering allows an improved management and control over the electricity grid [10]. Some of the benefits of Smart Meters are as follows:

a) Low operational cost.

b) Time saving to the consumers and utility companies for reporting the meter reading back to the energy providers.

c) Online electricity bill payment is allowed.

d) Power consumption can be greatly reduced during the high peaks with an intimation policy.

e) Has a feature of automatically terminating the appliances off when they are not in use [11].

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Smart Meter senses all the consumption generated inside the residents. Meter readings give a broader understanding to the energy utilities so that overall energy usage customs of the habitants can be altered. Finally, all the information that is generated by Smart Meter will increase help in noble generation. A simple picture of a Smart Meter is shown below.

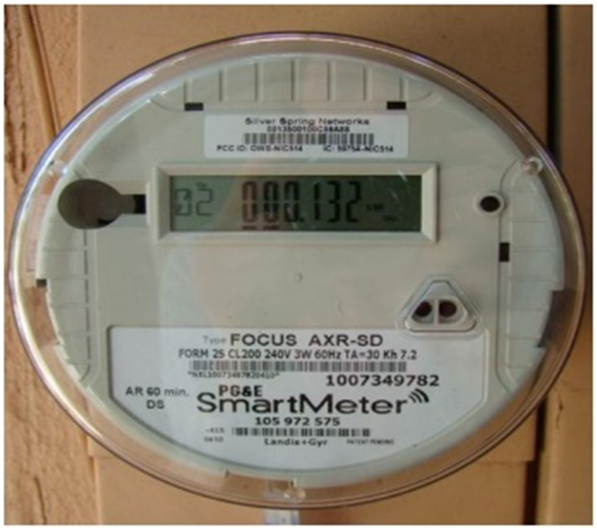

Figure 2.2: Smart Meter [12]

D. Metering As A System

The meter is key tool in any utility requiring efficient operation and maintenance as it links the utility with customers. A prepayment Metering System has been viewed as a system with many interrelated sub-systems. The General System Theory is one major theory at the root modern scientific approach to management Chadwick [13] defines a system as "a set of objects together with relationships between the objects and between their attributes," while Cole [14] looks at it as an interrelated set of activities which enables inputs to be converted into outputs. Systems may be closed or open. Closed systems are those which for practical purpose, are completely self-regulating and thus not interact with their environment. Therefore, in the context of this study, a prepayment metering system cannot be closed as it relies on inputs from the community where it is stimulated for its survival. In this regard, Cole [14] defines an open system as that which interacts with its community, on which it relies for obtaining essential inputs and for the discharge of system output. The inputs include people, materials, information, and finance, which are organized and activated so as to convert human skills and materials into products, services and other outputs that are discharge into the environment. The most important element of an open system is therefore, their inter-dependence on the community, which many are relatively stable or relatively uncertain at a particular point, [14].

According to Clelland [14], the management task of integrating various elements in the system is of paramount importance and this can only be effectively accomplished if the manager adopts the General Systems approach to the system he is managing. The system concept to prepayment metering in utilities is, therefore, a simple recognition that a prepayment metering is a system made up of sub- systems or the Master station, meter and the vending machine, each of which has its goals to achieve. In other words the meter record how much electricity has been consumed by the customer from the total produced by the utility while the master station ensures the customer has the correct amount of electricity sold to him through the vending machine and administers the whole system. "The boundaries between these subsystems called interfaces may be external or internal."[14] Consequently, in a system, some sub-systems have to deal with the inputs and the output for the system to work consistently at the external boundary e.g. meter reading, billing customers and distribution of bills and so forth. On the other hand, other sub-systems deal with consistent provision of services to others in the system at the internal boundaries e.g. human resources, management and accounts.

E. Prepared Metering

Prepayment Metering is a well-established technology being introduced by more and more utility companies. According to Keltless [15], "a Prepayment Metering System is a system where a customer pays for energy before using it." A Prepayment Metering System according to Kettless [15] basically comprises a system master station (which is a computer that operates and administers the whole system), a vending machine (where customers buy their electricity) and prepayment energy meters (or dispensers, which dispenses the electricity to the customer).

This meter has an interface to the customer for managing the transfer of credit and to display the meter and credit status. In this study, the benefits and problems of the Prepayment Metering System can only be assessed by looking at various subsystems as a whole and seeking to understand and measure the effectiveness of the system. Prepayment metering systems are basically categorized as either one way or two-way, referring to the flow of information between the vending machine and the meter. In the one-way system the information flows only in one direction, from the vending machine to the meter. This system can either be addressable or non-addressable. The addressable system uses tokens that are personalized to one meter and therefore cannot be used to credit any other meter. In the two-way system, information flows in both directions. In this system the meter also returns to the vending machine, information such as peak demand, average daily consumption etc. The system inherently requires expensive microprocessor smart cards, a sophisticated system of networked computers and vending stations.

F. Theoretical Framework

In [28], it was mentioned that the electromechanical enrollment meter works by checking the unrests of a non-drawing in metal plate which turns at a speed concerning the power experiencing the meter.

It was mentioned in [29] that the AMR framework is an effect for remote checking and controls private significance meter. AMR framework gives the data of meter dismembering control cut, mean stack utilized, control free and cementing on intrigue, or in many cases especially between times through SMS. The designing of web organizations based customized meter scrutinizing system has delineated.

It was mentioned in [30] that data sent and gotten by concerned energy Provider Company with the assistance of Global structure for flexible correspondence facilitates energy supplier getting the meter survey inside a second without visiting a man

It was mentioned in [31] that a novel Automatic Meter Reading (AMR) structure was proposed using the IEEE 802.15.4 obvious remote frameworks to visit with energy meter. The work deal with based Automatic Utility Data Collection System (AUDCS) gives a cost-capable design by inquisitive about the self affiliation, self-settling limits of the work organization, and using semiconductor chips and the radio handsets superb with IEEE 802.15.4 standard.

In [32] it was mentioned that Analog signals are been seen from the two information channels, which will be changed over into Digital signals by ADC uninhibitedly. With the two affected information signals transmitted to the microcontroller by techniques for SPI custom, dsPIC33F figures the power accordingly, imperativeness ate up will be gathered after a foreordained period.

In [33] it was mentioned that AMR is a framework whereby the Energy Meter sends the recorded power usage of a nuclear family in the particular between the time period to a "remotely" related, which could be a (PC) or central server of intensity dispersing affiliations

In [34] it was mentioned that GSM is an approach to remotely screen and control centrality meter readings. Its tendencies to take agander at imperativeness meters without visiting each house/affiliation. This structure contains a microcontroller, which takes the readings at general breaks and records it in its memory.

In [35] it was proposed two algorithms, namely clustered simple polling and neighbor relay polling, for solving the typical “silent node” problem in automatic meter reading (AMR) systems using power line communications (PLC)-access networks. A “silent node” is a meter unit that cannot receive signals directly from the Base Station or that cannot send its metering data back directly to the Base station. Here the factors responsible for an unreliable rate of data collection and significant time delay are the significant level of signal attenuation along cables, the noisy power-line environment, and the changing in home impedance. These schemes are tested through computer simulations to be both effective and efficient in overcoming the “silent node” problem in AMR systems. Also, a two-state transition Markov model is used to simulate a meter unit with such a “silent node” problem in a PLC network. The processing time model is established on a meter topology of three-level clustering. By using these models for our computer simulations, the performance of our proposed schemes can be evaluated in terms of reliability and efficiency. Polling is normally implemented in a system with a central controller that is called a Base station (BS).

The BS sends a “polling message” to each network station, in accordance with a round-robin procedure or any other cyclic order. When a network station receives a polling message from the BS and it has data to send back to the BS, it can transmit its data for a predefined time period. Then, the network station also transmits an acknowledgement (ACK) at the end of a packet transmission to inform the BS that its data transmission is completed before the stipulated time limit. If the network station has no data to send, it just sends an ACK to the BS to inform that it has no data to send. Afterwards, the BS polls the next network station in the same cycle immediately. If the BS cannot hear anything from the polled station after a stipulated time period, it will poll the next station anyway. Hence, the next network station in the same cycle can be polled. The NRP is a more effective mechanism because it can reach a nearly 100% data-collection success rate undernormal network conditions.

In some cases, the NRP cannot guarantee the data-collection time well below 30min due to additional time for the red polls. Under some extremely adverse network conditions, the meter units belonging to the same building and the same phase of the same transformer cannot be guaranteed as neighbors because they may not be able to communicate directly with each other. Hence, the polling message and metering data may need to go through more than one relaying meter.

G. Features And Challenges/ Issues Of Prepaid Smart Metering System

Tables 2.2-2.3 review a brief summary of features and challenges/issues of prepaid smart metering system, which were proposed by various researchers worldwide. Most of the research work, on electricity prepaid smart metering system in literature, has been focused on advantages of prepaid smart meters. However, these prepaid smart meters have many technological and communication limitations which are highlighted in Table 2.2. Table 2.3 also summarizes some existing prepaid smart meters challenges/issues proposed in the literature by various researchers and these prepaid smart meters are not appreciated due to advance payments. In addition, prepaid smart meters do not have an electricity anti-theft solution in case of any illegal activity occurrence.

Table 2.1: Features and challenges/issues in prepaid smart metering system.

