ANALYSIS OF ELECTRICAL POWER USAGE IN HOUSES USING SMART ELECTRICAL DISTRIBUTION SWITCH.

By

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STUDENT'S DECLARATION

I hereby declare this dissertation is the results of my own research and all books and information from various sources have been duly acknowledged and that no part of it has been presented for another degree in this university or elsewhere.

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DEDICATION

This research work is dedicated to the almighty God for his unrelenting grace and guidance throughout my life. Also to my parents, Kwame Okrah-Osum and Helena Abena Bediata.

ABSTRACT

There is high demand for electrical energy because electrical energy is very important in both industrial and domestic activities and that has call for the introduction of different energy meters by various electricity companies. In Ghana families living in large and compound houses wish to have separate energy meters from other occupants. This is because individual's cannot monitor and control the energy consumption of each individual and that brings misunderstanding in energy bill sharing which also brings about a household having about ten energy meters causing overcrowding of energy meters on the wall of a building which makes the wall loses its beauty and there is likelihood of fire outbreak in the house because the wires are not well arranged. Moreover, energy companies need huge sum of money and labour to produce more energy meters and this can cause financial loss to the energy companies. This has therefore call for the introduction of smart distribution switch which will enhance the monitoring and adequate sharing of energy purchased by the household base on the amount paid by each of the users of the meter. The amount paid will be entered into the system that will be stored on EPROM of a microcontroller that will reduce each consumer's energy base on the rate of consumption. The smart distribution switch may have different switches allocated to each user which monitor the consumption rate of each user. It will then isolate the user connected to a line out when he /she completely consumes his share.

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CHAPTER ONE

1.1 Introduction

Electrical Power is one of the most important demands of our daily life. Without it most of our activities will not be successful. Therefore it should be managed very well to enhance the judicious usage of it. Our homes and residential areas use power for a whole lot of activities. Because most of the Ghanaian communities live in large family houses, there is the need for each family or individual to have a separate energy meter that will measure and monitor the usage of power. Because each individual cannot monitor the consumption of other family, there is the need for each person or family to have separate meters, which in turn bring about a single house or home using multiples of energy meters. The energy companies need to provide these individuals with meters that constitute a huge sum of money and labour in their production.

This and other factors that will be elaborated on later have call for the introduction of Smart Electrical Distribution Switch (SEDS) that will call for only one meter but may have multiple phases of connection to the occupants of a house. The amount paid will be entered into the system that will be stored on EPROM of a microcontroller that will reduce each user's energy base on consumption rate. The smart distribution switch may have different switches allocated to each user.

It will then isolate the user connected to a line out when he/she completely consumes his share. Smart distribution switches are devices acting as an interface between the utility-controlled smart meters and the home area network. These devices control and take care of the data exchange between smart meters, utility or service providers and energy-consumption in-house objects.

They also manage the information for several homes, a multi utility controller, also known as gateway of energy, manage and control the exchange of data for a particular home. The smart distribution switch is operating as a Data concentrated unit (DCU) that manages the data input from the occupant in the house. Each network connected to an apartment will be managed and monitored by the DCU through a console based application written on the microcontroller. It coordinates the activities between the users and the meter.

1.2 Background to study

The technological advancement of this era of human life has made way for any automationto be implemented in our everyday life. With the help of information technology and electronic theories, a lot has been achieved in the electrical engineering field to supplement human activities. A lot of situations have arisen since the introduction of electrical energy generation and distribution towards its purchase and usage. The utility company is always concerned with efficiency, reliability and security. The primary difficulty to efficient power management are losses but can sometimes be minimized in a way. Losses are supposed to be any used energy that goes unbilled or unmetered. In the electrical field, non-technical losses are introduced by pilferage and theft.

Non-technical losses are energy pilferages and stealing of power, meters that are defective which create or generate wrong figures or errors in meter readings, wrongful estimation of meter readings, un-metered or consumers who don't use energy meters but they are rated (flat rate), customers who adjust or tamper with their meters, free power usage (for legally connected consumers), illegal connections, etc. These Non-technical losses (NTL) account for over 70% of the total losses representing several hundreds of kilo Volts Amperes. Critical consideration of all the non-technical losses sum up to metering losses. The reason is that suppliers of power cannot effectively monitor what is happening at the consumer end and therefore take the most efficient and necessary action. As a result of this, the electricity company of Ghana (ECG) has come out with a number of technologies in energy meter to address this problem. These included:
electromechanical induction meters or standard meters, prepayment card electric meters, solid state electric meters or electronic meters and presently, pole prepaid card meters. This piece of

work concentrates on the ability to monitor and control consumer end users. Electricity distribution is a sector of electricity where technological evolution is gradual at least in the network assets. However, there is a rapid advancement in telecommunication area in the last few years. The present goal is towards remote metering reading, and electricity or energy consumption monitoring consumption which is also known as advanced metering infrastructure. Drastic reduction in prices of metering and telecommunication equipment makes their usage and adoption feasible economically.

ECG is switching from postpaid (that is Electromechanical energy meter) to prepaid. Because the postpaid energy meter is not totally eliminated, the Smart Electrical Distribution Switch measures individual's consumption and the energy in Kwh is shown on the screen. The energy or power consumed is calculated according to ratios.

With the prepaid the total power bought is calculated according to the individual's contributions in ratios, and this will also be shown on the screen.

1.3 Problem Statement

The utility companies in Ghana have always proved less effective in monitoring and controlling the usage of electrical energy by individual consumers. The most common factors which play much role in these shortcomings are illegal power connections and poor billing systems. The former is one of the crucial areas which need to be addressed to promote our social economic development. Various individual premises like homes, hostels and other institutions involves more than one sub-users which crops up numerous problems in billing and monitoring of power usage of co-house mates. This has therefore made some of these environments less user friendly for many individuals who share bills with others. Some of these problems are therefore elaborated below;

1.3.1 Problems in energy bills sharing by occupants in a house.

Individuals find it difficult in how to share bills among users of energy meters in a house or areas. Different techniques and methods have been adopted in the sharing of bills. Some go through the process of checking each user's appliance and compute the bill base on how their power is rated and the devices or equipment used. This brings questions since it becomes difficult in checking whether the appliance was used or not. Others adopt a strategy of sharing on percentage base. Individuals identified with more gadgets are therefore given more bills.

1.3.2 Difficulty in monitoring power usage of tenants.

The day-to-day usage of the energy by individual sub-consumers in a premises is difficult to be tracked by co-tenants and this sometimes can create a room for secrete usage of loads whose usage cannot be monitored and billed. The visual way of inspecting individual electrical loads for sharing of bills is one way adopted for decades ago but because some individuals are not honest the real consumption exceeds the documented one since other loads are used without being captured on the shared data. To diversify the usage of energy in various premises among sub-users is therefore a great field of interest to the electrical engineer and other technicians as a whole.

1.3.3 Cost of providing extra energy meters

Applications for extra energy meters at the utility company by individual consumers has an aspect of demerits since it calls for extra order of new energy meter and attracts extra change on installations and other operations like documentary and control. As a governmental agency the ministry of energy is therefore a sector that requires not to contribute much into financial loss to the state. This has therefore been captured as one of the principal key point to our problems statement in this piece of work.

1.3.4 Threat to environmental beauty

The last but not the least, all engineering products are expected to provide a high level of goodlooking. This serves as a primary key to customer satisfaction in terms of sales and services. In reference to the local situations concerning the provision of multiple meters for separate consumers, the beauty of walls are affected since a number of metes are installed at the same point on the wall. Fig.1.1 show a cross-section of a wall with multiple energy meters in a section of the Sunyani Metropolitan Assembly.

Fig. 1.1 multiple meters on the wall

1.4 Aims of the research

The aim of this research is to find a solution to the above listed problems. The research work will help eradicate the problems associated with the usage of multiple meters in households and other premises by introduction of the SEDS. It shall entail the introduction of an electronic security system that may monitor and control the consumption of individual's sub-users. This piece of work is therefore required to be able to isolate a user from the mains if he/she does not meet the right validation of the embedded system. As the consumer uses the power, the microcontroller reduces the power allocated to the consumer till his or her power gets finished.

1.5 Scope of Work

The research work is limited to ten different energy meters consisting of five postpaid and five prepaid energy meters. This is due to financial constraint and other research limitations such as lack of maximum cooperation between the energy meter user or the consumer, power suppliers (Volta River Authority) and the researcher. The work is restricted to solving problems such as monitoring energy usage, control switching and providing security to houses base on energy consumption. Besides, the work concentrates on a central switch which monitors and control power usage by individuals.

1.6 Methods Used

The methods used to achieve this work is through both hardware and software implementation at desired stages in the design process. The work employs the prototyping method of project design to complete it. It also calls for the programming of a microcontroller based embedded system that monitors the usage of power and also provide a set of control commands for isolation when the entitled power is completely consumed. The idea of the work is depicted as a block diagram as shown in fig.1.3. The general architecture of the setup consists of four main parts to be interacted for the full functionality. The main work is demonstrated in the embedded control system.The system is mounted between the main switch and the loads of the individual consumers. Here the system monitors all individual loads connected through the main switch, and upon reading the power consumption at all instances, the consumption can be quantified to take further decisions.

The main embedded control system is partitioned into five sections and the diagram is shown in figure 1.3.

Sensor:

The sensor consists of a series resistor in the consumer live cable and a step down transformer across it which constantly measures the voltage of the output based on the current drawn by the consumer. With the help of other electronic circuits like rectifiers and operational amplifiers, the value is cut down to a manageable value that can easily be processed by the control unit.

ADC:

The signal to be process at all point is in the form of analogue signal which needs to be converted to a digital signal before it can be processed by the control unit. The ADC is an analogue to digital converter which converts the output from the sensor to digital value to be delivered to the control unit.

Control Unit:

The control unit serves as the brain of the whole unit. It consists of a microcontroller and its associated components which deal with the real computations of values and purposely for decision making. With any value exceeding threshold value key on it through the key pad and values stored in the EPROM, it issues commands for the buffer circuit to be activated for further actions to be taken. This can be done to either connect or disconnect individual consumer circuits.

Buffer:

The buffer circuit links the control unit and the relay driver circuit. It consist of a group of transistor circuits which are activated to cause current to flow for the groups of relays to make the connections and disconnections of the hot cable wires.

Relay Driver:

The relay driver is a group of relays connecting different consumer circuits. They are energized and de-energized based on the decision taken by the control unit through the buffer circuit. They are the only section which interacts directly with the consumer hot wire.

The final product is to be achieved through software implementation (simulation) using MATLAB programming environment.

ENERGY METER WITH SMART ELECTRICAL DISTRIBUTION SWITCH.

The smart distribution switch has multiple phases or ports of connection to the occupants of the household. It acts as an interface between the household wiring or users lines and the energy meter. It controls and takes care of the power exchange between the energy meter, utility and energy consumption in the household devices.

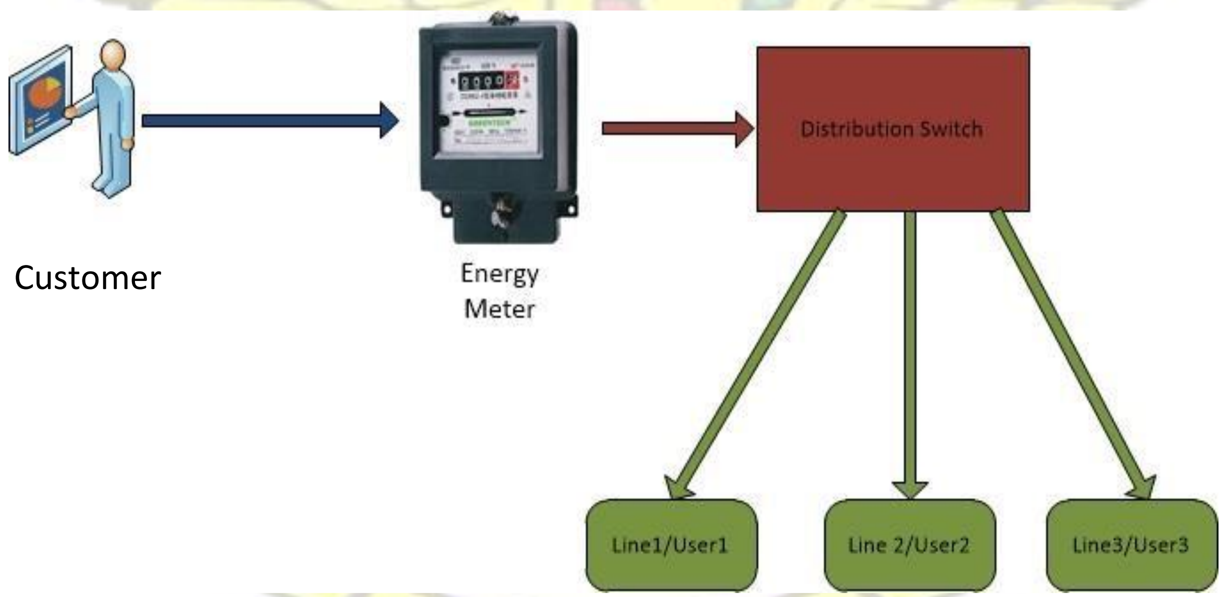


Figure 1.2. Energy meter and a block diagram of smart electrical distribution switch.

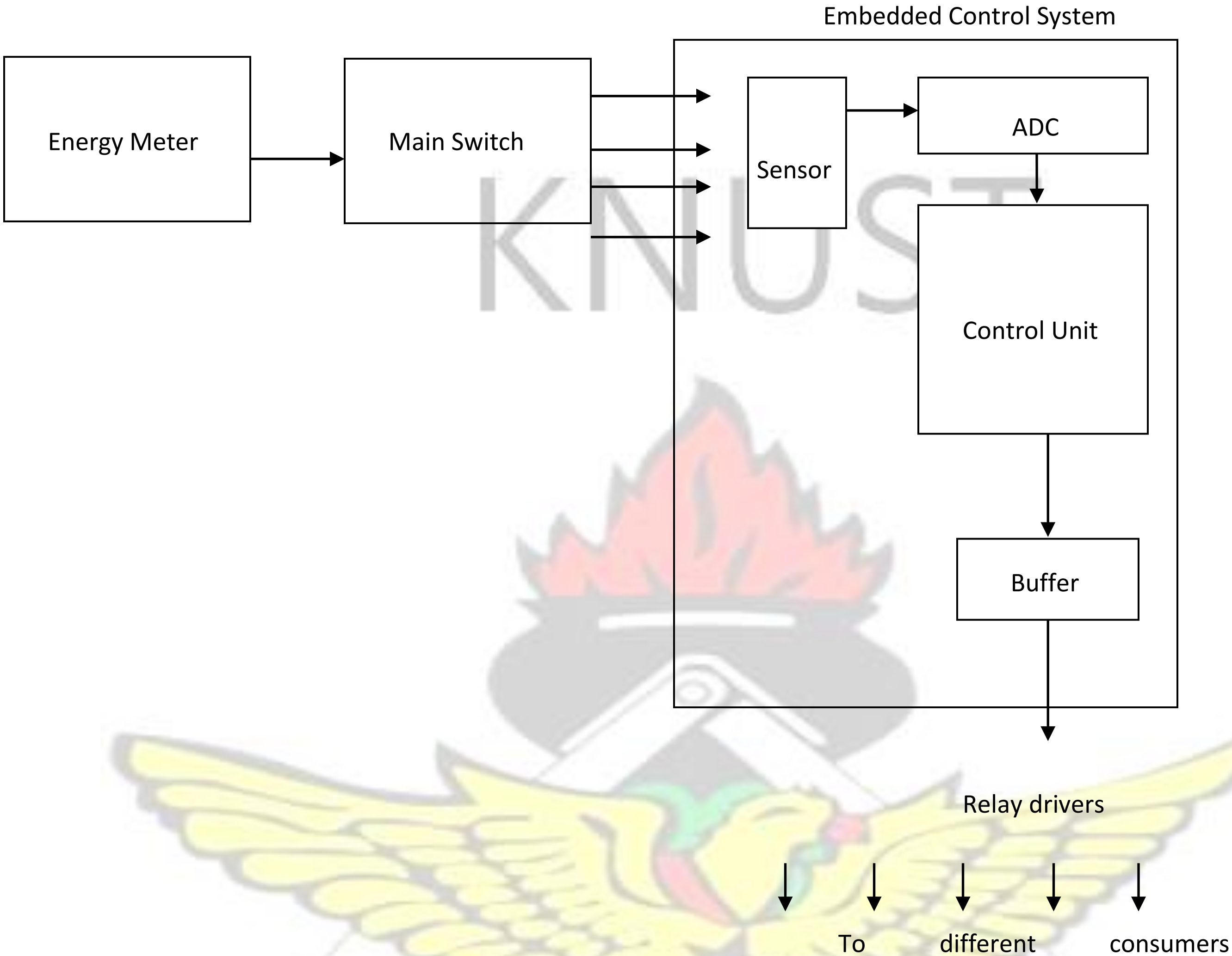


Figure1.3 Embedded control system.

1.7 Project Report Organization

Chapter 1 talks about the introduction to Smart Electrical Distribution Switch, follows by the background to the study, then the Problem's statement, Aims and objectives of the research work, follows by the research work's Scope, discussion of the methods used and project report organization.

Chapter 2 also presents a brief knowledge about smart systems and categorization of sensors based on the technology behind their manufacture. A number of techniques are therefore explained in this chapter. It includes a review of related works which provide a summary of the basic knowledge already available involving the issues of interest. Also, the identifiable lapses in the literature have been discussed and used as the basic theme of the research work.

Chapter 3, gives the details of the materials and methods used for the design and the science of the individual components for the implementation of the system.

A chapter 4 deal with the overview of the process modules based on their functionalities and explains the real design and implementation of the whole system. The results of the design based on simulation and physical operation is also completed in this chapter with massive discussion.

A guide to the installation and effective use of the designed system is also incorporated in this chapter. Chapter 5 presents the summary of the work and how it relates to other works of the same idea. A brief justification of the design is highlighted and recommended in different ways.

References elaborate the sources of ideas which were used in the process of the research work.

Appendix provides the code for the microcontroller. They are presented according to demonstration in their roles in the design.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The need for automation (That is Automation is the use of machines to do work that was previously done by people) in electrical equipment and gadgets in the industry, schools, banking systems, hotels, homes and other applicable institutions has recently become common in every day's life. There is a great variety of situations which require electrical energy management ranging from monitoring to full control to supplement human efficiency. Besides the level of power to be controlled, the local application of the electrical energy also contributes to the nature and type of automation to be implemented. The different types of requirements of the automation process have called for different embedded system design in the electrical industry. The theme of this piece of work as centered on the automation of the energy meter has created the need for a massive research into the evolution of the energy meter, its history as well as the principle and theory of embedded systems. There is also a massive research into how some people consume electric energy in their various houses using different types of electric gadgets. The review of related works has also being made for a similar goal of this piece of work.

2.2 Usage of electrical power by some consumers

Experiment was conducted on twenty credit or postpaid energy meters and twenty prepaid energy meters used by different energy consumers on how they consume energy based on the devices or loads they used. Those who used credit energy meters, their monthly energy bills were checked and the prepaid meter users were also checked on how often they bought energy. This was done in a period of twelve months.

The research reveals that the higher one consumes power the higher he/she is charged for it.

Gadgets like refrigerator, microwave, rice cooker, washing machine, hair dryer etc. consume high power. However, gadgets like radio, TV, energy saving bulb etc. consume low power.

The meter readers who read the postpaid meters were monitored well. Anytime they took their readings, there was a follow up to take the readings again. Correct readings were taken. The bills reflected with the readings. A house with plenty and high consuming gadgets had high reading and hence high power consumed with high energy bill.

Members who use the same meter quarrel among themselves about the sharing of the bills. This is because members were not sure of the devices everyone uses.

However, those who use less consuming gadgets had less bills and vice versa.

The prepaid meter user who used high consuming gadgets like refrigerator, hair dryer, microwave, etc. bought high power within a period of time. However, the one who used less consuming gadgets bought less power within a period of time.

2.3 Energy meter Automation

Energy meter automation system is the use or application of hardware components, software or combination of both technologies with associated electrical technologies to achieve a partial or fully monitoring and control purpose. This ranges from simple methods like induction based energy meter design, prepaid energy meter design, to fully automated complex systems with high artificial intelligence like telemetering and pre-paid energy meter monitoring system with amplified sound for industries. Electrical energy is one of the most flexible and efficient form of energy which is easy to be controlled and converted to other forms of energy for a specific intended purpose. The introduction of the microcontroller in electronic design system has proved economical and simple in many fields of engineering. As a result of the above positive effect, the electrical engineering field has benefited a great deal of flexibility by the introduction of this chip. That is the microcontroller.

2.4 Feedback Based Energy Control System

This research work is aimed at automating the feedback system or mechanism of the loads which are connected to the energy meter in individual households and this automating system makes use of a microcontroller and other activated devices to supply a fair consumption of the shared power among consumers of the same consumer unit. The use of electrical energy by households and industries is not visible to the user or the consumer most of the time. Most at times, the consumers don't have distinct or clear idea about how much energy they use in daily bases for different purposes and hence what they could do to change their behavior about how they use energy. It is therefore necessary and should not be looked down upon to understand feedback mechanism well because it can help one to control energy consumption. The feedback mechanism helps to teach energy users on how to use energy wisely. Feedback mechanism is good, an important element in studying to control the usage of energy, fuel and gas. In the 1970s and 1980s, some psychologists carried out the studies on feedback on the usage of energy, and it was mostly about sending a note to the consumer or user in each morning which informs the user about the consumption of energy in the previous day. Various researchers state that people use feedback to process information which could be used to study the behavior of some energy users. In 1989, Van Houwelingen and Van Raaij did some qualitative research on feedback on the usage of gas by electronic feedback. In fact, billing the energy user or consumer using the traditional way does not give adequate information that can help one to make absolute or conclusive decision on how to control energy consumption, and hence help one to change his or her behavior.

2.5 The Prepaid Energy Meter Technology

The user of this energy meter pays for the energy or power before he or she can use the power. If the power gets finished the prepaid card should be reloaded with and it is slotted in the energy meter before power is restored in the household. The service provider uses this technology to control the payment of energy bills. It also helps the customer to be discipline in power usage. The traditional billing of consumers using the electromechanical meters has been in the system or in use for several decades. There have been several ways to improve on the electrochemical meters. Some of these meters are analog and some others are digital. Despite these improvements, some people have some problems about fair usage of energy due to the insufficient means of monitoring and control of individual sub users who used the common consumer unit. There is therefore the need to automate the billing system. There are meters nowadays which take accurate readings, yet the old procedure is used in collecting bills. This usually brings misunderstanding between the service provider and the consumer because a deviant user or consumer may fail to pay his or her bills and the service or the utility provider may disconnect the user from the grid. Most at times these consumers don't pay the bills if they don't want to be connected back to the grid. To get rid of some of these irregularities, a prepaid energy meter is introduced. The prepaid energy meter helps the utility provider to collect the electricity bills from the consumer before using it. In United Kingdom for instance, those consumers who have poor records in paying electricity bills, the utility provider fix or install the prepaid energy meter for them. The prepaid energy meter is an automated meter reading, and the information about the user's consumption details is shown on its screen. The amount of energy that is bought is shown, and periodically the amount of energy consumed is shown and the energy that is left to be used or consumed is also shown on the screen. It gives an indication if the energy bought is about getting finished. The user can therefore load up his or her energy card. Even though, the system is effective, prevent illegal users, and control the consumers who have poor records in paying bills, however, if two or more users hook on to one energy meter there may still be problems on bill sharing. That will lead an individual user to go for his or her own energy meter. To get rid of this problem, the smart electrical distribution switch is introduced. Smart Electrical Distribution Switch (SEDS) is a newly proposed technology in this piece of work that only demands only one energy meter in a specific household but may have multiple lines of connection to individual sub-users on that unit. The amount paid will be entered into the system that will be stored on EPROM of a microcontroller that will reduce each user's energy base on consumption rate. The smart distribution switch may have different switches allocated to each user.

With this system, users shall be monitored and isolate users when their threshold values based on their payment expires.

2.6 Microcontroller Technology

Microcontroller is used to process data and to perform arithmetic operations. It is a true computer on a chip. It has all the features that are on a microprocessor. It has features such as RAM, ROM, serial input and output ports, counters, clock circuit and parallel input and output ports. Microcontrollers are used in photocopiers, weighing machines, industrial automation, traffic signals, washing machines stereo equipment, cars etc. Examples of microcontrollers are 8051 family and the Motorola MC68HC12 and MC68332 families. Both microcontrollers and microprocessors are used in embedded system. It is used to control the operation of a machine where fixed program which is stored in a ROM and which does not change over the lifetime of the system. The microcontroller has a limited set of instructions that are used to move code and data from internal memory to the Arithmetic Logic Unit (ALU). On the integrated circuit(IC) package, many of the instructions are coupled with programmable pins capable of having several different functions depending on the wishes of the programmer. Usually these are supposed to be just data processors performing exhaustive numeric operations.

2.6.1 Microcontrollers and Microprocessors

Microcontrollers have one or two operational codes but Microprocessors have many operational codes which move data to the CPU from the external memory.

Microcontrollers have bits that can be moved rapidly within the chip but in Microprocessors codes and data can be moved quickly from the external address to the chip.

Microcontrollers need no operational or external digital parts to function as a complete computer but Microprocessors must have some other operational parts before they can function as a complete computer.

Microcontroller has the following features: Internal RAM, Internal ROM, I/O Ports, Timer/Counter, Interrupts circuits, Clock circuit, Program counter, Stack Pointer, Registers, Accumulator and Arithmetic and Logic Unit (ALU), EPROM, CPU but Microprocessor has the following features: Arithmetic and Logic Unit, Accumulator, Registers, Program Counter, Stack Pointer, Clock circuit, Interrupt circuit, CPU.

Both microcontrollers and microprocessors are used in embedded systems, however, microcontrollers are used more in embedded systems than microprocessors because microcontrollers in embedded systems consume low power as compare to microprocessors.

Embedded controller is a controller which is fixed in a system or device to make the system or device performs a particular task rather than making the system or device performs computing in general purpose.

There are also difference in their Architecture, Instruction sets and Pin Configuration.

Examples of microcontroller are; Intel 8096 family, Motorola MC68332 and MC68HC12 families, and that of Microprocessor are; Zilog Z80, Intel 8088, Motorola 6809, etc ,

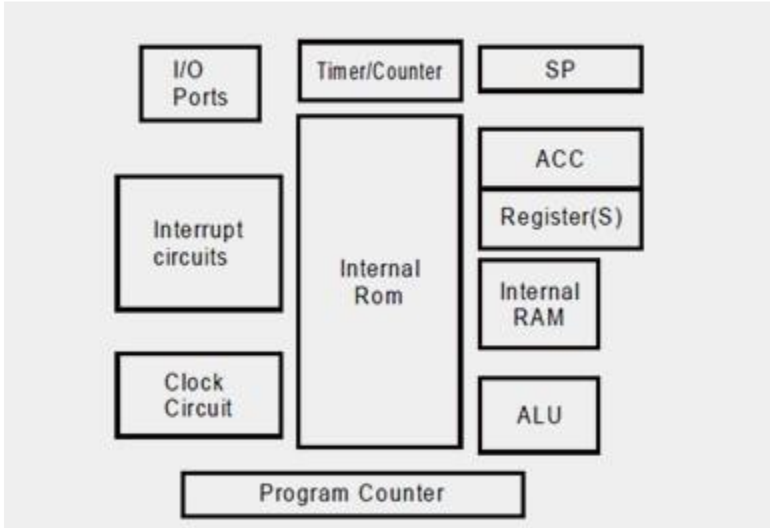


Fig. 2.1 Block diagram of a microcontroller

2.6.2 Types of Microcontrollers

Microcontrollers are classified into categories base on their Architecture, Internal Bus Width, Instruction Set, and Memory.

2.6.3 The 8, 16and 32-Bit Microcontrollers

THE 8-BIT MICROCONTROLLER

In the 8-bit microcontroller the Arithmetic Logic Unit is used to perform logical operations on 8bit or byte. It has 8-bit. It is used in simple machines to control the speed of machines. It is also used in collecting data. Examples are Intel 8051 family and the family of Motorola MC68HC11.

THE 16-BIT MICROCONTROLLER

This is used to perform logical operations on 16-bit or word. It has sixteen (16) bits. It is used to control high speed machines like robot arms. It has high computing capacity as compared to the 8-

bit microcontrollers. Intel 8096 family and the families of Motorola MC68HC12, MC68332 are examples 16-bit microcontroller.

THE 32-BIT MICROCONTROLLER

It is used to perform logical operations on 32-bit or double word at an instruction. It has 32-bits. It is used in robotics, automobiles, image processing telecommunications and highly intelligent instrumentation, etc. It has high computing capacity as compared to 16-bit microcontrollers. Intel 80960 family, Motorola M683xx and Intel/Atmel families are examples of 32-bit microcontroller.