Prepaid smart metering system	Features	Challenges/issue
European smart grid prospects, policies, and challenges [16]	• High capabilities to coordinate demand and supply in the energy network • Sustainable and secure power supply • Competitive and open markets	• Interoperability of SG • Program setup and design • Roll out of equipment • Integrating ICT system with existing system
A hybrid ICT-solution for smart meter data analytics [17]	• Send meter geographic locations • Indicate weather condition and user information	Compromised user privacy • Don't support three mod communication • Multiple layers issues
Collaborative service oriented smart grid, using the internet of things [18]	• Uses internet of thing for task management • Address the issues of interoperability, scalability and heterogeneity	• Involvement of multiple technologies • Protocol computability issues • Cost effective
Advanced smart metering infrastructure for futures mart homes [19]	Energy consumption • Based on smart devices in home • Home base display system for energy quality • Used for multipurpose like water and gas billing system	• Every home cannot be assumed to have smart home appliances • More wireless technologies are involved to get the meter reading from smart appliances • Frequent insertion of scratch balance cards into meter may decrease the performance of the balance card reader • Amount of wireless signals may dangerous for human health

Table 2.2: Features and challenges/issues in prepaid smart metering system.

Prepaid smart metering system	Features	Challenges/issue
A shipshape prepaid energy metering organism [20]	• Proposed server for electrical service board • Limit the extra usage of electricity	•Bidirectional communication between two ends • Advance payments • Cannot be reconfigure remotely
Power distribution scheme, using smart meter perspective [21]	• Prepaid base smart energy meter • Consumer define energy units for the month • Consumer empowerment by service provider	• The smart meter reading can be stopped through jammers • These meters are not capable of adjusting such variations • Cannot be statistically reconfigurable
Automatic energy meter reading system reviews [22]	• Remove the meter reader's visits in every location of meters • Sending meter reading, using radio frequency methods • Electricity board comes to know the consumption of energy	• Extra billing can be expected by electrical board • Consumer does not know to latest update of billing • Unable to provide on-demand electricity • Lack of real time three mode communication
A wireless automatic meter reading system based on digital image process and ZigBee-3G [23]	• Allows dynamically switching to alternative power backup (e.g., solar panel, UPS, generator) when the main power back up becomes unavailable • GSM module sends the signal to alternative power backup	• This system will only be activated when there is electricity load shedding or any fault • This is a lab based demon
Microcontroller and GSM based digital prepaid energy meter [24]	• Based on prepaid • Provide benefits for only power companies • Collects energy bills in advance	• When balance is exhausted the power is cut-off automatically without any warning or alters
Automatic meter reading and theft control system by using GSM [25]	•Meter is used in transformer for measuring total power consumption • Transmission of meter reading to power companies after 2 months	• Sends meter reading to only power companies, not to end consumers • Does not send meter reading to the service provider on daily basis
GSM based automatic energy meter reading system with instant billing [26]	• Sends meter reading wirelessly • Automatic bill generation • No human interaction	• Power consumption updates are sent every 30days, not on daily basis • No real time communication
Economical way of GPRS based fully automated energy metering system [27]	• Based on GPRS • Fully automatic system • Sends power consumption units to central data base on daily basis	• GPRS is economical but cannot have broader coverage • Does not support on-demand electrical power load management.

H. Research Gaps In Reviewed Literatures

The work above talked about power line communication which is an old fashioned method of communication. GSM based communication in this work was proposed for faster operation and higher efficiency.

It was proposed in [36] that power-line communication offers a networking communication over existing power lines and finds important applications in smart grid, home & business automation and automatic meter reading. However, the power-line channel is one of the harshest known communication channels currently in use and it requires robust forward error correction techniques. Powerful decoding algorithms tend to be complex and increase latency while robust modulation schemes offer lower data rates. The presented work extends the existing narrow-band power-line communication forward error correction scheme of concatenated Reed-Solomon Convolution codes in OFDM framework by introducing permutation codes as an inter-subcarrier encoding scheme in OFDM to combat narrowband interference and carrier frequency offsets. Permutation encoded OFDM has been presented as an alternative modulation scheme for narrow-band power-line communication. While it uses more bandwidth than OFDM, it performs much better in the presence of carrier frequency offsets. OFDM-MFSK is a similar scheme that was proposed by other researchers as another alternative. Although this scheme's performance is similar to that of the presented scheme, it is less efficient in terms of bandwidth utilization. Permutation encoded OFDM uses up to 103 subcarriers in a 256 length IFFT window, giving 40% bandwidth efficiency. On the other hand, OFDM-MFSK uses a maximum of only 64 subcarriers, translating to an efficiency of 25%. Permutation encoded OFDM therefore gives an improvement of 60% in terms of bandwidth efficiency on this scheme. In addition, MFSK-based schemes are limited to sending only $\log_2 M$ bits for every M frequency, while PE OFDM can employ higher order M-PSK schemes in OFDM subcarriers and achieve higher throughputs.

It was proposed in [37] the design of advanced physical layer for narrowband power line communications (NB-PLC) based on coded modulation . The coding modulation scheme is described and decoding process based on soft decoding is proposed. Using this innovative scheme, the decoder performs a gain of 3 dB at symbol error rate (SER) equal to 10-3 over traditional receiver with hard decoding. In the implementation analysis, both the digital signal processor (DSP) resources usage and the maximum data rate are considered. It is concluded that a transmission rate of 2.4kbps is reached for a robust NB-PLC and available resources can be used for full protocol stack implementation**.** This architecture greatly simplifies both the hardware and software design implementation of overall coding modulation NB-PLC modem.

Table 2.3: A summary of the major drawbacks of the above related works

S/NO	RELATED WORKS	DRAWBACKS
1	Smart metering for next generation energy efficiency and conservation by K.S.K Warenga and D.P Chandima	Though it talked about smart energy but arduino was not used
2	Improving the performance of mobile data collecting systems for electricity meter reading using wireless sensor network by N.Nhan et *al.*	This work made use of Zigbee communication which is outdated
3	Embedded energy meter by S. Maitra et *al*	A webpage wasn't created for checking the load status
4	GSM Based Automatic energy meter reading system with instant billing by S.N. George et *al*	Though a webpage was used in the work but it wasn't for showing the load status of the system.
5	Solution for the "Silent node" problem in an Automatic Meter Reading System using powerline communication by Q. Gao et *al*	It used power line communication which is an old fashioned method of communication

III. MATERIALS AND METHODS

A. Materials

Table 3.1: Summary of the Materials used for the project

MATERIALS	DESCRIPTION/ FUNCTIONS
IoT Wifi Module	Capable of either hosting an application or offloading all Wi-Fi networking functions from another application processes
Lampholders	Support lamps and connect them to electrical circuits. They hold light bulbs and make electrical contact to provide a bulb with power
Capacitors	Basically applied for filtering the output signal (electrolytic capacitor) or capacitive dropper (non-polarised capacitor)
Bulbs	Produces light on the application of electricity
Resistors	Majorly used as current limiters and voltage dividers
LM 7805 Voltage Regulator	Voltage regulator that outputs +5 volts
Relay	Used to isolate the consumer load from the power grid when either the loaded units are exhausted or the meter is been tampered with
BC 547 NPN Transistor	The NPN transistor is used for the switching of the relay. The BC 547 NPN transistor is selected based on current, voltage and power handling capabilities.
Liquid Crystal Display (LCD)	An LCD is an electronic display module, which uses liquid crystal to produce a visible image
SIM 900A GSM Module	SIM900A delivers GSM/GPRS 900/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption
Microcontroller (Arduino UNO)	The Arduino-Uno Microcontroller which is used in the proposed system for processing the input from sensors as well as providing necessary control signals to the peripherals.

B. Methods

1) System Description

The GSM Based Energy Meter Reader and Load Control System is an electronic unit design to take real time energy usage using a current sensing method which is then communicated to a microcontroller, who takes the appropriate calculations and displays on an LCD. A GSM MODEM is incorporated with the unit so as to make remote control of the meter unit by doing either of the following:

a) Connect the unit to the power grid
b) Disconnect the unit from power grid
c) Take meter reading
d) Recharge the meter unit
e) Reset the meter unit

2) System Block Diagram

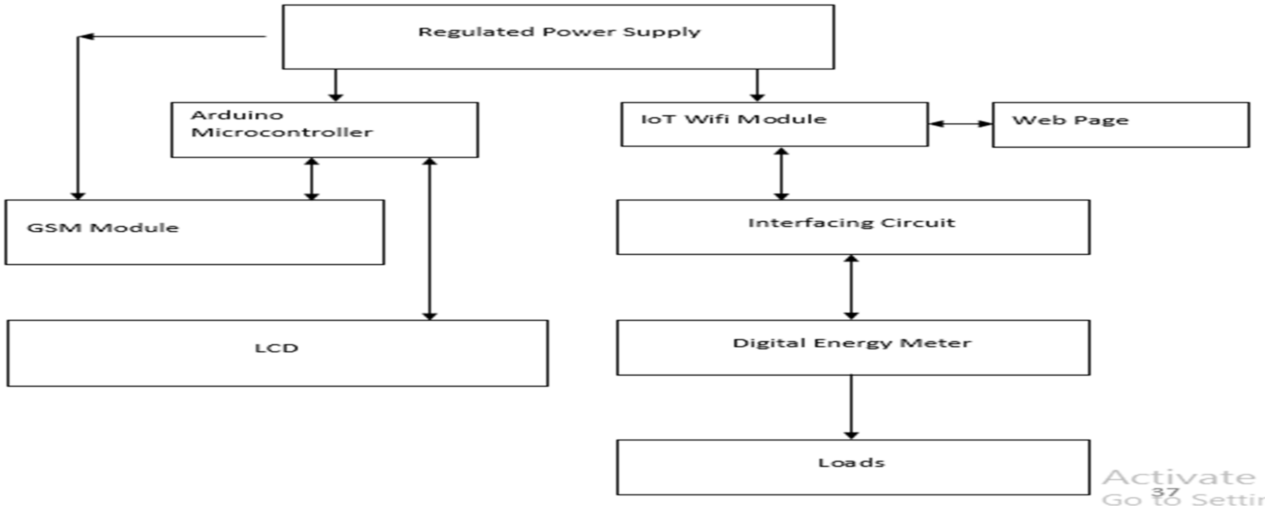

Figure 3.1: System Block Diagram

3) Hardware Design

This section describes the methods used in designing each component part of the system. Analyzing the choice of components and values as used in the circuit. The circuit was designed using Proteus 8. Design suite.