2.7 The Energy Metering System

The voltage from the main line ranged from 180V-220V is fed into the channels of the current and the voltage channels. This network is made of resistors to reduce or attenuate the voltage to about 200mV. The load current is produced by the voltage from the main line and this is fed in to the meter chip (ADE7755).There two Analog Digital Converters which change the analog signal to digital signal. The ADCs are 16-bit and have frequency of 900KHz. It has a high pass filter in the current channel which filters out any direct current (d.c) from the current signal. This removes the inaccuracies from the real power because of the fluctuations in the voltage or current signals. The real power is calculated from the instantaneous voltage signal using the formula;

Power = voltage (V) x current (I). The power factor (PF) is also calculated by the relation;

Power Factor = Real or Active power / Apparent power. In order to get the correct information about the real energy, the microcontroller (AT89C55WD) is used to accumulate or gather the real power information. Once the power is known the energy can be calculated using the relation; Power = energy / time.

Review of Related works

As a research work, knowledge of different criteria has been gathered from many academia of the same field of study. The energy meter has undergone many transformations or changes in its construction technology including the billing system and alert signaling system. A brief analysis is therefore made to review into a few of ideas on this area of study.

2.8.1 How to Design and Implement a Remotely- Monitored Single Phase Smart Energy Meter via Short Message Service (SMS).

These scholars D.A. Shomuyiwa and J.O. Ilevbare aimed at how single phase energy meter is designed and implemented which can also be monitored remotely by the use of Short-Message Service(SMS). They used some discrete components or devices and a metering chip (ADE7755) to design the energy meter. The Short-Message Service (SMS) with the meter was set up with the help of Neoway M590 Global System/Standard Mobile Communication (GSM) module. The GSM receives commands from mobile phone for communication. They used 4 x 3 keypad to load up energy token and energy information was received from the meter. There is a Liquid Crystal Display unit where the energy data or query is viewed. They locally manufactured single layer printed circuit board on which the project was put into effect or implemented by using a Software called Diptrace Software. They also used another Software called Proteuse Software, 8051 development kit and a serial port monitor to make the simulation of the electronic circuit designs. The energy meter could measure a minimum load of current of 2mA and a maximum load of current of 40A. The results showed that the energy meter could be used to measure an average real time power and instantaneous power that was used up or consumed when it (energy meter) was monitored and queried remotely. The range of the Voltage was 180V-250V, and the microcontroller AT89C55WD was programmed in C language using KeiluVision compiler.

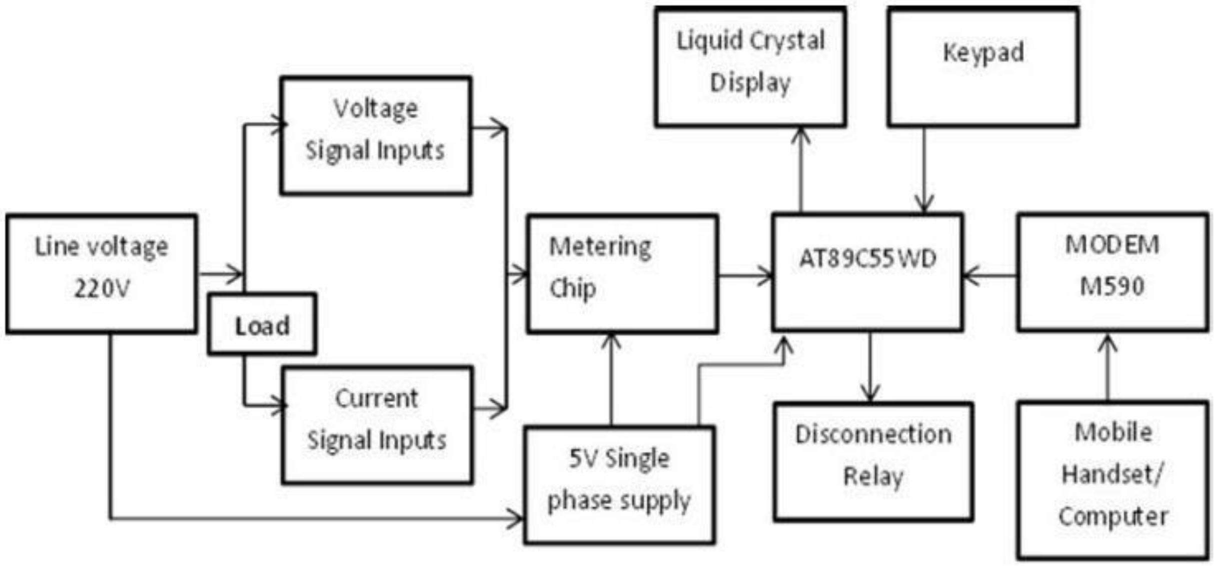


Figure 2.2 : Components of the metering system

2.8.2 How to Design and construct a microcontroller based wireless energy meter:

Reza Shahrara in his work, he designed a digital energy meter where he used Advanced Virtual RISC (AVR) microcontroller to transmit the data measured by wireless means to a computer. The circuit designed was implemented or put into effect on PCB, that is Printed Circuit Board. He used Microsoft visual studio C# to write a program to monitor the received. He used an 8-bit Advance Virtual RISC (AVR) low power microcontroller. The microcontroller had an extraordinary features which were versatile in programming and to transmit data. It also has timer/counters, separate oscillator and could be used to compute the difference in phase between voltage and current. The microcontroller was used to calculate the root mean square values of the voltage V and the current I including the power factor (PF), the active or real power, the apparent power and the reactive power. All these calculated values and energy values are transmitted to a computer by wireless means through serial port. The programming language used was Microsoft visual studio C#, and he used Bluetooth serial adaptor which easily communicate with other Bluetooth devices like ipad, mobile phone, laptop e.t.c to transmit the data.

2.8.3 Prepaid electricity system based on RFID

Fawzi Al-Naima and Bahaajalil focused at developing a management system which was prototype to manage prepaid electrical power meter. These scholars used wireless gateway, digital meter, microcontroller, and Radio Frequency Identification (RFID) reader to design the proposed prepaid electrical meter. This proposed prepaid meter had the client and the server. A circuit is designed which is to be put in effect or implemented to operate the digital meter by simulation. The designed circuit is connected to a computer, where Radio Frequency Identification (RFID) reader is used to read the information on the credit card. The RFID uses radio waves to identify things or objects and people automatically. On the client side, there is an RFID reader, digital meter which is controlled by microcontroller. The server is based on computer with database which uses MyQSL. There is a local sub-station where the server is fixed or installed and the client is fixed or installed in each house. The RFID reader reads the information on the ID card and this information is sent to the server to check if it is authentic and later the client receives the information. The microcontroller is used to administer the work of the system in the client. There is a wireless gateway through which the information of the ID is transmitted between the server and the client by wireless means. In the simulation of the microcontroller, a computer is used.

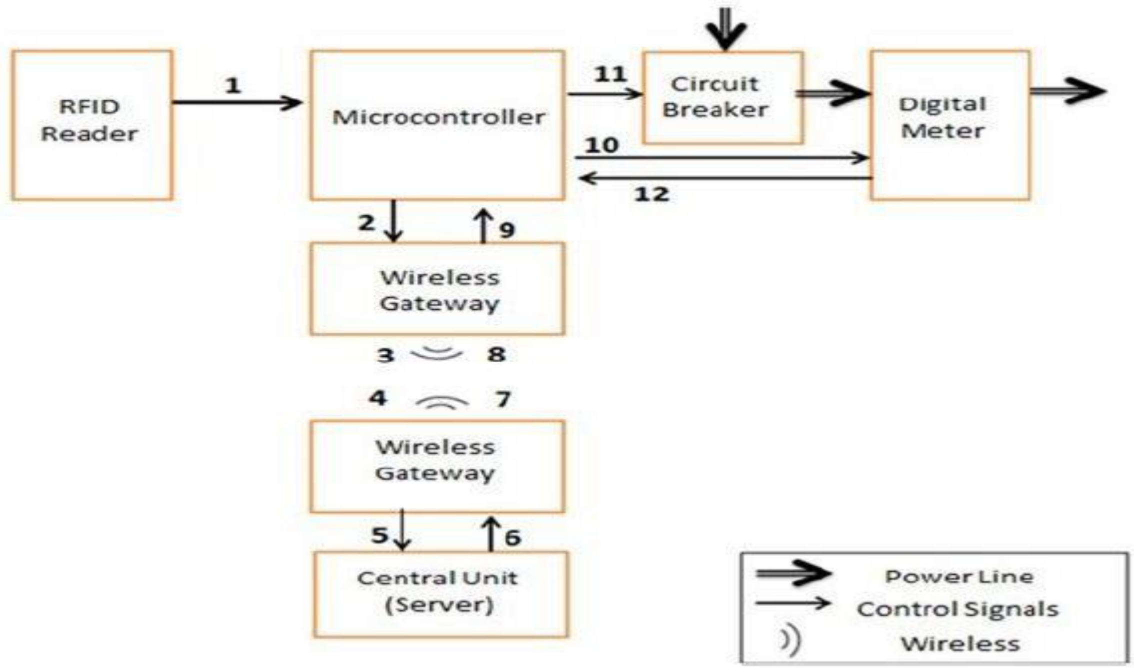


Fig. 2.3 shows the block diagram of the proposed electricity prepaid metering system

They used the following steps to explain the procedure of how the system works:

STEPS:

1. The RFID reader reads the information on the ID and sends it to the microcontroller.
2. The microcontroller takes care and manages the ID from the RFID and then sends it to the wireless gateway.
3. The wireless gateway sends the information received to the central unit.
4. The wireless gateway of central unit receives the information from the client's gateway.
5. The wireless gateway sends the information to the central unit.
6. The central unit checks if the card ID received is valid, and if it is valid, it sends back the validity announcement and the credit of that card. If the card is not valid, it sends invalidity announcement.
7. The wireless gateway sends the information received from the center unit to the client.
8. The wireless gateway of the client receives the information from the center unit.

9.The wireless gateway sends the information received to the microcontroller. The microcontroller then checks the information. If it is not valid, it will neglect that information and return back to the wait state.

10. If it is valid, the microcontroller sends a signal to the digital meter to reset its counter.
11. Also, if the card is valid, the microcontroller sends a signal to the circuit breaker to be in close state (On).
12. The digital meter sends the reading of the power consumption to the microcontroller which multiplies it by the power unit cost and subtracts the result from the credit and checks the answer. Assuming linear relation, if there is extra credit, no operation is done. However, if there is no extra credit, then the microcontroller sends a signal to the circuit breaker to be in open state (Off).

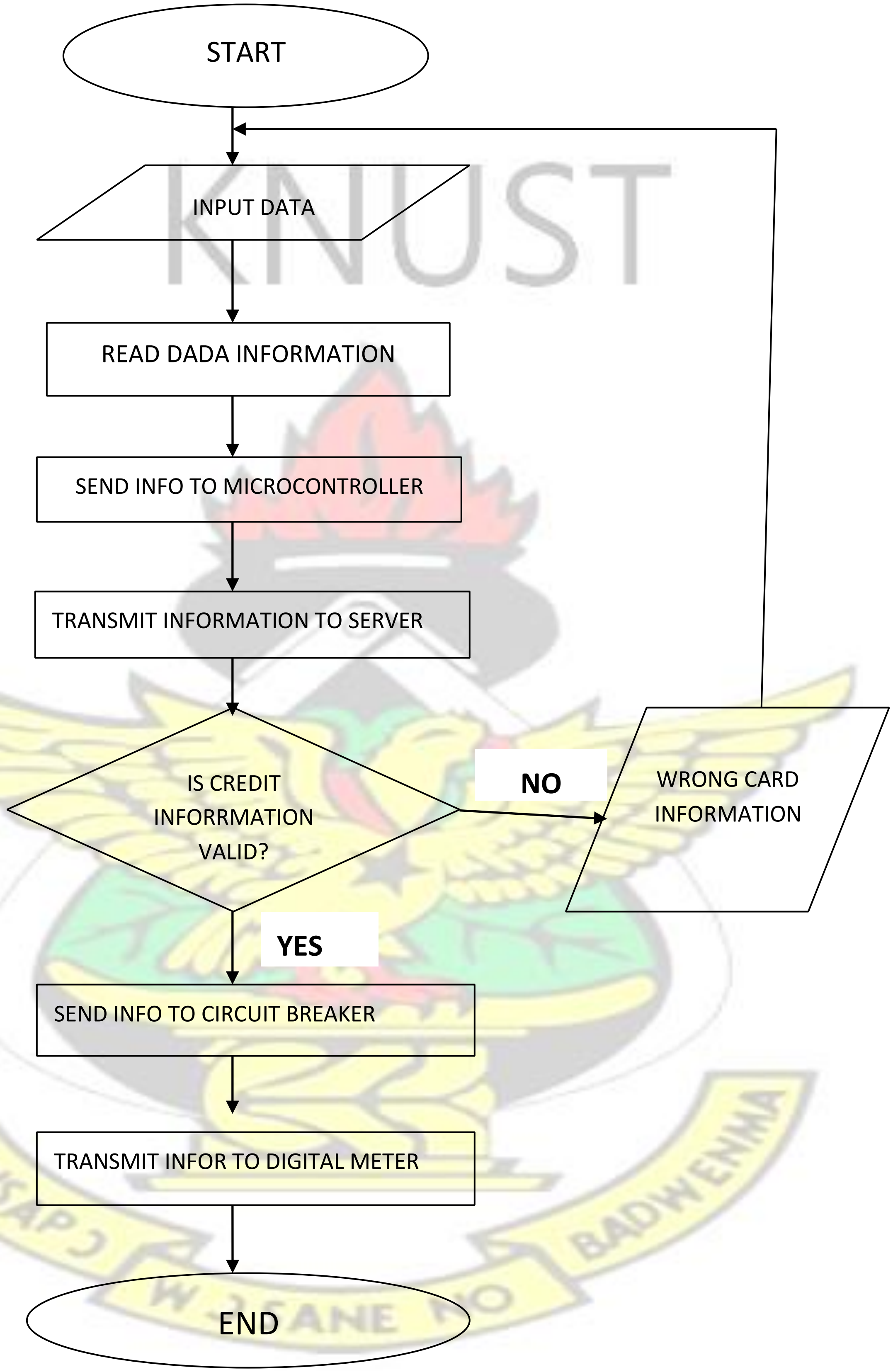


Figure 2.4: flowchart of proposed electricity prepaid metering system.

System Software

The client PC program is written to do the following tasks:

Opening the RS232 serial port and getting the ID of the card read by RFID reader.

Connecting with the server and sending the ID.

Receiving the ID information from the server, if it is valid then an action will be taken. If it is invalid, then an alternate action will be taken.

Decrementing meter credit.

Cutting the electricity power.

2.8.4 Arm Based Wireless Energy Meter Reading System ALONG with POWER on/off CIRCUIT V V.

These three academians Rajesh Parvathala, T Venkateswarareddy and N V G prasad aimed at developing a system of energy meter which uses wireless communication with a circuit in which the power can be on or off. The system is used to measure electrical energy bills and the information about the energy consumption is sent to the consumer. The dead line information about the payment of the bill is also sent to the consumer. The on or off automatic designed circuit is made to cut off or disconnect the power supply if the consumer refuses to pay the energy or electrical bill. The consumer is also made aware of the system's status. It also praises the consumer if he or she pays his or her bill. They used designed network circuit, wireless communication network technology and ARM7 Processor. In disconnecting the power supplied to the consumer, the correct switch which is located at the control unit is selected.

IMPORTANCE OF WIRELESS COMMUNICATION IN ENERGY METER READING.

In the era that there is a quick or rapid development in the area of wireless communication technology by using microcontrollers, Machines are automated to decrease human effort. Human way of meter reading is not very good or suitable because there are problems when it comes to calculating the readings and the billing in manual way. Now that the number of people who use or consume electricity or energy increases, it is therefore difficult to maintain and do the work manually at all times. If the person who sends the bill to the consumer is not available, then the consumer will not receive his or her bill. Even for the human operator to go to the house of every consumer to read the meter is a difficult task and takes much time. The work is so hard during rainy season and even when the operator is sick. If the consumer fails to pay his or her bill, the service provider's operator has to go to the house and disconnect or cut the power that is been supplied. These actions use or take much time and difficult to take care of. At times it is difficult for the service provider's operator to locate illegal connections done by the service user or consumer and hence disconnecting the power supply. The mistakes and errors from the operator create the chance for illegalities and corruption and this can lead to inefficiencies and inaccuracies.

The transmission and exchange of data, information is easier and faster because of wireless communication media. It is secured accurate. Wireless communication is possible because other communication media like the Global System or Standard Mobile communication (GSM) network, internet etc are available. Reading the energy consumed with the energy meter by wireless means helps both the service provider and the consumer to be in total control because both have in depth information about how power is been used. It also helps the service provider to control the supply of power. Wireless communication in conjunction with the GSM network is widely used to take care of how power is consumed in remote places. It automatically reads energy or power from a remote server. The wireless technique can be used to measure gas or water meters. The central server receives information about the meter readings such as in bill, voltage, current by Short-

Message Service and information is stored in the database for scrutiny or analysis and later the bill is sent to the customer through his or her mobile phone. The wireless communication technique can be used to collect data at any time. Nobody can intervene in the process of taking the data and therefore corruption and errors are prevented. The system will not be disrupted in collecting data even under bad weather conditions such as great storm or rain once the GSM networks is always in place. Readings like kilo-watt-hour (kWh), voltage, current, bill, etc. are sent by SMS to a central server. The central server then stores the information in database for analysis and sends the bill to the customer mobile phone. The SMS based data collection can be done very quickly and efficiently. Data can be collected after any desired time interval such as hourly, daily, weekly, or monthly basis. As there is no human intervention in the entire process, there is no chance of human error and corruption. In the extremely bad weather conditions like heavy snow, rain, storm, etc the system will not hamper on collecting data as long as Global System/Standard for Mobile Communication(GSM) networks are stable. The development cost of the SMS based remote meter will be higher than conventional meter but the electric supplier revenue will increase in the successive months because it will eliminate the possibility of corruption done by the customer or as of a reader. Remote meter can be used in residential apartments and especially in industrial consumers where bulk energy is consumed.

2.9 Summary

The thorough research into other related work provides an insight of what is to be designed and its related constraints and challenges. Besides, gaps and other loop holes can be detected and taken into consideration for any further design and implementation. .Research was done on how consumers of electrical energy used energy, why there is always misunderstanding in energy bill sharing and why individuals will want to get their separate energy meters. Smart electrical distribution switch is designed to interface the household network or wiring and the smart energy meter which will monitor and control individual's energy consumption. Thus with this brief study on how various technologies like the microcontroller and amplifier, a massive motivation and guide lines are being provided to the development of the system at hand.

With reference to the review of the related work above, the technique of providing feedback information to from the energy meter to alert operators of a fatal periods have not had a great application relative to the advancement of the embedded systems designed for the purpose of remote monitoring. This serves as a gap to fill by this project work and a great challenge to the design since an efficient and effective hardware system along with a software user interface is required to level the gaps of technological advancement. An embedded system is therefore constructed along with a power to issue this task in an efficient and effective manner.

CHAPTERTHREE

METHODOLOGY

3.0 Introduction

The approach to the design and construction of the work is divided into two parts: the hardware and the software. The hardware will cover component acquisition, testing and building the entire circuit whiles the software which will concentrate on programming of the Microcontroller to respond to command and activate set of instruction.

3.1 Components

The main components used in the construction of this thesis project are Infra-red emitter and detector, photo resistor, MCP602 op-amp, PIC16F877A microcontroller chip, LCD Display, Max232 and 20MHz crystal clock.

3.2 Tools

Tools used to build the circuit include the following: a working bench, a clean duster, a set of electrician screw drivers, a pair of pliers, cutters, scissors, files, sand paper, an electrical extension board, multimeter, soldering iron and led etc.

3.3 Testing.

Each of the components is tested using a multimeter to know of their accuracies before putting each of them into the circuit.

The multimeter as illustrated in figure 3.2, is a multiple function test instrument that can be used to test the value of a diode or transistor or capacitor etc, and hence the accuracy of the components before using it. It can also be used to measure voltage, resistance, and current. It is also called VOM (Volt-Ohm-Meter). It has red and black wires called probes or leads. The right or correct range on it is selected for whatever component you want to measure. It has some symbols such as V for voltage, A for ampere etc and some prefixes such as µ for micro,(one millionth), m for mill i(one thousandth), K for kilo(one thousand) etc.

3.4 Circuit Design Of The Proposed Model

The circuit is design on a paper and is transformed in to software using PROTEUS ISIS 8 software. The circuit is divided into sectors such as power supply, light detection sensor, PIC microcontroller and simulated separately. The PIC microcontroller is programmed and assembled with MikroC compiler.

The model in figure 3.3 shows the proposed design for the research. Each model is analysed into detail with their various circuit design in the next chapter.

A polished chip board, screws, glue, and veneer were used to house and enclose the system.

The power source provides the energy for the electrical system from the main grid.

The load absorbs the electrical energy supplied by the source. For example, bulb, computer, etc. The lead crystal display (LCD) shows or displays the credit loaded up in the system.

The keypad is a small set of buttons with numbers on it which is used to load up credit in the meter.

The relay is a control apparatus which when energised with current permit energy to flow through the system to do the appropriate work.

The microcontroller is a true computer on a single chip.

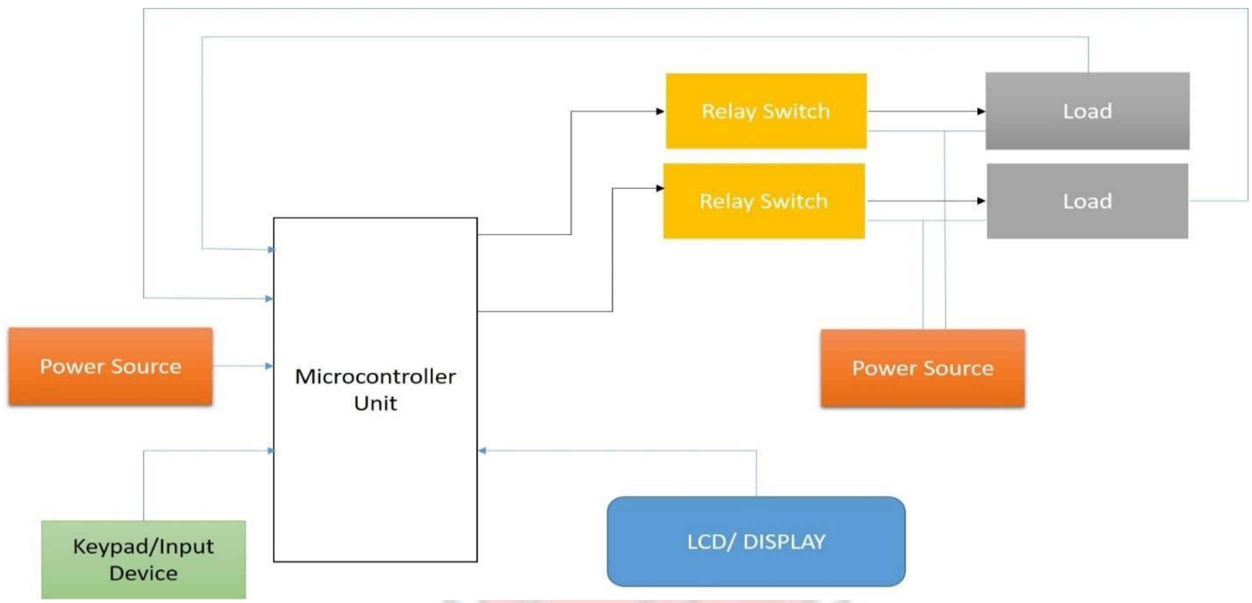
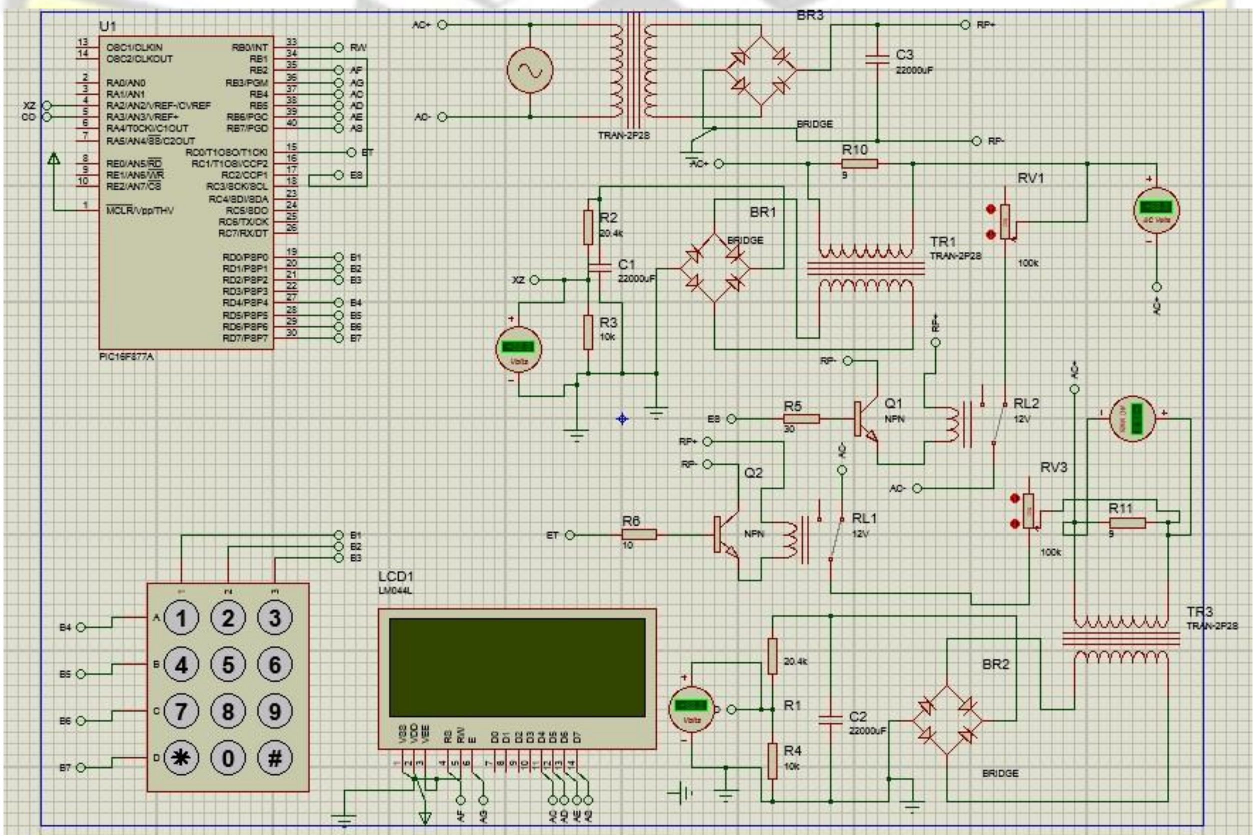


Figure 3.1 Proposed Model and Design

The circuit design layout of the proposed model.



3.5.0 Hardware components

3.5.1 Testing of Resistors

The indicated code value of the resister was red in the Schematic Diagram. Select an Ohm-scale way below the indicated value. A resistor is good if its resistance is almost closed to the value indicated on it. For example a resistor whose value is 1000 Ohms, when it is measured and the value is within the range of 950 Ohms to 1050 Ohms then the resistor is a good resistor. The tolerance has to be considered with Ohmmeter reading. When there is no reading of resistance on the ohmmeter scale settings, it means that the resistor is opened. A zero resistance reading on all Ohmmeter scale settings means that the resistor is shorted.

Example a 1KΩ resistor as illustrated in figure 3.4 was tested. It is represented with Brown, Black and Red Colors where Brown is one (1), Black is zero (0) and Red is the multiplier of 10^2, that is $10 \times 10^2$with Gold tolerance of ± 5%. The value is 10×10^2, which is the same as 1000Ω or 1KΩ.

Figure 3.2 Resistor

Reading with Digital Multi - meter

- An Ohmmeter range of 10KΩ was selected on the multi – meter
- The meter probes was placed at the two terminals of the resistor
- The reading of the resistor value is displayed on the screen

3.5.2 Testing of Capacitors

For electrolytic capacitor(capacitor with polarity), as illustrated in figure 3.5,short the terminals to discharge it prior to testing. Set the multimeter to Rx10 or Rx1K scale. The negative probe of the tester was connected to the positive terminal of the capacitor and the negative terminal was connected to the positive probe. A good indicator shows the meter needle deflecting towards zero and moves back again to infinite resistance position. For other capacitors with capacitance of less than 1.0 Micro farad, the meter did not deflect at all. A defective indication shows that the meter pointer will rest on zero and remain stationery at a point which is an indication that the capacitor is shorted.

In most cases, a capacitor fails due to the deterioration of the dielectric material between its plates. Defective capacitors can have an internal shorted terminals, excessive leakage or degradation of the capacitance meter. Reading with Capacitance Meter

- The range of the capacitance is selected on the meter
- The meter probes is placed at the two terminals of the Capacitor
- The value of the Capacitor after reading is displayed on the screen.