4) Circuit Analysis

The circuit is divided into 5 segments:

- The regulated power,
- Relay switching,
- microcontroller unit,
- LCD and
- Communication units.

a) Regulated Power Supply and Components

In this circuit there is only one voltage levels of 5V DC respectively, voltage regulator method, consisting of bridge rectifier, filtering capacitors, and a three terminal adjustable voltage regulator. With the 5V powering the LCD and the Microcontroller, and the Relay.

b) Bridge Rectifier

The 2W005G bridge rectifier has a diffused junction with a low forward voltage drop of 1V and a high current capability of 50A and an Average Rectified Output Current of 2A.

The output of rectifier voltage is given as

$$V = \sqrt{2} * V(RMS) * K - (2 * V.D) \quad \textbf{(3.1)}$$

$V(RMS) = 220V$

$V.D = 0.7V$

$K = 0.05$

$V = \sqrt{2} * 220 * 0.05 - (2 * 0.7)$

$V = 14.16V$

c) Filtering Capacitors

The filtering capacitors in this circuit are used to smooth the ripple of the rectifier output. When selecting a capacitor the important parameters are; the capacitance, working voltage and percentage ripple.

The working voltage is always given as

$\mathrm{Vwv} = 2\mathrm{Vp}$ **(3.2)**

Where Vp $=$ peak voltage given as

$\mathrm{Vp} = \sqrt{2} * \mathrm{Vrms}$ **(3.3)**

$\mathrm{Vp} = \sqrt{2} * 220$

$\mathrm{Vp} = 311.13\mathrm{V}$

$\therefore \mathrm{Vwv} = 2 * 311.13\mathrm{V}$3V

v=622.25V

The capacitance value can be obtained from the current formula of the capacitor given as;

$\mathrm{Ic} = \frac{\mathrm{dq}}{\mathrm{dt}}$ **(3.4)**

$\mathrm{q} =$ charge in coulombs

$\mathrm{q} = \mathrm{CV}$ **(3.5)**

$\mathrm{Ic} = \mathrm{C}\frac{\mathrm{dv}}{\mathrm{dt}}$ **(3.6)**

But $\mathrm{Fr} = \frac{1}{\mathrm{dt}}$ **(3.7)**

$\mathrm{Fr} =$ frequency ripple

$\mathrm{Ic} = \mathrm{CFrdv}$ **(3.8)**

$\mathrm{C} = \frac{\mathrm{Ic}}{\mathrm{Frdv}}$ **(3.9)**

Therefore, Fr is twice for full wave rectifier

R.M.S value of ripple voltage is given as:

$\mathrm{Vrms} = \gamma \mathrm{Vl(dc)}$ **(3.10)**

Where $\gamma =$ ripple factoror

dc=D.C voltage of the load

The voltage chosen for this project is 12V

$\therefore \mathrm{Vrms} = 0.482 * 12$12

.784V

So the capacitor value can also be determined by the given equation below:

$\mathrm{C} = \frac{\mathrm{Idc}}{4\sqrt{3}\mathrm{f}\gamma\mathrm{Vip}}$ **(3.11)**

$\mathrm{f} = 50\mathrm{Hz}$Hz

0.48

$\mathrm{Vip} = 14.16\mathrm{V}$6V

c=1A

Equation 3.11 becomes

$$\mathrm{C} = \frac{1}{4\sqrt{3} * 50 * 0.482 * 14.16}$$

$= 423\mathrm{picofarads}$

It can be deduced that the least capacitor value needed is 423µf, to get a high value of voltage; we require a large value of capacitance in the circuit. Thus, a capacitor with a value 1000µf was chosen. Which is more than twice the value of the needed capacitor value. This is used to provide safety in the circuit. Therefore, C4 and C5 are rated 1000µf.

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5) Interfacing the LCD with the Arduino Uno Microcontroller

A Liquid Crystal Display (LCD) is an electronic device that can be used to show numbers or text. There are two main types of LCD display, numeric displays (used in watches, calculators etc.) and alphanumeric text displays. LCD screen is an electronic display module and find a wide range of applications. A LCD display modules is preferred over seven segments and other multi segment LEDs [56].

A 20x4 LCD displays 20 characters per line and there are 4 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers: Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

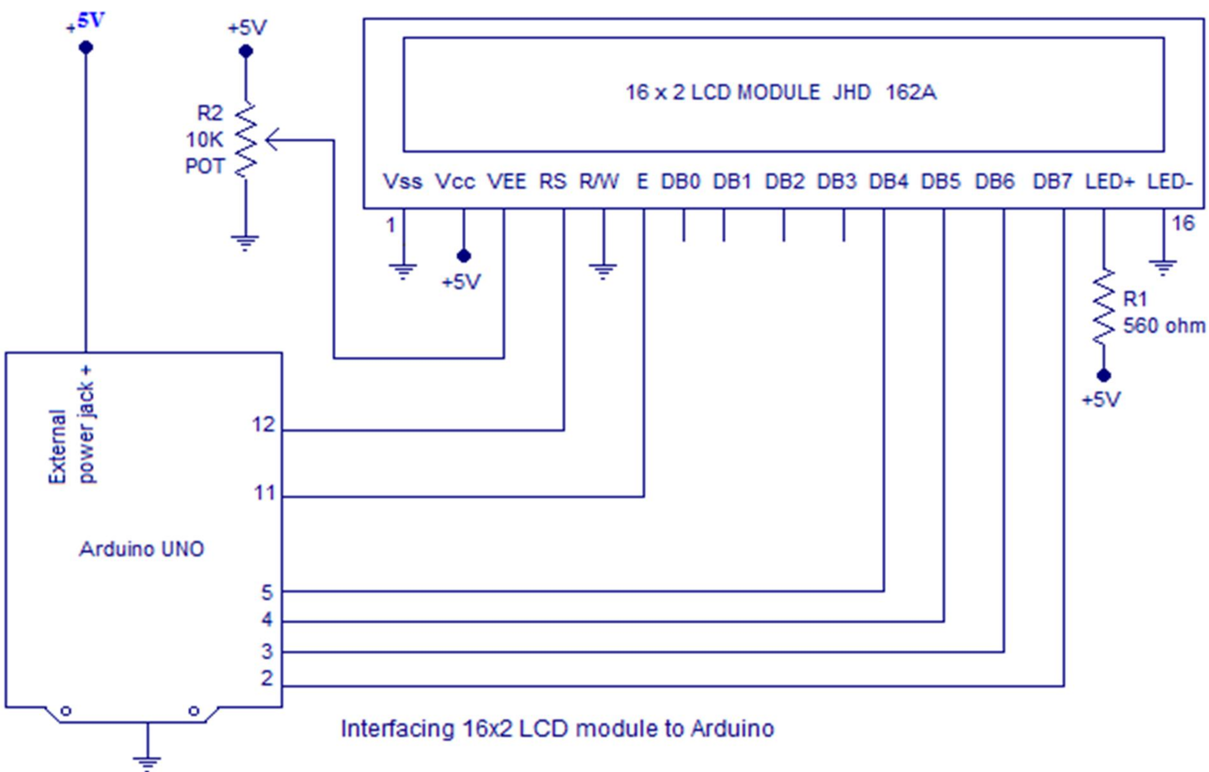

Figure 3.2: Interfacing LCD to Arduino [56]

6) Interfacing the GSM Module with the Arduino Uno Microcontroller

Table 3.1: Table showing the basic AT Commands (Source [58])

QUERY	AT COMMAND	RESPONSE
TEST COMMAND	AT+<X>=?	The mobile equipment returns list of parameters and values ranges set with the corresponding write command.
READ COMMAND	AT+<X>?	The command returns the currently set value of the parameters
WRITE COMMAND	AT+<X>=<…>	This command sets the user defined parameter values
EXECUTION COMMAND	AT+<X>	The execution command reads non-variable parameters affected by internal processes in the GSM modem

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a) Testing Your GSM Modem

- The GSM modem can be tested by connecting it with a PC. The modem is equipped with a RS232 cable. Just use a Serial to USB converter and connect it with the PC.
- Now you can proceed with sending the commands to the modem using any serial communication program like HyperTerminal, Mincom etc. Ensure the serial parameters are configured to 8N1 and the baud rate is set to 9600bps.
- For each command you send the modem acknowledges with a message.