Figure 3.3 Capacitor

3.5.3 Testing of Diodes

Set the multimeter knob to any of the resistances (x1, x10, x1K, x10K Ohm). The positive probe is connected to the anode and the negative probe is connected to the cathode. Then connect the negative probe to the anode and the positive probe to the cathode of the diode. A good indication in the first procedure will show the deflection of the meter very small and in some instance the deflection may not show at all. And in the second procedure, the meter will deflect towards zero. The real or actual reading of the resistance is the forward resistance of the diode. A defective indication shows that the meter will not deflect at all even when the probes are reversed. Or the meter deflects at the same time or almost the same resistance reading for both steps.

There are several diodes such as signal diode, power diode, zener diode, light emitting diode, etc, as illustrated in figure 3.6. Each of them has its own function.

The signal diode allows signal such as radio signal, television signal to be conducted in one direction.

The power diode allows alternating current (a.c) power source to be conducted in one direction.

The Zener diode regulates voltage. It acts as a voltage stabilizer. It also allows current to flow through in one direction.

The Light Emitting Diode (LCD) produces light and allows current to flow through in one direction.

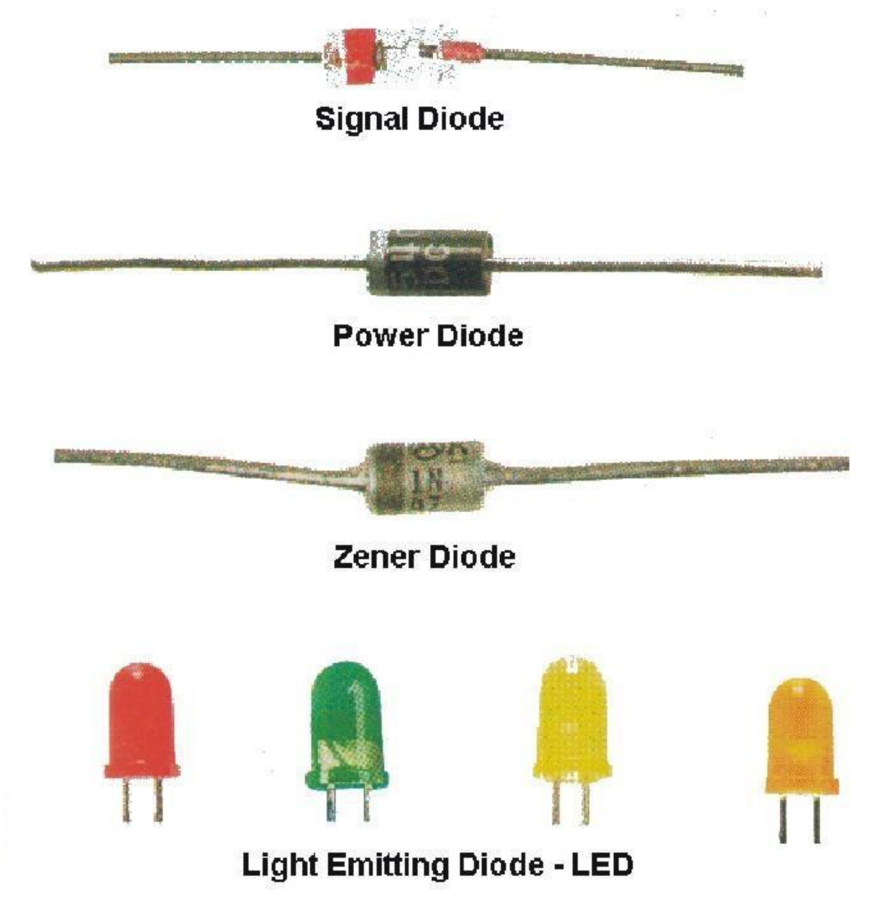


Figure 3.4   Diodes.

3.5.4 Testing of Transistors

Any circuit which contains Bipolar transistors as illustrated in figure 3.7can be checked or detected by means of an ohmmeter. When the ohmmeter is desired to check for resistance across the transistor emitter and collector, NPN or PNP, ohmmeter probes may be connected either way. The transistor which is good will show or indicate a reading above 1000 ohm. NPN or PNP transistor can be determined by indicating the correct terminals of the transistor. In the NPN transistor, current is mainly due to the flow of electrons from the emitter to the collector and in the PNP current is due to the flow of holes (positive charge carriers from the emitter to collector. The range selector on the multimeter is set to x1 or x10 ohm. The positive probe of the multimeter was connected to the emitter of the transistor and the negative probe to the base of the transistor. The reading was noted. Again, the positive probe still connected to the emitter and the negative probe connected to the other end terminal which is the collector of the transistor, and the reading was also noted. In both cases if the transistor reads above 1000 Ohms means the transistor is good. However, in the reverse testing, if there is a reading on the multimeter, it means the transistor is not good. That is to say that in the reverse testing there should be no reading on the multimeter.

If the positive probe of the multimeter is connected to the emitter and the negative probe to the base of the transistor or vice versa and the value is less than 150 Ohms then the transistor is an NPN. Also in the reverse testing if the value indicates infinity, it is also an NPN.

On the other hand if the positive probe of the multimeter is connected to the emitter and the negative probe to the base of the transistor or vice versa and the value is at infinity then the transistor is a PNP. Also in the reverse testing if the value indicates is less than 150 Ohms, it is also a PNP.

Some defective indications of transistors: Resistance between any pairs of terminals less than 10 ohms means that the transistor is shorted. Resistance between base and emitter or base collector for the forward and reverse application of ohmmeter probes is infinity (meter needle do not deflect), means that the transistor is open. Transistor overheats (except power transistors) during normal operating condition means that the transistor is shorted.

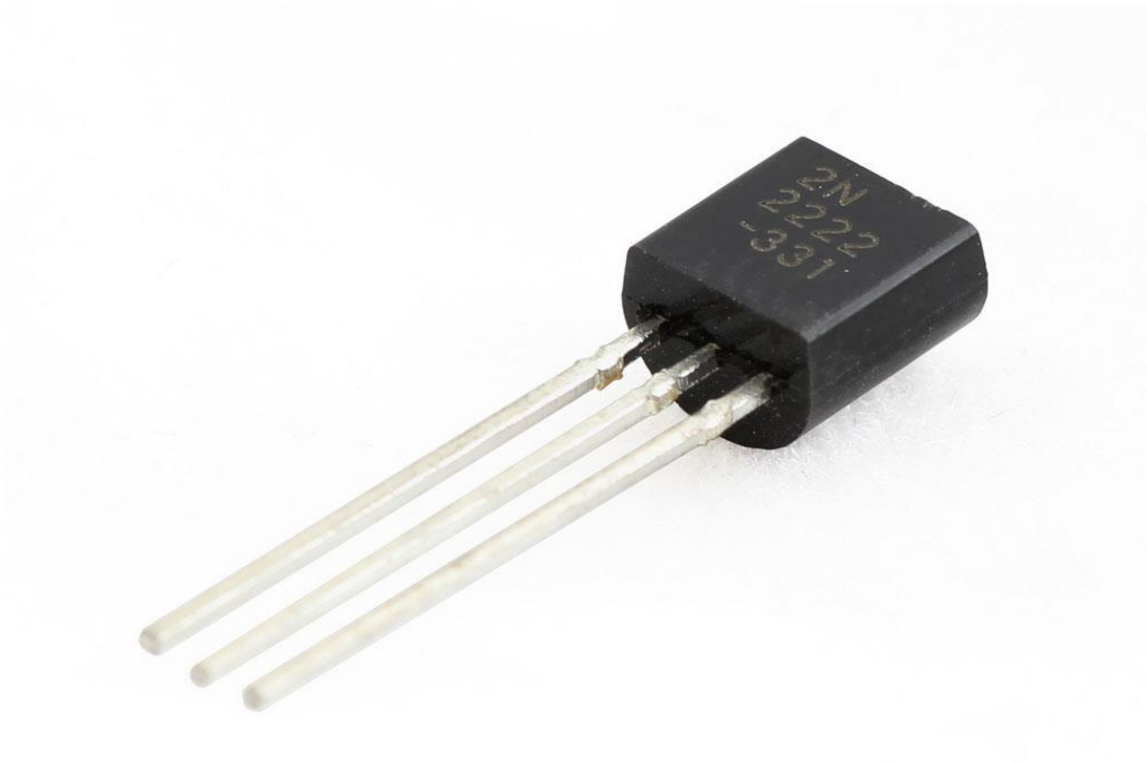


Figure 3.5 Transistor

3.6 Software Section

In this section simulation software example Proteus ISIS 7 and MikroC was used to test the performance parameters of the receiver which include test on Sensitivity, Fidelity and Image frequency rejection. The programming language used to run the microcontroller was MicroC compiler.

3.7 Programming

The programming language employed to run the microcontroller was MikroC compiler. The C programming language is a general-purpose programming language that provides or gives efficient code, elements of structured programming, and a rich set of operators. Its generality, combined with its absence of restrictions, make C a convenient and effective programming solution for a wide variety of software tasks. There are many applications or programs that can run well solved with C language than with other more specialized languages. The MikroC compiler generates code for the PIC microprocessor.

HOW THE OLD METERING SYSTEM WORKS WITHOUT SMART ELECTRICAL DISTRIBUTION SWITCH.

The current metering system without SEDS works in such a way that if two or more users use one energy meter, individual's consumption could not be monitored by the system, therefore there is always misunderstanding between the contributors and some of the contributors feel cheated.

Contributors may contribute the same amount of money to buy the power with different gadgets and at the end they will be isolated from the grid at the same time, and this happens when all the available power gets finished. In another situation the users may contribute different amount of money and in the same way they will be isolated from the grid at the same time when all the power is used up.

The following tables and graph show the nature of the consumption rate by the users when Smart Electrical Distribution Switch is not used.

The various tables 3.1, 3.2, 3.3, and 3.5 represent the amount of money paid by individual contributors and the equivalent power to be consumed. The energy or power consumed by individual contributor was calculated according to ratios using the expression:

Ct = $\frac{Es}{Z}$. Et(KWh); where

Ct represents each contributor's energy in KWh.

Es, represents each user's contribution in cedis. From the tables Es could be A or B or C or D.

Z, represents the total contribution of users in cedis. That is Z = A + B + C + D.

For example: $Ct_A = \frac{A}{A+B+C+D}.Et(KWh)$

$$= \frac{5}{5+6+9+7}(66KWh)$$

$$= \frac{5}{27}(66KWh)$$

$$= 12.2KWh$$

Table 3.1. Total Energy bought is 66KWh in GHS 27.00

User/Energy	Energy/GHS	Energy/Kwh
A	5.0	12.2
B	6.0	14.8
C	9.0	22.0
D	7.0	17.1

Table 3.2. Total Energy bought is 60.6KWh in GHS 25.00

User/Energy	Energy/GHS	Energy/KWh
A	8.0	19.4
B	6.0	14.5
C	4.0	9.7

D	7.0	17.0

Table 3.3. Total Energy bought is 59.5KWh in GHS 22.00

User/Energy	Energy/GHS	Energy/KWh
A	6.0	16.23
B	5.0	13.52
C	5.0	13.52
D	6.0	16.23

Table 3.4. Total Energy bought is 50.9KWh in GHS 20.00

User/Energy	Energy/GHS	Energy/KWh
A	3.0	7.63
B	6.0	15.27
C	7.0	17.82
D	4.0	10.18

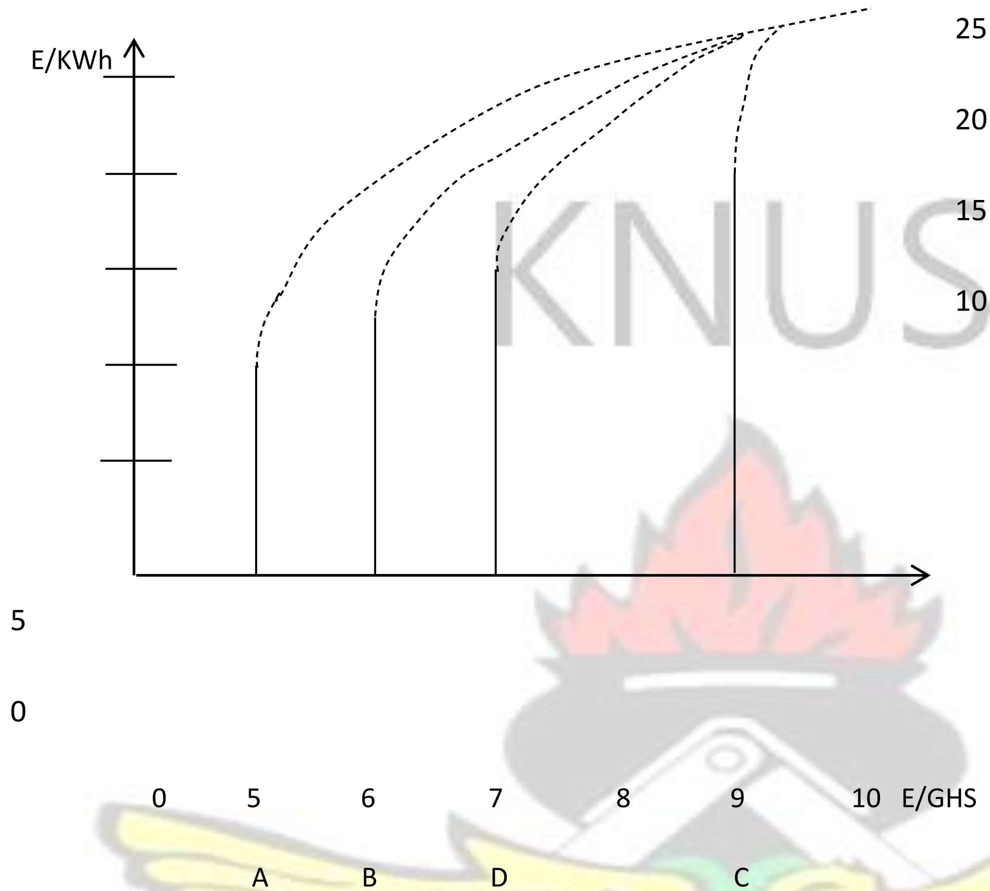
Table3.5. Total Energy bought is 62.8KWh in GHS 26.00

User/Energy	Energy/GHS	Energy/KWh
A	5.0	12.1
B	6.0	14.5

C	8.0	19.3
D	7.0	16.9

The graphs for the various tables follow a similar pattern. The graph shows the pattern. From the graph as shown in figure 3.8, the end of each continuous vertical line from the E/GHS axis shows that the contributor has finished consuming or using his or her share of power. However, because the system could not monitor the power consumption of the users, the system could not isolate the least contributors, they continue to depend on the share of others which is indicated by the broken lines till all the power gets finished and all of them are isolated at the same time.