Example: Just try sending "AT" to the modem. It sends back a result code "OK" which states that the modem is responding if it's not working fine, it sends "ERROR".

b) Booting up the GSM

- Insert the SIM card to module and lock it.
- Connect the adapter to module and turn it ON!
- Now wait for some time (say 1 minute) and see the blinking rate of 'status LED' (GSM module will take some time to establish connection with mobile network)
- Once the connection is established successfully, the status LED will blink continuously every 3 seconds.

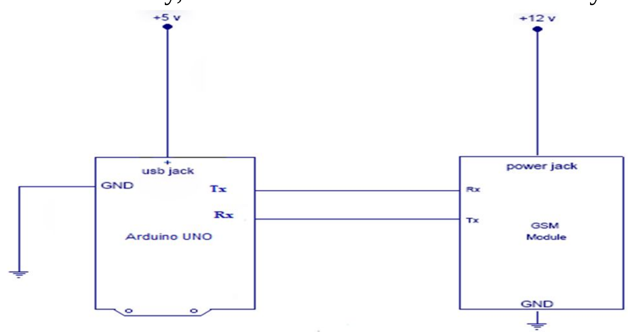

Figure 3.3: Interfacing GSM module to the Arduino [59]

c) Taking Pulse Out Of Energy Meter

- Using LDR we can take pulse from energy meter
- Open the Energy meter first
- Just Cut the Cathode terminal of the **Cal** LED
- Solder 2 wires on the 2 ends of the LED.
- Connect positive terminal of led to positive terminal of LDR and negative terminal of led to other end of LDR
- Interface the LDR and Arduino
- Connect the circuit as shown in figure

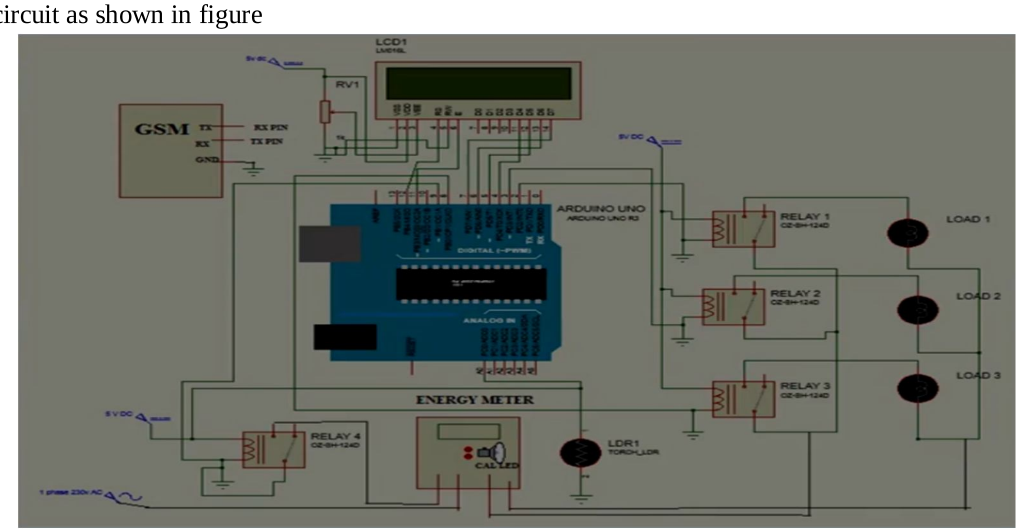

Fig.3.4: Circuit Diagram of a GSM Based Energy Meter Reader and Load Control System

7) Software Design

Been an embedded system, the programme was written in C# using the Arduino Integrated Development Environment (IDE). The program was then compiled to the memory of the Arduino Microcontroller. For any software design the following steps are considered:

- Understand the program
- Plan the logic
- Code the programmable
- Translate the program to machine language
- Test the program
- Put the program to production

According to the hardware circuit design features, meter reading terminal program flowchart was introduced as shown in figure 3.4. First the system initializes each module, and then reads the meter reading regularly and stores them. When the receiving the command, meter send the current status along with the energy consumption.

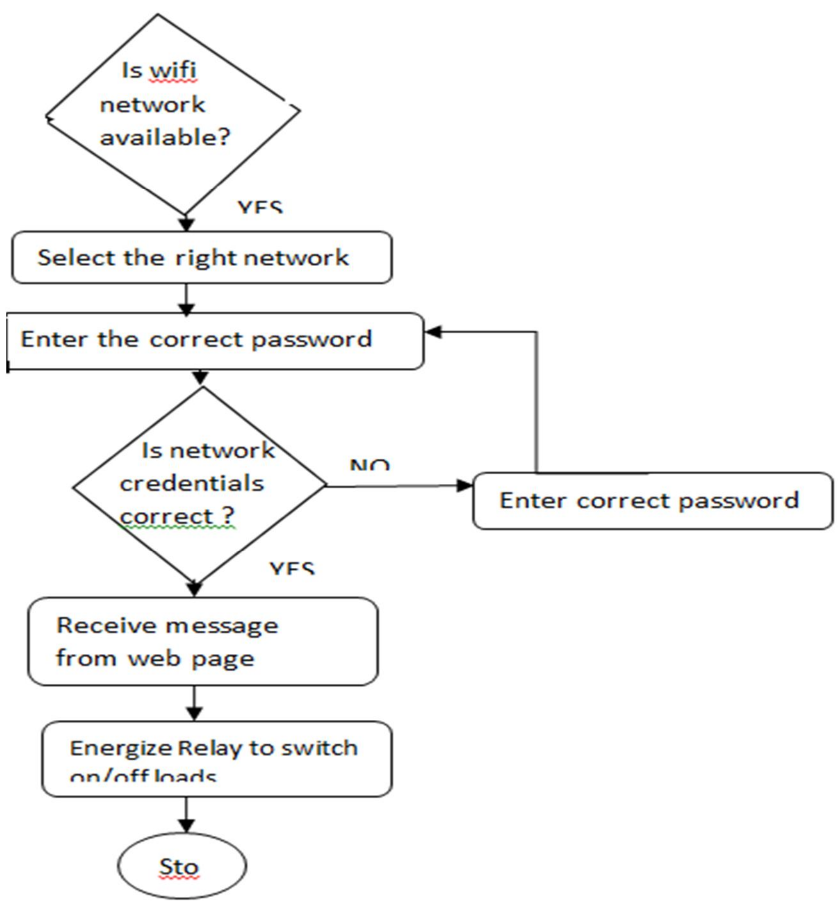

Figure 3.5: Flowchart for Modification of The GSM Based Energy Meter Reader and Load Control System

It can be seen from the above that web technology was added to the existing flowchart above in an attempt to modify it so that we can using two technologies namely: GSM and web to control the load and also get the energy meter consumption details anytime we want it.

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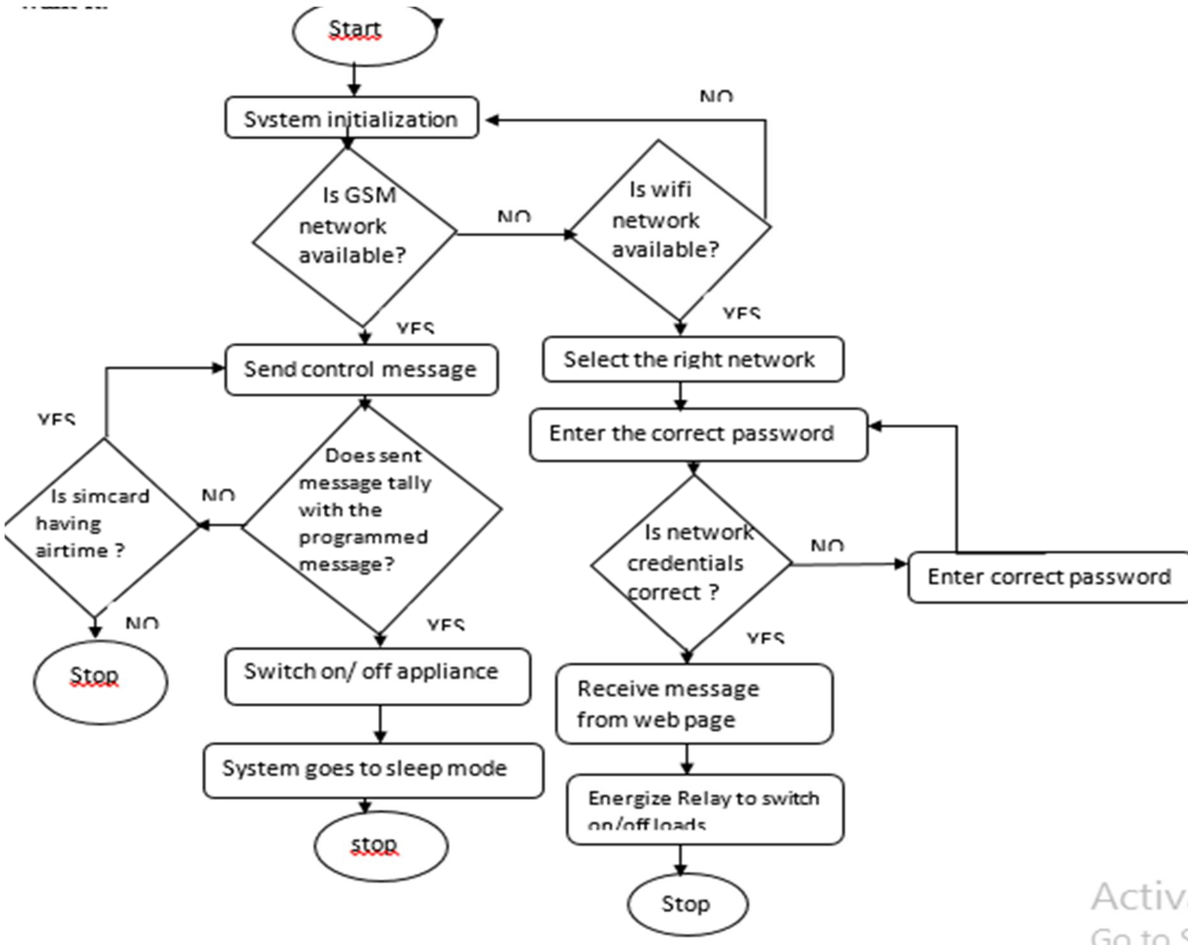

Figure 3.6: Flowchart of the GSM Based Energy Meter Reader and Load Control System with The GSM and Web Technology Incorporated Together

8) Circuit Design Using Veroboard

Veroboard is a brand of stripboard, a pre-formed circuit board material of copper strips on an insulating bonded paper board used to make electronic circuits, where some of the electrical connections are formed by strips of copper on the underside of the board.

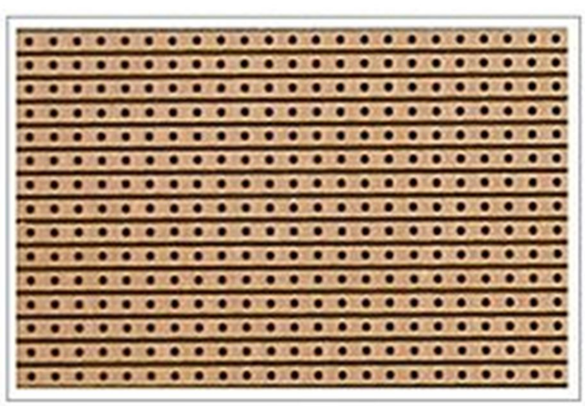

Figure 3.7: Veroboard [61]

9) Casing and Packaging

After the components were soldered to the PCB, continuity tests were carried out to ensure proper connections of the components. The packaging materials include a base for mounting the constructed which is placed in a plastic casing which houses the PCB and GSM modem. Below is the description of the base material. The casing used to house the PCB and GSM modem is a white ready-made PVC material. This was used as it fits the desired purpose and neatness. Holes were drilled on the cover to allow for the LCD screen. The side of the case was drilled also to allow the GSM modems antenna out and the external wirings. Below is a figure showing the dimensions of the PVC casing.

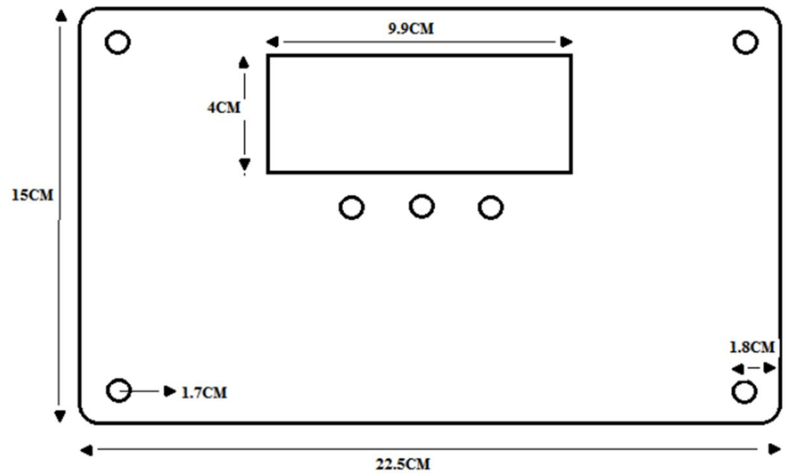

Figure 3.8: Top View of the PVC Casing

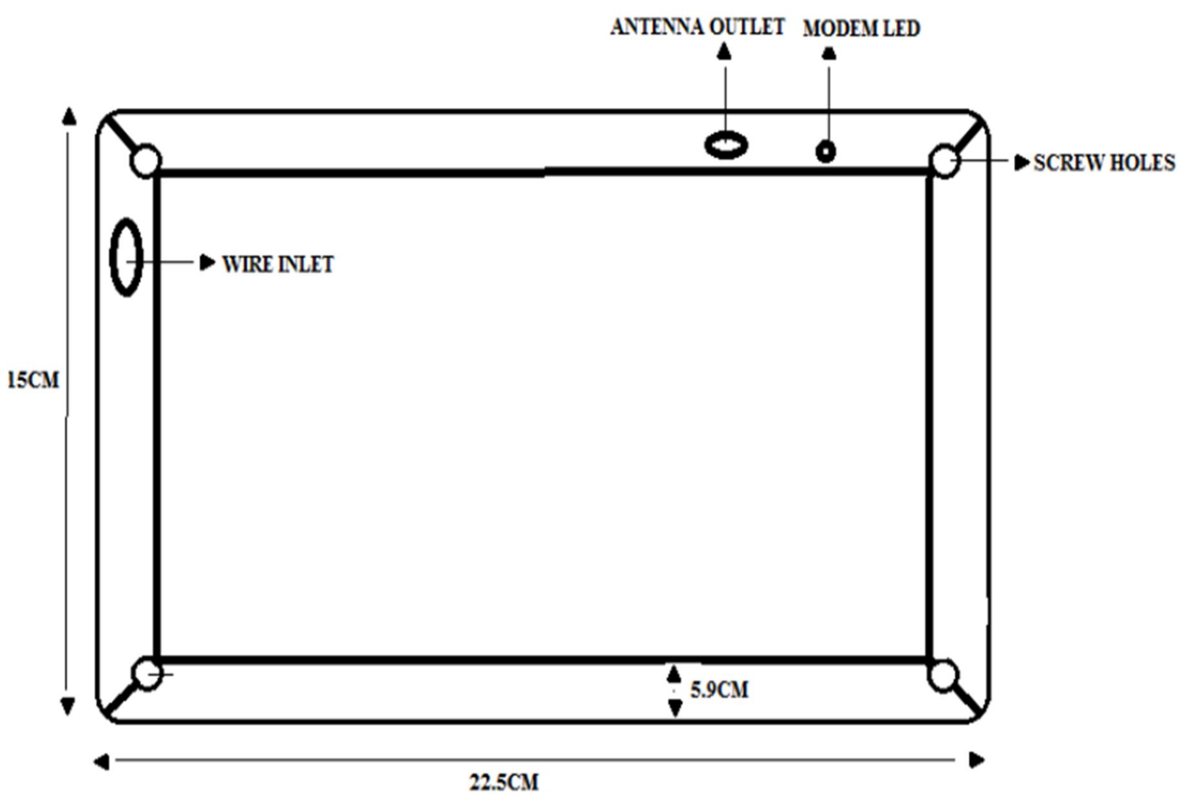

Figure 3.9: Inside view of PVC Casing

IV. RESULTS AND DISCUSSIONS

The following are the results for the various operations of the GSM Based Energy Meter Reader and Load Control System

A. *The Off State of the Loads*

Figure 4.1: The OFF state of all loads

B. *Sending of SMS from A Mobile to Switch On and Off the Load*

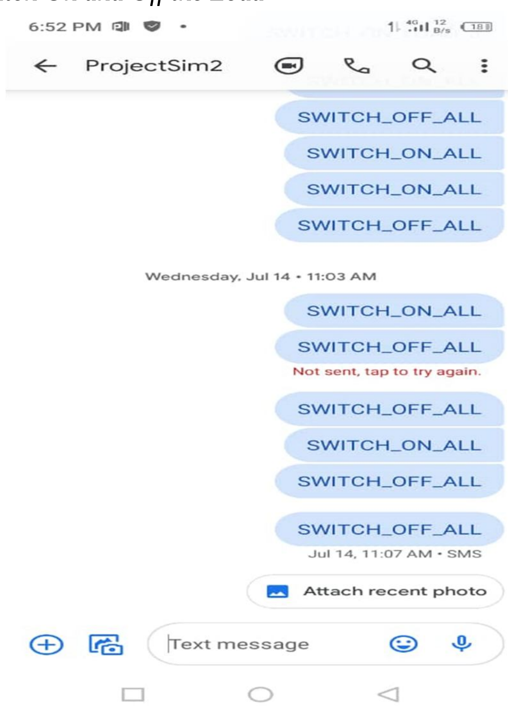

Fig.4.2: A screenshot of the messaging interfacing

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C. The On State of a Single Load After Sending of SMS