In order to monitor the consumption rate and the illegal usage of power by the contributors such that other contributors will not feel cheated, Smart Electrical Distribution Switch is introduced. This proposed system monitors the consumption rate of each contributor and isolate the user from the grid when he or she completely consumes his or her share.



The graph represents Energy/kwh against energy /GHS

Figure 3.6

TESTING OF THE SMART ELECTRICAL DISTRIBUTION SWITCH

The design circuit is connected using microcontrollers, resistors, capacitors, diodes, transistors which form the proposed model. The figure shows the proposed model and the circuit design layout.

Proposed model and design.

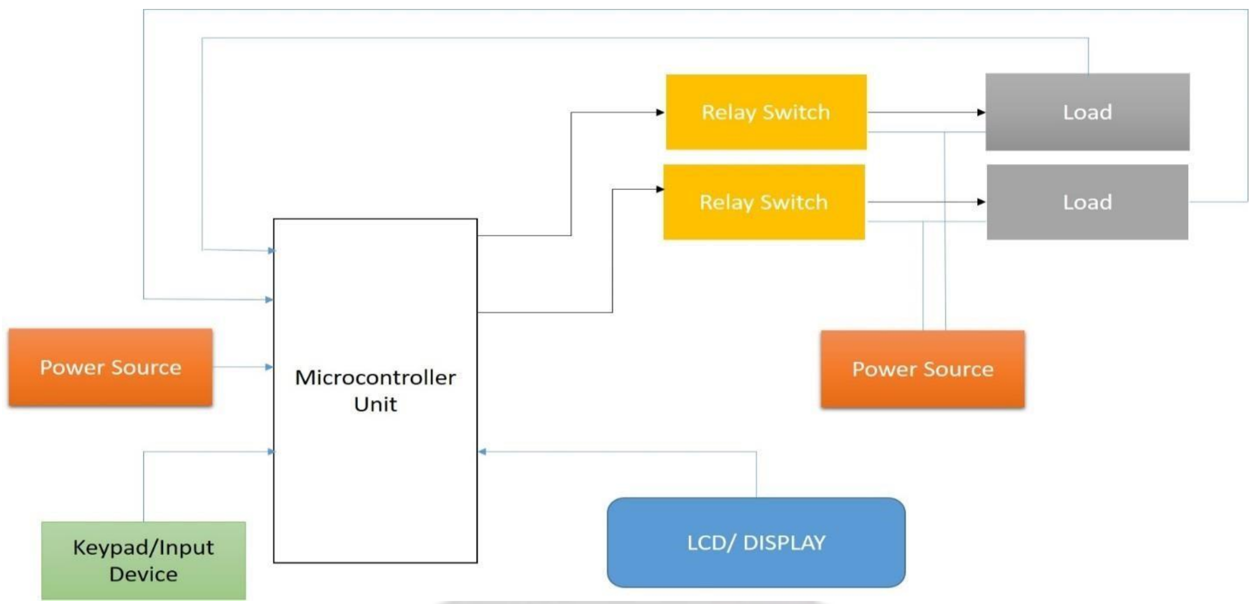


Figure 3.7 Proposed model.

The circuit design layout.

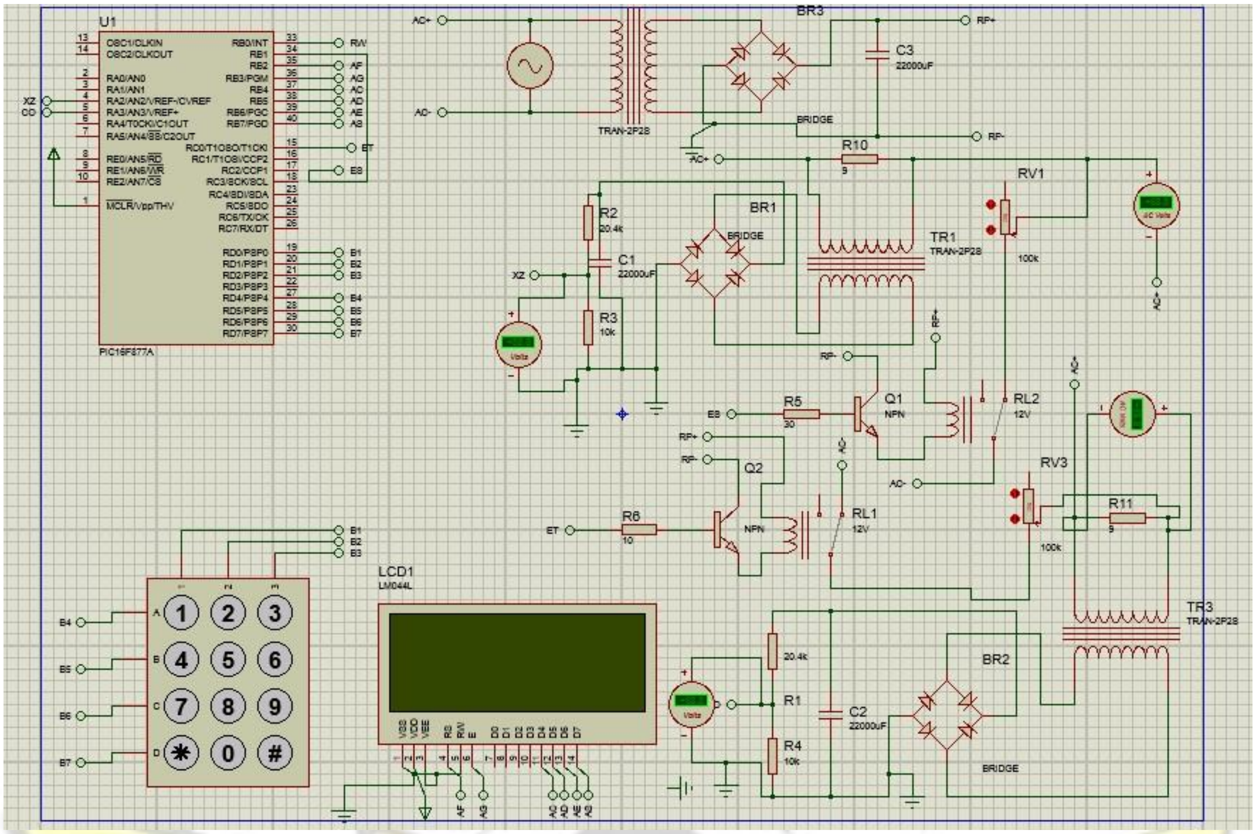


Figure 3.8 The circuit design layout

The various parts of the circuit design layout are briefly described.

The initial request input system has a 4 x 3 keypad to make an input which will be shown on a Lead Crystal Display (LCD).

Initial Request input system

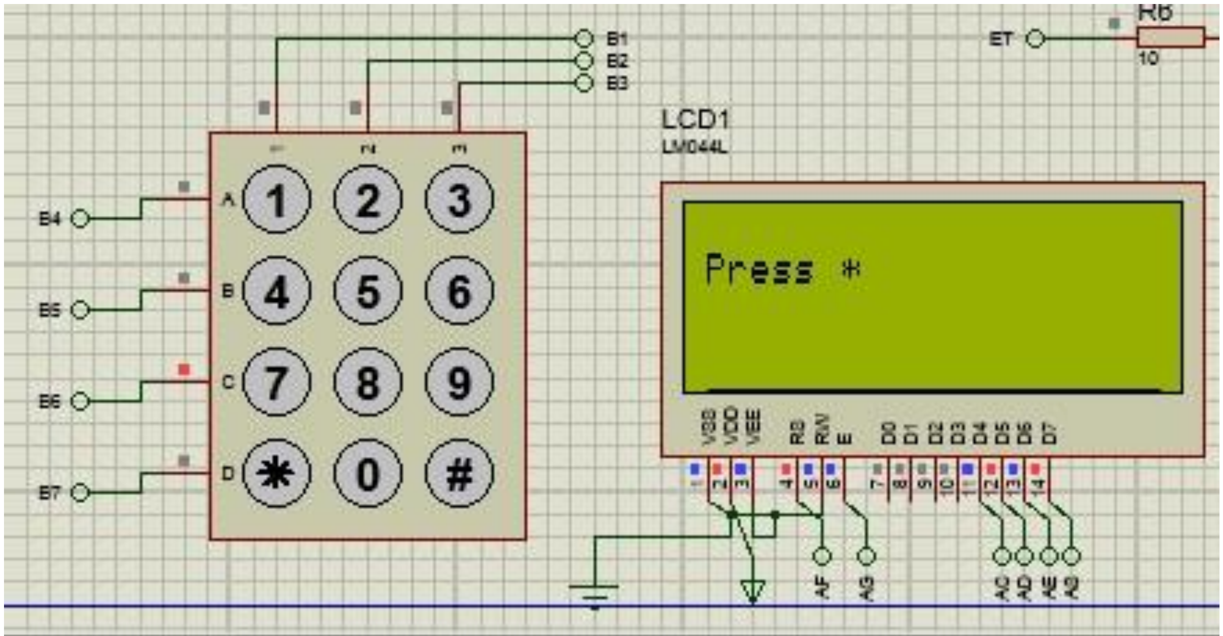
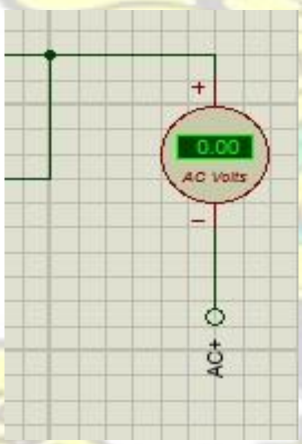


Figure 3.9 Initial Request input system.

Readings from Lead Crystal Display before credit input.

The reading from load 1 and load 2 before credit is loaded is shown in figures 3.12a and 3.12b



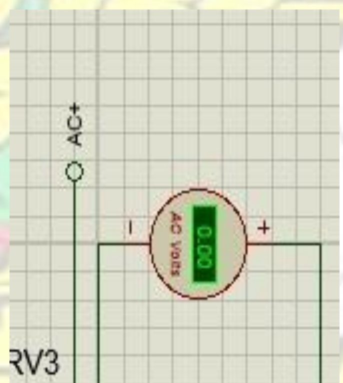


Figure 3.10a Load 1 reading

Figure 3.10b Load 2 reading

The reading from load 1 and load 2 before credit is loaded is shown in figure 3.10a and figure 3.10b

This reading was measured and recorded by the main meter when there was no credit for both user 1 and 2. These readings were achieved because there were no credit and the relay connecting both loads have opened. The relays will stay opened until credit is input onto the system. There are relays which act as switches.

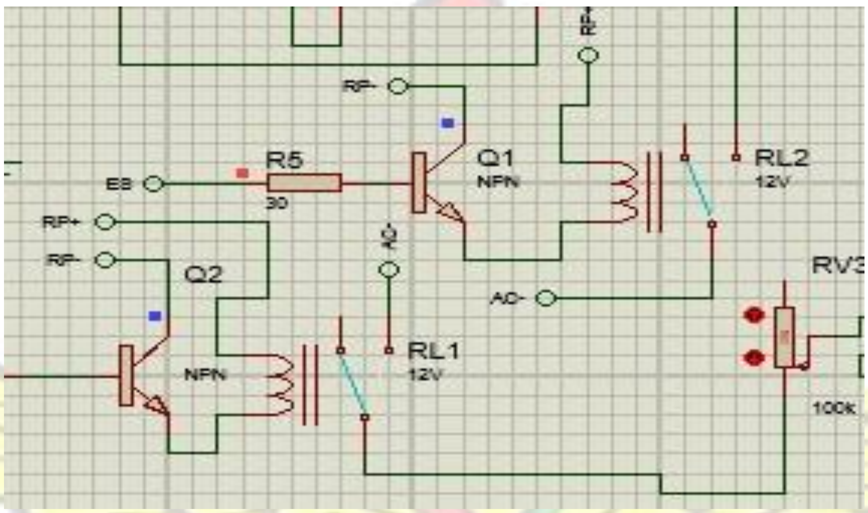


Figure 3.11 Relay 1 and 2 before credit

Figure 3.13 shows the relay 1 and 2 after the credit input. It will stay connected until the user completely consumes the power based on the type of electrical appliance used. Whenever there is current from the main grid in to the system through the transistor, the relay is energized to close the circuit, and when the credit get finished no current will flow through the transistor and the relay is de-energized to open the circuit.

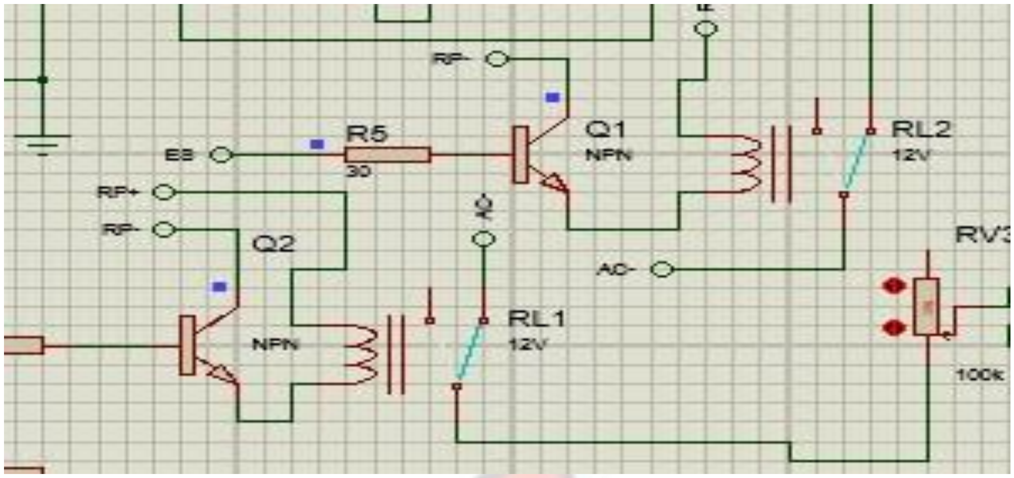


Figure 3.12: Relay 1 and 2 after credit input

FUNCTION OF THE LEAD CRYSTAL DISPLAY (LCD)

The Lead Crystal Display (LCD) indicates the credit input expressed in kilowatt hour because the energy from the supplier is expressed in kilowatt hour. User one (L1 units) has been supplied with 9KW of credit and user two (L2 units) is given 16KW. It is shown in figure 3.14

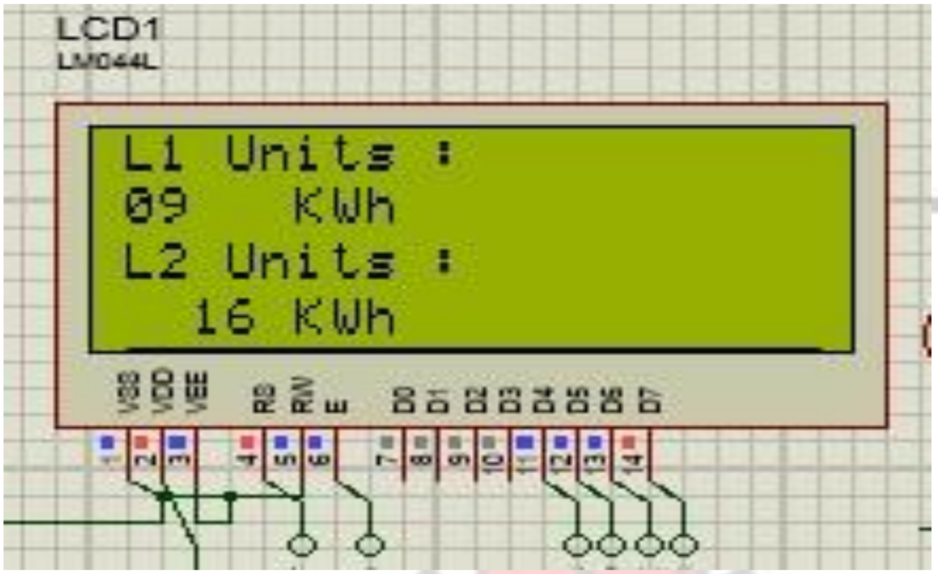


Figure 3.13 Shows input of credit for line 1 and line 2

TESTING THE SIMULATED SYSTEM

The simulated system was loaded up with 26KW of credit which was connected to a device of 2.2kw. As the load absorbed the credit supplied, the credit reduced until it finally got finished. The simulation time was recorded. When the simulated system was loaded up with more credit of 66KW and maintaining the 2.2kw load, it took more time for the credit to finish, hence more time to isolate the user from the system.

The tables 3.6, 3.7, 3.8, 3.9, and 3.10 illustrate the credit (amount of energy in Kw), load (Kw) and the simulation time in minutes.

Table 3.6

USER	ENERGY(KW)	LOAD(KW)	SIMULATION TIME (MINUTE)
A	5.0	2.2	1.00
B	6.0	2.2	1.20
C	7.0	2.2	1.40
D	8.0	2.2	1.6

Table 3.7

USER	ENERGY(KW)	LOAD(KW)	SIMULATION TIME (MINUTE)
A	12.2	2.2	2.44
B	14.8	2.2	2.96
C	17.0	2.2	4.40
D	22.0	2.2	4.40

Table 3.8

USER	ENERGY(KW)	LOAD(KW)	SIMULATION TIME (MINUTE)
A	9.7	2.2	1.94
B	14.5	2.2	2.90
C	17.0	2.2	3.40
D	19.4	2.2	3.88

Table 3.9

USER	ENERGY(KW)	LOAD(KW)	SIMULATION TIME (MINUTE)
A	9.0	2.2	1.80
B	10.0	2.2	2.21
C	15.0	2.2	2.26
D	16.0	2.2	2.39

Table 3.10

USER	ENERGY(KW)	LOAD(KW)	SIMULATION TIME (MINUTE)
A	12.1	2.2	2.42
B	14.5	2.2	2.90
C	1.9	2.2	3.38
D	19.3	2.2	3.86

The graphs for the tables 3.6, 3.7, 3.8, 3.9, 3.10 follow similar pattern as illustrated in figure

3.14.

The Smart Electrical Distribution Switch controls individual's power consumption and if a contributor's power gets finished, he or she is isolated from the grid.

From the graph illustrated in figure 3.16, provided the load (kw) is kept constant, the more the credit, the more time it takes for a user to be isolated from the system.

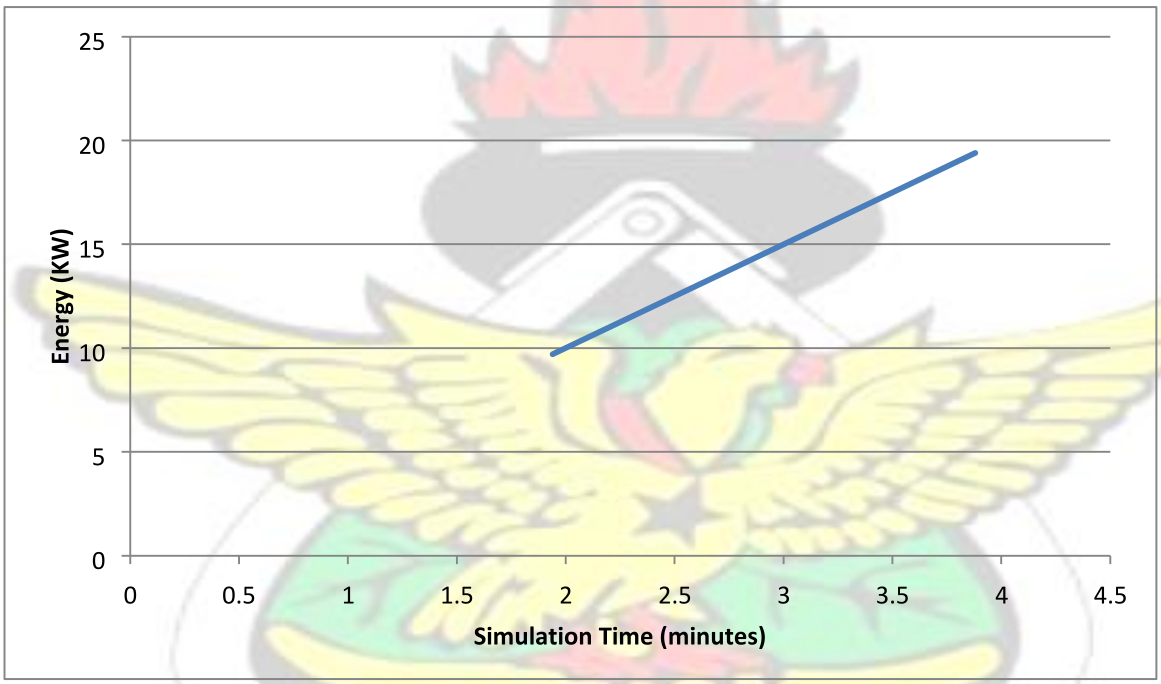


Figure 3.14. A graph of Energy (KW) against Simulation time (minutes)

CHAPTER FOUR

ANALYSIS OF ELECTRICAL USAGE I N HOUSEHOLD AND COMPARISON OF THE OLD AND THE PROPOSED SYSTEM

Programming

The programming language employed to run the microcontroller was MikroC compiler. The C programming language is a general-purpose programming language that provides or gives efficient code, elements of structured programming, and a rich set of operators. Its generality, combined with its absence of restrictions, make C a convenient and effective programming solution for a wide variety of software tasks. There are many applications or programs that can run well solved with C language than with other more specialized languages. The MikroC compiler generates code for the PIC microprocessor.

The Smart Electrical Distribution Switch is the proposed system which calls for one meter is introduced. The amount of money paid by each contributor is entered in to the system and stored in EPROM of a microcontroller that will reduce each user's energy of power base on the user's consumption rate. The system will monitor each contributor's consumption and isolates the user from the grid when he or she completely consumes his or her share.

The various tables show the values of individual contributors in cedis for five different households when Smart Electrical Distribution Switch is used which are converted in KWh using the expression:

$$Ct = \frac{Es}{Z}.\ Et(KWh);\ \text{where}$$

Ct, represents each contributor's energy in KWh.

Es, represents each user's contribution in cedis. From the tables Es could be A or B or C or D.

Z, represents the total contribution of users in cedis. That is Z = A + B + C + D.

For example: $Ct_A = \frac{A}{A+B+C+D}.Et(KWh)$

$$= \frac{4}{4+5+7+7}(57\text{KWh})$$

$$= \frac{5}{23}(57KWh) = 9.9\text{KWh}$$

Table 4. 1. Total Energy bought is 57KWh in GHS 23.00

User/Energy	Energy/GHS	Energy/KWh
A	4.0	9.9
B	5.0	12.4
C	7.0	17.4
D	7.0	17.4

Table 4.2 . Total Energy bought is 58KWh in GHS 24.00

User/Energy	Energy/GHS	Energy/KWh
A	4.0	9.7
B	6.0	14.5
C	5.0	12.6
D	9.0	21.8

Table 4.3 . Total Energy bought is 45KWh in GHS 15.00

User/Energy	Energy/GHS	Energy/KWh
A	4.0	12
B	4.0	12
C	5.0	15
D	2.0	6

Table 4.4 Total Energy bought is 78KWh in GHS 30.00

User/Energy	Energy/GHS	Energy/KWh
A	7.5	19.5
B	7.5	19.5
C	7.5	19.5
D	7.5	19.5

Table 4.5 Total Energy bought is 46,6KWh in GHS 16.00

User/Energy	Energy/GHS	Energy/KWh
A	5.0	14.56
B	4.0	11.65
C	3.0	8.74
D	4.0	11.65

The graphs for the various tables follow a similar pattern.

From the graph as shown in figure 4.1, the end of each continuous vertical line from the E/GHS axis shows that the contributor has finished consuming or using his or her share of power. However, this time, the Smart Electrical Distribution Switch was able to monitor each contributor's consumption or usage and isolate each contributor as soon as his or her share is completely consumed. Nobody uses anybody's share.

The graph represents Energy/KWH against Energy/GHS

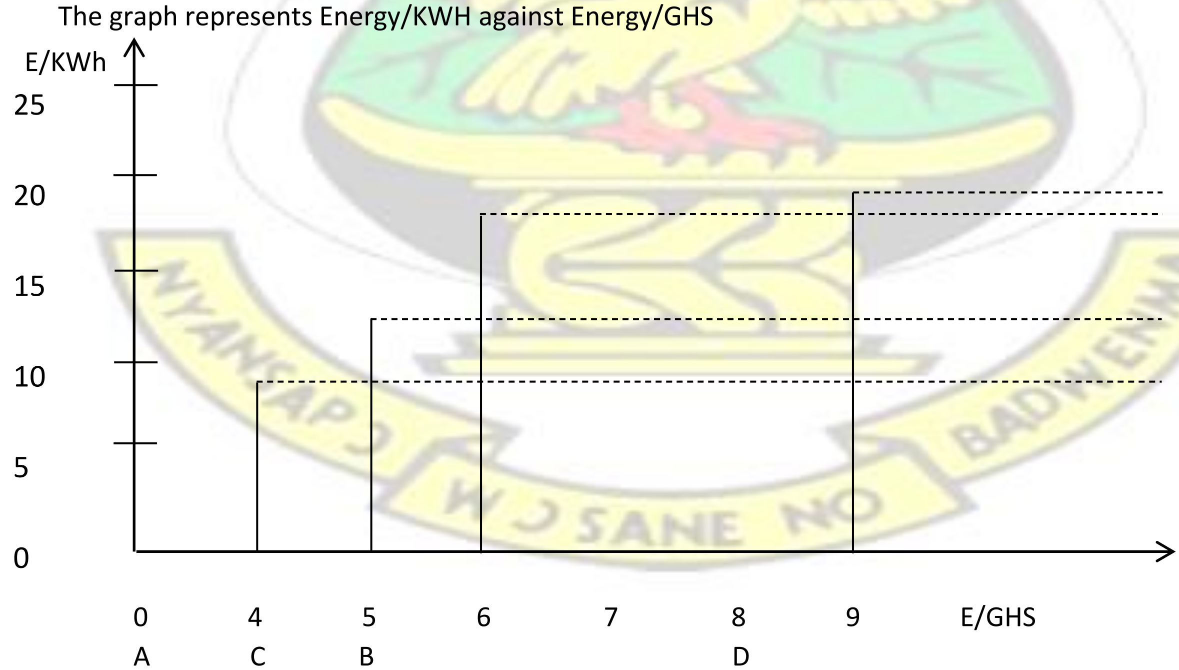


Figure 4.1, A graph of energy(Kwh) against energy(GHS).

4.2 Results after credit input

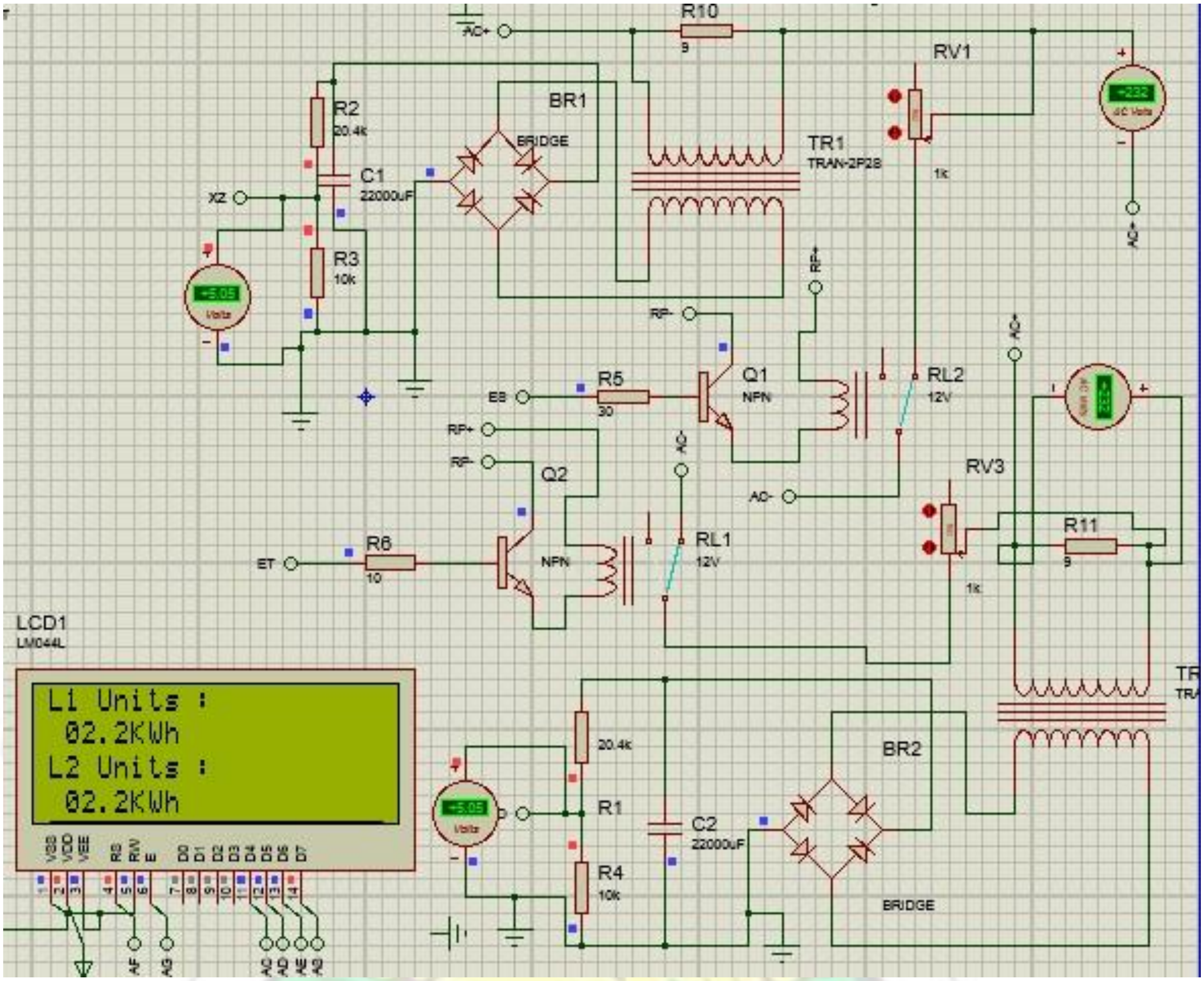


Figure 4.2Credit before complete consumption

The above reading showed the reading and load analysis by the system with 8kw and 16kw supplied to user 1 and 2 respectively. The load connected is 2.2Kwh each.