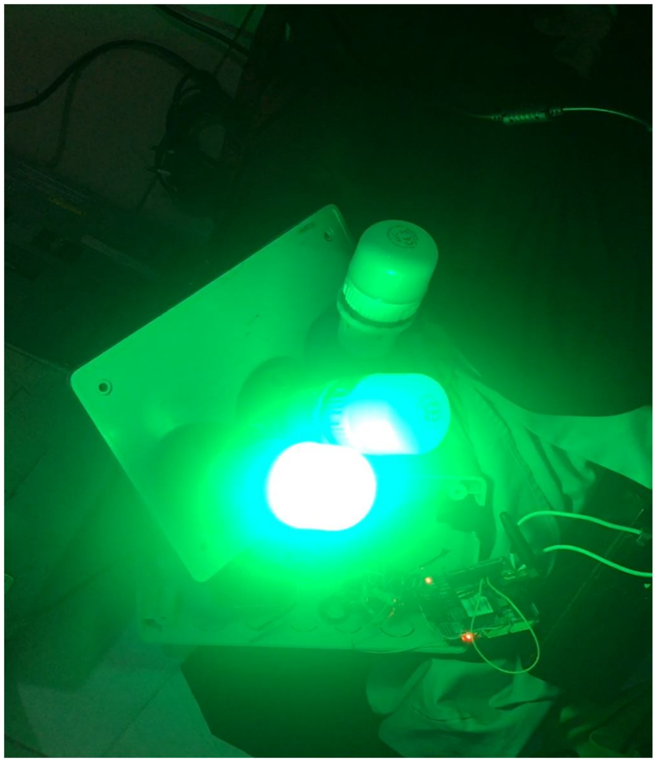

Fig.4.3: The ON state of a single load

D. The On State of Two Loads After Sending of SMS

Fig.4.4: The ON state of Two loads

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E. The On State of All the Load After Sending of SMS

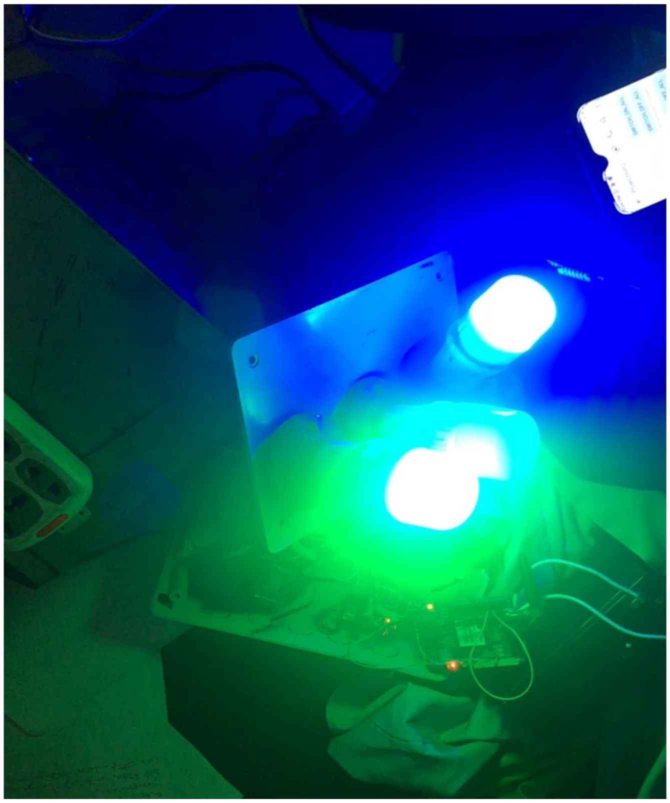

Fig.4.5: The ON state of all three loads

F. The Energy Meter Display the Energy Consumption Details

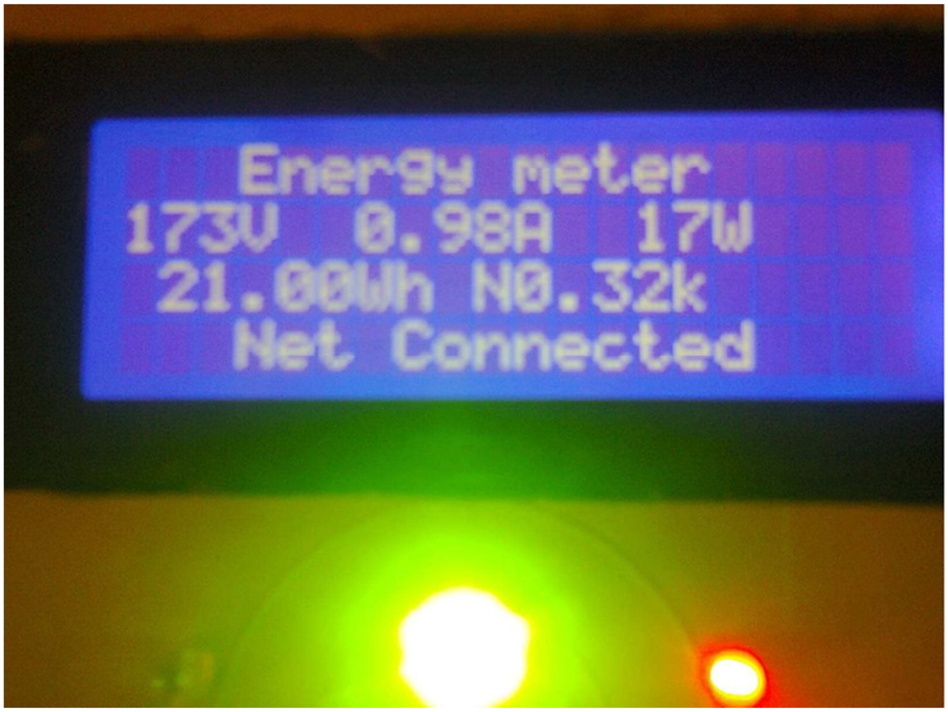

Fig.4.6: A display of the energy consumption details

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V. DISCUSSION

The GSM Based energy meter reader and Load control system was generally a successful project as most of the aims and objectives and how they were achieved are outlined below

The objective to design and model a GSM Based Energy meter reader and load control system circuit was achieved as explained in section 3.2 The objective to simulate the circuit using the proteus software was achieved

The objective of building a webpage was achieved by using simple HTML, CSS and Javascript

The objective of constructing and fabricating a GSM Based Energy Meter Reader and Load Control System circuit was achieved as explained in section 3.2

The project is seen to be cost effective as most components are readily available locally. The packaging as seen is a plastic casing. From the cost evaluation table below it can be deduced that the cost of producing a unit is quite expensive due to the procedures and methods of carrying out the project in a local setting. It should therefore be noted that for a mass production on a commercial scale the cost will reduce as much as 50% of the cost of producing a unit as components will be purchased in bulk. The use of an analog meter would not be required as it is used in the model for comparison.

The table below shows the list of all components used and the corresponding unit cost.

Table 5.1 Cost Evaluations

S/N	ITEMS	DESCRIPTION	QUANTITY	RATE (₦)	AMOUNT (₦)
1	ARDUINO UNO	MICRCONTROLLER	1	3000	3000
2	WIFI MODULE	IOT CONNECTION	1	1500	1500
6	5V RELAY MODULE	RELAY	1	2000	2000
7	BC 547	TRANSISTOR	1	200	200
8	ENERGY METER	ENERGY METER	1	17800	17800
9	LM7805	VOLTAGE REGULATOR	1	150	150
10	2W005G	BRIDGE RECTIFIER	1	150	150
11	SPST CONTROL SWITCH	SWITCH	1	1000	1000
12	BUZZER	BUZZER	1	50	50
13	BATERESS BOX	CASING	1	1500	1500
14	R1-R15	RESISTORS	20	10	200
15	C1, C2, C3, C8, C10, C13.	CERAMIC CAPACITORS	7	50	350
16	C4, C5, C7,C8, C9	POLARIZED CAPACITORS	5	100	500
17	C11	CAPACITOR	1	100	100
18	20*4 LCD	DISPLAY	1	3000	3000
19	WEBPAGE DESIGN	WEBPAGE DESIGN	-	40000	15000
20	SIM 900A	GSM MODEM	1	15000	15000
21	SIM CARD	MTN SIM CARD	1	300	300
22	JUMPERS	CONNECTORS	-	-	750
23	VEROBOARD	BOARD	1	500	500
24	PCB	BOARD	1	800	800
25	ENERGY BULB	BULBS	3	400	1200
26	LAMPHOLDER	LAMPHOLDER	3	150	450
27	MISCELENOUS				5000
28	TOTAL				70450

VI. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

Modern civilization would be brought to its knees, if a crisis of electricity scarcity ever looms. The cusp of society would collapse. Therefore, the undeniable need for uninterruptible electricity is the prelude to development of any nation in the world today. From the design of the system and development, it is realized that the implementation of the GSM BASED ENERGY METER READER AND LOAD CONTROL SYSTEM meets the objectives of its design as it was able to fully remote control the activities of the meter unit by doing the following making it beneficial to both utility company and consumer:

1) Connect the unit to Power grid
2) Disconnect the unit from power grid
3) Take meter reading
4) Reset the meter unit

Therefore meeting the requirements of providing a solution to power theft, load control, proper documentation of individual consumer energy usage over a period of time. Providing the power utility company to proper plan and design sufficient infrastructure equipment for power transmission.

B. Recommendations

1) Further development work can be done in the area of tampering in meters as this seem to be major setback, though as known no system is 100% safe.
2) The use of tamper proof seals and labels, tamper resistant screws and locks and providing non-magnetic enclosure.
3) The use of surveillance camera in the project in order to know if actually the load control is very efficient and operational

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APPENDICES

A. Appendix A

```
//Appendix A
//The Arduino code/sketch
#include <ESP8266WiFi.h>
#define LED 2
String header;
//String header;
String LED_ONE_STATE = "off";
String LED_TWO_STATE = "off";
String LED_THREE_STATE = "";
const int GPIO_PIN_NUMBER_22 = 4;
const int GPIO_PIN_NUMBER_23 = 2;
const int GPIO_PIN_NUMBER_15 = 15;
//LED AT GPIO4
//const char*ssid="Airtel 4G MiFi_EAED";
//const char*password="03868397";

//const char*ssid="victor okechukwu";
//const char*password="itcanonlybeGod";

const char*ssid="Glo Mobile WiFi";
const char*password="46528761";

unsigned char status_led=0;
WiFiServer server(80);
WiFiClient client;
//client = server.available();
void setup() {
 client = server.available();
  // put your setup code here, to run once:
Serial.begin(115200);
pinMode(GPIO_PIN_NUMBER_22, OUTPUT);
pinMode(GPIO_PIN_NUMBER_23, OUTPUT);
pinMode(GPIO_PIN_NUMBER_15, OUTPUT);
digitalWrite(GPIO_PIN_NUMBER_22, LOW);
digitalWrite(GPIO_PIN_NUMBER_23, LOW);
digitalWrite(GPIO_PIN_NUMBER_15, LOW);


Serial.print("Connecting to ");
//Serial.println(ssid);
//WiFi.begin(password);
```

```
WiFi.begin(ssid, password);

//WiFi.begin(WIFI_PASSWORD);
while (WiFi.status() != WL_CONNECTED) {
delay(1000);
Serial.print("Trying to connect to Wifi Network");
}
Serial.println("");
Serial.println("Successfully connected to WiFi network");
Serial.println("IP address: ");
//Serial.println(WiFi.localIP());
Serial.println(WiFi.localIP());
server.begin();
}
void loop(){
WiFiClient client = server.available();
if (client) {
Serial.println("New Client is requesting web page");
String current_data_line = "";
while (client.connected()) {
if (client.available()) {
char new_byte = client.read();
Serial.write(new_byte);
header += new_byte;
if (new_byte == '\n') {

if (current_data_line.length() == 0)
{

client.println("HTTP/1.1 200 OK");
client.println("Content-type:text/html");
client.println("Connection: close");
client.println();

if (header.indexOf("LED0=ON") != -1)
{
Serial.println("GPIO23 LED is ON");
LED_ONE_STATE = "on";
digitalWrite(GPIO_PIN_NUMBER_22, HIGH);
}
if (header.indexOf("LED0=OFF") != -1)
{
Serial.println("GPIO23 LED is OFF");
LED_ONE_STATE = "off";
digitalWrite(GPIO_PIN_NUMBER_22, LOW);
}
if (header.indexOf("LED1=ON") != -1)
{
Serial.println("GPIO23 LED is ON");
LED_TWO_STATE = "on";
```

```
digitalWrite(GPIO_PIN_NUMBER_23, HIGH);
}
if (header.indexOf("LED1=OFF") != -1)
{
Serial.println("GPIO23 LED is OFF");
LED_TWO_STATE = "off";
digitalWrite(GPIO_PIN_NUMBER_23, LOW);
}
if (header.indexOf("LED2=ON") != -1)
{
Serial.println("GPIO15 LED is ON");
LED_THREE_STATE = "on";
digitalWrite(GPIO_PIN_NUMBER_15, HIGH);
}
if(header.indexOf("LED2=OFF") != -1) {
Serial.println("GPIO15 LED is OFF");
LED_THREE_STATE = "off";
digitalWrite(GPIO_PIN_NUMBER_15, LOW);
}

client.println("<!DOCTYPE html><html>");
client.println("<head><meta name=\"viewport\" content=\"width=device-width, initial-scale=1\">");
client.println("<link rel=\"icon\" href=\"data:,\">");
client.println("<style>html { font-family: Helvetica; display: inline-block; margin: 0px auto; text-align: center;}");
client.println(".button { background-color: #4CAF50; border: 2px solid #4CAF50;; color: white; padding: 15px 32px; text-align: center; text-decoration: none; display: inline-block; font-size: 16px; margin: 4px 2px; cursor: pointer; }");
client.println("text-decoration: none; font-size: 30px; margin: 2px; cursor: pointer;}");
// Web Page Heading
client.println("</style></head>");
client.println("<body><center><h1>DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENEGINEERING,FEDERAL UNIVERSITY OF TECHNOLOGY,OWERRI</h1></center>");
client.println("<center><h2>PROJECT TOPIC: DESIGN AND CONSTRUCTION OF A GSM BASED ENERGY METER READER AND LOAD CONTROL SYSTEM</h2></center>" );

client.println("<center><h2>Names of Students and Registration Numbers</h2></center>" );
client.println("<center><h3>DIMKPA VINCENT CHIZIKE:  20151012853</h3></center>" );
client.println("<center><h3>OGU VICTOR UCHENNA:      20151019883</h3></center>" );
client.println("<center><h3>AGBA JOSHUA CHUKWUEBUKA: 20151018343</h3></center>" );
client.println("<center><h2>PROJECT SUPERVISOR: ENGR. DR. U.O. LAZARUS</h2></center>" );

client.println("<center><h2>Press on a designated button to turn ON/OFF a device of your choice in the house</h3></center>");
client.println("<form><center>");
client.println("<p>REFRIGERATOR IS " + LED_ONE_STATE + "</p>");
// If the PIN_NUMBER_22State is off, it displays the ON button
client.println("<center> <button class=\"button\" name=\"LED0\" value=\"OFF\" type=\"submit\">LED0 OFF</button>") ;
client.println("<button class=\"button\" name=\"LED0\" value=\"ON\" type=\"submit\">LED0 ON</button><br><br>");
client.println("<p>PARLOUR CEILING FAN IS " + LED_TWO_STATE + "</p>");
client.println("<button class=\"button\" name=\"LED1\" value=\"OFF\" type=\"submit\">LED1 OFF</button>");
client.println("<button class=\"button\" name=\"LED1\" value=\"ON\" type=\"submit\">LED1 ON</button> <br><br>");
client.println("<p>ADD NEXT LOADS HERE... " + LED_THREE_STATE + "</p>");
```

```
client.println ("<button class=\"button\" name=\"LED2\" value=\"OFF\" type=\"submit\">LED2 OFF</button>");
client.println ("<button class=\"button\" name=\"LED2\" value=\"ON\" type=\"submit\">LED2 ON</button></center>");
client.println("</center></form></body></html>");
client.println();
break;
}

else
{
current_data_line = "";
}
}
else if (new_byte != '\r')
{
current_data_line += new_byte;
}
}
}
// Clear the header variable
header = "";
// Close the connection
client.stop();
Serial.println("Client disconnected.");
Serial.println("");
}
}
```

B. Appendix B

```
LAMP_CONTROL_CODE_FOR_THREE_LOADS
/*
 * Complete Project Details https://randomnerdtutorials.com
 */

// Include Software Serial library to communicate with GSM
#include <SoftwareSerial.h>

// Configure software serial port
SoftwareSerial SIM900(8, 9);
const int BUTTON_PIN = 2;
int lastButtonState;    // the previous state of button
int currentButtonState; // the current state of button
char phone_no1[]= "+2348069467459";//MR VICTOR
// Variable to store text message
String textMessage;

// Create a variable to store Lamp state
String lampState = "HIGH";

// Relay connected to pin 12
const int relay=7;
```