After complete consumption of the available power the LCD shows 00.0KWh for both line one and two.

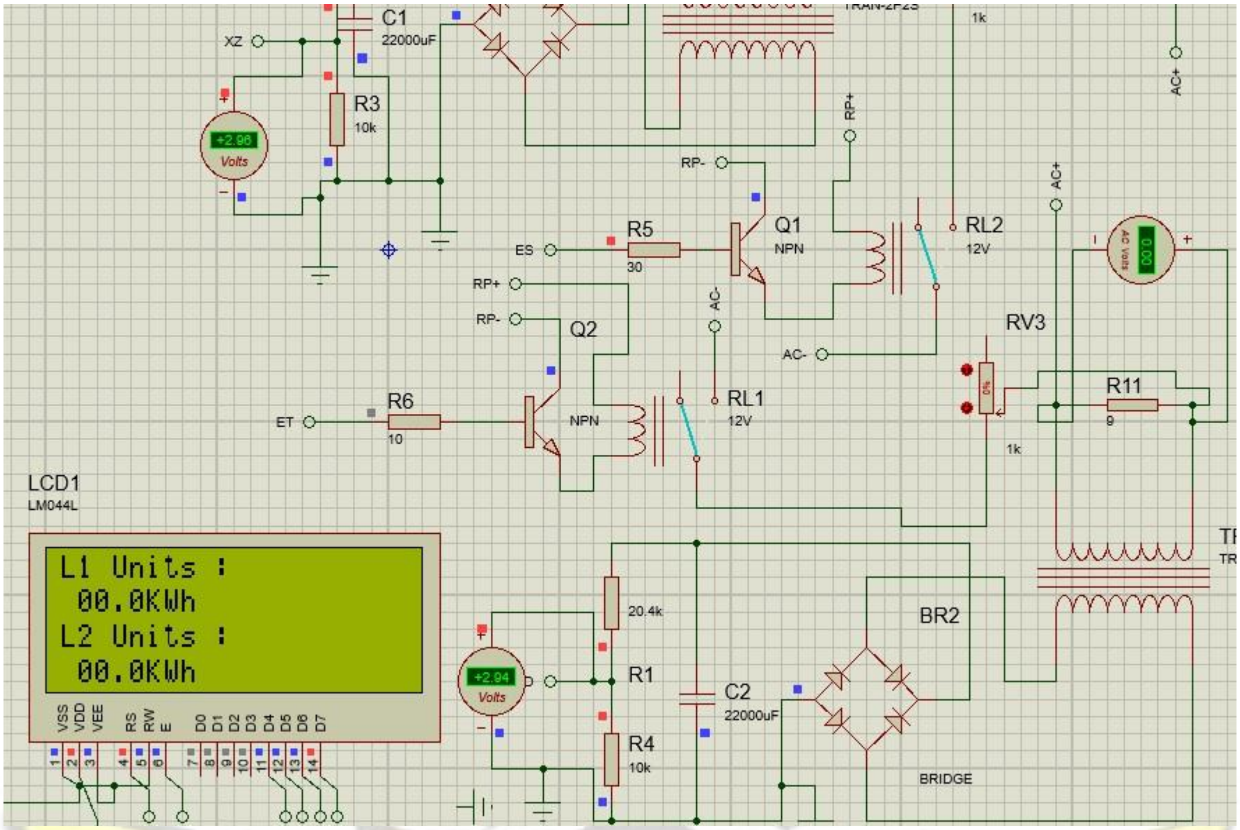


Figure 4.3: Results after complete consumption

4.3 Discussion

The test was successful as shown in the tables 4.1, 4.2, 4.3, 4.4, and 4.5. There are different readings as per the load and credit supplied. The system isolates the user as soon as the user's credit is completely used up. Provided the load is maintained, the more the credit, the more time it takes for a user to be isolated from the system.

4.4 Findings

After series of test and observation, it was observed that there were some minimal errors in the operation of the microcontroller circuitry and the whole layout. This error can be described as technical error from the programming of the microcontroller and the circuit design. The error was estimated around 3.0% of the normal reading which was considered as a threshold added to the readings obtained. It was also observed that a little change or fault can cause the setup to record error and therefore there was the need for optimization in designing and programming.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 Discussion

The idea of interfacing power sharing has been implemented with various levels of technologies in many applications. This research work was organized based on the ability to incorporate both hardware and software technologies to design a flexible monitoring system to be used in household wiring installations. This was made possible by using a microcontroller based embedded system with other electronic circuit to stimulate a software interface to serve as a security based entity to enable the desired purpose.

5.1 Social Impact

Based on the problem statements of this research work, a lot of positive impacts are reflected on the society. The problems stated above have been achieved in about 80% efficiency. With an interface to an LCD screen, the right status of the consumption is displayed on without manually sharing of credit and calculation of load used by individuals in a household. This research work has been one of the complex systems which combine multiple schools of taught in a single unit.

It therefore serves as an academic material for future students on the field of Electronic Engineering, Electrical Engineering and Computer Engineering. The whole work can also serve as a way of employment for the abovementioned category of engineers since the demand for such system is very high in Ghana and even beyond.

5.2 Recommendation

As a research work, the complete functionality was not attained within the designated period. Electronic, Electrical and Computer engineering as well as Information Technology students are therefore entreated to embark on this research to make it a final product to be delivered to individuals for installation for households and other type of consumers. It is therefore recommended that special kits be designed by technicians to support such an objective in diverse ways.

5.3 Conclusion

Electrical energy is one of the highest entities for human life in many ways. In Ghana the desired amount of electrical energy is distributed among individuals through energy meters. Users have cases of consumption by individuals. This research work was about the difficulties and the limitations that exist in the manual system for monitoring these systems and therefore embarked on this work to solve the problems noticed. This research work has demonstrated how to get a fully functional embedded product for monitoring the status of an electrical power usage in households and communicate the information to the user through software with minimal error conditions. This is implemented through the utilization of a dedicated electronic circuit, microcontroller and its assembly, and a graphical user interface installed at the consumer premises.

5.4 Further Study

Future research should focus on optimizing the code used in the system design to achieve the complete functionality of the system.

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Households with respective Meter Numbers: 1. 011010381101, 2. 204020021, 3. 204020030, 4. 011010118591, 5. 011010578821, 6. 251156134, 7. 011010376571, 8. 011010669471, 9. 011010677271, 10. 241846429.

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GLOSSARY

MC.Microcontroller. V.Voltage.

A Ampere.

LCD. Liquid Crystal Display.

R Resistor.

SEDS Smart Electrical Distribution Switch.

L1 Line 1 or Load 1.

L2 Line 2 or Load 2.

KWh Kilowatt hour.

GHS Ghana Cedi.

APPENDIX 1

Appendix 1 shows the codes that controls the system.

Software code for the Microcontroller

```
char *volt = "00.0"; char *volt2 = "00.0"; unsigned short kp;

char code1[10] ,user1[4], code2[10]; char msg1[20] =

"Initializing......",msg2[15] = "Enter L1 Units"; char msg3[15] =

"L1 Units : ",msg4[15] = "L2 Units : "; char msg5[15]  = "Enter

L2 unit"; int i=0,j,cnt, u1,u2, v1,v2;

// Keypad module connections

char  keypadPort at PORTD;

sbit LCD_RS at RB2_bit; sbit

LCD_EN at RB3_bit; sbit

LCD_D4 at RB4_bit; sbit

LCD_D5 at RB5_bit; sbit

LCD_D6 at RB6_bit; sbit

LCD_D7 at RB7_bit;
```

```
sbit LCD_RS_Direction at TRISB2_bit; sbit
LCD_EN_Direction   at   TRISB3_bit;   sbit
LCD_D4_Direction   at   TRISB4_bit;   sbit
LCD_D5_Direction   at   TRISB5_bit;   sbit
LCD_D6_Direction   at   TRISB6_bit;   sbit
LCD_D7_Direction at TRISB7_bit;
// End LCD module connection


void code_enter()
{ kp = 0;                              // Reset key code
variable // Wait for key to be pressed and released
do
//kp = Keypad_Key_Press();             // Store key code in kp variable kp
= Keypad_Key_Click();             // Store key code in kp variable while
(!kp);
// Prepare value for output, transform key to it's ASCII value switch
(kp)
 {   case  1: kp = '1'; break;
// 1   case  2: kp = '2';
break; // 2   case  3: kp =
'3'; break; // 3   case  5: kp
= '4'; break; // 4   case  6:
kp = '5'; break; // 5 case  7:
kp = '6'; break; // 6 case  9:
```

```
kp = '7'; break; // 7   case
10: kp = '8'; break; // 8
case 11: kp = '9'; break; // 9
case 13: kp = 42; break; // *
case 14: kp = 48; break; // 0
case 15: kp = 35; break; // #
 }  code1[i]  =
kp;
Lcd_Chr(2, i+1, code1[i]);                    // Print key ASCII value on Lcd
i++; } void code_enter2()
{ kp = 0;                              // Reset key code
variable // Wait for key to be pressed and released
do
//kp = Keypad_Key_Press();             // Store key code in kp variable kp
= Keypad_Key_Click();             // Store key code in kp variable while
(!kp);
// Prepare value for output, transform key to its ASCII value switch
(kp)
 { case  1: kp = '1'; break; //
  1 case  2: kp = '2'; break; //
  2   case  3: kp = '3'; break;
  // 3   case  5: kp = '4';
  break; // 4   case  6: kp =
  '5'; break; // 5   case  7: kp
```

```
 = '6'; break; // 6   case  9:
 kp = '7'; break; // 7   case
 10: kp = '8'; break; // 8
 case 11: kp = '9'; break; //
 9   case 13: kp = 42;
 break; // *   case 14: kp =
 48; break; // 0   case 15:
 kp = 35; break; // #
 }  code2[i]  =
kp;
Lcd_Chr(2, i+1, code2[i]);                    // Print key ASCII value on Lcd
i++; } void delay_20ms()
{
Delay_ms(20);
}         void
main()
{
  ADCON0 = 0b00001000; // Analog channel select @ AN2
  ADCON1 = 0x00;
//  CMCON0 = 0x07 ; // Disbale comparators
  TRISC = 0b00000000; // PORTC All Outputs
  TRISA = 0b00001100; // PORTA All Outputs, Except RA3 and RA2
 TRISB.F1=0;
 PORTC=1;
```

```
PORTB.F1=1;
Keypad_Init();                    // Initialize Keypad
Lcd_Init();                       // Initialize Lcd
//ADC_Init();
//If no code is stored then default is 0000
Lcd_Cmd(_LCD_CLEAR);              // Clear display
Lcd_Cmd(_LCD_CURSOR_OFF);         // Cursor off
Lcd_Out(1, 1, msg1 );
Delay_ms(500);
Lcd_Cmd(_LCD_CLEAR);
Lcd_Out(2, 1, "Press *");
 i = 0;
code_enter();
if(code1[0] == 42)
  {
   Lcd_Cmd(_LCD_CLEAR);           // Clear display
   Lcd_Out(1, 1,msg2);
   //delay_ms(500);
   i = 0;
code_enter();
code_enter();
u1=code1;    v1
=code1;
  }
```

```
 delay_ms(500);
 Lcd_Cmd(_LCD_CLEAR);
 Lcd_Out(2, 3, " Press * ");
i = 0;   code_enter2();
if(code2[0] == 42)
 {
  Lcd_Cmd(_LCD_CLEAR);                    // Clear display
Lcd_Out(1, 1,msg5);    delay_ms(500);
  i = 0;
code_enter2();
code_enter2();
u2=code2; v2
=code2;
  //i = 0;
 }
 //cnt=0;
 Lcd_Cmd(_LCD_CLEAR);
 Lcd_Out(1, 1, msg3);
 Lcd_Out(2, 1, u1);
Lcd_Out(2, 6, "KWh");
delay_ms(500);
 Lcd_Out(3, 1, msg4);
```

```
 Lcd_Out(4, 3, u2);
Lcd_Out(4, 6, "KWh");
delay_ms(500);

do
 {

   ADC_Value = ADC_Read(2);
DisplayVolt =(ADC_Value/670)*220;
volt[0] = DisplayVolt/1000 + 48;
volt[1] = (DisplayVolt/100)%10 + 48;
volt[3] = (DisplayVolt/10)%10 + 48;
v1= v1 - atol(volt); //volt = v1;
   Lcd_Cmd(_LCD_CLEAR);
   Lcd_Out(1, 1, msg3);
   Lcd_Out(2, 2, volt);
   Lcd_Out(2, 6,"KWh");
   ADC_Value = ADC_Read(3);
DisplayVolt = (ADC_Value/670)*220;
volt2[0] = DisplayVolt/1000 + 48;
volt2[1] = (DisplayVolt/100)%10 + 48;
volt2[3] = (DisplayVolt/10)%10 + 48;
v2= v2 - atol(volt2);    //volt2 = v2;
   //delay_ms(500);
```

```
  Lcd_Out(3, 1, msg4);
  Lcd_Out(4, 2, volt2);
Lcd_Out(4, 6, "KWh");
delay_ms(500);
if(v1<=0)
PORTC.F0=1;
    else
       PORTC.F0=0;
if(v2<=0)
PORTB.F1=1;
    else
       PORTB.F1=0;
delay_ms(500); }while(1);
}
```