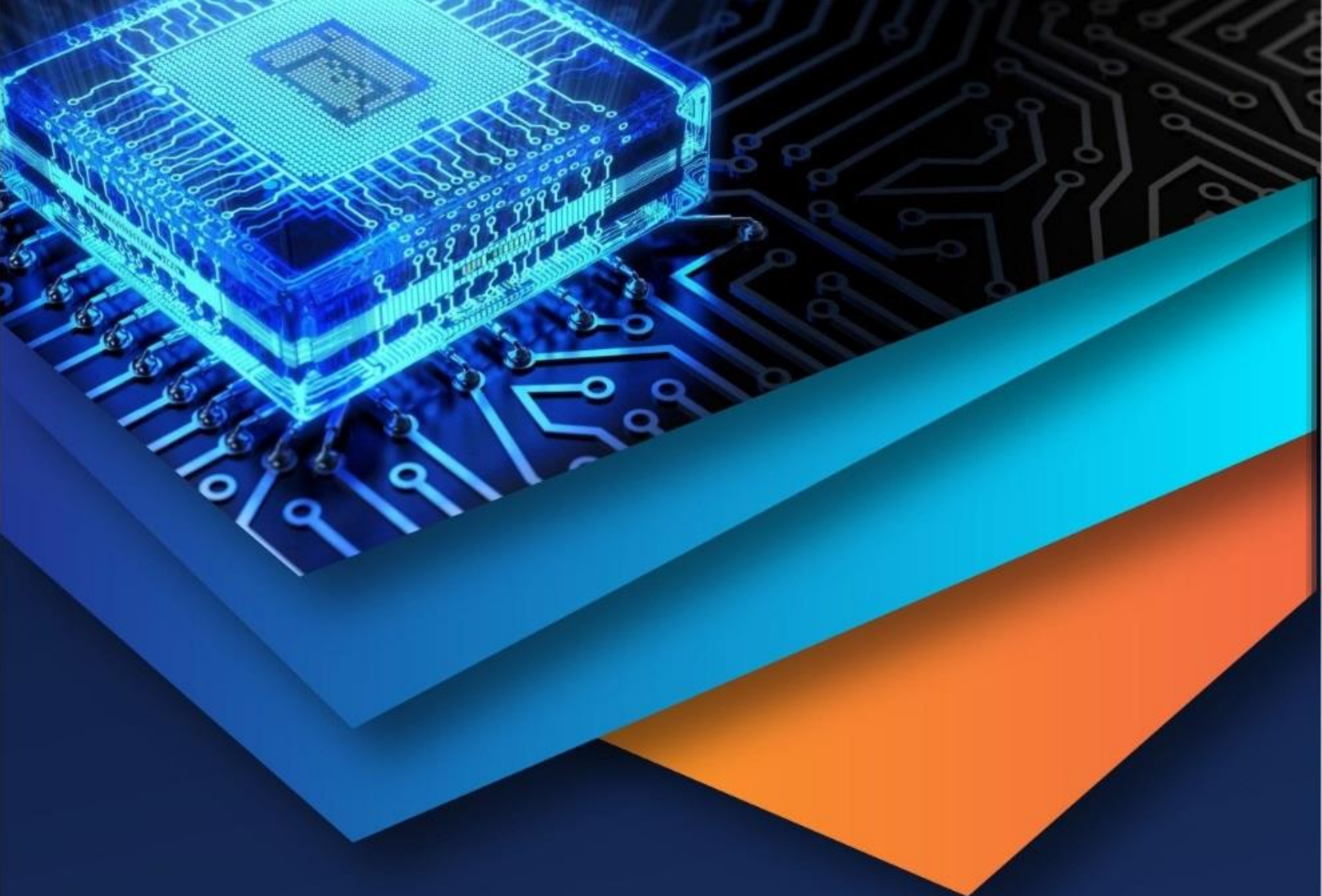
```
const int relay1=6;
const int relay2=5;

void setup() {
//pinMode(BUTTON_PIN, INPUT_PULLUP);
  //currentButtonState = digitalRead(BUTTON_PIN);
  // Automatically turn on the shield
  //digitalWrite(9, HIGH);
  delay(1000);
  //digitalWrite(9, LOW);
  delay(5000);

  // Set relay as OUTPUT
  pinMode(relay, OUTPUT);
  pinMode(relay1, OUTPUT);
  pinMode(relay2, OUTPUT);
   pinMode(BUTTON_PIN, OUTPUT);

  // By default the relay is off
  digitalWrite(relay, HIGH);
  digitalWrite(relay1, HIGH);
  digitalWrite(relay2, HIGH);
   digitalWrite(BUTTON_PIN, LOW);
  delay(1000);
   digitalWrite(BUTTON_PIN, HIGH);
  // Initializing serial commmunication
  Serial.begin(9600);
  SIM900.begin(9600);
//mySerial.begin(9600);
  // Give time to your GSM shield log on to network
  delay(20000);
  Serial.print("SIM900 ready...");

  // AT command to set SIM900 to SMS mode
  SIM900.print("AT+CMGF=1\r");
  delay(100);
  // Set module to send SMS data to serial out upon receipt
  SIM900.print("AT+CNMI=2,2,0,0,0\r");
  delay(100);
}

// Function that sends SMS
void sendSMS(String message){
  // AT command to set SIM900 to SMS mode
  SIM900.print("AT+CMGF=1\r");
  delay(100);

  // REPLACE THE X's WITH THE RECIPIENT'S MOBILE NUMBER
  // USE INTERNATIONAL FORMAT CODE FOR MOBILE NUMBERS
  SIM900.println("AT + CMGS = \"+2348069467459\"");
```

```
  delay(100);
  // Send the SMS
  SIM900.println(message);
  delay(100);

  // End AT command with a ^Z, ASCII code 26
  SIM900.println((char)26);
  delay(100);
  SIM900.println();
  // Give module time to send SMS
  delay(5000);
}


void loop(){
  if(SIM900.available()>0){
    textMessage = SIM900.readString();
    Serial.print(textMessage);
    delay(10);
  }
  if(textMessage.indexOf("SWITCH_ON_LOAD_1")>=0){
    // Turn on relay and save current state
    digitalWrite(relay, LOW);
    delay(1000);
//    lampState = "on";
//    Serial.println("Relay set to ON");
//    textMessage = "";
//delay(1000);
//  if(lastButtonState == HIGH && currentButtonState == LOW) {
//    Serial.println("The button is pressed");
//
//    // control relay arccoding to the toggled state
//    //digitalWrite(relay, HIGH);
//  }
  }


  if(textMessage.indexOf("SWITCH_OFF_LOAD_1")>=0){
    // Turn off relay and save current state
    digitalWrite(relay, HIGH);
    delay(1000);
//    lampState = "off";
//    Serial.println("Relay set to OFF");
//    textMessage = "";
//    delay(1000);
//CHECK HERE
//lastButtonState    = currentButtonState;      // save the last state
//  currentButtonState = digitalRead(BUTTON_PIN); // read new state
//
//  if(lastButtonState == HIGH && currentButtonState == LOW) {
```

```
//    Serial.println("The button is pressed");
//
//    // control relay arccoding to the toggled state
//    digitalWrite(relay, HIGH);
//
//  }
  }

if(textMessage.indexOf("SWITCH_ON_LOAD_2")>=0){
    // Turn on relay and save current state
    digitalWrite(relay1, LOW);
    lampState = "on";
    Serial.println("Relay set to ON");
    textMessage = "";
delay(1000);
//  if(lastButtonState == HIGH && currentButtonState == LOW) {
//    Serial.println("The button is pressed");
//
//    // control relay arccoding to the toggled state
//    digitalWrite(relay1, LOW);
//  }
  }

if(textMessage.indexOf("SWITCH_OFF_LOAD_2")>=0){
    // Turn off relay and save current state
    digitalWrite(relay1, HIGH);
    lampState = "off";
    Serial.println("Relay set to OFF");
    textMessage = "";
    delay(1000);
////CHECK HERE
//lastButtonState    = currentButtonState;      // save the last state
//  currentButtonState = digitalRead(BUTTON_PIN); // read new state
//
//  if(lastButtonState == HIGH && currentButtonState == LOW) {
//    Serial.println("The button is pressed");
//
//    // control relay arccoding to the toggled state
//    digitalWrite(relay1, HIGH);
//  }
  }

if(textMessage.indexOf("SWITCH_ON_LOAD_3")>=0){
    // Turn on relay and save current state
    digitalWrite(relay2, LOW);
    lampState = "on";
    Serial.println("Relay set to ON");
    textMessage = "";
delay(1000);
//  if(lastButtonState == HIGH && currentButtonState == LOW) {
```

```
//    Serial.println("The button is pressed");
//
//    // control relay arccoding to the toggled state
//    digitalWrite(relay2, LOW);
//  }
  }

if(textMessage.indexOf("SWITCH_OFF_LOAD_3")>=0){
    // Turn off relay and save current state
    digitalWrite(relay2, HIGH);
    lampState = "off";
    Serial.println("Relay set to OFF");
    textMessage = "";
    delay(1000);
////CHECK HERE
//lastButtonState    = currentButtonState;      // save the last state
//  currentButtonState = digitalRead(BUTTON_PIN); // read new state
//
//  if(lastButtonState == HIGH && currentButtonState == LOW) {
//    Serial.println("The button is pressed");
//
//    // control relay arccoding to the toggled state
//    digitalWrite(relay2, HIGH);
//  }
}

//ON/OFF ALL
if(textMessage.indexOf("SWITCH_OFF_ALL")>=0){
    // Turn on relay and save current state
    digitalWrite(relay, HIGH);
    digitalWrite(relay1, HIGH);
    digitalWrite(relay2, HIGH);
//    lampState = "on";
//    Serial.println("Relay set to ON");
//    textMessage = "";
//delay(1000);
//  if(lastButtonState == HIGH && currentButtonState == LOW) {
//    Serial.println("The button is pressed");

    // control relay arccoding to the toggled state
//    digitalWrite(relay, LOW);
//    digitalWrite(relay1, LOW);
//    digitalWrite(relay2, LOW);
  //  lampState = "on";
  }


if(textMessage.indexOf("SWITCH_ON_ALL")>=0){
    // Turn off relay and save current state
```

```
//    digitalWrite(relay, HIGH);
//   digitalWrite(relay1, HIGH);
//   digitalWrite(relay2, HIGH);
   digitalWrite(relay, LOW);
   digitalWrite(relay1, LOW);
   digitalWrite(relay2, LOW);
delay(1000);

//   lampState = "off";
//   Serial.println("Relay set to OFF");
//   textMessage = "";
//   delay(1000);
////CHECK HERE
//lastButtonState    = currentButtonState;      // save the last state
//  currentButtonState = digitalRead(BUTTON_PIN); // read new state
//
//  if(lastButtonState == HIGH && currentButtonState == LOW) {
//    Serial.println("The button is pressed");
//
//    // control relay arccoding to the toggled state
//
//    digitalWrite(relay, LOW);
//    digitalWrite(relay1, LOW);
//    digitalWrite(relay2, LOW);
//
//

//    digitalWrite(relay, HIGH);
//    digitalWrite(relay1, HIGH);
//    digitalWrite(relay2, HIGH);
}


//  if(textMessage.indexOf("STATE")>=0){
//
//    String message = "Lamp is " + lampState;
//    sendSMS(message);
//    Serial.println("Lamp state resquest");
//    textMessage = "";
//  }
else {
  digitalWrite(relay, HIGH);
  digitalWrite(relay1, HIGH);
  digitalWrite(relay2, HIGH);
}
}
```



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